

# **Appendix 1 – Part 1 – Summary of Existing Watershed Resources – Brief Descriptions**

## **Additional Vulnerability Analysis for Almonte WHPA Model (2007)**

The vulnerability analysis for the Almonte Wellhead Protection Area (WHPA) completed in 2003 was updated to the most recent Ministry of the Environment (MOE) groundwater vulnerability guidance module. Updates to the Almonte WHPA model included the delineation of a 5 year time of travel (TOT) capture zone, vulnerability scoring for the Nepean aquifer and uncertainty analysis.

## **A Multidisciplinary, Community-Based Study of the Environmental Health of the Rideau River: Final Report (2001)**

This report documents the results of the Rideau River Biodiversity Project (RRBP) which was conducted from 1998 to 2000 on the Rideau River from Smiths Falls to Ottawa. The projects goals were to assess the biodiversity of the Rideau River and to reconcile local needs with long-term sustainable management of its biological diversity. Eight biological components were monitored as part of the project and included: aquatic birds, aquatic invertebrates, aquatic plants, amphibians, fish, freshwater mussels, phytoplankton, and reptiles. In addition to the biological components of the study, water chemistry was also sampled and analyzed.

## **A Prioritization System for Wetlands within the Rideau Valley Watershed, Draft Report (2006)**

The purposes of this study were to develop an updated and comprehensive inventory of all Ontario Ministry of Natural Resources (OMNR) evaluated wetlands in the Rideau Valley Watershed, develop a wetland protection prioritization scheme that can be applied to all evaluated wetlands for identification of the most threatened wetland habitats and prepare a database containing information from the OMNR's evaluated wetland data records and the prioritized results for each evaluated wetland.

## **Aquifer Protection, Village of Carp (1992)**

The study was undertaken to address concerns regarding the protection of the groundwater supply for the proposed municipal supply well for the Village of Carp. The goals of the study were to define sensitive recharge areas for the Carp aquifer and determine the groundwater influence based on 20 years of pumping from the proposed well. Further information was required to define the sensitivity of the aquifer with regards to the sensitive recharge areas / clay thickness.

## **Baseline Surface Water Quality Program – Technical Report Five-Year Analysis 1998 through 2002 (2004)**

The City of Ottawa compiled a summary of the surface water quality monitoring program and it was presented in the Baseline Surface Water Quality Program – Technical Report (2004). The data within the report was also extended through 2004 with an attached letter documented sampling results from 2003 and 2004. Results of the CCME Water Quality Index indicated that the larger rivers have good to excellent water quality, major tributaries have fair to marginal water quality, rural creeks are generally marginal water quality and urban creeks are generally fair water quality.

### **Carp Communal Water Supply Project (1987)**

The study was undertaken to determine the viability of finding a groundwater source to supply the Village of Carp with drinking water. The municipal drinking water supply would be used to replace the private individual services within the Village of Carp. The private individual services in the Village of Carp were noted to be contaminated (type not specified). The study involved the installation of several groundwater monitoring wells and one test well in the Village of Carp and aquifer testing for both water quality and quantity. It was recommended that the aquifer is considered suitable for a municipal water supply and a number of potential well sites were identified.

### **Carp – First Engineer’s Report (2001)**

The report documents the findings and recommendations for the Carp Water Treatment Plant which supplies the former Village of Carp (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer’s reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Carp, Munster Hamlet and Kings Park – Wellhead Protection Area Maps (2007)**

The vulnerability analysis for the Carp, King’s Park (Richmond) and Munster Hamlet Wellhead Protection Areas (WHPA) completed in 2003 were updated to the most recent Ministry of the Environment (MOE) groundwater vulnerability guidance module. Updates to the Carp, King’s Park (Richmond) and Munster Hamlet WHPA models included the delineation of a 5 year time of travel (TOT) capture zone, vulnerability scoring for the overburden aquifer (Carp) and Nepean aquifer (King’s Park and Munster Hamlet) and uncertainty analysis.

### **Carp River Watershed / Subwatershed Study (2004)**

The Carp River Watershed / Subwatershed Study was completed to document the existing conditions of the watershed, establish watershed goals and objectives develop a watershed and subwatershed plans, and an implementation plan. The watershed study area is defined as consisting of all lands within the Carp River and its tributaries. The subwatershed study area defined for the project consists of only the lands within the headwaters of the Carp River, upstream of Richardson Side Road. The overall study goal was to develop and implement appropriate strategies in order to protect, enhance and restore the natural resources of the Carp Watershed under present conditions and as land use changes occur. Environmental goals and objectives were also set with regards to the following components: surface / ground water quantity, surface / ground water quality, aquatic resources, and terrestrial resources.

### **Carp Road Corridor Groundwater Study (2004)**

This study was performed on behalf of the City of Ottawa with the purpose of determining if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services. This study included five main tasks, including: [1] groundwater resource assessment; [2] groundwater use assessment; [3] potential contaminant source assessment; [4] groundwater sampling program; and [5] development of mitigation measures for new development.

### **City of Ottawa, Britannia Water Purification Plant, Engineer’s Report (2001)**

The report documents the findings and recommendations for the Britannia Water Purification Plant which supplies a portion of the City of Ottawa. The report was prepared for the Ontario

Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

**City of Ottawa, Lemieux Island Water Purification Plant, Engineer's Report (2001)**

The report documents the findings and recommendations for the Lemieux Island Water Purification Plant which supplies a portion of the City of Ottawa. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

**City of Ottawa, Munster Hamlet, Communal Well System, Engineer's Report (2001)**

The report documents the findings and recommendations for the Munster Hamlet Communal Well System which supplies the former Munster Hamlet (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

**City Stream Watch – 2003 Annual Report (2003)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2003 season consisted of Black Rapids Creek, Cardinal Creek, Mud Creek and Sawmill Creek.

**City Stream Watch – 2004 Annual Report (2004)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2004 season consisted of Bilberry Creek, Monterey Creek, Mosquito Creek and Stillwater Creek. Fish communities were also sampled on Bilberry Creek, Mosquito Creek and Stillwater Creek. In addition, three creek clean-up initiatives were organized and conducted on Sawmill Creek which was assessed during the 2003 program.

**City Stream Watch – 2005 Annual Report (2005)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2005 season consisted of Graham Creek, Greens Creek, Mosquito Creek and Stevens Creek. Fish communities were also sampled on Graham Creek, Greens Creek and Stevens Creek. In addition, five creek clean-up initiatives were organized and conducted on Greens Creek (two events) and Sawmill Creek (three events) which were assessed during previous City Stream Watch programs. One riparian rehabilitation planting project was also conducted on Sawmill Creek on an area with a failed bank.

### **City Stream Watch – 2006 Annual Report (2006)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2006 season consisted of Becketts Creek, Brassils Creek and Pinecrest Creek. Fish communities were also sampled on Brassils Creek, Greens Creek and Pinecrest Creek. In addition, three creek clean-up initiatives were organized and conducted on Pinecrest Creek (one event) and Sawmill Creek (two events) which were assessed during previous City Stream Watch programs. Four riparian rehabilitation planting projects were also conducted Graham Creek (one site), Mosquito Creek (one site) and Sawmill Creek (two sites).

### **Confirmatory Sampling of Well #2 to Examine GUDI Potential, Village of Westport (2006)**

The report was undertaken to establish whether or not the groundwater sources from the municipal supply well (Well 2) in the Village of Westport is under the direct influence of surface water (GUDI) following the abandonment of the former supply well (Well 1). This report is a follow up to the 2003 Hydrogeological Study which recommended the abandonment of Well 1. The report summarizes the results of a one year monitoring program on Well 2.

### **Construction and Testing of a Production Well (PW2) for the Village of Carp (1994)**

The construction and testing of the second production well for the municipal water supply system in the Village of Carp was conducted in 1994. This well was constructed to complement the existing pumping well that was completed in 1986. The second production well was constructed 10 m north of the existing pumping well and screened in the gravel aquifer. The testing conducted included both water quality and quantity.

### **Construction in Contaminated Areas, Village of Carp Sewer and Water Project, Carp, Ontario (1995)**

During the installation of the water and sewer servicing for the Village of Carp several areas of hydrocarbon contamination were encountered. Five potential sources of contamination based on historic information were identified. This report documents the investigation of these areas and the removal of hydrocarbon impacted material, both soil and groundwater, from the right of way at three of these locations. In addition to the removal of the hydrocarbon impacted material, trench drains and vapour extraction pipes were installed in the service trenches at these three areas as a contingency for future contamination from these areas.

### **Construction of Multi-Level Sentinel Wells for the King's Park Communal Wells, Village of Richmond (Ottawa), Ontario (2006)**

This report documents the installation of two sentinel groundwater monitoring wells for the municipal drinking water supply system at the King's Park Subdivision in the Village of Richmond which is located within the amalgamated City of Ottawa. The work was conducted to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the communal wells system in the Village of Richmond. The field program was conducted in the fall of 2004 and summer of 2005. Groundwater monitoring and sampling event was not conducted as part of the report but is to be conducted by the City of Ottawa at a later date.

### **Construction of Sentinel Wells for the Carp Communal Well System, Village of Carp (Ottawa), Ontario (2006)**

This report documents the installation of two sentinel groundwater monitoring wells for the municipal drinking water supply system in the Village of Carp which is located within the

amalgamated City of Ottawa. The work was conducted to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the communal wells system in the Village of Carp. The field program was conducted in the summer of 2004. A groundwater monitoring and sampling event was also conducted by the City of Ottawa in 2004 (results not included).

#### **Contaminant Plume Study, Township of Beckwith, Final Report (2001)**

The study was conducted to characterize the down-gradient extents of the contaminant plume associated with the historic chlorinated solvent groundwater contamination in the Township of Beckwith. The suspected source of the chlorinated solvent contamination is the former private landfill located near Blacks Corners. The private landfill was in operation from approximately 1968 until 1978. The aerial extent of the chlorinated solvent plume was determined to be approximately 9 km by 4 km from the private landfill. It was determined that plume will continue to expand downgradient for at least the next 20 years.

#### **Cranberry Hill Subdivision Groundwater Testing, Township of North Grenville, Ontario (2005)**

Historical groundwater contamination related to both nitrates and bacteriological parameters has been documented in the Cranberry Hill subdivision since 1984-1985. This groundwater monitoring program was conducted in 2005 to sample the private wells in the vicinity of the Cranberry Hill subdivision in the Municipality of North Grenville and the groundwater monitoring wells as sampled during the previous 2001 Groundwater Management Study. Nitrate was not detected in excess of the 10 mg/L criterion; however, 50 % of the private wells had nitrate concentrations in excess of 5 mg/L. Fourteen (14) wells and 13 wells during the two sampling events indicated unacceptable bacteriological water quality with respect to total coliforms. Four houses displayed positive *E. coli* concentrations during the sampling events indicating bacteriological contamination. As a result of the continued bacteriological impacts to the water quality in the Cranberry Hill subdivision, it was recommended that an alternate water source be investigated.

#### **Eastern Ontario Wetland Valuation System: A First Approximation, Technical Report (2003)**

The purpose of this study was to develop a methodology to assign a relative value for all known wetland features in eastern Ontario. The goals of the study were to provide local decision makers with the best available natural heritage information for decision making and to provide conservation organizations with information regarding conservation priorities within the study area. The nine criteria used included wetland size, wetland interior, wetland edge, adjacent vegetation, wetland disturbance, wetland habitat linkage, wetland hydrological linkage, headwater wetland and wetland flood attenuation. It was also noted that numerous other wetlands have yet to be identified in eastern Ontario.

#### **Engineer's Report for the Water Supply Facilities for the Town of Perth, The (2001)**

The report documents the findings and recommendations for the water supply facilities for the Town of Perth. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Perth. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Engineer's Report for Town of Carleton Place Water Works (2000)**

The report documents the findings and recommendations for the Carleton Place Water Works which supplies the Town of Carleton Place. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Carleton Place. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Engineers' Report for the Smiths Falls Water Work (2001)**

The report documents the findings and recommendations for the Smiths Falls Water Work which supplies the Town of Smiths Falls. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Smiths Falls. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Engineers Report for Waterworks – Kings Park Subdivision, Communal Well System, Former Village of Richmond (2001)**

The report documents the findings and recommendations for the King's Park Subdivision Communal Well System located in the former Village of Richmond (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Engineers' Report of Water Works, Town of Mississippi Mills (2001)**

The report documents the findings and recommendations for the Town of Mississippi Mills Well Supply located in the former Town of Almonte (now the amalgamated Town of Mississippi Mills). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Mississippi Mills. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Engineers' Report of Water Works, Township of North Grenville (2001)**

The report documents the findings and recommendations for the Municipality of North Grenville Well Supply located in the former Town of Kemptville (now the amalgamated Municipality of North Grenville). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Municipality of North Grenville. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Environmental Study Report, Communal Water System, Village of Lanark – Volumes 1 & 2 (1991)**

This report was prepared as part of a Class Environmental Assessment for the provision of a communal water system for the Village of Lanark. A need to implement a communal water system was identified due to the danger to public health caused by the drinking water contamination in the Village of Lanark. The preferred alternative for the communal water supply

was identified as Alternative 1 which consisted of an extensive water distribution system with provision for fire protection supplied by groundwater. Several test wells were drilled and tested as part of the project. It was also concluded that the residents would have to pay a portion of the share of the project. Ideally, a communal sewage system should be constructed at the same time as the communal water system but due to a number of technical and economic factors, it was not possible to construct the communal sewage system.

#### **Environmental Study Report – Phase 1: Village of Lanark Water and Wastewater (2002)**

This report was prepared as Phase 1 of a Municipal Class Environmental Assessment for the water and sewage study for the Township of Lanark Highlands in the area known as the Village of Lanark. The Phase 1 report was conducted to identify all of the background information regarding the provision of communal services to the Village of Lanark. This study is the latest effort to address the concerns of the Village of Lanark to address the contaminated groundwater in the Village. As a result it was identified that the “Do Nothing” approach was not a viable alternative and that the environmental assessment process should continue to the next phase.

#### **Existing Conditions and Trends in the Tay River Watershed (2000)**

The Existing Conditions and Trends in the Tay River Watershed (2000) report contained an evaluation of both surface and groundwater. Groundwater information was compiled from subdivision hydrogeologic investigations, landfill sites, and a groundwater sampling event conducted in 1999. Surface water quality was evaluated in both the lakes and within the Tay River (and tributaries). Information for the evaluation of the surface water quality within the lakes of the Tay River watershed were obtained from the MOE Cottagers’ Self-Help Program, MOE Lake Partner Program, MNR lake surveys and reports, the Clean Up Rural Beaches (CURB) program and from the Lake Associations.

#### **Fish Habitat of the Tay River Watershed: Existing Conditions and Opportunities for Enhancement (2002)**

This report was prepared to document the background information regarding the natural features, fish and fisheries of the Tay River Watershed. The compilation of this background information will help provide an introduction to fish, fish habitat, threats to fish habitat and the importance of fish habitat protection. The study was initiated as a continuation of several of the goals and objectives of the Tay River Watershed Management Plan.

#### **Greater Bobs and Crow Lakes Stewardship Plan – Imagine: Our lakes, our lands, and our people ... A Stewardship Plan for Bobs and Crow Lakes (2007)**

Bobs and Crow Lakes are located in the headwaters of the Tay River which is a major tributary of the Rideau River and is part of the headwaters of the Rideau basin. The Bobs and Crow Lakes Stewardship Plan is intended to develop a new framework for reference for the future of environmental and community sustainability. Background reports were prepared to document the following conditions on the lakes: water quality and water levels; fisheries and fishing; the natural environment; boating and recreation; emergency and municipal services; development; and, a sense of community.

#### **Groundwater Use Characterization of the Heart’s Desire Community, Ottawa, Ontario (2006)**

The study area consists of approximately 140 homes serviced by private wells and septic systems located in the southern end of the City of Ottawa. Currently there is development south and east with planned development to occur north of the community. This study was performed to determine the potential impact of the new development in the vicinity of the Heart’s Desire

community which relies upon private water for their water supply. The study evaluated the groundwater resources which included the following main tasks: assessing threats to groundwater quality, residential surveys, detailed hydrogeological characterization, and groundwater quality assessment.

**Hydrogeologic Evaluation; Potential for Village Expansion Based on Private Individual Services; Village of Richmond (1991)**

This study was undertaken to evaluate the potential for expansion in the population in the Village of Richmond that could be serviced from private residential wells. MODFLOW modeling was conducted to evaluate the potential drawdown in the shallow bedrock aquifer as a result of the increased population.

**Hydrogeologic Investigation of Four Communal Well Systems in the Regional Municipality of Ottawa-Carleton (1984)**

The study was undertaken to conduct hydrogeologic investigations on the communal water supply systems at the Carleton Lodge, Hillside Gardens Subdivision (Manotick), Julia Subdivision (Carp) and Munster Hamlet. The objectives of the study were to investigate the hydrogeologic setting for each communal well system, assess the capacity of the wells and reservoir for meeting present and future water consumption demands, and to provide recommendations to upgrade the water supply systems.

**Hydrogeological Assessment & Remedial Activity Summary, Munster Hamlet Production Wells 1 & 2 (2002)**

The hydrogeological assessment was undertaken at the Munster Hamlet communal well supply to assess the noted elevated turbidity levels encountered in production well no. 2. It was noted that the original well installation did not involve grouting of the well casings and as a result of the non-grouted casings, the potential for the groundwater wells to be under the direct influence of surface water (GUDI) has been identified. The results of the water quality analysis and the rehabilitation activities indicate that the production wells in Munster are not GUDI wells. It was hypothesized that the elevated turbidity levels were occurring as a result of removal of rust particles as a result of shock chlorination or cascading water within the upper water bearing zones of the production well.

**Hydrogeological Assessment of Village of Carp Well Supply, Carp, Ontario (2001)**

The hydrogeological assessment was conducted to evaluate the potential for groundwater contamination at the well site and within the local recharge area of the aquifer utilized by the supply wells. No potential sources of microbiological impact were identified during the study. Nine potential sources of contamination to the communal wells were identified. A monitoring program is currently in place for two of the potential contaminant sources. Recommendations were also made for some follow up work related to the other potential contaminant sources identified.

**Hydrogeological Evaluation of Municipal Water Supply – Village of Lanark Water Supply Study (2005)**

The purpose of this study was to identify a location and evaluate the potential to construct a communal groundwater supply system to resolve historical contamination problems experienced by domestic wells within the Village of Lanark. The results of this study were incorporated into a Municipal Class Environmental Assessment undertaken by the Township to address these issues.



### **Hydrogeological Study, King's Park Subdivision, Richmond (1991)**

The hydrogeological study was undertaken to determine the long term safe yields of the two communal wells, existing water quality, and wellhead protection measures. The existing municipal system consisted of two production wells with each pumping directly into the distribution system. Recommendations were made for the operation of the system, and any upgrades, improvements or additions that may be required. Several wellhead protection measures were also recommended.

### **Hydrogeological Study, Municipal Well Supply, Town of Kemptville (1991)**

The hydrogeological study was undertaken to determine the long term safe yields of the three town wells, existing water quality, well and pump rehabilitation requirements, and well and wellfield monitoring strategies. The existing municipal system consisted of three production wells with each pumping to a separate ground surface reservoir. Recommendations were made for the operation of the system, monitoring of the existing system and any upgrades, improvements or additions that may be required.

### **Hydrogeological Study, Munster Hamlet, Regional Municipality of Ottawa-Carleton (1990)**

The hydrogeological study was undertaken to determine the long term safe yields of the two communal wells, existing water quality, and wellhead protection measures. The existing municipal system consisted of two production wells with each pumping to a combined ground surface reservoir. Recommendations were made for the operation of the system, and any upgrades, improvements or additions that may be required. Several wellhead protection measures were also recommended.

### **Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water, Village of Westport (2003)**

The hydrogeologic study was undertaken to establish whether or not the groundwater sources from the municipal supply wells (Wells 1 and 2) in the Village of Westport are under the direct influence of surface water (GUDI). As a result of the poor water quality in Well 1, it was determined that there was some hydraulic connection between the surface water ponding or the intermittent stream and the borehole annulus of Well 1. It was recommended to either rehabilitate Well 1 or drill a new supply well. The report also contains an addendum to the hydrogeologic study which was included in one of the appendices. This addendum updates the recommended course of action from the hydrogeologic study which was to drill & install a new drinking water well (Well 3) located northwest of the existing Well 2. The water quality within the new well was found to be characterized by low turbidity and good microbial quality.

### **Hydrogeology and Development, March Township (1976)**

The study was completed to assess the suitability of the rural areas of March Township for development on private water and septic systems. Water quality in the March Township was generally found to be acceptable with excellent water sources found in the March and Nepean aquifers. The limitations with respect to development on private services in March Township were generally related to the surficial geology encountered and its corresponding suitability to accommodate septic systems. Recommendations for lot sizing were documented in the report.

### **Interim Report on the Functions and Status of Kemptville Creek – Kemptville Creek Watershed Plan – Volumes 1 and 2 (1996)**

Information for the surface water quality evaluation of Kemptville Creek and its tributaries was collected from the PWQMN (1985 – 1994), CURB program (1992 – 1994) and RVCA sampling

program initiated in 1994. Groundwater information was compiled from subdivision hydrogeologic investigations, landfill sites, and contamination investigations.

**Interim Watershed Plan - Mississippi Valley Conservation (1983)**

The report updates the watershed management plans to reflect policies and priorities in the MVCA. The policies and priorities of the MVCA specifically detailed in the Interim Watershed Plan include flood and erosion control, urban and rural drainage, wetlands, source and recharge areas, water quality, forestry, fish and wildlife, recreation, sensitive / unique areas and community relations.

**Interim Watershed Plan - Rideau Valley Conservation Authority (1983)**

The report updates the watershed management plans to reflect policies and priorities in the RVCA. The policies and priorities of the RVCA specifically detailed in the Interim Plan include flood and erosion control, water management, water-related land management, conservation areas / recreation, information / education and heritage conservation.

**Jock River Reach 2 and Mud Creek Existing Conditions Report (2005)**

The Existing Conditions Report is the first component of the subwatershed plan for the study area and comprises the basis from which the subwatershed plan will be developed. The existing conditions for the Jock River Reach 2 and Mud Creek were compiled for the following study areas: climate, geology and physiography, land use, surface and groundwater systems, aquatic resources, and terrestrial resources.

**Jock River Watershed Management Plan (2001)**

The Jock River Watershed Management Plan builds on the background information assembled during the Interim Report. The overall goal of the Jock River Watershed Plan is to achieve and maintain a healthy, sustainable Jock River Watershed. The vision for the Jock River involves three themes and 10 key elements described in the plan.

**Jock River Watershed Plan – Interim Report (1996)**

Information for the surface water quality evaluation of the Jock River and its tributaries was collected from the PWQMN, CURB program, RVCA sampling program initiated in 1995 and the Regional Municipality of Ottawa-Carleton sampling program (now the City of Ottawa Baseline Surface Water Quality monitoring program). Groundwater quality was also documented in the Jock River Watershed Plan.

**Kanata North Environmental / Stormwater Management Plan (2001)**

The Kanata North Environmental / Stormwater Management Plan was completed to address the development of areas in North Kanata in the Shirley’s Brook subwatershed. The development areas that the study focused on were identified as the Kanata North Urban Expansion Area Lands and the Kanata North Business Area. The Shirley’s Brooks subwatershed was part of the Shirley’s Brook / Watts Creek Subwatershed Study which was completed in 1999 by Dillon. The report presented recommendations with respect to aquatic and terrestrial environmental constraints and stormwater management.

**Kemptville Creek Watershed Plan (1999)**

The Kemptville Creek Watershed Plan builds on the background information assembled during the Interim Report. The purpose of the plan was to outline goals, objectives and methods for the rehabilitation, protection, and enhancement of the natural features and functions and health of the Kemptville Creek watershed; devise and outline a watershed management strategy based on the

“ecosystem approach” to resource management and land use planning; and address a number of unresolved issues (beaver management, water quality, recreation, water levels, dam operation, and wildlife habitat) afflicting the watershed.

#### **Kemptville Creek Watershed Plan Update (2006)**

The Kemptville Creek Watershed Plan Update was conducted by RVCA (2006). The update was conducted to identify changes and issues that have occurred since the completion of the watershed plan in 1999. Issues identified included water levels, surface water quality, groundwater quality and quantity, development in the Kemptville area and education and outreach. In addition, the original goals and objectives of the watershed plan were evaluated and if necessary updated.

#### **Life Science Areas of Natural and Scientific Interest in Site District 5-11: A Review and Assessment of Significant Natural Areas in Site District 5-11 (1990)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. Site District 5-11 is the largest site district in southern Ontario and comprises parts of Renfrew, Lanark, Lennox & Addington, Hastings, Frontenac, Peterborough and Haliburton Counties. Fragments of the site district are also located Victoria County and Nipissing District. Over 100 sites were evaluated in this study and 23 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 14 sites were considered to be regionally significant sites. The most significant natural characteristic of Site District 5-11 is the large area of thinly buried and exposed marble bedrock.

#### **Life Science Areas of Natural and Scientific Interest in Site District 6-10: A Review and Assessment of Significant Natural Areas in Site District 6-10 (1993)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. Site District 6-10 comprises parts of Leeds & Grenville and Frontenac Counties. Smaller portions of the site district are also located Lanark, Hastings, and Lennox & Addington Counties. Over 100 sites were evaluated in this study and 22 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 14 sites were considered to be regionally significant sites. The most significant natural characteristics of Site District 6-10 are the isolated exposed rock ridges, extensive rock barrens, the expansive ridge and valley topography and its associated forest, the numerous small and diverse wetlands, the extensive shorelines associated with the lakes, and the ‘knobs and flats’ landform.

#### **Life Science Areas of Natural and Scientific Interest in Site District 6-11: A Review and Assessment of Significant Natural Areas in Site District 6-11 (1992)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. Site District 6-11 comprises parts of Lanark and Leeds & Grenville Counties and the City of Ottawa. Over 70 sites were evaluated in this study and 17 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 9 sites were considered to be regionally significant sites. The most significant natural characteristics of Site District 6-11 are the expansive Smiths Falls Limestone Plain and its associated upland forest and alvar habitat, the extensive wetlands on organic landform and the wetlands of the clay plain landform.

### **Life Science Areas of Natural and Scientific Interest in Site District 6-12: A Review and Assessment of Significant Natural Areas in Site District 6-12 - Draft (1992)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. Site District 6-12 comprises all of Prescott & Russell and Stormont, Dundas and Glengarry Counties and parts of Leeds & Grenville County and the City of Ottawa. Site District 6-12 is one of the most extensively altered areas of Ontario with only 15-20% of the land remaining forested. A total of 40 candidate ANSI's were proposed to supplement the 14 existing reserve areas. From Site District 6-12, 15 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 25 sites were considered to be regionally significant sites. The most significant natural characteristic of Site District 6-12 is the National Capital Commission Greenbelt surrounding Ottawa which contains a number of the most significant sites.

### **Lower Rideau Watershed Strategy (2005)**

The Lower Rideau Watershed Strategy (Robinson Consultants Inc. et. al.) involved the completion of the Phase I Report (2003) and the Draft Final Report (2005). The Lower Rideau Watershed Strategy Draft Final Report builds on the background information assembled during the Phase I Report. The overall goal of the Lower Rideau Watershed Strategy is to protect the cultural and natural environments of the Lower Rideau River Watershed ecosystem for the benefits of humans and other terrestrial and aquatic life. Objectives were made with regards to communication and cooperation, surface water quantity, surface water quality, groundwater quality and quantity, aquatic communities and habitats, terrestrial communities and habitats, and water and riparian uses.

### **Lower Rideau Watershed Strategy – Phase I (2003)**

The Phase I Report documents the background conditions of the watershed with regards to the geology, physiography, surface water management, groundwater characteristics, surface water quality, erosion and stream morphology, aquatic communities and habitats, terrestrial communities and habitats, and land use. Information for the surface water quality evaluation of the Lower Rideau Watershed Strategy – Phase I draft report (2003) was collected from the City of Ottawa Baseline Surface Water Quality Program (1998 to 2002).

### **Mainstreaming Climate Change in Drinking Water Source Protection Planning in Ontario (2006)**

The report details how climate change is integral to the current source protection initiatives ongoing with respect to the *Clean Water Act*. Source water protection involves activities to keep drinking water sources free of contamination. This will involve the linkage between land use activities and water quality / quantity. Recent projections suggest that Ontario's climate in a hundred years will be different than today. Due to these potential climate change effects, past hydrological regimes may not be appropriate for the future hydrological regimes. As a result of these predicted changes, climate change may influence vulnerable areas, the vulnerability of future drinking water sources, and the quality of water sources that supply drinking water.

### **Mapping and Assessment of Former Industrial Sites, City of Ottawa (1988)**

This report contains an inventory of former industrial sites within the City of Ottawa from 1850 to 1984. The focus of the inventory was on sites that likely produced or handled hazardous wastes and materials. A total of 177 former industrial sites were identified during the study. Identified sites included manufacturing industrial operations and non-manufacturing operations, such as bulk fuel storage or railway yards/roundhouses.

### **Merrickville Water Works, First Engineer's Inspection Report for Water Works(2001)**

The report documents the findings and recommendations for the Merrickville Water Works located in the former Village of Merrickville (now the amalgamated Village of Merrickville-Wolford). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Village of Merrickville-Wolford. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

### **Microbial Source Tracking in Aquatic Ecosystems: The State of the Science and an Assessment of Needs (2006)**

This report was compiled based on a microbial source tracking (MST) workshop held in 2005 in Toronto. MST refers to the determination fecal contamination in water based on comparing the similarity of microorganisms to local fecal pollution sources. Fecal pollution of water can occur as a result of many different sources including municipal wastewater effluents, failing on-site septic systems, livestock manure and wildlife droppings.

### **Mississippi River Water Management Report (2005)**

The Mississippi River Water Management Plan was completed (French Planning Services Inc. et. al., 2005) to evaluate the current and future operating plans for the hydro-generating facilities and water control structures on the Mississippi River. Upon completion of the Mississippi River Water Management Plan some generating operating principles for the water control structures on the Mississippi River were developed. These principles allow for the operation of water control structures to accommodate for multiple and potentially conflicting uses such as flood protection, low flow augmentation, ice management, erosion control, recreation, wildlife and aquatic habitat. The updated operation plan for the Mississippi River included the continued operation of 11 of the 12 structures in accordance with the previous operating procedures. Updates to the operation of the Shabomeka Lake dam were recommended to be implemented to improve the spawning habitat in the Lake.

### **Mississippi Valley Conservation Report (1970)**

Report summarizes the existing conditions of the MVCA for the inception of the CA in 1970. Specific areas of focus for the report included a description of the history of the region as well as the existing conditions of the MVCA as they relate to land use, forestry, water, biology and recreation.

### **Mississippi Valley Watershed Strategy (1993)**

The mission of the Watershed Strategy is for the MVCA to assume a leadership role in the conservation, enhancement and development of the Mississippi Valley by way of watershed planning, integrated resource management programs and conservation awareness. Also included within the strategy were directions for the future programs conducted at the MVCA including environmental advocacy, watershed planning, cooperative resource management, conservation awareness, protection of natural areas, plan input and review for regulations, watershed information, stewardship, remedial actions and monitoring and evaluation of the success of the programs.

### **North Grenville Water and Wastewater Servicing Master Plan (2005)**

The Municipality of North Grenville developed a Servicing Master Plan (SMP) to evaluate the water and wastewater requirements for the proposed expansion of the former Town of

Kemptville, amalgamated into the Municipality of North Grenville. Several growth areas, detailed as the East and West Quadrants, have been identified as areas requiring future municipal service. As a result of this proposed expansion, five potential communal well locations were identified to provide additional supply to the water systems. In addition, a preliminary screening of existing or past land uses that may be potential contaminant sources proximate to the new well locations was identified. Preliminary scheduling has identified development of four locations into communal well supplies by 2020.

**Old Landfill Management Strategy, Phase 1 – Identification of Sites, City of Ottawa (2004)**

The study was limited to sites that were previously owned or operated by a municipality or currently owned by the (amalgamated) City of Ottawa. The main purposes of the study were to identify all old closed landfill sites, develop a database of all sites and link it to GIS. A total of 82 landfill sites were identified during the course of the study that the City of Ottawa had previous or current association with the sites. In addition to the 82 old landfills associated with the City of Ottawa, 41 other landfill sites that were privately owned or operated were also identified. Details as to these private sites were provided to the City in a separate report.

**Ottawa Riverkeeper’s River Report: Issue No. 1, Ecology and Impacts, May 2006 (2006)**

The report presents an overview of the Ottawa River watershed with respect to the physical and biological conditions. Watershed characteristics for the Ottawa River mentioned in the report include landforms, hydrology, ecosystem classification, ecosystem diversity, and protected areas. The report also documents several threats to the ecological health of the watershed. Indicators of change looked at in the report include water quality and biological diversity. The water quality of the Ottawa River was not looked at with respect to the chemistry of the river but rather indirectly through fish consumption advisories and beach closures.

**Preliminary Evaluation of Relative Aquifer Vulnerability – City of Ottawa (2001)**

The City of Ottawa (former Region of Ottawa-Carleton) initiated a “relative” aquifer vulnerability study during the fall of 2000, which identified potentially sensitive areas to surface contamination within the City of Ottawa boundaries. The majority of the City’s rural areas are considered to be of medium to high vulnerability, which indicates that groundwater resource management is an area requiring attention. The Villages that have high overall vulnerability include Greely, Osgoode and Vernon. The reason for the high rankings of both Greely and Osgoode are primarily due to the presence of sand and gravel overlying the bedrock aquifer without protection from silt and clay deposits.

**Preliminary Groundwater Study – Village of Westport (2003)**

The purpose of this study was to better define aquifer characteristics in the Westport region with the primary objective of providing results that will assist in the future development of a well head protection area (WHPA) study.

**Preliminary Report on Hydrogeology, Ottawa-Hull Area, Ontario and Quebec (1961)**

This report was prepared to document the potential for groundwater usage in the Ottawa-Hull area. The report was divided into two focus areas such as the use of groundwater for supply of groundwater to a single home and for more high-capacity wells for municipal supply, industry and irrigation.

**Preliminary Wellhead Protection Area Study – Village of Westport (2004)**

The purpose of the preliminary WHPA study was twofold: (1) to identify capture zones for the Westport municipal supply wells to assist the Village in developing a protection plan, and (2)

fulfill a requirement of the draft Certificate of Approval for the Village of Westport's water works. Due to a limited budget, this study identified four key objectives: (1) development and calibration of a preliminary numerical model, (2) incorporate data from two new nested monitoring wells to better delineate lithology and hydrogeological conditions, (3) delineation of capture zones (WHPAs) for the two existing municipal wells, and (4) assessment of potential contaminant sources within the WHPAs. Four tasks that are typically included in a WHPA study, but were omitted from this study (due to minimal funding) include aquifer vulnerability assessment, public consultation and the development of a groundwater protection and management plan.

#### **Private Individual Services in the Rural Area (1992)**

The report was conducted to determine development on private, individual services in the rural portions of the Regional Municipality of Ottawa-Carleton. The report documents the aquifers encountered in the region, water quality, water quantity, well construction, septic system requirements, cumulative impacts, and planning implications. Significantly larger lot sizes were recommended for future development. The lot sizes in the report virtually eliminate the concept of concentrated (0.2 ha lots) hamlet development on private individual services. It was recommended that a term of reference for future hydrogeologic investigations in support of development on private services be developed.

#### **Proposed Mississippi-Rideau Source Protection Region, Conceptual Understanding of the Water Budget, Draft Accepted (2007)**

The *Clean Water Act* was introduced for the purposes of protecting municipal drinking water supplies in Ontario. The Water Budget is one component of the technical assessment report related to water use and water quantity within the Mississippi-Rideau Source Protection Region (M-R SPR). The purpose of the Conceptual Water Budget is to describe how water moves throughout the hydrologic cycle within the M-R SPR. The premise of the Conceptual Water Budget is for the water budgeting to be completed on an average, annual basis for the entire watershed / region. The report summarizes the climate, land cover, geology, groundwater characterization, surface water systems and major water users of the M-R SPR. Average, annual estimates of water budget components and baseflow / groundwater recharge were then calculated for the region. A preliminary review of the regional water demand and stresses on water supplies was also completed for an average, annual basis.

#### **Regional Geoscience Information: Ottawa-Hull (1980)**

This study was initiated in 1970 to provide background data on the geological conditions of the Ottawa-Hull area for the purposes as reference material for regional planning (urban or environmental geology). The study documents the bedrock geology, both Precambrian and Paleozoic, and surficial geology encountered in the Ottawa-Hull area.

#### **Renfrew County – Mississippi - Rideau Groundwater Study (2003)**

The Renfrew County – Mississippi – Rideau Groundwater Study was as part of the provincial groundwater study initiatives. The goals of the Renfrew Study included to develop a database and geographic information system (GIS) for maintaining the groundwater resources; undertake a regional water balance; map the location of significant groundwater aquifers, groundwater flow system, and groundwater quality; assess the surface water quality; inventory major groundwater users; map areas where the aquifers are susceptible to contamination; identify known and potential contaminant sources; and inventory existing groundwater policies and management strategies.

### **Report on the Well Discovery Pilot Project, Village of Merrickville-Wolford, Eastern Ontario (2002)**

This project was initiated as a pilot project by the Ontario Ministry of the Environment (MOE) as part of the MOE's review of the well program and the water wells regulation. The pilot project involved contacting the individual homeowners within Merrickville-Wolford and having them allow access to the location of the private well on the property. Upon confirmation of the location of the well, an updated coordinate for the well was obtained from a handheld Global Positioning System (GPS) unit. This allows for the well to be located to within a few meters which was an upgrade over the previous location which was typically by lot and concession.

### **Revised Carp Capture Zones, Technical Memorandum (2004)**

The technical memorandum was completed to present the result of additional groundwater modeling for the Carp communal wells. The revised WHPA capture zones were delineated based on greater pumping rates (1,150 m<sup>3</sup>/day and 2,000 m<sup>3</sup>/day) than in the initial Wellhead Protection Study (467 m<sup>3</sup>/day) completed for the communal wells in 2003. These revised capture zones were completed in accordance with the 2001/2002 MOE Technical Guidance.

### **Rideau Canal Management Plan (1995)**

The Rideau Canal Management Plan was completed to develop the guiding principles for the on-going operation of the Rideau Canal.

### **Rideau Canal Water Management Study (1994)**

The Rideau Canal Water Management Study was conducted to evaluate the water management options for the operation of the Rideau Canal which includes both the Cataraqui River and the Rideau River basins. The study looked at the existing canal operation, water management issues, navigation and reservoir lakes evaluation, river reach operating policies, coordination of hydroelectric operation, and recommendations for future operations.

### **Rideau Lakes Basin: Carrying Capacities and Proposed Shoreland Development Policies (1992)**

This report was undertaken to evaluate the capacity of the Rideau Lakes Basin which includes the Rideau Lakes and Tay River subwatersheds to support development with respect to the following parameters: lake trophic state, shoreline development, sport fishing and boating. Throughout the Rideau Lakes Basin the lake trophic state based on the water quality and specifically on phosphorus levels was determined to be the prime limiting factor which would dictate more stringent conditions for shoreline development. Recommendations were made to establish a water quality objective for each lake expressed as a maximum chlorophyll a concentration. Other recommendations were also made with respect to septic upgrades / re-inspections, shoreline re-naturalization, restricted use of fertilizers and phosphorus-rich substances near water, increased phosphorus removal from municipal sewage treatment plants, prohibiting disposal of grey-water from boats, and reducing agricultural contributions of phosphorus to lakes.

### **Rideau River Shoreline Classification Survey – Kars Bridge to Mooney's Bay, Summer 2002 (2002)**

The study was conducted from the river by boat and involved mapping and classifying all man-made and natural features of the riparian areas (shoreline) of the Rideau River between the Kars Bridge and Mooney's Bay. In addition, areas of shoreline modifications and erosion or degradation in need of rehabilitation were documented. Of the 65 km of shoreline surveyed, the following percentages of shoreline were documented: 19% natural, 12% regenerative, 8% degraded and 61% ornamental.



### **Rideau River – State of the River Report (2001)**

The Rideau River – State of the River Report was completed in 2001 with a particular focus of the study was on the river between Smiths Falls and Ottawa. The report documents on the physical and biological conditions of the Rideau River with respect to water quality, biodiversity and aquatic habitat. Data gaps were identified with respect the water quality / quantity, biological, aquatic and shoreline habitat and management response indicators.

### **Rideau Valley Conservation Report (1968)**

Report summarizes the existing conditions of the RVCA for the inception of the CA in 1966. Sections of the report provide details on the history, land use and forest, water, biology, and recreation in the RVCA.

### **Rideau Valley Watershed Strategy (1992)**

The plan for the operation of the RVCA was updated within the Rideau Valley Watershed Strategy. The Rideau Valley Watershed Strategy included the vision for a healthy river involving a mission of a coordinated approach to watershed planning, resource management activities and conservation awareness. Also included within the strategy were directions for the future programs conducted at the RVCA including watershed planning, regulations and plan review, protection of natural areas, community stewardship, capital projects, conservation awareness, and monitoring and evaluation of the success of the programs.

### **Rural Wastewater Management Study – City of Ottawa (2004)**

The purpose of this study is to provide the City of Ottawa with a guide to address technical issues associated with septic systems and the management tools to plan for future development in Ottawa's rural sector while ensuring that on-site sewage systems are a permanent and sustainable solution to rural wastewater servicing. A four year management plan was presented which included: developing bylaws for lot sizing restrictions, public education programs, septic tank re-inspection programs, septic tank pump-out programs, septage management and enforcement for faulty on-site sewage systems under the Building Code Act.

### **Sawmill Creek Subwatershed Study Update (2003)**

The Sawmill Creek Subwatershed Study was updated in 2003 in order to reflect changes to development within the watershed, and changes to the focus of water quality and watershed protection within the City of Ottawa. The Sawmill Creek Subwatershed Study Update documents the terrestrial resources, aquatic resources, hydrology and hydrogeology, fluvial geomorphology, and water quality of Sawmill Creek.

### **Sawmill Creek Watershed Study, Interim Report: Data Collection (1992)**

This report documents the background data collected for the Sawmill Creek Watershed Study. Information collected on the watershed included streamflow monitoring, hydrology, hydrogeology, water and sediment quality, and survey and inventory of terrestrial vegetation, aquatic and wildlife habitat.

### **Sawmill Creek Watershed Study, Study Report (1994)**

Sawmill Creek is a tributary of the Rideau River, located within the urban boundary of the City of Ottawa. The Sawmill Creek Watershed Study (Gore & Storrie Ltd., 1994) consisted of three strategies including water management, valley lands management and implementation. The Sawmill Creek Watershed Study documents the streamflow monitoring, hydrology,

hydrogeology, water and sediment quality, and survey and inventory of terrestrial vegetation, aquatic and wildlife habitat of Sawmill Creek.

#### **Shirley's Brook / Watts Creek Subwatershed Study (1999)**

The Subwatershed Study documents the land use, aquatic biology, terrestrial biology, geology, hydrogeology, surface water quality, and surface water hydrology of both Shirley's Brook and Watts Creek. Key issues of the study included flooding and erosion problems, a lack of a comprehensive storm water management strategy, degraded fish and aquatic habitat, loss of terrestrial habitat and linkages, and groundwater supply and quality constraints. Goals, objectives and methods for the rehabilitation, protection, and enhancement of the natural features and functions of Shirley's Brook and Watts Creek subwatershed were also defined during the study.

#### **Shoreline Classification Project, 2003 Report (2004)**

The study was a continuation of the previous 2002 shoreline classification survey conducted on the Rideau River. The 2003 study involved the classification of the riparian areas with respect to man-made and natural features on the Rideau River from Merrickville to Kars. Of the 120 km of shoreline surveyed contained within 948 properties, the following percentages of shoreline were documented: 21% natural, 41% regenerative, <1% degraded and 38% ornamental.

#### **Shoreline Classification Project, 2004 Report (2005)**

The study was a continuation of the previous 2002 and 2003 shoreline classification survey conducted on the Rideau River. The 2004 study involved the classification of the riparian areas with respect to man-made and natural features on the Rideau River from Smiths Falls to Merrickville and Kemptville Creek from Kemptville to its confluence with the Rideau River. Of the 99 km of shoreline surveyed contained within 408 properties, the following percentages of shoreline were documented: 61% natural, 11% regenerative, <1% degraded and 27% ornamental.

#### **Soils and Hydrogeologic Investigation of PCE and Petroleum Contamination, Village of Manotick, Final Report (1994)**

In December 1991, the Ministry of the Environment and Energy (MOEE) collected water samples from private drinking water wells in the core of the Village of Manotick. Subsequent sampling of private wells in Manotick revealed that 42 to 65 wells were impacted with benzene and /or perchloroethene (PCE) in excess of the drinking water standards. As a result of the contamination, the Regional Municipality of Ottawa-Carleton extended the municipal water to the core of the Village of Manotick in the summer of 1993. Both the Upper Oxford aquifer (5 to 18 m deep) and the Lower March / Nepean aquifer (33 to at least 40 m deep) were found to be contaminated by chlorinated solvents and petroleum. Recommendations for further monitoring well installations, groundwater monitoring and future studies were made.

#### **Supplemental Bedrock Hydrogeologic Investigation of PCE Contamination, Village of Manotick, Final Report (1996)**

This study was conducted as a follow up to the 1994 investigation regarding the perchloroethene (PCE) contamination in the Village of Manotick. The focus of the study was to increase the certainty with regards to the potential fate of the PCE within the Lower Aquifer (March and Nepean Formations). PCE was not detected in either the Lower or Upper aquifers on Long Island. Based on the movement of the plume, the potential exists for the plume to migrate to private wells on Long Island. Recommendations were made to continue monitoring the status of the groundwater plume.

### **Tay River Watershed Management Plan (2002)**

The Tay River Watershed Management Plan builds on the background information assembled during the Existing Conditions Report. The purpose of the plan is to guide and help coordinate watershed management activities in the Tay River watershed over the next two decades. The plan is a high level planning document that identifies watershed issues, advises on broad environmental policy and direction, and identifies an implementation framework and priorities for action.

### **Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada (2001)**

The National Water Research Institute identified 15 water quality related threats to sources of drinking water and aquatic ecosystem health. These threats were defined as follows: acidification, algal toxins, endocrine disrupting substances (EDS), genetically modified organisms (GMOs), impacts of agricultural and forestry practices, industrial wastewater discharge, long-range atmospherically transported pollutants and persistent organic pollutants, municipal wastewater effluents, naturally occurring contaminants, nutrients, pathogens, pesticides, solid waste management practices, urban runoff, and water quantity changes affecting water quality due to climate change, diversions and extreme events.

### **Town of Kemptville – Municipal Well Head Protection Study (2000)**

This study was completed prior to the development of MOE Technical Terms of Reference as part of the MOE municipal groundwater studies initiative, therefore the methodologies used are different compared to more recent WHPA studies completed for other municipalities. Two objectives were identified for this study and include: (1) delineation of well head protection areas, and (2) inventory of potential contaminant sources.

### **Township of North Grenville, Groundwater Management Study (2001)**

Previous investigations by the Ontario Ministry of the Environment and private consultants from 1984 to 1998 have identified nitrated contamination in the groundwater west of Kemptville in the Municipality of North Grenville. The 1998 investigation by Oliver, Mangione, McCalla & Associates (OMM) which involved an assessment of available information concluded that nitrate concentrations in private wells have consistently exceeded the health related drinking water criterion of 10 mg/L and that the vertical and horizontal extents of the contamination had not been defined. It was recommended that all new wells in the area should be constructed by the protocol outlined by Gorrell Resource Investigations in 1994. This protocol involved the installation of a minimum of 80 feet of casing to bypass and isolate the shallow sand and gravel aquifer from the deeper limestone bedrock aquifer encountered at the site.

### **United Counties of Leeds & Grenville – Groundwater Management Study (2001)**

The purpose of this study was to assess the existing groundwater conditions and to recommend management and protection practices to maintain the quantity and quality of the groundwater resource. This study was divided into four key components, including: 1) water resources assessment, 2) assessment of existing groundwater use, 3) contaminant source inventory, and 4) economic evaluation, groundwater management and protection measures. The study also summarizes the groundwater management protection measures that are currently in place for the study area.

### **Upper Poole Creek Subwatershed Study (2000)**

The Upper Poole Creek subwatershed is one of the few cold or cool-water streams within the City of Ottawa. The Subwatershed Study documents the aquatic environment, fluvial geomorphology, groundwater system, surface water, and terrestrial environment of Upper Poole Creek.

### **Urban Geology of Canada's National Capital Area (1998)**

This paper presents the geological initiatives in the National Capital Area (Ottawa and Gatineau) and the development of a geological database. The urban geology of the area was first compiled in the 1970s and based on stratigraphic data from borehole logs which was documented in a Geological Survey of Canada paper in 1980 by Belanger and Harrison. In the early 1990s the project was updated and this study presents the results. The study documents the bedrock geology, both Precambrian and Paleozoic, and surficial geology encountered in the National Capital Area.

### **Urban Wells Study, City of Ottawa (2007)**

The study was undertaken to determine the use of water wells within the public water service areas of the City of Ottawa. The majority of these water supply wells in the urban area are primarily found within the private service enclaves, the suburban fringe or inside the Greenbelt. It was determined urban wells for residential potable purposes are appropriate in the private service enclaves where municipal services are not available and that where appropriate these should be subject to a development agreement to connect to municipal services when they become available. It was also determined that urban wells for residential non-potable purposes and non-residential potable purposes were not appropriate. It was recommended that the City use the existing development approval process to intervene on matters related to urban wells.

### **Village of Constance Bay Groundwater Study (2006)**

This study was performed to determine if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services. This study evaluated the groundwater resources which included the following main tasks: groundwater quality assessment; groundwater supply quantity assessment; groundwater use assessment; and potential contaminant source assessment.

### **Village of Lanark, Communal Water System, Phase I Report – Existing Conditions (1990)**

Based on the results of the water surveys in the late 1970's in the Village of Lanark, various private well and sewage systems were identified as requiring upgrades or new installations. In response to the poor water quality in 1980 and 1981 various individual corrections to the private water and sewer services were conducted. The results of the 1987 and 1990 water quality survey indicated that the individual corrections to the private wells and sewage systems in the Village of Lanark have not resolved the bacterial and chemical contamination.

### **Village of Lanark, Private Sewage and Water Systems (1979)**

A study was undertaken in 1977 and 1978 to determine the nature and extent of water contamination in individual domestic water supply wells and water pollution in surface water in the Village of Lanark. As a result of chemical and bacteriological contamination in the Village of Lanark, two options were presented to address the water quality concerns which included: improvements to existing water supply and sewage systems; and, provision of communal water and / or wastewater supply. Based on consideration of a number of factors it was determined that the improvements to individual systems would be the most appropriate solution for implementation. The report documents the various remedial measures that are required to improve the water quality concerns.

### **Village of Merrickville-Wolford – Municipal Groundwater Management Study (2000)**

The work included review and interpretation of existing data, groundwater sampling and analyses (39 private and 4 municipal wells analyzed for metals, bacteria, general chemistry), surface water

sampling and analyses (14 samples analyzed for metals and general chemistry), isotope analyses (10 samples analyzed for oxygen and hydrogen isotopes), hydraulic testing (7-hr pumping test on municipal well PW4) and numerical groundwater flow modeling.

#### **Village of North Gower Groundwater Study (2005)**

This study was performed to determine if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services. This study evaluated the groundwater resources which included the following main tasks: groundwater quality assessment; groundwater supply quantity assessment; groundwater use assessment; and potential contaminant source assessment.

#### **Vulnerability Pilot Study – Almonte Municipal Supply Wells (2005)**

The previous WHPA studies utilize reverse particle tracking methods in MODFLOW and only take into account the travel time in the saturated zone. This analysis method is termed Water table to Well Advection Time (WWAT). The Surface to Well Advection Time (SWAT) pilot study was incorporated into the existing MODFLOW model that was previously created.

#### **Water & Wastewater Alternative Servicing Solutions Study, Village of Cumberland (2003)**

A water and wastewater alternative servicing solutions study was conducted for the Village of Cumberland within the amalgamated City of Ottawa during 2001 and 2002. This study was performed as part of a Class Environmental Assessment for water and wastewater projects. The study was undertaken to evaluate the future servicing needs of the Village. This study included the following main tasks: groundwater quality assessment; surface water quality assessment; identification and evaluation of alternative solutions; and recommended solutions.

#### **Water Resources Study – City of Kanata Rural Area (1994)**

A Water Resources Study for the rural area of the City of Kanata (now incorporated within the amalgamated City of Ottawa) was conducted. The purpose of the report was to provide hydrogeologic information as to the suitability of reduced lot sizes for future residential development on private services in the rural area of the City of Kanata. Recommendations were made as to minimum lot size dependent upon the bedrock formations as well as the type of development. Due to the lack of significant overburden deposits, recommendations were also made with regards to well construction, private services and sensitive hydrogeologic areas.

#### **Water Well Sustainability in Ontario – Expert Panel Report (2006)**

This project was initiated by the Ontario Ministry of the Environment (MOE) to investigate, plan, and implement innovative approaches to water well maintenance and monitoring in order to extend and improve the integrity of water well infrastructure in Ontario. The panel's assessment involved the following components of sustainable water well infrastructure: design life of a water well; well infrastructure management; groundwater resources in Ontario; well water quality; water well records; public education and outreach; well construction; well maintenance and disinfection; well decommissioning; the regulatory framework; research needs; sustainable asset management; and current and emerging issues that might threaten the sustainability of wells over the long term.

#### **Wellhead Protection Area Study – Almonte (2003)**

This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source

inventory, and the development of an action plan for groundwater source protection for the Almonte municipal water supply wells.

**Wellhead Protection Study – Carp Communal Wells, City of Ottawa (2003)**

The primary objectives of this study were threefold, including: [1] to identify a WHPA for the Carp communal wells; [2] determine the recharge conditions within the WHPA; and, [3] to provide an inventory of potential contaminant sources within the WHPA. This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source inventory, and the development of an action plan for groundwater source protection for the Carp communal water supply wells.

**Wellhead Protection Study, King’s Park Subdivision, Village of Richmond (1996)**

A Wellhead Protection Study was completed for the communal well system in the King’s Park Subdivision in the Village of Richmond in 1996 by Jacques Whitford Environmental Ltd. This study was completed prior to the development of MOE Technical Terms of Reference as part of the MOE municipal groundwater studies initiative, therefore the methodologies used are different compared to more recent WHPA studies completed for other municipalities.

**Wellhead Protection Study – Munster Hamlet and Kings Park Communal Wells, City of Ottawa (2003)**

The primary objectives of this study were threefold, including: [1] to identify a reasonable, “theoretical” WHPA for the Kings Park Subdivision and the Hamlet of Munster communal wells; [2] determine the recharge conditions within the WHPA; and, [3] to provide an inventory of potential contaminant sources within the WHPA. This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source inventory, and the development of an action plan for groundwater source protection for the Munster and King’s Park communal water supply wells.

**Westport Water Works, First Engineers’ Inspection Report for Water Works (2001)**

The report documents the findings and recommendations for the Westport Water Works located in the Village of Westport. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Village of Westport. The Engineer’s reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

## **Appendix 1 – Part 2 – Summary of Existing Watershed Resources – Detailed Descriptions**

### **Additional Vulnerability Analysis for Almonte WHPA Model (2007)**

The vulnerability analysis for the Almonte Wellhead Protection Area (WHPA) completed in 2003 was updated to the most recent Ministry of the Environment (MOE) groundwater vulnerability guidance module. Updates to the Almonte WHPA model included the delineation of a 5 year time of travel (TOT) capture zone, vulnerability scoring for the Nepean aquifer and uncertainty analysis.

### **A Multidisciplinary, Community-Based Study of the Environmental Health of the Rideau River: Final Report (2001)**

This report documents the results of the Rideau River Biodiversity Project (RRBP) which was conducted from 1998 to 2000 on the Rideau River from Smiths Falls to Ottawa. The projects goals were to assess the biodiversity of the Rideau River and to reconcile local needs with long-term sustainable management of its biological diversity. Eight biological components were monitored as part of the project and included: aquatic birds, aquatic invertebrates, aquatic plants, amphibians, fish, freshwater mussels, phytoplankton, and reptiles. In addition to the biological components of the study, water chemistry was also sampled and analyzed. The general objectives of the study were to document the biological diversity of the biological components, monitor indicator species, to identify sensitive areas and recommend remedial actions.

As a result of the community consultation and advisory groups formed for the project, a community working group entitled the Rideau River Roundtable was established to carry forward after the conclusion of the RRBP. The main goal of this group is to facilitate the coordination of research activities, educational projects and monitoring initiatives within a long-term planning framework.

### **A Prioritization System for Wetlands within the Rideau Valley Watershed, Draft Report (2006)**

The purposes of this study were to develop an updated and comprehensive inventory of all Ontario Ministry of Natural Resources (OMNR) evaluated wetlands in the Rideau Valley Watershed, develop a wetland protection prioritization scheme that can be applied to all evaluated wetlands for identification of the most threatened wetland habitats and prepare a database containing information from the OMNR's evaluated wetland data records and the prioritized results for each evaluated wetland.

The prioritization criteria for evaluating the wetlands consisted of the biological values, ecological function, special features including species at risk and waterfowl, hydrology, social values, site designations, location, ownership, site type, and land use planning. The study involved the prioritization of 79 evaluated wetlands within the Rideau Valley Watershed. Of the wetlands prioritized, 66 of the 79 evaluated wetlands scored above 500 points which falls within the proposed extreme and high priority range for protection. One of the weaknesses of this prioritization system is that it cannot include unevaluated wetlands.

Recommendations were made with respect to wetland communication and cooperation, wetland regulation, wetland conservation, land-use plan input, wetland identification, wetland monitoring,

wetland hydrology, wetland waterfowl habitat, wetland evaluation updates, wetland database maintenance and new wetland evaluations. These recommendations are presented in Table A-1.

#### **Aquifer Protection, Village of Carp (1992)**

The study was undertaken to address concerns regarding the protection of the groundwater supply for the proposed municipal supply well for the Village of Carp. The goals of the study were to define sensitive recharge areas for the Carp aquifer and determine the groundwater influence based on 20 years of pumping from the proposed well. Sensitive recharge areas were generally defined as areas where the clay aquitard is less than 5 meters. It was noted that the geology of the area is variable and as such there are also variations in the thickness of the clay aquitard. Further information was required to define the sensitivity of the aquifer with regards to the sensitive recharge areas / clay thickness. The estimated groundwater influence was determined to be a 500 m radius from the pumping well. This area of influence also coincides with the core of the proposed service area within the Village of Carp.

#### **Baseline Surface Water Quality Program – Technical Report Five-Year Analysis 1998 through 2002 (2004)**

The City of Ottawa compiled a summary of the surface water quality monitoring program and it was presented in the Baseline Surface Water Quality Program – Technical Report (2004). The data within the report was also extended through 2004 with an attached letter documenting sampling results from 2003 and 2004. Surface water quality monitoring is conducted at 85 sample locations within the amalgamated City of Ottawa.

The surface water quality monitoring locations were divided into the following general classifications: large (major) rivers, large (major) tributaries and smaller tributaries. The major rivers within the City of Ottawa are the Ottawa, Rideau and Mississippi. The large tributaries within the City of Ottawa and the M-R SPR include the Carp River and Jock River. The smaller tributaries were divided between the urban and rural creeks.

Sixteen indicator parameters consisting of alkalinity, aluminum, chlorides, conductivity, copper, *E. Coli*, iron, lead, manganese, nitrates & nitrites, pH, sulphate, TKN, TP, TSS and zinc were selected out of the 43 parameters monitored. The following observations were noted from the average parameter concentrations sampled within the M-R SPR:

- Average concentrations for aluminum and lead exceeded the PWQO at all sampling locations. It should be noted that the lead criteria referenced in the document is the lowest value for interim PWQO (0.001 mg/L) and not the PWQO (0.005 to 0.025 mg/L). The average lead concentrations from the sample concentrations do not exceed the minimum PWQO for lead.
- Average total phosphorus concentrations exceeded the PWQO on the Rideau, Jock and Carp Rivers and the urban and rural creeks.
- Geometric mean *E. Coli* concentrations exceeded the PWQO in the urban creeks.
- Average chloride concentrations exceeded the criterion of 100 mg/L at the Carp River and urban creeks. The average concentrations of chloride at the Carp River and the urban creeks were less than the ODWS criterion of 250 mg/L.
- Average iron and manganese concentrations exceeded the PWQO in the Carp River and the urban and rural creeks.
- The remaining average concentrations reported for the indicator parameters listed above were found to be below their respective PWQO.



In addition, the water quality was also evaluated with respect to the Canadian Council of Ministers of the Environment (CCME) Water Quality Index. Results of the CCME Water Quality Index indicated that the larger rivers have good to excellent water quality, major tributaries have fair to marginal water quality, rural creeks have generally marginal water quality and urban creeks have generally fair water quality.

#### **Carp Communal Water Supply Project (1987)**

The study was undertaken to determine the viability of finding a groundwater source to supply the Village of Carp with drinking water. The municipal drinking water supply would be used to replace the private individual services within the Village of Carp. The private individual services in the Village of Carp were noted to be contaminated (type not specified). The study involved the installation of several groundwater monitoring wells and one test well in the Village of Carp and aquifer testing for both water quality and quantity.

The results of the study indicated that basal sand and gravel aquifer is laterally very extensive in the vicinity of Carp. In addition, the aquifer is generally confined by low permeability silts and clays. Based on the pumping results the test well was able to deliver greater than 566 imperial gallons per minute (igpm). Water quality obtained from the test well and other sources indicated acceptable quality. Minor elevated sodium and hydrogen sulphide concentrations were also documented. It was recommended that the aquifer is considered suitable for a municipal water supply and a number of potential well sites were identified.

#### **Carp – First Engineer’s Report (2001)**

The report documents the findings and recommendations for the Carp Water Treatment Plant which supplies the former Village of Carp (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer’s reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

The report did not identify any potential sources of microbial contamination at the municipal wells. Raw and treated water test results did not indicate any adverse microbiological results. Four samples from the distribution system indicated elevated Heterotrophic Plate Count (HPC). *E. coli* and fecal coliforms were not encountered in the distribution system.

Several raw water quality parameters (colour, hardness, HPC, organic nitrogen, sulphide and total dissolved solids) were found to exceed the Ontario Drinking Water Standards (ODWS). However, these parameters are mostly aesthetic or parameters that affect the operation of the plant. No treatment changes with respect to water quality were recommended.

One of the report appendices includes a Hydrogeological Assessment of the Village of Carp Well Supply conducted by Water & Earth Science Associates Ltd. which focused on the potential for groundwater contamination. Nine potential sources of non-microbiological impact were identified in the areas surrounding the municipal wells.

#### **Carp, Munster Hamlet and Kings Park – Wellhead Protection Area Maps (2007)**

The vulnerability analysis for the Carp, King’s Park (Richmond) and Munster Hamlet Wellhead Protection Areas (WHPA) completed in 2003 were updated to the most recent Ministry of the Environment (MOE) groundwater vulnerability guidance module. Updates to the Carp, King’s

Park (Richmond) and Munster Hamlet WHPA models included the delineation of a 5 year time of travel (TOT) capture zone, vulnerability scoring for the overburden aquifer (Carp) and Nepean aquifer (King's Park and Munster Hamlet) and uncertainty analysis.

#### **Carp River Watershed / Subwatershed Study (2004)**

The Carp River is a tributary of the Ottawa River basin, located in the northwest portion of the City of Ottawa and also the northern portion of the MVCA watershed. The Carp River Watershed / Subwatershed Study (Robinson Consultants Inc. et. al., 2004) was completed to document the existing conditions of the watershed, establish watershed goals and objectives develop a watershed and subwatershed plans, and an implementation plan. The Watershed / Subwatershed Study report consisted of two volumes, Main Report (Volume 1) and the Figures (Volume 2).

The Carp River Study has two distinct areas of focus, being the watershed and subwatershed delineations. The watershed study area is defined as consisting of all lands within the Carp River and its tributaries. The level of detail in the watershed study is focused on a regional basis and likened in scale to the Official Plan level. The subwatershed study area, lies within the overall watershed study area but is a smaller, more focused study area similar in scale to a Secondary Plan or Official Plan Amendment. The subwatershed study area defined for the project consists of only the lands within the headwaters of the Carp River, upstream of Richardson Side Road. Specific areas of the headwaters to be included within the subwatershed planning exercise included Feedmill Creek, a small portion of Huntley Creek, Poole Creek downstream of Stittsville Main Street (Lower Poole Creek), and the Carp River upstream of Richardson Side road. The headwater portions of Poole Creek upstream of Stittsville Main Street are not included within the subwatershed study as this area was the focus of the Upper Poole Creek Subwatershed Study completed by MMM & WESA in 2000.

The overall study goal was to develop and implement appropriate strategies in order to protect, enhance and restore the natural resources of the Carp Watershed under present conditions and as land use changes occur. Environmental goals and objectives were also set with regards to the following components: surface / ground water quantity, surface / ground water quality, aquatic resources, and terrestrial resources.

Within the watershed/subwatershed study the first component of the exercise involved a description of the existing conditions. These existing conditions were described with respect to the climate, land forming processes (geology and physiography), surface water system, groundwater resources, erosion and stream morphology, terrestrial and aquatic resources, and land use. Based on the study goals and objectives, a number of recommendations were made with regards to surface water management, groundwater management, and greenlands. These recommendations were presented for both the watershed and subwatershed portions of the study areas. A detailed list of the recommendations is provided in Table A-1.

Information for the surface water quality evaluation of the Carp River and its tributaries was based upon data collected from the City of Ottawa Baseline Surface Water Quality Program (1993 – 1999) at 25 stations. Indicator parameters of the surface water quality for the Carp River watershed included aluminum, ammonia (un-ionized), bacteria (*E. Coli*), chloride, copper, iron, nitrate, TP, TSS and zinc. Many water quality stations observed long-term mean concentrations in excess of the PWQO including total phosphorus (22 of 25 stations), *E. Coli* (22 of 25 stations), iron (18 of 25 stations) and aluminum (24 of 25 stations). Mean concentrations of the indicator

parameters were lower in the Carp River than in its tributaries. Mean concentrations in the Carp River were constant or exhibit decreases downstream from Hazeldean Road to Fitzroy Harbour.

Groundwater quality assessment was based upon water quality concentrations from the Renfrew – Mississippi – Rideau Groundwater Study (2003), Private Individual Services in the Rural Area (1992) and Hydrogeology of Southern Ontario (1996) studies. Groundwater quality within the bedrock aquifers of the Carp River watershed is generally good with elevated hardness and total dissolved solids.

#### **Carp Road Corridor Groundwater Study (2004)**

A groundwater study was completed for the Carp Road Corridor by Dillon Consulting Limited (2004), which focused on the nine kilometer length (approximately 2.8 km wide) of land centered along Carp Road and extending from Rothbourne Road in the south to March Road in the North. This study was performed on behalf of the City of Ottawa with the purpose of determining if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services.

This study included five main tasks, including: [1] groundwater resource assessment; [2] groundwater use assessment; [3] potential contaminant source assessment; [4] groundwater sampling program; and [5] development of mitigation measures for new development.

The study area is a mix of residential, agricultural, commercial and light to heavy industry land uses. Currently there are over 170 businesses and 220 residential dwellings the areas, which for the most part are serviced by private individual wells and septic systems. The majority of wells pump from the limestone aquifer with 75% of the wells being less than 30 m deep. Few wells are situated in areas with thicker overburden sand deposits and therefore access shallower groundwater from both confined and unconfined sand deposits. Most wells provide sufficient quantity of water to meet most supply needs (75% can pump at 20 L/minute where average domestic use is between 5 and 25 L/min). Overall, the estimated volume of groundwater use is between 600,000 and 700,000 m<sup>3</sup>/year, which is approximately 10% of the estimated total aquifer recharge, therefore the potential for area wide aquifer dewatering is deemed to be low.

A detailed water quality investigation included the sampling of 53 water wells at select residential and commercial properties with an attempt to obtain a valid cross section of data. Overall, no widespread problems with health related groundwater parameters were detected, however non-health related parameters are commonly found at concentrations above Ontario Drinking Water Standards (hardness, total dissolved solids, sulphides, sodium, chloride).

An inventory of potential environmental concerns was compiled for the study area which looked at both existing and historic land uses. Although the potential impact from each of the different sources ranged from negligible to severe, no evidence of area-wide impacts were observed during the sampling program.

#### **City of Ottawa, Britannia Water Purification Plant, Engineer's Report (2001)**

The report documents the findings and recommendations for the Britannia Water Purification Plant which supplies a portion of the City of Ottawa. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination were identified and these include the inherent susceptibility of surface water to contamination from runoff, effluent, vector contact, etc., access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. Extensive sampling of the raw water from the Ottawa River has been conducted for *Giardia* and *Cryptosporidium* cysts from 1994 to 2000. Based on the survey the occurrence of *Giardia* cysts in the raw water was determined to be 1 to 10 cysts per 100 L of water 95% of the time and *Cryptosporidium* cysts to be 1 to 16.5 cysts per 100 L of water 95% of the time. Sampling results of the raw water quality for Heterotrophic Plate Counts (HPC) or background colonies was not included within the report. In 2000, concentrations of total coliforms in the raw water ranged from 34 to >20,000 per 100 mL, with the average concentration being 1,372 per 100 mL. In 2000, concentrations of *E. coli* in the raw water ranged from not detectable to >5,000 per 100 mL, with the average concentration being 103 per 100 mL.

In the treated water prior to entering the distribution system detectable levels of HPC were also encountered in several samples. *E. coli* and total coliforms were not encountered in the treated water prior to entering the distribution system. Within the distribution system detectable levels of HPC were encountered in approximately 16% of the samples (3278 samples total from 1998 to 2000). In 1998, there were 8 total positive samples for total coliforms representing < 1% of the samples (2283 samples total in 1998). One location testing positive for total coliforms in 1998 was confirmed and removed from serviced, cleaned and re-disinfected and returned to service. In 1999, there were 7 total positive samples for total coliforms representing < 1% of the samples (2152 samples total in 1999). One location testing positive for total coliforms in 1999 was confirmed to be a non-pathogenic biofilm in piping at one location. This location was re-disinfected with a stronger dose of chlorine and returned to service. In 2000, there were 8 positive samples for total coliforms representing < 1% of the samples (2086 samples in 2000). No discussion of the total coliform positive samples was present in the report. In 1998, one sample tested positive for *E. coli* and it was determined that the fixture was the source of *E. coli* and upon disinfection was returned to service. *E. coli* was not detected in either 1999 or 2000.

Several raw water quality parameters (turbidity, alkalinity, colour, dissolved organic carbon (DOC), organic nitrogen and temperature) were found to exceed the Ontario Drinking Water Standards (ODWS). Turbidity is a health related ODWS which causes interference with the disinfection of the water. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report. No comments regarding changes to the treatment were recommended until the additional raw water quality testing was completed.

### **City of Ottawa, Lemieux Island Water Purification Plant, Engineer's Report (2001)**

The report documents the findings and recommendations for the Lemieux Island Water Purification Plant which supplies a portion of the City of Ottawa. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination were identified and these include the inherent susceptibility of surface water to contamination from runoff, effluent, vector contact, etc., access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. Extensive sampling of the raw water from the Ottawa River has been conducted for Giardia and Cryptosporidium cysts from 1994 to 2000. Based on the survey the occurrence of Giardia cysts in the raw water was determined to be 1 to 10 cysts per 100 L of water 95% of the time and Cryptosporidium cysts to be 1 to 16.5 cysts per 100 L of water 95% of the time. Sampling results of the raw water quality for Heterotrophic Plate Counts (HPC) or background colonies was not included within the report. In 2000, concentrations of total coliforms in the raw water ranged from 1 to >2,000 per 100 mL, with the average concentration being 464 per 100 mL. In 2000, concentrations of *E. coli* in the raw water ranged from 1 to 461 per 100 mL, with the average concentration being 58 per 100 mL. Discussions of the treated water quality and the distribution system are discussed in the Britannia Engineer's Report.

Several raw water quality parameters (turbidity, alkalinity, colour, dissolved organic carbon (DOC), organic nitrogen and temperature) were found to exceed the Ontario Drinking Water Standards (ODWS). Turbidity is a health related ODWS which causes interference with the disinfection of the water. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report. No comments regarding changes to the treatment were recommended until the additional raw water quality testing was completed.

#### **City of Ottawa, Munster Hamlet, Communal Well System, Engineer's Report (2001)**

The report documents the findings and recommendations for the Munster Hamlet Communal Well System which supplies the former Munster Hamlet (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and these include well head and aquifer through surface water entry, access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. Nine samples from 1998 and 1999 indicated detectable levels of Heterotrophic Plate Counts (HPC) within the raw water however at concentrations. Raw water test results did not indicate any detectable concentrations of *E. coli*. In the distribution system detectable levels of HPC were also encountered in three samples. *E. coli* and total coliforms were not encountered in the distribution system.

One raw water quality parameter (hardness) was found to exceed the Ontario Drinking Water Standards (ODWS). Hardness is a parameter that affects the operation of the plant. It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report. No comments regarding changes to the treatment were recommended until the additional raw water quality testing was completed.

#### **City Stream Watch – 2003 Annual Report (2003)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the

City of Ottawa. The four streams chosen for sampling during the 2003 season consisted of Black Rapids Creek, Cardinal Creek, Mud Creek and Sawmill Creek.

The stream assessments were based on the macro stream assessment protocol developed by the Ontario Ministry of Natural Resources and adapted by the Rideau Valley Conservation Authority. The assessment included documentation of human alterations to the streams, adjacent land uses, instream vegetation, bank stability, observed wildlife, and pollution. Recommendations with regards to the program and several independent projects were made.

#### **City Stream Watch – 2004 Annual Report (2004)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2004 season consisted of Bilberry Creek, Monterey Creek, Mosquito Creek and Stillwater Creek.

The stream assessments were based on the macro stream assessment protocol developed by the Ontario Ministry of Natural Resources and adapted by the Rideau Valley Conservation Authority. The assessment included documentation of human alterations to the streams, adjacent land uses, instream vegetation, bank stability, observed wildlife, and pollution. Fish communities were also sampled on Bilberry Creek, Mosquito Creek and Stillwater Creek. In addition, three creek clean-up initiatives were organized and conducted on Sawmill Creek which was assessed during the 2003 program. Recommendations with regards to the program and several independent projects were made.

#### **City Stream Watch – 2005 Annual Report (2005)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2005 season consisted of Graham Creek, Greens Creek, Mosquito Creek and Stevens Creek.

The stream assessments were based on the macro stream assessment protocol developed by the Ontario Ministry of Natural Resources and adapted by the Rideau Valley Conservation Authority. The assessment included documentation of human alterations to the streams, adjacent land uses, instream vegetation, temperature profiling, bank stability, observed wildlife, and pollution. Fish communities were also sampled on Graham Creek, Greens Creek and Stevens Creek. In addition, five creek clean-up initiatives were organized and conducted on Greens Creek (two events) and Sawmill Creek (three events) which were assessed during previous City Stream Watch programs. One riparian rehabilitation planting project was also conducted on Sawmill Creek on an area with a failed bank. Recommendations with regards to the program and several independent projects were made.

#### **City Stream Watch – 2006 Annual Report (2006)**

The City Stream Watch program was established in 2003 to obtain, record and manage information regarding the physical and biological characteristics of creeks and streams within the City of Ottawa. The four streams chosen for sampling during the 2006 season consisted of Becketts Creek, Brassils Creek and Pinecrest Creek.

The stream assessments were based on the macro stream assessment protocol developed by the Ontario Ministry of Natural Resources and adapted by the Rideau Valley Conservation Authority. The assessment included documentation of human alterations to the streams, adjacent land uses,

instream vegetation, temperature profiling, bank stability, observed wildlife, and pollution. Fish communities were also sampled on Brassils Creek, Greens Creek and Pinecrest Creek. In addition, three creek clean-up initiatives were organized and conducted on Pinecrest Creek (one event) and Sawmill Creek (two events) which were assessed during previous City Stream Watch programs. Four riparian rehabilitation planting projects were also conducted Graham Creek (one site), Mosquito Creek (one site) and Sawmill Creek (two sites). Recommendations with regards to the program and several independent projects were made.

#### **Confirmatory Sampling of Well #2 to Examine GUDI Potential, Village of Westport (2006)**

The report was undertaken to establish whether or not the groundwater sources from the municipal supply well (Well 2) in the Village of Westport is under the direct influence of surface water (GUDI) following the abandonment of the former supply well (Well 1). This report is a follow up to the 2003 Hydrogeological Study which recommended the abandonment of Well 1. The report summarizes the results of a one year monitoring program on Well 2.

The results of the water quality monitoring program indicated that the water quality in Well 2, with respect to the bacteriological parameters, improved following the decommissioning of Well 1. However, as the suggested trend was only observed over one year of data, it was recommended that additional data be collected and that a subsequent evaluation should be conducted in two years.

#### **Construction and Testing of a Production Well (PW2) for the Village of Carp (1994)**

The construction and testing of the second production well for the municipal water supply system in the Village of Carp was conducted in 1994. This well was constructed to complement the existing pumping well that was completed in 1986. The second production well was constructed 10 m north of the existing pumping well and screened in the gravel aquifer. The testing conducted included both water quality and quantity. The well was found to be able to produce water at 32.3 L/s (425 imperial gallons per minute (IGPM)). Water quality was found to meet all Ministry of the Environment (MOE) drinking water objectives with the exception of hardness and hydrogen sulphide. The treatment plant design includes treatment for hydrogen sulphide. It was noted that hardness treatment for aesthetic purposes may be conducted by the end users.

#### **Construction in Contaminated Areas, Village of Carp Sewer and Water Project, Carp, Ontario (1995)**

During the installation of the water and sewer servicing for the Village of Carp several areas of hydrocarbon contamination were encountered. Five potential sources of contamination based on historic information were identified. This report documents the investigation of these areas and the removal of hydrocarbon impacted material, both soil and groundwater, from the right of way at three of these locations. In addition to the removal of the hydrocarbon impacted material, trench drains and vapour extraction pipes were installed in the service trenches at these three areas as a contingency for future contamination from these areas.

#### **Construction of Multi-Level Sentinel Wells for the King's Park Communal Wells, Village of Richmond (Ottawa), Ontario (2006)**

This report documents the installation of two sentinel groundwater monitoring wells for the municipal drinking water supply system at the King's Park Subdivision in the Village of Richmond which is located within the amalgamated City of Ottawa. The work was conducted to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the communal wells system in the Village of Richmond. It was determined that the sentinel wells were to be located on City owned property

and at a 220 day travel time to the well. The Library sentinel well consists of five bedrock monitoring intervals and a separate overburden monitoring interval. The King Street sentinel well consists of four bedrock monitoring intervals and a separate overburden monitoring interval. The field program was conducted in the fall of 2004 and summer of 2005. Groundwater monitoring and sampling event was not conducted as part of the report but is to be conducted by the City of Ottawa at a later date.

### **Construction of Sentinel Wells for the Carp Communal Well System, Village of Carp (Ottawa), Ontario (2006)**

This report documents the installation of two sentinel groundwater monitoring wells for the municipal drinking water supply system in the Village of Carp which is located within the amalgamated City of Ottawa. The work was conducted to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the communal wells system in the Village of Carp. It was determined that the sentinel wells were to be located on City owned property and at a 220 day travel time to the well (approximately 145 metres from the wells). The first sentinel well consists of one groundwater monitoring interval and the second interval consists of a nest containing five monitoring intervals. In addition, to the installation of the sentinel groundwater monitoring wells, three existing unused monitoring wells were decommissioned. The field program was conducted in the summer of 2004. A groundwater monitoring and sampling event was also conducted by the City of Ottawa in 2004 (results not included).

### **Contaminant Plume Study, Township of Beckwith, Final Report (2001)**

The study was conducted to characterize the down-gradient extents of the contaminant plume associated with the historic chlorinated solvent groundwater contamination in the Township of Beckwith. The suspected source of the chlorinated solvent contamination is the former private landfill located near Blacks Corners. The primary contaminants of concern identified were the chlorinated solvents trichloroethene (TCE) and its associated degradation products 1,1-dichloroethene (1,1-DCE); cis and trans 1,2-DCE and VC. The private landfill was in operation from approximately 1968 until 1978; however a Certificate of Approval (C of A) was never obtained for the site.

In 1999, Beckwith Township retained Golder Associates Ltd. (GAL) to conduct an assessment of the former private landfill and the former Beckwith Township landfill. Vinyl chloride (VC) and benzene were encountered in the groundwater during this assessment. As a result of this assessment, the Ministry of the Environment (MOE) recommended that the Township of Beckwith undertake a domestic well sampling program and complete a detailed hydrogeologic study of both former landfills. The domestic well sampling program in 2000 indicated chlorinated solvent impacts. Duke Engineering & Services (Canada) Inc. (Duke) conducted a hydrogeologic study of the private landfill in 2000 that confirmed that the private landfill was the likely source of groundwater contamination in the area.

Water quality results indicated that some wells have chlorinated solvent concentrations in excess of the Ontario Drinking Water Standards (ODWS). Residences with impacted wells have been provided with bottled water and / or granular activated carbon (GAC) treatment systems. A groundwater monitoring program for the domestic wells was recommended.

The down-gradient extents of the plume were defined through the installation of 55 monitoring intervals at 22 locations. The aerial extent of the chlorinated solvent plume was determined to be approximately 9 km by 4 km from the private landfill. Groundwater modeling was conducted to



estimate the potential expansion of the plume. It was determined that plume will continue to expand downgradient for at least the next 20 years. Source removal or containment was recommended as it would have a beneficial impact on the plume. A detailed groundwater monitoring program for the groundwater plume was also recommended.

### **Cranberry Hill Subdivision Groundwater Testing, Township of North Grenville, Ontario (2005)**

Historical groundwater contamination related to both nitrates and bacteriological parameters has been documented in the Cranberry Hill subdivision since 1984-1985. This groundwater monitoring program was conducted in 2005 to sample the private wells in the vicinity of the Cranberry Hill subdivision in the Municipality of North Grenville and the groundwater monitoring wells as sampled during the previous 2001 Groundwater Management Study.

Two sampling events of 44 and 41 private wells, respectively, were conducted in the vicinity of the Cranberry Hill subdivision in June 2005. Nitrate was not detected in excess of the 10 mg/L criterion; however, 50 % of the private wells had nitrate concentrations in excess of 5 mg/L. Nitrate concentrations in ten of 21 wells indicated decreasing concentrations as compared to the 2001 data. Eight of the wells indicated relatively stable concentrations between the 2001 and 2005 data. Fourteen (14) wells and 13 wells during the two sampling events indicated unacceptable bacteriological water quality with respect to total coliforms. This poor bacteriological water quality results with respect to total coliforms was similar to the 2001 data. Four houses displayed positive *E. coli* concentrations during the sampling events indicating bacteriological contamination. As a result of the continued bacteriological impacts to the water quality in the Cranberry Hill subdivision, it was recommended that an alternate water source be investigated.

In addition, the monitoring wells in the vicinity of the Valley Sanitation site and west of the Cranberry Hill subdivision were also sampled during the monitoring program. Nitrate concentrations in the vicinity of the Valley Sanitation site remain elevated. However, these nitrate concentrations do not appear to be the source of nitrates in the Cranberry Hill subdivision.

### **Eastern Ontario Wetland Valuation System: A First Approximation, Technical Report (2003)**

The purpose of this study was to develop a methodology to assign a relative value for all known wetland features in eastern Ontario. The goals of the study were to provide local decision makers with the best available natural heritage information for decision making and to provide conservation organizations with information regarding conservation priorities within the study area. The nine criteria used included wetland size, wetland interior, wetland edge, adjacent vegetation, wetland disturbance, wetland habitat linkage, wetland hydrological linkage, headwater wetland and wetland flood attenuation. It was also noted that numerous other wetlands have yet to be identified in eastern Ontario.

### **Engineer's Report for the Water Supply Facilities for the Town of Perth, The (2001)**

The report documents the findings and recommendations for the water supply facilities for the Town of Perth. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Perth. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination were identified and these include the inherent susceptibility of surface water to contamination from runoff, effluent, vector contact, etc., access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. Sampling results of the raw water quality for Heterotrophic Plate Counts (HPC) or background colonies was not included within the report. In 2000, concentrations of total coliforms in the raw water ranged from non-detect to >5,000 per 100 mL, with nine of 52 samples being reported as > 5,000 per 100 mL. In 2000, concentrations of *E. coli* in the raw water ranged from non-detect to >5,000 per 100 mL, with one of 52 samples reported as >5,000 per 100 mL. One sample from the distribution system indicated the presence of total coliforms in 2000. It was determined to be a sampling error associated with the collection of the sample and subsequent tests were found to be negative for total coliforms at this location. In 2000, *E. coli* was not encountered in the distribution system.

It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report. An assessment of the risks to the water supply of the Town of Perth was included as an attachment to the report. Due to the location of the intake, a protocol between the golf course and the Town should be reached regarding the storage / use of pesticides. Several point sources of non-microbiological impact were identified in the areas upstream of the Town of Perth. In addition, several bridges across the Tay River or its tributaries were noted upstream of the Town of Perth.

#### **Engineer's Report for Town of Carleton Place Water Works (2000)**

The report documents the findings and recommendations for the Carleton Place Water Works which supplies the Town of Carleton Place. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Carleton Place. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination were identified and these include the inherent susceptibility of surface water to contamination from runoff, effluent, vector contact, etc., access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. It was also noted that the Mississippi River and Mississippi Lake are popular recreational water bodies and are also surrounded by agricultural land uses.

Raw water was sampled weekly for total coliforms and *E. coli* in 1999 and 2000. Based on 1999 data, total coliforms were found to range from non-detect to < 5,000 organisms per 100 mL, with six of 51 samples being reported as > 100 per 100 mL. In 2000 (partial results with only 43 weeks available), total coliforms was found to range from non-detect to < 5,000 organisms per 100 mL, with two of 43 samples being reported as > 100 per 100 mL. Based on 1999 data, *E. coli* was found to range from non-detect to < 10 organisms per 100 mL. In 2000 (partial results with only 43 weeks available), *E. coli* was found to range from non-detect to < 500 organisms per 100 mL, with two of 43 samples being reported as > 10 per 100 mL.

A review of the microbiological parameters for the distribution system and treatment plant was conducted from 1998 to 2000. In 1998, no samples from either the distribution system or treatment plant were reported to be unsafe. In 1999, two samples in the distribution system were found to be deteriorating (single detection of total coliforms but not *E. coli* or elevated background colonies / heterotrophic plate count) and re-sampling indicated safe sample results. In 1999, one sample from the treatment plant was found to be deteriorating with re-sampling

indicating safe results. In 2000, four samples were found to be deteriorating and re-testing indicated safe results.

Several raw water quality parameters (turbidity, colour, dissolved organic carbon (DOC) and pH) were found to exceed the Ontario Drinking Water Standards (ODWS). Turbidity is a health related ODWS which causes interference with the disinfection of the water. The high natural DOC content, when combined with chlorine, can form disinfection by-products such as trihalomethanes (THMs). As a result of these disinfection by-products major upgrades to the plant have been recommended and are intended to be implemented in 2001.

### **Engineers' Report for the Smiths Falls Water Work (2001)**

The report documents the findings and recommendations for the Smiths Falls Water Work which supplies the Town of Smiths Falls. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Smiths Falls. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination were identified and these include the inherent susceptibility of surface water to contamination from runoff, effluent, vector contact, etc., access openings to treated water reservoirs and maintenance work on piping and equipment in contact with the treated water. In addition as a result of the building being located within the flood plain and the clear well location below the grade of sanitary sewers, it was recommended that the treatment plant be relocated. Raw water was sampled weekly for total coliforms and *E. coli* in 1999 and 2000. In 1999, concentrations of total coliforms in the raw water ranged from non-detect to <5,000 per 100 mL, with four of 51 samples being reported as > 100 per 100 mL. In 2000, concentrations of total coliforms in the raw water ranged from non-detect to >5,000 per 100 mL, with seven of 52 samples being reported as >5,000 per 100 mL. In 1999, concentrations of *E. coli* in the raw water ranged from non-detect to <5,000 per 100 mL, with three of 51 samples reported as >100 per 100 mL. In 2000, concentrations of *E. coli* in the raw water ranged from non-detect to <5,000 per 100 mL, with ten of 52 samples reported as >100 per 100 mL. *E. coli* and total coliforms were not encountered in the distribution system.

Several raw water quality parameters (turbidity, aluminum, sodium, manganese, colour, dissolved organic carbon (DOC) and temperature) were found to exceed the Ontario Drinking Water Standards (ODWS). Turbidity is a health related ODWS which causes interference with the disinfection of the water. The sodium concentrations only exceeded the concentrations for the notification of the local Medical Officer of Health regarding patients on sodium restricted diets. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. Recommendations regarding the optimization of the coagulation / flocculation / sedimentation / filtration process to comply with the ODWS.

### **Engineers Report for Waterworks – Kings Park Subdivision, Communal Well System, Former Village of Richmond (2001)**

The report documents the findings and recommendations for the King's Park Subdivision Communal Well System located in the former Village of Richmond (now the amalgamated City of Ottawa). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the City of Ottawa. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for

microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and these included the former Richmond sewage lagoons, site grading at pumping well 1 with regards to the underground chlorine contact chambers, the close proximity of the Jock River and the Richmond sewage pumping station. Raw water test results did not indicate any adverse microbiological results. Elevated Heterotrophic Plate Counts (HPC) was encountered in the distribution system, however re-tested sampling was found to be in compliance. *E. coli* and total coliforms were not encountered in the distribution system.

Several raw water quality parameters (iron, hardness, conductivity and total dissolved solids) were found to exceed the Ontario Drinking Water Standards (ODWS). Iron is a non-health related parameter. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. There were no immediate additional treatment requirements for the facility; however buildup of scaling and/or sediments will normally occur with water supplies such as this. It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report.

A draft Well Head Protection Study of the King's Park Water Supply was conducted by Jacques Whitford Ltd. and is referenced in one of the appendices. Ten point sources of non-microbiological impact were identified in the areas surrounding the municipal wells. In addition, the CNR railway tracks were also identified east of the wells.

#### **Engineers' Report of Water Works, Town of Mississippi Mills (2001)**

The report documents the findings and recommendations for the Town of Mississippi Mills Well Supply located in the former Town of Almonte (now the amalgamated Town of Mississippi Mills). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Town of Mississippi Mills. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and these included the Town's sewage lagoons, sewage force mains, treated sewage outfall, pasture & crop lands. Raw water test results did not indicate any adverse microbiological results. Elevated Heterotrophic Plate Counts (HPC) was encountered in the distribution system. One sample from 1999 indicated presence of *E. coli* / fecal coliforms were not encountered in the distribution system. Several potential point sources of non-microbiological impact were identified in the areas surrounding the municipal wells.

Several raw water quality parameters (hardness, sodium, organic nitrogen, total dissolved solids, turbidity and aluminum) were found to exceed the Ontario Drinking Water Standards (ODWS). Historic elevated turbidity during high pumping rates has been documented at one of the wells. Turbidity is a health related ODWS which causes interference with the disinfection of the water. Nitrate concentrations have been documented at one of the wells but not at concentrations exceeding the ODWS. The sodium concentrations only exceeded the concentrations for the notification of the local Medical Officer of Health regarding patients on sodium restricted diets. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. There were no immediate additional treatment requirements for the facility.

### **Engineers' Report of Water Works, Township of North Grenville (2001)**

The report documents the findings and recommendations for the Municipality of North Grenville Well Supply located in the former Town of Kemptville (now the amalgamated Municipality of North Grenville). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Municipality of North Grenville. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and these included the access openings to untreated & treated water reservoirs, and location of one well within the reservoir. One area of known bacteria and nitrate contamination is known within the Municipality of North Grenville. Several raw water test results indicated the presence of background colonies and total coliforms. Re-testing of the raw water quality indicated that the contamination was not source related. *E. coli* was not detected in any of the raw water quality tests.

Several raw water quality parameters (hardness, sodium and colour) were found to exceed the Ontario Drinking Water Standards (ODWS). The sodium concentrations only exceeded the concentrations for the notification of the local Medical Officer of Health regarding patients on sodium restricted diets. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. There were no immediate additional treatment requirements for the facility. It should be noted that not all parameters in the ODWS were tested for before the completion of the report and were to be included as an addendum to the report.

### **Environmental Study Report, Communal Water System, Village of Lanark – Volumes 1 & 2 (1991)**

This report was prepared as part of a Class Environmental Assessment for the provision of a communal water system for the Village of Lanark. A need to implement a communal water system was identified due to the danger to public health caused by the drinking water contamination in the Village of Lanark. The contamination of the groundwater in the private wells in the Village of Lanark has been documented in previous reports (Village of Lanark, Communal Water System, Phase 1 Report – Existing Conditions (1990) and Village of Lanark, Private Sewage and Water Systems (1979)).

Alternatives for the communal water supply for the Village of Lanark were identified based on the design population, water source (surface water or groundwater) and distribution system. The preferred alternative for the communal water supply was identified as Alternative 1 which consisted of an extensive water distribution system with provision for fire protection supplied by groundwater. Several test wells were drilled and tested as part of the project. It was also concluded that the residents would have to pay a portion of the share of the project. Ideally, a communal sewage system should be constructed at the same time as the communal water system but due to a number of technical and economic factors, it was not possible to construct the communal sewage system.

### **Environmental Study Report – Phase 1: Village of Lanark Water and Wastewater (2002)**

This report was prepared as Phase 1 of a Municipal Class Environmental Assessment for the water and sewage study for the Township of Lanark Highlands in the area known as the Village

of Lanark. The Phase 1 report was conducted to identify all of the background information regarding the provision of communal services to the Village of Lanark.

Previous studies have identified the groundwater contamination in private wells (Village of Lanark, Communal Water System, Phase 1 Report – Existing Conditions (1990) and Village of Lanark, Private Sewage and Water Systems (1979)). An Environmental Study Report (ESR) was conducted in 1991 and identified the preferred solution as to construct a communal water system and repair the deficient private sewage systems. The recommendations were never implemented due mainly to the financial burden that would have been placed on the residents. Another study was conducted in 1994 which identified the preferred solution as the construction of a communal water system and wastewater lagoon. Again the recommendations were not implemented primarily due to the financial costs.

This study is the latest effort to address the concerns of the Village of Lanark to address the contaminated groundwater in the Village. Another groundwater sampling program was conducted in 2000 and involved the collection of samples from 329 wells. Nitrate concentrations in the groundwater wells sampled was found to exceed the provincial criterion of 10 mg/L in 14% of the wells and was approaching the criterion in 27% of the wells. Evidence of nitrate impacts were found in 75% of the wells sampled. Bacteriological sampling indicated that 16% of the wells were unsafe and that 8% showed some level of bacteriological impacts. These results were similar to the previous chemical and bacteriological concentrations reported in the Village of Lanark groundwater. As a result it was identified that the “Do Nothing” approach was not a viable alternative and that the environmental assessment process should continue to the next phase.

#### **Existing Conditions and Trends in the Tay River Watershed (2000)**

The Existing Conditions and Trends in the Tay River Watershed (2000) report contained an evaluation of both surface and groundwater. Groundwater information was compiled from subdivision hydrogeologic investigations, landfill sites, and a groundwater sampling event conducted in 1999. Most groundwater wells indicated high levels of hardness which exceeded the ODWS criterion. Selected locations were noted to exceed the ODWS for concentrations of manganese and iron. In addition, other metals such as beryllium, bismuth, nickel and sulphate were also noted to exceed the ODWS at some locations.

Surface water quality was evaluated in both the lakes and within the Tay River (and tributaries). Information for the evaluation of the surface water quality within the lakes of the Tay River watershed were obtained from the MOE Cottagers’ Self-Help Program, MOE Lake Partner Program, MNR lake surveys and reports, the Clean Up Rural Beaches (CURB) program and from the Lake Associations. Data collected from the various programs was generally collected for chlorophyll, total phosphorus and secchi disk and the surface water quality in the lakes was evaluated with respect to determining the trophic status of the lakes. The results of the surface water quality within the lakes of the Tay River watershed indicated that they are in reasonable health with most of the lakes having mesotrophic characteristics.

Information for the surface water quality evaluation of the Tay River and its tributaries was collected from the PWQMN, CURB program and the RVCA sampling program initiated in 1998. Indicator parameters from the surface water quality included bacterial (*E. Coli* and fecal coliforms), TP, TKN, TSS, dissolved oxygen, metals (aluminum, cadmium, calcium, iron, etc.), temperature and pH. The results of the water quality evaluation indicate that the water quality is reasonably good. One site (Port Elmsley) typically had concentrations of TP, TKN and *E. Coli* in

excess of the PWQO's in the spring. In addition, occasional elevated levels of nutrients and bacteria were also noted at Glen Tay Rd., Bolingbroke, Grants Creek and Pike Lake Dam.

### **Fish Habitat of the Tay River Watershed: Existing Conditions and Opportunities for Enhancement (2002)**

This report was prepared to document the background information regarding the natural features, fish and fisheries of the Tay River Watershed. The compilation of this background information will help provide an introduction to fish, fish habitat, threats to fish habitat and the importance of fish habitat protection. The study was initiated as a continuation of several of the goals and objectives of the Tay River Watershed Management Plan.

The following threats to fish habitat were identified in the Tay River watershed: Lack of buffer strips and shoreline destruction; Nutrient loading – agriculture, urban and cottage sources; Blockages of streams by dams, perched culverts, roads, etc.; Loss of littoral habitat critical for fish spawning and nursery; Loss or alterations to wetland habitat; Fluctuating water levels; Water quality; Water quantity; and Exotic species – Zebra mussels, Eurasian milfoil, purple loosestrife, etc. This study identified 23 shoreline and livestock access sites requiring management, 12 walleye spawning habitat rehabilitation projects, six lake trout spawning shoal enhancements, two major wetland habitat improvements and several clean-up initiatives.

### **Greater Bobs and Crow Lakes Stewardship Plan – Imagine: Our lakes, our lands, and our people ... A Stewardship Plan for Bobs and Crow Lakes (2007)**

Bobs and Crow Lakes are located in the headwaters of the Tay River which is a major tributary of the Rideau River and is part of the headwaters of the Rideau basin. The Bobs and Crow Lakes Stewardship Plan is intended to develop a new framework for reference for the future of environmental and community sustainability.

The aim of the lake stewardship plan is to: identify the qualities that make the area such a desirable place for people to live or visit and the challenges that put those qualities at risk; recommend a series of actions that will help to ensure the sustainability of the lakes, the lands, the natural ecosystem and the way of life that we value; and, serve as a reference and guide to support continued activity for the stewardship of the lakes. Background reports were prepared to document the following conditions on the lakes: water quality and water levels; fisheries and fishing; the natural environment; boating and recreation; emergency and municipal services; development; and, a sense of community.

Specific recommendations were also made with regards to Bobs and Crow Lakes. The recommendations were grouped according to each of the component reports identified above. A detailed list of the recommendations from these studies is presented in Table A-1.

### **Groundwater Use Characterization of the Heart's Desire Community, Ottawa, Ontario (2006)**

A groundwater study for the Heart's Desire Community within the amalgamated City of Ottawa was completed during 2004 by Golder Associates Ltd. (2006). A residential water quality characterization conducted by Robinson Consultants in 2004 is also included as an appendix to the Golder report. The study area consists of approximately 140 homes serviced by private wells and septic systems located in the southern end of the City of Ottawa. Currently there is development south and east with planned development to occur north of the community. This study was performed to determine the potential impact of the new development in the vicinity of the Heart's Desire community which relies upon private water for their water supply. The study

evaluated the groundwater resources which included the following main tasks: assessing threats to groundwater quality, residential surveys, detailed hydrogeological characterization, and groundwater quality assessment.

The majority of wells pump from the dolostone (Oxford) aquifer. Some deeper bedrock wells in the area (> 100 m deep) would likely draw water from the March or Nepean sandstone formations. A small number of residents also derive their private water supply from overburden deposits. Most overburden wells were found near the Rideau River within alluvial deposits or within the main area of the Heart's Desire community where the sand deposits in the drumlin are thickest. In general, the Oxford formation is regarded as a fair source of groundwater with sufficient water for domestic use. The underlying March and Nepean formations are excellent sources of groundwater with high yields of good quality water. Some wells completed in the overburden aquifer have reported problems with respect to groundwater quantity. The bedrock aquifer in the Heart's Desire area is semi-confined by a glacial till that is acting as a leaky aquitard suggesting that there is some connection between the overburden soils and the bedrock aquifer.

A detailed water quality investigation included the sampling of 80 water wells at select residential properties with an attempt to obtain a valid cross section of data. The groundwater in the Heart's Desire community may be characterized as being mineralized with elevated levels of hardness, calcium, magnesium and dissolved solids. Nitrate concentrations were not reported in excess of the ODWS, however nitrate concentrations (above detection limits) were reported in 50 % of the samples collected with 22% of the samples reporting concentrations between 2 and 10 mg/L. Approximately 60% of the samples reported chloride concentrations in excess of the ODWS. Sodium concentrations exceeded the ODWS AO (200 mg/L) in approximately 22% of the samples and all sodium concentrations were reported to be above the 20 mg/L for notification of the medical officer of health for low-sodium diets.

An inventory of potential environmental concerns was compiled for the study area which looked at both existing and historic land uses. Potential sources relating to the elevated parameters identified above include: septic system effluent, road salting and de-icing practices, water softener introduction to the aquifer from septic system effluent, and natural causes as a result of mineral dissolution.

### **Hydrogeologic Evaluation; Potential for Village Expansion Based on Private Individual Services; Village of Richmond (1991)**

This study was undertaken to evaluate the potential for expansion in the population in the Village of Richmond that could be serviced from private residential wells. MODFLOW modeling was conducted to evaluate the potential drawdown in the shallow bedrock aquifer as a result of the increased population. Based on the results of the modeling, it was determined that the capacity for the Village of Richmond could be increased to 7,680 persons plus associated commercial, industrial and institutional land uses.

The majority of the Village of Richmond is serviced by sanitary sewers. However, the southeast portion of the Village is not serviced by sanitary sewer. This portion of the Village of Richmond also corresponds with relatively shallow overburden soils that are not suited for septic systems. As a result it was recommended that the sewers be extended to this region.



### **Hydrogeologic Investigation of Four Communal Well Systems in the Regional Municipality of Ottawa-Carleton (1984)**

The study was undertaken to conduct hydrogeologic investigations on the communal water supply systems at the Carleton Lodge, Hillside Gardens Subdivision (Manotick), Julia Subdivision (Carp) and Munster Hamlet. The objectives of the study were to investigate the hydrogeologic setting for each communal well system, assess the capacity of the wells and reservoir for meeting present and future water consumption demands, and to provide recommendations to upgrade the water supply systems.

It was concluded that all four communal groundwater systems have a deficient water supply to a different degree. The Carleton Lodge system was found to have insufficient flow rates and reservoir volumes and as a result additional wells and increase in the size of the reservoir were recommended. The Hillside Gardens Subdivision was found to have insufficient flow rates and additional wells were recommended. It was noted that there may be potential interference with other residents on the Manotick Island. The Julia Subdivision system was found to have insufficient flow rates and reservoir volumes and as a result additional wells and increase in the size of the reservoir were recommended. Munster Hamlet system was found to have insufficient flow rates but that an increase in the pumping rates from the wells would be sufficient to remediate this.

### **Hydrogeological Assessment & Remedial Activity Summary, Munster Hamlet Production Wells 1 & 2 (2002)**

The hydrogeological assessment and remedial activities were undertaken at the Munster Hamlet communal well supply to assess the cause and origin of the noted elevated turbidity levels encountered in production well no. 2. In addition, it was noted that the original well installation did not involve grouting of the well casings. As a result of the non-grouted casings, the potential for the groundwater wells to be under the direct influence of surface water (GUDI) has been identified.

The remedial activities involved the installation of new grouted casing sleeves added below the existing casing depths at both production wells. In addition, an old observation well located near well no. 2 was also decommissioned. After the remedial activities were conducted additional hydrogeologic testing was conducted on the rehabilitated wells. The testing indicated similar production levels to previous tests prior to the rehabilitation activities. The water quality analysis indicated relatively good water quality, with a few parameters exceeding the Ontario Drinking Water Standards (ODWS) which included iron and turbidity. It was hypothesized that the elevated turbidity levels were occurring as a result of removal of rust particles as a result of shock chlorination or cascading water within the upper water bearing zones of the production well. The results of the water quality analysis and the rehabilitation activities indicate that the production wells in Munster are not GUDI wells.

### **Hydrogeological Assessment of Village of Carp Well Supply, Carp, Ontario (2001)**

The hydrogeological assessment was conducted to evaluate the potential for groundwater contamination at the well site and within the local recharge area of the aquifer utilized by the supply wells. The communal well system consists of two supply wells in the Village of Carp which supplies the drinking water for the southern end of the Village. The northern portion of the Village obtains its drinking water from a bedrock aquifer. The entire village is on municipal sewer services.

No potential sources of microbiological impact were identified during the study. Nine potential sources of contamination to the communal wells were identified. A monitoring program is currently in place for two of the potential contaminant sources. Recommendations were also made for some follow up work related to the other potential contaminant sources identified.

### **Hydrogeological Evaluation of Municipal Water Supply – Village of Lanark Water Supply Study (2005)**

Golder Associates Ltd. (2005) completed a hydrogeological investigation for the Village of Lanark Municipal Water Supply on behalf of the Township of Lanark. The purpose of this study was to identify a location and evaluate the potential to construct a communal groundwater supply system to resolve historical contamination problems experienced by domestic wells within the Village of Lanark. The results of this study were incorporated into a Municipal Class Environmental Assessment undertaken by the Township to address these issues.

This study provides background on the health-related concerns associated with the Village of Lanark current drinking water supply, summarizes five wells historically considered for communal water supply, evaluates four potential areas to perform test well drilling, summarizes the activities associated with drilling of two test wells (TW-1 and TW-2), pumping test analyses on the two test wells, water quality testing of the two test wells, and recommendations as to the potential to use either of these two wells for municipal supply.

Currently, all residences in the Village of Lanark are serviced by private domestic wells and septic systems. Historically, the groundwater quality from these domestic wells is poor with approximately 25% impacted by bacteria contamination and considered unsafe for human consumption. In addition, 15% of these wells have concentrations of nitrate in excess of the Ontario Drinking Water Standards (ODWS) Maximum Acceptable Concentration (MAC). The projected 20-year average pumping rate needed to supply the Village of Lanark is approximately 17.4 L/s (230 Igpm) and could be serviced by one single well, but more likely by multiple wells in a well field.

The geologic setting near Lanark includes shallow to non-existent overburden sediments underlain by Precambrian bedrock. The two test wells were drilled to depths of 140 and 91 m bgs, respectively, within the Precambrian marble bedrock aquifer and are located approximately 2 km northwest of the Village of Lanark. A 12-hour duration pumping test was performed on one test well and a 24-hour duration pumping tests was performed on the second test well.

The pumping test analyses showed that the combined safe yield of the two test wells is approximately 9.1 L/s (120 Igpm), about half of the projected 20-year design capacity. Therefore approximately 4 to 6 wells may be required to meet this demand. Water quality results show that both wells have groundwater quality that meets the ODWS drinking water standards. Recommendations were made to perform a full Groundwater Under the Direct Influence of surface water (GUDI) assessment if it is decided to proceed with the communal water supply project.

Public consultation involved one public information meeting and a presentation outlining the purpose and objectives of the study.

### **Hydrogeological Study, King's Park Subdivision, Richmond (1991)**

The hydrogeological study was undertaken to determine the long term safe yields of the two communal wells, existing water quality, and wellhead protection measures. The existing

municipal system consisted of two production wells with each pumping directly into the distribution system.

Water quality was found to be good with only iron, conductivity and turbidity being regularly above the Ontario Drinking Water Objectives (ODWO). Elevated turbidity levels should be addressed by either well rehabilitation or installation of a treatment system. Safe yields of the two wells were found to range from 425 to 1,021 imperial gallons per minute (igpm). The safe yield of the aquifer was determined to be 746 igpm. Previous testing had indicated a higher yield in the past and additional testing was recommended as the current yield does not meet the 2 hour fire demands. Recommendations were made for the operation of the system, and any upgrades, improvements or additions that may be required. Several wellhead protection measures were also recommended.

#### **Hydrogeological Study, Municipal Well Supply, Town of Kemptville (1991)**

The hydrogeological study was undertaken to determine the long term safe yields of the three town wells, existing water quality, well and pump rehabilitation requirements, and well and wellfield monitoring strategies. The existing municipal system consisted of three production wells with each pumping to a separate ground surface reservoir.

Water quality was found to be good with only iron, conductivity and turbidity occasionally above the Ontario Drinking Water Objectives (ODWO). Safe yields of the three wells were found to range between 200 and 450 imperial gallons per minute (igpm) with a total capacity of 950 igpm. The safe yield of the aquifer was determined to be 1450 igpm. As a result of the determination of the increased capacity for the safe yield of the aquifer it was recommended that the safe yield for the wells be increased to range between 400 and 500 igpm. Recommendations were made for the operation of the system, monitoring of the existing system and any upgrades, improvements or additions that may be required.

#### **Hydrogeological Study, Munster Hamlet, Regional Municipality of Ottawa-Carleton (1990)**

The hydrogeological study was undertaken to determine the long term safe yields of the two communal wells, existing water quality, and wellhead protection measures. The existing municipal system consisted of two production wells with each pumping to a combined ground surface reservoir.

Water quality was found to be good with only iron, conductivity and turbidity being regularly above the Ontario Drinking Water Objectives (ODWO). These parameters are generally only elevated in Well No. 2 and mixing within the reservoir results in all levels below the ODWO. Safe yields of the two wells were found to range from 158 to 286 imperial gallons per minute (igpm). The safe yield of the aquifer was determined to be 985 igpm. As a result of the determination of the increased capacity for the safe yield of the aquifer it was recommended that the safe yield for the wells be increased. Recommendations were made for the operation of the system, and any upgrades, improvements or additions that may be required. Several wellhead protection measures were also recommended.

#### **Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water, Village of Westport (2003)**

The hydrogeologic study was undertaken to establish whether or not the groundwater sources from the municipal supply wells (Wells 1 and 2) in the Village of Westport are under the direct influence of surface water (GUDI). In order to evaluate if the groundwater wells were GUDI, the following items were conducted: characterization of the local hydrogeological setting; description

of the local surface water features; assessment of the physical condition of the wells; and evaluation of source groundwater quality.

The local hydrogeologic setting is found to be fine grained sediments (0 – 19 m) overlying the March and Nepean sandstone bedrock formations. The thickness of the sandstone bedrock layer has not been accurately identified in this area as no local boreholes have fully penetrated through this bedrock unit to the underlying Precambrian bedrock. The thickness of the sandstone bedrock aquifer has been conservatively estimated to be 25 m. The groundwater recharge area for this bedrock aquifer is southwest, with Westport Pond north of the Village and Upper Rideau Lake east of the Village acting as discharge points. Several intermittent streams were identified upgradient of the municipal wells. In addition, the Village sewage lagoon is also located upgradient, estimated to be approximately 10 year travel time to the wells. The closest of the surface water features to the well is the stream which originates in a wooded swampy area and passes through agricultural land before passing approximately 7 m south of Well 1. In addition, at times of the year surface water ponding has been known to occur in the vicinity of Well 1. Re-grading of the site is occurring to reduce the ponding.

The municipal wells were constructed in 1969 and the physical condition of the well construction was detailed in the water well records. The wells were found to be in general compliance with O. Reg. 903. However, no documentation was found to confirm if the wells were grouted from ground surface to 1.2 m below grade. The well records indicated grouting from 1.2 to 4 m below grade. A video inspection of the interior of the wells was conducted in the fall of 2002. Some corrosion of the joints was observed but no leakage through the joints was noted. Water quality from Well 1 indicates frequent positive tests for total coliforms and occasional positive tests for *E. coli*. There was found to be a strong correlation between precipitation and incidences of poor bacterial water quality in Well 1. There was also a season trend with poorer water quality being noted in spring and fall.

As a result of the poor water quality in Well 1, it was determined that there was some hydraulic connection between the surface water ponding or the intermittent stream and the borehole annulus of Well 1. It was recommended to either rehabilitate Well 1 or drill a new supply well. The report also contains an addendum to the hydrogeologic study which was included in one of the appendices. This addendum updates the recommended course of action from the hydrogeologic study which was to drill & install a new drinking water well (Well 3) located northwest of the existing Well 2. The water quality within the new well was found to be characterized by low turbidity and good microbial quality.

### **Interim Report on the Functions and Status of Kemptville Creek – Kemptville Creek Watershed Plan – Volumes 1 and 2 (1996)**

Information for the surface water quality evaluation of Kemptville Creek and its tributaries was collected from the PWQMN (1985 – 1994), CURB program (1992 – 1994) and RVCA sampling program initiated in 1994. Indicator parameters for the surface water quality of the Kemptville Creek watershed included ammonia (un-ionized), bacteria (*E. Coli*), dissolved oxygen, nitrogen (TKN, nitrates and nitrites), TP and TSS.

Overall water quality within Kemptville Creek was classified as fair above the former Town of Kemptville and degraded downstream of the town. *E. Coli* concentrations were below the PWQO for most sampling events above Oxford Mills. The highest *E. Coli* concentrations, in excess of the PWQO criterion, were routinely detected on Barnes Creek. TP concentrations within Kemptville Creek and its tributaries were found to be above the PWQO criterion with the highest

concentrations reported in the former Town of Kemptville and Barnes Creek. Barnes Creek also reported concentrations of un-ionized ammonia exceeding the PWQO. The North Branch of Kemptville Creek and Barnes Creek have elevated levels of TSS. Low dissolved oxygen concentrations were observed in the lower reaches of Kemptville Creek and Barnes Creek.

Groundwater information was compiled from subdivision hydrogeologic investigations, landfill sites, and contamination investigations. Most groundwater wells indicated high levels of hardness which exceeded the ODWS criterion. Selected locations were noted to exceed the ODWS for concentrations of fluoride, manganese, sulphate and iron.

### **Hydrogeology and Development, March Township (1976)**

The study was completed to assess the suitability of the rural areas of March Township for development on private water and septic systems. Water quality in the March Township was generally found to be acceptable with excellent water sources found in the March and Nepean aquifers. The limitations with respect to development on private services in March Township were generally related to the surficial geology encountered and its corresponding suitability to accommodate septic systems. Recommendations for lot sizing were documented in the report.

### **Interim Watershed Plan - Mississippi Valley Conservation (1983)**

An Interim Watershed Plan was completed for the MVCA (MVCA, 1983). The report updates the watershed management plans to reflect policies and priorities in the MVCA. The policies and priorities of the MVCA specifically detailed in the Interim Plan include flood and erosion control, urban and rural drainage, wetlands, source and recharge areas, water quality, forestry, fish and wildlife, recreation, sensitive / unique areas and community relations.

### **Interim Watershed Plan - Rideau Valley Conservation Authority (1983)**

An Interim Watershed Plan for the RVCA (RVCA, 1983) was also conducted. The report updates the watershed management plans to reflect policies and priorities in the RVCA. The policies and priorities of the RVCA specifically detailed in the Interim Plan include flood and erosion control, water management, water-related land management, conservation areas / recreation, information / education and heritage conservation.

### **Jock River Reach 2 and Mud Creek Existing Conditions Report (2005)**

Jock River Reach 2 / Mud Creek Subwatershed Study – Existing Conditions Report (MMM & WESA, 2005) consisting of three volumes: Volume 1 – Text, Volume 2 – Figures, and Volume 3 – Appendices. The Jock River Reach 2 study area consists of a portion of the Jock River from the Richmond Fen Wetland to Highway 16, which was previously defined within the Jock River Watershed Plan (RVCA 2001). Mud Creek is a subwatershed of the Rideau River located southwest of Manotick.

The Existing Conditions Report is the first component of the subwatershed plan for the study area and comprises the basis from which the subwatershed plan will be developed. The existing conditions for the Jock River Reach 2 and Mud Creek were compiled for the following study areas: climate, geology and physiography, land use, surface and groundwater systems, aquatic resources, and terrestrial resources.

Information for the surface water quality evaluation of the Jock River Reach 2 and Mud Creek subwatersheds was collected from the City of Ottawa Baseline Surface Water Quality Program. Thirteen indicator parameters consisting of chlorides, copper, *E. Coli*, iron, lead, manganese, nitrates & nitrites, pH, sulphate, temperature, TKN, TP, TSS and zinc were selected out of the 43

parameters monitored. The following observations were noted from the parameter concentrations:

- TP concentrations in Mud Creek and Jock River Reach 2 exceeded the PWQO with the exception of one sample location in the headwaters of Flowing Creek.
- Nitrate & nitrite concentrations in Mud Creek and Jock River Reach 2 vary from < 0.3 mg/L to > 2 mg/L.
- TSS concentrations in Mud Creek and Jock River Reach 2 vary from < 10 mg/L to 100 mg/L.
- *E. Coli* concentrations in Mud Creek and Jock River Reach 2 exceeded the PWQO with the exception of sections within the Monahan Drain and one sample location in the headwaters of Flowing Creek.
- Copper concentrations in Jock River Reach 2 were below the PWQO with the exception of a few stations. Copper concentrations in Mud Creek were below the PWQO for the area east of Highway 416 and copper concentrations west of Highway 416 were in excess of the PWQO criterion.
- Water temperatures indicate warm water fisheries in Mud Creek and Jock River Reach 2.

In addition, the water quality was also evaluated with respect to the CCME Water Quality Index. Results of the CCME Water Quality Index indicated that for Mud Creek water quality ranges from marginal to poor, Jock River Reach 2 water quality is fair, Leamy Creek (Jock River sub-basin) water quality ranges from marginal to poor, Flowing Creek and Monahan Drain (Jock River sub-basins) water quality ranges from fair to poor.

### **Jock River Watershed Management Plan (2001)**

The Jock River is also a major tributary of the Rideau River, located in the western central portion of the RVCA watershed. A Jock River Watershed Plan Interim Report (RVCA et. al., 1996) was completed to document the background conditions of the tributary watershed. The Interim Report consisted of two volumes, a condensed version (Volume 1) and the component reports (Volume 2). The reports document the existing conditions of the Jock River with regards to the land use, recreation, wetlands, ecological features, surface water quantity and quality, and groundwater.

The surface water quality assessment referenced in the Jock River Watershed Management Plan (2001) was conducted during the Jock River Watershed Plan – Interim Report (1996). The Jock River watershed was divided into four reaches. Reach One is from the mouth of the river upstream to Highway 416, Reach Two is from Highway 416 upstream to the Richmond Fen, Reach Three is from the Richmond Fen upstream to the Ashton Dam and Reach Four is from the Ashton Dam to the headwaters.

Surface water quality in the entire Jock River watershed generally had mild to moderate water quality impairment as a result of high concentrations of bacteria and nutrients and low suspended sediments. Water quality within Reach One was consistent with the general water quality for the entire watershed (high bacteria and nutrients and low suspended sediments). Water quality in Reach Two was also poor within this area with high levels of bacteria and nutrients. In addition, the tributaries within Reach Two were also noted to have high levels of suspended sediments. Water quality in Reach Three also had high levels of bacteria and nutrients with the exception of the King's Creek tributary which had bacteria concentrations below the PWQO and lower concentrations of TP, however still exceeding the PWQO. Within Reach Four the amount of water quality information was limited, however high levels of bacteria and nutrients were still reported.

The Jock River Watershed Management Plan (RVCA, 2001) builds on the background information assembled during the Interim Report. The overall goal of the Jock River Watershed Plan is to achieve and maintain a healthy, sustainable Jock River Watershed. The vision for the Jock River involves three themes and 10 key elements detailed below:

- Theme – People understanding the River, consisting of key elements including:
  - Commitment to stewardship;
  - Open dialogue and cooperation between stakeholders; and
  - Awareness through information and education.
- Theme – Green Way of Life, consisting of key elements including:
  - Sustainable agricultural practices;
  - Stewardship of vegetation in woodlands, wetlands and riparian corridors;
  - Maintenance of rural character; and
  - Conservation of wildlife habitat diversity.
- Theme – Comfort with the River, consisting of key elements:
  - Recreation potential in river corridor;
  - Surface and groundwater quality suitable to human and aquatic habitat needs; and
  - Normal fluctuation in water levels and flows neither excessively low nor excessively high.

Specific recommendations were also made with regards to the Jock River. The recommendations from the Watershed Management Plan were grouped according to the specific reaches (Reach One to Four) or watershed wide. Recommendations in the Interim Report were grouped according to each of the component reports: land use, recreation and public land ownership, wetlands, ecological features, surface water quantity, surface water quality, and groundwater. A detailed list of the recommendations from these studies is presented in Table A-1.

### **Jock River Watershed Plan – Interim Report (1996)**

Information for the surface water quality evaluation of the Jock River and its tributaries was collected from the PWQMN, CURB program, RVCA sampling program initiated in 1995 and the Regional Municipality of Ottawa-Carleton sampling program (now the City of Ottawa Baseline Surface Water Quality monitoring program). Indicator parameters of the surface water quality for the Jock River watershed included ammonia (un-ionized), bacteria (*E. Coli*), dissolved oxygen, metals (cadmium, copper, zinc, etc.), pH, temperature, TKN, TP and TSS.

Water quality within the Jock River was classified as ranging from good to very poor (mild to moderate impairment) for the indicator parameters identified above. *E. Coli* and TP concentrations within the Jock River and its tributaries were found to be above the PWQO criteria, with the exception of the bacterial concentrations in the King's Creek tributary which are below the PWQO criterion. Localized areas with concentrations of un-ionized ammonia exceeding the PWQO were also documented. Leamy and Flowing Creeks have TSS in excess of the PWQO criterion. Low dissolved oxygen concentrations were observed in Leamy and King's Creeks and within the Jock River at the Ashton Dam and above Ashton (at Cemetery Rd.). Concentrations of six metals in excess of the PWQO were also documented in the Jock River at Moodie Drive. High levels of iron were also documented throughout the Jock River watershed.

Groundwater quality was also documented in the Jock River Watershed Plan. Groundwater quality assessment was based upon water quality concentrations from the Velderman (1993) study. Groundwater quality within the bedrock aquifers of the Jock River watershed was

generally good with localized concentrations of aluminum, chloride, iron, manganese, pH and sodium exceeding the ODWS criteria.

### **Kanata North Environmental / Stormwater Management Plan (2001)**

The Kanata North Environmental / Stormwater Management Plan was completed to address the development of areas in North Kanata in the Shirley's Brook subwatershed. The development areas that the study focused on were identified as the Kanata North Urban Expansion Area Lands and the Kanata North Business Area. The Shirley's Brooks subwatershed was part of the Shirley's Brook / Watts Creek Subwatershed Study which was completed in 1999 by Dillon. The report presented recommendations with respect to aquatic and terrestrial environmental constraints and stormwater management. A detailed listing of the recommendations is presented in Table A-1.

### **Kemptville Creek Watershed Plan (1999)**

Kemptville Creek is one of the major tributaries of the Rideau River basin, located in the southeast portion of the RVCA watershed. An Interim Report on the Functions and Status of Kemptville Creek (RVCA et. al., 1996) was completed to document the background conditions of the tributary watershed. The Interim Report consisted of two volumes, a condensed version (Volume 1) and the component reports (Volume 2). The reports document the existing conditions of Kemptville Creek with regards to the hydrology, hydrogeology, water quality, ecology and land use.

The surface water quality assessment referenced in the Kemptville Creek Watershed Management Plan (1999) was conducted during the Interim Report on the Functions and Status of Kemptville Creek (1996). Indicator parameters for the surface water quality assessment of Kemptville Creek included dissolved oxygen, *E. Coli*, TP, TKN and un-ionized ammonia.

Upstream of the Town of Kemptville the surface water quality is generally satisfactory. Low dissolved oxygen levels were observed upstream of the Oxford Mills dam and on the North Branch of Kemptville Creek. The remaining indicator parameters were generally found at acceptable levels with only occasional concentrations in excess of the criterion. Within the Town of Kemptville and downstream of the town, surface water quality is degraded. Regular concentrations exceeding the PWQO for *E. Coli* and TP were observed. A tributary of Kemptville Creek, Barnes Creek was noted to have bacteria, phosphorus and ammonia concentrations in excess of the criteria.

The Kemptville Creek Watershed Plan (RVCA, 1999) builds on the background information assembled during the Interim Report. The purpose of the plan was to:

- Outline goals, objectives and methods for the rehabilitation, protection, and enhancement of the natural features and functions and health of the Kemptville Creek watershed;
- Devise and outline a watershed management strategy based on the "ecosystem approach" to resource management and land use planning; and
- Address a number of unresolved issues (beaver management, water quality, recreation, water levels, dam operation, and wildlife habitat) afflicting the watershed.

Specific recommendations were also made with regards to the Kemptville Creek. The recommendations from the Interim Report were grouped according to each of the component reports: hydrology/hydraulics, water quality, ecology, hydrogeology, and land use regulatory / policy fabric. The recommendations from the Watershed Plan were grouped according to the



watershed objectives as they relate to water quality, wildlife, socio-economic, and water quantity. A detailed list of the recommendations from these studies is presented in Table A-1.

### **Kemptville Creek Watershed Plan Update (2006)**

The Kemptville Creek Watershed Plan Update was conducted by RVCA (2006). Part of the update included an evaluation of the surface water quality. Surface water quality monitoring reported upon during the initial Kemptville Creek Watershed Plan was based on water quality concentrations from 1991 to 1994. The updated surface water quality reporting period was from 1995 to 2004 and consists of 14 locations within the Kemptville Creek watershed (one PWQMN station and 13 sites maintained by the RVCA).

Some observations were noted with regards to bacteria (*E. Coli*), TKN, TP, dissolved oxygen and metals. Bacterial concentrations of *E. Coli* exceeding the PWQO were detected in 35% of the samples from 1995-2004 (677 samples in total) which is reduced from 56% of the samples from 1991-1994 (236 samples). TP concentrations exceeding the PWQO were detected in 61% of the samples from 1995-2004 (650 samples in total) which is a slight decrease from 70% of the samples from 1991-1994 (189 samples). TKN concentrations exceeding the EC guideline were detected in 97% of the samples from 1995-2004 (635 samples in total) which is an increase from 87% of the samples from 1991-1994 (194 samples). Dissolved oxygen concentrations below (non-compliance) the PWQO have been observed at South Branch Road, North Augusta, Patterson's Bridge and downstream of Oxford Mills. Metals concentrations are below the PWQO criteria with the exception of copper in Barnes Creek (three events in excess of the PWQO criterion).

### **Life Science Areas of Natural and Scientific Interest in Site District 5-11: A Review and Assessment of Significant Natural Areas in Site District 5-11 (1990)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. The protection objective is considered to have two components: an earth science or geological component and a life science or biological component. These sites identified will be considered to be nominated as candidate areas of natural or scientific interest (ANSI).

Site District 5-11 is the largest site district in southern Ontario and comprises parts of Renfrew, Lanark, Lennox & Addington, Hastings, Frontenac, Peterborough and Haliburton Counties. Fragments of the site district are also located Victoria County and Nipissing District. There are four subdistricts located within Site District 5-11 which are the Kawartha, Mazinaw, Madawaska and Bonnechere Subdistricts. The site district is characterized by the rolling landscape consisting of thin glacial soil over Precambrian bedrock of the Canadian Shield.

Over 100 sites were evaluated in this study and 23 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 14 sites were considered to be regionally significant sites. The most significant natural characteristic of Site District 5-11 is the large area of thinly buried and exposed marble bedrock.

### **Life Science Areas of Natural and Scientific Interest in Site District 6-10: A Review and Assessment of Significant Natural Areas in Site District 6-10 (1993)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. The protection objective is considered to have two components: an earth science or geological component and a

life science or biological component. These sites identified will be considered to be nominated as candidate areas of natural or scientific interest (ANSI).

Site District 6-10 comprises parts of Leeds & Grenville and Frontenac Counties. Smaller portions of the site district are also located Lanark, Hastings, and Lennox & Addington Counties. There are three subdistricts located within Site District 6-10 which are the Kaladar, Frontenac and Leeds Subdistricts. The site district generally coincides with the southern extension of the Canadian Shield (Frontenac Axis) that connects the Algonquin Highlands to the Adirondack Mountains of New York State.

Over 100 sites were evaluated in this study and 22 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 14 sites were considered to be regionally significant sites. The most significant natural characteristics of Site District 6-10 are the isolated exposed rock ridges, extensive rock barrens, the expansive ridge and valley topography and its associated forest, the numerous small and diverse wetlands, the extensive shorelines associated with the lakes, and the 'knobs and flats' landform.

#### **Life Science Areas of Natural and Scientific Interest in Site District 6-11: A Review and Assessment of Significant Natural Areas in Site District 6-11 (1992)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. The protection objective is considered to have two components: an earth science or geological component and a life science or biological component. These sites identified will be considered to be nominated as candidate areas of natural or scientific interest (ANSI).

Site District 6-11 comprises parts of Lanark and Leeds & Grenville Counties and the City of Ottawa. The site district generally coincides with the Smiths Falls Limestone Plain that contains the largest continuous area of shallow soils over limestone in southern Ontario.

Over 70 sites were evaluated in this study and 17 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 9 sites were considered to be regionally significant sites. The most significant natural characteristics of Site District 6-11 are the expansive Smiths Falls Limestone Plain and its associated upland forest and alvar habitat, the extensive wetlands on organic landform and the wetlands of the clay plain landform.

#### **Life Science Areas of Natural and Scientific Interest in Site District 6-12: A Review and Assessment of Significant Natural Areas in Site District 6-12 - Draft (1992)**

This report is one of a series commissioned to identify provincially significant elements of the natural and cultural landscape of Ontario for the purposes of protecting them. The protection objective is considered to have two components: an earth science or geological component and a life science or biological component. These sites identified will be considered to be nominated as candidate areas of natural or scientific interest (ANSI).

Site District 6-12 comprises all of Prescott & Russell and Stormont, Dundas and Glengarry Counties and parts of Leeds & Grenville County and the City of Ottawa. There are five subdistricts located within Site District 6-12 which are the Carp-Mississippi, Rideau, South Nation, St. Lawrence and Rigaud Subdistricts. The site district is generally a relatively level area

of till and marine deposits over deep buried sedimentary bedrock with the exception of the Carp Ridge.

Site District 6-12 is one of the most extensively altered areas of Ontario with only 15-20% of the land remaining forested. A total of 40 candidate ANSI's were proposed to supplement the 14 existing reserve areas. From Site District 6-12, 15 were considered to offer the best representation of the landform-vegetation features of the site district (provincially significant). In addition, another 25 sites were considered to be regionally significant sites. The most significant natural characteristic of Site District 6-12 is the National Capital Commission Greenbelt surrounding Ottawa which contains a number of the most significant sites.

### **Lower Rideau Watershed Strategy (2006)**

The Lower Rideau watershed is defined as the lands draining to the Rideau River downstream of Burritt's Rapids, located within the RVCA boundaries. The majority of the Lower Rideau watershed resides within the City of Ottawa. The confluence of both the Jock River and Kemptville Creek, which are major tributaries of the Rideau River, occurs within the Lower Rideau watershed.

The Lower Rideau Watershed Strategy (Robinson Consultants Inc. et. al.) involved the completion of the Phase I Report (2003) and the Draft Final Report (2005). The Phase I Report documents the background conditions of the watershed with regards to the geology, physiography, surface water management, groundwater characteristics, surface water quality, erosion and stream morphology, aquatic communities and habitats, terrestrial communities and habitats, and land use.

The Lower Rideau Watershed Strategy (2006) contained evaluation of surface water. Indicator parameters of the surface water quality for the Lower Rideau River watershed included bacteria (*E. Coli*), dissolved oxygen, metals, TP and TSS. Good water quality condition (within provincial guidelines) with respect to trace contaminants, bacteria and suspended sediment was observed within the reaches of the Lower Rideau River. Poor water quality condition (exceeding provincial guidelines) with respect to nutrients and bacteria was observed within the tributaries of the Lower Rideau River watershed. Groundwater quality assessment was based upon water quality concentrations from the Renfrew – Mississippi – Rideau Groundwater Study (2003).

The Lower Rideau Watershed Strategy Draft Final Report builds on the background information assembled during the Phase I Report. The overall goal of the Lower Rideau Watershed Strategy is to protect the cultural and natural environments of the Lower Rideau River Watershed ecosystem for the benefits of humans and other terrestrial and aquatic life. Objectives were made with regards to communication and cooperation, surface water quantity, surface water quality, groundwater quality and quantity, aquatic communities and habitats, terrestrial communities and habitats, and water and riparian uses. Recommendations in the Draft Final Report were grouped according to public education and outreach, control of nutrients and pathogens, river and stream corridor management, control of flows and water levels, and integrated watershed monitoring and reporting. A detailed list of the recommendations from these studies is presented in Table A-1.

### **Lower Rideau Watershed Strategy – Phase I (2003)**

Information for the surface water quality evaluation of the Lower Rideau Watershed Strategy – Phase I draft report (2003) was collected from the City of Ottawa Baseline Surface Water Quality Program (1998 to 2002). Seven indicator parameters consisting of chlorides, conductivity, copper, dissolved oxygen, *E. Coli*, temperature, TP and TSS were selected out of the 43

parameters monitored. The following observations were noted from the parameter percentile concentrations:

- TP concentrations at the selected stations were below the PWQO criterion ranging from 10% (Rideau River at Black Rapids & Stevens Creek) to 70% (Rideau River at Burritts Rapids) of the samples at each station.
- TSS concentrations at the selected stations were below 10 mg/L in 85 to 100% of the samples at each station with the exception of Stevens Creek which had only 65% of the samples below 10 mg/L.
- *E. Coli* concentrations at the selected stations were below the PWQO criterion from 60% (Stevens Creek) to 98% (Rideau River at Burritts Rapids and Roger Stevens Road) of the samples at each station.
- Copper concentrations at the selected stations were below the PWQO criterion from 90 to 98% of the samples at each station.
- Limited dissolved oxygen data is available (two stations only). Dissolved oxygen concentrations from the two stations (Stevens Creek and Rideau River – Mooney’s Bay) are > 4 mg/L at approximately 85% and 98% of the sample results.
- Water temperatures indicate warm / cool water fisheries in the Lower Rideau watershed.

### **Mainstreaming Climate Change in Drinking Water Source Protection Planning in Ontario (2006)**

The report details how climate change is integral to the current source protection initiatives ongoing with respect to the *Clean Water Act*. Source water protection involves activities to keep drinking water sources free of contamination. This will involve the linkage between land use activities and water quality / quantity.

Recent projections suggest that Ontario’s climate in a hundred years will be different than today. Expected changes include increased temperature in all seasons, changes in the seasonal distribution of precipitation and increases in precipitation extremes (high-intensity rainfall events and droughts). Studies of the impacts of climate change with respect to the hydrologic cycle point to significant changes to stream flow, lake levels, water quality, groundwater infiltration and groundwater recharge / discharge.

Climate change could impact source protection initiatives in some of the following manners decreased runoff during summer is likely to lead to reduced water quality, which will result in greater water treatment costs. In addition, decreased runoff can result in reduced water quantity which can result in greater competition and potential conflict for the reduced water supplies. Reduced groundwater recharge could reduce groundwater levels which may in turn reduce groundwater discharge to streams and lakes.

Due to these potential climate change effects, past hydrological regimes may not be appropriate for the future hydrological regimes. As a result of these predicted changes, climate change may influence vulnerable areas, the vulnerability of future drinking water sources, and the quality of water sources that supply drinking water.

### **Mapping and Assessment of Former Industrial Sites, City of Ottawa (1988)**

Intra Information Technologies (Canada) Ltd. (1988) completed an inventory of former industrial sites within the City of Ottawa from 1850 to 1984. The focus of the inventory was on sites that likely produced or handled hazardous wastes and materials.

A total of 177 former industrial sites were identified during the study. Identified sites included manufacturing industrial operations and non-manufacturing operations, such as bulk fuel storage or railway yards/roundhouses. Of the 177 former industrial sites, 166 were verified on historical maps (specifically fire insurance plans). A list of the data sources for each municipality is presented in Table 4.2-1. The locations of the former industrial sites are presented in Table 4.2-2. Site visits were conducted at 53 of the former industrial sites to identify the potential environmental impacts. Information sheets and fire insurance plans for each of these 53 sites included within Volume 2.

A screening to determine the level of priority of potential environmental impact was also conducted. The former industrial sites were classified into three groups (Group I – high priority, Group II – moderate priority and Group III – low priority). Five (5) sites were identified in Group I (two bulk fuel facilities, two coal gasification plants and one coal tar distillation plant). Eighteen (18) sites were identified in Group II (eleven bulk fuel facilities, three asphalt plants, two government sites, a paint works and a sweeping compound manufacturer). The remainder of the sites (154 sites) were classified as Group III.

#### **Merrickville Water Works, First Engineer's Inspection Report for Water Works(2001)**

The report documents the findings and recommendations for the Merrickville Water Works located in the former Village of Merrickville (now the amalgamated Village of Merrickville-Wolford). The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Village of Merrickville-Wolford. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and included site grading allowing surface water entry, access openings to untreated & treated water reservoirs, abandoned or improperly decommissioned wells within the Village. Raw water test results in 1999 did not indicate any adverse microbiological results. Raw water quality test results in 2000 indicated elevated concentrations of total coliforms and background colonies at several sampling events. *E. coli* was not encountered in the raw water quality from 2000. One sample of elevated background colonies (Heterotrophic Plate Counts (HPC)) was encountered in the distribution system. *E. coli* and total coliforms were not encountered in the distribution system.

Several raw water quality parameters (sodium, hardness, colour and turbidity) were found to exceed the Ontario Drinking Water Standards (ODWS). Turbidity is a health related ODWS which causes interference with the disinfection of the water. The sodium concentrations only exceeded the concentrations for the notification of the local Medical Officer of Health regarding patients on sodium restricted diets. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. Several upgrades were recommended for the facility.

#### **Microbial Source Tracking in Aquatic Ecosystems: The State of the Science and an Assessment of Needs (2006)**

This report was compiled based on a microbial source tracking (MST) workshop held in 2005 in Toronto. MST refers to the determination fecal contamination in water based on comparing the similarity of microorganisms to local fecal pollution sources. Fecal pollution of water can occur as a result of many different sources including municipal wastewater effluents, failing on-site septic systems, livestock manure and wildlife droppings.

The MST field is still under development and as a result there are few standardized methods and unknown reliability / accuracy of the MST techniques. However, there is still high interest in MST as it may help provide a scientific basis to resolve the sources of fecal pollution.

### **Mississippi River Water Management Report (2005)**

The Mississippi River Water Management Plan was completed (French Planning Services Inc. et. al., 2005) to evaluate the current and future operating plans for the hydro-generating facilities and water control structures on the Mississippi River. Within the Mississippi River system there are many water control structures, 12 of which are large enough to have significant impacts on the water levels and flows. These larger water control structures which are the focus of the water management on the Mississippi River are owned by four different corporations or agencies, consisting of the MVCA, Ontario Power Generation, Independent Power and the MNR.

The objectives of the Mississippi River Water Management Plan included:

- Maintain or improve aquatic ecosystem health throughout the system;
- Address public safety and minimize property damage;
- Maintain water levels throughout the system for navigation, recreation, cultural and social opportunities;
- Recognize power generation values from the system; and
- Develop public awareness on current conditions.

Upon completion of the Mississippi River Water Management Plan some generating operating principles for the water control structures on the Mississippi River were developed. These principles allow for the operation of water control structures to accommodate for multiple and potentially conflicting uses such as flood protection, low flow augmentation, ice management, erosion control, recreation, wildlife and aquatic habitat. The updated operation plan for the Mississippi River included the continued operation of 11 of the 12 structures in accordance with the previous operating procedures. Updates to the operation of the Shabomeka Lake dam were recommended to be implemented to improve the spawning habitat in the Lake. In addition, a detailed list of recommendations with regards to further information to be collected is presented in Table A-1.

### **Mississippi Valley Conservation Report (1970)**

The Mississippi Valley Conservation Report (MVCA Conservation Report) was completed in 1970 (Ontario Department of Energy and Resources Management, 1970) after the formation of the MVCA in 1968. The MVCA Conservation Report involved a detailed survey of the newly formed conservation authority. Specific areas of focus for the report included a description of the history of the region as well as the existing conditions of the MVCA as they relate to land use, forestry, water, biology and recreation.

The Mississippi Valley Conservation Report (1970) included an evaluation of surface water quality. The water quality of the Mississippi River was generally considered to be good and relatively free of suspended sediment. Water samples for biochemical oxygen demand, coliforms, dissolved oxygen, pH, nitrites and nitrates were collected in the summer of 1968. Additional sampling has historically been conducted by the Ontario Water Resources Commission. Only one location has water quality sampling at regular intervals (Mississippi River near Galetta). Locations of high concentrations of coliforms and BOD were encountered on the Clyde River in Lanark and Mississippi River in Carleton Place. Coliform concentrations at the Galetta monitoring station were also noted to have reported elevated concentrations.

Localized areas of sedimentation were observed (Dalhousie, Mississippi, Bennett and Shabomeka Lakes and downstream of the Lanark). Other locations with obvious sewage discharge to surface water were also noted in the report, without specific water quality analysis.

Specific recommendations were also made to ensure the conservation of the MVCA. These recommendations were grouped according to general policies and water, fish and wildlife, recreation, and land use and forestry development policies. A detailed list of the recommendations from the MVCA Conservation Report is presented in Table A-1.

### **Mississippi Valley Watershed Strategy (1993)**

The Mississippi Valley Watershed Strategy (MVCA, 1993) establishes a process of watershed planning and resource management utilizing local expertise. The mission of the Watershed Strategy is for the MVCA to assume a leadership role in the conservation, enhancement and development of the Mississippi Valley by way of watershed planning, integrated resource management programs and conservation awareness. The specific goals included:

- Minimize threat to life and destruction of property from flooding and preserve, or re-establish where possible, the natural functions of the flood plain;
- To restore, protect and enhance water quality, wetlands and associated aquatic resources and water supplies;
- To conserve, protect and restore the natural resources (land, water, forest and wildlife) of the watershed;
- To restore, protect, develop and enhance the historic, cultural, recreational and visual amenities of rural and urban stream corridors; and
- To provide opportunities for economic and human development in harmony with the natural environment

Also included within the strategy were directions for the future programs conducted at the MVCA including environmental advocacy, watershed planning, cooperative resource management, conservation awareness, protection of natural areas, plan input and review for regulations, watershed information, stewardship, remedial actions and monitoring and evaluation of the success of the programs.

### **North Grenville Water and Wastewater Servicing Master Plan (2005)**

The Municipality of North Grenville developed a Servicing Master Plan (SMP) to evaluate the water and wastewater requirements for the proposed expansion of the former Town of Kemptville, amalgamated into the Municipality of North Grenville. Several growth areas, detailed as the East and West Quadrants, have been identified as areas requiring future municipal service. In order to service these areas expansion of both the water and wastewater infrastructure in the Municipality of North Grenville is required.

As a result of this proposed expansion, five potential communal well locations were identified to provide additional supply to the water systems. In addition, a preliminary screening of existing or past land uses that may be potential contaminant sources proximate to the new well locations was identified. Preliminary scheduling has identified development of four locations into communal well supplies by 2020.

### **Old Landfill Management Strategy, Phase 1 – Identification of Sites, City of Ottawa (2004)**

Golder Associates (2004) completed the Old Landfill Management Strategy, Phase 1 – Identification of Sites for the City of Ottawa in order to evaluate the environmental considerations

associated with these properties. The study was limited to sites that were previously owned or operated by a municipality or currently owned by the (amalgamated) City of Ottawa. The main purposes of the study were to identify all old closed landfill sites, develop a database of all sites and link it to GIS.

A total of 82 landfill sites were identified during the course of the study that the City of Ottawa had previous or current association with the sites. A list of the data sources for each municipality is presented in Table 4.2-1. The locations of the old landfill sites are presented in Table 4.2-2m. A detailed list of the sources of information for the locations and potential contamination associated with the old landfills is presented in the report.

The sites were evaluated based on the source, pathways and receptors with regards to the waste deposited at the Site. Key public health and the environment parameters that were evaluated for each site included the subsurface condition, distance to buildings or private water supplies, age and size of the site, and distance to surface water.

The previous investigations of the old landfills vary significantly by site. Many of the landfills have been closed for more than 50 years and may not have any investigative activities conducted on-site. Twenty-three of the landfills have or are currently undergoing remediation or investigation. Eight (of the 23) landfills have undergone extensive investigation or remediation activities as a result of activities not necessarily associated with the former landfill. Based on these key parameters and previous investigations, data gaps and priorities for assessing them were determined for the old landfills.

In addition to the 82 old landfills associated with the City of Ottawa, 41 other landfill sites that were privately owned or operated were also identified. Details as to these private sites were provided to the City in a separate report.

#### **Ottawa Riverkeeper's River Report: Issue No. 1, Ecology and Impacts, May 2006 (2006)**

The report presents an overview of the Ottawa River watershed with respect to the physical and biological conditions. The emphasis of the report is on the ecological values of the watershed. Watershed characteristics for the Ottawa River mentioned in the report include landforms, hydrology, ecosystem classification, ecosystem diversity, and protected areas.

The report also documents several threats to the ecological health of the watershed. Specific threats discussed include dams and generating stations, municipal and industrial wastewater, non-point source pollution, urban and shoreline development and climate change. Indicators of change looked at in the report include water quality and biological diversity. The water quality of the Ottawa River was not looked at with respect to the chemistry of the river but rather indirectly through fish consumption advisories and beach closures.

#### **Preliminary Evaluation of Relative Aquifer Vulnerability – City of Ottawa (2001)**

The City of Ottawa (former Region of Ottawa-Carleton) initiated a “relative” aquifer vulnerability study during the fall of 2000, which identified potentially sensitive areas to surface contamination within the City of Ottawa boundaries. The evaluation of relative aquifer vulnerability is a process of determining which aquifers are the most likely to become contaminated if they are exposed to a contaminant source. The results of this study are summarized by Waterloo Hydrogeologic Inc. and CH2M HILL Canada Limited (2001) which build on the knowledge gained through the Eastern Ontario Water Resources Management Study (EOWRMS). The greatest emphasis in the analysis is placed on areas of denser development



(e.g. rural villages and development areas) beyond the urban boundary. This study is considered to be one of the first steps towards the development of the City's Rural Servicing/Aquifer Management Strategy and is a regional interpretation of aquifer vulnerability.

This study was completed prior to the technical guidance produced by the MOE for the recently completed municipal groundwater studies and therefore does not follow the same procedures for estimating vulnerability. Alternatively, a modified version of the DRASTIC approach, as developed by the United States Environmental Protection Agency (US EPA) (Aller et al., 1987), was used. This method uses a GIS-based approach that incorporates the following 7 different hydrogeological characteristics: Depth to water table, Recharge, Aquifer media, Soil media, Topography, Impact of vadose zone media, and Conductivity. This approach assigns values for each of the seven variables throughout the study area using a GIS grid cell resolution of 0.25 ha. Due to the large resolution of this approach, it is only intended for interpretation of areas greater than 40 ha (100 acres). Therefore, more detailed evaluations will need to be completed to develop an effective aquifer management strategy at the local scale (i.e. less than 40 ha).

The majority of the City's rural areas are considered to be of medium to high vulnerability, which indicates that groundwater resource management is an area requiring attention. The Villages that have high overall vulnerability include Greely, Osgoode and Vernon. The reason for the high rankings of both Greely and Osgoode are primarily due to the presence of sand and gravel overlying the bedrock aquifer without protection from silt and clay deposits.

Recommendations from this report include: a contaminant sources inventory, land cover analysis, baseline water quality survey, a well and septic system audit, field analyses to confirm or better characterize the parameters used in DRASTIC, and three-dimensional groundwater modeling at the local and regional scale.

This study did not include any public participation.

### **Preliminary Groundwater Study – Village of Westport (2003)**

Malroz Engineering Inc. (2003) completed a preliminary groundwater study for the Village of Westport. The purpose of this study was to better define aquifer characteristics in the Westport region with the primary objective of providing results that will assist in the future development of a WHPA study.

Due to the narrow budget (<\$5,000), this study was primarily a desktop review of MOE well records and published geological and hydrogeological reports. As such, the scope of this work was narrowed to three key objectives: (1) validation of the UTM coordinates and elevation for the 265 MOE water well records that exist within the study area, (2) development of a conceptual geologic model, and (3) assessment of water use sorted by aquifer, flow direction, hydraulic gradients, aquifer yields and recharge areas.

Of the 265 MOE water well records that exist within the study area, approximately 50% were located incorrectly (25% rectified, 25% rejected for this study). The aquifer in the study area comprises the Paleozoic bedrock units of the Nepean and March Formations. This aquifer is interpreted to be a single confined aquifer and therefore no differentiation between the two bedrock units was made.

### **Preliminary Report on Hydrogeology, Ottawa-Hull Area, Ontario and Quebec (1961)**

This report was prepared to document the potential for groundwater usage in the Ottawa-Hull area. The report was divided into two focus areas such as the use of groundwater for supply of groundwater to a single home and for more high-capacity wells for municipal supply, industry and irrigation.

### **Preliminary Wellhead Protection Area Study – Village of Westport (2004)**

A Preliminary Wellhead Protection Area (WHPA) study was conducted for the Village of Westport by Malroz Engineering Inc. (2004) and builds on the preliminary groundwater study (Malroz, 2003). The purpose of the preliminary WHPA study was twofold: (1) to identify capture zones for the Westport municipal supply wells to assist the Village in developing a protection plan, and (2) fulfill a requirement of the draft Certificate of Approval for the Village of Westport's water works. This study was completed in accordance with the MOE Technical Guidance as part of the 2001/2002 MOE municipal groundwater studies initiative.

Due to a limited budget, this study identified four key objectives: (1) development and calibration of a preliminary numerical model, (2) incorporate data from two new nested monitoring wells to better delineate lithology and hydrogeological conditions, (3) delineation of capture zones (WHPAs) for the two existing municipal wells, and (4) assessment of potential contaminant sources within the WHPAs. Four tasks that are typically included in a WHPA study, but were omitted from this study (due to minimal funding) include aquifer vulnerability assessment, public consultation and the development of a groundwater protection and management plan.

The Village of Westport operates two drilled municipal supply wells that obtain groundwater from the March and Nepean Formations. Reverse TOT capture zones for the supply wells were defined based on 50 day, 2 year, 10 year and 25 year saturated zone travel times to these wells. A sensitivity analyses was completed using hydraulic conductivity of the bedrock units and the amount of infiltration. The contaminant source inventory identified six businesses within the WHPA of the municipal wells.

### **Private Individual Services in the Rural Area (1992)**

The report was conducted to determine development on private, individual services in the rural portions of the Regional Municipality of Ottawa-Carleton. The report documents the aquifers encountered in the region, water quality, water quantity, well construction, septic system requirements, cumulative impacts, and planning implications.

It was documented that several bedrock aquifers, a basal gravel aquifer and overburden aquifers were present within the study area. Throughout the majority of the area, these aquifers provide adequate quantity and quality of water for residential demand. Areas of non-potable water were encountered more commonly in the bedrock aquifers in the eastern portion of the region and selected reaches along the Ottawa River, where saline water was encountered. Local septic system contaminant problems were found and generally where the overburden is thin or where the same geologic unit is used as a source of water and also for disposal of septic system effluent. No widespread anthropogenic contamination of the aquifers was documented.

Private individual sewage disposal and specifically septic system design was discussed in regards to the various soil conditions encountered on site. It should be noted that conventional septic systems do not denitrify nitrates and as such the only reduction in nitrate concentrations are as a result of dilution. This mechanism results in large lots that need to be situated correctly to the

groundwater flow direction. Wide lots are required for impermeable soils as a result of effluent mounding and deeper lots to accommodate nitrate plumes in permeable soils.

With regards to the cumulative impacts and planning implications it was recommended that development be approached in a phased method. This would ensure that the next phase of development will not proceed unless no adverse effects have occurred. Significantly larger lot sizes were recommended for future development. The lot sizes in the report virtually eliminate the concept of concentrated (0.2 ha lots) hamlet development on private individual services. It was recommended that a term of reference for future hydrogeologic investigations in support of development on private services be developed. A detailed list of recommendations is provided in Table A-1.

### **Proposed Mississippi-Rideau Source Protection Region, Conceptual Understanding of the Water Budget, Draft Accepted (2007)**

The *Clean Water Act* was introduced for the purposes of protecting municipal drinking water supplies in Ontario. In order to protect these drinking water supplies, a science-based, locally developed source protection plan is to be developed. The science-based background work for the plan will be comprised of the technical assessment report. The Water Budget is one component of the technical assessment report related to water use and water quantity within the Mississippi-Rideau Source Protection Region (M-R SPR). The Conceptual Water Budget is the first phase of the Water Budget work and was prepared in accordance with the Guidance Module 7 - Draft Water Budget and Water Quantity Risk Assessment Technical Direction, Version 5.0 (Province of Ontario, 2006). The purpose of the Conceptual Water Budget is to describe how water moves throughout the hydrologic cycle within the M-R SPR. The second phase of the Water Budget work is to complete a Tier 1 Water Budget that will quantify the movement and storage of water on a watershed / subwatershed basis. All drinking water source protection regions will be required to complete both the Conceptual and Tier 1 Water Budgets.

The hydrologic cycle begins with water evaporating from surface water into the atmosphere. As the moist air rises, the water vapour condenses and becomes precipitation (either rain or snow). Precipitation falls to the ground and either runs off directly to surface water bodies or infiltrates into the soil. The water that infiltrates into the soil travels in three general manners such as: uptake by vegetation (transpiration), subsurface flow that discharges back to surface water or recharge to the water table (groundwater recharge). A water budget is the amount of water in each of the components of the hydrologic cycle.

The premise of the Conceptual Water Budget is for the water budgeting to be completed on an average, annual basis for the entire watershed / region. The report summarizes the climate, land cover, geology, groundwater characterization, surface water systems and major water users of the M-R SPR. Average, annual estimates of water budget components and baseflow / groundwater recharge were then calculated for the region. A preliminary review of the regional water demand and stresses on water supplies was also completed for an average, annual basis. Recommendations are presented in Table A-1.

### **Regional Geoscience Information: Ottawa-Hull (1980)**

This study was initiated in 1970 to provide background data on the geological conditions of the Ottawa-Hull area for the purposes as reference material for regional planning (urban or environmental geology). The study documents the bedrock geology, both Precambrian and Paleozoic, and surficial geology encountered in the Ottawa-Hull area.

### **Renfrew County – Mississippi - Rideau Groundwater Study (2003)**

The Renfrew County – Mississippi – Rideau Groundwater Study (Renfrew Study) was completed in 2003 (Golder Associates Ltd. et. al., 2003) as part of the provincial groundwater study initiatives led by the Ontario Ministry of the Environment (MOE). The Renfrew Study included all of the lands within the M-R SPR as well as Renfrew County, which is outside of the watershed region.

The goals of the Renfrew Study included to:

- Develop a database and geographic information system (GIS) for maintaining the groundwater resources;
- Undertake a regional water balance;
- Map the location of significant groundwater aquifers, groundwater flow system, and groundwater quality;
- Assess the surface water quality;
- Inventory major groundwater users;
- Map areas where the aquifers are susceptible to contamination;
- Identify known and potential contaminant sources; and
- Inventory existing groundwater policies and management strategies.

The Renfrew Study developed a groundwater management strategy (GMS) which includes specific GMS that were identified and grouped by the following land uses and activities:

- General Planning Policy
- Small Scale Development, consisting of individually serviced properties
- Larger Scale Development, consisting of new multi-lot/multi-unit developments
- Commercial and Industrial Land Use
- Agricultural Land Use
- Areas on Private Services that are Adjacent to Serviced Municipalities
- Road Salt Practices
- Ecological and Habitat Sensitive Areas
- Groundwater Monitoring Network
- Data Management and GIS Management
- Community Awareness and Education

A detailed list of the recommendations from the Renfrew Study is presented in Table A-1.

### **Report on the Well Discovery Pilot Project, Village of Merrickville-Wolford, Eastern Ontario (2002)**

This project was initiated as a pilot project by the Ontario Ministry of the Environment (MOE) as part of the MOE's review of the well program and the water wells regulation. The project was to improve the management of all wells across the province. Part of the improvement with regards to private well management is for the stakeholder to know that there is a well on the property and the location of the well.

The pilot project involved contacting the individual homeowners within Merrickville-Wolford and having them allow access to the location of the private well on the property. Upon confirmation of the location of the well, an updated coordinate for the well was obtained from a handheld Global Positioning System (GPS) unit. This allows for the well to be located to within a few meters which was an upgrade over the previous location which was typically by lot and concession.

The project involved visiting 264 properties in Merrickville-Wolford over the summer of 2002. From these properties visited there was a very high level of public cooperation which resulted in the location of 202 wells. From the 202 wells located 182 wells were able to be geo-referenced by GPS. Of the wells located, only 49 of the 202 (approximately 24%) wells could be matched with a well record.

#### **Revised Carp Capture Zones, Technical Memorandum (2004)**

The technical memorandum was completed to present the result of additional groundwater modeling for the Carp communal wells. The revised WHPA capture zones were delineated based on greater pumping rates (1,150 m<sup>3</sup>/day and 2,000 m<sup>3</sup>/day) than in the initial Wellhead Protection Study (467 m<sup>3</sup>/day) completed for the communal wells in 2003. These revised capture zones were completed in accordance with the 2001/2002 MOE Technical Guidance.

Reverse TOT capture zones for the supply wells were defined based on 50 day, 2 year, 10 year and 25 year saturated zone travel times to these wells. For the 1,150 m<sup>3</sup>/day pumping rate the capture zones were found to increase in size with the most noticeable increases found to the Northwest and South of the communal wells. For the 2,000 m<sup>3</sup>/day pumping rate the capture zones were also found to further increase in size with the greatest increases in the same areas (Northwest and South of the communal wells). The aerial extent of the 2,000 m<sup>3</sup>/day pumping rate 25 year capture zone is approximately 5.6 km<sup>2</sup>.

The contaminant source inventory identified eleven potential contaminant sources that are located within, or in close proximity to the WHPAs for the Carp municipal supply wells. The high risk associated with these sites is related to the high aquifer vulnerability and the high rate of infiltration where the aquifer is not protected by a low permeability layer. Five of these potential contaminant sources are located within the WHPA (2 to 10 year).

#### **Rideau Canal Management Plan (1995)**

The Rideau Canal Management Plan was completed to develop the guiding principles for the on-going operation of the Rideau Canal (Parks Canada, 1995). As detailed in the Rideau Canal Management Plan, the following items represent the vision for the operation of the Rideau Canal:

- The Rideau Canal is managed in a manner that fully recognizes its status as a nationally significant 19<sup>th</sup> century engineering achievement contributing towards the preservation and presentation of Canadian and global heritage.
- The Canal's operating tradition as a functional navigable historic waterway is maintained.
- The Rideau Canal Corridor is internationally recognized as a model of sustainable use, offering a balance of protection, recreation and development.
- The Rideau Canal Corridor is managed as an ecosystem resulting in a clean, useable system.
- The diversity of the Canal Corridor's cultural landscapes are protected and enhanced through wise land use and development decisions.
- Decisions on land use and protection are based on sound co-operative research and information to ensure development along the Canal Corridor takes place in a manner which respects the heritage values and ecological health of the Canal Corridor.
- The Rideau Canal is regarded as a valuable tourism and recreation resource contributing substantially to the economy of Eastern Ontario.
- The Rideau Canal is recognized and promoted as a component of the national and international cultural tourism industry.

- A variety of recreational activities – from boating to fishing to hiking and picnicking – are enjoyed by residents and visitors. The Canal Corridor partners work together to provide quality services on Canal lands and throughout the Canal Corridor to accommodate compatible recreational opportunities in a safe environment.
- People of all ages experience the Canal’s unique learning opportunities through viewing and participating in activities along this 19<sup>th</sup> century operating Canal.
- Canal staff is proud of their stewardship role and display leadership through their actions.
- Residents and visitors are proud of the Rideau Canal Corridor – proud of the strong heritage flavour found within communities, at Canal lock stations and throughout the Canal Corridor, proud of its national importance and proud of their own accomplishments in ensuring a healthy environment is passed on to their children.

### **Rideau Canal Water Management Study (1994)**

The Rideau Canal Water Management Study was conducted to evaluate the water management options for the operation of the Rideau Canal (Acres International Ltd., 1994) which includes both the Cataragui River and the Rideau River basins. The study looked at the existing canal operation, water management issues, navigation and reservoir lakes evaluation, river reach operating policies, coordination of hydroelectric operation, and recommendations for future operations.

Specific recommendations were also made to select the operating policy for the Rideau Canal. These recommendations were grouped according to hydrometric data collection, control structure improvements, river reach operations, flow forecasting, and canal system operations. A detailed list of the recommendations from the Rideau Canal Water Management Study is presented in Table A-1.

### **Rideau Lakes Basin: Carrying Capacities and Proposed Shoreland Development Policies (1992)**

This report was undertaken to evaluate the capacity of the Rideau Lakes Basin which includes the Rideau Lakes and Tay River subwatersheds to support development with respect to the following parameters: lake trophic state, shoreline development, sport fishing and boating. Trophic state was evaluated for 59 lakes within the Rideau Lakes subwatershed. Shoreline development, sport fishing and boating were evaluated on a smaller subset of 11 lakes consisting of Upper Rideau, Big Rideau, Lower Rideau, Adams, Bass, Black, Burridge, Long (North Burgess), Westport Sand and Wolfe Lakes and Mill Pond.

Throughout the Rideau Lakes Basin the lake trophic state based the water quality and specifically on phosphorus levels was determined to be the prime limiting factor which would dictate more stringent conditions for shoreline development. Shoreland development capability does not significantly limit development. Limitations with regards to the detached shoreline lots are based on the fact that the majority of the lots are already subdivided and / or developed. More intensive shoreline redevelopment or back lots creation would not limit development as it could be physically accommodated but would not be socially or aesthetically acceptable to the existing community. Available information does not demonstrate whether or not sport fisheries are being overexploited, however problems regarding specific species on specific lakes were documented. Over-fishing would be best dealt with by regulating angling and not constraints on development. Boating was also not found to be a significant constraint to development; however local congestion problems were documented.

Recommendations were made to establish a water quality objective for each lake expressed as a maximum chlorophyll a concentration. The objective was determined to be whichever concentration was less: either the chlorophyll a concentration that was predicted concentration from the study model or 9.0 µg/L. On lakes which have reached or exceeded their objectives, or whose downstream lakes have reached or exceeded their objectives, development applications must demonstrate that phosphorus loads would not exceed background loads previously existing. Other recommendations were also made with respect to septic upgrades / re-inspections, shoreline re-naturalization, restricted use of fertilizers and phosphorus-rich substances near water, increased phosphorus removal from municipal sewage treatment plants, prohibiting disposal of grey-water from boats, and reducing agricultural contributions of phosphorus to lakes.

### **Rideau River Shoreline Classification Survey – Kars Bridge to Mooney’s Bay, Summer 2002 (2002)**

The study was conducted from the river by boat and involved mapping and classifying all man-made and natural features of the riparian areas (shoreline) of the Rideau River between the Kars Bridge and Mooney’s Bay. In addition, areas of shoreline modifications and erosion or degradation in need of rehabilitation were documented. The scope of the survey was from the shoreline up to the front of the house and the shorelines were classified as ornamental, degraded, natural, or regenerative. Each property was referenced to the associated flood map. Information collected was stored in a geographical information system (GIS) database. Of the 65 km of shoreline surveyed, the following percentages of shoreline were documented: 19% natural, 12% regenerative, 8% degraded and 61% ornamental.

### **Rideau River – State of the River Report (2001)**

The Rideau River – State of the River Report was completed in 2001 (Rideau River Roundtable, 2001) with a particular focus of the study was on the river between Smiths Falls and Ottawa. The report documents on the physical and biological conditions of the Rideau River with respect to water quality, biodiversity and aquatic habitat.

The Rideau River – State of the River Report (2001) contained an evaluation of surface water with respect to water quality for aquatic habitat and recreational contact. Information for the evaluation of the surface water quality within the Rideau River was obtained from the MOE, RVCA, City of Ottawa (formerly RMOC), the Canadian Museum of Nature, health units and University of Ottawa. Indicator parameters selected included total phosphorus, nitrate/nitrite nitrogen, dissolved oxygen, chlorophyll a, metals and *E. Coli*.

The results of the surface water quality in the Rideau River with respect to total phosphorus indicate a gradual decrease in concentrations since the 1960. However TP concentrations in the lower Rideau still exceed the PWQO. The concentrations of nitrate/nitrate generally remain low upstream of Kars, with increased concentrations downstream of this point. Concentrations of nitrate/nitrate are still well below the CCME and ODWS criteria. DO concentrations remain above 4 mg/L during the day. Lower concentrations of DO were observed at Mooney’s Bay. Chlorophyll a concentrations are somewhat lower than reported in other lowland rivers in eastern Canada. Occasional exceedances of the PWQO for aluminum, cadmium, cobalt, lead and zinc were observed (< 8% of the samples). Concentrations of *E. Coli* are typically low in the Rideau River. Elevated levels of *E. Coli* are detected in Ottawa near St. Patrick St. and at the “Junior” beach in Smiths Falls.

Data gaps were identified with respect the water quality / quantity, biological, aquatic and shoreline habitat and management response indicators. Specific recommendations were also

made with regards to the Rideau River. A detailed list of the recommendations from this study is presented in Table A-1.

### **Rideau Valley Conservation Report (1968)**

The Rideau Valley Conservation Report (RVCA Conservation Report) was completed in 1968 (Ontario Department of Energy and Resources Management, 1968) after the formation of the RVCA in 1966. The RVCA Conservation Report involved a detailed survey of the newly formed conservation authority. Specific areas of focus for the report included a description of the history of the region as well as the existing conditions of the RVCA as they relate to land use and forest, water, biology and recreation.

The Rideau Valley Conservation Report (1968) included an evaluation of surface water quality. The water quality of the Rideau River was generally considered to be good in the headwaters above Perth and Smith's Falls. Water samples were collected in the summer survey. Additional sampling has historically been conducted by the Ontario Water Resources Commission at six locations – Rideau River at Sussex Drive in Ottawa, east of Smith's Falls, Old Slys Locks, Narrows Locks; Tay River in Perth and Kemptville Creek at Highway 43. Locations of high concentrations of coliforms, BOD, total kjeldahl nitrogen and phenol were observed in the Rideau River east of Smiths Falls. Low dissolved oxygen concentrations were also observed in Kemptville Creek. Locations of scattered individual sources of pollution were identified throughout the watershed, without specific water quality analysis.

Specific recommendations were also made to ensure the conservation of the RVCA. These recommendations were grouped according to land use, water, biology, and recreation. A detailed list of the recommendations from the RVCA Conservation Report is presented in Table A-1.

### **Rideau Valley Watershed Strategy (1992)**

In 1992, the plan for the operation of the RVCA was updated within the Rideau Valley Watershed Strategy (RVCA, 1992). The Rideau Valley Watershed Strategy included the vision for a healthy river involving a mission of a coordinated approach to watershed planning, resource management activities and conservation awareness. Several guiding principles were incorporated within this Watershed Strategy including the following items:

- Ecosystem approach – consequences of an action on all other parts of the ecosystem, including the cumulative effects of numerous small actions will be monitored and evaluated before the action is undertaken;
- Critical importance of the “Ribbon of Life” – consisting of the following areas: shore land (flood plain or riparian zone); shoreline (normally the high water mark); and littoral zone (shallow water area where sunlight reaches to the bottom – area where rooted aquatic plants grow); and
- Sustainable development – seeking the balance between the rights of the individual vs. the rights of the public to ensure an unimpaired future environment for generations to come.

Also included within the strategy were directions for the future programs conducted at the RVCA including watershed planning, regulations and plan review, protection of natural areas, community stewardship, capital projects, conservation awareness, and monitoring and evaluation of the success of the programs. In keeping with the guiding principles the keys to success for the Watershed Strategy were identified to be the ecosystem approach, cooperation among agencies, and public trust and support.



### **Rural Wastewater Management Study – City of Ottawa (2004)**

A rural wastewater management study (septic systems) was completed for the City of Ottawa by R.J. Burnside and Associates Ltd. (2004). The purpose of this study is to provide the City of Ottawa with a guide to address technical issues associated with septic systems and the management tools to plan for future development in Ottawa's rural sector while ensuring that on-site sewage systems are a permanent and sustainable solution to rural wastewater servicing.

The majority of information used in this study was collected during 2002. An estimated 30,000 on-site septic systems exist within the rural areas of the City of Ottawa with approximately 600 new systems installed each year. Currently the rural septic systems are managed by the Ottawa Septic System Office as part of joint program between MVCA, RVCA and SNC. It is estimated that approximately half of the septic systems are greater than 25 years old, and therefore are nearing the end of the design life. In addition, it is estimated that approximately half of the lots in the villages are less than 0.2 ha (0.5 acres), which suggests that there is a potential for groundwater contamination. A key product of this study is a template for "Lot Sizing Reference Guidelines" to help address these issues.

This study compiles a comprehensive overview of the design and effectiveness of on-site wastewater treatment alternatives (common and innovative approaches) and provides a list of wastewater treatment system suppliers and associated technical information. Approximately 20% of all new on-site wastewater treatment systems in the Ottawa area use alternative technologies, including: aerobic systems, biofilters, nutrient removal, and various methods of dispersion. In addition an overview of past and present on-site wastewater system regulatory, planning, construction and operation practices within the City of Ottawa and other jurisdictions is presented.

A risk model was developed for the purpose of establishing management priorities of both existing and future systems. Risks from current systems are to be managed through processes such as septic tank re-inspections, while risks from future systems are to be managed through processes such as lot size restrictions. The risk model incorporated various data pertaining to contaminant loading (population density, lot size, age of system), contaminant pathways (soil type, depth to groundwater, aquifer hydraulic conductivity, floodplain mapping), and receptors (drinking water sources, surface water bodies). The results of this risk model indicated that the following six rural areas should be prioritized for management of on-site septic systems: Constance Bay, Fitzroy Harbour, Osgoode, Ashton, Kars, and Greely. Likewise the prioritization of future development areas includes: Ashton, Fitzroy Harbour, Dunrobin, Constance Bay, Navan and Greely. Primary contributing factors for these problems include: small lot sizes, aged septic system, filter media beds, shallow sand points or dug wells and high water table conditions.

A four year management plan was presented which included: developing bylaws for lot sizing restrictions, public education programs, septic tank re-inspection programs, septic tank pump-out programs, septage management and enforcement for faulty on-site sewage systems under the Building Code Act.

### **Sawmill Creek Subwatershed Study Update (2003)**

Sawmill Creek is a tributary of the Rideau River, located within the urban boundary of the City of Ottawa. The Sawmill Creek Watershed Study (Gore & Storrie Ltd., 1994) consisted of three strategies including water management, valley lands management and implementation. The Sawmill Creek Subwatershed Study was updated (CH2M Hill Canada Ltd., 2003) in order to

reflect changes to development within the watershed, and changes to the focus of water quality and watershed protection within the City of Ottawa.

The Sawmill Creek Subwatershed Study Update documents the terrestrial resources, aquatic resources, hydrology and hydrogeology, fluvial geomorphology, and water quality of Sawmill Creek.

Previous water quality from the Sawmill Creek Subwatershed Study (1994) indicated that elevated bacterial concentrations were observed during wet weather events. In addition, increasing TP and TSS were observed downstream. Information for the surface water quality evaluation of the Sawmill Creek subwatershed was collected from the City of Ottawa Baseline Surface Water Quality Monitoring Program (formerly the Regional Municipality of Ottawa-Carleton sampling program) from 1994 to 2001.

Indicator parameters of the surface water quality for the Sawmill Creek subwatershed included bacteria (*E. Coli*), TP and TSS. Elevated concentrations of total suspended solids were observed at the outfall of Sawmill Creek. TP and *E. Coli* concentrations generally exceed the PWQOs. Water quality is generally more degraded further downstream in Sawmill Creek. These water quality conditions were consistent with the findings of the 1992 water quality results.

Specific recommendations were also made with regards to the water and valley lands management of Sawmill Creek. A detailed list of the recommendations from these studies is presented in Table A-1.

#### **Sawmill Creek Watershed Study, Interim Report: Data Collection (1992)**

This report documents the background data collected for the Sawmill Creek Watershed Study. Information collected on the watershed included streamflow monitoring, hydrology, hydrogeology, water and sediment quality, and survey and inventory of terrestrial vegetation, aquatic and wildlife habitat.

#### **Sawmill Creek Watershed Study, Study Report (1994)**

Sawmill Creek is a tributary of the Rideau River, located within the urban boundary of the City of Ottawa. The Sawmill Creek Watershed Study (Gore & Storrie Ltd., 1994) consisted of three strategies including water management, valley lands management and implementation. The Sawmill Creek Watershed Study documents the streamflow monitoring, hydrology, hydrogeology, water and sediment quality, and survey and inventory of terrestrial vegetation, aquatic and wildlife habitat of Sawmill Creek.

Specific recommendations were also made with regards to the water and valley lands management of Sawmill Creek. A detailed list of the recommendations from these studies is presented in Table A-1.

#### **Shirley's Brook / Watts Creek Subwatershed Study (1999)**

Shirley's Brook and Watts Creek are two subwatersheds of the Ottawa River, located in the northeast portion of the MVCA watershed, within the amalgamated City of Ottawa (former Cities of Kanata and Nepean, and Region of Ottawa-Carleton). The Shirley's Brook and Watts Creek Subwatershed Study (Dillon Consulting Ltd., 1999) consists of three documents, a Summary Document, Final Report and Appendices.

The Subwatershed Study documents the land use, aquatic biology, terrestrial biology, geology, hydrogeology, surface water quality, and surface water hydrology of both Shirley's Brook and Watts Creek. The Shirley's Brook and Watts Creek Subwatershed Study (1999) involved an evaluation of surface water quality. TP, *E. Coli* and fecal coliform concentrations were consistently detected at concentrations in excess of the PWQOs. Elevated levels of sodium, iron, aluminum, cobalt, manganese, zinc and chloride were also documented throughout the subwatersheds. The results of the surface water analysis indicated that Shirley's Brook and Watts Creek have similar water quality characteristics and both have been impacted by human activities.

Key issues of the study included flooding and erosion problems, a lack of a comprehensive storm water management strategy, degraded fish and aquatic habitat, loss of terrestrial habitat and linkages, and groundwater supply and quality constraints. Goals, objectives and methods for the rehabilitation, protection, and enhancement of the natural features and functions of Shirley's Brook and Watts Creek subwatershed were also defined during the study.

Specific recommendations were also made with regards to Shirley's Brook and Watts Creek. The recommendations from the Subwatershed Study were grouped according to the public sector, community and corporate involvement, and developers as they relate to management of natural areas, floods, erosion, groundwater quantity and quality, agriculture and rural lands, urban storm water. A detailed list of the recommendations from these studies is presented in Table A-1.

#### **Shoreline Classification Project, 2003 Report (2004)**

The study was a continuation of the previous 2002 shoreline classification survey conducted on the Rideau River. The 2003 study involved the classification of the riparian areas with respect to man-made and natural features on the Rideau River from Merrickville to Kars. In addition, several additional shoreline attributes were documented including aquatic vegetation, land use, shoreline modifications and areas of erosion or degradation in need of rehabilitation were documented. The scope of the survey was from the shoreline up to the front of the house and the shorelines were classified as ornamental, degraded, natural, or regenerative. Each property was referenced to the associated flood map. Information collected was stored in a geographical information system (GIS) database. Of the 120 km of shoreline surveyed contained within 948 properties, the following percentages of shoreline were documented: 21% natural, 41% regenerative, <1% degraded and 38% ornamental.

#### **Shoreline Classification Project, 2004 Report (2005)**

The study was a continuation of the previous 2002 and 2003 shoreline classification survey conducted on the Rideau River. The 2004 study involved the classification of the riparian areas with respect to man-made and natural features on the Rideau River from Smiths Falls to Merrickville and Kemptville Creek from Kemptville to its confluence with the Rideau River. In addition, several additional shoreline attributes were documented including aquatic vegetation, land use, shoreline modifications and areas of erosion or degradation in need of rehabilitation were documented. The scope of the survey was from the shoreline up to the front of the house and the shorelines were classified as ornamental, degraded, natural, or regenerative. Each property was referenced to the associated flood map. Information collected was stored in a geographical information system (GIS) database. Of the 99 km of shoreline surveyed contained within 408 properties, the following percentages of shoreline were documented: 61% natural, 11% regenerative, <1% degraded and 27% ornamental.

## **Soils and Hydrogeologic Investigation of PCE and Petroleum Contamination, Village of Manotick, Final Report (1994)**

In December 1991, the Ministry of the Environment and Energy (MOEE) collected water samples from private drinking water wells in the core of the Village of Manotick. The sampling was conducted in response to complaints of water quality deterioration. Subsequent sampling of private wells in Manotick revealed that 42 to 65 wells were impacted with benzene and /or perchloroethene (PCE) in excess of the drinking water standards. As a result of the contamination, the Regional Municipality of Ottawa-Carleton extended the municipal water to the core of the Village of Manotick in the summer of 1993. Any residential homes that were connected to municipal water were required to decommission their existing private drinking water wells.

This study was conducted to determine the extent of soil and groundwater impacts associated with the observed benzene and PCE contamination to the private wells in Manotick. Both the Upper Oxford aquifer (5 to 18 m deep) and the Lower March / Nepean aquifer (33 to at least 40 m deep) were found to be contaminated by chlorinated solvents and petroleum.

The main PCE plume in both aquifers (Upper and Lower) are approximately 300 m by 200 m. An additional smaller PCE plume was also identified in both aquifers. The commercial dry cleaning operation in Manotick was in operation from the mid 1970's until approximately 1985. An underground concrete holding tank that was used to store liquid wastes from the dry cleaning operations. Upon removal of the tank in 1985, it was noted that the tank was in poor condition with evidence of leakage. It was also suspected that disposal of PCE waste to the building floor drains occurred. Contamination of drinking water wells in the area is known to have existed since 1984 as one well in the vicinity of the site was abandoned and re-drilled to a greater depth to find potable water. Soil impacts associated with the former dry cleaning operations were also defined as part of the study.

The sources of benzene were associated with several former and current fuel service stations within the core of Manotick. Two benzene plumes, which are smaller than the PCE plume, were identified in the Upper Oxford aquifer. One benzene plume was also found to be within the Lower March / Nepean aquifer. Soil impacts associated with the fuel service stations were also identified.

Numerical modeling was also conducted to determine the steady state conditions of the PCE plume. Groundwater from the Upper aquifer is known to discharge to the Rideau River and is also likely to discharge to the Rideau River from the Lower aquifer. The surface water within the Rideau River was tested and PCE was not detected in the water. There is uncertainty with the connection between the Lower aquifer and the Rideau River and as such the plume may migrate to the private wells on Long Island. It was also determined that a current heat pump extraction well located near the plume is having an effect on the migration of the plume.

Risk based pathways associated with exposure to indoor air quality from PCE contaminated soils and groundwater was also conducted. The results of the pathways assessment indicated that for the purposes of the protection of human health that the PCE impacted soil or groundwater does not require active remediation. Recommendations for further monitoring well installations, groundwater monitoring and future studies were made.

### **Supplemental Bedrock Hydrogeologic Investigation of PCE Contamination, Village of Manotick, Final Report (1996)**

This study was conducted as a follow up to the 1994 investigation regarding the perchloroethene (PCE) contamination in the Village of Manotick. The focus of the study was to increase the certainty with regards to the potential fate of the PCE within the Lower Aquifer (March and Nepean Formations). Additional monitoring wells were constructed as part of this study, groundwater monitoring and sampling and updated modeling were completed.

The study indicated that the PCE plume in the Upper aquifer had been reduced in size as compared to the 1994 study, however the source area had remained relatively stable. The plume within the Lower aquifer decreased in width but increased in size indicating migration of the plume. The concentrations in the Lower aquifer decreased significantly from the previous investigation indicating that the PCE may have been introduced to the Lower aquifer via the former open water wells near the source area that were decommissioned after the provision of municipal services. The front of the PCE plume has migrated to below the Rideau River. PCE was not detected in either the Lower or Upper aquifers on Long Island. Based on the movement of the plume, the potential exists for the plume to migrate to private wells on Long Island. Recommendations were made to continue monitoring the status of the groundwater plume.

### **Tay River Watershed Management Plan (2002)**

The Tay River is a major tributary of the Rideau River and is part of the headwaters of the Rideau basin. The Tay River is located in the southwestern portion of the RVCA watershed. An Existing Conditions and Trends in the Tay River Watershed report (RVCA et. al., 2000) was completed to document the background conditions of the tributary watershed. The Existing Conditions report documents the Tay River with regards to the people and land use, water quantity, groundwater, water quality, and wetlands and watershed ecology.

The Tay River Watershed Management Plan (2002) included an evaluation of surface water quality. Localized impairment of water quality has been observed in and around the Town of Perth. Otherwise, the overall water quality has been characterized as good. Metals and suspended solid concentrations were not identified in the watershed. High bacteria levels were found within the Town of Perth. High phosphorus concentrations were found within Grants Creek (a tributary to the Tay River). More consistent water quality monitoring for bacteria and nutrients in the upstream lakes, tributaries and Tay River were identified as a concern. More information is required to characterize the groundwater regime within the Tay River watershed.

The Tay River Watershed Management Plan (RVCA, 2002) and builds on the background information assembled during the Existing Conditions Report. The purpose of the plan is to guide and help coordinate watershed management activities in the Tay River watershed over the next two decades. The plan is a high level planning document that identifies watershed issues, advises on broad environmental policy and direction, and identifies an implementation framework and priorities for action.

Specific recommendations were also made with regards to the Tay River. The recommendations from the Existing Conditions report were grouped according to each of the component reports: people and land use, water quantity, groundwater, water quality, and wetlands and watershed ecology. The Watershed Management Plan recommendations were presented as a watershed action list. A detailed list of the recommendations from these studies is presented in Table A-1.

### **Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada (2001)**

The National Water Research Institute identified 15 water quality related threats to sources of drinking water and aquatic ecosystem health. These threats were defined as follows: acidification, algal toxins, endocrine disrupting substances (EDS), genetically modified organisms (GMOs), impacts of agricultural and forestry practices, industrial wastewater discharge, long-range atmospherically transported pollutants and persistent organic pollutants, municipal wastewater effluents, naturally occurring contaminants, nutrients, pathogens, pesticides, solid waste management practices, urban runoff, and water quantity changes affecting water quality due to climate change, diversions and extreme events. Some of the threats are groupings of similar contaminants (i.e. pesticides) and others are mixtures of contaminants (i.e. municipal wastewater effluents). As a result, several of the threats identified above are inter-related.

### **Town of Kemptville – Municipal Well Head Protection Study (2000)**

A Municipal Well Head Protection Study was completed for the Town of Kemptville in 2000 by Oliver, Mangione, McCalla & Associates (OMMA, 2000). This study was completed prior to the development of MOE Technical Terms of Reference as part of the MOE municipal groundwater studies initiative, therefore the methodologies used are different compared to more recent WHPA studies completed for other municipalities. Two objectives were identified for this study and include: (1) delineation of well head protection areas, and (2) inventory of potential contaminant sources.

The Town of Kemptville currently operates three municipal wells that currently service approximately 3,270 people. In addition, two backup wells and a test well exist that currently act as monitoring wells and could be used for municipal supply in the future. Local domestic wells are typically drilled to depths less than 40 meters and completed in the Oxford Formation dolostone. The municipal wells are drilled deeper and obtain water from the March Formation sandy-dolostone and the Nepean Formation sandstone.

OMMA reviewed pumping test data for the Oxford, March and Nepean Formation aquifers and concluded that all three aquifers could be simulated in a 2D numerical model as a single hydrogeological unit. Reverse time-of-travel capture zones (5 year and 10 year) were delineated for the three active municipal wells using the 2D numerical groundwater flow model, Flowpath II and applying the maximum permitted PTTW value for each municipal well. The resulting 10-year WHPA encompasses nearly the entire urban area within the Town of Kemptville.

A review of historical information to determine past and present land usage within the study area identified approximately 46 historical or current potential contaminant sources within the WHPAs for the Kemptville municipal wells. OMMA did not verify the locations or existence of these potential contaminant sources and notes that due to the redevelopment of many of these sites, it is likely that some of the contaminants that may have been present have already been removed.

### **Township of North Grenville, Groundwater Management Study (2001)**

Previous investigations by the Ontario Ministry of the Environment and private consultants from 1984 to 1998 have identified nitrated contamination in the groundwater west of Kemptville in the Municipality of North Grenville. The 1998 investigation by Oliver, Mangione, McCalla & Associates (OMM) which involved an assessment of available information concluded that nitrate concentrations in private wells have consistently exceeded the health related drinking water criterion of 10 mg/L and that the vertical and horizontal extents of the contamination had not been

defined. A potential source of contamination for the Oxford Heights subdivision was identified as the former Valley Sanitation septage disposal location. As a result of the previously identified groundwater nitrate contamination, this groundwater management study was undertaken in 2000 and 2001.

The first phase of the project involved collection of existing information and sampling of existing groundwater wells for bacteriological and nitrate. The second phase of the project involved a detailed hydrogeologic investigation to identify the current magnitude and extent of the bacteriological and nitrate contamination in the area. For the investigation area, there were two aquifers identified at the site, which consist of a shallow sand and gravel aquifer and a deeper limestone bedrock aquifer.

The most significant water quality problem occurs in the Cranberry Hill subdivision in which 83% of homes had unacceptable bacteriological water quality and 10-20 % exceeded the nitrate criterion of 10 mg/L. In addition, 40-50 % of the homes had nitrate concentrations that were greater than 7 mg/L. These nitrate and bacteriological impacts have been detected in the groundwater since 1985 and the likely source of the impacts was implied to be private septic systems and not the Valley Sanitation site. Recommendations were made to provide an alternate water source for the residents of the Cranberry Hill Subdivision. A public consultation process to decide the appropriate course of action was also recommended.

County Road 18 in the vicinity of Sommerville Road also has impacted groundwater quality with respect to bacteriological water quality with 47% of the homes exceeding the drinking water standards for bacteria. None of the wells exceeded the nitrate criteria, however 16 % were found to be greater than 7 mg/L. Potential sources of contamination were indicated to be self contamination from private septic systems (bacteria and nitrates) or potential up-gradient sources (Valley Sanitation or Cranberry Hill subdivision likely only for nitrates due to the distance).

Highway 43, Johnston and Muldoon Roads indicated generally good water quality with only 15% of the wells exceeding the bacteriological water quality standards. Nine percent of the wells had nitrate in excess of the 10 mg/L criterion.

Phase I of the Oxford Heights subdivision indicated that 100% of the wells met the drinking water criteria for nitrate and bacteriological parameters. Only 2 of the tested wells were found to have nitrate concentrations greater than 7 mg/L. The higher standards of well construction for the Oxford Heights subdivision are considered to be directly reflected in the better water quality. The proposed Phase II of the Oxford Heights subdivision is to be located between the existing Phase I development and the up-gradient source of groundwater contamination from the Valley Sanitation site. As such, it was recommended that the proposed Phase II development of the Oxford Heights subdivision not be supported at this time.

It was recommended that all new wells in the area should be constructed by the protocol outlined by Gorrell Resource Investigations in 1994. This protocol involved the installation of a minimum of 80 feet of casing to bypass and isolate the shallow sand and gravel aquifer from the deeper limestone bedrock aquifer encountered at the site. The results of this study indicate the effectiveness of this well construction method as indicated by the water quality in Phase I of the Oxford Heights subdivision.

### **United Counties of Leeds & Grenville – Groundwater Management Study (2001)**

A regional groundwater management study, conducted by Dillon Consulting Limited (2001), was completed for The United Counties of Leeds & Grenville. The purpose of this study was to assess the existing groundwater conditions and to recommend management and protection practices to maintain the quantity and quality of the groundwater resource. The total study area is approximately 3,350 km<sup>2</sup>, of which 38% (1,275 km<sup>2</sup>) overlaps with the M-R SPR in the southeastern portion of RVCA.

The primary data source for this study included the MOE water wells database (current to 1999) which included approximately 23,750 records, of which only 9,600 were geo-referenced. All information was compiled and interpreted in a GIS environment, resulting in 60 maps included in the report.

The study area has an estimated population of 104,000, of which 70,000 people (67%) obtain potable water from groundwater and 92% of these users are supplied from non-municipal private systems. There are two main aquifer sources: bedrock (Precambrian, Sandstone and Dolostone Formations) and overburden (surficial sand, glaciofluvial sand and gravel, and basal sand and gravel tills). 97% of the entire study area is obtains groundwater from the bedrock aquifers which are all capable of producing adequate yields for domestic use (>22 L/min). Four communities operate municipal groundwater supply systems: Kemptville, Landsdowne, Westport and Merrickville. All of these systems are within the M-R SPR except for Landsdowne.

This study was divided into four key components, including: 1) water resources assessment, 2) assessment of existing groundwater use, 3) contaminant source inventory, and 4) economic evaluation, groundwater management and protection measures.

The water resources assessment included the compilation of regional data, characterization of the regional groundwater flow system, and an aquifer vulnerability assessment using “aquifer vulnerability index” (AVI) methods. The AVI mapping indicates that over 90% of the study area may be mapped as highly vulnerable due to thin overburden sediments on top of fractured bedrock; however this regional assessment is not suited to site specific contamination risk studies.

The groundwater use assessment included compiling all data related to the existing groundwater extractions (Permit to Take Water (PTTW), domestic uses, etc.), determining the long term sustainability of the groundwater resources, and the delineation of preliminary well head protection areas (WHPAs) for the communities of Westport and Landsdowne using analytical and MODFLOW numerical modeling methods. Time-of-travel (TOT) within saturated zone capture zones (2-yr, 5-yr and 10-yr) were delineated using reverse particle tracking methods, however, many assumptions were incorporated into these models and Dillon cautions the results to only be interpreted as preliminary.

The contaminant source inventory identified 90 historical sources of groundwater contamination which primarily includes landfills, fuel storage and handling facilities, human and animal waste handling facilities spills, industrial facilities, and road de-icing and road salt handling operations.

The study also summarizes the groundwater management protection measures that are currently in place for the study area.



### **Upper Poole Creek Subwatershed Study (2000)**

Poole Creek is a tributary of the Carp River. The Upper Poole Creek Subwatershed Study (Marshall Macklin Monahan Ltd. (MMM) and Water and Earth Science Associates Ltd. (WESA), 2000) consists of the portions of Poole Creek located upstream of the Lower Poole Creek Wetland (west of Stittsville Main Street) in the amalgamated City of Ottawa (formerly Stittsville). The study area is within northeast portion of the MVCA watershed.

The Upper Poole Creek subwatershed is one of the few cold or cool-water streams within the City of Ottawa. The Subwatershed Study documents the aquatic environment, fluvial geomorphology, groundwater system, surface water, and terrestrial environment of Upper Poole Creek. Specific recommendations were also made with regards to Upper Poole Creek according to the study team recommendations as well as potential enhancement recommendations. A detailed list of the recommendations from this study is presented in Table A-1.

### **Urban Geology of Canada's National Capital Area (1998)**

This paper presents the geological initiatives in the National Capital Area (Ottawa and Gatineau) and the development of a geological database. The urban geology of the area was first compiled in the 1970s and based on stratigraphic data from borehole logs which was documented in a Geological Survey of Canada paper in 1980 by Belanger and Harrison. In the early 1990s the project was updated and this study presents the results. The study documents the bedrock geology, both Precambrian and Paleozoic, and surficial geology encountered in the National Capital Area.

### **Urban Wells Study, City of Ottawa (2007)**

The study was undertaken to determine the use of water wells within the public water service areas of the City of Ottawa. The majority of these water supply wells in the urban area are primarily found within the private service enclaves, the suburban fringe or inside the Greenbelt. The wells were assessed in four subgroups which included residential potable, residential non-potable, non-residential potable and non-residential non-potable. It was also noted the Province of Ontario retains the ultimate jurisdiction over the management of water resources which includes private wells.

It was determined urban wells for residential potable purposes are appropriate in the private service enclaves where municipal services are not available and that where appropriate these should be subject to a development agreement to connect to municipal services when they become available. It was also determined that urban wells for residential non-potable purposes and non-residential potable purposes were not appropriate. Urban wells for non-residential non-potable purposes should be reviewed on a case-by-case purpose. It was recommended that the City use the existing development approval process to intervene on matters related to urban wells.

### **Village of Constance Bay Groundwater Study (2006)**

A groundwater study for the Village of Constance Bay within the amalgamated City of Ottawa was completed during August 2005 by Dillon Consulting Limited (2006). This study was performed to determine if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services. This study evaluated the groundwater resources which included the following main tasks: groundwater quality assessment; groundwater supply quantity assessment; groundwater use assessment; and potential contaminant source assessment.

The study area is a rural village designated within the City of Ottawa which is primarily residential with some commercial land uses. The largest portion of the Village, approximately 59% of the total area, is undeveloped land, most of which is part of the Torbolton Forest (a protected natural environment area). The estimated population of the Village (based on the 2001 census) is 2,330. All current development is serviced by private individual wells and septic systems.

The Village of Constance Bay is characterized by shallow sands overlying clay and/or bedrock at depth. The average overburden thickness exceeds 40 m however in the northern portion of the peninsula bedrock is encountered at less than 5 m below ground surface. The majority of wells (98%) extract water from the shallow sand aquifer. Many of the wells are dug wells or sand points and range in depth from 5 to 15 m. Underlying the sand deposits, the limestone and dolostone aquifers (Rockcliffe and Oxford formation) are present. Due to the presence of the shallow sand aquifer, the general vulnerability of the area is classified as highly vulnerable. Most wells provide sufficient quantity of water to meet most supply needs. Overall, the estimated volume of groundwater use is between 250,000 and 400,000 m<sup>3</sup>/year, which is between 15 to 30% of the estimated total aquifer recharge. Based on the assumption that the majority of the groundwater use is sourced from the overburden sand aquifer and discharged through septic beds back to the same aquifer the potential for area wide aquifer dewatering is deemed to be low.

A detailed water quality investigation included the sampling of 69 water wells at select residential and commercial properties with an attempt to obtain a valid cross section of data. Water quality from the overburden sand aquifer appears to be of good natural water quality. However, significant nitrate concentrations have been detected (average concentration of 5.2 mg/L with 19% of the samples exceeding the ODWS). These nitrate concentrations appear to be a result of the septic loading within the Village of Constance Bay. Detection of bacteria was not widespread and was likely related to well construction and / or maintenance and not septic loading.

An inventory of potential environmental concerns was compiled for the study area which looked at both existing and historic land uses. Although the potential impact from each of the different sources ranged from negligible to severe, no evidence of area-wide impacts were observed during the sampling program.

#### **Village of Lanark, Communal Water System, Phase I Report – Existing Conditions (1990)**

Based on the results of the water surveys in the late 1970's in the Village of Lanark, various private well and sewage systems were identified as requiring upgrades or new installations. In response to the poor water quality in 1980 and 1981 various individual corrections to the private water and sewer services were conducted.

A survey in 1986 by the Leeds, Grenville and Lanark Health Unit identified that 31 of 88 wells sampled indicated water of unsatisfactory quality and 13 indicated doubtful quality. As a result of the 1986 survey, a follow-up survey was conducted by the Ministry of the Environment in 1987 and involved the sampling of 261 wells in the Village. The results of the 1987 survey indicated that 35% of the wells were unsatisfactory and 16% were doubtful with respect to bacteriological contamination. In addition, during the 1987 survey five of 38 wells sampled for nitrates indicated levels in excess of the provincial criterion of 10 mg/L.

A sampling program was conducted in 1990 which involved the sampling of 299 wells in the Village of Lanark, which represents greater than 99% of the wells within the Village. Bacterial sample results during the 1990 survey indicated 7% of the wells as unsatisfactory and 10% of the

wells as doubtful. The differences in bacterial quality from the 1987 survey were attributed to the seasonality of the survey (1987 survey in July and 1990 survey in April). Nitrate impacts were identified in approximately 75% of the wells sampled with 25% approaching the provincial criterion and 17% exceeding the criterion. The results of the 1987 and 1990 survey indicated that the individual corrections to the private wells and sewage systems in the Village of Lanark have not resolved the bacterial and chemical contamination.

#### **Village of Lanark, Private Sewage and Water Systems (1979)**

A study was undertaken in 1977 and 1978 to determine the nature and extent of water contamination in individual domestic water supply wells and water pollution in surface water in the Village of Lanark. A total of 260 houses were investigated for bacteriological contamination. A random subset of samples (totaling 38 houses) was also selected for chemical characterization. Based on this chemical characterization iron and total nitrates were present above the Ministry of Environment Drinking Water Objectives in 18% of the samples. Chloride was also detected in excess of the objectives in 13 % of the samples.

Water supplies for each house were classified as satisfactory, doubtful, contaminated or substandard. Based on the results of the water testing 63% of the samples were deemed satisfactory (164 of 260 samples). Thirty-one (31) homes contained contaminated water which represents 12% of the homes tested. Sewage systems for each house were also classified into similar categories which included satisfactory, deteriorating, substandard or unacceptable. Based on the results of the septic inspections 59% of the homes were deemed satisfactory. Seventeen (17) homes contained unacceptable sewage disposal facilities which represent 7% of the homes inspected.

As a result of chemical and bacteriological contamination in the Village of Lanark, two options were presented to address the water quality concerns which included: improvements to existing water supply and sewage systems; and, provision of communal water and / or wastewater supply. Based on consideration of a number of factors it was determined that the improvements to individual systems would be the most appropriate solution for implementation. The report documents the various remedial measures that are required to improve the water quality concerns. Recommendations of the remedial measures are presented in Table A-1.

#### **Village of Merrickville-Wolford – Municipal Groundwater Management Study (2000)**

A municipal groundwater management study for the Village of Merrickville-Wolford, jointly funded by the Village and the MOE, was completed during January to September 2000. The work was completed by Golder (2000) and included review and interpretation of existing data, groundwater sampling and analyses (39 private and 4 municipal wells analyzed for metals, bacteria, general chemistry), surface water sampling and analyses (14 samples analyzed for metals and general chemistry), isotope analyses (10 samples analyzed for oxygen and hydrogen isotopes), hydraulic testing (7-hr pumping test on municipal well PW4) and numerical groundwater flow modeling. The primary data source for this study was the MOE well records from within the study area as well as neighbouring Townships.

The Village of Merrickville-Wolford is situated within the Smiths Falls Limestone Plain physiographic region as discussed in Section 1.2.5. Generally, overburden is characterized by thin to non-existent pockets of sand, silt, clay, till and organic deposits. Paleozoic bedrock outcrops throughout the region and approximately 50% of the municipality is covered by marshes and seasonally inundated areas.

The Village of Merrickville-Wolford is divided into two wards: the Merrickville Ward and the Wolford Ward. The Merrickville Ward has a population of approximately 1000 people, all of which receive potable water from a municipal system comprising 4 municipal wells. These wells primarily extract groundwater from the Paleozoic bedrock aquifers of the March, Oxford Formations with some contribution from the Nepean Formation. The Wolford Ward has a population of approximately 1500 people who all receive their water from private individual services which access the March and Oxford bedrock formations.

As part of the numerical model development, this study provided an overview of hydraulic conductivity estimates for overburden and bedrock units. In addition, the following information was presented in electronic maps: groundwater and surface water sampling locations, drainage divides, infiltration potential, overburden thickness bedrock topography, bedrock potentiometric surfaces, bedrock aquifer yields, groundwater quality distribution, recharge and discharge areas and potential sources of contaminants.

The numerical modeling aquifer assessment indicated that the origin of the groundwater pumped at the Merrickville municipal wells is likely from a recharge area located near the Rideau River, approximately 4.2 km southwest of the municipal wells. The projected horizontal travel time from the recharge area to the wells is approximately 90 days to 1 year and is highly dependent on the nature of the bedrock fractures.

The hydraulic testing estimated that the radius of influence (limit of drawdown) from the municipal wells is approximately 1.1 km. The municipal wells are reported to be pumping at 84% efficiency, which is considered good. The 20-year pumping rate sustainable yield was calculated to be approximately 11,260 m<sup>3</sup>/day or 16.5 times the projected pumping rate of 680 m<sup>3</sup>/day.

This study included public participation in the form of a website, a questionnaire and two public meetings. In addition, this study was reviewed and directed by a steering committee (7 members) and a technical committee (3 members).

#### **Village of North Gower Groundwater Study (2005)**

A groundwater study for the Village of North Gower within the amalgamated City of Ottawa was completed during October and November 2004 by Dillon Consulting Limited (2005). This study was performed to determine if there are any area-wide groundwater quality or quantity concerns that may affect future development on private services. This study evaluated the groundwater resources which included the following main tasks: groundwater quality assessment; groundwater supply quantity assessment; groundwater use assessment; and potential contaminant source assessment.

The study area is a rural village designated within the City of Ottawa which is a mix of residential, agricultural, commercial and industrial land uses. The largest portion of the village remains as undeveloped agricultural lands. The estimated population of the Village (based on the 2001 census) is 1,675. In addition, there are approximately 25 parcels of land used for commercial, government, industry or institutional land uses. All current development is serviced by private individual wells and septic systems.

The majority of wells pump from the limestone (Oxford / March) aquifer. An overburden sand and gravel aquifer also exists in area but it is not used as frequently. Approximately 74% of the wells are between 10 to 30 m deep with the average well depth, based upon the MOE well

records, of 25 m. The general vulnerability of the area is classified as moderately vulnerable as a result of the clay deposits near surface. However, areas of higher vulnerability associated with thinner overburden and sand and gravel deposits are also noted in the Village. Most wells provide sufficient quantity of water to meet most supply needs. Overall, the estimated volume of groundwater use is between 190,000 and 320,000 m<sup>3</sup>/year, which is less than 10% of the estimated total aquifer recharge, therefore the potential for area wide aquifer dewatering is deemed to be low.

A detailed water quality investigation included the sampling of 60 water wells at select residential and commercial properties with an attempt to obtain a valid cross section of data. Overall, no widespread problems with health related groundwater parameters were detected; however non-health related parameters are commonly found at concentrations above Ontario Drinking Water Standards (hardness, total dissolved solids, and iron).

An inventory of potential environmental concerns was compiled for the study area which looked at both existing and historic land uses. Although the potential impact from each of the different sources ranged from negligible to severe, no evidence of area-wide impacts were observed during the sampling program.

#### **Vulnerability Pilot Study – Almonte Municipal Supply Wells (2005)**

The MOE initiated a pilot study to map the WHPAs for municipal supply wells using actual travel times from ground surface to the well, which incorporates unsaturated travel time plus saturated travel time. The previous WHPA studies utilize reverse particle tracking methods in MODFLOW and only take into account the travel time in the saturated zone. This analysis method is termed Water table to Well Advection Time (WWAT).

The Surface to Well Advection Time (SWAT) pilot study was completed by INTERA (2005) and incorporated the existing MODFLOW model that was previously created. The results of this study indicate that the actual travel times from ground surface to the municipal wells are in the order of 2 to 25 years for wells 5 and 6 (southwest of Mississippi River) and greater than 25 years for wells 3, 7 and 8 (northeast of Mississippi River). Sensitivity analyses were completed on various parameters including residual moisture content of unsaturated zone, hydraulic conductivity of bedrock units, and porosity of bedrock units.

#### **Water & Wastewater Alternative Servicing Solutions Study, Village of Cumberland (2003)**

A water and wastewater alternative servicing solutions study was conducted for the Village of Cumberland within the amalgamated City of Ottawa during 2001 and 2002 by Golder Associates Limited (2003). This study was performed as part of a Class Environmental Assessment for water and wastewater projects. The study was undertaken to evaluate the future servicing needs of the Village. This study included the following main tasks: groundwater quality assessment; surface water quality assessment; identification and evaluation of alternative solutions; and recommended solutions.

The study area is a rural village designated within the City of Ottawa which is primarily residential with some commercial and institutional land uses. Fewer than 20 commercial and institutional properties exist within the Village. The estimated population of the Village is approximately 1,500. All current development is serviced by private individual wells and septic systems.

Three sources of groundwater were identified within the Village of Cumberland: surficial sand and gravel aquifer; till / upper weathered bedrock aquifer; and deep bedrock aquifer. Based on the MOE well records, approximately 25 % of the wells were completed within the till / upper weathered bedrock aquifer and approximately 73 % of the wells are completed within the deeper bedrock aquifer. Aquifer vulnerability varies throughout the Village based on the geologic units present. Low vulnerability sections of the Village are associated with thick deposits of clay overlying the bedrock (30 to 70 m in thickness). High vulnerability is associated with other portions of the Village have less than 1 m of overburden.

Historic groundwater quality issues related to elevated chloride, nitrate and bacteria. A database of historic sample results and a sampling event in 2000 was conducted by Stantec. Elevated concentrations of total coliforms, nitrate, sodium and chloride concentrations were detected during the 2000 sampling event. Elevated sodium and chloride concentrations within the Village area are suspected to be naturally occurring.

Based on these historical sampling results a detailed groundwater quality assessment was conducted which included the installation and sampling of 13 monitoring wells at four locations and sampling of 148 water wells at select residential and commercial properties with an attempt to obtain a valid cross section of data. Based on the results of the study the following samples were noted to exceed the ODWS:

- 61 of 148 samples (41%) for chloride (250 mg/L);
- 32 of 148 samples (22%) for sodium (200 mg/L);
- 40 of 195 samples (21%) for total coliforms (non-detect);
- 3 of 195 samples (2%) for *E. Coli* (non-detect);

Elevated nitrate concentrations were detected in the water wells in the study area but not a level in excess of the ODWS. In addition, several of the non-health related parameters commonly found at concentrations above ODWS (hardness, total dissolved solids, and iron) were also detected at concentrations in excess of the criteria.

The surface water quality sampling program was conducted in spring (15 samples) and fall (52 samples) 2001. Surface water results indicated elevated concentrations bacteria, nitrate, ammonia and total phosphorus. These elevated concentrations in surface water were attributed to the discharge from septic systems, road de-icing, water softener backwash discharges and grey water discharges.

Based on the impacts to both surface and groundwater, alternative solutions for both water supply and wastewater disposal were evaluated for the Village of Cumberland. The preferred solution for the water supply is to extend the central water supply from Ottawa. The central treatment plant is located in downtown Ottawa which is approximately 25 km the Village of Cumberland. The closest serviced area from the Ottawa urban area is the eastern portion of Orleans located approximately 5 km west of the Village of Cumberland. The preferred solution for the wastewater supply is to extend the central wastewater service from Ottawa. However based on the costs to provide these services, the residents consider these alternatives to be unaffordable without government funding and as a result they are only supportive if funding was available.

#### **Water Resources Study – City of Kanata Rural Area (1994)**

A Water Resources Study for the rural area of the City of Kanata (now incorporated within the amalgamated City of Ottawa) was conducted by Raven Beck Environmental Ltd. (Raven Beck, 1994). The purpose of the report was to provide hydrogeologic information as to the suitability of reduced lot sizes for future residential development on private services in the rural area of the

City of Kanata. The study involved a review of available hydrogeologic data (subdivision reports, etc.), completion of a water quality survey (sampling of existing residences), and installation of several monitoring wells.

Development within the rural area of the study has historically relied upon water supply from bedrock aquifers. Three bedrock hydrostratigraphic units were identified in the area:

- Gull River / Rockcliffe shale and limestone;
- Nepean / March / Oxford sandstone and dolostone; and
- Precambrian granite.

Deep poorly producing wells have been reported within the Gull River /Rockcliffe and Precambrian formations. However, sufficient water quantity for residential development is present within these formations. The Nepean / March / Oxford formation is more permeable with a higher quantity of water.

Overburden is generally less than 5 m in thickness, and does not provide a secure water source. Due to the relatively shallow overburden deposits, the groundwater resources in the area are sensitive to surface contamination. Isolated areas of groundwater contamination due to road salting, bacteria and nitrate impacts were identified.

Recommendations were made as to minimum lot size dependent upon the bedrock formations as well as the type of development. Due to the lack of significant overburden deposits, recommendations were also made with regards to well construction, private services and sensitive hydrogeologic areas. A detailed list of the recommendations from the Water Resources Study is presented in Table A-1.

### **Water Well Sustainability in Ontario – Expert Panel Report (2006)**

This project was initiated by the Ontario Ministry of the Environment (MOE) to investigate, plan, and implement innovative approaches to water well maintenance and monitoring in order to extend and improve the integrity of water well infrastructure in Ontario. The expert panel was established to investigate the state of wells in Ontario and to determine how to increase well longevity. A terms of reference was determined for the expert panel that involved three objectives: 1) produce a “state of knowledge” document on Ontario’s water well infrastructure, 2) identify emerging threats to water well infrastructure and assess Ontario’s ability to mitigate these, and 3) provide peer review of the findings of two “Think-Tanks” conducted previously on the topic.

The panel’s assessment involved the following components of sustainable water well infrastructure: design life of a water well; well infrastructure management; groundwater resources in Ontario; well water quality; water well records; public education and outreach; well construction; well maintenance and disinfection; well decommissioning; the regulatory framework; research needs; sustainable asset management; and current and emerging issues that might threaten the sustainability of wells over the long term. The panel identified 44 recommendations addressing all aspects of water well sustainability. Ten of the recommendations were identified as critical initiatives to promote the longevity of water wells in Ontario: Province-wide well water quality survey; public groundwater / well water survey; skilled groundwater workforce; industry outreach and education; third party enforcement of well regulation; water well database initiative; expand well aware program; subsidy program for well

upgrades and decommissioning; a new water well service industry; and disclosure of water well status.

### **Wellhead Protection Area Study – Almonte (2003)**

As part of the 2001/2002 MOE municipal groundwater study initiative, INTERA (2003) completed a Wellhead Protection Area Study for the Town of Almonte in accordance with the MOE Technical Terms of Reference. This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source inventory, and the development of an action plan for groundwater source protection for the Almonte municipal water supply wells.

The primary data source for this work was the MOE wells database (current to 2001) and included a study area approximately 88 km<sup>2</sup> centered on the Town of Almonte. The Town of Almonte operates five municipal supply wells and provides drinking water to approximately 4,660 persons.

Reverse TOT capture zones for the supply wells were defined based on 50 day, 2 year, 10 year and 25 year saturated zone travel times to these wells. In addition, a parameter sensitivity analyses was completed on pumping rate, infiltration, bedrock aquifer hydraulic conductivity, and bedrock aquifer porosity. Municipal wells located northeast of the Mississippi River (wells 3, 7 and 8) are characterized by low vulnerability to surface contamination while the municipal wells located southwest of the river (wells 5 and 6) are characterized by medium to high vulnerability.

The contaminant source inventory identified approximately 60 commercial properties or businesses that operate within the WHPAs for the Almonte municipal supply wells. Based on aquifer vulnerability, type of business operation or land use, and proximity to the closest municipal supply well, only five of these businesses/properties pose a potential risk to the municipal well supplies.

This study included public participation in the form of a questionnaire for local businesses and a presentation to Town council. In addition, this study was reviewed and directed by a steering committee and a technical advisory group.

### **Wellhead Protection Study – Carp Communal Wells, City of Ottawa (2003)**

A Wellhead Protection Study was completed for the communal wells in the Village of Carp by Golder Associates Ltd. (2003) on behalf of the City of Ottawa. This study was completed in accordance with the MOE Technical Guidance as part of the 2001/2002 MOE municipal groundwater studies initiative and was managed by the Mississippi Valley Conservation Study Group. The primary objectives of this study were threefold, including: [1] to identify a WHPA for the Carp communal wells; [2] determine the recharge conditions within the WHPA; and, [3] to provide an inventory of potential contaminant sources within the WHPA.

The Village of Carp currently operates two municipal wells, both of which are screened overburden wells located in an elongated, relatively extensive, permeable sand and gravel esker deposit. The wells are located in the middle of the Village; therefore urban development is a concern for wellhead protection strategies. The wells currently serve approximately 450 residences plus commercial and institutional facilities and pump at a rate of approximately 230 m<sup>3</sup>/d, which is approximately 8% of the wells rated capacity, therefore water quantity issues are not a concern for future development.



This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source inventory, and the development of an action plan for groundwater source protection for the Carp communal water supply wells.

Reverse TOT capture zones for the supply wells were defined based on 50 day, 2 year, 10 year and 25 year saturated zone travel times to these wells. The 3D numerical model covered an area of approximately 39 km<sup>2</sup>, centered on the Village of Carp. Both communal wells are characterized by high aquifer vulnerability to surface contamination.

The contaminant source inventory identified five potential contaminant sources that are located within, or in close proximity to the WHPAs for the Carp municipal supply wells. The high risk associated with these sites is related to the high aquifer vulnerability and the high rate of infiltration where the aquifer is not protected by a low permeability layer. Only two of these potential contaminant sources are located within the WHPA (2 to 10 year).

This study included public participation in the form of two public open houses, a website, and an information newsletter. In addition, this study was reviewed and directed by a steering committee and a technical advisory group.

#### **Wellhead Protection Study, King's Park Subdivision, Village of Richmond (1996)**

A Wellhead Protection Study was completed for the communal well system in the King's Park Subdivision in the Village of Richmond in 1996 by Jacques Whitford Environmental Ltd. This study was completed prior to the development of MOE Technical Terms of Reference as part of the MOE municipal groundwater studies initiative; therefore the methodologies used are different compared to more recent WHPA studies completed for other municipalities. The goal of the WHPA study was to preserve and protect the public health of the King's Park residents by protecting and the communal drinking water supply. The objective of the WHPA study is to protect the quality of the well water by preventing contaminants from reaching the supply.

Travel times were calculated using the United States Environmental Protection Agency (US EPA) semi-analytical model "WHPA" for the delineation of the wellhead protection areas. It was determined that there was insufficient data to determine the direction and magnitude of the hydraulic gradient. As a result of the lack of a hydraulic gradient input parameter into the model the WHPAs delineated as part of this study are basically a fixed radius based on the estimated flow times to the wells. Travel times were calculated to determine a 250 day and 2500 day travel time to the wells. A review of historical information to determine past and present land usage within the study area identified a total of 12 historical or current potential contaminant sources within the 2500 day WHPAs for the King's Park communal wells.

#### **Wellhead Protection Study – Munster Hamlet and Kings Park Communal Wells, City of Ottawa (2003)**

A Wellhead Protection Study was completed for the communal wells at Munster Hamlet and Kings Park Subdivision by Golder Associates Ltd. (2003) on behalf of the City of Ottawa. This study was completed in accordance with the MOE Technical Guidance as part of the 2001/2002 MOE municipal groundwater studies initiative and was managed by the Mississippi Valley Conservation Study Group. The primary objectives of this study were threefold, including: [1] to identify a reasonable, "theoretical" WHPA for the Kings Park Subdivision and the Hamlet of

Munster communal wells; [2] determine the recharge conditions within the WHPA; and, [3] to provide an inventory of potential contaminant sources within the WHPA.

Munster Hamlet currently operates two municipal wells, both of which penetrate March and Oxford Formation dolostones and is completed as open boreholes within the Nepean Formation sandstone at a depth of approximately 120 m bgs. The wells are located in the southeastern limit of Munster, approximately 1500 m northeast of the Jock River. The wells currently service approximately 440 residences and pump at a rate of approximately 420 m<sup>3</sup>/d, which is approximately 8% of the wells rated capacity, therefore water quantity issues are not a concern for future development.

Kings Park Subdivision, located in Richmond, currently operates two communal wells, both of which penetrate March and Oxford Formation dolostones and is completed as open boreholes within the Nepean Formation sandstone at a depth of approximately 65 m bgs. The wells are located in the northeastern portion of Richmond, less than 500 m east of the Jock River. The wells currently service approximately 153 residences and pump at a rate of approximately 210 m<sup>3</sup>/d, which is approximately 20% of the wells rated capacity, therefore water quantity issues are not a concern for future development.

This study included: compilation of hydrogeologic data, development of a site-specific conceptual model, delineation of WHPA using a 3D numerical groundwater flow model (MODFLOW), assessment of aquifer vulnerability, compilation of a detailed contaminant source inventory, and the development of an action plan for groundwater source protection for the Kings Park Subdivision and Munster Hamlet communal water supply wells.

Reverse TOT capture zones for the supply wells were defined based on 50 day, 2 year, 10 year and 25 year saturated zone travel times to these wells. One 3D numerical groundwater flow model was constructed that covered both study area (approximately 880 km<sup>2</sup>), centered on the Richmond/Munster area. The Nepean sandstone aquifer that services all four communal wells is considered to be a semi-confined aquifer, overlain by leaky aquifer and aquitard materials, therefore it is characterized by low aquifer vulnerability to surface contamination.

The contaminant source inventory identified 16 potential contaminant sources within the WHPAs (14 – Kings Park, 2 – Munster) that are considered to have high relative risks associated with them due to being located within highly vulnerable areas.

This study included public participation in the form of two public open houses, a website, and an information newsletter. In addition, this study was reviewed and directed by a steering committee and a technical advisory group.

### **Westport Water Works, First Engineers' Inspection Report for Water Works (2001)**

The report documents the findings and recommendations for the Westport Water Works located in the Village of Westport. The report was prepared for the Ontario Ministry of the Environment in accordance with O. Reg. 459/00 on behalf of the Village of Westport. The Engineer's reports document the description of the waterworks, certificates / permits for the facility, assessment of the potential for microbial contamination, characterization of the raw water source, assessment of the operational procedures and physical works and monitoring program.

Several potential sources of microbial contamination to the municipal wells were identified and included a small stream originating in agricultural land west of the site is directed to a culvert less

than 10 m from one of the wells, the Village's sewage lagoons, sanitary sewers, sewage "Snowfluent" facility, pasture & crop lands, site grading allowing surface water entry and cracks and distortions in the elevated tank. One of the report appendices includes a Hydrogeological Assessment of the Westport Water System conducted by Malroz Engineering Inc. which focused on the raw water characteristics and potential for groundwater contamination. Raw water test results in 1999 and 2000 indicated elevated concentrations of total coliforms and *E. coli* at several sampling events. It was noted that Well 2 had fewer samples exceeding the criteria for microbial contamination as compared to Well 1. It was also documented that the poor raw microbial water quality was noted in late summer / early fall. Elevated concentrations of Heterotrophic Plate Counts (HPC) were not encountered in the raw water quality. Several samples of elevated HPC were encountered in the distribution system. *E. coli* and total coliforms were not encountered in the distribution system.

Several raw water quality parameters (arsenic, iron, sodium, hardness and turbidity) were found to exceed the Ontario Drinking Water Standards (ODWS). Elevated iron concentrations were documented during a Ministry of the Environment (MOE) inspection report in 2000 (concentration of iron was not specified). Arsenic is a health related ODWS parameter and was only detected at levels in excess of the ODWS once. Confirmatory sampling of the raw water quality did not indicate the presence of arsenic in December 2000. Turbidity is a health related ODWS which causes interference with the disinfection of the water. The elevated turbidity concentrations were only encountered in Well 1. The sodium concentrations only exceeded the concentrations for the notification of the local Medical Officer of Health regarding patients on sodium restricted diets. The remaining parameters are mostly aesthetic or parameters that affect the operation of the plant. Investigations into the source of bacteria and turbidity in Well 1 were recommended. Several upgrades were recommended for the facility.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
A Multidisciplinary, Community-Based Study of the Environmental Health of the Rideau River: Final Report	2001	RVCA	Conclusions	<p>Over the course of three years, the <i>Rideau River Biodiversity Project</i> became an innovative project in several areas, foremost being the team approach to scientific study paired with traditional knowledge. This approach translated into a thorough study of an important waterway based on a collaborative effort between the science experts and the community residents and partners who have a stake in understanding the river's ecosystem.</p> <p>Project activities included scientific research, community consultation and public awareness. Results of the study include a list of specific recommendations for continued sampling and monitoring, as well as for further research activities.</p> <p>However, the impact of the study goes beyond the important quantitative and qualitative results of research and awareness-building activities. The creation of the Rideau River Roundtable, whose goal is to facilitate the coordination of research activities, educational projects and monitoring activities within a long-term planning framework, attests to the success of the community-based approach to a scientific study. The creation of this committee is an acknowledgement by the community of the need to pursue the work undertaken over the last three years.</p> <p>The success of the community-based approach for the <i>Rideau River Biodiversity Project</i> has been documented in various media and has been shared through many publications and conferences. It now constitutes a model for other communities across the country as a means to gather all the stakeholders in a concerted effort to share knowledge, to learn about biodiversity and to assume responsibility for the health of the environment in which they live, work and play.</p>
A Prioritization System for Wetlands within the Rideau Valley Watershed, Draft Report	2006	RVCA	<p>Wetland Communication and Cooperation - Recommendations</p> <p>Wetland Regulation - Recommendations</p>	<p><i>Recommendation - The Rideau Valley Conservation Authority (RVCA) and other agencies responsible for landscape planning and wetland conservation within the Rideau Valley watershed develop a regular means of open communication and establish cooperative agreements.</i></p> <p>Given the extensive network of wetlands within the Rideau Valley Watershed and their stated importance to its citizens, wetland conservation should be a shared responsibility. Federal, provincial and municipal agencies, conservation authorities, non-government organizations (like Ducks Unlimited Canada and the Nature Conservancy of Canada) and the public need to cooperate in this enormous task.</p> <p>The RVCA has indicated a willingness to accept a leadership and facilitating role in watershed planning for the major subwatersheds of the Rideau River, but will require assistance in this task.</p> <p>Several cooperative agreements exist already with respect to wetland protection. Under agreement with Fisheries and Oceans Canada (DFO), the RVCA acts as the screening agency for all projects in or near water that are considered to be or have the ability to be fish habitat. Cooperation and communication between conservation authorities and the Ontario Ministry of Natural Resources (OMNR) is very important for wetland information transfer. OMNR has staff experienced in wetland evaluation and geographical information systems (GIS) and has a mandate to supply wetland data to conservation authorities and municipalities through the continued evaluation of wetlands in Ontario. Fulfilment of this mandate is crucial since hundreds of wetlands remain unevaluated within the watershed. Conservation authorities and municipalities will have a much greater need to streamline their goals for wetland conservation in order to reduce red tape and reduce appeals to the Ontario Municipal Board. Federal agencies may have more limited roles that pertain directly to fisheries or migratory birds, however they can provide critical support for stewardship activities.</p> <p><i>Recommendation - The RVCA regulate all wetlands that have been ranked as an extreme or high priority using this prioritization system.</i></p> <p>Sixty-six of 79 evaluated wetlands scored above 500 points using the ten criteria, meaning that they fall within the proposed extreme and high priority range (see Appendix 2) and should be protected. The remaining 13 evaluated wetlands below a score of 500 points are in the range of the proposed moderate priority protection level; of these 13, eight are provincially significant and five are locally significant.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Of the 66 wetlands recommended for regulatory inclusion, 55 have been included in the RVCA's regulatory schedule (mapping), leaving 11 remaining unprotected. The questions that arises is whether or not the RVCA should actively administer and enforce regulation of all wetlands or the 66 identified here, knowing that these 66 wetlands represent approximately xx percent of all known wetlands in the Rideau Valley Watershed (using Ontario Base Mapping (OBM)), both evaluated and unevaluated. Also, as additional wetland evaluation information becomes available from OMNR and other sources, new wetlands may also require regulation.
			Wetland Conservation - Recommendations	<p><i>Recommendation - The RVCA and other agencies responsible for landscape planning and wetland conservation should work towards maintaining at least 10% wetland habitat cover within the Rideau Valley Watershed and no less than 6% within the individual subwatershed, in keeping with Environment Canada (2005) guidelines.</i></p> <p>In the document "How much habitat is enough? A framework for guiding habitat rehabilitation in Great Lakes Areas of Concern", it was suggested that at least 10% of a major watershed area must be composed of wetlands in order to maintain ecological integrity within the landscape and greater than 6% of each subwatershed should be maintained in wetland habitat (Environment Canada 2005). It is recommended that the RVCA and other agencies responsible for landscape planning and wetland conservation within the Rideau Valley Watershed work towards achieving or exceeding this goal.</p> <p>The RVCA has mapping showing the percentage of wetlands, both evaluated and unevaluated, in each subwatershed and is committed to updating this information on a regular basis - at least every five or ten years (if not sooner). If the mapping shows that a specific subwatershed contains less than 6% wetlands by area, then all wetlands should be considered highly significant for local planning purposes. Although on a regional scale some of the wetlands may not be a priority for regulation under the Conservation Authorities Act, it is within the means of local municipalities to afford protection of all wetlands through official plans and zoning by-laws.</p>
			Land-Use Plan Input - Recommendations	<p><i>Recommendation - The RVCA initiate discussions with municipalities with the aim of ensuring that all evaluated wetlands, including locally significant ones, are recognized and receive an appropriate level of protection in their official plans and zoning by-laws.</i></p> <p>It is the responsibility of each municipality to ensure that official plans and zoning by-laws incorporate the most up-to-date information on wetlands that is available. To do otherwise would be a disservice to its citizens.</p> <p>The RVCA and municipalities rely heavily upon the technical expertise on wetlands and wetland mapping that is established in the OMNR. This study revealed several instances where evaluated wetlands were either not included in GIS mapping or boundaries were incorrect. OMNR in Kemptville is working towards ensuring the accuracy of its wetland mapping; however efforts by OMNR, Kingston need to be improved. It is also essential that the transfer of wetland evaluation information and mapping form the OMNR to these agencies is conducted on a regular basis and no less than every six months.</p> <p>Potential conflicts with developers and landowners may be avoided and many dollars saved if a clear direction is provided. A precautionary approach such as that employed by the Township of South Frontenac (2003) or the District of Muskoka (2002) may best serve all interests.</p> <p>The Provincial Policy Statement (PPS) states that development should not be permitted within a Provincially Significant Wetland (PSW). If development is proposed within 120 m of a PSW, an Environmental Impact Study must be conducted. If an application under the <i>Planning Act</i> is not required, then an EIS is not required. Activities that do not require a Planning Act application include: dredging, filling, tree cutting. Municipalities also have the power to regulate tree cutting and topsoil removal in wetlands through the establishment of bylaws. These mechanisms may be important in maintaining the ecological integrity of wetlands, particularly in urban areas.</p>
			Wetland Identification - Recommendations	<p><i>Recommendation - The RVCA work to ensure that all wetlands are identified within all (sub)watershed plans in the RVCA area of jurisdiction, and that (sub)watershed plans identify the appropriate level of protection using instruments under the Planning Act (official plans and zoning bylaws) for all wetlands (including unevaluated wetlands), and recommend the same to its member municipalities.</i></p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>One weakness of this prioritization system is that it cannot include unevaluated wetlands. It was not within the mandate of this study to address this issue. Within the Rideau Valley Watershed there are approximately ? hectares of wetland that has not yet been evaluated by OMNR using the Ontario Wetland Evaluation System (OWES) (Figure 2). In the wetland maps accompanying the wetland reports in Appendix 3, these areas are shown as "unevaluated permanent wetland" and their mapping is based on GIS layers found in Natural Resource Value Information System (NRVIS), an information system maintained by OMNR. These areas can sometimes be extensive reaching up to several hundreds hectares in size. Sometimes they are immediately adjacent to the evaluated wetland boundaries.</p> <p>For the past several years there has been a drive within the OMNR to find a means of evaluating all wetlands within southern Ontario without conducting extensive fieldwork. This has been necessitated by a reduction in provincial funding for wetland studies and also a growing resistance from landowners to allow access to their properties for wetland data gathering and evaluation purposes. The cost of OWES field-based surveys is high, averaging \$1000 for every 50 acres of wetland (Davies et al. 1996).</p> <p>A Southern Ontario Land Information System (SOLARIS) has been developed based on satellite imagery, however it does not compare to the value of on-site inventories and evaluations. Environment Canada and OMNR (2003) concluded that LANDSAT data (25-30 m resolution) is ineffective in terms of providing accurate information on the location, size and type of wetlands. Recently Findlay (2005) attempted to develop basic tools in the form of statistical models with which conservation authorities and municipalities may predict with confidence OWES scores for wetlands within their jurisdictions without the expense of extensive field work. Both the statistical modeling and neural net results indicated that the predictive power of remote-sensed information for component OWES score, total score, and wetland designation is generally rather low.</p> <p>Studies by Chisholm et al. (1997) and Hogg et al. (2003) have promoted the use of Rapid Assessment Techniques (RAT) and LANDSAT TM Imagery as a preliminary screening tool to determine priority wetlands that require field evaluation. In those studies ninety-seven percent of the areas were correctly identified as wetland. Classification was correct for 78% of swamp ecosites and 71% of marsh ecosites (Hogg et al. 2003). It was not able to distinguish between fens and bogs.</p> <p>The District of Muskoka (2002) has shown how satellite imagery studies of wetlands can be effectively used in landscape planning. Relatively few wetlands in Muskoka have been evaluated. Given the size and nature of Muskoka and increasing development pressure, it was unreasonable to assume that a significant number of full wetland evaluations could be undertaken in anticipation of future development. In recognition of this situation, Muskoka supported work being undertaken by Ducks Unlimited and OMNR to develop a satellite-based system to identify wetlands and a computer-based model to evaluate them. This model provided a preliminary assessment of wetlands and gave a rough indication of their significance. The information provided through this process was recommended for incorporation into Official Plan policy as a constraint to development. A key recommendation was that those areas that demonstrated a high potential to be provincially significant should be evaluated in the field using the OWES prior to development proceeding.</p> <p>There are a large number of wetlands within the Rideau Valley Watershed that have not been evaluated. Official plans and zoning bylaws must be updated to recognize both provincially and local significant wetlands while providing adequate policy protection for the unevaluated wetlands. Policy that recognizes new wetland information as it becomes available should be incorporated in official plans in order to ensure the best and most effective level of protection for these areas. Policy should provide the flexibility to request an evaluation to determine if a wetland is provincially significant particularly in the case of a major development. District of Muskoka (2002) recommended for minor proposals that development should be setback 30 metres from an unevaluated wetland. It also suggested that limited development, compatible with both the wetland and surrounding area, should only be permitted in an unevaluated wetland or closer than 30 metres to the wetland where a wetland impact assessment demonstrates that the integrity of the wetland can be maintained and the lot is suitable for development.</p>
			Wetland Monitoring - Recommendations	<i>Establish a monitoring program aimed at compiling information and periodically reporting on the condition of wetlands within the RVCA's watersheds.</i>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Wetlands are worthy of protection because of the well documented ecological, social and economic benefits that can be attributed to them and their overall contribution to our quality of life (OMNR 1993; 1999). Despite the existence of several provincial and municipal policies and regulations to protect them, wetlands are still being lost or degraded throughout the province. The status (condition and extent) of wetlands in the Rideau Valley Watershed is uncertain. Therefore, in the absence of evidence to the contrary, and in keeping with the precautionary principle, it should be assumed that wetlands are still being lost or degraded. A formal monitoring program is needed to determine if, in fact, this is occurring around the watershed.
			Wetland Hydrology - Recommendations	<p><i>Recommendation - The RVCA seeks to better understand the hydrologic function of wetlands for watershed management purposes.</i></p> <p>Since the primary objective of the Conservation Authorities regulations will be to conserve / protect the hydrologic function of wetlands, the most important criteria that should be followed when selecting wetlands for inclusion in the RVCA's regulations package should be those that have to do with their hydrologic functions.</p> <p>The RVCA is addressing this need through efforts that are already underway, including conducting further analysis of the (collective) hydrologic significance of wetlands within the watersheds and subwatersheds of the Rideau Valley, using hydrologic modeling tools. As an example, it is anticipated that the model will be able to answer the following questions: Hydrologically speaking, what would happen if five, ten or even twenty percent of existing wetlands in subwatersheds were lost due to infilling or drainage works; what would the resulting effect on peak flood flows and summer low flows be at different points within the system (and on human / non-human users)?</p>
			Wetland Waterfowl Habitat - Recommendations	<p><i>Recommendation - Establish a list of wetlands that are considered provincially or regionally significant for waterfowl production, moulting and staging.</i></p> <p>Under the OWES, wetlands containing provincially significant waterfowl habitat are give 100 points for supporting either breeding or moulting and / or staging habitat and regionally significant habitat is given 50 points. Nationally significant habitat is worth 150 points. Since OMNR has not developed a system for evaluating regionally significant waterfowl breeding, moulting and staging areas, there are no clear guidelines for the designation of such areas under the OWES. The result is that OMNR wildlife biologists generally have not nominated wetlands for this designation resulting in under-evaluation of this important criterion. In fact until the publication of the Significant Wildlife Habitat Technical Guide (OMNR, 2000), the criteria for selection of provincially significant waterfowl sites were also unclear.</p> <p>The waterfowl component of the Significant Wildlife Habitat Technical Guide (OMNR 2000, Appendix K) identifies five categories of waterfowl that are considered significant in Ontario. They include: A) Species whose populations are in decline (Black Duck); B) Species for which Ontario provides a large portion of their continental breeding and staging habitat (Common Goldeneye, Canvasback, Redhead, Ringnecked Duck, Scaup (2 species), Hooded Merganser, Old Squaw, Scoters (3 species), Mississippi Valley &amp; Southern Ontario Canada goose); C) Species for which Ontario provides an important component of continental breeding and staging habitat (Wood Duck, Merganser (2 species), Coot, Wigeon, Gadwall, Blue-winged Teal, Gree-winged Teal, lesser Snow goose, Mallard); D) Species for which breeding, staging and wintering habitat is limited in Ontario (Ruddy Duck, King &amp; Common Eider, Trumpeter Swan, Atlantic Brant); and E) Species that are dependant on transitory habitats (Pintail, Tundra Swan, Shoveler).</p> <p>These were developed by a working group with representatives from OMNR, Canadian Wildlife Service, Ducks Unlimited and private consultants. Significant waterfowl species which breed within the Rideau Valley Watershed include American Black Duck, Mallard, Merganser, Coot, American Wigeon, Northern Shoveler, Gadwall, Redhead, Ring-necked Duck, Lesser Scaup, Blue-winged Teal, Green-winged Teal, Northern Pintail, Hooded Merganser, Common Merganser and Canada Goose (Cadman et al. 1987, 2004). In order to determine benchmarks for the evaluation of waterfowl significance within the watershed, waterfowl data could be utilized from the Ontario Breeding Bird Atlas. This approach is preferred to the more traditional one of assessing "potentially significant waterfowl habitat" since it incorporates real biological data on waterfowl populations. Although Ontario Atlas data is based on a 10 km by 10 km squares and cannot necessarily be attributed to individual wetlands it has been generally accepted for use in determining the status and diversity of a species within various regions of Ontario (Brownell 2005).</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				According to Rubec (1999) a wetland should be considered internationally important for waterfowl if: a) it regularly supports 20,000 waterfowl; b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity; or c) where data on populations are available, it regularly supports 1 percent of the individuals in a population of one species or subspecies of waterfowl.
			Wetland Evaluation Updates -	<p><i>Recommendation - Update existing evaluated wetland data records and GIS mapping, particularly those wetlands evaluated under version 2 of the OWES, and review wetland complexing within the Rideau Valley Watershed.</i></p> <p>A prioritization system is only as good as the information upon which it is based. If the data is out-of-date or is of poor quality, then the prioritization is less valuable. Several factors which may affect the ranking are the version of the wetland evaluation and complexing. In order for the ranking to be completely equitable, then all wetlands should be evaluated using the most recent version of the OWES (version 3) and OMNR (2002). If a wetland evaluation is updated from version 2 to version 3 or a version 3 evaluation is updated using information from OMNR (2002), then the RVCA can readily revise the list of prioritized wetlands simply by entering the new OWES scores into the database. Should any new evaluations be conducted of unevaluated wetlands, then application of the ten criteria would ascertain their rank.</p> <p>Areas discussed under section 2.2 "Wetland Complexes" of this report should be officially recognized and mapped as wetland complexes by OMNR. In addition, an overall approach to wetland complexing throughout the Rideau Valley Watershed needs to be developed.</p> <p>It should also be noted that while biological, ecological, social and hydrological values are not expected to change substantially for wetlands evaluated under version 3 of the OWES, values for special features are not as stable. As indicated in OMNR (2002) lists are constantly being revised. All wetland data records and scoring should be updated annually with respect to special features. The protection of endangered and threatened species and their habitats is necessary in order to slow or prevent the extirpation of species from the province, and, in some cases, to help prevent their extinction on a global basis. More and more species are at risk of extirpation, and lists of these species are changing yearly.</p> <p>The 2005 PPS, issued under Section 3 of the <i>Planning Act</i>, states that "Development and site alteration shall not be permitted in significant habitat of endangered and threatened species." Wetlands that provide breeding habitat for an endangered or threatened species automatically receive very high scores for this special feature. All species recognized by the PPS including fish shall be scored here. The PPS defines "endangered" as those species listed in the Regulations under Ontario's Endangered Species Act.</p> <p>The Natural Heritage Reference Manual (OMNR 1999), prepared in support of Policy 2.3 of the 1997 PPS, defines "threatened" species as those identified as threatened by OMNR on the Vulnerable, Threatened, Endangered, Extirpated or Extinct (VTEEE) species list, or as endangered by the national Committee on the status of Endangered Wildlife in Canada (COSEWIC). The most up to date lists of endangered or threatened species are shown on the VTEEE list at: <a href="http://www.mnr.gov.on.ca/mnr/fwmenu.html">www.mnr.gov.on.ca/mnr/fwmenu.html</a>. The VTEEE list is updated, at a minimum annually, or may be revised or renamed. The provincial rank of fauna and flora is established by the Natural Heritage Information Centre (NHIC) and can be accessed electronically at: <a href="http://www.mnr.gov.on.ca/mnr/nhic/nhic.html">www.mnr.gov.on.ca/mnr/nhic/nhic.html</a>.</p> <p>Certain wetlands may be eligible for additional points in the special features component due to recent revisions in the OWES (OMNR 2002). When an animal species that is endangered, threatened or provincially, regionally or locally significant, is found outside the wetland edge in the surrounding upland, but where it also makes sense that that individual or group of animals is dependent on that wetland for an essential part of its life cycle, then, that species can be scored in the appropriate category.</p> <p><i>Recommendation - Develop a regional flora and fauna species list and support studies on local plant and animal significance.</i></p> <p>Regionally and locally rare species also receive scores under the Special Features component of the OWES. Regionally and locally significant species are those that occur in a few populations or in very restricted distribution on a regional or local scale. The OWES has adopted Hills (1961) and Jalava et al. (1996) concepts of site regions for Ontario. Site Region refers to an ecological subdivision of the land, based upon a combination of climate, physiography, and biological productivity. Currently it is possible to score only locally significant species in few areas of southern Ontario. Regional lists exist only for bird species. Ecological Site Regions and Site Districts are the basis for assessment of significant species, however appropriately organized data do not currently exist for most groups of species.</p>



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				In the past, documentation of significant species has focused on counties, regional municipalities and other administrative areas. For groups of species or geographic areas with no list of rare species, no score can be assigned for this component. A species protocol recently developed by Brownell (2005) for Lake Ontario Waterfront in Durham and Northumberland Counties could provide a template for such an initiative in OMNR's Kemptonville District.
			Wetland Database Maintenance - Recommendations	<i>Recommendation - The RVCA maintain the wetland database through an annual program of information gathering and updates.</i>  The RVCA should ensure that the wetland database created as part of the Wetland Prioritization Project, is kept current and accurate through working arrangements with OMNR and other agencies. Maintaining the RVCA wetland database will ensure that land-use planning and regulatory decisions are justifiable.
			New Wetland Evaluations - Recommendations	<i>Recommendation - A program with clear targets for conducting new wetland evaluations be established within the Rideau River Watershed.</i>  As development pressure continues, it is important to identify and evaluate additional wetlands in order to ensure that appropriate consideration is given to the protection of the function and values of the wetland through the development process. For the past twenty years the OMNR has conducted an evaluation program directed at identifying wetlands of provincial significance. This program has dwindled over the years and it is currently barely being maintained. Additional manpower and funding are essential to being able to provide the quantity and quality of data that is required. The Minister of Natural Resources is now responsible for authorizing Conservation Authority Regulations under Section 28 and as such has a responsibility to support the efforts of conservation authorities in wetland protection.
Aquifer Protection, Village of	1992	MVCA (Ottawa)	Recommendations	The following recommendations are proposed as a result of this investigation.  This study is designed to be used as a planning tool only. If additional site specific information becomes available that refines the parameters used to establish the criteria this information must be integrated into the results and interpretation presented and may form the basis for change or realignment of the divisions presented.  In areas which are included in the sensitive areas or are close to the boundary lines the onus should be on the proponent to demonstrate that the proposed development may be undertaken without undue risk to the well field.  Development controls should be considered outside the zone of hydraulic influence in areas defined as sensitive.  Development within the sensitive areas should be restricted to "dry activity" which does not result in the handling of hazardous raw materials or the generation of waste materials either liquid or solid in quantities or concentrations that are either registerable, hazardous or acutely hazardous as defined by Ontario Regulation 309. Examples of the types of activities which would not conform would include but not be limited to dry cleaning facilities, gas stations, bulk chemical storage, painting, plating or etching works.
Baseline Surface Water Quality Program - Technical Report Five-Year Analysis 1998 Through	2004	M-R SPR & City of Ottawa (out of study area)	Recommendations	The baseline-water-quality-information presented in this report should be used as a general reference to project specific interpretation on water quality data for planning, design, and analysis purposes for the City of Ottawa.  Implementing management actions that protect smaller tributaries (creeks) with the net benefit of protecting all systems, large and small, specifically addressing: a - Citywide phosphorus sources; b - Local E. coli sources and problems, recognizing E. coli is a local rather than system wide issue; c - Urban sources of metals before they are discharged to small tributaries.  Assess: a - Methods for ensuring clay free samples when analyzing aluminum water quality parameters; b - Phosphorus for rural creeks in terms of agricultural versus general rural to see if the source is primarily one of the two land uses.  Update this report every five (5) years.
Carp Communal Water Supply Project	1987	MVCA (City of Ottawa)	Recommendations	The following recommendations have been formulated based on the results of this study.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>If the aquifer is to be considered as a long term water supply source, the salt and sand pile at the Municipal yard should be placed on a sealed pad and covered to prevent further salt leaching.</p> <p>Any number of potential well sites exist in the vicinity of Carp. A location outside of the existing village core and located on a moderate thickness of low permeability material is most appropriate from a contaminant hydrogeology viewpoint. Existing poorly sealed well casings and dug wells are a known point source contaminant hazard.</p> <p>Very high short term yields are available from the aquifer. It is recommended that these high yields be investigated as a method by which municipal storage requirements may be reduced through over-sized pumping facilities.</p> <p>Initial groundwater development could take place with the installation of a single 500 mm by 250 mm artificially gravel packed, cable tool installed production well at the municipal yard site. This well could be adapted to produce a minimum of 45.5 L/sec (600 imperial gallon per minute (igpm)). The existing test well could be modified for use as a standby production facility.</p> <p>Treatment for hydrogen sulphide and sodium should be investigated.</p>
Carp - First Engineer's Report	2001	MVCA (City of Ottawa)	Summary of Findings and Recommendations for Mitigation of Potential Microbiological Contamination	<p>In summary, Water and Earth Science Associates Ltd. (WESA) did not observe any potential sources of microbiological contamination but has identified nine non-microbiological potential sources of impact. With the exception of the Co-op feed mill, WESA has categorized the risk of impacts from these sources as unlikely. The Co-op feed mill was deemed a moderate risk for impacts on the groundwater. WESA has recommended the monitoring of several of these sources for long-term impacts to the groundwater. The City currently has a monitoring program but WESA has concluded that the two monitoring wells are too shallow to penetrate into the aquifer. It is recommended that new monitoring wells be installed to a depth that will penetrate the aquifer. It is also recommended that the source of trihalomethanes (THMs) found in monitoring well MW95-1 be located.</p> <p>WESA also recommends an old monitoring well south of the Fire Station be sampled for hydrocarbon impacts to ensure the previously removed tank had no impacts on the groundwater. This well should then be properly sealed and abandoned. The new aboveground storage tank, in the same vicinity, should also be fitted with a spill containment system to prevent possible spills. With regard to the two underground storage tanks (UST) located on the subject property, WESA has recommended documentation regarding the tank removal be located to determine whether or not there may be impacts from the previously removed UST.</p> <p>Additionally it is recommended that the City of Ottawa consider registering a complaint to initiate an investigation of the Co-op Feed Mill. The Ministry of the Environment's Ottawa Office has recommended that a complaint be launched under the Environmental Protection Act or the Ontario Water Resources Act. Elevated nitrogen levels in the groundwater in the vicinity of the Co-op indicate that there may be improper handling of fertilizer and provide grounds for the investigation.</p> <p>Four test results during 1999 and 2000 show elevated heterotrophic plate count (HPC) results in samples from the distribution system. With the new regulations and resampling requirements for adverse test results, elevated HPC results will be easier to confirm.</p>
			Recommendations to Address Deficiencies of the Operations Manual	<p>The Operations Guidelines Manual is generally a good document that clearly describes the equipment and the operation of the facility. However, the Manual requires some modifications to reflect some minor changes. These include: 1. Revise the plant schematic shown on Figure 2.2 and written description in Section 5.6 to reflect the elimination of the meter FIT 221, and the addition of the continuous turbidity and total chlorine monitors; 2. Revise Section 4.2 Chemical Feed to reflect the use of 6% sodium hypochlorite instead of 12%; 3. The Manual should be open-ended to allow for additions and amendments over time; 4. The Operations Manual should include contingency plans for all emergencies, including a list of emergency contacts. A contingency plan should be developed in case of a train derailment event in the vicinity of the Carp Supply / Treatment / Storage Works (STSW) facility; 5. The Operations Manual should be on-site and readily available to all Operators for quick reference; 6. The Operations Manual should include the procedure for determining the well draw-down manually; 7. A complete set of up-to-date record drawings should be kept o</p>
			Recommendations for Improvements / Corrections to Operational	<p>The Carp STSW is a clean facility that appears to be a well run and properly maintained. There is no indication that there has been any operational problems or concerns. The operator reported that he was not aware of any changes to the Operations Guidelines Manual. However, the following items are recommended for consideration to improve operational procedures.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommendations for Physical Improvements	Staffing: During the site visit, the operator advised that he was not completely conversant with all the details of the plant piping layout and configuration. It is recommended that all employees be familiar with the each facility they are assigned to. This may require additional training to understand the layout and operation of the facility. Staffing: Note: Additional 36 hours of training will be required every three (3) years as per new Ontario Drinking Water Standards (ODWS) in addition to the current 40 hours / year required training.
				Operation: The standby sodium hypochlorite pump at the Carp pumping station is a manually adjusted pump that is not paced to the flow. At some time in the future, as the flow approaches the ultimate peak and detention times are lower, consideration should be given to providing a standby pump that is automatically switched on in the event of failure of the duty pump. The operation of these pumps could also be alternated to reduce wear on one pump. This standby pump should be equipped with automatic flow pacing. It is recommended that continuous total chlorine residual monitor be converted to monitor for free chlorine residual. Maintenance of free chlorine residuals above 0.2 mg/L can be accomplished through changes to operational procedures (i.e. adjusting sodium hypochlorite dose) and free chlorine residual testing.
			Summary of Conclusions and Recommendations	This Section briefly highlights the main conclusions and recommendations of this report. For full explanations, refer to Sections 3, 4, 5, 6, and 7 of this report, and to Appendix B - Hydrogeologic Assessment Report. WESA did not observe any potential sources of microbiological contamination at the municipal wells. The hydrogeological report has identified nine potential sources of non-microbiological impact with two of these sites warranting long-term monitoring. The current monitoring wells appear too shallow in depth to penetrate through to the aquifer. WESA has recommended new monitoring wells be installed with enough depth to penetrate into the aquifer. WESA has also recommended the following: The source of THMs in MW95-1 be determined; The monitoring well south of the Fire Station should be sampled for hydrocarbons to ensure there were no impacts from the previously removed fuel tank; The monitoring well would of the Fire Station be properly sealed an abandoned after the above-mentioned sampling; The new aboveground storage tank should be fitted with a spill containment system; Documentation regarding the USTs removed in 1994 to determine soils conditions and whether or not there may be impacts from the previously removed USTs. Raw and treated water test results did not indicate any adverse microbiological results. All raw, treated and distribution samples from 1999 and 2000 tested negative for <i>E. coli</i> and fecal coliforms. Four samples from the distribution system had elevated HPC results exceeding the ODWS. Maintaining free chlorine residuals above the required 0.2 mg/L through maintenance of higher levels of total chlorine the occurrences of elevated HPC results may decrease. With the new regulations and resampling requirements to adverse test results, elevated HPC results will be easier to confirm. HPC tests should be monitored carefully as they may indicate a possible source of contamination in the distribution sample. There are several raw water parameters that exceed ODWS but these are mostly aesthetic parameters or parameters that affect the operation of the plant. No changes in treatment are recommended. It is recommended that total chlorine residual monitors be converted to continuous free chlorine residual monitors. A review of chlorine residuals of the treated water leaving the facility and in the distribution system indicates the changes to the disinfection system are needed to ensure the minimum free chlorine residual of 0.2 mg/L is maintained. Current sampling locations in the distribution system are too close to the plant. Sampling of the distribution system should be performed at the extremities of the distribution system to ensure that the minimum chlorine residual of 0.2 mg/L is maintained at all points in the distribution system. Operational changes (i.e. dose of sodium hypochlorite) may be required to maintain minimum free chlorine residuals. The following are other items that should be addressed as part of this report: Operating Manuals should undergo minor modifications as recommended in Section 5; Monitoring and sampling programs should be updated to reflect the new Regulations and Section 7 of this report; Staff should be familiar with the facilities and undergo appropriate training; The City of Ottawa may wish to consider registering a complaint under the Environmental Protection Act or Ontario Water Resources Act regarding the Co-op Feed Mill.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Carp River Watershed / Subwatershed Study	2004	MVCA (City of Ottawa)	Watershed Plan (WP) - Surface Water Management Plan	Program emphasis on reducing flooding impacts on agricultural lands through stream restoration, wetland / forest protection measures as described below. Wetland restoration and reforestation of non-productive farmland (Section 9.2.1.1)
			WP - SWMP - Erosion and Sediment Control	Stream restoration using natural channel design and engineered natural channel measures along 15.4 km of priority 1 tributaries and 13 km of priority 1 Carp River segments. Control livestock access restrictions and installation of alternate water sources on livestock operations in priority 1 subwatersheds and along priority 1 Carp River segments. Riparian zone plantings along 24.2 km of priority 1 tributaries and 9 km of priority 1 Carp River segments. Riparian zone plantings along 18.2 km of priority 2 streams. Implement conservation land management practices on about 4,500 ha of priority 1 and about 2,500 ha of priority 2 agricultural lands in priority 1 subwatersheds to reduce soil erosion. Reconstruction of roadside ditch systems to address erosion and sedimentation problems. Site specific erosion control measures (livestock access control, instream / roadside grade controls, streambank stabilization) in priority 2 streams.
			WP - SWMP - Surface Water Quality	Implement non-structural BMP's on all farmsteads on priority 1 and 2 agricultural lands, beginning with those operations contributing directly to priority 1 and 2 watercourses and priority 1 Carp River segments (approximately 50 farms). Implement structural BMP's on all farmsteads contributing directly to priority 1 watercourses and priority 1 Carp River segments (approximately 20 farms).
			WP - Groundwater Management Plan (GMP)	Integrate groundwater management recommendations into the City's Groundwater Management Strategy (2003) Initiate a septic system inspection program and repair / replace faulty systems. Implement Rural BMP's on agricultural lands in high / moderate recharge (priority 1 and 2 agricultural areas). Develop a more detailed record of actual water takings from surface and groundwater supplies. Require hydrogeological investigations for land development proposals (MOE Guideline D5-5).
			WP - Greenland Plan (GP) - Terrestrial	Protect all Category 1 features - Centres of Ecological Significance, Candidate ANSI's, woodlands and wetlands in high recharge areas, riparian corridors (see detailed description in 9.2.3.2). Include centres of ecological significant in City Acquisition Plan. Conduct EIS on all Category 2 features (see detailed description in 9.2.3.2) - woodlands contiguous with Level 1/2 riparian corridors, features in low / moderate recharge, adjacent lands (30 or 120 m setbacks) - applies only to development applications. Undertake a stewardship / education program to promote protection and regeneration of Category 1 areas to a natural state (see detailed description of Category 3 areas in 9.2.3.2). Undertake a stewardship / education program to promote protection and regeneration of Centres of Ecological Significance.
			WP - GP - Stream and Valley Corridor System	Protect valley and stream corridors adjacent to all classified streams including intermittent watercourses through Official Plan Policies Conservation Authority Act, Fisheries Act and other tools to ensure their protection as land use change occurs. Implement a stewardship program to encourage buffer plantings adjacent to all classified streams to reduce sediment loadings to streams.
			WP - GP - Recreation	Develop Recreational trail system plan and implementation strategy for the Carp River Corridor and connections.
			Subwatershed Plan (SP) - SWMP - Flood Control	Implement modified floodplain policy along the upper Carp from Glen Cairn pond to Richardson Side Road. Undertake Floodplain Mapping for Carp River, Poole Creek, and Feedmill Creek downstream of Highway 417.
			SP - SWMP - Erosion and Sediment Control	Carp River Corridor Plan: Restore upper Carp River to riverine wetland with floodplain features and recreational trail system (approximately 5000 m).

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Protect stream corridors along Carp (100 m), Poole (80 m) (downstream of Hazeldean Road) and Feedmill (70 m) downstream of Queensway.
				Implement riparian planting along 2,000 m of Feedmill Creek and 5,000 m of Poole Creek as per riparian corridor targets (75% of the corridor vegetated with woody species).
				Implement natural channel design restoration for designated reaches of Poole and Feedmill (approximately 1,000 m).
				Implement GREE design restoration for designated reaches of Poole (approximately 800 m).
				Restore lower reaches of Poole and Feedmill Creek to riparian wetland systems contiguous with Carp River corridor plan (approximately 1,000 m)
				Implement source control measures.
			SP - SWMP - Surface Water Quality	Centralized stormwater management facilities within Kanata West (Options 1 or 2) must meet water quality and runoff targets.
			SP - GMP	Prepare a groundwater characterization study on a subwatershed wide basis to determine groundwater gradients and divides, to preserve groundwater discharge (baseflow), to access feasibility of infiltration-based Stormwater management of BMPs and to maintain a pre-development water balance
			SP - GP - Terrestrial	Protect all Category 1 features (see detailed description in Section 9.4.3) - Centres of Ecological Significance, Candidate ANSI's, woodlands and wetlands in high recharge areas, riparian corridors include centres of ecological significance in City Acquisition Program.
				Conduct EIS on all Category 2 features (see detailed description in 8.4.3) - natural features contiguous with Category 1 areas features in low / moderate recharge, adjacent lands (30 or 120 m trigger).
SP - GP - Stream Valley Corridor System	A stewardship / education program to promote protection and regeneration of Category 3 areas (see detailed description in Section 8.4.3) to a natural state. A stewardship / education to promote protection and habitat enhancement within Category 1 areas.			
	Protect valley and stream corridors along upper Carp, Poole and Feedmill Creeks (See Section 9.4.2). Dedicate stream corridors in public ownership through the development review process.			
	Review current aggregate operations in Feedmill headwaters and review opportunities to augment baseflows in both Feedmill and Poole. Confirm that rehabilitation plan devotes restoring significant lands to natural state.			
SP - GP - Recreation	Maintain key functions of valley and stream corridors in Halzeldean and unnamed tributaries.			
				Recreational trail system.
Carp Road Corridor - Groundwater Study	2004	MVCA (City of Ottawa)	Recommendations	<p>A performance zoning approach is recommended for new commercial and industrial land development. The proponent would be required to demonstrate that the proposed development will not impact groundwater from both a quality and quantity perspective prior to approval being granted. Refer to section 8.1.6. Elements of the proponent's proposal for development may include: a detailed assessment of the site's hydrogeologic characteristics, the design of protection engineering systems to reduce the risk of chemical discharges, identification and abandonment of unused wells, the design of a groundwater monitoring system, establishment of a spill response plan, plans to encourage natural infiltration and possible bonding to cover future environmental clean-up efforts.</p> <p>For existing land uses, it is recommended that mitigation actions be primarily through voluntary mechanisms including: promotion of Best Management Practices to agriculture, commerce and industry, education of the public to aquifer sensitivities, development of incentive programs to reduce contamination risk, and the review of road salting practices in the area to reduce salt loading to the aquifers.</p> <p>For development of new subdivisions, a hydrogeologic assessment should be performed to City standards. For development by consent, neighbouring wells should be sampled and favourable chemistry results be obtained.</p> <p>It is recommended that the Carp Road Corridor Groundwater Study be updated every 5 years. The update should include groundwater quality assessment through sampling, a groundwater use assessment, and a review of the Carp Road Corridor design plan and applicable zoning bylaws to ensure that the environment can continue to support further development on private services.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Agricultural Resource Area (Area A) - Recommendations for New Development	<p>The area near the intersection of March Road and Carp Road is within the 10 to 25 year time of travel well head protection zone for the Carp Village municipal wells (See Figure 2). New land uses in this area should be restricted to those permitted in the Well Head Protection Area to be identified in the City's new zoning bylaw in 2006.</p> <p>Naturally elevated iron and sulphide levels are common in Area A and therefore, water treatment may be required for new development. A list of suitable water treatment technologies for iron and sulphide problems are listed in Table 8.1 and Table 8.2.</p>
			Marginal Resource Area (Area B & C) - Recommendations for New Development	<p>New residential development is limited primarily to country lot subdivisions. As stated in the City of Ottawa Official Plan, all development will be based on a hydrogeological study and terrain analysis. It is expected that hydrogeological studies in support of subdivision applications may indicate that larger lot sizes are required in the low and high infiltration areas, as depicted in Figure 6, and shallow bedrock areas as depicted in Figure 3. The City's Official Plan states that the minimum lot size shall be 0.8 hectares but studies may indicate the requirement for larger lots (Section 3.7.2).</p> <p>Area B is down gradient (down flow) from the commercial and industrial land uses that are allowed in Area D and Area E. Currently, there is no evidence of widespread impacts to Area B from these upgradient land uses based on the sampling program. Future residential development in Area B, and their supporting technical studies, should have regard to the commercial and industrial land uses that are allowed in Areas D and E.</p> <p>For development by consent in the absence of a detailed hydrogeological investigation, favourable well water quality results from adjoining properties would be required.</p> <p>Naturally elevated iron and sulphide levels are common in Area B and Area C, and therefore, water treatment may be required for new development. A list of suitable water treatment technologies for iron and sulphide problems are listed in Table 8.1 and Table 8.2.</p>
			Highway Commercial Area (Area D) - Recommendations for New Development	<p>New commercial / industrial development should have regard to the land use activities downgradient of Area D, in particular Area A and Area B. It is recommended that mitigation measures be used in new development to ensure that handling / storage of hazardous chemicals is performed in a proper fashion to reduce the risk of spillage and impacts to the groundwater system.</p> <p>Land along Carp Road, either side of McGee Side Road, has been identified as a locally significant recharge zone (See Figure 7), where both downward hydraulic gradients exist and permeable materials are present at surface. It is recommended that future development minimize reduction of groundwater infiltration in this area.</p> <p>Naturally elevated iron and sulphide levels are common in Area D and therefore, water treatment may be required for new development. A list of suitable water treatment technologies for iron and sulphide problems are listed in Table 8.1 and Table 8.2.</p>
			Light Industrial Area (Area E) - Recommendations for New Development	<p>It is recommended that mitigation measures be used in new development to ensure that handling / storage of hazardous chemicals is performed in a proper fashion to reduce the risk of spillage and impacts to the groundwater system. The City should promote the enforcement of existing environmental regulations.</p> <p>Area E is mapped as being primarily in a groundwater recharge environment where aquifer vulnerability is moderate to high. New commercial / industrial development should have regard to the downgradient land use activities in Area B. As a result, any development should consider mitigation activities to ensure that the aquifer is not being impacted, especially considering that residential land uses (Area B) are present downgradient. The City should promote enforcement of existing environmental regulations.</p> <p>Naturally elevated iron, sulphide and chloride levels are common in Area E, and therefore, water treatment may be required for new development. A list of suitable water treatment technologies for iron and sulphide problems are listed in Table 8.1 and Table 8.2. Treatment of chloride impacts is more difficult; however, reverse osmosis will reduce concentrations.</p>
			Heavy and Light Industrial Area (Area F) - Recommendations for New Development	<p>It is recommended that mitigation measures be used in new development to ensure that handling / storage of hazardous chemicals is performed in a proper fashion to reduce the risk of spillage and impacts to the groundwater system. The City should promote the enforcement of existing environmental regulations.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The area along Carp Road, south of Highway 417, has been identified as a locally significant recharge zone (See Figure 7), where both downward hydraulic gradients and permeable materials exist at surface. It is recommended that future development minimize reduction of infiltration in this area.</p> <p>The non-health related water quality parameters of sulphide, chloride and sodium in Area F are elevated. Sulphide concentrations are naturally high in the bedrock aquifer. Elevated chloride and sodium concentrations are attributed to a combination of possible naturally high concentrations in the aquifer and road salt impacts. Treatment technologies to improve water quality for these parameters are presented in Table 8.1 and Table 8.2. Treatment of chloride impacts is more difficult; however, reverse osmosis will reduce concentrations.</p> <p>Total coliform concentrations were detected in excess of the Ontario Drinking Water Standards in 25% of the sampled wells. The increased frequency may be attributed to the shallow bedrock and higher aquifer vulnerability. Treatment technologies that are effective at removing total coliforms in the water supply are presented in Table 8.1 and Table 8.2.</p>
			Areas D, E & F - Approach for Commercial / Industrial Development	<p>Prior to the approval of new land uses with the potential to contaminate groundwater, the City should require detailed management plans to minimize the risk to the groundwater. The proposal should have some or all of the following elements:</p> <p>Characterization of site aquifer characteristics, potential contaminant pathways and receptors, a presence of significant aquifer recharge zones. The potential risk to each receptor in terms of water quality and quantity impacts should be assessed.</p> <p>Design of engineered systems to ensure protection of the aquifer from chemical releases (e.g., double walled tanks, lined areas, corrosion protection, spill containment, leak detection). Ensure that provincial requirements for installation, registration, upgrading or removal of tanks are being followed.</p> <p>Limits to the development of large impervious surfaces in identified locally significant recharge areas to encourage artificial recharge (parts of Area D and Area F, see Figures 6 and 7).</p> <p>Development of hazardous material handling and spill management protocols.</p> <p>Groundwater monitoring system for early detection of impacts including the installation of sentry monitoring wells near contaminant sources and downgradient of land uses with potential risks.</p> <p>Spill response plan for handling unforeseen accidents within an area.</p> <p>Ecosystem enhancement, such as the development of new wetlands where existing ones are disturbed, or the re-establishment of natural recharge potential in areas where groundwater recharge has significantly deteriorated due to development.</p> <p>Bonding posted by the proponent to cover future environmental clean-up efforts.</p>
			General Recommendations for New Development - Wells and	<p>Increase enforcement of existing well construction regulations through municipal involvement in well inspection.</p> <p>Require more stringent well construction protocols. Wells should be cased at least 10 m below ground, and for bedrock wells the casing should penetrate at least 2 m into bedrock where the aquifer has been mapped as moderate to high vulnerability (see Figure 8) unless hydrogeologic studies indicate otherwise.</p> <p>Require that all wells be drilled (i.e. no bored or sand point wells).</p> <p>Identify and abandon unused wells prior to development. The municipality could require proof of proper abandonment of unused water wells, monitor wells or boreholes as a condition of development approval.</p> <p>Require a hydrogeological assessment to City standards by a licensed professional of all new subdivision development prior to approval. The study should assess potential interference on neighbouring wells from a quality and quantity perspective and comment on risk of impacts from adjacent properties. Study should include sampling of nearby wells and recommend minimum lot sizes, the configuration of the leaching bed relative to on-site and neighbouring water wells, and provide specifications for well construction.</p> <p>Determine if more restrictive septic tile bed specifications are needed over and above Building Code requirements through the undertaking of a detailed hydrogeological assessment.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				For development by consent, neighbouring wells should be sampled and favourable chemical testing results obtained. In general, the concentration of developments by consent should not be greater than 5 lots in a 5 hectare area.
				Require each development identify a spare leaching bed.
				Development on marginal terrain should be conducted in phases, with proof of favourable operation of earlier phases being required prior to approving latter phases.
				Prohibit development on private septic systems where native soil cover is <0.3 m in depth.
			General Recommendations for New Development - Fuel	Use municipal powers related to development approvals and servicing to ensure that the provincial requirements are being followed.
				Municipalities could require proof of proper installation, registration, upgrading or removal of any storage tanks as a condition of development approval.
			General Recommendations for Existing Development	Promote proactive Best Management Practices (BMPs) and educate existing landowners of the sensitivity of the aquifers to environmental threats. In Area D, focus should be placed on land uses that potentially handle or store hazardous materials such as the retail fuel outlet, excavating contractor, auto sales company, equipment manufacturer, printing company and machine shop. In Area E, focus should be placed on equipment manufacturers, service station maintenance, concrete forming company, sanitation service business, and the auto sales business. In Area F, BMP initiatives should be directed to the quarry operations, repair shops, equipment storage yards, manufacturers, and gasoline station. Some of the key BMPs that should be promoted include waste management, spill protocols and fuel / chemical storage and management.
				Educate the general public and businesses on the need to protect groundwater.
				Develop incentive programs to reduce contamination risks such as funding abandonment of unused wells, removal of storage tanks, etc.
				Review road salting practices in co-ordination with the Ministry of Transportation in an effort to minimize salt application quantities. High road salting activities along Carp Road and the Highway 417 / Carp Road intersection may have caused chloride and sodium contamination to the groundwater.
				Control of land practices in agricultural zoned areas (e.g. Area A) as it relates to nutrient management is primarily controlled by the Nutrient Management Act and associated regulations. Additional controls that the City can enact are limited. The City may best protect the groundwater resource by promoting BMPs in conjunction with other stakeholders such as the Ontario Federation of
			Recommendations for Existing Development - Water Quality and Treatment	All of the water quality problems encountered during the sampling program are treatable. Table 8.1 provides instructions to private well owners about some of the common water quality problems experienced in the Carp Road Corridor. A summary of common treatment technologies for private well systems, also developed by the Ministry of Health, is reprinted as Table 8.2.
			Recommendations for Existing Development - Large Water Takings	For the Carp Road Corridor, it is recommended that the City ask the Ministry of Environment to seek the municipality's comments on Permit to Take Water applications. The City should ensure that the proponent has assessed, to the City's satisfaction, the risks that the taking has to water levels in the aquifer or sensitive receptors such as Huntley Creek. A hydrogeologist should perform the evaluation. Aspects that should be evaluated include the risk of aquifer dewatering, reductions to base flow of surface water streams, potential interference with neighbouring wells, record keeping protocols and adequacy of monitoring programs.
City of Ottawa, Britannia Water Purification Plant Engineer's Report	2001	RVCA (City of Ottawa)	Microbiological Contamination - Summary of Recommendations	The following is a summary of the recommendations to mitigate the potential for microbiological contamination at the Britannia Water Purification Plant (WPP).
				A backflow preventer should be installed at the main in-plant service water connection.
				Accesses to the clearwell should only be opened when the clearwell is out of service and appropriate disinfection procedures must be followed when returning the clearwell to service.



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Maintenance work in the treated water system should be done by certified operators familiar with the precautions necessary to minimize the entry of contaminants into the system and the procedures to disinfect the system properly when returning it to service.
			Operations Procedures - Summary of Recommendations	The operations manual should be updated to meet the operational guidelines as outlined in Section 6.1.
			Physical Works - Summary of Recommendations	Chlorination Procedures - The following recommendations are made to provide for meeting the requirements of Procedure B13-3: Study and implement modifications to the WPP facility and / or process to achieve a 4-log removal / inactivation of <i>Giardia</i> cysts and a 5-log removal / inactivation of viruses at the plant design flow. This study should also investigate at the same time the increased potential for the formation of disinfection by-products resulting from the need to achieve the stated log inactivations; Provide sufficient combined chlorine residual leaving the WPP to maintain a combined chlorine residual of 1.0 mg/L at all points in the distribution system.  Ten State Standards - In addition to the above, the following modifications should be made to the Britannia WPP to comply with these guidelines: Modify the plant to provide for feeding disinfectant to the settled water and the filtered water. Study this requirement in conjunction with the study in Section 9.3.1.  Other Regulations - The City should study and implement the necessary modifications to the backwash and wastewater disposal system to meet the requirements for discharging to a receiving water body as prescribed by the document entitled "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment".
			Monitoring Program - Summary of Recommendations	The monitoring program for the entire water works to ensure compliance with the Ontario Drinking Water Standards (ODWS) and the Regulation (459/00) as outlined in Section 8.0 should be implemented.
City of Ottawa, Lemieux Island Water Purification Plant Engineer's Report	2001	RVCA (City of Ottawa)	Microbiological Contamination - Summary of Recommendations	The following is a summary of the recommendations to mitigate the potential for microbiological contamination at the Lemieux Island Water Purification Plant (WPP).  A backflow preventer should be installed at the main in-plant service water connection.  Accesses to the clearwell should only be opened when the clearwell is out of service and appropriate disinfection procedures must be followed when returning the clearwell to service.  Maintenance work in the treated water system should be done by certified operators familiar with the precautions necessary to minimize the entry of contaminants into the system and the procedures to disinfect the system properly when returning it to service.
			Operations Procedures - Summary of Recommendations	The operations manual should be updated to meet the operational guidelines as outlined in Section 6.1.
			Physical Works - Summary of Recommendations	Chlorination Procedures - The following recommendations are made to provide for meeting the requirements of Procedure B13-3: Study and implement modifications to the WPP facility and / or process to achieve a 4-log removal / inactivation of <i>Giardia</i> cysts and a 5-log removal / inactivation of viruses at the plant design flow. This study should also investigate at the same time the increased potential for the formation of disinfection by-products resulting from the need to achieve the stated log inactivations; Provide sufficient combined chlorine residual leaving the WPP to maintain a combined chlorine residual of 1.0 mg/L at all points in the distribution system.  Ten State Standards - In addition to the above, the following modifications should be made to the Lemieux Island WPP to comply with these guidelines: Modify the plant to provide for feeding disinfectant to the settled water and the filtered water. Study this requirement in conjunction with the study in Section 9.3.1; Install curbs around the filters to prevent floor drainage flowing to the filters.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation		
				Other Regulations - The City should study and implement the necessary modifications to the backwash and wastewater disposal system to meet the requirements for discharging to a receiving water body as prescribed by the document entitled "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment".		
			Monitoring Program - Summary of Recommendations	The monitoring program for the entire water works to ensure compliance with the Ontario Drinking Water Standards (ODWS) and the Regulation (459/00) as outlined in Section 8.0 should be implemented.		
City of Ottawa, Munster Hamlet Communal Well System Engineer's Report	2001	RVCA (City of Ottawa)	Microbiological Contamination - Summary of Recommendations	The following is a summary of the recommendations to mitigate the potential for microbiological contamination at the Munster Hamlet Supply / Treatment / Storage Works (STSW).  Provide a water tight seal between the well casing and the floor in the well buildings for each well. Implement the well head protection measures as outlined in Section 4.3.1. Accesses to the reservoirs should only be opened when the reservoir cell is out of service and appropriate disinfection procedures must be followed when returning a reservoir cell to services. Maintenance work on the treated water system should only be done by certified operators.		
			Raw Water Source - Summary of Recommendations	See section 9.1.1 above (water tight seal). In addition to the recommendations in Section 9.1.1, a hydrogeological evaluation of Well No. 2 to study the problems with the elevated turbidity levels should be conducted and solutions implemented before returning the well to regular service.		
			Operations Procedures - Summary of Recommendations	An operations manual should be prepared to meet the operational guidelines as outlined in Section 6.1.		
			Physical Works - Summary of Recommendations	Chlorination Procedures - No modifications are required in the system to achieve the Chlorination Procedures standards.  Ten State Standards - The following modifications should be made to the Munster Hamlet STSW to comply with the standards: Make provisions to feed sodium hypochlorite to water entering the distribution system; Provide valves on the sodium hypochlorite solution tank drains.		
			Monitoring Program - Summary of Recommendations	The monitoring program for the entire water works to ensure compliance with the Ontario Drinking Water Standards (ODWS) and the Regulation (459/00) as outlined in Section 8 should be implemented.		
City Stream Watch - 2003 Annual Report	2003	MVCA & RVCA (City of Ottawa)	Recommendations	It is important that City Stream Watch be sustained in order to inform, involve, and educate community residents of the state of urban creeks and streams, as well as to encourage restoration projects and sound stewardship practices. To this end, the City Stream Watch program should further build on the successes achieved during its first year. Through its ongoing implementation, temporal and spatial environmental trends of creeks in the Ottawa area may be observed and recorded. The data will complement work conducted by a few municipal and regional programs, most of which do not sample the smaller urban streams that is the focus of this program. As well, the intrinsic values of community based environmental monitoring, such as community involvement and social capital, will be further developed.  The following are recommendations to improve the program.  The Community: Continue to develop creative means in order to contact, as well as insure the involvement and ongoing interest of, all concerned members of the community; Continue collaboration with the Ottawa RiverKeeper to maximize community involvement and stream assessment; Begin contacting community earlier in the year to maximize both the involvement and the diversity of participants; Foster relationships with high school groups and clubs (i.e. environmental, geography, biology) to facilitate student involvement; Continue to insure that the needs of the participating community are satisfied as they relate to their continued involvement in the program.		

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Environmental Monitoring: Consider altering the macro stream assessment protocol from sampling 100-meter sections of stream to 50-meter sections of stream. This will improve the accuracy and precision of the data collected, as well as the ease in which volunteers can interpret and categorize existing stream conditions; Reduce sampling to three creeks per season in order to ensure that each creek is sampled in its entirety; Consider hiring a student to fill an assistant position to assist the coordinator. The student would assist community volunteers with sampling, allowing the coordinator to concentrate more on community outreach and volunteer recruitment.</p> <p>In addition, opportunities for the creation of several independent projects were identified as a result of the completion of the macro stream assessment forms during the 2003 season.</p> <p>Action - A well-organized project could be undertaken to facilitate the proper and safe collection, removal, and disposal of garbage from each of the four creeks.</p> <p>Action - A stewardship activity could be initiated to restrict cattle from Mud Creek in sections 36 and 37.</p> <p>Action - A project could be undertaken to restore riparian vegetation, and consequently improve bank stability and reduce erosion of sediment, through replanting of native flora in sections of stream where high levels of bank instability occur.</p>
City Stream Watch - 2004 Annual Report	2004	MVCA & RVCA (City of Ottawa)	<p>Recommendations</p> <p>Program Improvement - Recommendations</p> <p>Special Projects - Recommendations</p>	<p>It is important that City Stream Watch be sustained in order to inform, involve, and educate community residents of the state of urban creeks and streams, as well as to encourage restoration projects and sound stewardship practices. To this end, the City Stream Watch program should further build on the successes achieved during its first two years. Through its ongoing implementation, temporal and spatial environmental trends of creeks in the Ottawa area may be observed and recorded. The data will complement work conducted by a few municipal and regional programs, most of which do not sample the smaller urban streams that is the focus of this program. As well, the intrinsic values of community based environmental monitoring, such as community involvement and social capital, will be further developed.</p> <p>The following are recommendations to improve the program: Continue to develop creative means in order to contact, as well as insure the involvement and ongoing interest of, all concerned members of the community; Continue collaboration with other community groups, such as the Ottawa RiverKeeper and the National Defence Headquarters Fish and Game Club, to maximize community involvement, stream monitoring, and habitat restoration; Continue contacting community early in the year to maximize both the involvement and the diversity of participants; Foster relationships with environmentally oriented groups (i.e. The Sierra Club, Scouts Canada) to facilitate student involvement; Develop a more aggressive approach to youth recruitment to entice educators and students to participate in the program; Continue to insure that the needs of the participating community are satisfied as they related to their continued involvement in the program; Complete the creeks that have not been entirely sampled as of November 2004.</p> <p>The following are projects that have been developed from information obtained through monitoring, and could be implemented through City Stream Watch or other community based environmental initiatives.</p> <p>Location - The mouth of Sawmill Creek where it empties into the Rideau River near Billings Estate just east of the corner of Bank Street and Riverside Drive. Approximately 150 m section of creek not including infrastructure. Issue - The rock rubble that was used to armour the banks has proven to be incompetent due to the steepness of the slope and high flow rates. The banks are exposed and undercut, and much of the geotextile has been removed by flows and is positioned in the channel bed or is exposed. The resulting excavation and deposition of the silty clay material from the banks is causing the deterioration of walleye spawning habitat at the mouth of the creek, which was created as compensation for a past project on Sawmill Creek.</p> <p>Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this rehabilitation effort. A combination of several bioengineering systems (live staking, live fascines, bare root shrubs, coco matting, brush mats) should be applied to re-stabilize the slope. Due to periodic high velocity flows, the toe of the slope requires protection against undercutting and resultant slumping of the existing rock rubble on the steep banks. Expected Results - Effective streambank protection from erosion; Community involvement and ownership; Reduce siltation of existing walleye spawning habitat; The enhancement of conditions for natural colonization of existing plant community; Produce streamside fish and wildlife habitat; Reduction of sediment that negatively impacts benthic invertebrate community; Overall net gain for the aquatic community.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Location - Many locations along Sawmill Creek and Bilberry Creek. Issue - The accumulation of garbage and refuse at various sites along both creeks. This has resulted in the degradation of fish and wildlife habitat, the deterioration of water quality, and the deterioration of both creek's aesthetic appeal. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this rehabilitation effort. Community clean-up days should be organized on both creeks to facilitate the safe and proper removal of human produced material from the creek bed and riparian zones. Natural material should be left undisturbed. Expected Results - Community involvement and ownership; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.</p> <p>Location - The mouth of Bilberry Creek where it empties into the Ottawa River. Issue - A lack of shallow back water areas suitable for spawning and nursery habitat for certain fish species (yellow perch, northern pike and muskellunge). Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this rehabilitation effort. Construct a small embayment off the main creek channel, creating additional aquatic habitat (including but not limited to fish spawning and nursery habitat). Expected Results - Community involvement and ownership; Enhancement of aquatic habitat, in particular yellow perch, northern pike, and muskellunge spawning and nursery habitat; Creation of quality habitat for amphibians.</p> <p>Location - Locations along Stillwater Creek and Bilberry Creek. Issue - Un-vegetated unstable banks along both creeks. As a result, the excavation of material from the banks and deposition of this material in the stream bed are having negative impacts on fish habitat and the benthic invertebrate community. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this rehabilitation effort. Many opportunities exist for the facilitation of a combination of bioengineering techniques and riparian plantings. Expected Results - Community involvement and ownership; Creation of additional sensitive fish habitat; Enhancement of the creek's aesthetic qualities.</p>
City Stream Watch - 2005 Annual Report	2005	MVCA & RVCA (City of Ottawa)	<p>Recommendations</p> <p>Program Improvement - Recommendations</p> <p>Special Projects - Recommendations</p>	<p>It is important that City Stream Watch be sustained in order to inform, involve, and educate community residents of the state of urban creeks and streams, as well as to encourage restoration projects and sound stewardship practices. To this end, the City Stream Watch program should further build on the successes achieved during its first three years. Through its ongoing implementation, temporal and spatial environmental trends of creeks in the Ottawa area may be observed and recorded. The data will complement work conducted by a few municipal and watershed-based programs, most of which do not sample the smaller urban streams that are the focus of this program. As well, the intrinsic values of community based environmental monitoring, such as community involvement and social capital, will be further developed.</p> <p>The following are recommendations to improve the program: Continue to develop creative means in order to contact, as well as ensure, the involvement and ongoing interest of all concerned members of the community; Continue contacting community early in the year to maximize both the involvement and the diversity of participants; Foster relationships with environmentally oriented groups (i.e. The Sierra Club, Scouts Canada) to facilitate student involvement; Continue to run stream cleanups on city streams to enhance fish and wildlife habitat and maintain the natural beauty of our city's streams; Develop a more aggressive approach to youth recruitment to entice educators and high school students to participate in the program. Hours of participation can be counted toward the student's volunteer hours to graduate; Develop new, creative projects to keep volunteer interest high; Continue to insure that the needs of the participating community are satisfied as they relate to their continued involvement in the program; Attract funding opportunities from outside funders for the program and rehabilitation programs;</p> <p>The following are recommendations to improve the program: Develop relationships with universities to attract students to participate to gain experience.</p> <p>The following are projects that have been developed from information obtained through monitoring, and could be implemented through City Stream Watch or other community based environmental initiatives.</p> <p>Location - The mouth of Sawmill Creek where it empties into the Rideau River near Billings Estate just east of the corner of Bank Street and Riverside Drive. Approximately 150 m section of creek not including infrastructure. Issue - The rock rubble that was used to armour the banks has failed at this site. The banks have failed and much of the geotextile has been left exposed. The resulting erosion and deposition of the silty clay material from the banks is causing the deterioration of walleye spawning habitat at the mouth of the creek.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this rehabilitation effort. A combination of several bioengineering systems (live staking, live fascines and bare root shrubs) should be applied along the slope. The toe of the slope requires protection against undermining and resultant slumping with appropriate sized rock rubble due to flashy flows. Expected Results - Effective streambank protection from erosion; Community involvement; Reduce siltation of existing walleye spawning habitat; The enhancement of conditions for natural colonization of existing plant community; Produce streamside fish and wildlife habitat.</p>
				<p>Location - Sawmill Creek just north of Heron Park Community Centre (Heron Rd.). One failed bank as well as three bank slumps upstream. Issue - Phase II - The planting site on Sawmill Creek hopes to further rehabilitate a failed bank on the east side of the stream just north of Heron Rd. Phase I was carried out in May of 2005 in hopes to stabilize bank. The lower sections of bank, close to the stream did well throughout the growing season although the higher portions did not due to dry conditions. In May of 2006 we will plant more vegetation on the top section of the bank failure as well as fill in necessary sections in the lower section that may have been wiped out due to spring flows. Three additional bank slumps have been identified upstream and will be planted in the Phase II rehabilitation project.</p>
				<p>Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and residents from the Heron Park area to participate in this rehabilitation effort. Interested members can monitor progress of areas planted and report back to the coordinator with updates. Expected Results - Promote community involvement in rehabilitation projects; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities; Erosion control.</p>
				<p>Location - Graham Creek shoreline in between Acres Rd. and Carling Ave. Issue - High water is eroding banks causing them to fail resulting in trees falling into stream. Landowners are worried that stream erosion may encroach on their land. Remediation Strategy Utilize existing volunteer base of the City Stream Watch program to participate in this effort. Plant shrubs and trees to stabilize banks to help stop erosion. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Reduce erosion of banks Eliminate possibility of bank failure causing tree collapse into stream.</p>
				<p>Location - Many sections of Sawmill Creek (South Keys Shopping Area of primary concern). Issue - The accumulation of garbage and refuse along various stretches of Sawmill Creek is an ongoing problem. Not only does man made pollution take away from the aesthetic quality of the stream but it limits and degrades fish and wildlife habitat. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this cleanup effort. Sawmill Creek cleanup days should be carried out in the summer and fall to facilitate the proper removal of garbage and to rid the stream and riparian areas of pollution of human origin. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.</p>
				<p>Location - Graham Creek at Andrew Haydon Park. On right bank just downstream from bridge. Issue - High water is eroding banks causing banks to fail and trees to fall into stream. Siltation can be affecting fish spawning and nursery habitat. Remediation Strategy Utilize existing volunteer base of the City Stream Watch program and recruit volunteers from neighbouring communities to participate in this rehabilitation effort. Expected Results - Community involvement; Effective stream bank protection; Reduce siltation of fish spawning habitat; The enhancement of conditions for natural colonization of existing plant community; Produce streamside wildlife habitat.</p>
				<p>Location - Greens and Graham Creeks. Issue - Frequency of litter on these two systems is high. Though not a lot of pollution is present, many sections have plastic bags and other small items in them. Walk along cleanups involve members of the community walking certain stretches of stream with garbage bags and removing items such as bags, styrofoam, lumber, bottles etc. to rid the stream of human oriented debris. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and recruit volunteers from the communities around the streams to participate in this cleanup effort. The goal would be to facilitate the proper removal of garbage and to rid the stream of garbage and to rid the stream and riparian areas of (man made) pollution. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Location - Stevens Creek at North Gower. Issue - Stevens Creek is a natural flowing creek although some sections would benefit from a weekend cleanup. The stretches which contain pollution are in and downstream of North Gower. Items observed were tires, plastic bags and bottles, styrofoam and buckets. Remediation Strategy - Recruit volunteers from the communities around North Gower to participate in this cleanup effort. Stevens Creek cleanup could be completed on a weekend in the fall when the water levels are low. The goal would be to facilitate the proper removal of garbage and to rid the stream and riparian areas of (man made) pollution. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.
City Stream Watch - 2006 Annual Report	2006	MVCA & RVCA (City of Ottawa)	Recommendations	It is important that City Stream Watch be sustained in order to inform, involve, and educate community residents of the state of urban creeks and streams, as well as to encourage restoration projects and sound stewardship practices. To this end, the City Stream Watch program should further build on the successes achieved during its first four years. Through its ongoing implementation, temporal and spatial environmental trends of creeks in the Ottawa area may be observed and recorded. The data will complement work conducted by a few municipal and watershed-based programs, most of which do not sample the smaller urban streams that are the focus of this program. As well, the intrinsic values of community based environmental monitoring, such as community involvement and social capital, will be further developed.
			Program Improvement - Recommendations	The following are recommendations to improve the program: Continue to develop creative means in order to contact, as well as ensure, the involvement and ongoing interest of all concerned members of the community; Employ a summer student to help with fieldwork and allow more flexibility to match volunteer schedules; Recruit assistance from universities to help with the program; Continue contacting community early in the year to maximize both the involvement and the diversity of participants; Foster relationships with environmentally oriented groups (i.e. The Sierra Club, Scouts Canada) to facilitate student involvement; Continue to run stream cleanups on city streams to enhance fish and wildlife habitat and maintain the natural beauty of our city's streams; Develop a more aggressive approach to youth recruitment to entice educators and high school students to participate in the program. Hours of participation can be counted toward the student's volunteer hours to graduate; Develop new, creative projects to keep volunteer interest high; Continue to ensure that the needs of the participating community are satisfied as they relate to their continued
			Special Projects - Recommendations	The following are recommendations to improve the program: Attract funding opportunities from outside funders for the program and rehabilitation programs; Develop relationships with universities and colleges to attract students to participate to gain experience; Enhance participation for existing and new potential collaborative partners.
				The following are projects that have been developed from information obtained through monitoring, and could be implemented through City Stream Watch or other community based environmental initiatives.
				Location - Graham Creek shoreline in between Acres Rd. and Carling Ave. Issue - High water is eroding banks causing them to fail resulting in trees falling into stream. Landowners are worried that stream erosion may encroach on their land. Bioengineering work may take place in 2007. This could be a possible planting initiative after construction work is completed. Work would be best completed in spring of 2008. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this effort. Plant shrubs and trees to stabilize banks to help stop erosion. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Reduce erosion of banks; Eliminate possibility of bank failure causing tree collapse into stream.
				Location - Sawmill Creek - just north of Heron Park Community Centre (Heron Road). Issue - A bank failure just upstream of the Phase II planting site on Sawmill Creek is an area of concern. The bank failure has caused many trees to fall into the stream causing blockages as well as a considerable amount of siltation. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and residents from the Heron Park area to participate in this rehabilitation effort. Interested members can monitor progress of areas planted and report back to the coordinator with updates. Expected Results - Promote community involvement in rehabilitation projects; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities; Erosion control.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Location - Sawmill Creek - just north of Hunt Club Road. Issue - Woody debris has accumulated at an abandoned culvert on Sawmill Creek. The wood has dammed up the stream pooling water above the abandoned culvert resulting in a channel restriction impacting flow. This has caused the stream to alter its course, creating an erosion and siltation problem. Secondly a cement wall has failed (as seen in the picture) creating a flow deflector, which is severely eroding the east bank. Remediation Strategy - Examine ways and obtain partners to remove the abandoned culvert. Utilize existing volunteer base of the City Stream Watch program to participate in this effort. Plant shrubs and trees to stabilize banks to help stop erosion. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Reduce erosion of banks; Eliminate possibility of bank failure causing tree collapse into stream; Improve natural flow conditions; Remove potential fish barrier.</p>
				<p>Location - Many sections of Sawmill Creek (South Keys Shopping Area of primary concern). Issue - The accumulation of garbage and refuse along various stretches of Sawmill Creek is an ongoing problem. Not only does man made pollution take away from the aesthetic quality of the stream but it limits and degrades fish and wildlife habitat. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program to participate in this cleanup effort. Sawmill Creek cleanup days should be carried out in the summer and fall to properly remove garbage and rid the stream and riparian areas of pollution of human origin. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.</p>
				<p>Location - Graham Creek at Andrew Haydon Park. On east bank just downstream from bridge. Issue - Phase II - The phase II planting site on Graham Creek in Andrew Haydon Park hopes to further rehabilitate a highly eroded bank on the east side of the stream just north of Carling Rd. Phase I was carried out in early June of 2006 in hopes to stabilize the bank and prevent further erosion. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and recruit volunteers from neighbouring communities to participate in this rehabilitation effort. Expected Results - Community involvement; Effective stream bank protection; Reduce siltation of fish spawning habitat; The enhancement of conditions for natural colonization of existing plant community; Produce streamside wildlife habitat; Enhancement of the creek's aesthetic qualities.</p>
				<p>Location - Mosquito Creek downstream of Spratt Road within the Riverside South community. Issue - Phase II - Erosion of stream banks along Mosquito Creek is an issue. Development along with creation of roads, bridges and residential properties has increased runoff and caused significant erosion along the stream. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and recruit volunteers from neighbouring communities to participate in this rehabilitation effort. Expected Results - Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities; Effective stream bank protection; Erosion control.</p>
				<p>Location - Pinecrest Creek. Issue - Frequency of litter on this system is high. Walk along cleanups involve members of the community walking certain stretches of stream with garbage bags and removing items such as bags, styrofoam, lumber, bottles etc. to rid the stream of human oriented debris. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and recruit volunteers from the communities around the stream to participate in this cleanup effort. The goal would be to facilitate the proper removal of garbage and to rid the stream and riparian areas of (man made) pollution. Expected Results - Community involvement; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities.</p>
				<p>Location - Pinecrest Creek. Issue - Erosion of stream banks along Pinecrest Creek is of major concern. The National Capital Commission (NCC) is leading an initiative to implement a to create a remediation strategy to eliminate erosion and help rehabilitate the stream. Remediation Strategy - NCC Remediation Strategy. Expected Results - Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities; Effective stream bank protection; Erosion control.</p>
				<p>Location - Sawmill Creek just north of Heron Park Community Centre (Heron Rd.). Issue - Phase I and Phase II planting took place on in 2005 and 2006 to help rehabilitate a failed bank on Sawmill Creek. Planting work has been successful although monitoring needs to be done often to ensure planting communities are successful. If trampling and further erosion are noticed, more planting may be needed. Remediation Strategy - Utilize existing volunteer base of the City Stream Watch program and residents from the Heron Park area to monitor success of planning site and report back to the coordinator with updates. Expected Results - Promote community involvement in rehabilitation projects; Enhancement of fish and wildlife habitat; Enhancement of the creek's aesthetic qualities; Erosion control.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Confirmatory Sampling of Well #2 to Examine GUDI Potential - Village of Westport	2006	RVCA (Leeds & Grenville)	Conclusions and Recommendations	<p>Based on the results of the 2006 raw water chemistry, it is the opinion of Malroz that the abandonment of Well #1 has improved the water quality of Well #2. The abandonment of Well #1 has sealed the annulus and therefore eliminated the hydraulic communication between the near surface contaminants (standing water, intermittent stream and sewer line) and the aquifer. Based on the groundwater modeling and chemistry, it is the opinion of Malroz that Well #2 is not under the direct influence of surface water.</p> <p>We recommend that a subsequent evaluation be conducted in 2 years to confirm the observed trends.</p>
Construction and Testing of a Production Well (PW2) for the	1994	MVCA (Ottawa)	Conclusions and Recommendations	<p>The following conclusions and recommendations have been derived from the work conducted for this study.</p> <p>A production well has been successfully completed in a gravel aquifer situated in the Village of Carp. The construction of the communal water supply well is in compliance with the design specifications of the Tender contract and the required specifications of the Regional Municipality of Ottawa-Carleton (RMOC) and the Ontario Water Resources Act (Ontario Regulation 903).</p> <p>Aquifer testing of the new production well (PW2) indicates that the well is capable of providing a sand free water supply at a twenty year yield of 32.3 L/s (425 imperial gallons per minute (IGPM)). Well efficiency is excellent. Little, if any notable well interference is expected at the proposed design flow rates for the well.</p> <p>Expansion of the proposed design flow rate for the production well should only be considered after the performance of the aquifer has been monitored.</p> <p>The water quality in production well PW2 meets the Ministry of the Environment and Energy (MOEE) objectives for all communal water supply drinking water parameters except hydrogen sulphide and hardness. Treatment for hydrogen sulphide is included in the communal water system reservoir and treatment plant design. Hardness levels are acceptable for the communal water supply. Treatment of hardness for aesthetic purposes may be conducted by the end user if desired.</p> <p>Recommendations outlined previously in the "Aquifer Protection" Study, Village of Carp (Water and Earth Science Associates Ltd., May 1992) should be implemented for long term protection of the aquifer water quality.</p>
Construction in Contaminated Areas, Village of Carp Sewer and Water Project, Carp, Ontario	1995	MVCA (Ottawa)	Summary	<p>During the installation of underground sewer and water services in the Village of Carp, contaminated soil and water were encountered at three locations. At all three locations, the contamination appeared to be gasoline emanating from poorly defined and abandoned sources on adjacent private properties. During construction, contaminated soil exceeding Level I was removed from the service trenches from these locations for off-site disposal. Contaminated water was removed from the trenches and either hauled away for immediate disposal (if appropriate), hauled away and treated off site (early in the program) or treated on-site and effluent disposed of at the Robert O Pickard Centre (ROPC).</p> <p>As part of a long-term control measure and contingency, trench drains and vapour extraction pipes were installed in the service trenches. The trench drain network was designed as a contingency to control and, if necessary, withdraw contaminated water from the alignment and adjacent properties for treatment. Similarly, the vapour extraction pipes are in place to remove vapour and/or introduce oxygen to facilitate in situ biodegradation in the subsurface.</p> <p>Work was undertaken in conjunction with groundwater control problems associated with high water tables and permeable gravels in the Rivington Street area. This work involved data collection, monitoring and impact assessment related to both the physical as well as chemical aspects of the dewatering program.</p>
Construction of Multi-Level Sentinel Wells for the King's Park Communal Wells, Village of Richmond (Ottawa), Ontario	2006	RVCA (Ottawa)	Summary	<p>In December of 2003, Golder began work for the City to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the King's Park communal well system in the Village of Richmond. Within the C of A, the ministry requested the installation of two new monitoring wells that penetrated the existing production aquifer (sentinel wells)</p>



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The purpose of the sentinel wells was to provide a warning to the City, through an adequate groundwater monitoring program, in the event that dissolved contaminants migrate into the water bearing units in which the communal wells are constructed. During December of 2004 Golder installed the first multi-level groundwater monitoring well (sentinel well) at the Richmond Library Location. During June of 2005, Golder installed the second sentinel well at the King Street Location. Both wells were installed on, or near the boundary of an estimated 220-day Time of Travel (ToT) groundwater capture zone.</p> <p>The multi-level system at the Library Location consists of 5 monitoring intervals that isolated identified groundwater transmitting zones within the bedrock, and a separate overburden monitoring well. The multi-level system at the King Street Location consists of 4 monitoring intervals that isolated identified groundwater transmitting zones within the bedrock, and a separate overburden monitoring well. An ongoing groundwater monitoring program will be completed by the City using the sentinel wells at the Library and King Street Locations to monitor for potential groundwater contamination migrating towards the communal wells. The frequency of the groundwater monitoring and the parameters to be sampled are to be determined by the City.</p>
Construction of Sentinel Wells for the Carp Communal Well System, Village of Carp (Ottawa), Ontario	2006	MVCA (Ottawa)	Summary	<p>In December of 2003, Golder began work for the City to satisfy new requirements imposed by the Ministry of Environment (MOE) as part of the Certificate of Approval (C of A) to operate the communal wells system in the Village of Carp. Within the C of A, the ministry requested the abandonment (as per Ontario Regulation 903) of all unused monitoring wells, and the installation of two new monitoring wells that penetrated the existing production aquifer (sentinel wells).</p> <p>The purpose of the sentinel wells was to provide a warning to the City, through an adequate groundwater monitoring program, in the event that dissolved contaminants migrate into the water bearing unit(s) in which the communal wells are constructed. During the summer of 2004 Golder installed sentinel wells at two locations in the Village of Carp at the boundary of an estimated 200-day groundwater Time of Travel (ToT) capture zone. At the first location one groundwater monitoring wells was installed, and at the second location, a nest consisting of five monitoring wells was installed.</p> <p>After the installation of the sentinel wells, groundwater from each monitoring interval was sampled for parameters selected by the City. An ongoing groundwater monitoring program will be completed by the City using the Sentinel Well 1 and the Sentinel Well 2 Nest to monitor for potential groundwater contamination migrating towards the communal wells. The frequency of the groundwater monitoring and the parameters to be sampled are to be determined by the City.</p>
Contaminant Plume Study, Township of Beckwith, Final Report	2001	MVCA and RVCA (Lanark)	Recommendations - Domestic Well Monitoring Program	<p>The following monitoring program was developed and previously provided to the Ministry of the Environment (MOE) in February 2001 based on information available at that time. Based on the recommendations provide herein and input from stakeholders, the MOE developed a modified monitoring program for the domestic wells. Following notification of all affected residents, this modified monitoring program is being introduced in July 2001.</p> <p>The following factors were considered by Aqua Terre in establishing recommendations for a domestic well sampling program: 1) The primary mode of contaminant transport in groundwater systems is by advection-dispersion. Because groundwater velocities are low (even in this case where groundwater velocities maybe be relatively fast, they are still likely only on the order of 100's of metres per year), and the source consists of a relatively constant release over a long period of time (caused by the dissolution of dense non-aqueous phase liquids over time) groundwater concentrations will generally change gradually over time. 2) There is a significant quantity of data on domestic well Volatile Organic Compound (VOC) concentrations in the Township. Many of the locations have been subjected to 20 or more monitoring rounds since May 2000. Concentrations in a domestic well will be influenced by well construction, household consumption practices, and local heterogenities, in addition to general groundwater plume concentrations.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The following factors were considered by Aqua Terre in establishing recommendations for a domestic well sampling program: 3) The risk associated with most Ontario Drinking Water Standards (ODWS) (typically set at one in a million) has been established assuming consumption of 2 L/day of water over a 70 year lifespan. The risk associated with consumption of water at these standards for a shorter period of time would be proportionately lower (e.g. the risk associated with consumption of water at the ODWS for one month would be 1 in 8.4 x 10<sup>8</sup> (106 x 12 x 70)). 4) Concentrations of dissolved VOCs that are on the same order of magnitude as the detection limit (e.g. within a factor of 2-3), are difficult to quantify, and may be less reliable than values reported for higher concentrations. 5) The contaminant concentrations of concern are 5 µg/L for trichloroethene (TCE) and 2 µg/L for vinyl chloride (VC).</p>
				<p>The following factors were considered by Aqua Terre in establishing recommendations for a domestic well sampling program: 6) Treatment systems consist of two Granular Activated Carbon (GAC) filters installed in series. Very little site specific information on filter life is available at present. Filter life is dependent on a number of factors the most significant being the contaminant levels in the influent and the flowrate or usage of the system. Only two filters (2229 10th Line and 385 Megan Drive) have been rebedded to date based on detections of low levels of contaminants at the mid-point between filters. Both of these sites have significantly elevated contaminant levels however they not have the highest levels of TCE or VC for homes with filters.</p>
				<p>It has also been assumed that the water consumption patterns will not change significantly in the residences being sampled. Changes in these patterns (e.g. higher usage rates) could affect the recommended sampling frequency.</p>
				<p>Based on the information collected to date, the following categories and associated recommendations were developed: 1) Homes with treatment systems - Obtain two consecutive downstream samples to verify that the system is working. Reduce sampling frequency on influent (raw water) to once every calendar quarter. Estimate filter life based on historical performance or engineering principles. Commence sampling at the mid-point between filters after 75% of filter life has been reached. Sampling should be conducted at a frequency of approximately 10% of estimated filter life. Alternatively the filter can be rebedded after 75% of filter life has been reached, however this will prevent an exact determination of filter life. Site specific filter lives can be refined and sampling frequencies adjusted as more performance data becomes available. When the filter is re-bedded the downstream filter should be moved into the upstream position and the re-bedded filter moved into the downstream position.</p>
				<p>Based on the information collected to date, the following categories and associated recommendations were developed: 2) Quarterly Sampling - Homes that have a low frequency of detectable concentrations (&lt;25% of the rounds) and low peak concentrations (&lt;1.25 µg/L TCE and &lt;0.5 µg/L VC) and have sufficient record (e.g. six or more rounds). 3) Bi-monthly Sampling - Homes that have a medium frequency of detectable concentrations (&lt;50% of the rounds) and peak concentrations less than 50% of the concentration of concern (&lt;2.5 µg/L TCE and &lt;1.0 µg/L VC), reduce sampling to once every two months. 4) Monthly Sampling - Homes that have a high frequency of detectable concentrations (&gt;50% of the rounds) and peak concentrations less than 50% of the concentration of concern (&lt;2.5 µg/L TCE and &lt;1.0 µg/L VC), reduce sampling to once a month. 5) Twice Monthly Sampling - Homes that have a high frequency of detectable concentrations (&gt;50% of the rounds) and peak concentrations greater than 50% of the concentration of concern (&gt;2.5 µg/L TCE and &gt;1.0 µg/L VC), continue sampling twice a month.</p>
				<p>Based on the information collected to date, the following categories and associated recommendations were developed: 6) Long Term Sampling - This includes wells that are upgradient (e.g. McGregor Dr., Northcote Dr.) and wells that are not on the plume path-line (e.g. 7th Line) or those located sufficiently far downgradient with sentinel well locations between the home and the plume. Infrequent (e.g. annual or greater) sampling of these wells is currently recommended. However, it may be necessary to increase the sampling frequency of wells located far downgradient in the future.</p>
				<p>Appendix G presents the proposed domestic well monitoring plan for Beckwith Township based on current sampling locations and available data. It must be stressed that this monitoring program is based on information available as of February 2001. The monitoring program will need to be reviewed and updated within 6 months.</p>
				<p>Continued monitoring for a selected set of three VOC, namely TCE, 1,1-dichloroethene (1,1-DCE) and VC is satisfactory to address the contaminants of concern. Quality assurance / quality control (QA/QC) analyses of a limited number of samples at MOE laboratories for an expanded set of parameters including perchloroethene (PCE), TCE, 1,1-DCE, Trans-1,2-DCE, Cis-1,2-DCE and VC is also recommended.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommendations - Monitoring Well Program	Based on the observations made during the investigations the following general recommendations are made: 1) A detailed monitoring program, for the purpose of updating groundwater flow and contaminant transport mechanisms, should be continued. This monitoring program would include collecting hydraulic head data and sampling those monitoring wells which intersect the active portion of the plume at regular periods, at least twice per year. Analytes should include TCE and its degradation products. 2) The numerical model should be updated after one to two years of monitoring to refine plume forecasts. 3) The future monitoring program and numerical modeling updates should be identified in the Environmental Study Report (ESR) process.
Cranberry Hill Subdivision Groundwater Testing, Township of North Grenville, Ontario	2005	RVCA (Leeds & Grenville)	Discussion	Based on the above-noted results, it is unlikely that the nitrate and bacteriological impacts to the residential wells in the Cranberry Hill and Clothier Avenue area come from the Valley Sanitation site which is consistent with the conclusions from the 2001 study. The septic systems of the eastern residential properties are likely continuing to cause contamination in the eastern part of the study area.  When comparing the 2005 analytical results to the sampling program conducted in 2001, the nitrate concentrations have generally decreased. However, the nitrate and total coliform concentrations in several wells remain elevated and <i>E. coli</i> was again detected in several wells. This indicates that the groundwater quality in parts of the area remains poor. It is still recommended that alternate water sources be investigated given the lack of improvement in the water quality in the past four years. Trow also recommends that an annual groundwater monitoring program be carried out in the area to document any changes to the groundwater chemistry and to determine any trends that may be occurring over time.
Eastern Ontario Wetland Valuation System: A First Approximation, Technical Report	2003	M-R SPR & outside of region	Conclusion	The wetland valuation system provides biological and ecological importance to known wetlands in eastern Ontario. Nine criteria were developed based upon sound biological and ecological science, which was gathered from the Ontario Wetland Evaluation System, A Framework For Guiding Habitat Rehabilitation in Great Lakes Areas of Concern and other literature. The amalgamation of the nine criteria resulted in the production of a final wetland valuation system geographical information system (GIS) layer which provides a landscape level analysis of wetland habitats in eastern Ontario. The landscape analysis can then be used in conjunction with significant woodlands, significant wildlife habitat, and significant corridors mapping to identify key natural heritage features / areas within the study area. The identification of these natural heritage areas will be useful to conservation organizations in focusing future restoration or protection efforts. The natural heritage areas will also provide local decision makers with a tool for effective land-use planning.  The wetland valuation system can serve as a tool in identifying potentially provincially significant wetlands based upon biological and ecological features. This tool could then be used by the Ontario Ministry of Natural Resources to focus future wetland evaluations. As a result, more provincially significant wetlands will be identified for protection under the Provincial Policy Statement and land-use planning.  The wetland valuation system was applied using the best available data to analyze known wetlands within eastern Ontario. However, many more wetlands have yet to be identified. Future work should focus on identification of wetlands within the study area. This can be accomplished by classifying satellite imagery and by obtaining other relevant data. A similar project was conducted in partnership with the Ontario Ministry of Natural Resources and Ducks Unlimited for the municipality of Muskoka with great success. Their developed methodology would be useful in identifying wetlands in eastern Ontario (Appendix 1). Once the wetlands have been identified, the criteria could be modified and improved based upon the data available for analysis (Appendix 2).
Engineer's Report for the Water Supply Facilities for the Town of	2001	RVCA (Lanark)	Characterization of the Raw Water Source	At the time that this report was being prepared, results of the raw analysis were not available. This will be forwarded with any recommendations upon receipt of the analysis.  There is not believed to be any danger of radionuclide contamination. To confirm this estimate, analysis is being undertaken to determine if there are any appreciable radionuclide influences by measuring Gross Alpha, Gross Beta and Tritium levels in the raw water. The results of the analysis with necessary recommendations will be forwarded when received.
			Deviations from Ten States Standards	Listed below are items which were revealed during inspections which do not meet <i>Ten State Standards</i> . The specific reference is shown in parenthesis at the end of each item.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				There is no cross connection control between the distribution system (including water used within the plant for human consumption) and either the surface wash or the chemical rooms. The installation of required backflow prevention devices must be considered. (Sect 2.11 & 5.1.6)
				The top filter to clear well bypass is unnecessary and presents a risk of accidental filter bypass. This feature should be eliminated. (Sect 2.11)
				There is no cross connection control between the bulk fill station which provides water for domestic use and the either the surface wash / chemical room supply. Likewise there is a possibility of cross connection from a water truck back into the plant system. A separate backflow preventor situated between the distribution supply and the bulk load facility should be installed. (Sect 2.11)
				Pipe colour coding does not comply in entirety with the Ten State Standards. (Sect 2.14 & 5.1.12.d)
				There is only one rapid mix unit. The time in the rapid mix chamber is greater than that in the standards. This is not considered a significant deficiency, however it could be remedied by placing an inline static mixer upstream of the existing rapid mix chamber and then utilizing the existing chamber as a feed box to the flocculation chambers. (Sect 4.1 and 4.1.2)
				The process rates in the settling tanks do not meet the Standards. See comments in section 6.3.d. (Sect 4.1.4)
				There are no particle counters. This is not considered a serious deficiency as each filter has a turbidimeter. (Sect 4.2.1.10.b.4)
				There are no day tanks for liquid chemicals. The level indicator in the NaOCl appears to have the necessary accuracy to provide for dosage control. There is no such ability on the alum system. A day tank and transfer pump should be considered for the alum system. (Sect 5.1.11.a)
				The Operations & Maintenance (O & M) Manual does not reflect current equipment nor does it have some information normally found in these manuals such as emergency reporting procedures. The manual should be updated to reflect current operating procedures and thereafter reviewed as set forth in Ontario Regulation (OR) 435/93. (Sect 2.16)
				There is only one clear well, the standards require two. This is not considered a serious shortcoming, as this was the accepted practice when the plant was designed. (Sect 7.1.2.d)
			Summary of Other Problems and Recommended	The following is a list of problem areas, other than deficiencies in meeting the Ten State Standards.
				There are numerous locations within the plant where spills could migrate into either the raw / process stream or into the finished water prior to pumping into the distribution system. These include the screening well hatches, the raw water well hatches and valve accesses, the service well hatches and valve accesses. The need for curbing and / or containment throughout the plant should be identified and installed.
				The tower is apt to retain stagnant water (and therefore lowering chlorine levels) because the only exchange of water in the tower under normal conditions is the lower part of the supply pipe up to the tank. Until such time that a feed pipe is installed to feed into the tank, to remedy this problem procedures should be established so that during periods of low pressure demand the tower tank should be allowed to empty or nearly empty. On refilling fresh water will then be reintroduced into the tank.
				Source water protection as mentioned in sections 3 and 7 of this report should be implemented at the earliest opportunity. This should include signage at public crossings of the Tay River downstream of Christie Lake and an annual notification of owners of property abutting this reach with alerts that the river provides the source water for the Town of Perth. In addition, given the apparent risk of pesticides entering the source water from activities at the golf course, the requirements of Guideline B - 15 ( <i>Use and Storage of Pesticides at Waterworks</i> ) must be complied with by the golf course. A protocol in this regard between Ministry of the Environment (MOE), the golf course operators and the Town should be considered. It may be necessary for a Director to invoke Section 33 of the Ontario Water Resources Act (OWRA) to establish limits on the use of pesticides in the area of the intake and those parts of the upstream reach to which the golf course abuts.
				Treatment plant waste residue is directed to the Tay River without treatment. As an immediate measure a system to remove chlorine from the waste stream should be considered. Fortunately by plant design this can be accomplished without excessive costs. A study should be undertake in the near future to develop a treatment waste management plan.
				The lack of storage of treated water is not considered to be a serious shortcoming at this time. However it should be addressed in long term plans.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Operational procedures should be restudied to ensure they meet currently accepted practices. For example during filter startup after backwash, filtered water should be directed to waste for a short period of time.</p> <p>There is an unused transformer on the filter room floor. This transformer has been decommissioned and is within a containment area. However given the nature of older transformers, it may be prudent to consider removing this from the Supply / Treatment / Storage Works (STSW). Discussions should be held in this regard with MOE staff to ensure that during the removal the process is protected.</p> <p>A plant with the capacity of that in Perth with fluorodation would normally have online fluorine monitoring. Consideration should be given to such.</p> <p>During the inspection of the facilities, it was not possible to determine the types of diffusers used for chemical applications into the control wells between the clear well and either the reservoir or the service wells. A more detailed assessment should be made to ensure that the proper mixing is achieved.</p>
Engineer's Report for Town of Carleton Place Water Works	2000	MVCA (Lanark)	Summary of Recommended Improvements to the Physical Works	<p>As previously indicated, a major upgrade for the Water Treatment Plant (WTP) is under way, which will effectively convert the direct filtration plant into a conventional treatment plant and modify the way in which the distribution system is provided with a disinfectant. The intention of these upgrades was originally intended to address high trihalomethanes (THMs) in the treated water. However, in addition, this process retrofit will address other requirements outlined in the Drinking Water Protection Regulation (DWPR) (Ontario Regulation 459/00) and other guidelines (Ten State Standards, Procedure B13-3 and the Ontario Drinking Water Standards (ODWS)). These include ensuring adequate Contact Time (CT) requirements during cleaning of the clearwell, in-line turbidity measurements from the filters, disinfection requirements of the distribution system and other design standard requirements.</p> <p>The upgrade is to utilize an innovative treatment process (Actiflo®) which combines ballasted flocculation (using microsand) and lamella clarification (using tube settlers). It allows for very high loading rates to the clarifiers which requires a much smaller footprint than conventional clarification techniques. In the case of the Carleton Place WTP, no expansion in the existing plant footprint will be required, which has a positive benefit. An existing area of the plant (the contact tanks) will be modified to accommodate the Actiflo® process equipment and to provide access for Operations staff.</p> <p>The chloramination facilities will involve modifying a room within the existing plant to provide storage and containment for equipment and components for an ammonia storage and feed system, including containment and weigh scale, feed pumps, piping and instrumentation.</p> <p>Chloramine will not form THMs in the distribution system and is also known to be a more persistent disinfectant than chlorine, which will assist in addressing problems with chlorine residuals at the extremities of the distribution system.</p> <p>Additional recommendations for physical works improvements based on this investigation include the following: Implementation of a feedback loop from the chlorine analyzer and turbidimeters and fluoride, which would shut down the high lift pumps in the event of a low chlorine residual or high turbidity and fluoride. This could be included in the proposed upgrades for the plant instrumentation currently underway; Automatic switchover of chlorine cylinders (currently being investigated by the Ontario Clean Water Agency (OCWA); Physical and / or operational modifications to ensure adequate chlorine disinfection during cleaning of the clearwell (currently planned to be included in the plant upgrades); Installation of in-line turbidity analyzers on the discharge lines from the three sets of filters (currently being implemented by OCWA); Installation of a chlorine booster station at the water tower with chlorination of the influent to the tower (currently being implemented by OCWA). This would only be used on a temporary basis until the plant upgrades are complete;</p> <p>Additional recommendations for physical works improvements based on this investigation include the following: Looping of the 300 mm diameter watermain which extends from Lake Avenue West to Hwy 7; Fine tuning of the Supervisory Control and Data Acquisition (SCADA) system should be completed during the planned plant upgrades, in accordance with direction provided by the Engineer and Operators. potentially overload the backwash water treatment system.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Summary of Recommended Improvements to the Operations	<p>A review of the operations indicates that the following actions should be taken to reduce the risk of microbiological contamination and to improve the overall performance of the water treatment plant and distribution system: Contingency plans should be expanded and updated to include other infrequent events which could occur and to address the specific requirements of the DWPR; The current WTP Operations Manual should be updated on an ongoing basis to reflect increased knowledge obtained by the operator and any changes to the physical components of the plant, such as the recent enhancements to the SCADA system; The Town should update its procedure for disinfection of new mains using American Water Works Association (AWWA) standard procedures. These should also be included in the OCWA contingency plans and procedures (e.g. for cleaning out the clearwell); Preventative maintenance should focus firstly on the primary components of the WTP, such as the chlorinators, chlorine analyzer, chemical feed pumps, filters, pumps, etc. Work should be prioritized to ensure that critical components are serviced prior to less critical components;</p> <p>A review of the operations indicates that the following actions should be taken to reduce the risk of microbiological contamination and to improve the overall performance of the water treatment plant and distribution system: Filters should be shock chlorinated periodically in accordance with procedures developed during the treatability study and documented in the Operations Manual; Key spare parts for the chlorinators should be kept on-site for maintenance purposes; Results of all chlorine analyses in the distribution system should be kept on file; Efforts should be made to continually rotate sampling locations in all areas of the distribution system, particularly at the far ends (the operator indicated that some areas are inaccessible due to lack of appropriate sampling locations. Efforts should be made to identify sampling locations in all areas; A procedure for the operators to file documentation with the Town and for the Town to maintain this information in an easily accessible location should be formalized; The current level of operations staffing, particularly for maintenance, should be reviewed and increased, if necessary;</p> <p>A review of the operations indicates that the following actions should be taken to reduce the risk of microbiological contamination and to improve the overall performance of the water treatment plant and distribution system: The raw water screen should be cleaned on a more frequent basis, particularly during the summer; The pre-chlorinator should be exercised periodically to ensure it is functioning properly; Ensure that flow meters are calibrated at regular intervals, not exceeding 12 months. Currently, this is being completed by an OCWA technician; Ensure that water quality analysers are calibrated as specified by the instrument manufacturer's specifications or at minimum intervals which ensure operation during at least 95% of plant operating time. Based on discussions with the operator, this practice is currently being completed; The Chief Operator should obtain a classification consistent with the plant rating.</p>
			Summary of Recommended Modifications to Existing (Monitoring) Program	<p>The parameters and sampling frequency outlined in the monitoring program in Appendix 'G' is very similar to the current program followed for the Carleton Place water works, with the following exceptions: Turbidity measurements on the effluent from each filter line are currently not being undertaken, however, this is to be addressed by OCWA; Raw water sampling and testing for Alkalinity, Dissolved Organic Carbon, Total Organic Carbon and aluminum (and fluoride) is currently undertaken on a weekly basis; the recommended frequency for these parameters is monthly, although more frequent samples could always be taken at the discretion of the operator; It is recommended that treated water be analyzed for Alkalinity, Dissolved Organic Carbon and Total Organic Carbon at least on a monthly basis and pH, colour, turbidity, temperature and aluminum residual (dissolved and total) at least on a weekly basis</p> <p>The parameters and sampling frequency outlined in the monitoring program in Appendix 'G' is very similar to the current program followed for the Carleton Place water works, with the following exceptions: Total chlorine residual will be measured in the treated water and in the distribution system if chloramine is used as the disinfectant in the distribution system, while free chlorine residual will be measured in the treated water and the distribution system if chlorine is used as the disinfectant in the distribution system; Sampling of the supernatant pumped back to the river from the backwash holding tank should be monitored for Suspended Solids at least on a monthly basis.</p> <p>In addition to the above, it is recommended that additional sampling locations in the distribution system be established and rotated regularly, particularly in the western sections of the Town.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommendations	It is recommended that: the physical modifications outlined in Section 4.6 and the operational improvements outlined in Section 5.9 be implemented in order to reduce the risk of microbiological contamination and improve the overall quality of the treated water supplied to the residents of the Town of Carleton Place; the minimum requirements outlined in the monitoring program outlined in Appendix 'F' continue to be carried out in accordance with the DWPR and other standards; a new Certificate of Approval be obtained which reflects the requirements outlined in the Model Conditions for Certificates of Approval and incorporates the new physical modifications associated with the plant upgrade (an Application for a Certificate of Approval has been submitted, along with the supporting documentation for this proposed modification).
Engineers' Report for the Smiths Falls Water Works	2001	RVCA (Smiths Falls)	Summary of Recommendations	<p>The purpose of this report was to review the Smiths Falls Water Treatment Plant (WTP) and make recommendations for improvements that should be implemented to comply with the new Ontario Drinking Water Standards (ODWS). Accordingly, the following recommendations are made through the report and are summarized as follows:</p> <p>A study is recommended to be undertaken to determine the location of weak points in the system and to implement possible alternatives to mitigate this problem (looping the dead ends, additional chlorination booster stations in the distribution system).</p> <p>It is recommended that the building's roof be replaced.</p> <p>It is recommended that the building's exterior walls be fixed.</p> <p>It is recommended that the WTP building be relocated.</p> <p>It is recommended that a double link seal penetration be incorporated at the backwash waste trough.</p> <p>It is recommended that the existing clearwell hatches be replaced with watertight hatches.</p> <p>The coagulation / flocculation / sedimentation / filtration process should be optimized.</p> <p>More in-line instruments should be installed such as: flow meters, turbidity meters, pH meters, chlorine residual analyzers, and thermometers.</p> <p>It is recommended that the addition of chlorine residual be flow paced and trimmed by the free chlorine residual (compound loop control).</p> <p>In order to meet the requirements of the new procedure the Town should consider upgrading the disinfection facilities.</p> <p>It is recommended that the slush ice control system to be reviewed.</p> <p>It is recommended that the monitoring for zebra mussel to be done more frequently.</p> <p>It is recommended that one flow meter be installed on the raw water supply line, which beside the monitoring purpose will also control the chemical addition.</p> <p>It is recommended to incorporate an in-line flash mixer on the raw water supply line.</p> <p>It is recommended to increase the retention time by adding additional flocculation volume and to provide mechanical flocculators to help the flocs formation.</p> <p>It is recommended to install an additional sedimentation tank to increase the retention time and to decrease the loading rate.</p> <p>It is recommended the incorporation of a mechanical system for the sludge removal from the sedimentation tanks.</p> <p>It is recommended to install flow meters on the filter influent conduits.</p> <p>The filter backwash should be done automatically based on elapsed time, turbidity breakthrough or loss of head.</p> <p>It is recommended that a rate control valve be installed on the backwash supply line to monitor and regulate the flow to each filter.</p> <p>It is recommended that one turbidity meter be installed on the discharge of each filter.</p> <p>It is recommended to modify the existing configuration of the Clearwell Nos. 2 and 3 to provide better operational conditions.</p> <p>It is recommended to relocate the diesel pump to a different floor to prevent the equipment flooding.</p> <p>An additional chlorine injection point should be located in the high lift pumps discharge header prior to entering into the distribution system.</p> <p>It is recommended that a chlorine scrubber be installed or switching to sodium hypochlorite be considered.</p> <p>It is recommended that the disinfection piping system be upgraded.</p> <p>It is recommended that one fluoride residual analyzer be installed.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>It is recommended that a residue management facility be incorporated at the Smiths Falls WTP.</p> <p>It is recommended that the septic tank be replaced with a new tank or a pumping station to convey the sanitary waste, generated at the WTP, into the Town's sewer system should be considered.</p> <p>It is recommended that a stand-by generator be installed or to replace the turbine generator.</p> <p>It is recommended that the Water Distribution and Storage Requirements Report be updated based on the existing conditions and future development (commercial and residential).</p> <p>It is recommended that a recirculation system be incorporated at the elevated tank, which will keep the water in continue movement during cold periods.</p>
Engineers Report for Waterworks - Kings Park Subdivision, Communal Well System, Former	2001	RVCA (City of Ottawa)	Conclusions and Recommendations	<p>One of the results of this investigation and report will be the issuance of a single, consolidated Certificate of Approval for the operation of the King's Park System. The lack of a present Certificate of Approval has been documented on several occasions in the past.</p> <p>In order for the Ministry to issue a Certificate of Approval following the review of this package, the following recommendations are made in accordance with the requirements of the Ontario Drinking Water Regulation:</p>
			Operational Procedures and Sampling	<p>Compilation of Operations and Maintenance Manuals, (in accordance with Section II - Model Conditions for Certificates of Approval) to be located at each station.</p> <p>The City of Ottawa will be sampling the raw water Kings Park Wells 1 and 2 for all parameters listed in the Ontario Drinking Water Standards (ODWS). The City expects that the results will likely be available at the end of February. An addendum to this report will be issued once the list results are analyzed.</p>
			Physical Works / Upgrades	<p>Regrading surface area around chlorine contact chamber at Pumping Station No. 1</p> <p>Provide spill containment for chlorine storage tanks at each well</p> <p>Connect the floor drains at each well building to the respective sanitary sewer on Chanonhouse Drive.</p>
			Additional Programs	<p>Additional programs or policies which would reduce the potential for microbiological contamination include the following: Implement the Wellhead Protection Plan (Regional / City / Local) including inspection of existing wells and casings; Expand hydrogeological investigations in support of the Well Head Protection Plan sufficiently to establish groundwater system characteristics including water table depth, gradient, and groundwater flows; Consider the impact of the preferred alternative for the Richmond Pumping Station and Forcemain Contingency Plan on the well head and aquifer prior to implementing the contingency; Add a monitoring well (or wells) near Wells No. 1 and No. 2 located outside the 200-day travel time zone, and as appropriate for direction of groundwater flows; and Coordinate well head protection with the spills response plan for the Canadian National Railway (CNR) Line.</p>
Engineers' Report of Water Works - Town of Mississippi Mills	2001	MVCA (Lanark)	Recommendations to Mitigate the Potential for Microbiological	<p>Due to the small number of results available for both bacteriological and chlorine residual testing, it is difficult to assess, characterize, or find trends in the results or make recommendations on improvements.</p> <p>However based on the information available, some recommendations for improvement are: 1) Review the existing sampling and testing locations; 2) Choose additional locations. New and existing locations could be alternated during the year, for a total of 13 locations; 3) Review locations within the existing system that are dead-ended. These locations, as much as possible, should be looped during further construction; 4) Review existing chlorination procedures as a result of the low chlorine residual readings found in the distribution system indicated in Ontario Clean Water Agency's (OCWA) 4th Quarter results.</p>
			Recommendations for Operations Manual	<p>Based on review of the Ministry of the Environment (MOE) Model Conditions, it is recommended that the Town consolidate operational information detailed in the previous section into a single Operations Manual.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>In particular, the Operations Manual should include the following: A detailed flow schematic; A complete set of drawings reflecting existing conditions at each pumping station; A description of the daily tasks to be conducted at each pumping station; A detailed summary of the monitoring, sampling and reporting requirements for the raw and treated water at each pumping station; A complete list of equipment within each of the three pumping stations; A maintenance schedule for all equipment; A detailed description of maintenance procedures with respect to the distribution system and disinfection system; A contingency plan and procedures outlining how to deal with emergencies, equipment breakdown, etc.; and A step by step procedure for notification of the Medical Officer of Health and the Ministry.</p> <p>The Town is encouraged to refer to the MOE's Model Condition when preparing the operations manual in order to comply with all the requirements.</p>
			Recommendations for Improvements of Operational Procedures	<p>In order to mitigate the potential for microbiological contamination of the drinking water in the Town of Mississippi Mills groundwater supply system, the following improvements are suggested: The Township prepares a formal operations manual that meets all relevant requirements of the MOE's Model Conditions; The manual should include procedures for disinfection of water mains following construction and maintenance activities, and these procedures should be referenced to the applicable American Water Works Association (AWWA) standards; Regular calibration of flow measuring devices; Ensure that the Town of Mississippi Mills retains a minimum of 5 years of records; Review and revise of the application of chlorine for disinfection to obtain the minimum 0.2 mg/L of free chlorine after a minimum of 15 minutes of contact time as T<sub>10</sub> at maximum flow in the distribution system before the first consumer.</p>
			Recommendations for Improvements (Physical Works)	<p>In order to achieve the goals outlined in section 1.1 of Procedure B13-3 and based on review of Procedure B13-3, the Ontario Drinking Water Standards and Regulation 459/00, the following recommendations for physical improvements should be made: 1) Address the low level of free chlorine residual in the distribution system; 2) Install additional chlorine metering pumps as standby units at each pumping station; 3) Prepare and implement disinfection procedures for all water mains; 4) Establish an inventory of spare parts for emergency purposes; 5) Consider secondary spill containment units for the sodium hypochlorite solution tanks to mitigate contamination in the event of accidental spills or overflows; 6) Modify the design in the pump rooms to assure imperious nature of the floors.</p>
			Summary of Recommended Testing and Analysis (Monitoring)	<p>In accordance with regulation 459/00, Drinking Water Protection, samples of raw and treated water shall be collected and analyzed for at least the parameters at the indicated locations and frequencies (Please refer to Appendix C for complete list of testing and sampling requirements):</p> <p>Raw Water - Weekly: Total Coliform, Fecal Coliform, Heterotrophic Plate Count; Monthly: Nitrate; Yearly: No additional testing required.</p> <p>Treated Water - Daily: Free Chlorine Residual, Total Chlorine Residual, Turbidity; Weekly: Total Coliform, Fecal Coliform, Heterotrophic Plate Count; Quarterly: Nitrate, Nitrite, Table B - Volatile Organics, Table D - Pesticides &amp; Polychlorinated Byphenols (PCBs); Annually: Fluoride; Every 3 Years: Table C - Inorganics; Every 5 years: Sodium.</p> <p>Distribution System Water - Daily: Not required; Weekly: Total Coliform, Fecal Coliform, Heterotrophic Plate Count, Free, Combined Chlorine Residual; Quarterly: Trihalomethanes; Annually: Lead.</p>
Engineers' Report of Water Works - Township of North Grenville	2001	RVCA (Leeds & Grenville)	Recommendations for Operations Manual	<p>Based on review of the documentation provided by the Township of North Grenville and comparison to the Ministry of the Environment (MOE) Model Conditions it is recommended that the Township consolidate operational information detailed in the previous section into a single Operations Manual.</p> <p>In particular, the Operations Manual should include the following: A detailed flow schematic; A complete set of drawings reflecting existing conditions at each pumping station; A description of the daily tasks to be conducted at each pumping station; A detailed summary of the monitoring, sampling and reporting requirements for the raw and treated water at each pumping station; A complete list of equipment within each of the three pumping stations; A maintenance schedule for all equipment; A detailed description of maintenance procedures with respect to the distribution system and disinfection system; A contingency plan and procedures outlining how to deal with emergencies, equipment breakdown, etc.; and A step by step procedure for notification of the Medical Officer of Health and the Ministry.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				The Town is encouraged to refer to the MOE's Model Condition when preparing the operations manual in order to comply with all the requirements.
			Recommendations for Improvements of Operational Procedures	In order to mitigate the potential for microbiological contamination of drinking water in the Township of North Grenville groundwater supply system, the following improvements are suggested: The Township prepare a formal operations manual that meets all relevant requirements of the MOE's Model Conditions; and The chlorine analyzers (including sensors, monitors and recorders) should be returned to operation status or replaced and calibrated annually.
			Recommendations for Improvements (Physical Works)	In order to achieve the goals outlined in section 1.1 of Procedure B13-3 and based on review of Procedure B13-3, the Ontario Drinking Water Standards and Regulation 459/00, the following recommendations for physical improvements should be made: 1) Address the low level of free chlorine residual in the distribution system; 2) Repair and / or replace the chlorine analyzers such that they are in proper working order; 3) Install additional chlorine metering pumps as standby units; 4) Install an alarm system to detect the performance of the active chlorine analyzers and perform routine checks to ensure annunciation; 5) Prepare and implement disinfection procedures for all water mains; 6) Establish an inventory of spare parts for emergency purposes; 7) Repair chlorination piping and connections such that they prevent potential for contamination of the water in the reservoirs; 8) Consider secondary spill containment units for the sodium hypochlorite solution tanks to mitigate contamination in the event of accidental spills or overflows; 9) Modify the design in the pump rooms to assure imperious nature of the floors.
Environmental Study Report, Communal Water System, Village of Lanark - Volumes 1 & 2	1991	MVCA (Lanark)	Conclusions and Recommendations	<p>It is recommended that a communal water system be implemented. Alternative 1, a large communal water system with provision for fire protection, is recommended. This system would cover most of the built-up portion of Lanark excluding some streets in the periphery where the low density does not justify the construction of watermains.</p> <p>Based on the present Direct Grant subsidy program, the Village does not have the borrowing capacity to cover their share of the cost. Consequently, the Village should encourage residents to pay their share up front. Presently, only 30 persons have indicated they prefer this method of payment. This is not sufficient to cover the difference between the share of the Village and the borrowing capacity of the Municipality. If, at the time of tender, there are not enough residents who have pledged to pay their share up front, the extent of the water distribution system may have to be reduced.</p> <p>Ideally, a sewage system should be built at the same time as the water system. There are a number of technical issues associated with such an undertaking which would have to be resolved. However, because of the economic impact on the Municipality, it is not possible at this time to consider such a system. The deficient individual sewage disposal systems which have been identified in this study should be corrected individually.</p> <p>A second well should be drilled at least 150 m from Test Well B-3 to serve as a back-up source of water in case of mechanical failure in the other well pumping station. Any groundwater communal water system should have at least two wells.</p> <p>The Village should undertake negotiations with the land owners to obtain options for the second well and the water storage tank. The option for well B-3 should be exercised before it expires on August 31, 1992.</p> <p>The Village should approach the Perth Public Utility Commission to finalize agreements for the operation and maintenance of the communal well system.</p>
Environmental Study Report - Phase 1: Village of Lanark Water and Wastewater	2002	MVCA (Lanark)	Problem Definition Statement	<p>In light of the new regulations regarding safe drinking water and the documented history of private well contamination and septic system failures in the Village of Lanark, there is enough evidence to support Council's decision to proceed with Phase 2 of the study and find an acceptable solution to address the needs and concerns of the residents of the Village of Lanark.</p> <p>It is both understood and acknowledged that the preferred solution for water and wastewater servicing will be subject to the amount of Provincial funding available as well as the financial constraints of the residents of the Village of Lanark.</p> <p>There is an ongoing risk that private wells in the Village of Lanark may be providing unsafe drinking water supply. We recognize that these risks are not necessarily events that have occurred, but rather events that may occur and could adversely impact the lives of the residents of the Village of Lanark.</p> <p>It is concluded that the "Do Nothing" approach is not a viable alternative for the Village and that a successful remediation action plan with appropriate cost estimating and apportionment scenarios can and will be developed through the Environmental Study Report (ESR) process.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Existing Conditions and Trends in the Tay River Watershed	2000	RVCA (Frontenac, Lanark, and	Land Use - Information Management	There is limited resource information available on an ecosystem scale, making it difficult to develop sound regional management recommendations and decisions.
				Whereas information loss is a problem with amalgamations and down-sizing efforts, that the RVCA's potential role in data management be considered, in cooperation with other watershed natural resource managers, and a data management plan be prepared.
				That the RVCA participate or coordinate participation in efforts such as the zebra mussel monitoring program and other invasive species watches and public education efforts.
				That the RVCA gather information on the number of undeveloped lots of record across the Tay River watershed with a view to anticipating and planning for potential development in the areas that are now classed as natural.
				That the RVCA consider gathering a comprehensive land use history of the Tay River watershed, including aboriginal land use, to better understand its ecological trajectory.
				That the RVCA obtain a full economic valuation of the Tay River watershed, assessing the value of its natural areas.
				Whereas archaeological information can improve public understanding of the ecological impacts of human activities, that the RVCA support assessment of known archaeological information, identification of cultural landscapes, and encourage their protection through approaches such as land use planning, support of land trusts, and other stewardship initiatives.
				That in cooperation with other watershed stakeholders, the RVCA develop a watershed monitoring program.
				That the RVCA incorporate into an ecosystem monitoring program an indicator(s) intended to assess recreational capability versus sustainability.
				That the RVCA develop a complete list of watershed stakeholders (including open house attendees, local representatives of provincial groups, stewardship councils, local fish and game clubs, etc.).
		Land Use - Coordination and Integration of Planning	A lack of coordination and integration among the multiple layers of planning control allows some resource issues to fall through the cracks between agency mandates, and in duplication of effort on other issues. As well, changes to the way planning is done in Ontario have resulted in significant changes for many of the agencies previously important to the process.	
			Whereas consistency in planning across the watershed should be fostered, and municipalities would benefit from the broader perspective of watershed-scale information, that the RVCA, in cooperation with other watershed stakeholders, provide watershed municipalities with natural resource values mapping, and interpretation of that information.	
			That the RVCA, in cooperation with other watershed stakeholders, support municipalities, particularly as new Zoning By-Laws are prepared, in a better understanding of their (local) role in protecting and managing landscape natural values.	
			That the RVCA, in cooperation with other watershed stakeholders, foster consistency across watershed municipalities in the treatment of natural areas such as wetlands, waterways, etc.	
			That the RVCA, in cooperation with other watershed stakeholders, foster and support the promotion of shoreline and other stewardship initiatives.	
			That the RVCA and other ecosystem stakeholders include as part of their visioning exercise, a broad assessment of land use policies and practices in the watershed, against a variety of potential impacts (e.g., ecological, social, economic).	
			That the RVCA and other watershed stakeholders develop common goals and objectives, to support the identification and implementation of specific management tasks.	
			That the RVCA, in cooperation with other watershed stakeholders, examine the need for increased local protection of Canadian Shield (versus non-shield) areas where provincial natural heritage planning policies provide less protection.	
		Water Quantity	There is sufficient local data in various forms to support the development, calibration and verification of a basic hydrologic model for low-flow to mean flow conditions.	
			The water level records of the Rideau Canal provide a considerable supplement to the existing hydrologic database for the Tay River watershed. These records should be made available and they should be processed in order to identify gaps and to assist in the selection and development of a hydrologic model if necessary.	

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The possibility of maintaining continuous recording of the Gauge 02LA024 (Tay River at Perth) should be investigated, given its significance with respect to uncontrolled contributions to the watercourse, and its proximity to the developed portion of the basin.</p> <p>Should funds and manpower be available to maintain continuous data collection and verification for this station, measures should be undertaken to improve the low flow condition such that the low flow estimates are less prone to error.</p> <p>Once specific watershed planning objectives are established, and the available resources are assessed, a decision should be made with respect to the nature of future hydrologic and hydraulic analyses.</p> <p>Upon identification of future hydrologic and hydraulic analyses directions, data processing can be undertaken to provide the required input.</p> <p>Should a modeling exercise be undertaken, the model selection should give due consideration to the various watershed objectives, as well as compatibility with modeling of the Rideau system, and existing modeling efforts in the Tay River watershed.</p> <p>The possibility of maintaining more regular informal water level records throughout the watershed should be investigated, especially on un-gauged and uncontrolled sub-watersheds. There has been considerable interest from the public with respect to the watershed planning process, and it may be possible to gain valuable information from this interest.</p> <p>A more detailed water balance calculation is required in order to reduce uncertainty in the evapotranspiration figures. This would require a soil moisture accounting procedure. This effort would be best spent once a more comprehensive flow data set is available and efforts have been made to weight the precipitation data contributions to the watershed.</p> <p>Frequency analyses of flows could be undertaken once the Rideau Canal data is processed. The effect of regulation on the flows should be considered carefully in the selection of a suitable frequency distribution for the data. It may be possible to define a transfer function for transposition of the historic record at Bobs Lake to Perth based on the recent Perth Gauge data providing that sufficient high flow events have been recorded at the Perth gauge.</p>
			Groundwater	<p>Quantification of the different inflow and outflow components and completing the water balance of the watershed.</p> <p>An overall assessment of the effects of the environmental constraints, such as pits and quarries, heat pumps, etc.</p> <p>Integration of land use and other surface water (quantity/quality) parameters, and mapping of the groundwater vulnerable zones.</p> <p>Overall analysis of the watershed's eco-system based on all the integrated information.</p>
			Water Quality	<p>Septic system surveys ought to be done for all developed lakes to ensure that systems are functioning properly and not releasing contaminants to the waterbody. Shoreline surveys should be done at the same time to create an inventory database of structures, vegetation, slope, soil type/depth, bedrock type/depth, etc. to be used in the MOE Lakeshore Capacity Assessment model. The model is a "planning tool that is used to predict how much development a lake can withstand without having impaired water quality" (MOE, MNR, MMAH, 1999).</p> <p>All owners of lake or river side property should ensure that their septic system is maintained in good operational condition so that it is not a source of surface or ground water pollution.</p> <p>To ensure the quality of any lake environment, lake associations and municipalities should establish shoreline revegetation programs in partnership with groups such as MAPLE and government agencies (MNR, Conservation Authorities).</p> <p>Municipalities should consider enacting means to require a full septic system inspection and restoration if required as a routine part of every lake and river shoreline property transaction.</p> <p>Lake Associations ought to initiate a Watershed Watch water monitoring program similar to that in the Mississippi River watershed and it should include periodic tests for clarity, surface and bottom total phosphorus, dissolved oxygen / temperature profiling at least once per year and bacteria sampling covering nearshore areas to monitor for possible sources of contamination (i.e., faulty septic systems). Such a program would be particularly worthwhile where the lake is the primary source of drinking water or where there are aging septic systems along the shoreline.</p> <p>Where applicable, lake water quality monitoring programs need to be tailored to specific sampling for the preservation of lake trout habitat. Lake Associations might become involved in lake stocking programs and look at measures how to improve stocking initiatives and how water quality changes may be affecting survival rates of stocked fish.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Routine surface water sampling should be continued for the immediate future to extend the dataset.
				Investigative water sampling of Grants and Rudsdale Creeks ought to be conducted to locate/verify sources of elevated pollutant counts.
				Means of reducing the bacteria and other associated pollutant loading of the Tay River in the Town of Perth should be considered and implemented where possible.
				Investigative sampling of the Tay downstream of the Town of Perth should be done to determine impacts on and the role of the Tay Marsh.
				Cattle access to Tay watershed lakes and streams is a persistent problem throughout the watershed. Through an education and, conceivably, grant funding program, fencing out and alternative watering projects should be initiated with a partnership of all or some of the farm community, local chapter of the Ontario Federation of Agriculture, OMAFRA, Conservation Authority and perhaps the local MNR stewardship coordinator and a municipal representative. Possibly, such a program could be eligible for funding under RiverCare 2000.
				MOE has considered requiring the use of benthic macroinvertebrate sampling as the method of choice to determine the impacts of development on a watercourse. The RVCA has established 15 sites in the Rideau River watershed with 5 in the Tay watershed to establish baseline conditions. It is recommended that this program be continued in the following years to establish water quality and species trends and provide accurate support and data to surface water quality sampling programs. With further data, the macroinvertebrate sampling program may be able to predict, or determine, possible areas of contamination of pollution as sites under stress may be more readily recognized than with standard water quality methods.
				Following the completion of the Rideau Lakes carrying capacity study in 1992, some municipalities enacted policies requiring that development could not be the cause of any net reduction in water quality. It is recommended that all municipalities in the Tay River watershed adopt such policies and, further, that a compliance monitoring program must be undertaken by the proponent as part of the development process at least for properties adjacent to a waterbody. A monitoring plan should be submitted prior to approval of the development proposal including a baseline sampling phase which would have to be conducted prior to any work being done on the site.
			Forest Ecosystem Management Priorities	For the Tay River watershed, there is an identified lack of knowledge regarding individual forest stand condition and ecological value.
				In addition to a lack of basic data, there are several existing and potential stressors within the Tay River watershed that are influencing the integrity of the forest ecosystem.
				Lakeshore Buffers - The protection and restoration of forest cover around developed lakeshore areas would provide important buffering capacity against sediment runoff and nutrient loading, an identified concern in certain lake systems. It would also provide additional wildlife habitat for riparian species. The loss of lakeshore vegetation along portions of the Rideau Canal have been identified as contributing factors in diminished water quality in that system.
				Stand Representation and Fragmentation in the Limestone Plain - The poor representation of upland forest stands across the limestone plains region has been identified by White (1992). Remaining stands are small, and subjected to intense management practices including maple syrup and fuelwood production. There may be opportunities available to restore some of these stands through cooperative actions with private landowners.
				Old Growth Stands - Many stands in the watershed are mature, and there may be a number of stands that are gaining old growth features that will contribute to the maintenance of regional biodiversity. An identification of these stands, and an assessment of their status should be undertaken in order to rank those that are in the greatest need of protection and monitoring.
				Transportation Corridors - There is a need for planning authorities to understand issues of forest fragmentation when designing new road systems regardless of their size. Certain stands may be utilized by wildlife as corridors between critical habitats, such as wetlands or other forest stands.

## Table A-1

### Previous Study Recommendations

#### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
				Algonquin to Adirondacks Corridor - Various agencies are seeking to maintain the high level of mature forest cover between the Algonquin / Madawaska Highlands and the Adirondacks as a potentially critical wildlife corridor and habitat buffer. It is recommended that RVCA enter into a cooperative agreement with CPAWS to explore issues relating to land stewardship and protection of forests occurring across the Canadian Shield portion of the watershed.
				Farming Practices - Within the Canadian Shield region, cattle grazing takes place within forest stands as open pastureland is scarce. This practice contributes to a number of ecological stresses within the stand including trampling of seedlings and saplings, soil compaction, erosion, and introduction of invasive species. Furthermore, in riparian areas, grazing can lead to water contamination and degradation of fish and wildlife habitat. It is recommended that RVCA work with area farmers and agricultural agencies to limit this practice where possible.
			Forest Ecosystem Monitoring (FEM)	The development of an effective ecosystem monitoring program for the Tay River forest system is required.
			FEM - Level 1 - Assessment of Forest Ecosystem Features and	Identify the boundaries of the forest ecosystems that are to be monitored and managed.
				Identify the ecological processes that extend beyond the effective management range, and identify to what extent they influence the ecosystem.
				Identify the ecosystem attributes, processes, and stressors that require monitoring, and what specific indicators that would provide the most valuable information.
				Identify the level of change that is acceptable for those ecosystem components deemed important. Select a monitoring regime that is responsive to variance in the frequency, intensity and spatial scale of important ecological processes that influence species richness and community structure. For most forest monitoring applications, data collected annually at the landscape and individual stand level is generally appropriate.
				Select physical and biological indicators that distinguish between natural and anthropogenic disturbances, such as land use change effects.
				Select a data collection methodology that is convenient, cost-effective and repeatable.
			FEM - Level 2 - Specific Management Actions	Identify the agencies, groups and individuals that will be involved in the monitoring program.
				Consider the form that monitoring information will be presented in for analysis, e.g., digital, tabular, graphical.
				Improve monitoring efficiency through the selection of more precise response indicators as they become available. For example, improved remote image data may eventually provide a cost-effective means of assessing forest fragmentation at a landscape scale.
			FEM - Level 3 - Forest Ecosystem Protection and Recovery	Establish management priorities in relation to the information gained from the monitoring process.
				Ensure that sufficient redundancy exists in the monitoring program to validate achievements attributed to specific management actions.
			Lakes & Fisheries (L&F) - Health of the Waterbodies in the Tay Watershed	Trophic State - Review and monitor PEARL work completed in the watershed in the context of water quality management.
				Fish - Continue to conduct fisheries assessments in the watershed in order to assess trends, characterize fisheries populations and develop a watershed fisheries conservation plan.
				Fish Habitat - Continue to conduct fisheries studies in order to identify and characterize the fish habitat in the watershed, and vigorously pursue the development and implementation of a watershed fish habitat conservation program.
			L&F - Aquatic Integrity of the Tay River and Jebb's	Undertake stream assessment work for Grants Creek.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Synthesize and catalogue the 1999 stream forms for Jebb's Creek and the Tay River into a management map. The map should show recognizable habitat zones (e.g., riffle complexes, lowland forests, marsh) impact zones, and critical fish habitat. This synthesis is important as it can highlight areas where protection efforts should be focused.</p> <p>Complete a seine netting survey on the Tay River and its tributaries to help complete the fish record.</p> <p>Determine the proportion of natural and cleared shoreline as a baseline for further assessment work.</p>
			Wetlands	<p>Four wetlands identified for complete wetland evaluation because of their potential importance.</p> <p>Three wetlands recommended for mapping to determine if they are part of an existing significant wetland complex.</p> <p>Six wetlands recommended for ecological reconnaissance to characterize the wetland vegetation and highlight special ecological functions.</p> <p>Fourteen (14) wetlands under surveillance with complete evaluations to be done in response to development pressures or other risks of loss.</p>
Fish Habitat of the Tay River Watershed: Existing Conditions and Opportunities for Enhancement	2002	RVCA (Lanark, Leeds & Grenville and Frontenac)	Summary of Enhancement Projects - Priorities and Recommendations	<p>The Tay River watershed provides a diversity of aquatic habitat that is utilized by 44 documented fish species. In most areas of the watershed fish habitat is not limiting fish productivity. However, some locations within the watershed exhibit fish habitat that is degraded or demonstrates potential for enhancement, which would result in increased fish production and improved fishing opportunities. Identified within this report are threats to fish habitat such as: a) Lack of buffer strips and shoreline destruction; b) Nutrient loading - agricultural, urban and cottage sources; c) Blockages of streams by dams, perched culverts, roads, etc.; d) Loss of littoral habitat critical for fish spawning and nursery; e) Loss or alterations to wetland habitat; f) Fluctuating water levels; g) Water quality; h) Water quantity; i) Exotic species - Zebra mussels, Eurasian milfoil, purple loosestrife, etc.</p> <p>Table 3.1.1 lists several potential projects that would help address the issues listed above. These projects fall under five broad categories: 1) lake trout and walleye spawning bed creation and improvement; 2) assessment, repair and maintenance of water control structures; 3) restoration of riparian and shoreline vegetation (buffer strips); 4) fencing of stream banks and lake shorelines to prevent livestock access; and 5) wetland protection and enhancement.</p> <p>Such enhancement and rehabilitation projects are suggested since they: i. mitigate impacts commonly observed throughout the watershed; ii. contribute to resolving multiple issues (identified above); iii. are easily implemented and provide direct, noticeable results to the groups conducting the work; and iv. will promote the productivity of native and naturalized self sustaining fish populations.</p> <p>Suggested fish habitat enhancement projects are summarized in Table 3.1.1 below.</p> <p>It is important to note that all fish habitat enhancement projects focus on rehabilitation for or to establish native, natural, existing and self-sustaining fish populations. Aquatic habitat should not be manipulated to accommodate and introduced fish species. If implemented, the above projects could greatly improve existing fish habitat conditions, and in turn, increase the productivity of selected fish populations within the Tay River watershed.</p>
			Prioritization of Sub-watersheds - Priorities and Recommendations	<p>To maximize the use of limited financial resources, prioritization of each sub-watershed is an important planning exercise.</p> <p>Prioritization of sub-watersheds within the Tay River basin was based on a methodology developed for the Ausable Bayfield Conservation Authority (ABCA) Fish Habitat Management Plan (ABCA 2000). To establish priority, each subwatershed within the Tay River basin was evaluated using the following criteria: 1) fish habitat status and capability; 2) sensitivity of the resource; 3) current land use stress (outlined in Table 3.2.1); and 4) number and scale of enhancement opportunities.</p> <p>Additional criteria such as: cost effectiveness, community interest, educational purposes, landowner interest, fishing pressure, position in watershed (i.e. headwater vs. mainstem), natural heritage features (provincially significant wetlands and areas of natural scientific interest (ANSIs)), etc. could also be used to further prioritize sub-watersheds in the future. Using these criteria, this scoring system was utilized to weight and prioritize sub-watersheds (Table 3.2.3). Although these categories are somewhat subjective, they act as guidelines to direct attention to the key areas of the watershed that require fish habitat enhancement. In situations where limited financial support is available these guidelines may be followed to direct project money to the highest priority sub-watersheds. The priorities established in the report may also be used by stewardship councils and other groups to focus resource improvement and educational efforts. It is stressed that ranking sub-watersheds under priorities are not intended to discourage the undertaking of any of the habitat improvement projects identified in this report.</p>

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Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Using this scoring system, sub-watersheds can be broken-down into three classes of priorities. Based on the above criteria, the T3 (Bobs and Crow Lakes Sub-watershed) and T6 (Tay River Main Stem - Christie Lake outflow to Glen Tay) sub-watersheds ranked as Priority 1 (high). The T3 sub-watershed was ranked as high priority due to cold water, sensitive lake trout habitat, reservoir for system, number and scale of enhancement opportunities, and community interest (Bobs / Crow Lake Association past habitat work). The T6 sub-watershed exhibits several critical spawning beds for resident Tay River walleye and migratory Christie Lake walleye. The sensitivity of this resource, land use stress, community interest, and education and partnership building placed this area under Priority 1 (high). Although the sub-watersheds ranked under Priority 2 (medium) provide substantial fish habitat they tend to exhibit relatively fewer enhancement opportunities or have less sensitive resources. Generally, those sub-watersheds ranked as Priority 3 (low) display relatively untouched resources, are less sensitive, and have few enhancement opportunities.</p>
			<p>Priority Sub-watersheds by Restoration Target - Priorities and Recommendations</p>	<p>Throughout this report common issues and solutions are documented to enhance fish habitat. To direct funding for particularly common concerns and problems it is then necessary to separate issues impacting on fish habitat. Five 'keystone' issues have been determined to have the greatest impact on fish habitat within the Tay River basin. If the following problems are addressed, issues such as water quality, will be dealt with in the process. The five keystone issues facing fish habitat in the Tay River watershed are: a) lake trout and walleye spawning bed creation and improvements, and nursery area preservation; b) assessment, repair and maintenance of water control structures; c) restoration of riparian and shoreline vegetation (buffer strips); d) fencing of stream banks and lake shorelines to prevent livestock access; and e) wetland protection and enhancement.</p> <p>Restricting Livestock Access - Livestock, particularly cattle, have many points of access to water within the Tay River watershed. As stated throughout this report, most of the agricultural activity occurs in the Smiths Falls Limestone Plain east of Christie Lake and as such the majority of cattle access sites are located in this area. The main-stem of the Tay River and its tributaries have been documented as the most critical areas for this problem. Land stewardship activities for restricting cattle from water should focus on the following sub-watersheds, listed in priority: 1. Grant's Creek (G2 sub-watershed); 2. Tay River from Tay Marsh dam to Port Elmsley (T9 sub-watershed); 3. Tay River from Bobs Lake to Christie Lake (T4 sub-watershed); 4. Tay River from Christie Lake to Glen Tay (T6 sub-watershed); 5. Tay River from Glen Tay to Perth (T7 sub-watershed); 6. Bobs Lake (T3 sub-watershed); and 7. Long Lake (T1 sub-watershed).</p> <p>Lack of Buffer Strips / Riparian Vegetation - The loss of riparian vegetation commonly occurs in concert with cattle access sites and cottage or residential development, especially in the eastern portion of the watershed. This area exhibits relatively intensive cottage and rural development, and associated riparian degradation. If riparian vegetation is to be restored by replanting efforts, sub-watersheds should be considered in the following priority: 1. Grant's Creek (G2 subwatershed); 2. Tay River from Tay Marsh dam to Port Elmsley (T9 subwatershed); 3. Tay River from Christie Lake to Glen Tay (T6 sub-watershed); 4. Tay River from Glen Tay to Perth (T7 sub-watershed); 5. Tay River from Bobs Lake to Christie Lake (T4 sub-watershed); 6. Otty Lake (J1 sub-watershed); and 7. Pike Lake (G1 sub-watershed).</p> <p>Water Control Structures - A total of 16 water control structures (dams, weirs, etc.) are identified in this report (refer to Appendix 4). These control structures significantly impact fish habitat within the Tay River watershed. Most dams in the watershed are operated to control water levels for specific human uses, such as recreation, navigation, irrigation and for water storage in milling operations. Much of these control structures were not built with regard to fish migration or fish habitat, and through time have fragmented or destroyed significant fisheries and fish habitat. Many of the dams on the Tay River served past purposes (i.e. milling operations), but serve no present function and only disrupt the natural function of the Tay River. The following sub-watersheds exhibit fish habitat most heavily impacted by water control structures.</p> <p>Water Control Structures - Water control structures in the following sub-watersheds should be studied to determine their present day function, environmental effects and options for mitigating their impact on fish migration: 1. Tay River from Glen Tay to Perth (T7 sub-watershed); 2. Tay River from Christie Lake to Glen Tay (T6 sub-watershed); 3. Grant's Creek (G2 sub-watershed); and 4. Pike Lake (G1 sub-watershed).</p>



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Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Enhancement of Spawning Habitat - In the Tay River watershed, the loss of spawning habitat is closely related to water level manipulation. Fluctuating water levels in many portions of the watershed have negatively impacted fish reproductive success. Recent coordination of partners concerned with protection of fish habitat and water level manipulation has directed attention to concerns over fish habitat during critical life history events. This cooperation should continue between agencies, but fish habitat improvements should also be undertaken to remedy this issue. The following sub-watersheds are identified as the most heavily impacted with respect to loss of fish spawning habitat: 1. Tay River from Christie Lake to Glen Tay (walleye) (T6 sub-watershed); 2. Tay River from Bobs Lake to Christie Lake (walleye) (T4 sub-watershed); 3. Bobs and Crow Lakes (lake trout) (T3 sub-watershed); 4. Christie Lake (walleye) (T5 sub-watershed); and 5. Pike Lake (walleye) (G1 sub-watershed).</p> <p>Loss or Alteration to Wetlands - Wetlands provide critical spawning, nursery and rearing habitat for fish, preserve water quality and are hubs of biodiversity, and as such they should be targeted for protection and enhancement. In the Tay River basin, many large and provincially significant wetlands have been lost or altered due to human land use practices. The following sub-watersheds require priority rehabilitation and protection: 1. Grant's Creek Wetland (G2 sub-watershed); 2. Tay Marsh (T8 sub-watershed); 3. Michael's Creek Wetland (T3 sub-watershed); and 4. Christie Lake Wetland (T4 sub-watershed).</p>
			Funding Options - Priorities and Recommendations	<p>Community Fisheries and Wildlife Involvement Program (CFWIP) - The CFWIP is one of the most successful partnership programs of the Ontario Ministry of Natural Resources (OMNR). Thousands of habitat (or habitat related) projects have been completed through active hands-on participation of eager volunteers to benefit Ontario's fish and wildlife populations (CFWIP 1998). The OMNR provides the expertise and seed money for the enhancement project and interested groups pitch in volunteers to complete the task. Examples of traditional CFWIP projects relating to fish habitat that receive funding include: creating or enhancing fish spawning habitat, and stabilizing riverbanks or shorelines. OMNR reviews all applications to determine if they meet the criteria for the program and then prioritize them to direct funding. Since most enhancement work is conducted on Crown property, all projects must be reviewed by OMNR to determine if a work permit is required. This exceptional program provides a mutual benefit for all parties involved. The OMNR satisfies its mandate to protect and improve fisheries resources, the project educates volunteers of fish and fish</p> <p>Rideau Valley Clean Water Program - Recently, the Rideau Valley Conservation Authority (RVCA) announced a program beginning in January 2002 called the Rideau Valley Clean Water Program. This program will offer grant funding to farmers to reduce run-off of nutrients and chemicals from their property to streams, lakes, and wells in the area bordering the Rideau River and its tributaries (Kemptonville Creek, Tay River, and others). Grant money will be provided to cover 50-75% of project costs as an incentive to help individual landowners. Types of projects eligible for funding include: nutrient management plans, fencing livestock away from stream banks, planting and maintaining riparian buffer strips, erosion control, well protection, septic system repairs, fuel storage and handling improvements, and chemical storage facilities.</p> <p>Wetland Habitat Fund - The Wetland Habitat fund (WHF) provides private landowners with financial assistance for projects that improve the ecological integrity of wetland habitats. The WHF is supported directly by Wildlife Habitat Canada, the Province of Ontario and internationally by the North American Waterfowl Management Plan partners. Wildlife Habitat Canada is a national, not-for-profit organization based in Ottawa. Funds for conservation projects are generated through the Wildlife Habitat Conservation Stamp Program, the same conservation stamps migratory waterfowl hunters are required to purchase when obtaining a Migratory Bird Hunting Permit.</p> <p>Wetland Habitat Fund - The WHF favours projects with conservation plans that: contribute to the improvement or restoration of local wildlife habitat; address local wetland wildlife habitat issues; target specific wetland habitat issues but reflect the broader landscape ecology; lead to benefits that can be enjoyed either directly or indirectly by the general public; encourage partnerships and foster co-operation among landowners, interest groups and conservation agencies; provide evidence of permission from the landowner(s) for any proposed work on private land. Habitat project that conform to the WHF criteria may be eligible for funds up to a maximum of 50% of project costs or \$5 000 (which ever is less).</p>

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				<p>Living by Water Project - The Living by Water Project is a national incentive focusing attention upon protecting, conserving, enhancing, restoring, and support those interested in improving the health of Canada's shorelines. This project works with community conservation and stewardship groups, cottage associations, agencies, and government ministries to deliver its programs. Although this program does not provide financial support it encourages voluntary commitment of waterfront residences through programs such as the: shoreline action checklist, workshop-in-a-box, shoreline ambassador, homesite assessment, children's ribbon of life, and shoreline celebration and event planning manual.</p> <p>Many additional sources of financial or other assistance are available from other government and non-government agencies for projects that protect and improve fish and / or wildlife habitat. Interested individuals or groups wishing more information should contact the OMNR Stewardship or District offices or the Land Owner Resource Centre in Manotick.</p>
			Land Use Planning - Priorities and Recommendations	<p>Present and future development has and will continue to tremendously impact on fish habitat within the Tay system. Therefore, it is critical for all municipalities within the Tay River watershed to receive this document. This document recommends municipalities within the watershed conduct the following: Identify and protect sensitive natural features and areas such as wetlands, ANSI's and fish habitat in official planning documents and appropriate zoning by-laws; Protect natural shorelines and riparian areas throughout the watershed in all planning processes using conservation easements, setbacks, buffers and zoning to minimize the impacts of human development on sensitive fish habitats; Protect all wetlands in the watershed through appropriate measures in municipal planning documents, private land stewardship incentives, land trusts and public acquisition.</p> <p>Due to their obligations to development planning, municipalities have a major role in the protection of fish habitat in the Tay watershed. All partners should support municipal efforts by participating in discussions and advocating the protection of fish and their habitats.</p>
			Stewardship and Education - Priorities and Recommendations	<p>Many of the projects described in this report could be completed by farmers, private landowners, cottage and lake associations, and fish and game clubs. If projects are implemented by various groups and members of the public a sense of resource conservation and stewardship will be gained, at the same time educating involved parties of requirements essential to quality fish habitat.</p> <p>Recommendations - The following stewardship and educational initiatives are needed in order to protect and enhance fish habitat within the Tay watershed: This report should be distributed and presented to all groups and organizations within the Tay River watershed; Educational packages should be prepared for each lake / cottage association and farmers to provide property owners with information and things they can do to improve water quality, shoreline vegetation, control invasive species, etc. to protect and enhance fish habitat; Promote incentive stewardship programs to encourage farmers to apply best management practices such as cattle fencing, erosion control, manure management, alternate watering systems, Environmental Farm Plans, conservation tillage, and pesticide / fertilizer management which aid in the protection of fish habitat. Special attention should be given to farmers to help with the task of environmental protection because of the high cost of meeting today's environmental standards by family farm operations;</p> <p>Recommendations - The following stewardship and educational initiatives are needed in order to protect and enhance fish habitat within the Tay watershed: Encourage and support the establishment of lake associations on lakes that are not already organized. Once all lake associations are established, all should join the Alliance of Rideau Lakes Association to enhance the strength of the group to maintain water quality, fish habitat, natural shorelines and other environmental aspects; Promotion of angling, especially for young people, provides local residents with opportunities to value local fisheries resources. Cottage and lake associations or local fish and game clubs could organize fun, recreational fishing events during Family Fishing Weekend or Take a Kid Fishing Week in early July; Establish and support a Tay River Discovery Centre to provide information, educate and promote the protection of fish and fish habitat within the watershed; Encourage special events such as the Tay River EcoFest to promote awareness and stewardship of the natural resources of the Tay watershed;</p> <p>Recommendations - The following stewardship and educational initiatives are needed in order to protect and enhance fish habitat within the Tay watershed: Promote the "Friends of the Tay Watershed" group in implementing recommendations of fish habitat enhancement projects, educational activities, and communication between stakeholders.</p>

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**Previous Study Recommendations**

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Previous Study	Date	Watershed Area	Topic	Recommendation
			Monitoring and Future Studies - Priorities and Recommendations	<p>This report identifies current information available for the Tay River watershed and also cites areas where data gaps exist in reference to fish habitat. The following studies are recommended to improve our knowledge of fish habitat within the Tay River watershed.</p> <p>Recommendations: Evaluate or re-evaluate all identified wetlands; Conduct septic system surveys on shoreline properties within the Tay watershed to ensure they are functioning properly and not leaching excessive nutrients to the water; Conduct revised lake shoreline capacity modeling system for all lakes within the Tay watershed; Water Quality Monitoring: a) lake associations should continue to monitor nitrogen and phosphorus concentrations to demonstrate trends through time; b) RVCA should continue intensive water quality monitoring and benthic invertebrate sampling on an annual basis, consider the monitoring of point sources known to degrade water quality detailed in this report; Lake Associations in partnership with government agencies should undertake comprehensive Lake Management Plans to protect fish habitat and the aquatic environment. These plans could include long term monitoring for water quality, fish habitat surveys, CFWIP projects, septic system and shoreline surveys, etc. and published in lake association newsletters.</p> <p>Recommendations: OMNR and its partners should continue to monitor the health of fish populations within lakes and streams of the Tay watershed; Small tributaries and feeder creeks not identified in this report should be assessed with respect to fish habitat to determine if these habitats are degraded due to cattle access, improper culvert installation, water control structures, etc.; Near-shore habitat mapping and shoreline videotaping should be done on lake where this has not previously been conducted; Fish Habitat Studies - Information gaps pertaining to fish habitat could be filled by Cottage Associations undertaking annual spawning habitat inventories during peak spawning events for various species within their lakes (i.e. especially for walleye, lake trout, and bass). With minimal instruction, supervision, and equipment such studies could be conducted, and the data utilized by agencies and the associations to improve knowledge of critical habitat and detect changes in habitat use or degradation over time. This would also develop and promote a sense of resource stewardship and education, and aid in protecting sensitive fish habitats.</p> <p>Recommendations: All dams and weirs should be studied to determine their impact on fish and wildlife habitat. Opportunity exists to improve fish passage around future water control structures; Water levels - a) Explore the possibility of devising a long-term Water Management Plan for the Tay River watershed; b) OMNR, Department of Fisheries (DFO), and RVCA should continue to integrate management plans and communicate with Parks Canada - Rideau Canal to help minimize the disturbance of critical fish habitats due to water level manipulations; Monitoring should take place after any of the enhancement opportunities described in this document are implemented. Follow-up monitoring studies should be designed to be measurable and repeatable to determine if the project was effective, if improvements are required, and if alternatives should be considered for future projects; An additional follow-up assessment should be conducted three to five years after the implementation of this report to determine what has been accomplished and what still needs to be done.</p>
			Conclusion - Priorities and Recommendations	<p>From cold water lake trout lakes to warm water shallow ponds, provincially significant wetlands and riverine environments, the Tay River watershed boasts some of the most diverse fish habitat in eastern Ontario. With an ever-growing human population within driving distance of the watershed, the biodiversity of the Tay must be conserved at the present and into the future through community based resource management. This approach will foster a sense of resource stewardship, allowing the community to realize how important the Tay River watershed is for their quality of life. As described throughout this report, there are solutions to the complex problems and issues within the Tay River watershed, which incorporate the best interests of all the watershed inhabitants. This report, however, merely identifies the problems and only provides suggestions for improvement. If fish habitat is to be enhanced within the watershed it is up to everyone to work together and do their part in the conservation and protection of the natural resources of the Tay.</p> <p>When this occurs, the goals of the watershed plan will be met, and our mission statement will be realized. Above all, the vision of a watershed that is "healthy-environmentally, socially, and economically - and the character, quality of life and heritage feature of the area are maintained or improved" will become tangible.</p>
Greater Bobs and Crow Lakes Stewardship Plan	2007	RVCA (Frontenac and	Seven Primary Objectives	Water Quality and Water Levels: to maintain and improve our current standard of good water quality and water level management.

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Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Fisheries and Fishing: to protect and enhance the natural elements that fish depend on to ensure a healthy population and to provide a sustainable fisher for anglers.</p> <p>Natural Environment: to protect and enhance our natural surroundings to ensure a high quality environment for fish, wildlife, vegetation and people now and for the future.</p> <p>Boating and Recreation: to ensure the enjoyment of boating and other recreational activities on and around the lakes while respecting the desire for peace and tranquility, with special emphasis on the challenges posed by boating.</p> <p>Emergency and Municipal Services: to work with municipalities to improve the consistency of the administration of the lakes area, to maintain and improve our police and emergency services and to ensure the lake community receives an adequate level of attention to its needs for services and value for its tax contributions.</p> <p>Development: to ensure that our development activities, landscaping practices and resource extractions are in keeping with the character of our social, physical and natural environment.</p> <p>Sense of Community: to bring together the people of the lakes and build a common sense of ownership and responsibility for protecting the lakes, beginning with implementing the Lake Stewardship Plan.</p>
			Water Quality - Options for Action	<p>Continue water quality monitoring and include new criteria for testing such as: dissolved oxygen, temperature, bacteria such as e-coli, elements such as road salt, and toxins such as those that are left by gasoline.</p> <p>In particular, Green Bay and Crow Lake should be re-evaluated with respect to meeting the new "mean volume weighted hypolimnetic dissolved oxygen" (MVWHDO) objective of 7.0 mg/L (see Section 4.1 - Lake Trout).</p> <p>Educate people about best shoreline living practices with regard to: a - restricting the use of pesticides, herbicides, and fertilizers, with a possible exception of fertilizer for agricultural purposes; b - eliminating the use of detergents, including soap and shampoo in lakes; c - maintaining a phosphorus free life style; d - restricting shoreline alterations and maintaining or restoring a natural buffer along the shore.</p> <p>Ensure septic systems are functional, and promote such actions as: a - requiring new development (creation of lots, new buildings on vacant lots) to use new septic technology that reduces the amount of phosphorus that reaches the lakes (e.g. Waterloo Biofilter at <a href="http://www.waterloo-biofilter.com/">www.waterloo-biofilter.com/</a>); b - inspecting all existing septic systems periodically (<a href="http://www.ene.gov.on.ca/envision/water/septic/septic_qa.htm">www.ene.gov.on.ca/envision/water/septic/septic_qa.htm</a>); c - establishing a septic system re-inspection bylaw that would require a re-inspection at the time of sale of properties (where 5 years have passed since last inspection).</p> <p>Work with municipalities and railway companies to improve their practices (use of road salt, road and rail construction and maintenance, beaver dam removal, emergency measures, including derailments) to reduce impacts on water quality.</p> <p>Work with the farming community to encourage farming practices which minimize the impact on water quality such as restricting cattle access to the water.</p> <p>Assess the impact that upstream sources have, including McEwan's Creek, Fish Creek, Sucker Creek, Eagle Creek and others.</p> <p>Determine the necessary improvements to laws to protect the quality of water in the lakes, including those which may jeopardize water quality (such as mining laws).</p>
			Water Levels - Options for Action	<p>Consider the need for, and conduct as necessary, further studies, such as: a - a water budget that will assist in determining what changes, if any, to the existing management could be implemented, (e.g., a reduced rate of draw down from mid-August until October); b - research on maximum water takings - either from the lakes directly or from groundwater sources (e.g. wells) - that would protect water table and ensure sustainable development; c - examine flows from Eagle Lake and Long Lake into Bobs Lake to maximize their inflows; d - establish additional water level monitoring sites upstream of Bobs and Crow Lakes.</p> <p>Work with others (Rideau Canal Office of Parks Canada, other lake associations, Rideau Valley Conservation Authority and Friends of the Tay Watershed) to improve the management of water on our lakes.</p> <p>Make a formal request to the Rideau Canal Office of Parks Canada for information on the physical condition, vulnerability and safety of the dam and plans for maintenance and improvement.</p> <p>Determine necessary improvements to laws to protect the lakes with reference to dam operation and related matters.</p>

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Previous Study	Date	Watershed Area	Topic	Recommendation
				Establish an education and communication programme about managing water levels on Bobs and Crow Lakes so that people are aware of possibilities and limitations.
				Prepare contingencies for the situation of abnormal water levels in the future.
				Work with the Ministry of Natural Resources, Rideau Valley Conservation Authority and the Canadian Pacific Railway to address concerns of beaver dams releasing flood waters, in order to ensure the safety of the rail tracks on the northern shore of Crow Lake, and to avoid potential derailment and possible contamination of the lakes and the Tay Watershed.
			Fish and Fisheries - Options for Action	Improve and promote education on the merits of managing a sustainable fishery.
			Fish and Fisheries - Options for Action	Assess the effectiveness of previous projects designed to rehabilitate spawning sites to determine success and future directions.
			Fish and Fisheries - Options for Action	Work with the Ministry of Natural Resources and other groups to identify, rehabilitate, monitor and maintain fish spawning grounds.
			Fish and Fisheries - Options for Action	Work with the Ministry of Natural Resources to consider actions to improve the fishery by, for example: a - reducing the creel limit; b - increasing the size limit or using slot limit; c - altering or reducing the season; d - enter into an angler diary programme in partnership with the Ministry of Natural Resources; e - other regulatory measures to improve the fishery.
			Fish and Fisheries - Options for Action	Work with the Ministry of Natural Resources to encourage greater enforcement of existing fishing regulations (e.g. bass and walleye habit).
			Fish and Fisheries - Options for Action	Create a local education programme to: a - promote catch-and-release; b - promote the use of barb-less hooks; c - discourage the use of lead sinkers and weights; d - encourage anglers to complete angler diaries; e - encourage people to report poaching (bearing in mind that this does not include aboriginal fishing treaty rights which are often mistaken for poaching).
			Fish and Fisheries - Options for Action	Work with the municipalities and planning agencies to ensure that approvals for new development take into consideration the protection of fish habitat such as near-shore nursery and spawning habitat.
			Fish and Fisheries - Options for Action	Educate shoreline owners about near-shore and in-water activities that destroy fish habitat such as removal of rock rubble substrates, removal of submerged wood materials, removal of aquatic plants, and the creation of sand swimming areas over spawning sites for bass and other species.
			Natural Environment - Options for Action	Undertake an assessment of all habitats and species to establish baselines of information in order to assess the ongoing health and abundance of populations and determine continuing monitoring programmes related to the long-term sustainability of the ecosystem. This would include plants, forests, wetlands, reptiles and amphibians, fish and mammals. The baseline for birds has been recently established as described in Section 5.
			Natural Environment - Options for Action	Continue to update the Bobs and Crow Lakes Map with new information as it is generated and share this information with municipalities and Ministry of Natural Resources, and the Rideau Valley Conservation Authority.
			Natural Environment - Options for Action	Establish a "Ribbon of Life" programme: a - Work with all three municipalities to implement the highest consistent land use policies regarding development in the watershed; b - Develop an education package that informs all property owners about best management practices; c - Develop a landowner contact programme to provide assistance to those who want to naturalize their shorelines and properties.
			Natural Environment - Options for Action	Ensure that local official plans and zoning bylaws identify the location of all wetlands (provincially and locally significant), fish habitat and other habitat areas not currently included and establish policies to ensure their protection.
			Natural Environment - Options for Action	Undertake programmes (regulations or education) to protect wildlife nesting sites from human disturbance and to promote nesting of species such as Wood Ducks and Loons.
			Natural Environment - Options for Action	Establish education and communication campaigns: a - to promote awareness of habitat requirements for rare and endangered species; b - to promote awareness among property owners about the requirements of healthy bird populations, including many that each individual land owner can undertake; c - to educate young people on the importance of protecting the environment on the lakes.

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				Establish an "Invasive Species Programme": a - to monitor invasive plants and animals, including zebra mussels, spiny water flea, Eurasian water-milfoil (Tay River and lakes), purple loosestrife, gypsy moth, and others; b - to establish a boat washing station to reduce the risk presented by foreign invasive species; c - to post signage at all access points to the lake regarding methods to prevent the spread of invasive species into the lake.
			Boating and Recreation - Options for Action	<p>Inclusion of lake stakeholders in discussions by municipalities on additional public access points on Bobs and Crow Lakes. Any such decisions must be considered in light of the 'need' for it within the context of the potential for increased boat traffic, safety issues and the associated impacts on the environment and adjacent properties and neighbourhoods.</p> <p>Continue Greater Bobs and Crow Lakes Association efforts to promote the safe operation of boats by developing a communication / education campaign about the following: a - creating awareness of existing safety regulations such as boat speed near shores, in channels and in dangerous areas; b - developing a "Boating Code of Conduct" manual to be distributed to all households and commercial camps on the lakes with emphasis on responsible boating practices and the effect of wakes, noise and dangerous behaviour; c - developing youth workshops to teach skills about the responsible handling of power and non-power watercraft; d - posting additional signs concerning speed and safety.</p> <p>Create awareness about the impacts of 2 stroke engines and promote the use of new fuel efficient technology (e.g. high efficiency 2 stroke engines and 4 stroke engines).</p> <p>Increase enforcement in established high hazard areas (e.g. narrows, environmentally sensitive areas like wildlife and fish nesting sites and high density population areas): a - continue Greater Bobs and Crow Lakes Association work with the Ontario Provincial Police; b - consider establishing a private boat patrol for the lake; c - encourage residents to report serious boating problems to the Ontario Provincial Police.</p> <p>Encourage commercial operators and private cottage renters to promote awareness about boating safety, and rules among their visitors.</p> <p>Consider a ban on boat races before such events come to our lakes.</p>
			Emergency and Municipal Services - Options for	<p>Work with the three municipalities to design and implement the highest consistent land use policies for sustainable development.</p> <p>Work with municipalities to deliver appropriate waste management services for permanent, seasonal and visitor occupation, with a continued increasing demand in mind.</p> <p>Work with municipalities and other organizations to lobby the Ontario government for mandatory septic inspections for all areas of the province.</p> <p>Work with municipalities to deliver appropriate road access and maintenance, with continued increasing demand in mind.</p> <p>Work with other groups to lobby for changes to the municipal taxation process to achieve a more equitable share of the local tax burden or an equitable share of services.</p> <p>Investigate ways of enabling the voices of non-Canadian property owners to be heard by the municipal administrations.</p> <p>Continue to support dialogue between all emergency services and provide them with information about our lakes that will help improve their level of care and service.</p> <p>Continue regular meetings with the Ontario Provincial Police and support and promote neighbourhood watch programmes.</p> <p>Continue to educate residents on fire regulations and the 15-foot road and laneway clearance requirements.</p> <p>Work with the emergency service providers to ensure they are able to respond effectively to emergencies on water access properties (e.g. islands) and have identified the location and availability of aircraft and watercraft landing sites (able to handle stretchers) for use by all emergency services.</p> <p>Work towards the establishment of medical emergency helipad sites in the area.</p>
			Development - Options for Action	Establish a "Ribbon of Life" campaign to enable a comprehensive approach to protecting our lakes and its shorelines from inappropriate human actions. The campaign must balance education and regulation approaches.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Work with all three municipalities to design and implement consistent land use policies for sustainable shoreline development. Such policies could include: a - a clear and identifiable vision statement for the entire lake; b - consistent high standards for new lot creation and development; c - confirmation of important values identified by the community (e.g. locally significant natural areas or points of interest, light and noise pollution, etc.); d - support for the retention of all Crown shorelines; e - setting appropriate limits for development along shorelines and back lands; f - setting limits on the size and scale of cottages and buildings immediately along, or visible from, the shoreline; g - limiting the cutting of trees; h - limiting change to the natural environment; i - prohibiting mining and mineral aggregate operations within an appropriate distance of the shoreline or the sightline (whichever is greater) of the lake.</p> <p>Work with the three municipalities and other agencies to develop an education package to inform shoreline property owners about best management practices such as: a - maintenance and care of septic systems; b - protecting and restoring natural shorelines and lake character; c - architectural design guidelines; d - limiting glare and prevention of light trespass; e - sources of water quality and levels information.</p> <p>Educate lake residents regarding light pollution and noise pollution.</p> <p>Develop a land owner contact programme to meet with people face to face and provide assistance with: a - naturalizing shorelines and properties; b - promoting natural sightlines; c - limiting tree cutting and other changes to the natural environment; d - establishing land trusts or conservation easements.</p> <p>Participate in future Forest Management Planning processes to ensure important values are maintained, such as sightlines, setbacks from water bodies and protection of sensitive natural features.</p> <p>Continue to support Bedford Mining Alert and the Citizens Mining Advisory Group.</p>
			Sense of Community - Options for Action	<p>Determining the interest in our community of building stronger links within the Bobs and Crow Lakes watershed and with others in the region.</p> <p>Liaising with other interested groups or communities within the area and developing further contacts as they arise.</p> <p>Determining the best communication approaches to promote a sense of community and instill the ethics and actions of the Lake Stewardship Plan.</p> <p>Reaching out specifically to youth to instill a sense of ownership and stewardship as they are the future of the lakes.</p> <p>Determining and undertaking new programmes or events that could bring our community together.</p>
Groundwater Use Characterization of the Heart's Desire Community, Ottawa, Ontario	2006	RVCA (City of Ottawa)	Conclusions	<p>The results of the 2004 residential sampling program within the community of Heart's Desire have confirmed the presence of several elevated concentrations. Several samples were observed to have chloride and sodium concentrations above the Ministry of the Environment (MOE) aesthetic objective concentration. Nitrate concentrations were below the MOE maximum acceptable concentration at all wells but concentrations were elevated at several wells. Total coliforms were identified in 5 of the 80 samples and the mineralization of the groundwater was found to be widespread within the community.</p> <p>The potential sources for the elevated parameter concentrations include: septic system effluent; road salting and de-icing practices; softened water introduction to the aquifer via septic system effluent and groundwater use practices; and natural causes as a result of mineral dissolution along the flow path.</p> <p>The groundwater use characterization suggests that elevated parameter concentrations within the community are primarily the result of a local recharge mechanism from overburden formations (which contain impacted soil / groundwater) to the bedrock aquifer. Pumping tests completed for the South Nepean Collector project indicated that the shallow bedrock formation behaves as a semi-confined aquifer. As such, the bedrock aquifer could be vulnerable to any substance introduced at the surface up gradient of the community.</p> <p>The Heart's Desire community is located in an area under recent development pressure. The main issues with respect to development pressure would be to manage the fertilizer / lawn care product and herbicide / pesticide use and road salt application in the vicinity of the community. The Heart's Desire community water resource is sensitive to the use of chemicals at a local scale. Chemicals that are introduced at surface in close proximity to the Heart's Desire community have the potential to enter the water resource as a result of local bedrock aquifer recharge and as a result, care must be taken to limit such loadings in the area of the Heart's Desire community.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The hydrogeological characterization made it clear that the Jock River acts as a groundwater discharge area (Velderman, 1993). As a result of the presence of this area, the groundwater flow system to the south of the Jock River (i.e. beneath the Stonebridge residential development) is interpreted to discharge to the Jock River. In addition, north of the Jock River the presence of the drumlin which underlies the Heart's Desire community is interpreted to create a bedrock groundwater flow to the south with discharge to the Jock River. Therefore, groundwater from south of the Jock River does not migrate to wells in the Heart's Desire community (north of the Jock River). It is notable that sampling within the Stonebridge residential development has indicated groundwater of better quality than was observed within the Heart's Desire community. This presents another line of evidence, in addition to evidence provided by the hydrogeological characterization presented above, that the groundwater within Heart's Desire is unrelated to groundwater within the Stonebridge residential development.</p> <p>Development pressure in the area of the Heart's Desire community could potentially threaten the quality of the Heart's Desire groundwater resource. Although the recharge area for the bedrock aquifer is interpreted to be several kilometres from the community west of the Village of Richmond, the potential for groundwater quality interference does exist should overburden in the lands to the north of the community become impacted as a result of development. The groundwater flow direction is inferred to have a southerly component (towards the Heart's Desire community) and the aquifer providing water to the community is interpreted to be semi-confined and thus, substances of concern may be introduced into the aquifers. In particular, the overburden wells within the Heart's Desire community could be vulnerable to potential groundwater deterioration brought about by future development. Development to the north could potentially lead to further degradation of water quality in the community if certain practices within the new development are not limited / managed.</p> <p>A surface water management plan should be developed for the lands to the north of the Heart's Desire community as a preliminary step to land development. Because groundwater recharge to the bedrock aquifer is interpreted to be some distance from the community, groundwater quantity should not be affected, in wells accessing the bedrock aquifer, by development to the north. There may be some effect on groundwater quality for those residences whose wells access the overburden aquifer. Development to the south of the community (i.e. in the general area of the Stonebridge residential development) is not expected to contribute to groundwater deterioration in the Heart's Desire community because this area is interpreted to fall within a separate groundwater flow regime. Some consideration should be given to the possibility that groundwater quality could be threatened by practices that occur in the vicinity of the groundwater recharge area.</p>
			Groundwater Monitoring Program	<p>Selected wells within the community had both nitrate and bacteria levels that were cause for concern and further guidance has been provided to these well owners by the Health Unit. In order to manage changes in water quality, implementation of a groundwater monitoring / testing program to serve as an early detection system for groundwater deterioration would be desirable. The monitoring wells that were constructed for the purposes of monitoring the effects of the construction of the South Nepean Collector sewer could be used for implementation of the monitoring program.</p>
Hydrogeologic Evaluation; Potential for Village Expansion Based on Private Individual Services, Village of Richmond	1991	RVCA (Ottawa)	Recommendations	<p>The simulations of the aquifer yield suggest that the water demands for a residential population of 7680 plus its industrial commercial and institutional allocations can be met using the bedrock aquifer. Because an increase in groundwater mineralization can be expected due to the upconing of water from deeper bedrock aquifers, a monitoring program to document the performance of the bedrock aquifer is recommended. The monitoring program should be implemented immediately. The total population may be revised subsequent to the appraisal of the performance of the aquifer when compared to the simulation.</p> <p>In order to monitor aquifer quality and drawdown within the Village, observation wells should be installed and monitored. The actual effects of the development can then be assessed. The monitoring program will confirm the simulated conditions. Drawdown readings of test wells are recommended. This monitoring program should be complemented by a water quality survey of indicator parameters. The quality survey should be completed at regular time intervals to verify the behaviour of the aquifer system. Seasonal variations of water quality could be experienced. High seasonal water consumption activities such as lawn watering should be restricted in particularly dry years.</p>



## Table A-1

### Previous Study Recommendations

#### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Figures 11 and 12 outlines the drawdown induced by interim population development equivalent to 5000 and 7500 population (i.e. 2740 and 3865 m<sup>3</sup>/day respectively). The model output summaries calibrated for a transmissivity of T = 15 m<sup>2</sup>/day are provided in Tables A-5 and A-6 for the two interim development scenarios.</p> <p>All non-domestic individual well water supply should be registered with the Township and should possess a water taking permit on file at the Township even though below the 50,000 L/day consumption criteria, in order to keep control on aquifer uses. The use of the aquifer as heat exchange for heat pumps should not be permitted in Richmond. The use of groundwater as heat exchange could affect the groundwater quality by altering the solubility of chemical compounds.</p> <p>In the southeast portion of the Village, where the overburden is thinner, the terrain has a relatively lower suitability for accepting septic system effluents. Because this area contributes to the bedrock aquifer recharge, we recommend that great care be taken in the management of the land use. Ideally, the sanitary sewer should be extended to service this areas to prevent contaminant loading to the groundwater systems. If development on private services is unavoidable, the commercial activities permitted in the southeast corner of the Village should be restricted to a dry type industry with minimal liquid waste generation. Low population industry such as warehousing is preferable. All septic system effluent should be handled by municipally operated class V systems (i.e. holding tanks).</p> <p>The handling of any industrial liquids should be done with great care to avoid spills which would readily access the groundwater supply. A well head protection plan should be implemented over the recharge area to account for the large volumetric contribution of the leaky clay aquitard to the bedrock aquifer.</p> <p>The overall development density equivalent to approximately 7.2 m<sup>3</sup>/day per hectare should not be exceeded. The concentration of higher density development will modify the simulated drawdown configuration and may create a detrimental impact. A previous study of a property in the northern portion of Richmond indicated that individual domestic wells with small separation distances could be accommodated on the basis of the aquifer potential, localized area within the Village boundary could be developed in row house type clusters but the overall average lot density for the Village should be adhered to. The impact of projects with localized high well yields however should be evaluated on an individual basis.</p> <p>Future development should be supported by detailed hydrogeological reports (Appendix H). They should include well interference measurements and an assessment of the contributing cumulative drawdown induced on the parcel subject to development. In addition, these site specific reports should complete an exhaustive survey of all nearby existing wells by water well record review and by interviews of existing owners. This survey should document well type, depth, available drawdown, and quality (i.e. major ions). An opinion should be formulated on the probability of detrimental impacts to these existing wells. The number of wells surveyed should be at a minimum include the wells located within the area of cumulative zone of influence of the proposed development in consideration. Hydrogeologic reports should specify well completion, including casing length and grouting methods.</p> <p>Because of the financial impacts that could be caused by a deterioration of the groundwater resource in Richmond, it is imperative that all wells be adequately grouted. In the Northern portion of the Village the thick clay soils will serve to some extent as a natural safeguard to the underlying bedrock aquifer. However, poorly sealed wells could provide paths for contaminant migration to the water bearing zones. Field verification of adequate grouting should be mandatory for all wells.</p> <p>As an additional precaution, all buried chemical reservoirs (e.g., service station gas tanks or tanks for petroleum products or solvents) should be identified and equipped with a double walled tank system with sensors connected to an alarm system between the double walls. As an alternative, all reservoirs should be constructed above ground with proper diking or another means of spill containment. Emergency teams should be made aware of the potential impact of a spill to the water supply and they should be trained to react with celerity to such accidental events. In particular, these recommendations should be implemented in the southeast corner of Richmond (shallow soil over rock).</p> <p>A number (1 to 2 hundred, possibly more) residences are expected to be serviced by older substandard wells constructed by individual owners (personal communication, H. Mains, H. Mains Drilling Co. Ltd.). Shallow wells completed by post hole auger or dug wells in the clay have been reported in Richmond. Furthermore, these wells are likely equipped with shallow (i.e. suction) type pumps. It was not possible to accurately assess the number of, or the location of the substandard wells within the mandate of this study. It is also not possible to accurately predict the impact of the increased groundwater demand on these "clay wells".</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>These wells could experience a reduction in yield. These clay wells should be properly abandoned and replaced with grouted bedrock wells.</p> <p>A program of abandonment and replacement of drilled wells equipped with submersible pump may provide sufficient incentive to ensure the upgrading of existing well water supplies in Richmond.</p>
Hydrogeologic Investigation of Four Communal Well Systems in the Regional Municipality of	1984	M-R SPR (Ottawa)	<p>Julia Subdivision (Carp) - Remedial Alternatives</p> <p>Hillside Gardens Subdivision (Manotick) - Remedial Alternatives</p>	<p>The preliminary assessment of the existing water supply system at the Julia Subdivision confirms the undersizing of the communal water supply system. The existing well appears to be produced at its optimum capacity, and improvements on the existing well such as lowering of the pump setting or increasing of the pump size are not recommended at this time.</p> <p>In order to meet the Region design criteria for water supply, the preferred alternative would be to construct additional well(s). A priori (i.e. before experimental drilling exploration), the preferred well will be completed in the overburden. This single well producing 275 Litres per minute (Lpm) (60 gallon per minute (gpm)) could be located in the vicinity of the existing well, with minimum well interference since the two nearby wells would be tapping different aquifers. The new well could be typically 50 metres (150 ft.) in depth, completed with a screen and drilled using a 25 cm tricone bit and the bentonite mud rotary technique, until a permeable and adequately sorted coarse grained bed is encountered through examination of drill cuttings and circulation losses. Screen size should be determined from a sand sample subsequent to hole completion.</p> <p>Pursuant to non-favourable results during the exploratory drilling of the overburden aquifer, a bedrock well field could be completed within the westernmost portion of the Julia Subdivision. These three new wells producing a minimum of 90 Lpm (20 gpm) will have to be space adequately to minimize well interference. These new wells could be typically 70 metres (225 ft.) in depth using conventional 25 cm air rotary drilling. These could be extended to 90 metres (300 ft) below ground surface if unsuccessful at intersecting a shallower permeable fracture system. The final locations of wells could be confirmed subsequent to the exploratory drilling programme.</p> <p>In order to abide by the recent Ministry of the Environment (MOE) guidelines on well completion each bedrock well should be drilled, cased and pressure grouted into the bedrock. The wells should be drilled as an open hole down to a depth of a minimum of 0.5 metres into the bedrock (typically 50 metres or 160 ft. from the ground surface). The use of an experienced driller is recommended to ensure that a proper seal is placed in the annulus space of the casing. This seal could be ideally made of a cement slurry. This well completion technique which is outlined in Figure 2.12 and Table 2.3 will ensure the preservation of the integrity of the groundwater supply.</p> <p>In the case of an overburden well, such a seal should be installed in the upper 15 metres of the well, in order to bind the annular space of the casing with the marine clay aquitard overlying the confined sanitary aquifer.</p> <p>The preliminary assessment of the existing water supply system at the Hillside Gardens Subdivision confirms the undersizing of the communal water supply system. The existing wells appear to be produced at their optimum capacity, and improvements on the existing wells such as lowering of the pump setting or increasing of the pump size are not recommended at this time.</p> <p>In order to meet the Region design criteria for water supply, the preferred alternative would be to construct additional wells. A bedrock well field could be completed within the Hillside Gardens Subdivision. Three new wells producing a minimum yield of 136 Lpm (30 gpm) each will have to be spaced adequately to minimize well interference. These new wells could be typically 60 metres (200 ft.) in depth using conventional 25 cm air rotary drillings. If unsuccessful in intersecting adequate permeable fractures, wells could be extended further into the Nepean sandstone to 90 metres (300 ft) in depth.</p> <p>In order to abide by the recent Ministry of the Environment (MOE) guidelines on well completion each new well should be drilled, cased and pressure grouted into the bedrock. The wells should be drilled as an open hole down to a depth of a minimum of 0.5 metres into the bedrock (typically 23 metres or 75 ft. from the ground surface). The use of an experienced driller is recommended to ensure that a proper seal is placed in the annulus space of the casing. This seal could be ideally made of a cement slurry. This well completion technique which is outlined in Figure 2.12 and Table 2.3 will ensure the preservation of the integrity of the groundwater supply. In addition, the separation distance between the well and any septic system should be maximized. In any event it should not be less than 15 metres, preferably 30 metres.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Carleton Lodge - Remedial Alternatives	<p>The preliminary assessment of the existing water supply system at the Carleton Lodge confirms the undersizing of the system. The existing well capacities have decreased over the years and improvements on the existing wells such as lowering of the pump setting or increasing of the pump size are not recommended at this time.</p> <p>In order to meet the Region design criteria for water supply, the construction of additional wells is necessary. The preferred option is to construct two wells in the overburden. These well producing an average 300 Lpm (65 gpm) could be located in the vicinity of the existing well No. 2, with minimum well interference since they would be tapping different aquifers. The new well would be typically 25 metres (80 ft.) in depth, complete with a screen and would be drilled using a 25 cm tricone bit and the bentonite mud rotary technique until a permeable and coarse grained pocket of gravel is encountered through examination of drill cuttings and circulation losses. Screen size should be determined from a sand sample subsequent to hole completion.</p> <p>Pursuant to non-favourable results in search of high yielding overburden wells, option two consists of constructing a bedrock well field. These four new wells producing a minimum of 136 Lpm (30 gpm) will have to be spaced adequately to minimize mutual well interference. These new wells could be typically 70 metres (225 ft.) in depth using conventional 25 cm air rotary drilling. These could be extended to 90 metres (300 ft.) below ground surface if unsuccessful at intersecting a shallower permeable fracture system. The final locations of wells could be confirmed subsequent to the exploratory drilling programme.</p> <p>In order to abide by the recent Ministry of the Environment (MOE) guidelines on well completion each bedrock well should be drilled, cased and pressure grouted into the bedrock. The wells should be drilled as an open hole down to a depth of a minimum of 0.5 metres into the bedrock (typically 50 metres or 160 ft. from the ground surface). The use of an experienced driller is recommended to ensure that a proper seal is placed in the annulus space of the casing. This seal could be ideally made of a cement slurry. This well completion technique which is outlined in Figure 2.12 and Table 2.3 will ensure the preservation of the integrity of the groundwater supply.</p> <p>In the case of the overburden wells, such a seal should be installed in the upper 15 metres of the well.</p>
			Munster Hamlet - Remedial Alternatives	<p>The preliminary assessment of the existing water supply system at Munster Hamlet indicated that the existing system fails to meet the Regional Municipality of Ottawa-Carleton (RMOC) design criteria by only a small amount and that the existing system offers a good potential to be upgraded without the construction of a new well. It is our understanding that although this increase may meet the design criteria, it may not be sufficient to satisfy the very high instantaneous water consumption demanded by such activity as lawn watering in the summer months.</p>
			Conclusions	<p>A review of communal groundwater supply systems was completed for the Jiulia Subdivision, the Hillside Gardens Subdivision, Carleton Lodge, and the Hamlet of Munster. For each system, we have provided an outline of the geologic and hydrogeologic settings, a description of the communal water system, including a discussion of the recorded water consumption, an assessment of the water supply requirements and available aquifer capabilities and a guideline for recommended remedial activities. It was concluded that all four communal groundwater systems have a deficient water supply to a different degree. A summary of recommendations contained in this report are provided in Table 6.1.</p> <p>Jiulia Subdivision - Both the flow rate and reservoir volume were found to be insufficient at the Jiulia Subdivision's communal groundwater supply. A total of 274 Lpm (60 gpm) of additional pumping capacity is required for the existing subdivision. A series of three (3) new bedrock wells is recommended as an additional source of water. As an alternative, one overburden well could possibly satisfy the required water demand. The occurrence of an adequate water bearing zone in the overburden should be confirmed during an exploratory drilling programme. In addition, the ground level reservoir capacity should be increased by 47 m<sup>3</sup> (0.010 mg) in order to satisfy the minimum RMOC design criteria.</p> <p>Hillside Garden - Only the flow rate of the water supply system was found to be insufficient at the Hillside Garden Subdivision. A total 400 Lpm (88 gpm) of additional pumping capacity is required for the existing subdivision. A series of three (3) new bedrock wells are recommended as a source of water. A concern was expressed on the possible well interference due to the high ground water use in this section of Manotick Island. This may mean that this additional flow rate may not be provided without interfering with existing or future bedrock wells.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Carleton Lodge - Both the flow rate and the reservoir volume were found to be insufficient for the Carleton Lodge communal groundwater supply. In fact, the greatest system deficiency was noted when compared with the 3 other study areas. A total of 593 Lpm (130 gpm) of additional pumping capacity is required for the existing subdivision. The construction of two (2) overburden wells is recommended for an additional source of water. If unsuccessful in finding high yielding water bearing zones in the overburden then a second option consisting of the construction of four (4) or possibly three (3) bedrock wells is recommended. The occurrence of an adequate water bearing zone in the overburden should be confirmed during an exploratory drilling programme. In addition, the ground level reservoir capacity should be increased by 226 m<sup>3</sup> (0.050 mg) in order to satisfy the minimum RMOC design criteria.</p> <p>Munster Hamlet - Based on the results of our investigation, the water volume design criteria could be provided from the existing wells in Munster Hamlet. However, a controlled increase of the well pumping rate may not be sufficient to supply very high instantaneous water consumption demanded by such activities as intense lawn watering. Recommended work activities include the identification of well water level fluctuations under normal operating mode, a reassessment of well capacities to sustain a small pumping rate increase (44 Lpm) , and an appraisal of the present pumping equipment to ascertain their capacity to lift that much more water. It is recommended that an instantaneous flow gauge is installed in order to assess actual high peak flows. No additional water storage volumes are required for Munster Hamlet.</p>
Hydrogeological Assessment and Remedial Activity Summary, Munster Hamlet Production Wells 1 & 2	2002	RVCA (City of Ottawa)	Recommendations	<p>In addition to the monitoring conditions attached to the Certificate of Approval, the City should monitor Turbidity levels periodically, particularly at well #2, to ensure concentrations remain below the Ontario Drinking Water Standards (ODWS) value. The City may also wish to test the soundness of the water main between well #2 and the reservoir, if significant Turbidity fluctuations reoccur this location in the future. In addition to pump cycle and pumping rate already monitored by the City, well water levels should be monitored at the two wells. Wells could be equipped with pressure transducers, similar to the Solinst water level logger, or equivalent.</p>
Hydrogeological Assessment of Village of Carp Well Supply,	2001	MVCA (City of Ottawa)	Recommendations	<p>The following recommendations have been developed based on the findings of the study.</p> <p>The two existing aquifer monitoring wells are too shallow in depth and should be replaced by new installations that fully penetrate the aquifer utilized by the Village of Carp wells. This recommendation is supported by reports that the existing wells demonstrate poor recovery. This condition should not exist given the highly transmissive properties of the sand and gravel aquifer.</p> <p>A polyvinyl chloride (PVC) monitoring well, thought to have been constructed during the Trow, 1990 environmental site assessment of the well site property still exists behind the former Fire Department garage. Since this well serves no current purpose and is not being maintained, it should be properly sealed and abandoned. Prior to its abandonment, it is recommended that the monitoring well be purged and a groundwater sample be collected for petroleum hydrocarbon analyses. The rationale for the sampling is that the monitoring well is situated in close proximity to the former furnace oil tank behind the garage. Consequently, the groundwater</p> <p>Subsequent to the removal of the old furnace oil tank behind the former Fire Department garage, the City has now installed a new oil tank at this location. The operation of the new furnace oil tank continues to present the concern that a fuel oil spill could occur at this location (approximately 50 metres from the wells). In this regard, it is recommended that a spill containment system be constructed if the tank is to remain at its current location on the outside of the garage. Alternatively, it is suggested that the tank be relocated within the building structure, thereby reducing the potential for vandalism and accidental damage to the tank.</p> <p>In 1994, two underground storage tanks (USTs) were removed from the well site property. Documentation related to the observed condition of the USTs and/or the observed condition of the surrounding soils during the tank removal should be compiled by the City. This information is necessary to confirm that the former location of the USTs is not a potential source of contamination for the Carp wells.</p> <p>Trihalomethanes (THMs) were detected for groundwater samples collected at monitoring well MW95-1 (MW #1) for both the 1999 sampling and the February 2001 sampling events. Further investigation should be carried out by the City to identify the source of THMs at the monitoring well location.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Hydrogeological Evaluation of Municipal Water Supply - Village of Lanark Water Supply System	2005	MVCA (Lanark)	Conclusions and Recommendations	Two deep bedrock wells TW-1 and TW-2 were drilled into the Precambrian marble bedrock and evaluated through pump testing. Test well TW-1 demonstrated an individual yield of about 3.4 L/s (45 lpm), whereas the safe yield of TW-2 was evaluated to range between 7.6 and 10.3 L/s (100 to 136 lpm) depending on the constraints used. The transmissivity of the bedrock aquifer in the vicinity of test well TW-1 was measured to be 24 m <sup>2</sup> /day, whereas analysis of the pumping test data from TW-2 resulted in a transmissivity of about 32.3 m <sup>2</sup> /day. The storativity of the aquifer was evaluated based on pumping test data from TW-2 at about 8.3 x 10 <sup>-6</sup> . <u>The aquifer tapped by the test wells is interpreted to be confined</u>
				Based on the superposition principle, if the two test wells TW-1 and TW-2 are pumped simultaneously at their pumping test discharge rates, this may cause excessive drawdown at TW-1 which would result in dewatering of the shallow water bearing fractures and reduction of well yield. Given that the major bearing zones are located at much greater depth for TW-2, there is no similar concern for TW-2. The safe combined yield of the two wells is therefore evaluated at 9.1 L/s (120 lpm), about half of the design 20-year requirement for the Village of Lanark.
				Drawdown data measured at the neighbouring observation wells indicated that the cone of influence produced by pumping at well TW-2 extended to less than 360 metres from the pumping well after 24 hours of pumping. At that time, the pumping was approaching steady state conditions.
				The water supply in the area of test wells is through domestic wells. A drawdown of several metres was created by the pumping action of TW-2 at a neighbouring well located about 70 metres from the test well. This effect is interpreted to not compromise the domestic water supply at this location given the available drawdown. Given that other private residences are located at about 500 metres or more from the test wells, they would likely not be affected by the operation of the test wells as production wells.
				The water quality testing conducted at each test well demonstrated that the groundwater meets Ontario Drinking Water Standards, Objectives and Guidelines (June 2003).
				TW-1 and TW-2 have been constructed such that they are suitable for future use as production wells. It is likely that the test wells TW-1 and TW-2 will classify as non-groundwater under the direct influence of surface water (GUDI), based on the results of water quality testing findings and the installation of the wells with deep grouted casing. In light of the current regulatory environment, it is suggested that a full GUDI review of the wells be completed once it is decided to proceed with the communal water supply project.
				The geologic and hydrogeologic conditions in the area of Test Well Site #2 are indicated to be favourable for the development of a communal groundwater supply for the Village of Lanark.
				Since the ultimate goal for water supply for the Village of Lanark is 17.4 L/s (230 lpm), and based on information available at this time, it is expected that between 4 to 6 wells could be required in a well field to produce the desired supply rate. It is recommended that any additional test well constructed for this project be separated by at least 100 metres to minimize well interference.
It is recommended that the public be informed of the strategy of water supply for the Village of Lanark, and in particular the local residents in the neighbourhood of the test well area and that future test wells be positioned as far away as possible from existing residences in the area.				
Hydrogeological Study, King's Park Subdivision, Richmond	1991	RVCA (Ottawa)	Recommendations	A number of recommendations are made with respect to the upgrading, maintenance and monitoring of the well system for King's Park Subdivision, Richmond.
			Water Quantity - Recommendations	The system is capable of supplying significantly greater volumes of water than are presently required for the system. Therefore the following recommendations are with respect to maintenance of the pump equipment.
			A pump test should be carried out on Well No. 2 at a rate of 2618 m <sup>3</sup> /day (400 imperial gallons per minute (igpm)) in order to verify the yield and to determine pump efficiency. Provided the results of the pump test are positive, an application should then be made to the Ministry of the Environment (MOE) to increase the permitted capacity of Well No. 2 to 2618 m <sup>3</sup> /day (400 igpm).	

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Specific yields of the wells should be determined semi-annually by running short term, 6 hour pump tests, at the maximum flow rates available from the pumps. Decreases in specific yield should be used to determine when well maintenance is required. Water levels and pumping rates should also be compared with pump characteristic curves to determine whether pump maintenance is required. At a minimum, well pumps should be pulled and inspected every five years.</p> <p>Water level and water use data should be monitored on the same basis as at present, i.e. daily, and this information should be reviewed annually to assess whether there are any major changes in aquifer conditions or water use patterns.</p>
			Water Quality - Recommendations	<p>The elevated Turbidity should be remediated, either by the installation of screened wells / gravel packs, or by provision of a treatment system. Both of these options should be evaluated from a feasibility and economic standpoint, and the most cost-effective solution should be implemented immediately.</p> <p>The hydrogen sulphide problem should be addressed. Water samples should be taken from those households which have indicated hydrogen sulphide odours. These samples should be analyzed for iron and sulphur bacteria. At the same time, the water mains should be inspected, either by physically exposing the lines, or by a video inspection. If encrustation or other sources or sites for bacteria buildup are present, the lines should be cleaned. After the lines have been cleaned and flushed, the same households should be again sampled to determine if there has been any decrease in concentration.</p> <p>General monitoring of water quality should continue on the same basis as it is presently conducted, i.e. monthly, and the parameters tested should remain the same. After remedial measures are taken with respect to Turbidity, the frequency of monitoring should be increased to twice a month for a minimum of 1 year to determine the effectiveness of the remedial action. This information should be reviewed on a quarterly basis to evaluate any changes in chemical quality.</p>
			System Inspection - Recommendations	<p>The system inspection revealed only one deficiency that may need to be corrected immediately depending on the results of further testing, which is the lack of grout seal outside the well casing. Other deficiencies are summarized as follows: connection of Well No. 2 to Supervisory Control And Data Acquisition (SCADA) system; sizing of free discharge piping and drain; pump house construction, i.e. separate rooms for chemicals and generator, double entrance doors (hollow insulated metal) and proper hatches; telephone service; vandal-proof outside lighting at both pump houses; lightning arrestors at both pump houses; access roads and fencing.</p>
			Wellhead Protection - Recommendations	<p>Another important component of a communal system is a well-head protection strategy. Such a strategy normally includes: 1. a zone of immediate remediation adjacent to the well, where cleanup of contamination can and must occur before it affects the water supply; 2. an attenuation zone within which natural environmental processes such as dispersion and chemical or biological transformation will reduce contaminant concentrations to acceptable levels. This could typically be twice the zone of influence of the wells, or a limit of 10 to 20 years of groundwater travel time to the well; 3. a zone of aquifer management which encompasses the entire recharge area of the aquifer, and within which some control can be maintained over development and land use.</p> <p>There are two major concerns within the well-head protection zone, i.e. the presence of the sewage lagoons northeast of Well No. 2, and the railway tracks southeast of the subdivision (Drawing No. 30056-1).</p> <p>The railway line is of concern because of the possibility of accidental spills of hazardous materials. The presence of a creek adjacent to the railway line should mitigate the potential hazard because it will direct flow away from the well-head. Otherwise, the Regional Municipality of Ottawa-Carleton (RMOC) should simply be aware of the potential hazard, and be prepared to take whatever steps are necessary, such as the installation of interceptor wells or drains, etc., should contamination occur. There is sufficient distance to the well that it should be possible to prevent contamination provided response is timely.</p> <p>The sewage lagoons are of more concern because they could be leaking slowly for a long period of time without detection. Therefore it is recommended that a number of monitoring wells be installed between the sewage lagoons and Well No. 2 to ascertain whether any contamination has taken place. These monitoring wells could then be sampled on an on-going basis, quarterly, as protection for the well.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Summary - Recommendations	<p>In summary, the main recommendations leading from this study are as follows: 1. A tracer test should be carried out at each well to ascertain whether there is a grout seal around the well casing at each well; 2. Remediation to decrease the elevated Turbidity should be carried out, after identifying and assessing the various options from a technical and economic standpoint; 3. Monitoring of groundwater quality should continue on the present basis, with frequency increased to twice a month for a period of one year after the remediation for Turbidity is carried out; 4. Monitoring of water use and water level data should continue on the same basis, i.e. daily; 5. A pump test should be carried out on Well No. 2 to verify that it will yield 2618 m<sup>3</sup>/day (400 igpm), and then the permitted capacity of the well should be increased; 6. Specific yields should be evaluated semi-annually; 7. Well pumps should be pulled and inspected every five years;</p> <p>In summary, the main recommendations leading from this study are as follows: 8. Monitoring wells should be installed between Well No. 2 and the sewage lagoons, and tested to determine whether contamination is taking place. They should then be monitored for water quality quarterly as an on-going protective measure.</p>
Hydrogeological Study, Municipal Well Supply, Town of Kemptville	1991	RVCA (Leeds & Grenville)	Recommendations	<p>Water Quality Monitoring - The Organic Nitrogen and Phenol levels encountered in Well No. 1 and Well No. 4 should be confirmed by a series of weekly sampling for a period of a month. The results should be assessed at the end of the re-testing period. A general program of well water quality monitoring should be implemented, on a quarterly basis. Parameters to be analyzed should include Total and Fecal Coliforms, major ions (sodium, potassium, calcium, magnesium, chloride, sulphate, bicarbonate), major metals (iron and manganese), aesthetic parameters (colour, total dissolved solids (TDS), hardness, conductivity), nutrients (nitrate, nitrite, ammonia) and turbidity, alkalinity and pH. Temperature of the water should also be analyzed.</p> <p>Water Quality Monitoring - On an annual basis, samples of the system water should be tested for priority pollutant indicators.</p> <p>Water Quality Treatment - This water is considered to be hard and alkaline, and could cause scale precipitation on heating appliances, or excessive soap consumption. Water softeners may be considered, either on a system basis, or at point of use, depending on individual preference. A variety of commercially available methods could be considered.</p> <p>Water Quality Treatment - The turbidity associated with high capacity Well No. 2 could be reduced by reconstructing the well with larger diameter and screen-stabilized borehole to reduce the entrance velocity of the water. The action may also extend pump life.</p> <p>Well Construction Considerations - The present pumping test investigation implies high yield potential for Well No. 2, in excess of the test rate. If it is desired to increase the water supply capacity of the well field from existing or new wells, consideration should be given to improving the well efficiency. Yields in excess of 2600 m<sup>3</sup>/day (400 imperial gallons per minute (igpm)) should have larger diameter (300 mm minimum) wells, with the formation stabilized by screening of slotting casing. For Well No. 2 it is suggested that pump equipment be installed capable of producing the recommended increase permitted capacity (2946 m<sup>3</sup>/day) and that the water quality under operating conditions at that flow rate be monitored on a weekly basis for 6 months. If water quality remains satisfactory, no further work would be required, but any decrease in water quality would suggest that the well should be enlarged and stabilized. Alternatively, additional well exploration could be conducted along the Kemptville Creek, between Wells No. 2 and No. 4.</p> <p>Pumping Equipment - In order to utilize the indicated increased capacity of the existing wells, it would be necessary to replace the existing pumps in each case, as they are not of sufficient capacity. It would also be necessary to upgrade / expand other system components such as reservoirs and water main sizing, in order to allow full use of the expanded well capacity. Recommendations could be given for specific pump sizing, if well yield requirements are known.</p> <p>Well and Well Field Monitoring - Long term monitoring of water levels in the production and observation wells should be carried out. It will be necessary to either install dedicated pressure transducer / data logger type systems in each well, or upgrade the existing "bubbler" system. The latter would be less expensive, and wouldn't require removal and reinstallation of the existing pumps. Whichever system is installed, monitoring should be carried out on a minimum of a daily basis.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Well and Well Field Monitoring - All of the existing wells should be monitored over a period of one year to determine the effect of seasonal precipitation and recharge on the predicted safe yield of the wells and aquifer. Daily recording of the pumping water level and well discharge should be maintained for each of the production wells. Well discharge should ideally consist of metering of flow from the well pump, but could also consist of monitoring of pump operating times on a daily basis, assuming the pumping rate at which the pump has been set is known and does not vary significantly. Assessment of the data after one year of monitoring will be useful in determining the sustainable rates of the wells. In conjunction with the quarterly water quality data, an assessment of seasonal water quality (hardness and salinity) can be made.</p> <p>Well and Well Field Monitoring - If pressure transducers / data loggers are not considered, at least one observation well should be equipped with an automatic chart recorder to measure annual water level variations. Ideally, two wells should be used, one outside the zone of influence of the production wells for background fluctuations, and one influenced by the wells to assess aquifer fluctuations.</p> <p>Well Head Protection - Another important component of a communal system is a well-head protection strategy. Such strategy normally includes: 1. a zone of immediate remediation adjacent to the well, where cleanup of contamination can and must occur before it affects the water supply; 2. an attenuation zone within which natural environmental processes such as dispersion and chemical or biological transformation will reduce contaminant concentrations to acceptable levels. This could be twice the zone of influence of the wells, or a limit of 10 to 20 years of groundwater travel time to the well; 3. a zone of aquifer management which encompasses the entire recharge area of the aquifer, and within which some control can be maintained over development and land use.</p> <p>Well Head Protection - It is recommended that several well-head protection measures be taken. These would include the provision of absorbent material in storage at the pump houses in case of spills of hazardous materials in the immediate area. It is also recommended that the pump house / reservoir area be fenced.</p>
Hydrogeological Study, Munster Hamlet, Regional Municipality of	1990	RVCA (City of Ottawa)	Recommendations	<p>A number of recommendations are made with respect to the upgrading, maintenance and monitoring of the well system for Munster Hamlet.</p> <p>The system inspection revealed only one deficiency that should be corrected immediately, which is the lack of well seal between the well casing and pump shaft, in both wells. Other deficiencies are summarized as follows: plumbness of Well No. 2; level gauges on chemical day tanks; connection of Well No. 2 to Supervisory Control And Data Acquisition (SCADA) system; pump pedestals to support well pumps; pump house construction, i.e. should be fire-resistant, with double entrance doors (hollow insulated metal) and proper hatches; exhaust fan in pump house at Well No. 2 and dedicated exhaust fan in chemical room of pump house for Well No. 1; only a single cell in the reservoir; lighting at pump house for Well No. 2; access roads and fencing.</p> <p>The pump in Well No. 2 should be pressure tested and then pulled and inspected for wear. If any maintenance is required, it should be supplied and then the pump should be reinstalled. After 1 year of use, the pump should again be pressure tested and pulled. If excessive wear is taking place, caused by mis-alignment of the well casing, it may be necessary to re-drill the well.</p> <p>The pump in Well No. 1 should be replaced with one of larger capacity, about 1800 m<sup>3</sup>/day (275 imperial gallons per minute (igpm)). Well No. 1 should then be pump tested at this higher rate to determine long term safe yield more accurately, and to supply information required for application to increase the permitted yield of the well. It may be necessary to stabilize the well with a well screen because the higher pumping rates could introduce unacceptably high turbidity levels for instance. It is also recommended that both wells be pumped simultaneously for 7 days at capacity to determine long term drawdown.</p> <p>Monitoring of water quality should continue on the same basis as it is presently conducted, i.e. monthly, and the parameters tested should remain the same. In addition, analysis of total dissolved solids (TDS), total organic carbon (TOC) and chromium should be conducted for a minimum of 1 year, to determine whether the slightly elevated readings obtained during the present study are true results. The chemical information should be reviewed on at least a semi-annual basis to evaluate any changes in chemical quality.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Water level data should be monitored on a more frequent basis, especially during the high use periods (June, July and August). It is our understanding that continuous monitoring will be available once the water level equipment is connected to the SCADA system. The water use data should also be monitored more frequently during the high use periods, preferably on an hourly basis. This would require installation of remote monitoring capabilities for water use as well as water level determination. The combination of water use and water level data from this time period should be assessed to determine whether water quantity shortfalls are occurring, and the additional supply required. It is suggested that this monitoring be carried out for at least to high use periods before recommendations are given with respect to additional requirements.</p> <p>In addition to the recommendations with respect to pumps given above, specific yields of the wells should be determined semi-annually by running short term, 6 hour pump tests, at the maximum flow rates available from the pumps. Decreases in specific yield should be used to determine when well maintenance is required. Water levels and pumping rates should also be compared with pump characteristic curves to determine whether pump maintenance is required. At a minimum, well pumps should be pulled and inspected every five years.</p> <p>Another important component of a communal system is a well-head protection strategy. Such a strategy normally includes: 1) a zone of immediate remediation adjacent to the well, where cleanup of contamination can and must occur before it affects the water supply; 2) an attenuation zone within which natural environmental processes such as dispersion and chemical or biological transformation will reduce contaminant concentrations to acceptable levels. This could typically be twice the influence of the wells, or a limit of 10 to 20 years of groundwater travel time to the well; 3) a zone of aquifer management which encompasses the entire recharge area of the aquifer, and within which some control can be maintained over development and use.</p> <p>It is recommended that several wellhead protection measures be taken, especially for Well No. 2. These would include the provision of absorbent material in storage at the pump house in case of spills on the adjacent road. Also, consideration should be given to creating an asphalt lined ditch in this area, so that any contaminants that are spilled are directed away from the well area.</p> <p>In summary, the main recommendations leading from this study are as follows: 1) A pump pedestal and water tight well seal should be installed in both pump houses to protect the wells from accidental contamination; 2) A pump of increased capacity should be installed in Well No. 1, and further testing take place; 3) Monitoring of groundwater quality should continue on the present basis; 4) There should be increased frequency of monitoring of water use and water level data, especially during high use periods; 5) Specific yields should be evaluated semi-annually; 6) Well pumps should be pulled and inspected every five years; 7) Wellhead protective measures should be taken, i.e. making absorbent material available at Well No. 2 and installation of an asphalt lined ditch.</p>
Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water - Village of	2003	RVCA (Leeds & Grenville)	Conclusions and Recommendations	<p>We conclude that the bacteriological detects are the results of hydraulic communication between the local surface water ponding / intermittent stream and the borehole annulus of Well #1. This was suggested in the First Engineers' Report, and the current study continues to support this interpretation.</p> <p>The municipality has two options for addressing this: i. Seal Well #1: This can be accomplished by installing a 13 cm (5") diameter casing liner. The liner would need to extend below the 20 cm (8") casing and the annular space grouted. The current pump would then be replaced with a new 10 cm (4") diameter submersible. The drawback to this option is that the costs are high and it may be difficult to provide adequate grouting; ii. Drill a new well: Drill a new well a further distance from the surface water sources (ponding and intermittent stream), and grout the entire length of overburden. The well should be constructed to current standards. This may be the most economical option. Testing would be required to confirm that the well is free of bacteriological impacts and provides a suitable yield for municipal purposes. If so, then piping can be installed and the well put into production. Well #1 can then be properly abandoned.</p> <p>If the well tests show the absence of bacteriological parameters, then this would reduce the reliance on treatment and minimize the 'human' factor, thereby providing a more reliable source of water for the treatment plant.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				We recommend the second option due to its higher probability of creating a good seal from surface water, and it's more removed location from surface water sources. We also believe that Well #2 impact may be diminished following this work because the potential pathway between Well #1 and #2 would be eliminated. Our recommended course of action is as follows: 1. drill and test a new well (Well #3); 2. put the new well into production (assuming tests okay); 3. abandon Well #1; 4. monitor Well #2 to confirm reduced bacteriological detects; 5. initiate a wellhead protection study.
			Addendum Conclusions and Recommendations	Given the information presented in our earlier report of March and herein, it is our opinion that the water supply is not under the direct influence of surface water, and that the raw water is effectively filtered for Wells #2 and #3. The location and frequent detects of coliforms in Well #1 continue to reinforce our opinion that Well #1 is communicating near surface water through its annulus.
				Our recommended course of action has been updated to reflect the new information collected over the past 4 months. The recommended course of action is as follows: 1. conduct a complete suite of chemical analyses on Well #3 in conformance of Tables 1 through 4 of the Ontario Drinking Water Standards (ODWS); 2. apply for amendment to the Certificate of Approval to have Well #3 included as a supply well and Well #1 eliminated as a supply well; 3. abandon Well #1 in conformance with current regulations; 4. monitor Well #2 to confirm reduced bacteriological detects; and 5. initiate a wellhead protection study.
Hydrogeology and Development, March Township	1976	MVCA (Ottawa)	Conclusions and Recommendations	Terrain in March Township has been evaluated for development on private services on lot size categories which range from 1 to 3 acres and up to 25 acres as shown on Figure 9. Constraints and capabilities of the various terrains are presented with respect to groundwater resources, septic tank suitability, engineering and environmental concerns. The major conclusions are given in this section along with certain recommendations shown in italics. One of the prime uses of this work is to provide a fundamental resource framework for development of a master plan for March Township.
			Groundwater Resources - Conclusions and Recommendations	Groundwater potential for residences is substantial in March Township in most places and for light industry in locations underlain by the March and Nepean Formations. The area contains size zones of varying aquifer potential rated as poor, fair, good, excellent as shown on Figure 7. The best aquifers in terms of water quantity include the March Formation and the Nepean Formation located near the surface in zone III of Figure 7. Wells should be within 150 feet deep in this terrain. In zone IV adequate water can be obtained from the Oxford Formation or underlying March Formation in wells which may range from 50 to 200 feet deep. Wells in the order of 200 feet deep into the Oxford Formation may be required in zone V since the shallower bedrock formations are known to be unreliable aquifers in places. Precambrian terrain underlies zone II and wells usually have to be in excess of 200 feet deep to insure adequate water quantity. Surficial aquifers are limited in extent and generally are not located in much of the developable terrain. Certain well completion techniques for specific terrain conditions are given in the report.
				Well completion techniques and suggestions for the choice of an aquifer as presented in this report should be followed for any new development. Proper well completion procedures will greatly decrease the possibility of contamination.
				Water quality is generally good in March Township although sulphurous water is common in shaley formations and where thick clay occurs.
				A detailed water quality survey should be conducted in areas of residential development. This survey should set out to define aspects of these developments which may be contributing to groundwater pollution if it exists. All development in the veneered lowlands, terrain unit 9, should be checked immediately. The lots in this unit are too small, terrain conditions are unfavourable for septic drain tile fields in many locations and well completions may be suspect.
				Further development in residential centres along roads in terrain units with near-surface bedrock (terrain units 9, 10, 11) must be strongly curtailed. Expert hydrogeologic advice is required for any future proposed development. Also, the effect of road construction and similar development is known to seriously impede or alter the groundwater regime and may completely prohibit strip type development which in any case is undesirable.
			Terrain Suitability for Septic Drain Tile Fields and Lot Sizes - Conclusions and	Poorly drained terrain, stream valleys and flood plains, scarps and bare bedrock (terrain units 1, 2 and 3) are undevelopable on private services.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Limits of flood plains should be accurately established for all stream valleys in the area. All development within at least 100 feet of the 100 year flood level should be prohibited. Run-off calculations should be based on futuristic projections using the Soil Conservation Service method, United States Department of Agriculture.
				The best terrain for residential development on private services with respect to terrain, hydrogeology and regional criteria, in March Township consists of gently to moderately rolling forested terrain of terrain units 11 and 13, where at least 4 to 5 feet of suitable soil exists and where a good aquifer occurs. Lot sizes may range from 3 acres to 5 acres in size for these localities; they are shown in stipple pattern on Figure 9. A summary of terrain suitability for single family residential development on private services is given in Table 5 where four classifications are used - very best, best, marginal and unsuitable.
				Stippled localities in Figure 9 should be given priority for development on private services because of their comparatively high suitability. These are the "very best" localities.
				Detailed site investigations are required for selection of a building site and tile field for any development. Particular attention should be given to the effect of roads on natural drainage, near-surface groundwater flow and regulations of the Ministry of the Environment.
				Because of the variety of terrain conditions which occur, developers should be encouraged to design buildings that are particularly harmonious and aesthetically pleasing with respect to the physical and biological environment.
				Although clay terrain of the lowlands is rated for 5 to 10 acre lot sizes, drainage is often a problem and from regional criteria of country lot development, this terrain is unsuitable for that type of development. Much of it lacks forest cover and is of agricultural value.
				Clay terrain of the lowlands is not suitable for residential development for the above reasons, but especially because of its agricultural potential.
				No further transportation routes such as the Queensway extension should be located across agricultural terrain. There is adequate marginal terrain for such permanent engineering projects.
				Veneered uplands are suitable for lots 5 to 25 acres in size on private services, but much of this terrain (#10) is classed as marginal suitability (Table 5). The northern most portion of the uplands is rated for lots 3 to 5 acres in size within the well drained, gently rolling and forested thin till terrain unit (#11). Wells in excess of 200 feet deep are usually required.
				Bedrock occurs at or near surface in many parts of the upland, drainage can be a great problem and tree cover is sparse in places. Careful selection of building site is required. Water wells should be in the order of 200 feet deep to obtain a good water supply.
				Public access to the Ottawa River shoreline is severely restricted. Pursuant to this, the terrain between Innis Point and the YMCA Camp may be highly suitable for some type of water oriented day-use. A study on the recreational potential of this site is therefore strongly suggested. A modest public facility at this location may greatly curtail the constant invasion of privacy experienced by present shoreline residents.
				The veneered lowlands terrain unit (#9) is extensive in March Township. Much of it will prove to be undevelopable on private services because of bedrock and drainage problems. Generally, however, the terrain is rated for lots 10 to 25 acres in size but classed as marginally suitable. This unit contains Constance Lake which is known to be in a precarious environmental situation.
				Residential development should be greatly restricted in the veneered lowlands. Existing residences should be subjected to a detailed study to determine possible pollution problems associated with failure of drain tile fields and water well contamination. Drilled wells should be located "upstream" from tile fields with respect to groundwater flow, and wells should be cased and grouted 25 feet from the surface.
				The sources of pollution in Constance Lake should be determined immediately by conducting an in-depth surface water quality study of all tributaries. The impact of drain tile fields adjacent to the lake and concentrated livestock yards in the watershed should be evaluated. The possible installation of drain tile fields in polluted barn yards should not be excluded. The integrity of Constance Lake must be insured.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Rugged Precambrian terrain (#14) occupies about the same area as the Uplands in March Township. This terrain is rated for lots 10 to 25 acres in size and classed as marginally suitable in a comparative sense. However, parts of the Precambrian terrain may be developable and others not. Considerable variation occurs in topography, soil types, drainage, and foundation conditions. Lots as small as 3 to 5 acres are feasible where suitable soil occurs but because this terrain is classified as conservation-recreation, and because of its inherent variability, the larger lot size is justified for a township wide rating system. The high cost of roads, engineering and foundation preparation in this terrain are major constraints to development, and there may be environmental factors to be considered in places.</p> <p>Development in Precambrian terrain requires detailed site selection and stringently controlled building policies. Development must be preceded by a hydrogeologic study. Water wells in excess of 200 feet deep are required in most localities.</p>
			Other Recommendations	<p>A detailed biophysical inventory should be conducted for the Pinhey's Point conservation site. Near-shore fluvial processes and 100 year flood level of the Ottawa River should also be included in the inventory. This information base is critically important as the first step in formulation of a master plan of the property. Work on a master plan of the property should begin immediately. The impact of sail boats which are commonly at anchor in the bay should be assessed at once with respect to water pollution and shoreline use at the site.</p> <p>A pamphlet of development guidelines should be produced to assist projection of Township and Regional planning criteria to the public and to graphically explain terrain conditions to potential and present land owners. Careful selection of material from the present report and an imaginative approach to such a pamphlet is mandatory so that it is clearly understandable to a layman. Information available from the Ministry of the Environment concerning, for example, the integrity of tile beds should be included in the pamphlet.</p> <p>Consideration should be given to further definition and elaboration of various natural features in the Township. For example, many features occur which illustrate aspects of the geologic history such as the Ice Age, Crustal Unrest, Geomorphic Development, to mention only a few. This is also true of the biologic spectrum.</p> <p>Since the rural area depends on groundwater, all industries including such enterprises as gas stations, should be required to locate and design installations to avoid groundwater pollution. Strict controls on toxic chemicals, salt, petroleum products and similar potential pollutants should be formulated. An inventory of the present institutions should be conducted at once.</p> <p>A general groundwater recharge area occurs in a band paralleling but east of the Carp Ridge, and another occurs in the area of the Uplands. Concentrated development of any type in these areas should be thoroughly assessed in advance as to their impact on the hydrogeologic regime.</p> <p>Considerable new resource information has been generated in this study, enough to justify a revision of the boundaries of the categories in the Regional Plan of March Township. A thorough study of this is strongly suggested. The work should incorporate Township concerns and the complete scope of resource factors involved in the regional plan, and should be conducted in conjunction with the formulation of a master plan for March Township. Although information in this report has been written and presented especially for planners, there are certain limits with regard to interpretation of the data. Therefore, any scenario conceived must be subjected to critical scrutiny by hydrogeologic experts, before adoption of a master plan.</p>
Interim Report on the Functions and Status of Kemptville Creek - Vol 2	1996	RVCA (Leeds & Grenville)	Hydrology / Hydraulics	<p>One or two temporary gauging sites (for baseflow) should be established along the watershed between Bishops Mills and East Oxford.</p>
			Surface Water Quality	<p>Field investigations should be carried out to identify sources of pollution on Kemptville and Barnes Creeks.</p> <p>Future water quality monitoring programs should be designed to identify point and non-point sources of pollution.</p> <p>A baseline water quality monitoring program should be continued if there are plans to revisit the watershed plans in the future, to evaluate its effectiveness.</p> <p>Data already obtained from the Kemptville Creek should be statistically analysed, in conjunction with future data, to determine temporal trends in water quality.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Permanent vegetated buffer strips should be established along all drainage systems within the Kemptville Creek watershed which would cause improvements in the water quality as follows: filtering of sediments and nutrients in runoff; streambank erosion control protection; moderating water temperatures; providing food to aquatic organisms; and providing cover for fish.
				Environmental awareness programs for rural and urban landowners must be developed and maintained to establish preventative contamination measures and ensure a good stewardship ethic.
				Any disturbance of the channel bottom material within the Town of Kemptville should be done only after a thorough analysis is completed.
			Ecology	Information gaps such as the lack of up to date information on fish species and health, other fauna such as insects, forest type and species composition and data concerning the ecological history of the watershed are acknowledged. Filling these gaps would produce a more accurate, comprehensive assessment of the function and status of the ecology of the Kemptville Creek watershed.
			Hydrogeology	The hydrogeological database compiled during this study be kept current through regular incorporation of new information from other government agencies, e.g. new well record and contaminant site information from MOEE, yearly water quality data from the Health Unit, site specific studies from the municipalities, wetland studies, etc. This information could also be used to further differentiate recharge and discharge areas within the watershed.
			The existing database along with more detailed (larger scale) information be used to further examine and/or monitor the spatial relationships between various hydrogeological phenomena and human activities, e.g. aggregate extraction within potentially significant recharge areas; average hydraulic head levels over time for various parts of the watershed undergoing significant land development.	
			Where appropriate, the water quality program include sampling points coincident with the groundwater contaminant sites noted in this report.	
			The baseflow monitoring program include a survey to identify the location and nature, including water chemistry, of groundwater discharge points, natural and artificial. The location of the baseflow monitoring points should provide data on the impacts of at least one of the upland wetlands on baseflow.	
			A study, including field investigations, of the hydrogeological regimes of selected wetland sites within the watershed be undertaken. The information from these investigations could be used to augment the hydrogeological database developed during this study.	
			Land Use	Further improvements (infrastructure) are required for any substantial future development (Kemptville)
Any development in any area of the watershed must be cognisant of the variety of statutes and regulations affecting growth.				
An education system highlighting the location of public lands would likely increase the recreational use of them and help rectify conflicts of use of private lands.				
Interim Watershed Plan - Mississippi Valley Conservation	1983	MVCA	Flood Control Program	Goal: To develop and implement a comprehensive water management program designed to prevent or reduce the risk to loss of life and property damage due to flooding.
				Objective - To identify flood susceptible areas where hazard to life and property damage due to flooding exists.
				Objective - To enact fill, construction and alteration to waterways regulations as permitted under The Conservation Authorities Act, on watercourses and lakes where floodplain mapping has been prepared to prevent the creation of additional flood susceptible development.
				Objective - To define flood damage centres through the preparation of floodplain mapping, evaluate flood protection measures for existing development in accordance with Provincial floodplain management policy and develop a priority based program to reduce the risk of flooding in the flood damage centres where such protection is economically, socially and / or environmentally justifiable.
				Objective - To develop and maintain a hydrometeorological data acquisition system to enable the Authority to provide accurate data to assist in the design and operation of the Authority, municipal and private water control structures.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Objective - To develop and maintain an effective flood forecasting and flood warning system which will provide the earliest possible warning of flood hazards to the Authority's member municipalities.
				Objective - To develop and / or update operating plans for Authority controlled dams to ensure an integrated approach to operations while recognizing the various interests in the watershed.
				Objective - To maintain flood control structures as required to ensure they continue to perform as designed.
				Objective - To encourage the cooperation of member municipalities in preventing further development in flood susceptible areas through the inclusion of appropriate land use designations and statements in official plans and secondary plans, and through the enactment of restricted area zoning by-laws and / or development control by-laws, restrict development in flood hazard areas in accordance with Provincial floodplain management policies and objectives.
				Objective - To provide member municipalities with flood hazard information on which they can base municipal land use controls and standards for floodplains.
				Objective - To undertake a comprehensive Community Relations Program to familiarize the member municipalities and watershed residents with the floodplain management principles and policies of the Authority and the Province of Ontario.
			Urban Drainage	Goal: Encourage and promote storm water management in urban areas to ensure adequate flood and erosion protection and optimize the environmental and recreational attributes of urban watercourses.
			Urban Drainage	Objective - To ensure recognition of storm water management principles and concepts in the planning and development of new urban areas.
			Urban Drainage	Objective - To encourage the inclusion and recognition of storm water management principles and concepts in municipal planning documents.
			Urban Drainage	Objective - To assist and cooperate with municipalities in the preparation of master drainage plans and storm water management plans in developing areas.
			Urban Drainage	Objective - To ensure the preparation and implementation of storm water management plans recognizes and reflects the water management programs of the Authority and are in accordance with Provincial floodplain management policy.
			Rural Drainage	Goal: To contribute to and encourage wise rural water management with a multiple-use perspective consistent with the goals of floodplain management and erosion control.
			Rural Drainage	Objective - In conjunction with the Ministry of Agriculture and Food to integrate rural water management in an overall watershed management framework with a multi-use perspective.
			Rural Drainage	Objective - To provide a greater depth and range to Plan Input and Review comments on rural drainage issues to include: impact on flooding, erosion, watershed hydrology, and environmental concerns, specifically wetlands and headwaters.
			Rural Drainage	Objective - To assist and encourage sound rural water management, specifically erosion and sedimentation, on public and private lands through special projects and a Conservation Extension Services Program.
			Erosion Control	Goal: To develop and implement an erosion control program to prevent or reduce the risk of erosion to life and property and enhance the water quality in lakes and streams through the control of sediment.
			Erosion Control	Objective - To identify erosion hazard sites and unstable slope areas where a hazard to life and property exists.
			Erosion Control	Objective - To enact fill, construction and alteration to waterways as permitted under The Conservation Authorities Act where fill line mapping has been prepared to prevent new development and filling in erosion prone and unstable slope areas.
			Erosion Control	Objective - To implement an erosion control program where the costs of protective works are justifiable in consideration of the economic, social and environmental implications.
			Erosion Control	Objective - To encourage the recognition of defined erosion hazard areas and unstable slope areas in municipal planning documents.
			Erosion Control	Objective - To assess erosion and sediment control on rural lands and evaluate the development of an Extension Services Program to respond to defined problems and needs.
			Erosion Control	Objective - To expand plan review of agricultural drainage proposals to ensure adequate consideration of erosion concerns.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Wetlands, Source Areas, Recharge Areas	<p>Goal: To contribute to and encourage the conservation and management of wetlands and headwater areas and to foster the realization of wetland resource benefits.</p> <p>Objective - To acquire a comprehensive data base of the nature, extent and hydrological, biological and unique values of wetland and headwater areas within the Mississippi watershed.</p> <p>Objective - By means of the floodplain, urban and rural drainage management programs, to encourage the beneficial uses of wetland and headwater areas.</p> <p>Objective - Through the Plan Input and Review Program to advise municipalities, other agencies and private interests of wetland and headwater issues, constraints and in particular hydrological benefits and encourage recognition of these in municipal planning documents.</p> <p>Objective - Through special projects and a Conservation Extension Services Program to actively seek the conservation and wise management of wetlands and headwater areas.</p>
			Water Quality	<p>Goal: To ensure that surface waters within the jurisdiction of the Conservation Authority are of a quality which meets Ministry of Environment guidelines for recreational and aquatic life to maintain the multiple uses of this resource.</p> <p>Objective - To continue to carry out a water quality monitoring program in cooperation with the Ministry of the Environment and to liaise with this Ministry on an expanded basis on water quality issues and considerations within the Authority's watershed.</p> <p>Objective - To ensure water quality data and trend information is provided to the member municipalities and to encourage remedial and corrective works where deemed necessary.</p> <p>Objective - To support and assist the Ministry of the Environment in expanding the Self Help Monitoring to increase the water quality data base for lakes within the jurisdiction of the Authority.</p>
			Forestry	<p>Goal: To encourage and assist the wise use of forest resources and the enhancement of other water or land resources through forestry and vegetation management.</p> <p>Objective - To develop forest management program policies to direct future Authority programs in the conservation and wise use of this resource.</p> <p>Objective - To support the Ministry of Natural Resources in the attainment of their forestry targets and objectives where the targets and objectives are consistent with Authority forestry policies and other resource management program objectives.</p> <p>Objective - To enhance the environmental quality of floodplain and headwater areas through forest management and conservation.</p> <p>Objective - To initiate a program of erosion and sediment abatement by means of forestry and vegetation management.</p> <p>Objective - To contribute to the enhancement of fish and wildlife habitat by forest and vegetation management.</p>
			Fish and Wildlife	<p>Goal: To contribute to the conservation and enhancement of fish and wildlife habitat, particularly in floodplains, wetlands and headwater areas.</p> <p>Objective - To develop fish and wildlife program policies to direct future Authority programs and ensure the conservation and wise use of this important resource.</p> <p>Objective - Through the water management program, to maintain water levels such that fish, wildlife and other water-based resources optimum habitat and physical requirements are satisfied, ancillary to the primary objectives of flood protection.</p> <p>Objective - To undertake a program of erosion and sediment control, stream improvements, floodplain enhancement, forestry and vegetation management on public and private lands that would directly or indirectly contribute to the conservation and enhancement of fish and wildlife habitat.</p>
			Recreation Program	<p>Goal: To continue to enhance public enjoyment of the natural environment by promoting and providing a variety of day-use recreation opportunities in which the public can discover, experience and appreciate the distinctive features and elements of the natural resources of the watershed.</p> <p>Objective - To permit recreational uses and public access on Authority lands consistent with the natural resources of the site and cognizant of other resource management objectives of the Authority.</p> <p>Objective - To promote and encourage the cooperation of all agencies involved in provision of recreational opportunities to ensure watershed residents are provided a variety of recreation opportunities in a cost effective manner.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Sensitive / Unique Areas	Objective - To prepare and maintain master development plans for Authority lands which optimize multiple-uses compatible with site resources.
				Objective - To manage and develop Authority lands in a manner that is compatible with the water management objectives of the Authority.
				Goal: To contribute to the conservation and management of significant areas, in particular those located in floodplains, wetlands or headwater areas, and to give consideration to other areas recognized as regionally, provincially, or nationally significant areas.
				Objective - To advise municipalities, other agencies, and private interests through the Plan Input and Review Program of the nature and value of significant areas and to suggest management strategies that would accommodate conservation of significant areas.
			Community Relations Program	Objective - To assist municipalities, other resource oriented agencies and private interest groups and landowners in the protection and conservation of significant areas.
				Objective - To conserve significant areas by means of acquisition, lease, management, dedication, or other available means.
				Goal: To communicate the goals, objectives and programs of the Authority to watershed residents.
				Goal: To inspire an appreciation of the natural resources of the watershed.
				Goal: To create an awareness of the need for the conservation and proper management of the natural resources in the watershed.
				Objective - Provide opportunities for learning by providing a conservation education program in cooperation with Boards of Education.
				Objective - Provide conservation areas for use in conservation education studies and activities.
				Objective - Promote the protection of natural areas which are sensitive to use and which have unique features important for learning opportunities.
				Objective - Ensure the recognition of the education program in the development of other Authority owned land.
				Objective - Provide facilities to accommodate education program participants where deemed necessary.
Objective - Cooperate with other resource management agencies, in particular other Conservation Authorities, to provide opportunities for outdoor education.				
Objective - Provide reference material and staff to other groups in the watershed interested in learning about conservation education and the Authority.				
Interim Watershed Plan - Rideau Valley Conservation Authority	1983	RVCA	Flood and Erosion Control	Strategy Goal: to develop, undertake, and support flood and erosion control projects and programs designed to reduce the risk of loss of life and property damage caused by flooding and / or slope failure.
				Flood Control Objective - to undertake a comprehensive program of flood control designed to prevent the loss of life, minimize property damage, and to encourage a coordinated approach to the use and management of flood prone lands.
				Erosion Control and Slope Stability Objective - to minimize erosion and slope instability so as to prevent property damage and loss of life, and to maintain a high quality environment in and surrounding the watercourses and waterbodies of the watershed.
			Water Management	Strategy Goal: to undertake projects and programs designed to moderate peak streamflows, augment low streamflows, and enhance water quality by promoting urban stormwater management, good agricultural drainage practices, and the protection of source and recharge areas.
				Recharge and Source Areas Objective - to identify all important recharge / source areas and determine the combination of regulations and / or acquisition which should be undertaken to protect them.
				Rural Land Drainage Objective - to review and comment on municipal drain proposals as they might affect the management of water resources and eventually encourage municipalities to plan rural drainage systems on a regional or watershed scale.



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Urban Stormwater Management Objective - to encourage municipalities to develop master drainage plans for urban development areas, which recognize the limitations of watercourses to receive urban drainage.
			Water-Related Land Management	Strategy Goal: to contribute to the quality of land and water resources through a program aimed toward the enhancement and maintenance of environmental quality including water quality, forest cover, and fish and wildlife resources within the Rideau River watershed.
				Nutrients and Sedimentation Objective - to cooperate with other agencies; encourage programs to minimize nutrient enrichment and sedimentation and their adverse effects on water quality; and to coordinate a program of aquatic plant control
				Forest Management Objective - to acquire and manage Authority forest lands; and to offer assistance to private landowners to promote the development and management of forest resources on private lands.
				Fish and Wildlife Management Objective - to acquire significant wildlife habitat areas; to manage fish and wildlife habitat on Authority lands; and to offer assistance to private landowners to promote the protection and improvement of fish and wildlife habitat on private lands.
			Conservation Areas / Recreation	Strategy Goal: to acquire conservation lands in order to conserve significant and sensitive land for the benefit of the people of the watershed, and apply the multiple-use management concept to all Authority-owned lands where the public can engage in outdoor recreation pursuits in a natural setting and acquire an appreciation of wise natural resource management.
				Significant and Sensitive Features Objective - to inventory, evaluate and participate in the protection and conservation of significant and sensitive features within the watershed for the benefit of present and future generations.
				Significant and Sensitive Features Objective - to provide open space and public lands within the Rideau River corridor as defined by the Canada-Ontario Rideau-Trent-Severn (CORTS) study group.
				Recreation Objective - to prepare master plans and to provide for the multiple use of Authority lands.
				Recreation Objective - to provide opportunities for public access to Authority lands where the public can engage in water-based or natural resource-related forms of outdoor recreation.
			Information and Education	Strategy Goal: to communicate Authority goals, objectives and programs to watershed residents; to provide opportunities for learning about natural resource management concepts as an integral part of Authority programs and facilities; to emphasize the importance of the watershed concept in conservation work; and to promote public understanding and appreciation of Authority programs and activities.
				Conservation Education Objective - to work closely with valleys school boards, teacher's groups and other youth leaders to involve students from all grade levels in a participatory, outdoor learning experience which will foster a desire to continue exploring the natural environment as a life-long process.
				Conservation Education Objective - to increase student's awareness of ecological systems and processes.
				Conservation Education Objective - to emphasize the importance of the watershed approach to conservation and to ensure that conservation messages are an integral part of any Authority education program.
				Conservation Information Objective - to provide the opportunity for the general public to learn about and understand their natural surroundings, while stressing practical, personal solutions to environmental concerns.
				Conservation Information Objective - to inform all watershed residents of Authority programs and services which may be of importance to them.
				Conservation Information Objective - to provide a service whereby the members and public can obtain a wide range of conservation and environmental information from the Authority library or staff.
				Public Relations Objective - to present the Conservation Authority as a competent and credible public manager of renewable natural resources in the watershed.
				Public Relations Objective - to promote effective two-way communications between the Authority and the public.
				Public Relations Objective - to ensure that all Authority members, member municipalities and staff have an understanding of the Authority's role and function.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Heritage Conservation	Strategy Goal: to restore and interpret to the public the heritage resources existing on Authority-owned lands, and to encourage the conservation of significant heritage resources, particularly those related to historical water and forestry activities, elsewhere in the watershed.
Jock River Reach 2 & Mud Creek Subwatershed Study - Existing Conditions Report	2005	RVCA (City of Ottawa and Lanark)	Synthesis of Key Findings	<p>Land use in both subwatersheds is predominantly rural / agricultural and will remain so for the foreseeable future. Hence improvements in watershed health will require actions in these areas and cooperation of the rural / agricultural community to implement them.</p> <p>Appropriate environmental management / stormwater management practices will be needed to prevent future impacts from urbanization.</p> <p>All remaining natural areas are of importance in contributing to achievement of minimum recommended levels of natural cover. In many cases, these natural areas coincide with source areas for the watercourses and create riparian cover. This makes them doubly important in terms of fish habitat, recharge / discharge and water quality protection.</p> <p>Large sections of the watercourses have been radically altered for agricultural purposes and have very low riparian cover. This creates conditions of dynamic instability. Approaches to improve these sections should be considered.</p> <p>Three aquifers have been identified in the subwatersheds. These include the highly productive deep bedrock aquifer, mostly exploited for use for municipal wells, and industries. The most widely used aquifer is the shallow bedrock, comprised of the Oxford and March formations. In areas where there are glacio-fluvial deposits, there are wells that extract water from the overburden materials. Groundwater use for domestic purposes amounts to less than 1% of the annual estimated recharge to the various aquifers.</p> <p>Clear interactions between surface and groundwater systems have been identified in the headwaters of the Jock River Reach 2 and in the Kars Esker area of Mud Creek. In both cases these support cool water / cold water refuges which provide habitat for more sensitive fish species. Protection of these areas should be considered.</p> <p>Water quality is generally marginal with some areas of fair quality. Bacterial contamination is the most notable form of degradation. Approaches to improve this situation should be considered.</p> <p>Factors which define stream and valley corridor protection areas have been evaluated. These can be combined to identify constraint areas and opportunities within them to restore and enhance riparian functions can be identified.</p>
Jock River Watershed Management Plan	2001	RVCA (City of Ottawa and Lanark)	Watershed-wide recommendations	<p>Continue baseline water quality and macro invertebrate monitoring</p> <p>Continue performance based monitoring of storm sewer and waste water systems</p> <p>Carryout investigative water quality monitoring</p> <p>Initiate baseline monitoring</p> <p>Install stream gauges</p> <p>Assess impacts of development on groundwater resources</p> <p>Review water taking permit process</p> <p>Undertake aquifer management strategy</p> <p>Continue and promote stewardship programs</p> <p>Support "Friends of the Jock River"</p> <p>Develop watershed action committee</p> <p>Develop and promote "Adopt a River" program</p> <p>Create recreation corridor the length of the river</p> <p>Determine water budget</p> <p>Protect habitat in planning documents</p>
			Recommendations Specific to Reach 1	<p>Improve riparian vegetation</p> <p>Implement recommendations of the South Urban Community Master Drainage Plan</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Update flood risk mapping
				Decide on the future of the Heart's Desire Weir
				Install identification and interpretive signs
			Recommendations Specific to Reach 2	Initiate subwatershed plan for Flowing Creek
				Improve riparian vegetation
				Update flood risk mapping
				Install identification and interpretive signs
				Develop interpretive plan
				Decide on the future of the Richmond Weir
			Recommendations Specific to Reach 3	Protect farm land in planning documents
				Improve riparian vegetation
				Prepare flood risk mapping
			Recommendations Specific to Reach 4	Install identification and interpretive signs
				Decide on future of Ashton Dam
				Prepare flood risk mapping
Jock River Watershed Plan - Volume II - Component Reports	2000	RVCA (City of Ottawa and Lanark)	Land Use	Of major concern throughout are the gaps in the information available concerning the Jock River watershed. Historical data concerning the state of the water table is, at best sketchy, information dealing with flooding is available at one station (Moodie Drive) and only for a limited period. Water quality data, both ground water and surface water, is very limited and as a result, it is not possible to determine trends. Since this information is fundamental to the understanding of the watershed and to planning for the preservation of the natural resources, a comprehensive data acquisition programme must be implemented. The present restructuring of public sector activities may favour a joint venture between the Authority and the colleges and universities located in the region.
				Recreation and Public Land Use
				A full scale recreational study for the Jock River watershed would better identify the limitations and potential for the area to provided quality recreational experiences.
			Wetlands	Protection of significant wetland areas and functions through provisions of the Conservation Authorities Act and municipal planning, is
				All wetland areas identified in this study should be evaluated or re-evaluated using the Third Edition of the Ontario Wetland Evaluation System: Southern Manual 1993, prior to undertaking the next phase of land use planning within the watershed
				The lower reach of the watershed where wetlands represent a very small percentage of the remaining natural environment, evaluation criteria should be developed to identify locally significant wetlands
			Ecological Features	That "adjacent lands" land use designations be identified for wetlands, within the context of protecting key wetland function which maintain the ecological health of the watershed
				For the lower reaches of the watershed, wetland restoration and/or creation should be considered in future land use planning to
				Field investigations should be undertaken to fill information gaps in fisheries habitat in sub-catchment basins, wildlife habitat and upland flora. Field work could be coordinated with the RMOC NESS field program.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Based on the information obtained in this study, the ecological impact of the Ashton Dam appears to be neutral. However, for a definitive assessment of the role and significance, from an ecological perspective, of the Ashton Dam and other water control structures on the Jock River further detailed study is recommended.</p> <p>With regard to watershed management and planning issues, protection of provincially significant features/areas should be given priority. Developing planning policies or guidelines for the protection of significant features at the watershed level (i.e. not provincially significant) will require additional analysis.</p> <p>Except for natural features which have been identified as provincially significant, for the determination of significant natural features and functions at the watershed level, the evaluation criteria as developed by the RMOC could be considered and developed within the context of the Jock River watershed as the planning area.</p> <p>Unless there is a commitment to undertake further detailed field investigations and to develop significance evaluation criteria at the watershed level, it is recommended that for the development of an ecologically based land use plan, a simple overly approach be used with provincially significant features as the corner stones.</p> <p>With regards to land use planning, to improve the ecological health of the watershed, for those ecological features and functions which have been identified as under stress, the goal of the management plan should be to reduce these stresses through the determination of appropriate land use.</p> <p>As a goal for the watershed management plan, land use planning should support the restoration of: 1) the Jock River corridor, 2) channelized tributaries of the Jock River, and 3) wetland functions in the lower reach of the watershed.</p>
			Surface Water Quantity	<p>It is recommended that the two temporary stations installed in 1995 (located downstream of two major wetland complexes: the Goodwood Marsh and the Richmond Fen) remain in operation for a minimum of two years to carry on the collection of streamflow data and to develop a proper stage discharge curve which would be representative for all flow conditions. This data could be used to determine the hydrological impacts (flow augmentation, routing, etc.) of these two complex wetland systems and could also facilitate the representation of the interaction between rainfall/snowmelt and surface runoff.</p> <p>Additional flow gauging stations be installed at the downstream end of each major tributaries for a minimum of 2 years. Flow data at Kings's Creek, Nichols Creek, Flowing Creek and Monahan Drain could be used to better determine their flow contributions on the Jock River.</p>
			Surface Water Quality	<p>Field investigations should be carried out to pinpoint sources of pollution from land management and land use activities within the Jock River and tributaries.</p> <p>Future water quality monitoring programs should be designed to identify point and non-point sources of pollution.</p> <p>A baseline water quality monitoring program should be continued if there are plans to revisit the watershed plan in the future, to evaluate it effectiveness.</p> <p>Monaghan Drain, Leamy Creek and Flowing Creek should be examined in more detail, because it may be very easy to determine the suspected sources of pollution (i.e. urban or agricultural).</p> <p>A program to monitor water quality and quantity upstream and downstream of Richmond may provide support for installation of urban stormwater facilities.</p> <p>Environmental awareness programs for rural and urban landowners must be continued and maintained for preventive contamination measures and to ensure a good stewardship ethic.</p> <p>Sources of nutrient loading should be identified and the problems rectified in order to prevent or correct ecological and biological problems associated with these contaminants.</p>
			Groundwater	<p>Develop a groundwater management plan for the Jock River watershed. The goals of this plan would be to preserve groundwater quantity and preserve groundwater quality.</p> <p>Obtain a better understanding of the significance of groundwater to the health of the Jock River.</p> <p>Develop a groundwater flow model for the Jock River watershed.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Kanata North Environmental / Stormwater Management Plan	2001	MVCA (City of Ottawa)	Recommendations for Protection of Aquatic Habitat	The aquatic habitat and recommended enhancement measures for Shirley's Brook are discussed in detail in the section on Stream Condition Assessment and Restoration. In addition to the core Shirley's Brook watercourse, the above section, Tributaries, and Figure 2 identify the watercourses in the study area requiring protection. The objective of this section is to identify the extent of the setback required to provide that protection based on a combination of aquatic habitat setbacks, floodplains and meander belt requirements.
			Aquatic Habitat Setback - Recommendations for Protection of Aquatic Habitat	As discussed in Stream Condition Assessment, the aquatic habitat of Shirley's Brook is limited by the lack of runs and riffle habitat and the dominance of clay, silts or exposed bedrock substrate. This reduces the likelihood that critical habitat functions such as important spawning or nursery areas occur within the study area, a conclusion confirmed by the detailed field surveys. Thus no Type 1 aquatic habitat is identified for the study area. However, the aquatic habitat is still important for a warmwater coarse fish population downstream considerations and from an aesthetic perspective. To protect and encourage enhancement of the fish and aquatic habitats, a 15 metre riparian buffer area setback from each top-of-bank of the watercourse, is considered adequate. Policy 5.2.2 (5) of the Regional of Ottawa-Carleton Official Plan requires a setback of 30 metres from the normal high water mark or 15 metres from the top-of-bank whichever is greater, unless an exception is being made in accordance with an approved sub-watershed plan or with the advice of the Conservation Authority. Throughout the study area the 15 metres from the top-of-bank will be less than 30 metres from the high water mark. Although the proposed riparian setback is a reduction from the Official Plan policy, the setback is considered sufficient for protection of the existing features and functions. This setback applies to Shirley's Brook and other watercourses as shown on Figure 2. Figure 2 also identifies watercourses where no protection is recommended as discussed in the above section, Tributaries. A section of Shirley's Brook upstream of Klondike Road is recommended for a 20 m from top-of-bank setback to allow for future meandering within the regulatory floodline for that particular section. Within the 15 metre setback, the existing aquatic habitat will be protected and enhanced through development of riparian vegetation and corresponding treatment of surface water, bank stability and stream cover. This will reduce erosion and sediment inputs. In addition, removal of current blockages to fish movement will enhance access throughout the aquatic system. The protected stream corridor belt will also provide sufficient area for more extensive rehabilitation measures including natural channel design. These enhancement and rehabilitation measures are discussed on a site-specific basis in the Stream Condition Assessment section.
			Floodway / Flood Fringe - Recommendations for Protection of Aquatic Habitat	Floodline mapping of Shirley's Brook was prepared for the Mississippi Valley Conservation Authority by AJ Robinson in 1999. Based on this mapping, the area located north of Klondike Road and upstream of both Fourth Line Road and the Ottawa-Carleton Railway (OCR) line has large portions within the regulatory floodline. Without widespread filling, large portions of this area are essentially undevelopable. Along the other sections of Brook within the study area, the floodplain follows more regular patterns, generally following the channel and varying somewhat in width, but with an absence of spill zones or large scale irregularities. One notable exception is the area in the Kanata Research Park where the new golf course is being constructed. However, a large area with somewhat degraded and undefined channel that included a spill zone to the Kizell Drain has been realigned and restored as part of the golf course construction, and is thus no longer a concern. As is discussed further in the section on meander belts, with few exceptions where meander belts and / or aquatic protection setbacks dictate, the floodplain is generally the widest protected zone along the creek corridor. It is recommended that the full floodplain continue to be protected everywhere in the study area except for the area immediately upstream of the OCR line and the area between the OCR and Fourth Line Road. In this section, the two zone Floodway / Flood Fringe concept is recommended for implementation to allow for some development to occur in the low lying floodplain areas provided full compensation for lost floodplain storage is provided.
			Meander Belt Width - Recommendations for Protection of Aquatic Habitat	In most cases, the setbacks from the watercourse identified for aquatic habitat protection and meander belts will be contained within the floodplain limits. However, the recommended aquatic habitat protected corridor (15 m from top of bank on each side of the Brook should be the minimum protected corridor in any section of the creek, regardless of the floodplain or meander belt influences.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Dillon (1999) identified meander belt widths to take into account the migratory tendencies of watercourses. Dillon (1999) explained that watercourses naturally meander in an effort to dissipate energy and to obtain a planform that is in equilibrium with the flow and sediment regimes that are conveyed within it. While discharge and the energy gradient are the primary driving forces of a meander pattern, other variables affect the rate with which the meanders can form or migrate. These variables include proximity and erodibility of valley walls, floodplain sediment composition and variability and extent of riparian vegetation. The relative resistance of valley walls and floodplain materials is evident in the pattern of meanders and in the presence of relict oxbow lakes and meander scars on the floodplain.</p> <p>To quantify the width of the meander belt, in very general terms, lines are drawn tangentially to the outside bends of meanders of a reach, and the distance between these lines represents the belt width (Dillon 1999). The meander belt width requirements in the study area are generally reduced due to the low gradient and lack of relict oxbow lakes and meander scars on the floodplain.</p> <p>The meander belt width (lower limit) recommended by Dillon (1999) extends beyond the floodplain limits only in the following locations on Shirley's Brook: downstream of the confluence with the North Branch (south bank); upstream and downstream of Klondike Road (east bank); upstream of Shirley's Brook Drive (west bank); and upstream of Hines Road to Terry Fox Drive.</p> <p>Dillon (1999) indicated that meander belt widths usually extend beyond the floodplain limits where the channel is actively eroding its valley wall. This is especially evident within portions of the above identified locations including Hines Road to Legget Road, immediately downstream of Klondike Road downstream of the armour stone and downstream of the confluence with the North Branch.</p> <p>To provide for potential meandering in the above areas, it is proposed to modify the proposed setback for protection of aquatic habitat as follows: <u>Downstream of the confluence with the North Branch (south bank)</u>: The proposed meander belt width (lower limit) is within the proposed 15 m setback for protection of aquatic habitat and therefore no additional setback is recommended.</p> <p>To provide for potential meandering in the above areas, it is proposed to modify the proposed setback for protection of aquatic habitat as follows: <u>Upstream and downstream of Klondike Road (east bank)</u>: Upstream of Klondike Road, extensive bank erosion was not observed. However, the brook is not notably entrenched in this location and the potential for additional meandering exists. It is proposed to increase the setback to twenty metres from the top-of-bank for the portion of the brook between the old bridge crossing and Klondike Road. Downstream of Klondike Road, the proposed meander belt width (lower limit) is within the proposed setback for protection of aquatic habitat and therefore no additional setback is recommended.</p> <p>To provide for potential meandering in the above areas, it is proposed to modify the proposed setback for protection of aquatic habitat as follows: <u>Upstream of Shirley's Brook Drive (west bank)</u>: Due to the existing developed nature of this area and no reasonable potential for additional meandering beyond the fifteen metre (each side) aquatic habitat setback, no additional setback is recommended.</p> <p>To provide for potential meandering in the above areas, it is proposed to modify the proposed setback for protection of aquatic habitat as follows: <u>Upstream of Hines Road to Terry Fox Drive</u>: For the reach downstream of Hines Road, no recommendations are provided due to the approved restoration work associated with the NorthTech and golf course developments. The natural channel design for Shirley's Brook within the golf course provided for a meander belt, although the belt was often less than the 40 to 55 metres recommended by Dillon (1999).</p> <p>To provide for potential meandering in the above areas, it is proposed to modify the proposed setback for protection of aquatic habitat as follows: <u>Upstream of Hines Road to Terry Fox Drive</u>: Upstream of Hines Road, the 15 m from top of bank aquatic protection setback is considered adequate, as the total protected belt will be within the 40 to 55 m belt recommended by Dillon once the width of the creek between the top of banks is included.</p>
			Recommendations for Protection and Enhancement of Terrestrial Features	<p>Dillon (1999) noted that although as much woodlot as possible should be preserved, it is realized that this is not realistic for areas to be developed. It is recommended that if possible, sizeable portions of woodlots should be preserved in order to provide some amount of habitat for birds and other wildlife. These smaller "islands" of habitat are still very important to the overall wildlife corridor system within the subwatershed. It is proposed to retain these islands of habitat in the study area through the retention of Morgan's Grant Woods, Klondike Road Park, the open space in the southwest portions of the South March Community, Trillium Woods, Alcatel Woods, wooded portions of the golf course, a portion of Klondike Woods and the wetland areas east of Second Line Road.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The "Wildlife Protection during Construction" protocol approved by Regional Council should be adhered to as part of construction activity in and adjacent to the natural areas identified in this report. In particular no tree removal should occur between May 15th and July 1st for protection of breeding birds. No instream construction should be done between March 15th and June 15th, the major spawning period for most warm water forage and coarse fish. Initiation of heavy construction activity should not occur in the vicinity of the osprey nest once the ospreys are utilizing the nest.</p> <p>Other general guidelines to mitigate habitat disruption include proper sediment and erosion control in the vicinity of watercourses and ponds, limiting grubbing as much as possible in areas where revegetation will occur and grading is not required, proper setbacks from existing vegetation to ensure the trees and shrubs identified for retention are not damaged in the long-term, use of snow fencing to restrict access from other sensitive locations, and prompt reinstatement of cleared areas.</p>
			South March Community including Kanata North Urban Expansion Area Lands West of March Road - Recommendations for Protection and Enhancement of Terrestrial Features	<p>To provide protection for a series of environmental values including the osprey, wetland areas and a regionally rare plant, and to allow further regeneration of the wetlands, it is recommended that a setback with a radius of 100 metres be maintained around the osprey nest. Approximately 50 metres of this setback will be present on the hydro corridor. An option to providing a setback around the existing nest location is to relocate the osprey nest. Hydro One will relocate osprey nests when the nest is in a poor location on the tower or during a construction project where work is to be done on a structure. The entire nest is relocated to a nesting platform on a pole that is erected on the edge of the Hydro One corridor. Nests may also be moved to better locations on the same tower. Nests must be moved when they are not occupied, which would generally provide a window of September to February for the work. However relocation of the osprey nest will not address the wetland area and regionally significant flora, although white vervain is a reasonable candidate for transplanting.</p> <p>Blocks of individual trees within the forested areas, including the sugar maple representation and the remnant larger coniferous trees, should also be retained through a tree protection and conservation plan.</p> <p>To further protect the environmental values of the area, the natural design of the channel in the vicinity of Second Line Road and the associated wet areas of the small creek that flows through the northwest portion of the wooded area in the triangle of land between the hydro corridor and Second Line Road should be retained in its existing configuration. The retention of the natural drainage and associated functions can be undertaken in conjunction with recommendations associated with the tree protection and conservation plan. The wet areas are concentrated in the portion of the creek closer to Second Line Road and are 20 - 30 metres in width. The hydrologic function of this channel is also important, as provides conveyance of flows for a larger upstream area draining to the North Branch of Shirley's Brook.</p> <p>The above recommendations should be further delineated through the preparation of an Environmental Impact Statement, including a Wetland Impact Study, prior to site plan approval. This report is required due to representation of the South March Highlands Provincially significant wetland complex west of Second Line Road and a local official plan amendment passed by the City of Kanata.</p>
			Kanata North Urban Expansion Area Lands East of March Road - Recommendations for Protection and Enhancement of Terrestrial Features	<p>The forested area immediately east of the railway represents the best developed understorey and ground cover, the greatest regeneration of saplings and seedlings, and is the oldest and least disturbed forest community in the study area. The core of the natural area is represented by a dry-fresh maple deciduous forest, with little recent disturbances. Fewer stumps indicating historical logging were observed in this area. Red maple, sugar maple, black maple, white elm, white ash and bur oak are common tree species. The tree heights are in excess of 25 metres with average diameters of 30 cm diameter at breast height (dbh). The core area is also distinguishable by good regeneration of maple and white ash stems, and undisturbed native ground flora including ostrich fern, blue cohosh, squirrel corn, white trillium and baneberry. Retention of a significant representation of this core area can be accomplished by preserving a contiguous 2 hectare portion of the forest in the general current state (a passive recreational trail could be accommodated) as depicted on Figure 2. Retention of the regenerating stems will ensure a sustainable forest.</p> <p>To maximize the integrity of the core area functions, there should be a relatively undisturbed edge against the retained core forested area. No grading or extensive grubbing should occur within the west portion of this transition zone. Additional retention of natural features will occur in the portions of the forest retained along Shirley's Brook, including a sugar maple forest with good maple regeneration. Hop hornbeam, basswood and butternut are also present.</p>

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**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>A tree protection and conservation plan should be prepared that will address the retention of notable features such as black maple and larger bur oak and conifer trees outside of the core area retention described above and along Shirley's Brook. The conservation plan should examine not only retention of individual trees and their root systems, but groupings of trees to provide additional wildlife habitat and improve the likelihood for successful tree retention. Examples of individual trees that should be considered for retention include a 95 cm dbh maple southeast of the abandoned shack, a twin-stem maple east of the shack, a 52 cm dbh white spruce approximately 140 metres west of Fourth Line Road, a 100 cm dbh maple 300 metres west of Fourth Line Road, and a 67 cm dbh bur oak 230 metres west of Fourth Line Road. Some of the other larger trees are not considered priorities for protection due to damaged limbs and trunks along with stripped branches. The tree preservation plan should also consider retention of dead or senescent trees along the Shirley's Brook corridor. These snags provide good habitat for cavity nesters and other wildlife.</p>
				<p>The preservation and tree retention in this area north of Shirley's Brook may be integrated into the design of the end-of-pipe facility and floodplain compensation proposed for this area.</p>
				<p>Using the woodland features developed by the City of Ottawa as part of their Natural and Open Spaces Study, Klondike Woods overall scored 17 (using a scoring system of 3 points for high, 2 points for moderate and 1 point for low) which is at the higher threshold for an overall woodlot criteria ranking of moderate. Our field experience suggests that the overall ranking of moderate (at the high end) for Klondike Woods is consistent with ranking for other natural areas. No rare species or vegetation communities were identified in the woods. The two rankings which would change as a result of reducing the forest cover as described above are the number of woodland communities and the size of the forest. The ranking for both of these criteria would decrease from a high to moderate score. The overall score for the forest would decrease to 15 from 17. This remains a moderate ranking, although near the middle of the moderate ranking rather than in the higher end of the range.</p>
			<p>Kanata North Business Area - Recommendations for Protection and Enhancement of Terrestrial Features</p>	<p>To minimize potential impacts of the golf course development on the wetlands, just over forty percent of the existing wetlands were retained in their existing condition. However, much of this retention of wetland area is outside of the boundaries of this study. In addition, as part of the golf course construction there are several wetland areas adjacent to Shirley's Brook which have been rehabilitated or developed with the use of hydric soils. Cattails and other vegetation are already established in several of these areas</p>
			<p>Restoration Recommendations - Kanata North Urban Expansion Area Lands - Stream Condition</p>	<p>The number one priority for rehabilitation is the removal of cattle access from the section of the Brook around the north / south branch confluence through the construction of fences or other means. Once the cattle access is addressed, improvements to the morphology of the extreme downstream portion of the North Branch through the restoration of the natural sinuosity characteristics and improvements in riparian vegetation for better stream cover and bank stability should be undertaken.</p>
				<p>The dams caused by beaver activity, fallen trees and / or woody debris located upstream of the confluence with the North Branch, downstream of the confluence and at the railway tracks should be removed along with other anthropogenic debris as they are causing ponding and complete a blockage of fish movement. The debris should be cleared and areas of erosion stabilized with native plantings and other bio-engineering techniques. Many of the cut banks will require fascines, brushmattresses and terraced slopes to encourage vegetation establishment.</p>
				<p>Tree and shrub plantings should be placed along the riparian corridor to provide stream cover and bank stability. Riparian cover is particularly lacking along the east bank downstream of Klondike Road and west of the west portion of Klondike Woods. Erosion concerns from cut banks along Shirley's Brook in the east portion of Klondike Woods, upstream of Fourth Line Road, should be addressed through bioengineering materials such as coconut fibre fabric and live willow stakes to encourage the establishment of additional riparian vegetation and associated bank stability.</p>
				<p>Another recommended enhancement measure is to encourage the development of a low flow channel downstream of the confluence with the North Branch to increase the amount of run habitat. This can be done with deflector structures of physical creation of a low flow channel. In addition, the stream bed structure should be further enhanced through sensitive placement of gravel and rubble to provide coarse exposed substrate.</p>



**Table A-1**

**Previous Study Recommendations  
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Previous Study	Date	Watershed Area	Topic	Recommendation
				The portions of Shirley's Brook identified for the above restoration recommendations include the reach of Shirley's Brook downstream of the confluence with the North Branch, downstream of Klondike Road which was one of six areas recommended by Dillon (1999) for restoration.
			Restoration Recommendations - Kanata North Business Area - Stream Condition	<p>There are several areas of erosion along Shirley's Brook downstream of Hines Road. A rehabilitation plan to stabilize the streambanks with riparian vegetation, brushmattresses and fascines has been approved as part of the NorthTech development, although the work has not been completed. This is one of six areas recommended for stream restoration in Dillon (1999) and the implementation of this approved restoration plan should be undertaken by the NorthTech campus proponents as soon as possible.</p> <p>Specific areas to address are: sites of erosion, with bare soil conditions. In many areas, the riparian vegetation will likely be lost over time as the tree roots have become exposed due to the erosive action. Utilize natural channel design to provide bank stability through natural materials such as root wads, brush bundles, cuttings and live stakes, which are insterted deep into the bank to increase stability. On the steeper banks, the vegetation should be planted using a terraced approach; improvement of the low flow characteristics and energy dissipation of the watercourses through the reinstatement of a regular riffle pool complex riffles, addition of exposed coarse substrate, and the confinement and deepening of the low flow channel. The goal here is to restore instream habitat structure that has been blown out by erosive action; improvements of the fish habitat through the placement of additional boulders and logs, and colonization of emergent vegetation; and,</p> <p>Specific areas to address are: addition of riparian cover to further improve bank stability and fish habitat. The additional tree and shrub cover will also improve the groundwater regime, provide shade, increase vegetative diversity and enhance terrestrial habitats.</p> <p>As part of the golf course construction, the aquatic habitat of Shirley's Brook between Legget Drive and Terry Fox Drive was improved by increasing the meandering of the brook, providing a meander belt and increasing the instream structure through placement of boulders, logs and aquatic plants. Fascines were placed in several areas to provide protection against erosion. This is also one of six areas along Shirley's Brook recommended for stream restoration in Dillon (1999). The realigned channel of Shirley's Brook was dug and connected in the summer of 2000. By September 2000, frogs, minnows and aquatic insects were present in the reach. Where a fifteen metre setback of natural vegetation from Shirley's Brook was not possible due to the golf course requirements, the water quality and natural features have been protected by grading the surface water away from the watercourse to catch basins which drain to stormwater management ponds and prohibiting application of pesticides and fertilizers within fifteen metres of Shirley's Brook</p> <p>Wetland enhancement and creation was undertaken in the stormwater management facilities and adjacent to the watercourses to provide another opportunity to integrate and enhance fish habitat as part of the golf course development.</p> <p>The reaches upstream of Shirley's Brook Drive and upstream of Klondike Road are also two of the six areas along Shirley's Brook recommended for stream restoration in Dillon (1999). Recommended rehabilitation measures in these reaches include planting of woody riparian vegetation on the west side of the channel south of Shirley's Brook Drive and promotion of pool structures and other instream structure with rock wiers and deflector logs. To provide additional treatment in the vicinity of the discharge of the piped tributary, additional cattails could be encouraged with the spreading of hydric soils. In addition, the unmowed setback from the pond area north of Shirley's Brook Drive should be increased in areas where the grass is currently mowed to the cattail vegetation. Removal of woody debris and old beaver dams downstream of Shirley's Brook Drive would improve fish access through this reach and the flushing ability of the watercourse.</p> <p>There are stormwater outlets on the west side of Shirley's Brook both upstream and downstream of Klondike Road. If these outlets are to remain in service, consideration should be given to pulling back the outlets and providing a shelf of wetland vegetation for surface water treatment before the water enters Shirley's Brook.</p>
			Specific Recommendations for Lands Draining to the Duck Club Pond - Review of Stormwater Management Options	<p>Water quantity and quality control for development property in the Kanata Research Park (KRP), as well as areas south of Klondike Road and west of the rail line, is being dealt with in the Duck Club Pond, located on the east side of March Road near the intersection with Klondike Road. However, source and conveyance controls should still be included in the development plans for these areas. The list of controls that should be implemented includes: pervious pipe underdrains in combination with grassed swales for conveyance, especially for flows from parking areas and roof tops; direction of flows from impervious areas onto grassed areas prior to collection in the conveyance system - this should be easily implemented into the golf course business park design of the KRP lands.</p>

**Table A-1**

**Previous Study Recommendations  
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Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommended Stormwater Facility Design Details	<p>Facility designs for Kanata North should be undertaken to adhere to the recommendations provided in the Shirley's Brook / Watt's Creek Subwatershed Study (SBWCSWS) (see Appendix G) as well as the Ministry of the Environment (MOE) Stormwater Management Planning and Design Manuals (1994, and the 1999 Draft). Typical features, such as the incorporation of a sediment forebay, prescribed minimum length-to-width ratios, built in provisions for future maintenance, low flow drains, wetland perimeter plantings etc. should be incorporated into the design.</p> <p>The MOE documents also provide guidelines for the allocation of treatment storage between permanent pools and live storage, recommended permanent pool depths, and forebay sizing parameters which must be adhered to.</p> <p>Each of the new facilities will require a Certificate of Approval from the MOE, and as such ongoing consultation with local MOE staff will be required to finalize facility monitoring requirements. It is anticipated that a standard monitoring program for inlet and outlet pollutant concentrations will be required, at least for the first several years of operations, to confirm that each facility is achieving target pollutant removal rates.</p>
			Stormwater Facility Operations and Maintenance Considerations - Recommended	<p>Each of the proposed stormwater facilities will ultimately owned, operated and maintained by the municipality, and as such should be designed with future works in mind. Access roads need to be provided to the facility inlets and outlets, and into forebay bottoms. Consideration should be given to providing hardened forebay bottoms to facilitate future cleanouts, and a sediment drying area should be incorporated into the design.</p> <p>The 1994 and Draft 1999 MOE Stormwater Management guidelines should be consulted for the range of issues to be considered, and ongoing consultation with City staff during design will ensure that final facility designs are acceptable to the Municipality.</p>
			Floodplain Management Requirements - Floodplain Analysis and Recommendations	<p>For the development lands east of Shirley's Brooks to Fourth Line Road, a significant technical issue is the width and extent of the Regulatory floodplain, particularly just west of the OCR culvert, and between the OCR and Fourth Line Road. The hydraulic constrictions provided by the culvert and rail and roadway embankments, coupled with the local low-relief topography result in a wide floodplain area associated with flood "spill" zones.</p> <p>A particular issue raised by land developers' representatives is the impact of floodplain regulatory requirements with respect to land currently controlled by Kanata Research Park Corporation ("KRP lands"). The concern is that strict adherence to regulations regarding floodplain protection could unnecessarily constrain development of those lands.</p> <p>The general regulatory requirements regarding floodplain protection and management are that no building construction should take place within the Regulatory floodplain, and that property development should not result in any increase in Regulatory flood flows or flood levels upstream or downstream of the development property. From the perspective of watershed hydrology and watercourse hydraulics, these targets imply the need to ensure that the water storage capacity of the Regulatory floodplain should also be protected. Removal of such storage will reduce the flow attenuation provided by the floodway and therefore result in downstream increases in flood flows.</p>
			Floodplain Management Options for the KRP Lands - Floodplain Analysis and Recommendations	<p>Within the project area, floodplain regulation is administered by the Mississippi Valley Conservation Authority (MVCA). Through the course of this project, the MVCA has indicated that the above guidelines regarding flood flows, flood levels and protection of floodplain storage capacity should be adhered to.</p> <p>However, MVCA has also indicated that with particular regard to the floodplain area on the KRP lands, the Authority would consider options in which portions of the existing floodplain area could be filled in, provided that compensatory increase is provided elsewhere within the same development property. In effect, the MVCA has indicated that it will consider development proposals for the KRP lands that include what might be termed "redesign" of the floodplain on KRP lands. The following targets would have to be met: 1. The 100-year flood flows at the downstream limit of the property (i.e. at Fourth Line Road) cannot be increased (because of the requirement to protect downstream properties from any increase in flood risk); 2. The 100-year Regulatory flood level at the upstream property boundary cannot be increased (so as to protect upstream properties); 3. The total water storage capacity on the KRP lands below the 100-year flood level should not be reduced.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Specific floodplain alteration concepts that have been accepted as possibilities by the MVCA include: Filling in the wide floodplain areas north and south of the Brook that are situated just upstream of the OCR culvert, with compensatory storage provided between Fourth Line Road and the OCR culvert; Filling in the floodplain spill area south of Klondike Road, with compensatory storage provided north of Klondike Road.</p> <p>As well, MVCA has indicated that it will be acceptable to consider the option of increasing flood elevations across the KRP lands, provided that targets 1 &amp; 2 listed above (no increase in downstream flows or flood levels and no increase in flood levels at the upstream property limit) is met. This option could potentially be used to provide some of the compensatory storage needed to offset floodplain fill areas.</p> <p>In order to provide a clearer definition of what could be required if floodplain alteration strategies are pursued, estimates of the water storage capacity in selected portions of the flood zone have been made, based on the Regulatory floodplain mapping sheets provided by MVCA (Shirley's Brook Flood Risk Mapping, revised 1989). The following are the Floodplain Storage Volume Estimates: Portion of the Flood Zone - West of OCR rail line, upstream as far as floodplain section number 5399 (per Shirley's Brook Flood Risk Mapping, revised 1989, Map Sheet 11) excluding the minimum 15-m setback zone from the top of the watercourse bank, Estimated water storage capacity below Regulatory flood elevations - 18,000 m<sup>3</sup>; Portion of the Flood Zone - South of Klondike Road, between Fourth Line Road and the OCR rail line, Estimated water storage capacity below Regulatory flood elevations 5,000 m<sup>3</sup>; Portion of Flood Zone - North of Klondike Road, south of Shirley's Brook, between Fourth Line Road and the OCR rail line, excluding a minimum 15-m setback zone from the top of the watercourse bank, Estimated water storage capacity below Regulatory flood elevation</p>
			Integrating Stormwater Management Facilities - Floodplain Analysis and Recommendations	<p>A further issue related to the alteration of the existing floodplain area on the KRP lands is the need for stormwater management ponds to serve these development lands.</p> <p>As described in this report, a concept involving two SWM facilities has been presented as possibly the preferred approach to meeting stormwater treatment and outflow targets for development properties east of Shirley's Brook, including the KRP lands. Both SWM ponds would be situated between Fourth Line Road and the CNR rail line, one pond being situated north of the Brook and the other south of the Brook. Figure 11 shows the proposed location, and Table 7 provides estimates of required size for each of these facilities.</p> <p>Both ponds would be situated within the floodplain zone, and their designs would need to be an integral part of the floodplain alteration scheme. One possible design approach would be to design these facilities such that they are hydraulically isolated from the watercourse during more frequent design events (e.g. up the 5-year event) but become hydraulically connected to the floodplain (i.e. effectively flooded out by rising level in the watercourse) during the more extreme events such as the 100-year flood. This approach may provide some advantages by effectively allowing use of floodplain storage and the hydraulic restriction provided by Fourth Line Road culvert to control the impact of proposed development on downstream flood flows; some cost and land savings could result. Acceptance of this design approach will require hydrologic and hydraulic analyses to prove that there will be no increase in flood flows downstream of the Fourth Line Road culvert.</p>
			Recommendations - Floodplain Analysis and Recommendations	<p>On the basis of the above considerations, the following recommendations are made:</p> <p>As part of overall site design, land developers should undertake hydrotechnical analyses to determine an optimized strategy for alteration of the floodplain of Shirley's Brook between Fourth Line Road and Flood Risk Mapping section number 5399. The hydrotechnical analysis should: be based on meeting the targets stated above with respect to downstream 100-year flood flows, 100-year flood levels and floodplain storage capacity; be based on considering the 100-year flood event hydrograph for future watershed build-out conditions (as defined in the current Official Plan) at the upstream limit of the area of concern, and the flow attenuation effects of the existing floodplain storage on that hydrograph; demonstrate through hydraulic analysis that a proposed floodplain alteration design will not increase the peak 100-year flow on the downstream side of Fourth Line Road, and will not increase the 100-year peak flood level at the upstream end of the area of concern (i.e. section 5399);</p>

**Table A-1**

**Previous Study Recommendations  
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Previous Study	Date	Watershed Area	Topic	Recommendation
				The hydrotechnical analysis should: demonstrate how proposed SWM ponds can be integrated within a proposed floodplain alteration design while meeting the site runoff control targets presented in this report; be carried out in consultation with MVCA staff who can provide guidance on acceptable floodplain alteration plans and acceptability of marginal changes in flood levels or floodplain storage capacities in critical areas.
Kemptville Creek Watershed Plan	1999	RVCA (Leeds & Grenville)	Water Quality Objective (W Quality O) - Reduce Nutrient Loadings	Initiate a subwatershed plan on Barnes Creek. Poor water quality prevails in this creek and further study would assist in identifying and rectifying sources of impairment.
				Create a Kemptville Creek stewardship action group to conduct water sampling, plant trees, conduct creek clean ups, raise the awareness level of the community regarding the creek.
				Continue volunteer baseline water sampling program conducted by residents within the watershed.
				Conduct investigative water quality monitoring in order to maintain baseline data and to seek out sources of pollution. Benthic macro invertebrate inventories will assist in assessing the level of water quality impairment as baseline information.
				Conduct intensive surveys of land use and land management practices in and below Kemptville and in the Barnes Creek watershed to determine sources of water quality impairment. A determination of a watershed nutrient budget will assist in determining the carrying capacity of the creek.
				Initiate community education and awareness program.
				Initiate a stewardship program aimed at supporting landowners who wish to improve their land management practices but who lack the financial or other incentive to do so.
				Revegetate shorelines, and upland areas and provide vegetative buffers between farm lands and water courses.
				Establish stream buffers and setbacks in municipal planning documents.
				W Quality O - Reduce Bacteria Loads
				Encourage the use of stormwater management techniques for large scale development (subdivision).
				Repair infrastructure to Kemptville sewers.
			W Quality O - Maintain and improve WQ	Attempt to ensure stream flow by removing obstructions.
				Adopt and implement nutrient management by-laws.
				Reduce excessive amounts of nutrient and bacteria loads through Best Management Practices.
			W Quality O - Maintain and improve GW quality	Protect groundwater recharge areas in all planning documents.
				Conduct studies regarding groundwater quality and quantity.
				Provide educational materials regarding groundwater.
				Standardize and enforce well installation, operation and capping regulations.
			Wildlife Objective (WO) - Encourage and enhance biodiversity	Document the various landforms and the plant and animal communities associated with these landforms as opportunities areas (i.e. through development proposals). Evaluate all unevaluated wetlands and update wetland evaluations on a regular basis (every 5 years).
WO - Protect and enhance ecological linkages	Identify and protect ecological linkages in planning documents.			
	Identify areas where natural native populations could be enhanced and conduct stewardship activities to do so.			
	Protect wetlands in planning documents.			
WO - Enhance fisheries populations and habitat	Develop a fisheries management plan for Kemptville Creek.			
	Identify potential and existing fish habitat sites (spawning and rearing) as well as identification of sites where rehabilitation is needed or desired.			
WO - Maintain baseflows	Investigate and assess the role of beavers and wetlands on baseflow.			

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Socio-Economic Objective (SEO) - Develop and enhance recreation	Support and implement the recommendations of this plan that focus on improving the natural environment. Map and promote the location of public lands, creek access points, and existing recreation opportunities. Encourage the use of existing trails and parks. Create a recreation corridor along Kemptville Creek.
			SEO - Increase tourism	Improve the health of the natural environment, thereby increasing recreation and tourism opportunities and potential.
			SEO - Preserve rural character of watershed	Adopt and implement development policies which restrict strip development. Encourage sense of awareness, pride and responsibility in local community.
			SEO - Protect agricultural viability	Encourage participation in the Environmental Farm Plan program. Provide financial and other incentives to landowners to alter their land management practices to sustainable farming. Provide educational information. Implement planning policies which protect viable agricultural land.
			SEO - Provide stakeholders with educational material	Continue to learn, education and share information with all stakeholders, residents, landowners, agencies, municipalities about the merits, importance, function and needs of a healthy natural environment.
			Water Quantity Objective (W Quantity O) - Resolve conflicts between beaver and land drainage	Survey and plot an accurate creek profile to obtain a more thorough understanding of the slope, drainage, elevation of outlets (hydraulic characteristics) etc. and how they relate to one another. Define and communicate guiding principles for beaver management. Install and monitor gauges designed to obtain more information regarding water levels and flow. Conduct a study to explore the feasibility of channelizing portions of the creek channel where flow is restricted due to excessive vegetation, beaver activity or other factors.
			W Quantity O - Resolve conflicts between Oxford Mills dam and land	Establish dam operation strategy for Oxford Mills dam.
			W Quantity O - Maintain groundwater resources	Monitor groundwater resources. Establish a groundwater monitoring network to gather baseline data on groundwater quantity (static water levels in aquifers, water table fluctuations) and quality. Enforce existing regulations regarding the operation, rehabilitation of all pits and quarries so that groundwater quality and quantity are protected. Protect groundwater recharge and discharge in municipal planning documents.
			W Quantity O - Maintain baseflows	Conduct further investigations into the relationship between surface water and groundwater (baseflow monitoring).
			W Quantity O - Avoid increases in flood damage potential	Update and extend Kemptville Creek flood risk mapping from the Rideau River to the Oxford Mills dam. Use the estimated flood risk mapping generated by this study (North Augusta to Oxford Mills and the North Branch) as a guideline when making land use planning decisions in those affected areas. Continue to enforce Conservation Authority Fill, Construction and Alteration to Waterways Regulations. Develop and operate a flood forecasting and warning system to provide information in advance of flood conditions.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Life Science Areas of Natural and Scientific Interest in Site District 5-11: A Review and Assessment of Significant Natural Areas in Site	1990	MVCA (Frontenac, Lanark, and Lennox &	Recommendations	Several major recommendations flow from the findings of this study. They are as follows:
				Life science inventories will be required for all provincially significant candidate Areas of Natural and Scientific Interest (ANSI) in Site District 5-11 to refine the findings of this study and to establish a firm boundary for each area.
				Candidate ANSI adjacent to existing provincial parks should be appended to them and zones as nature reserves, following confirmation of boundaries.
				Areas within existing provincial parks containing candidate ANSI should be zoned as nature reserve areas, subsequent to field inventories to confirm boundaries.
				The complex of provincially and regionally significant candidate ANSI in northern Frontenac and southern Renfrew Counties (Figure 7) should be managed as a single unit with existing park areas so as to provide effective and integrated life science management.
				The Renfrew / Frontenac ANSI complex can be considered as the center of an area within which a large tract of provincially significant tolerant hardwoods on marble substrate could be designated for protection in the long term (Figure 7).
Life Science Areas of Natural and Scientific Interest in Site District 6-10: A Review and Assessment of Significant Natural Areas in Site	1993	M-R SPR (Frontenac and Leeds & Grenville) and	Recommendations	The Ontario Ministry of Natural Resources (MNR) should designate all provincial significant Areas of Natural and Scientific Interest (ANSI) that are already designated in District Land Use Guidelines.
				For ANSI that occur on land managed by MNR, the protection of the natural features of the sites should be the primary consideration in all management decisions, both in the ANSI itself and in adjacent lands.
				Several ANSI in this report occur on public land that is not managed by MNR, such as the islands that are part of St. Lawrence Islands National Park, or most of the Mellon Lake ANSI that is managed by the Moira River Conservation Authority. These agencies must be made aware of the significant features on their properties and their cooperation must be sought in protecting such features.
				Many ANSI occur on private land. The owners must be made aware of the significant features on their properties and encouraged - perhaps with financial incentives - to enter into stewardship arrangements to help protect Ontario's natural heritage.
				Regionally significant ANSI should be afforded the same protection currently given to the provincially significant ANSI. If the regionally significant areas are to serve as alternate or backup sites to the provincially significant areas, the former will need to be as well protected as the provincially significant sites.
				Conduct detailed life science inventories for all provincially and regionally significant candidate ANSI in Site District 6-10 to refine their boundaries and more fully document their life science values.
				Maintain a database on all species of concern as well as on all significant natural areas, including - but not restricted to - all sites documented in Appendix B.
				This report emphasizes vegetation and landform features at the expense of high quality fish and wildlife habitats (such as critical fish spawning sites or deer yards), unless they are part of a representative landform or vegetation unit. Additional ANSI that represent these faunal values will have to be identified, in this as well as other site districts.
				Maintain an open system for updating the ANSI system. As additional life science studies are conducted in the site district, undoubtedly new sites of life science value will be discovered that either are not adequately represented in the present suite of candidate ANSI or that have superior values to those presently chosen. There should be an easily understood process for including these new areas into the ANSI program or for replacing an existing ANSI if a better site is found.
				When studies are completed for the nearby Site District 6-12, review the representation for the under-represented features of Clay Plain forests in the present site district. If the representation in the adjacent site district is not adequate to also offer representation for the present site district, it may be necessary to re-evaluate the locally significant areas in Appendix B, or other areas not considered in the present report, to ensure adequate representation of these Clay Plain features.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Develop a comprehensive, province-wide system for formally evaluating the biological significance of all candidate Areas of Natural and Scientific Interest. To be effective, such a system would need to be at least as comprehensive as the wetland evaluation system (OMNR, 1993).</p> <p>Expand the boundaries of two of the designated provincially significant ANSI as indicated in the Appendix A maps: the Portland Swamp should include additional area to the north in order to incorporate the deciduous forest that supports the provincially rare Red-shouldered Hawk that breeds in that forest stand; the Hebert Fen should be expanded to the north to include the small bog that complements the fen area.</p> <p>The Frontenac Provincial Park - Hardwood Bay ANSI contains one of only two palustrine fens known in the site district. Since the fen is actually outside the present park boundary, it should be acquired or formal stewardship arrangements should be made to ensure its protection.</p> <p>Conduct a comparative study and evaluation of the Westport Bog and Maberly Bog sites to determine if the latter is a superior site for representing extensive bog communities. Should the sites be found to complement each other's features, they should both be considered provincially significant.</p> <p>Conduct a comparative evaluation of rock barren sites in the Kaladar Subdistrict - Mellon Lake, Kaladar Jack Pine Barrens, and Puzzle Lake - and refine their boundaries. The Mellon Lake and Kaladar Jack Pine Barrens sites occur in close proximity and contain many complementary features and communities. They should be amalgamated into one large ANSI or there should be a broad connecting link between the two sites. If the features and communities that occur in the Puzzle Lake ANSI complement those of the other two sites, the Puzzle Lake ANSI should be elevated to provincial status. Since these three areas are extensive and occur largely on Crown land, there may be less need than elsewhere to identify additional regionally significant sites to backup these provincially significant sites.</p> <p>When the Mellon Lake ANSI is studied in more detail, the study area should include the extensive rock barrens and ridge / valley topography that continue for several kilometres northeastward from the present northern boundary that was set artificially at the power line.</p> <p>When the Hamilton Lake ANSI is studied in more detail, the inventory should include land to the southeast toward the north end of Loughborough Lake. This area contains a diversity of wetlands and ridge / valley topography that may contain features not represented in the ANSI.</p> <p>In this and previous site district studies, submerged aquatic communities have received less attention than land-based communities. Although aquatic communities are represented in many of the candidate ANSI in this report, their range and diversity has not been well investigated. The geological diversity and plentiful lakes and waterways in Site District 6-10 suggest that the aquatic diversity is high. Specific studies should be undertaken to examine the diversity of aquatic communities in the site district and evaluate the degree to which they are represented in the candidate ANSI in this report. It is likely that additional sites will be required to fully represent this aquatic diversity.</p> <p>Kame Moraine - albeit rare in Site District 6-10 - is only represented by one small area that supports rather disturbed mixed forest in the regionally significant Oak Bay ANSI. If better examples of vegetation on Kame Moraine cannot be found elsewhere, the Oak Bay ANSI, or a portion of it, should be elevated to provincially significant status.</p> <p>Sand Plain - albeit rare in Site District 6-10 - is only represented by one small area that supports rather disturbed mixed forest in the provincially significant Piccadilly Swamp ANSI. If adequate representation of Sand Plain forests is not achieved in the suite of ANSI chosen in the adjacent Site District 6-12 (Brunton, in prep.), forests in the Piccadilly and Parham areas should be re-examined for possible candidate ANSI that could provide additional representation in the long-term if they were given sufficient protection.</p>
Life Science Areas of Natural and Scientific Interest in Site District 6-11: A Review and Assessment of Significant Natural Areas in Site	1992	M-R SPR (Lanark, Leeds & Grenville and Ottawa) and	Recommendations	The Ontario Ministry of Natural Resources (MNR) should designate all provincial significant Areas of Natural and Scientific Interest (ANSI) that are already designated in District Land Use Guidelines.

## Table A-1

### Previous Study Recommendations

### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
				For ANSI that occur on land managed by MNR, the protection of the natural features of the sites should be the primary consideration in all management decisions, both in the ANSI itself and in adjacent lands.
				Many ANSI occur on private land. The owners must be made aware of the significant features on their properties and encouraged - perhaps with financial incentives - to enter into stewardship arrangements to help protect Ontario's natural heritage.
				Regionally significant ANSI should be afforded the same protection currently given to the provincially significant ANSI. If the regionally significant areas are to serve as alternate or backup sites to the provincially significant areas, the former will need to be as well protected as the provincially significant sites.
				Conduct detailed life science inventories for all provincially and regionally significant candidate ANSI in Site District 6-11 to refine their boundaries and more fully document their life science values.
				Maintain a database on all species of concern as well as on all significant natural areas, including - but not restricted to - all sites documented in Appendix B.
				This report emphasizes vegetation and landform features at the expense of high quality fish and wildlife habitats (such as critical fish spawning sites or deer yards), unless they are part of a representative landform or vegetation unit. Additional ANSI that represent these faunal values will have to be identified, in this as well as other site districts.
				Maintain an open system for updating the ANSI system. As additional life science studies are conducted in the site district, undoubtedly new sites of life science value will be discovered that either are not adequately represented in the present suite of candidate ANSI or that have superior values to those presently chosen. There should be an easily understood process for including these new areas into the ANSI program or for replacing an existing ANSI if a better site is found.
				The ancient shoreline of the postglacial Champlain Sea crosses portions of the site district and occurs along the boundary with Site District 6-10. This shoreline could support features and communities unrepresented in the suite of recommended ANSI in the present report. Studies should be undertaken to determine if this old shoreline does support unique features, and if so, candidate area(s) should be identified and protected. One area recommended by a reviewer occurs north of the Innisville Wetlands ANSI.
				In this and previous site district studies, submerged aquatic communities have received less attention than land-based communities. Although aquatic communities are represented in many of the candidate ANSI in this report, their range and diversity has not been well investigated. The plentiful lakes and waterways in Site District 6-11 suggest that the aquatic diversity is high. Specific studies should be undertaken to examine the diversity of aquatic communities in the site district and evaluate the degree to which they are represented in the candidate ANSI in this report. It is likely that additional sites will be required to fully represent this aquatic diversity.
				A number of the ANSI identified in this report occur in close proximity to other ANSI. The establishment of protected "linkages" between these adjacent areas would increase the life science value and long-term viability of each area.
				Due to the general shortfall of upland forest sites on limestone plain in the present suite of recommended areas, it may be necessary to re-evaluate the locally significant areas in Appendix B that were considered to be too disturbed to meet ANSI standards, or other areas not considered in the present report, to identify additional candidates for protection.
				When site district studies are completed for the adjacent 6-12 and 6-10, review the representation in those site districts for the under-represented features of the minor landform types in the present site district. If the representation in those adjacent site districts is not adequate to also offer representation for the present site district, re-evaluate the other documented sites in Appendix B or other areas not considered in the present report to ensure adequate representation of these features.
				When studies are completed for the nearby Site District 6-12, review the representation for the under-represented features of Clay Plain forests in the present site district. If the representation in the adjacent site district is not adequate to also offer representation for the present site district, it may be necessary to re-evaluate the locally significant areas in Appendix B, or other areas not considered in the present report, to ensure adequate representation of these Clay Plain features.



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Expand the formal boundaries of three of the designated provincially significant ANSI as indicated in the Appendix A checklist maps: the Merrickville Bog should include additional area to the south in order to incorporate the lacustrine bog areas associated with Lissons Lake; the Numogate Mud Lake Fen should include the northern portion of the mixed swamp since all the swamp drains into the significant lake and fen areas; and the Brockville Long Swamp Fen should include most of the rest of the wetland because it is probably integral to the central fen areas. Peat harvesting in the Merrickville Bog by MNR for the Kemptville tree nursery should be discontinued.</p> <p>The boundary of the Manion Corners Long Swamp - as designated in the MNR District Land Use Guideline - excludes a central area of sandy old field. This field has been greatly modified by human activity and does not relate directly to the main swamp and fen habitats, however, it does occupy a strategic location in the ANSI. Any proposed development there must be very carefully weighed against the possible negative impact on the adjacent wetland communities.</p>
Life Science Areas of Natural and Scientific Interest in Site District 6-12: A Review and Assessment of Significant Natural Areas in Site	1992	M-R SPR (Leeds & Grenville and Ottawa) and	Recommendations	<p>The recommendations for future actions and research resulting from this study are as follows:</p> <p>Life science inventories should be undertaken for each of the provincially significant candidate Areas of Natural and Scientific Interest (ANSI) proposed for Site District 6-12 in order to fully document the life science contributions of each area. Boundary requirements should be determined to develop ecological management plans and strategies.</p> <p>Preservation management plans aimed at encouraging the development of more mature examples of the most poorly represented landform-vegetation complexes - especially on upland sites - should be initiated for the appropriate candidate ANSIs.</p> <p>Nature Reserve zones should be established in Carillon and Fitzroy Provincial Parks to accommodate the values of representational significance identified in this study as occurring here.</p> <p>Some areas examined briefly or not at all (see Appendix B: Documented Sites of Biological Significance, p. 159) have potential representational significance. Many of these sites should receive a reconnaissance level survey.</p> <p>Mechanisms are required to ensure that effective preservation management and protection (not just identification) are provided for the significant ANSI sites described in this study.</p>
Lower Rideau Watershed Strategy - Draft Final Report	2005	RVCA (City of Ottawa and Lanark)	<p>Implementation Recommendations (IM) - Fine Tuning Water Management Actions</p> <p>IM - Keeping Nutrients and Bacteria Out of the Rideau</p>	<p>Study to map critical fish habitat in relation to water levels (expand existing program) - walleye, pike, muskie.</p> <p>Develop watershed model to link land use changes to watershed response - hydrology / hydraulics, water balance.</p> <p>Continue current strategy of managing spring / fall water level changes on a best effort basis.</p> <p>Investigate phosphorus cycle and role of insitu phosphorus to better quantify nutrient sources and implement abatement measures to allow for improved tracking of the success of.</p> <p>Investigate whether aquatic weeds/algae can be better managed and what role they play in eutrophication and fish habitat.</p> <p>Agencies (including City and MOE) to endorse LRRWMS with respect to indicators, targets, actions which will lead to new City standards for Stormwater Management focused on developing areas.</p> <p>Implement targeted program of Rural BMP measures - structural and non-structural.</p> <p>Targeted Program for Nutrient Control (education, funding, staffing) - a. agriculture; b. Rural; c. Urban.</p> <p>Expand search and destroy program for cross connections.</p> <p>Testing of new infrastructure - laterals / mainlines for leakage, cross connections, structural integrity.</p> <p>Investigate opportunities to expand the range of programs and projects eligible for funding under the City Cash-in-Lieu program.</p> <p>Implement program of SWM retrofits using treatment train technology.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			IM - Revitalizing River and Stream Corridors	Study to assess sensitivity of shorelines to boat wakes - Awareness campaign on negative effects of boat wakes. Prioritize and accelerate implementation of Subwatershed-Based Studies. Protect / Manage uses, natural functions in riparian zone. Rehabilitation program for natural riparian buffer and natural stream channels. Protect high quality fish habitats / special status species, enhance marginal habitats, prevent further degradation of poor habitats. Implement environmentally sound municipal drain maintenance. Expand navigation regulations, speed restrictions, increase signage and enforcement to reduce incidence of wake-induced shoreline erosion.
			IM - Public Education / Community Outreach	A comprehensive education and stewardship program directed at shoreline landowners and landowners on tributaries on their properties to promote a conservation ethic. Develop Web Site to provide information on Riparian / River issues. A stewardship / education program to educate landowners on the benefits of stormwater retrofit technology, including lot-level / source measures, conveyance and end-of-pipe measures. Develop Education Programs re: boat use and etiquette. Include promotion of Clean Boaters Program. A stewardship / education program targeting farmers to assist with the implementation of rural BMP measures. Develop / Promote Community Monitoring Program.
			IM - Integrated Monitoring for Adaptive Management	Improved, integrated, multifaceted environmental program.
Lower Rideau Watershed Strategy - Phase I	2003	RVCA (City of Ottawa and	Communication and Cooperation	To promote environmental stewardship and better understanding of the importance of natural features and functions of the Rideau River.
			Surface Water Quantity	Maintain or improve water resources to support natural and human uses of the river. Manage flooding risks to human life and property to within acceptable limits. Maintain or improve natural flows in tributaries to support aquatic habitat functions.
			Surface Water Quality	Manage the quality and quantity of "non-point source runoff" Manage surface and groundwater contamination from point source discharges.
			Groundwater Quality and Quantity	Maintain groundwater levels and discharges Protect groundwater quality.
			Aquatic Communities and Habitats	Maintain or improve populations of native aquatic species and communities. Maintain or improve the stability, diversity and linkages between habitats that support aquatic species and communities.
			Terrestrial Communities and Habitats	Maintain or improve the stability, diversity and linkages between habitats that support terrestrial species and communities. Minimize the impact of land use on terrestrial habitat.
			Water and Riparian Uses	Manage the Rideau waterway to provide reasonable outdoor recreational / tourist uses, within sustainable limits. Manage the use of surface water and groundwater (including water withdrawals and hydropower) within sustainable limits.
Mapping and Assessment of Former Industrial Sites, City of Ottawa	1988	RVCA & MVCA (City of Ottawa)	Recommendations	The 177 former industrial sites identified in this report were assessed for potential environmental impact and based on potential for environmental impact these sites were categorized into three groups I, II and III. Group recommendations are developed for sites in Groups III and II and individual site recommendations are developed for sites in Group I.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>One hundred and fifty-four (154) sites were included in Group III. Group III sites are low priority sites where it is unlikely that significant quantities of waste exist at the sites today and therefore the potential for environmental impact, even considering redevelopment and excavation, is minimal. No recommendations for further action are considered necessary for these sites.</p> <p>Eighteen (18) sites are included in Group II as having sufficient evidence to indicate that wastes may be remnant in the soil and groundwater of the site. For all sites included in Group II it is recommended that any future development involving excavation be conducted with caution and the knowledge that wastes are likely present in the subsurface soils. Soils excavated from these sites may be considered registerable solid or hazardous waste and Regulation 309 leachate testing of soils is recommended at these sites prior to excavation to confirm the appropriate disposal of excavated material. Sites in Group II should be identified on the City of Ottawa Development Information System (DIS) to ensure that prospective developers are cognizant of potential site hazards.</p> <p>Five sites are included in Group I as having sufficient evidence to indicate that wastes are likely present on-site and that there is high potential for environmental impact. These sites include Site No. 12 - Currie Products Ltd., Site No. 14 - Ottawa Gas Works, Site No. 22 - F.W. Argue Fuel Oil Depot, Site No. 129 - Imperial Oil Ltd., and Site No. 140 - Bytown Gas Works. These sites should also be listed on the City of Ottawa Development Information System.</p> <p>At the Currie Products Ltd. site, remedial investigations are recommended to assist in site clean-up and to evaluate the potential coal tar migration pathway of the bedding material of the adjacent City of Ottawa storm sewer. Such studies are planned and pending the results of these studies further recommendations at this site are not warranted.</p> <p>Recommendations for the Ottawa Gas Works (Lees Avenue) site are similarly not required at this time as property owners at the site have retained consultants to assist in site clean up and remediation with the approval of the Ontario Ministry of the Environment.</p> <p>Since identification of the F.W. Argue Fuel Oil Depot site, the property owners have undertaken site remediation and site cleanup including removal of underground storage tanks and contaminated soil. As this cleanup is being conducted with the knowledge of the Ontario Ministry of the Environment, recommendations for further action at this site are also not required.</p> <p>At the Imperial Oil Co. Ltd. bulk gasoline and oil storage facility there is potential for contaminated groundwater to leach to the Ottawa River and therefore exploratory investigations are recommended to quantify the extent and levels of suspected contamination at the site. A shallow soil, soil gas and groundwater sampling program is recommended at this site.</p> <p>The Bytown Gas Work site has potential for off-site migration of coal tar and coal tar contaminated groundwater. Recommendations for further action at this site include performance of an off-site drilling and soil sampling program to define the extent of coal tar contamination in the area of the site.</p>
Merrickville Water Works, First Engineer's Inspection Report for Water Works	2001	RVCA (Leeds & Grenville)	Investigations, Study Requirements - Summary of Recommendations and	<p>A feasibility study of Well No. 3 should be performed to assess options for upgrading or decommissioning the well. An estimate for the feasibility study is \$12,000.</p> <p>An investigation of water levels in the drainage ditch at the main pumphouse should be undertaken. A hydrological / hydraulic investigation is estimated at \$3,000.</p> <p>Borehole geophysics on municipal water wells should be performed to confirm the source of groundwater in the village. The estimated cost is \$10,000 per well investigation.</p> <p>Since Merrickville ward has been on municipal water supply, private wells within the ward have likely not been in use for a number of years. Wells that have not been decommissioned or improperly decommissioned may provide access points for contamination of groundwater supplies in the Village. The Village should perform a survey of all wells in the ward. The cost of the abandonment survey is estimated to range from \$5,000 to \$10,000. This cost does not include proper decommissioning of wells.</p> <p>The cost to implement a Well Head Protection Area is expected to range between \$50,000 and \$100,000.</p>
			Facility Works - Summary of Recommendations and	<p>Facility correction works required to mitigate the potential for bacteriological contamination (Section 4.1) is estimated at approximately \$31,300, exclusive of investigation efforts.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>A number of concerns have been identified in the Ministry of Environment (MOE) inspection reports with respect to microbiological contamination. One of the remedial actions recommended to address these issues include installation of duplicate disinfection meters (duty and standby) flow controlled complete with valves and a calibrated column on a new panel. The cost to change the chlorine feed system is estimated at \$10,000.</p> <p>Sodium hypochlorite should be applied to all raw water supply lines in the clearwell. This may be accomplished by combined supply pipes into one pipe manifold with a injector in the centre of the pipe. The cost to undertake pipe modifications is estimated at \$5,000.</p> <p>A review of water quality indicates that some physical / chemical parameters exceed the Ontario Drinking Water Standards (ODWS). These parameters include sodium, iron, manganese, turbidity and colour. The marginal cost to upgrade water treatment in the Village to produce water meeting the ODWS is estimated at \$160,000 (\$160/m<sup>3</sup>). Upgrading the water treatment plant is considered a Schedule B project (screening process) under the Municipal Class Environmental Assessment (EA).</p> <p>A number of deviations from the Ten States Standards are identified in Sections 7.2 and 7.3. Supplementary corrective measures required include: Install security fencing; Undertake clearwell overflow pipe modifications; and Separate the clearwell into two compartments. Initiation of maintenance and upgrading work in the clearwell will require interim storage to ensure minimum disinfection requirements. Refurbishing the clearwell is considered a Schedule A project (pre-approved) under the Municipal Class EA. Expansion of clearwell storage is a Schedule B project (screening process) under the Municipal Class EA.</p> <p>Construction of a separation compartment wall in the clearwell and expansion of the clearwell storage (210 m<sup>3</sup>) to meet MOE storage requirements is estimated at \$115,000.</p>
			Operations and Maintenance Issues - Summary of	<p>An operations and maintenance manual and as built records should be prepared for the Merrickville Water Works. The cost to prepare a manual is \$10,000. The cost to prepare 'as built' documentation is estimated at \$5,000.</p> <p>Additional sampling is required as identified in section 5.5 of this report and itemized under Table 5 of the ODWS.</p>
Mississippi River Water Management Plan	2005	MVCA	Information Needs	<p>Eels - Keep informed of broader research being done.</p> <p>Instream Flow Requirements - Specific minimum flows through each of the control structures required to maintain ecological integrity. The specific minimum flows need to be established through current research on in-stream flow requirements. Implementation of this research will be addressed in future amendments to this plan.</p> <p>Status of Amphibian, Reptile, Mammal &amp; Invertebrate Populations - Keep informed of research being undertaken on the impact of lower winter water levels on the abundance of amphibians, reptiles, mammals and invertebrate populations.</p> <p>Lake Trout Spawning - High Priority for Effectiveness Monitoring. Little baseline information exists on the impacts of water levels on the long term sustainability of the naturally reproducing lake trout. The status of the population needs to be assessed on an on-going basis to measure the population response to the new operating regime.</p> <p>Waste Assimilation - Confirm waste assimilation requirements on lower river system during low flow periods.</p> <p>Hydro-meteorological Network - Enhance hydro-meteorological monitoring across the Mississippi watershed.</p> <p>Walleye Assessment - Crotch Lake: walleye spawning assessment, including upstream, in the lake and downstream; effect of 2 major drawdowns in all 3 locations and effect of low flow downstream.</p> <p>Socio-economic Data - Additional information on the socio-economic conditions for the river system, particularly data on the economic value of tourism and recreation.</p>
			Areas to be Updated	<p>Bathymetric Mapping - Bathymetric mapping of the following lakes: Kashwakamak, Gull, Mississagagon, Dalhousie, and Mississippi.</p> <p>Species at Risk - Monitoring the species at risk and keep informed of broader research being completed (i.e. Blanding's turtle).</p> <p>Water Taking Permits - Confirm the number and volume of water taking permits issued on the river system.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Other Spawning - Spawning sites of other species should be assessed.
				Mazinaw Lake Rehabilitation Project - Mazinaw Lake assessment of spawning bed rehabilitation project.
				Wild Rice Research - Conduct literature search and compilation of how changes in flows would impact the rice. May also include further consultation with First Nations.
				Dam Safety Assessment - Proposed changes to the Shabomeka Dam operating regime requires a structural review of loading conditions on Shabomeka Lake Dam.
Mississippi Valley Conservation R	1970	MVCA	General Policies	<p>Management of all existing natural resources must be compatible with the needs and demands of the population and the growth and development of the municipalities.</p> <p>MVCA will coordinate its activities with other agencies affecting resources, such as the Department of Lands and Forests, Agriculture and Food, Municipal Affairs, and Highways; and District Health Units, Ontario Water Resources Commission and the National Capital Commission.</p> <p>MVCA will encourage local municipalities and planning boards to adopt land-use regulations, and will endeavour to have incorporated within these regulations, policies which are consistent with the resource management objectives of the MVC.</p> <p>MVCA will prepare and register fill and construction regulations under the provisions of Section 26 of The Conservation Authorities Act, 1968, and coordinate these with Official Plans and zoning by-laws. Top priority will be given to urban or urbanizing areas, and areas of intense cottage development.</p> <p>MVCA will encourage and participate actively in converting marginal and submarginal land to more productive land uses, including recreation, with a view to improving the overall economy and resource management of the watershed.</p> <p>The principle of multiple-land-use will be recognized and particularly in areas of higher population densities.</p> <p>The preservation of the natural environment including areas of natural, scenic, biological and historic interest will be acknowledged in the MVCA's program of resource management.</p> <p>In cooperation with other interested agencies, MVCA will endeavour to ensure adequate stream flows and the improvement of the quantity and quality of surface water supplies.</p> <p>The financial levy in any year to a member municipality shall not exceed 0.5 mills on the provincial equalized assessment, except where the municipalities concerned request a special project and are prepared to assume the MVCA's share of the cost.</p> <p>Because of its limited financial base, initially, MVCA will emphasize the acquisition of lands required for its various projects, and will defer or limit its expenditures on actual development.</p> <p>MVCA will establish advisory boards in order to enlist the skills and interests of qualified citizens as well as those of MVCA members.</p>
			Water Development Policies - Dams &	<p>Action will be taken, by acquisition or other means as soon as possible, to gain control of lands necessary for the future construction of dams and reservoirs.</p> <p>MVCA will initiate a phased program of design and construction for those dam and reservoir sites recommended in this report and shown on Figure 5-1, and in addition will investigate other project sites as required.</p> <p>Generally, water control projects will be designed for multiple-use including flood protection, maintenance of adequate flows and recreation facilities.</p> <p>Dams and reservoirs shall be designed for multiple-use wherever practical and to give protection against at least flows of the magnitude of once-in-one-hundred years.</p> <p>Spillway capacities shall be designed to meet local conditions.</p>
			Water Development Policies - Channel Improvements &	<p>Where reservoir sites are not readily available, or their acquisition is not economically feasible, flood protection by the construction of channel improvements and diversions will be considered.</p> <p>All channel improvements and diversions shall be engineered to withstand high flows and velocities without creating adverse downstream effects.</p>

## Table A-1

### Previous Study Recommendations

#### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
				In advance of construction, necessary rights-of-way for channel improvements will be protected, by various means, from developments which would interfere with the eventual proper development of the projects.
			Water Development Policies - Land Use Regulations	Action will be taken to restrict the use of flood-prone areas and valley slopes to such non-intensive uses as agriculture, parks and recreation, through Regulations pursuant to Section 26 of The Conservation Authorities Act, 1968, and through cooperation with municipalities in zoning and development control. A systematic program of flood plain and stream valley land mapping will be initiated to provide information to municipalities and private owners on flood and erosion-vulnerable lands.
			Water Development Policies - Water Quality	A program of periodic water sampling will be established to assist the Ontario Water Resources Commission in locating and controlling sources of water pollution.
			Fish & Wildlife Development Policies	MVCA is keenly interested in establishing, where necessary, and maintaining an optimum population of fish, wildlife and plant communities, and to this end will pursue the following policies: Continuous liaison will be maintained with the Tweed and Kemptville District offices of the Department of Lands and Forests. Landowners will be advised and/or assisted in such improvements as the installation of Wood Duck nesting boxes. On MVCA-owned lands and on privately or publicly-owned lands, such land management practices and studies will be encouraged, as will improve browsing conditions for deer. Action will be taken to acquire, wherever possible, small areas having rare species of fauna or flora of special interest to naturalists. Except in areas where there is a conflict of activities, MVCA-owned lands will be made available for hunting during suitable periods. In cooperation with the Department of Lands and Forests efforts will be made to improve the "sportsman-landowner" relationships, in order to minimize the posting of land, thereby making available prime lands for hunting and fishing.
			Recreational Development Policies	MVCA will embark on a phased program of establishing a network of trails, routes and conservation areas, as shown on Figure 21-3, and in doing so will adhere to the following policies: All developments will be of a high quality, and will be developed with the assistance of professionals, such as landscape architects. A Conservation Area Classification and Zoning System will be adopted and applied in the development of all MVCA lands. Liaison will be established and maintained with public agencies such as the Department of Lands and Forests. Member municipalities will be encourage to incorporate within Official Plans, sub-division approvals and zoning by-laws, provisions which will enhance the natural beauty and environment of the watershed.
			Land Use and Forestry Development Policies.	Under the guidance of its Land Use and Forestry Advisory Board, and with the assistance of the District Offices of the Department of Lands and Forests and the Department of Agriculture and Food, MVCA will pursue the following policies to ensure the wise use of land and forest resources: A phased program of acquisition of submarginal agricultural land will be established with the aim of acquiring approximately 500 acres per year. Where the lands mentioned above are best suited for the single purpose of forest management, the purchasing will be concentrated in that area of the MVCA generally west of the line from the river mouth to Carleton Place. Purchases will be such that consolidated blocks of property are eventually created. Lands having small ponds, stream shorelines and wet lands as major features will not be acquired solely for forest production, but will be developed for combined forestry, wildlife and other compatible uses. In areas where land is held mainly by the Crown, competition with the province for purchase of privately owned lands will be avoided. Liaison will be maintained with ARDA in order to enable the MVCA to have lands unsuitable for agriculture, under the farm consolidation program, set aside for MVCA purposes.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Private land advisory and assistance programs will be set up for areas of potential intensive agricultural production to promote: i) better drainage systems; ii) erosion controls through proper cultivation practices, and the establishment of grassed waterways; and iii) stream-bank stabilization and improvement through the establishment of vegetative cover and protection from livestock.
Mississippi Valley Watershed Strategy	1993	MVCA	Directions for the Future	<p>Watershed Planning - Watershed planning will be undertaken throughout the Mississippi Valley Conservation Authority (MVCA) watershed to establish ecosystem objectives.</p> <p>Co-operative Resource Management - That partnerships between government agencies, non-government organizations and community groups will be promoted and developed to achieve integrated resource management on a watershed basis.</p> <p>Conservation Awareness - Increased public and political awareness of the importance of conservation is crucial to achieving the objectives of the watershed strategy by building strong local support and commitment to the strategy.</p> <p>Watershed Information - A watershed information system will be established containing current state information of the natural resources of the watershed.</p> <p>Monitoring and Evaluation - Monitoring programs will be developed to track the effectiveness of resource management efforts by monitoring representative watershed indicators.</p>
Municipal Well Head Protection Study - Town of Kemptville, Township of North Grenville	2000	RVCA (Leeds & Grenville)	Major Recommendations	<p>A limitation of the groundwater modeling exercise reported herein is the limited data upon which to calibrate the model. As with any exercise of this type, the accuracy of the model is entirely dependent upon the quality of the data upon which it is constructed. It is therefore recommended that as part of its planning, the Town should undertake a detailed hydraulic testing program of the Town wells and groundwater flow system. The data obtained from this testing program would be used to calibrate and refine the groundwater flow model, which would then be used to more accurately delineate the WHPA.</p> <p>There are a number of avenues available to the Township to address both existing and potential future sources of contamination. An inventory of past land uses, which have the potential and underlying potential, to introduce contaminants to the subsurface has been completed. At best this list is incomplete and the Township should continue to update this list as more information becomes available. With respect to the existing sources identified, the Township should, within its power under the Planning Act, request information on the environmental conditions of these properties when they undergo redevelopment.</p> <p>The Township may wish to become involved during the clean up of contaminated sites. Under the MOE Guidelines for Use at Contaminated Sites, there may be a tendency for proponents to use Generic Table B criteria for Non-Potable Groundwater Conditions. The exercise completed justifies the use of the more stringent Table A criteria for Potable Groundwater situations. It is our recommendation that in the interest of protecting the Town water supply that the Township requires clean up to Generic Table A Criteria. Alternatively a Site Specific Risk Assessment and Monitoring Program in accordance with the Guidelines could be undertaken.</p> <p>In addition to the commercial and industrial sources of contamination, there is the widespread use of organic pesticides and herbicides on residential, agricultural and commercial lands. Monitoring the Town's water supply for these components is currently required under the Certificate of Approval, with the frequency of monitoring to be drastically increased with the implementation of the new Ontario Water Regulations. To our knowledge, these compounds have not been detected in the municipal water supply. Literature suggests that the compounds are generally not prevalent in groundwater, being retained and degraded in the near surface soil environment. The Township could, however, consider proactive elimination of these from the water flow system as a precautionary measure to protect the drinking water supply.</p> <p>A review of Water Well Records indicate that there are a number of wells completed within the Town of Kemptville, the current status of which are unknown. There is a particular concern regarding high yield well known to have been located on existing commercial properties. The Town should require the owners to identify the location of these wells and have them properly abandoned, in accordance with and as required by, Regulation 903 under the Ontario Water Resources Act.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Finally, the Township should endeavour to protect the groundwater supply by imposing land use controls on future development. Proposals should be requested to identify potential sources of contamination and define mechanisms and systems, which will prevent these from being introduced to the subsurface environment (e.g. a Pollution Prevention Plan). This could require a monitoring or reporting requirement.
North Grenville Water and Wastewater Servicing Master Plan	2005	RVCA (Leeds & Grenville)	Recommended Solutions	<p>The initial phase of the infrastructure development of the East and West Quadrants will include the construction of new transmission watermain and truck sewers. The proposed alignments for the watermain infrastructure in this Servicing Master Plan (SMP) provide sufficient looping and redundancy while ensuring that all parcels of property can be serviced. The proposed alignments for the sewer infrastructure utilize the existing topography to reduce costs while also ensuring all parcels of property can be serviced.</p> <p>There is limited capacity in the Municipal water supply to provide for growth. In fact, according to the uncommitted reserve capacity analysis carried out for the 2005 Servicing Options Study, there is insufficient supply for what has already been committed. As part of the current undertaking, Golder Associates have commenced a source identification process called "constraint mapping". The results of this exercise found in Appendix C identified 5 potential sites suggested for further investigation. It is recommended that the Municipality move forward with securing land options on various sites and proceed with a groundwater source investigation for new capacity. Following the commissioning of a new well, there will be sufficient capacity in the interim to consider taking individual wells offline for further testing to increase their rated capacities to what was demonstrated during original testing or greater.</p> <p>In addition to source restrictions, there is a limited amount of storage; in fact, the available capacity (including the recent Kernahan upgrade) is slightly insufficient to meet the Ministry of the Environment (MOE) design guidelines based on existing serviced population. Since storage is required with additional source capacity, it is recommended that a new reservoir be sited in conjunction with the new groundwater source. Future storage will be required alongside of future source requirements. There is no hydraulic benefit or cost savings associated with elevated storage.</p> <p>In order for the sewer system to be complete, a pumping station and forcemain is required for each of the quadrants. Preferred locations for new wastewater pumping stations were identified based on topography and hydraulics. It is recommended that the Municipality proceed with securing land options on various lands within the vicinity of the proposed pumping stations. The current design recommendation is to ensure that each pumping station is capable of transferring the peak flows for each quadrant as described in Section 4.0. Consideration may also be given to servicing flows from lands outside of the focus area. The Oxford Landing, Cranberry Hill and Henderson subdivisions are examples of such areas. The proposed alignment of the West Quadrant sewers and watermain already considers these subdivisions, however the diameters of the sewers will have to take these developments into consideration during the design stage.</p> <p>The crossing of the Kemptville Creek is possibly the most environmental sensitive issue following the expansion of the wastewater treatment plant. It is recommended that either a trenchless technology or bridge suspension be considered for this crossing to limit the impact on the surrounding environment.</p> <p>Based on existing per capita flow rates, the existing wastewater treatment plant is capable of handling an equivalent population of 8500 persons. While the design of the plant was originally designed for 5500 persons, there was a separate allowance provided for in the design for industrial and commercial development. In order to service the projected growth of 19,572 equivalent persons, a twinning (or equivalent) of the plant will be required. The Municipality may wish to carry out optimization programs - one for the plant and one on the sewers, in order to defer the costly expansion to future years. Considerations should be given to carrying out assimilation studies on the Rideau River in the early planning stages to determine the treatment requirements and feasibility of plant expansion.</p>



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The current service population is an estimated 3550 persons. The build-out equivalent population is an estimated 19,572 persons. This future population is almost five and one half times the current population. It stands to reason that the infrastructure required to service this population would be proportional as well. The estimated capital cost to service the entire growth area is \$33.2 million. The interim cost to allow development to proceed is estimated to be approximately \$9.2 million. These costs do not include the optimization of the wastewater treatment plant, as a study is needed to determine these costs. As well, it does not include the relining of sewers cost that would be determined in the I/I study. It is further noted that these costs consider water source, water storage and wastewater treatment costs for Oxford Landing but not the piping or pumping infrastructure.</p> <p>Figures 6.1 to 6.3 provide milestones for when additional infrastructure is required based on an equivalent population scale. The timing presented in Table 6.1 and 6.3 assume growth will occur over a 20-year horizon. If development is to occur more quickly or slowly, the appropriate horizon can be applied to Figures 6.1 to 6.3. It is important that prior to the infrastructure milestones identified in Table 6.1 and 6.3 are reached; the Environmental Assessments and additional studies need to be completed.</p>
Old Landfill Management Strategy, Phase 1 - Identification of Sites, City of Ottawa	2004	M-R SPR & City of Ottawa (out of study area)	Conclusions and Recommendations	<p>Eighty-two (82) sites were identified fitting the description of the old landfill sites as defined by the City of Ottawa. Of these, 51 are located within the former City of Ottawa, with the remaining 31 sites located in the former municipalities of West Carleton (9), Goulbourn (4), Rideau (2), Osgoode (1), Kanata (1), Nepean (2), Gloucester (4) and Cumberland (8). The majority of sites (78) had previously been identified within the Historical Land Use Inventory (HLUI). Forty-seven (47) of the sites were found to be greater than 50 years old. These older landfills are less likely to produce landfill gas because organics in the waste have already broken down or possibly were reduced prior to disposal via incineration. Seventeen (17) City owned old landfill sites were found to be currently developed as parks or publicly accessible recreational areas.</p> <p>The sites were grouped in three categories of ownership: 23 sites were found to be owned in their entirety by the City of Ottawa, 19 were jointly owned by the City of Ottawa and another party, and 40 sites were non-City owned sites (owned by private individual, business, institution or other level of government).</p> <p>The five key parameters developed to characterize sites in the context of the protection of human health and the safeguard of the environment provided a brief overview of the sites. The key parameters were: age and size of the landfill, the distance to human receptor (building or private well) and to a body of surface water, and subsurface conditions which dictate the potential migration of contamination.</p> <p>The data gap analysis carried out for each of the sites revealed that assessment of further information was required to develop a sound understanding of the issues required to assess the sites in terms of potential health and environmental effects. Data gaps were related to the following parameters: definition of the waste area, characterization of groundwater and surface water quality, assessment of landfill gas generation, and characterization of the landfill cover.</p> <p>As identified in the City of Ottawa's Old Landfill Management Strategy, Phase 2 will include field investigations to define the degree of potential public health and environmental impacts. The data gap information identified in the Phase 1 study will allow for scoping of these Phase 2 investigations.</p>
Ottawa Riverkeeper's River Report: Issue No. 1, Ecology and Impacts, May 2006	2006	M-R SPR & outside of study area	Threats to Ecological Health of the River - Dams and Generating Stations - Riverkeeper's Recommendations	<p>Because of our dependence on hydroelectricity and our need for some flood control, solutions to the problems we have highlighted are limited. Design and operating choices, however, can be controlled at this point in time. We recommend the following actions be taken to reduce the impact dams are having on our river system: 1. Ensure no dams are constructed on the Dumoine River, as this is our only experimental control within the watershed that can characterize the natural range of variability on an undammed river; 2. Modify current operating regimes of the dams to mimic the natural flow of the river with respect to daily and seasonal variability; 3. Build fish ladders allowing fish to pass through the existing dams that are having an impact on migratory species; 4. For future projects, allow only low impact hydro on our rivers. Low impact hydro helps to protect indigenous species and habitat, mimic natural water flows, maintain good water quality, and ensure fish migration patterns.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Threats to Ecological Health of the River - Municipal Wastewater - Riverkeeper's Recommendations	Given the huge variation around municipal wastewater treatment throughout the watershed, and the lack of data about total loadings into the Ottawa River, there are a number of actions we can take to improve our current situation: 1. Practice water conservation - decreasing water consumption would substantially decrease costs of wastewater treatment and address concerns of capacity; 2. Improve pollution prevention (Industrial Waste Programs, Household Hazardous Waste Programs, and Public Information Programs) reduce chemicals of concern from the sources; 3. Carefully consider the spreading of biosolids and septage and never apply either to frozen ground to prevent pollutants from being discharged directly into the river during snowmelt; 4. Prioritize treatment facilities for upgrades based on total loadings of pollutants into the river; 5. Develop consistent sewer use bylaws to be applied to all municipalities; 6. Ensure transparent reporting on monitoring and compliance.
			Threats to Ecological Health of the River - Industrial Wastewater - Riverkeeper's	1. Provide incentives for mills to operate closed-cycle technology that minimizes water pollution and forces industry to exploit new, cleaner methods of sludge disposal; 2. Implement totally chlorine free bleaching processes; 3. Publish monitoring and compliance data from all pulp mills. The regulatory agencies should make the data publicly available; 4. Increase pressure on governments to enforce the existing regulations.
			Threats to Ecological Health of the River - Non-Point Source Pollution - Riverkeeper's Recommendations	Polluted runoff is largely the result of the way we develop, use and maintain our land. The sources are many, and how we respond to clean up of non-point source pollution will take the concerted efforts of everyone. 1. Encourage municipalities to review and improve their stormwater management plan; 2. Undertake a comprehensive evaluation of septic systems throughout the watershed to determine their cumulative impact on the river systems and solutions for improving the situation; 3. Reduce agricultural runoff by improving riparian buffers, on-site manure management and reducing use of pesticides and fertilizers; 4. Refrain from non-essential use of lawn and garden chemicals including pesticides, herbicides, insecticides and fertilizers.
			Threats to Ecological Health of the River - Urban and Shoreline Development - Riverkeeper's	1. No development in the floodplain should be permitted unless there is scientific evidence that there will be no significant impact on fish habitat or river hydrology; 2. Watershed management plans should be completed and publicly approved for each major tributary of the Ottawa River - plans should include ecologically sensitive areas to protect from development; 3. New urban development should minimize impact on the hydrologic regime by implementing 'smart growth' designs. 4. Both the provinces and the municipalities should enforce shoreline development regulations.
			Boaters - Take Action! What Can you do?	Whenever possible, give your business to a Green Marina, choose an Eco-Rated Marina or Yacht Club to house your boat; Remember what you clean your boat with ends up in the river so be sure to use non-toxic and phosphate-free cleaners; always consider a four-stroke engine, older 2-stroke engines can dump up to 30% of their unburned fuel into the water; never dump untreated sewage into the river, remember throwing trash overboard is illegal; be respectful of where you travel - stay out of ecologically sensitive areas, proceed slowly in shallow areas and watch your wake; prevent the introduction of non-native species by thoroughly cleaning your boat before traveling to a new water body.
			Fishermen - Take Action! What Can you do?	Fish for the thrill of the catch and safely release your fish to allow them to be caught again; don't use lead sinkers or jigs, many alternatives are available; be careful of what you eat, always check the "Guide to Eating Sport Fish" in your region.
			Homeowners - Take Action! What Can you do?	Remember your pipes are linked to the river so use environment-friendly household cleaners and dispose of hazardous materials properly; refrain from non-essential use of lawn and garden chemicals including pesticides, herbicides, insecticides and fertilizers; conserve water - treating drinking water and sewage is costly.
			Shoreline Residents - Take Action! What Can you do?	Keep your shoreline natural to minimize erosion and runoff and protect your shoreline habitat for aquatic life; remember to use safe septic practices, a malfunctioning septic system allows phosphorus and bacteria to leach into the river; the river needs trees on its banks, consider planting native species.
			Everyone - YOU can make a difference - Take Action! What Can you do?	Get involved and participate actively in local decisions that may impact the river where you live; participate in the Ottawa Riverwatch Program, check our website at <a href="http://www.ottawariverkeeper.ca/programs/river_watch">www.ottawariverkeeper.ca/programs/river_watch</a> ; support a group that is actively involved, you will find a list of the active Ottawa River Watershed stewardship groups on our website at <a href="http://www.ottawariverkeeper.ca/resources">www.ottawariverkeeper.ca/resources</a> ; volunteer your time and skills, for current Ottawa Riverkeeper volunteer opportunities, check our website at <a href="http://www.ottawariverkeeper.ca/get_involved/volunteer">www.ottawariverkeeper.ca/get_involved/volunteer</a> ; show your support for a healthy river by participating in shoreline clean-ups or other community events that focus on the river; call our toll-free Pollution Hotline 1-888-9KEEPER to report pollution or development in your local area that may be impacting the river system; become a member of Ottawa Riverkeeper, join us and protect the Ottawa River, our voice gets stronger with each new member.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Ottawa Riverkeeper's RiverWatch Program - Take Action! What Can you do?	<p>Given the enormity of the Ottawa River watershed, the diversity of its communities and limited resources of Ottawa Riverkeeper, it is impossible for the Riverkeeper to be aware of everything that is happening on and around the river. Ottawa RiverWatch is a program designed to build a network of citizens and stewardship groups interested in the Ottawa River who work cooperatively with Ottawa Riverkeeper to maintain and enhance its overall ecological integrity and health. This program demonstrates the importance of working together to promote environmental sustainability throughout the watershed.</p> <p>A RiverWatcher spends a significant amount of time on or near the Ottawa River or one of its tributaries and can make observations. A RiverWatcher listens to local residents who have concerns about the river, listens to local news to inform themselves about potential impacts on the river, and a RiverWatcher may organize a local meeting, shoreline cleanup in their community, or a paddle on the river with others to appreciate the river's beauty. A RiverWatcher tells others about their observations and concerns about the river, helps others understand the importance of having a clean and healthy river and how we can work together to protect the river. A RiverWatcher reports to Ottawa Riverkeeper with observations, news, or photos from their area.</p> <p>We currently have eight RiverWatch programs from Petrie Island to Petawawa, including the Ottawa Riverkeeper Air Force - a group of pilots who frequently fly over the river and are concerned with some of the changes they are seeing on the river. A bird's eye view of the river is extremely valuable and our pilots are an excellent example of individuals who are dedicated to the river and willing to give back.</p> <p>Each RiverWatcher has a page on our website that gives details about the history and ecological significance of their area as well as local issues or concerns. We are striving to implement a water quality monitoring component to the RiverWatch program in the future.</p>
			Look Out for Your Local Stream - Take Action! What Can you do?	<p>The Jock River runs through suburban Ottawa and empties into the Rideau River. To the folks who live nearby, it is a piece of paradise. Every spring, enthusiastic canoeists compete in the Jock River Canoe Race. Occasionally, sewage spills into the river but it rarely goes unnoticed. The Friends of the Jock River are a stewardship group dedicated to preserving the health of their local river. This requires vigilance but it pays off.</p> <p>For example, a golf course situated on the river recently applied for a permit to take water from the Jock River. They already had a permit to take some water, but they wanted more. When the Friends of the Jock River studied the application, they realized the Jock could not take such a large water withdrawal. Already the summer flows were getting dangerously low. The stewardship group communicated their concerns to the appropriate authorities as well as Ottawa Riverkeeper. Letters were written to the Environment Minister, urging her to refuse the application based on the science. Eventually the application to take water was denied. This is one small success story that demonstrates how groups like the Friends of the Jock River and Ottawa Riverkeeper are influencing decisions that impact our rivers.</p>
			Conservation and Education in McLaurin and Clement Bays - Take Action! What Can you do?	<p>When the Carillon dam was built in the late sixties, extensive shoreline areas were flooded. In the ensuing years wetlands developed with abundant organic matter. In the last 20 years, Faune Quebec and Ducks Unlimited purchased a 50 km stretch of wetlands, starting in the City of Gatineau (old Templeton) to Plaisance National Park (Thurso). Work was done to improve water circulation, which created better water habitat for waterfowl and fauna. Many species of amphibians and turtles inhabit these, some endangered species among them.</p> <p>These wetlands vary from marshes, tall grass wetlands and forested wetlands. Silver maples and nettle trees cover a good part of the western section of the wetlands. This is the northern most area where nettle trees can be found in North America. Beef cattle used to roam some wetlands and farmers cultivated hay close by. With the agreement signed with Faune Quebec, cattle can graze in certain fields after the nesting period and grasses in the wetlands keep the geese out of the farmers hay fields.</p> <p>Ducks Unlimited maintains the Marais Trepanier as a demonstration site for marshes in an agricultural setting while the Conseil Regional de l'Environnement et du Developpement Durable de l'Outaouais is constructing a 1.3 km pedestrian path which consists of floating docks, boulders and wooded sidewalks at the western edge of McLaurin Bay. The first path was completed in October 2005. There is a bicycle access and parking on Hurtubise street along the river and a car park in Martin Park on Notre-Dame street.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>This is a first of a series of pathways planned along the different marshes to permit observation of wildlife and avian species, some of which are on the endangered list. The Outaouais is one of the only regions of Quebec where certain species can be found in great numbers.</p> <p>One marsh named Les grenouillettes, is literally teeming with frogs in the spring while others accommodate many mating duck couples. The project over the years will give access to people so they can observe the abundance of fauna and flora. Observation towers, other walking paths and floating docks are planned, but it all depends on financing. Another activity in the planning is the revival of the Festival des bernaches (Canada Goose Festival) and the linking with Plaisance National Park and the different bike paths planned along Highway 148.</p> <p>Conservation is of course the first and foremost reason for the creation of this project; therefore, there are areas where access will be forbidden. Education is second. Interpretation panels will be erected and eventually guides or self-guided tours will be available. Wetlands are an integral part of watershed management; they serve as sponges to control overflow, filter contaminants and of course they are natural habitat for countless species.</p>
			Heritage River Designation for the Ottawa River - Take Action! What Can you do?	<p>Canada honours and respects its leading rivers by distinguishing them as Canadian Heritage Rivers. Having outstanding natural and / or cultural values, and offering quality recreational opportunities, these rivers showcase the benefits and enjoyment of healthy river environments, now and in the future. Rivers in the Canadian Heritage Rivers System must have their heritage values and integrity protected. In the Ottawa River system there are currently two tributaries with heritage status: the Mattawa River and the Rideau River.</p> <p>Currently a group comprised of representatives from the Ontario and Quebec sides of the river, including First Nations is actively pursuing Heritage Designation for the Ottawa River.</p> <p>The group has completed a background study of the river and now a Nomination Document must be prepared for presentation to the Canadian Heritage Rivers Board, who will hopefully recommend approval. The Board meets once a year and if the river is nominated for Heritage Status, the Ontario government has three years to come up with a management plan for the river. Quebec has yet to officially sign onto the project, as they are worried it interferes with their protected areas program.</p> <p>Ottawa Riverkeeper supports the designation of the Ottawa River as a Heritage River. However, we feel that we cannot rely on such a title to provide adequate protection or conservation for the river. The designation is a stepping-stone that will communicate the richness and significance of the Ottawa River and bring people together to think about a management strategy for the river.</p>
Preliminary Evaluation of Relative Aquifer Vulnerability: City of Ottawa	2001	M-R SPR & City of Ottawa (out of study area)	Contaminant Sources Inventory	In this report potential contaminant sources have been inferred for each type of land use while a specific vulnerability to septic contamination has been determined for larger villages. Although this approach is useful in a general sense, a contaminated sites inventory, and potential contaminant source inventory should be carried out to: identify possible contaminants in the study area; develop a list of contaminants of primary concern (COPC) with the City of Ottawa with respect to groundwater; evaluate the specific vulnerability for each COPC using a similar method to septic loading whereby numerical ranking of vulnerable areas can be developed; rank all areas within the City of Ottawa (e.g. Villages) reflecting the combined specific vulnerability to all COPC.
			Land Cover Analysis	A land cover analysis would allow for the determination of specific land uses in agricultural and rural areas. The determination of crop type, forest or pasture from land cover analysis can be used to supplement the contaminant source inventory within different zones of an agricultural area.
			Baseline Water Quality Survey	A baseline water quality survey can be used to identify what contaminants currently exist in groundwater in the City of Ottawa. This assessment can be correlated with current land uses and industries and is the first step in identifying the contaminants of primary concern (COC). Efforts should be linked to the Baseline Water Quality Program of OMAFRA.
			Well and Septic System Audits	Poorly constructed and maintained wells and septic systems represent the most preventable threats to aquifer water quality. In addition, abandoned wells provide a direct conduit for contaminants released at surface to reach the aquifer. Education, audits, repair, and proper abandonment of these systems will reduce the potential for direct contamination of an aquifer by septic systems or surface runoff.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Sensitivity Analysis	To obtain a full understanding of the effect of the individual parameter weights on the intrinsic vulnerability, a full sensitivity analysis is recommended. Through such an analysis, each weighting factor would be modified in a systematic manner to determine its effect. This work would allow the effect of each DRASTIC weight to be fully quantified and provide a greater understanding of the variation in intrinsic vulnerability.
			Field Analysis	Field analyses to confirm or better characterize the parameters used in DRASTIC should be undertaken, particularly at Greely, Vernon, and Osgood. These field analyses will expand the current analysis and facilitate site specific analysis of potential sources of contamination. Such field analysis may include: Drilling of new boreholes for the collection of soil samples and the installation of monitoring wells to verify hydraulic gradients and soil characteristics; Pumping tests to verify hydraulic conductivity within the aquifer; Chemical / isotopic analysis of groundwater samples for recharge and discharge zone verification; GPS location of wells without firm UTM coordinates; and Geophysical surveys can be used to map aquifer extents locally and identify areas of direct connection to contact zone aquifer.
			Well Capture Zone and Groundwater Flow Modeling	Three-dimensional groundwater modeling of the area can be useful to: evaluate the flow path(s) of potential contaminants from sources within high vulnerability areas; evaluate the potential impact of land uses on vulnerable areas within existing capture zones; assess the potential benefit of agricultural best management practices on the water quality within the aquifers; evaluate the cumulative effects within the aquifer system due to potential contamination from bio-solids application on vulnerable areas; evaluate the cumulative mass loading impacts within the aquifer system due to dense septic system discharges from villages and rural development on vulnerable areas; and simulate contaminant transport processes within the vadose zone to assess the attenuation capabilities of the unsaturated zone and the expected concentrations that will reach the water table.
Preliminary Report on Hydrogeology, Ottawa-Hull Area,	1961	M-R SPR & out of study area	Conclusions	The sand layers within the glacial deposits store and transmit a much greater quantity than all the rock formations. Greater attention should be paid to locating and developing these sand lenses for high-capacity wells. Mineralized and saline waters are found in deep wells in some sections. Insufficient data is available to outline the ground-water drainage basins or to estimate recharge, but there is no evidence of a significant change in ground-water levels in the past 10 years.
Private Individual Services in the Rural Area	1992	M-R SPR & out of study area	Water Quality - Recommendations	When a groundwater source meets the health related parameters but the aesthetic parameters fall short of meeting the Ontario Drinking Water Objectives (ODWO), it is recommended that it be accepted only if one parameter lies in the treatability range. Experience has shown that when more than one parameter exceeds the limit, treatment interference may occur with commercial units. Even if no treatability limits have been set for hardness and sodium, it is recommended that their presence be accounted for in the treatment assessment. A technical review of treatment systems must be performed for each individual case where more than one parameter falls in the treatability range. The rationale pertains to their ability to perform on a long term basis with low cost and simple maintenance. This performance review should be completed by qualified process engineers and will require written assurance of reliability with a bench test treatment. In areas with a high potential to be affected by industrial or farming activities, it is recommended that the drinking water guideline list be expanded to include the following: pesticides (from ODWO list), volatile organics (from United States Environmental Protection Agency (USEPA) list) and other inorganics (from USEPA list). Septic tank cleansers such as trichloroethylene (TCE) contribute organic solvents to groundwater supplies. Like in some northeastern United States, TCE based solvents used as cleansers for septic systems should be prohibited in the study area.
			Water Quality Distribution - Recommendations	Areas with groundwater quality deficiencies as outlined by Part VIII Directors are shown in Figure 6. The water quality distribution outlines localized poor groundwater quality which varies over a short distance. The outlined areas are based on incomplete information. An extensive water quality survey of existing wells should be undertaken in order to obtain a more complete view of this issue.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Well Construction - Recommendations	<p>The sustainability of development based on private services depends upon the control of well construction techniques. It is recommended that more inspections of well construction be conducted with emphasis on grouting (i.e. ensuring complete circulation of the grout mixture in the annular space, bottom upwards) and proper casing installation. A minimum of 6 m of grouted casing should be used. No need for additional requirements is deemed necessary since lot size will control cumulative impact.</p> <p>A moratorium on the use of groundwater heat pumps should be put in effect until controlled and regulated. Furthermore it should be ensured that groundwater heat pump use will not adversely affect potable water quality. This could possibly be achieved by a control on water quality of all water bearing zones and the bypassing of drinking water supply zones. Furthermore it should be assured that the systems utilized for heat pump use can not introduce foreign compounds into the groundwater.</p> <p>Lot layout in all development should ensure that the location of wells is: a) upgradient from the lot's septic system; b) outside the 10 mg/L nitrate plume; c) not directly downgradient from an adjacent property's septic system.</p> <p>The completion of a well with an adequate supply of potable water should be included as a condition of all consent approvals which create new building lots. The one year period to prove this capability before the consent lapses is more than adequate. An unsuspecting purchaser should not be burdened with the responsibility of finding potable water after the deed for a new lot has been stamped.</p>
			Aquifer Recharge - Recommendations	<p>In areas of development pressure, water budget studies are essential. Growth areas on private water supplies will only have a very limited effect on the regional supply in areas where relatively thick overburden is present. This however may not be the case for the areas situated in shallow overburden. Future work should include the evaluation of: flow mechanisms; long term yield studies; the nature and connection between the main hydrogeological units; the degree of urbanization and its effect on recharge; the aquifer boundaries; the aquifer block flow time; hydrogeochemical patterns within each groundwater system; expected isotope signals for flow system and groundwater age evaluation; additional numerical modeling of densely developed areas.</p> <p>In addition, the Ontario Government should consider the establishment of well head protection legislation as has been done in Europe and in the United States of America.</p> <p>Water quantity for private individual supply can be met in most cases by the regional aquifers in the study area. Only a few areas are known where aquifers do not meet this demand. In many cases, additional storage can often provide the maximum peak demand. The performance of marginal aquifers needs to be more carefully evaluated from a cumulative impact point of view.</p> <p>Due to the susceptibility of the aquifer to contamination in recharge areas, development on private services should be discouraged in these areas. Furthermore we recommend that a "watch dog" monitoring system be developed for the above identified pollution sources to safeguard the groundwater resources. Municipalities should take leadership in monitoring these activities and their impacts on the groundwater. The application of Reasonable Use Criteria should be enforced on new developments. Developments belonging to this group should be allowed to proceed only on the presentation of a satisfactory impact review and a satisfactory contingency plan.</p>
			Private Sewage Disposal - Recommendations	<p>Table 5 summarizes the recommendations as a flow chart process. It is recommended that, in this study area, 1.2 m of mineral unsaturated soil be present in the leaching bed areas. When low hydraulic conductivity soil is present, lot size should be determined by mounding calculations. This will typically result in lots of 1.5 to 2.1 ha in size. Caution should be given to fractures and fissures in the clays, particularly in thin deposits. The bulk hydraulic conductivity may behave more like a granular material in which case plume delineation should be determined.</p> <p>When the overlying material has at least <math>10^{-3}</math> cm/sec. hydraulic conductivity and is a potential aquifer, the flowthrough method should be completed. Typical lot size will be 1.7 ha where underlying material is 10 m of saturated sand and 2.5 mg/L is the nitrate criterion.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>When the overlying coarse grained soil has no potential for aquifer use and the bedrock is the main aquifer, the underlying stratigraphic unit should be verified. If the sand or permeable material is underlain by at least 1.2 m of native clay soils with no fracturing and low hydraulic conductivity, mounding assessment should be completed. A typical lot size will be 1.5 ha. If the sand or permeable material is underlain by less than 1.2 m of clay type soils and is mainly underlain by bedrock, a flowthrough assessment in the bedrock aquifer should be completed. Typical lot size will be greater than 2.2 ha. Selected hydraulic conductivity values should be based on field measurements. The use of the Guelph Permeameter is strongly recommended to standardize the in-situ values.</p> <p>It is recognized that the level of confidence of flowthrough assessment in bedrock aquifers is low. The high velocities and the reduced attenuation in fracture flows only suggest very large lots. In-situ conditions should be evaluated and lot size determined by the 2.5 mg/L nitrate plume outline.</p> <p>From the surficial geology map and the overburden thickness map, the aquifer management system generated a terrain suitability for septic systems map (Appendix H). The protection of the aquifer as a potable groundwater resource is the main focus underlying the terrain suitability map (Figure 17). The best areas basically consist of thick, low hydraulic conductivity soils which offer a natural safeguard to the protection of any underlying aquifers. In places, the thick clay will be overlain by higher hydraulic conductivity soils which do not have an aquifer potential. In these terrain conditions, where the underlying aquifer is good, the lot size will be approximately 1.0 ha based on mounding conditions.</p> <p>Furthermore, where seasonal high water tables are below ground surface, mounding calculations suggest smaller lot sizes.</p>
			Private Sewage Disposal - Common Sense Hydrogeology - Recommendations	<p>The above lot size determinations are based on our best knowledge of how natural systems may respond to effluent loading from leaching beds. All input parameters were evaluated to represent our best assessment of reality. Modeled nitrate loading outputs represent worst case scenarios since it is assumed that no denitrification will occur in the soil. Even if denitrification can be documented in the short term, buffering capability may be used up over time. Proposed lot sizes are scientifically defensible.</p> <p>However any proposed development on private individual services on specific terrain conditions may differ from these recommendations. It is recommended that development on marginal terrain be phased in order to observe actual results before allowing subsequent phases of the developments (say 20 lots or 50% of the subdivision). The location of services should be based on field evidence of shallow groundwater flow characteristics. It is understood that, in certain circumstances, the 2 year monitoring period could be replaced adequately by the monitoring of existing nearby septic systems.</p> <p>The nitrate plume should be simulated base on site specific conditions, and should be monitored for 2 years following the continuous use of the sewage system. The extent of the 2 year plume of 2.5 mg/L NO<sub>3</sub>-N should be compared with the site specific simulated outline in order to assess for any denitrification processes. If the aquifer systems perform better than predicted at that location (e.g., because of elevated organic contents (fraction organic carbon (f.o.c.)), the density of the development could be altered from the present recommendations. Caution should be exercised in assuming that the denitrification process will continue indefinitely.</p> <p>The Ministry of the Environment (MOE) South Eastern Region has adopted guidelines that require an impact assessment for lot sizes less than 1 ha on areas that have not been designated by the Part VIII Director. These guidelines require that the impact assessment demonstrates that 10 mg/L Nitrate is met at the property boundary. In the impact assessment denitrification and other nitrate reducing processes are taken into account. The Ministry position assumes that nitrate reducing processes will likely reduce nitrate to less than 2.5 mg/L.</p>
			Private Sewage Disposal - Alternative Technologies - Recommendations	<p>Alternative technologies are being developed to treat septic system effluent. These systems provide a level of treatment of septic system effluent and require less area to reduce loading of the systems to background levels. As these alternative technologies become accepted by the Ontario regulatory agencies, lot sizes could be reduced, as less area is required for dilution.</p> <p>A non-exhaustive list of alternative treatment systems include the following: a) Aquarobics - A mini nitrification-denitrification plant, where the end result is treated effluent to near background levels. Presently, the plants are expensive (in excess of \$10,000) and require substantial maintenance, and as such they are not ready for widespread applications; b) Class 6 system - Several units are available that reduce the biochemical oxygen demand (BOD) of the effluent. Nitrate treatment is not provided however and the question of dilution still remains;</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>A non-exhaustive list of alternative treatment systems include the following: c) Peat Beds - A specific grade of peat is used to provide treatment of effluent. The system is successful in reducing nitrate to within Reasonable Use levels. Costs are similar to conventional systems and the source materials are abundant in Southeastern Ontario. The State of Maine has accepted this system for sewage disposal and treatment. Some pilot projects are underway in Ontario. Peat beds appear to offer the greatest potential for treatment. This may imply that, once accepted, lot size requirements on permeable soil may be reduced significantly from the sizes proposed in this document.</p> <p>Until new technologies are approved in Ontario, conventional septic systems developed on permeable soils will generate plumes, and large lots will be required. Interim options to large, individually serviced lots may include the following: a) Moratorium on privately serviced development; b) Communal systems - A cluster of residents could be hooked up to a central treatment plant (MOE would currently require that the municipality maintain or be ultimately responsible for it); c) Holding tanks - The municipality contracts with a hauler and the pumped sewage is hauled to a sewage treatment plant or lagoon maintained by the municipality (this assumes that reserve capacity is available at nearby sewage treatment plants and that the municipality is willing to accept it); d) Greater emphasis is placed on fully serviced planned development.</p>
			Cumulative Impact and Distribution of Rural Development - Recommendations	<p>Ideally the minimum requirements to assess cumulative impact should address the following: I) For Water Supply: a) Aquifer boundary conditions; b) Aquifer long term sources, i.e. Leakage from upper aquifers, Surface waters, Infiltration; c) Changes in water quality due to pumping by exhaustive survey of existing nearby wells; d) Effects on existing users; e) Calculations and methodology to address hydraulic impacts.</p> <p>Ideally the minimum requirements to assess cumulative impact should address the following: II) For Septic Systems: a) Nitrate loading on the shallow groundwater and aquifer and surface water on and off site; b) Other contaminant loading to the shallow groundwater and surface water (if applicable); c) Determine flow paths of contaminants prior to development and after development; d) Mounding calculations; e) Determine the appropriate lot size based on the detailed study.</p> <p>In order to be able to assess changes due to development, sampling stations should be set up in undeveloped areas and developed areas. Cost of these monitoring stations should be borne by the developer. Upon acceptance of the subdivision, ownership of these wells should be transferred to the municipality. These locations should be monitored for changes in base level of the aquifer and in the quality of the water supply.</p> <p>Presently, the Regional Municipality of Ottawa-Carleton (RMOC) has a guideline of 40 lots at a time per subdivision applications. It may be desirable to review the impact of development on a 20 lot phasing, and of one development on other developments. This phasing should take into account the site's hydrogeologic conditions on the lot layout. Contiguous developments should not take place until the performance of the wells and septic systems from the existing nearby development has been assessed.</p> <p>In order to ensure the integration of cumulative impact considerations in the creation of future lots with sustainable individual private services in the rural area, the Reasonable Use Criteria should apply for the creation of new lots sized with the flowthrough method (i.e. 2.5 mg/L nitrate), where the overburden is used as an aquifer. It also means that no significant hydraulic head generated by the septic system mounding would permit a flow of effluent onto neighbouring land. Development density limitation is the only control that will allow the cumulative impact to be acceptable.</p> <p>New development adjacent to an existing subdivision should only be permitted if it meets the following criteria: a) The existing phased subdivision should be sufficiently developed to demonstrate its ability to function on a sustainable basis; b) Groundwater quantity and quality at the earlier phase of the subdivision are performing as expected; c) Monitored mounding and nitrate loading are better than simulated.</p> <p>Also, documentation of the aquifer behaviour should be initiated for long term monitoring. This could typically include the installation of wells in the several available aquifers in strategic locations. These wells should be provided by developers and ownership transferred to the municipality which will manage a network of monitoring points. Furthermore, these stations could be monitored to document water quality changes with aquifer use. Further study should be undertaken to address the following issues: Detailed documentation of aquifer flow; Determination of effects on flow patterns with increased urbanization; Determination of water quality changes brought about by development; Determination of long term groundwater level changes as a result of development; Determination of guidelines for groundwater heat pumps; Determination of aquifer replenishments cycles; Creation of long term aquifer gauging stations.</p>



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Rural Development Policies - Recommendations	<p>The RMOC should take a leadership role in the study area and further refine, manage and supplement the information contained in the Aquifer Management System. Although the Ontario Water Resources Act states that the Minister of the Environment is responsible for the supervision of all groundwater in Ontario, the Planning Act assigns responsibility to local governments to ensure the health and safety of the future inhabitants. Increasingly, the results of inaction are likely to be costs borne by local taxpayers. The RMOC is in the process of setting up its own Geographically Referenced Information System (GRIS). A logical next step is to incorporate the aquifer management system in the GRIS and to continue to upgrade the aquifer management system within the GRIS tool. The RMOC should make the information generated available to the Health Units and abutting municipalities. At an appropriate time in the future, the Health Units may wish to establish their own systems.</p> <p>The RMOC should consider employing its own qualified hydrogeologist. The management of the study area's groundwater resources requires the attention of qualified individuals who can conduct relevant research, collate data, produce useful results, monitor well construction, sewage disposal system installations and septage application / disposal sites, coordinated public education programs or develop new programs such as sewage disposal system remediation or mandatory inspection of systems when a home is resold and generally deal with the multitude of matters which ultimately impact upon the sustainable use of groundwater resources. Some of the costs could be recouped through application fees or inspection fees.</p> <p>The Ministry of the Environment (MOE) should increase its efforts to conduct research on alternative sewage treatment technologies and assist the municipalities in the development of effective policy approaches.</p> <p>While isolated groundwater problems exist, there is not such a sense of urgency that drastic measures such as Interim Control By-laws are required. However, planning policies need to more comprehensively deal with groundwater protection that they have in the past.</p> <p>The creation of small lots in Hamlets on private services should be immediately curtailed pending a full investigation of servicing implications.</p> <p>The potential use of communal water systems in the rural area should be considered by the study area municipalities in location where site specific high yield capability is available since they offer the ability to be more closely controlled during construction, allow for ongoing monitoring by a public agency and provide an opportunity for communal treatment where required.</p> <p>A terms of reference for adequate and reasonable hydrogeologic investigations should be developed for the study area, in consultation with representatives of the hydrogeology firms working in the area. This is the approach used by the Regional Municipality of Waterloo in developing its terms of reference.</p> <p>There is a great need for Provincial sensitivity to the problems of local land use planning, requiring more assistance and less obstructionism, and recognizing the legitimate growth pressures which exist. Cooperative leadership is required and consistency in the way that Ministry policies are applied throughout the study area (inside RMOC and outside). It is a paradox that Provincial assistance is more readily available for groundwater clean up than it is for prevention. It is strongly recommended that the Provincial Government give serious consideration to assistance programs for serviced development, rather than limiting itself to partial assistance for the expansion of overloaded servicing systems.</p> <p>A strict licensing procedure should be developed to ensure that all new wells are tested and all investigation results are submitted to the Regional Hydrogeologist. This will help ensure a complete database.</p> <p>A licensing procedure should be developed to ensure that handlers / users of potential contaminants exercise an appropriate level of caution.</p> <p>Approval policies for privately serviced development should focus on environmental compatibility, based on continuing research. Mitigation and buffering techniques should be explored. The purchase of down gradient development rights could be considered or designs could ensure that only parks and open spaces uses occur in potential impact areas. Phases smaller than 40 lots should be considered (about 20 lots) with detailed monitoring policies enforced as a prerequisite to additional development.</p> <p>A comprehensive well water survey should be undertaken in the study area to determine the overall status of drinking water quality.</p> <p>A monitoring program should be established to determine whether private sewage disposal systems in approved subdivisions are performing in the manner predicted by the hydrogeology studies.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Well head protection measures should be undertaken to ensure that existing communal water supply systems can continue to function safely and economically.
				Subdivision application forms and applicant guidelines should be revised to stress the importance of adequate hydrogeological information at the earliest stages of the rural development process.
				Multiple consents should be severely limited. The consent process was simply not designed to deal with the complexities of multiple lot developments. The subdivision process requires corresponding improvement so that the multiple consent process is not such an attractive alternative.
				The creation of single lots by consent should involve the collection of basic information on soil type, groundwater flow direction and proximity to wells and sewage disposal systems on neighbouring lots in areas where development exists or is anticipated. In isolated circumstances, such as a farm retirement lot, or for very large lots, this information may be less critical. There is no technical justification for the creations of inferior lots through the consent process.
Proposed Mississippi-Rideau Source Protection Region - Conceptual Understanding of the Water Budget - Draft Accepted	2007	M-R SPR	Conclusions and Recommendations	<p>Most of the climate and surface water data has been collected and evaluated for the Mississippi-Rideau (M-R) Region. Long-term (average), annual estimates for various components of the water budget (precipitation, depth of runoff, and evapotranspiration (ET)) have been estimated over a 30-year period from 1971-2000 for the Mississippi and Rideau River regions and for the combined Mississippi-Rideau Region. ET was derived from average precipitation and runoff data (Precipitation - Runoff). ET was also calculated using Thornthwaite and Mather (1955, 1957). Calculated ET values compared well to derived ET values.</p> <p>Long-term, annual, regional values were also used to estimate baseflow and groundwater recharge. Regional groundwater recharge estimates from the Ministry of the Environment (MOE) 1995 methodology (customized to the M-R Region) compared fairly well to estimates from the United States Geological Survey (USGS) 2005 BFLOW method. Preliminary drinking water low flow stress evaluations and water demand calculations have also been completed.</p> <p>Based on a limited review of the data, no drinking water stresses have been found on an average, annual, regional scale. Average, annual, regional demand for water represents less than one percent of the water supply in the M-R Region. Demand estimates included takings from public systems, private well consumption, agriculture and OMYA. Supply was estimated as the amount of water available from precipitation after ET. Supply and demand will vary temporally and spatially across the Region. Monthly estimates of water demand at the subwatershed level in Tier 1 may reveal considerable vulnerability to seasonal fluctuations and spatial effects (drought conditions will not be assessed until Tier 2). It should be noted that the supply amount did not account for a reserve amount for other water uses (ecological, recreational, flow control, etc.). A reserve amount will be calculated in Tier 1.</p> <p>Conclusions from this study apply only on an average, annual, regional scale. Long-term, annual, regional values do not apply to individual years or to individual subwatersheds. Estimates will vary temporally and spatially across the region and will be refined more in Tier 1.</p> <p>Potential groundwater recharge estimates have been completed for the M-R Region using the 1995 MOE approach modified to the M-R Region (Appendix F). The results appear reasonable although the approach still presents some limitations. The approach may be more suitable for determining infiltration to shallow unconfined aquifers rather than deeper confined aquifers. Further work is required to confirm infiltration values in shallow bedrock and in urban areas.</p> <p>Long-term, annual, regional baseflow estimates have been prepared using the USGS BFLOW method (Neff et al., 2005). Baseflow will vary by month and by season, and so, changes in seasonal / monthly indices have to be considered for monthly water budgeting in Tier 1. Tier 1 work can be completed with available data however beyond Tier 1, if warranted, a field program could be established to measure baseflow and help identify recharge / discharge areas.</p> <p>Potential recharge and discharge areas were identified conceptually using multiple methods, however further work is necessary to better determine where these features are considered to be significant. In addition, further work is necessary to determine the long term groundwater levels in both monitoring wells and municipal wells. The overall interaction between surface water and groundwater lacks understanding and therefore also requires further study.</p>
			Screening Decisions for Tier 1 Modeling	The Provincial Guidance document provides a series of screening questions in order to determine how to proceed to Tier 1. Interim direction was recently provided with advanced screening criteria.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Based on the guidance and criteria mentioned above, drinking water intakes on the Ottawa River (Britannia and Lemieux) will be excluded from Tier 1 as there are no water quantity issues.</p> <p>The remaining intakes: Carleton Place, Smiths Falls, and Perth are located on inland rivers including the Mississippi River, Rideau River, and Tay River respectively. Water budgeting will be necessary for these watersheds.</p> <p>In addition, water budgeting will be required for the remaining subwatersheds (including Ottawa River subwatersheds) as they contain a significant number of private wells.</p> <p>For Tier 1 modeling, a simple "steady-state" spreadsheet approach to water budgeting will be used. Geographical Information Systems (GIS) will be used where necessary. Water budget components will be estimated on a monthly basis for each subwatershed in the Region. The key outcome of the Tier 1 will be water budget estimates used to undertake the Water Quality Risk Assessment, which will evaluate existing water supply (and reserve amounts) and existing and future water demands. Water quantity issues will be identified in Tier 1 before determining if it is necessary to proceed to Tier 2.</p> <p>A map of the Tier 1 water budgeting locations and municipal water supplies is given in Figure A.36. Water budgeting will be done on the drainage areas to the streamflow gauges. Water budgeting may be done for the drainage areas to the inland river water plants. Ground-watersheds may be treated separately from surface-watersheds. Water budgeting for municipal wells may be based on an estimated groundwater aquifer contributing area. This will be considered further in Tier 1.</p>
			Considerations for Tier 2 Modeling	<p>Subwatersheds experiencing a moderate or significant stress identified in Tier 1, and containing a municipal water system, will move forward to Tier 2, which will involve complex modeling at the watershed / subwatershed scale. Subwatersheds that do not contain a municipal system will not move forward to Tier 2.</p> <p>Reservoirs in the upstream parts of the Region are needed for maintaining downstream flows in the Rideau Canal (controlled by Parks Canada) and for hydroelectric power generation on the Mississippi (controlled by various agencies). The implications of flow control on drinking water issues in the Region are unknown at this time. One area of concern may be the Tay River, which is controlled by the federal government solely for navigation purposes. Flows may be reduced substantially without storage upstream at Bob's Lake.</p> <p>At this time, it is not anticipated that a regional complex groundwater flow model will be required.</p>
Regional Geoscience Information: Ottawa-Hull	1980	M-R SPR & out of study area	Conclusions	<p>This report and maps represents a modest contribution to what is hoped will be a growing trend to provide more geoscience data for planning uses in urban areas. This study should encourage planning authorities to become collectors and custodians of geoscience data as a matter of economic and social benefit. The availability of such information should result in it being incorporated into the urban planning process and being documented in case studies. With data freely available, the next step is to demonstrate their usefulness in practice which can be done only by those charged with the responsibility of planning the future of the region.</p> <p>The kinds of geoscience information presented here are, in the opinion of the authors, essential ingredients in the drafting of a good plan for regional development. Planning that does not take into account the physical environment risks the senseless destruction of the environment and, in the extreme, risks the loss of human life and property.</p> <p>Finally, it is hoped that this study contributes to an awareness by the general public of the composition and characteristics of the physical environment. With increasing emphasis on involving the public in the planning process, it is important that the public be well informed.</p>
Renfrew County - Mississippi - Rideau Groundwater Study	2003	M-R SPR & Renfrew County (out of study area)	Major Recommendations for Further Study	<p>Groundwater management strategies (GMS) outlined in this report should be considered for implementation for all municipalities and Conservation Authorities that participated in this study.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Geographical Information System (GIS) environment that has been established for this project be used to update the data as new information becomes available. To meet this end, a long-term maintenance plan would be required to maintain the GIS system and many of the study findings in a current state in order to facilitate future updates of the groundwater management strategy. The long-term maintenance plan could involve updates to the GIS at the municipal, Conservation Authority or provincial ministry level. Partnership opportunities also exist, as data sharing between public agencies and jurisdictions have become commonplace as agencies endeavour to maximize the use of collected data and minimize the cost of collecting the data.</p> <p>Additional precipitation data should be obtained in the area between Arnprior and Chalk River, since there is a general lack of such information in the western part of the Study Area. This information can be used to improve the accuracy of the water budget and the collection of this information is deemed a high priority.</p> <p>Approximately half of the Ministry of the Environment (MOE) water well records are not geo-referenced, but because of the scarcity of data in most parts of the Study Area, they were used in this analysis. All hydrogeological maps should be updated once the MOE water well record database has been updated. Field truthing should be performed to verify accuracy of maps in key locations.</p> <p>The interrelationship between groundwater and sensitive surface water and wetland receptors should be further investigated. Several regions were identified where water bodies are suspected to have a greater than average base flow component. Evaluation of potentially sensitive surface water resources would involve the compilation of a database of all relevant information.</p> <p>The database of groundwater quality parameters developed should be expanded and updated. At a minimum data should be collected for bacteria and nitrates. Near industrial areas, volatile organic compounds and solvents should be collected. Selection of areas to be sampled could be based on either aquifer vulnerability and land use mapping.</p> <p>Accurate estimation of actual water usage through the existing Permit to Take water records is difficult. Effort should be made to monitor, or otherwise obtain information on the actual water used by large water takers so that a more realistic accounting of the water demand can be completed.</p> <p>Monitoring wells should be installed in select areas to record groundwater levels and assess groundwater quality over time. Wells could be strategically placed in all overburden and bedrock aquifers identified in this study. Priority can be given to installing wells near communities that rely on private wells.</p> <p>Individual municipalities could improve the accuracy of the aquifer vulnerability map by performing smaller scale (finer detail) aquifer mapping and incorporating additional local scale information. A map showing the uncertainty in the estimated aquifer vulnerability should accompany any future vulnerability map.</p> <p>The database of potential and known contaminated sites should be updated on a regular basis. This database should include information on the stations/success of measures undertaken to mitigate or remediate the contamination. The database should be expanded to include zoning information for land uses that may pose a risk to groundwater resources. Known issues of concern should be ranked, in order to prioritize remedial efforts.</p>
			GMS - General Planning Policy	<p>Establish a Committee to consider, prioritize and implement the recommendations of this study.</p> <p>Create/update Official Plan policy to protect groundwater, including the definition of areas where uses should be restricted, the types of development/uses that will be permitted, and the type of study required prior to development being approved. The aquifer vulnerability mapping will provide a technical basis for this policy.</p> <p>Official plans and zoning by-laws should consider categorizing land uses in terms of their potential risks to groundwater resources. Such as the three category ranking system (A - high risk, B - moderate risk, C - lower risk) adopted in the County of Oxford and the Region of Waterloo.</p> <p>Protecting Ontario's drinking water: Towards a watershed based source protection planning framework.</p>
			GMS - Small Scale Development - Individual Services	<p>Education program for existing owners of individual services that addresses routine inspection of wells and septic systems; promote decommissioning of unused wells and replacement of dug wells with new drilled wells (where possible) and extension of buried wells to above ground using pitless adapters; promote regular testing of wells for indicator bacteria; promote maintenance of existing water softeners; promote proper use of pesticides.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Require new development to have a minimum lot size and require detailed groundwater and terrain assessment for developments. Any limits on pumping recommended in groundwater assessment should be implemented. Geo-reference database for septic tank approvals. A minimum standard of one (1) hectare per lot could be applied where no supporting studies demonstrate that a higher (or lower) development density is appropriate.</p> <p>Development requirements for well construction specific to the type of subsurface conditions and impose them on all new development. Inspect the construction of new potable water wells to ensure MOE minimum well construction requirements are met, either as under O.Reg. 903 or as enhanced as per the specific requirements. Require proof of licensing for well contractor, well technician and plumber.</p> <p>Encourage the use of new technology for septic systems, where appropriate.</p> <p>Healthy Futures (from Ontario Federation of Agriculture) where non-farm residents can obtain assistance for well upgrading or decommissioning.</p>
			GMS - Larger Scale Development	<p>Develop enhanced requirements for hydrogeological and groundwater supply studies for new larger scale developments, whether proposed on individual or communal services. The aquifer vulnerability maps should be used as guidance to identify areas with potential problems and support the requirements for more detailed study.</p> <p>Perform hydrogeological studies and aquifer sensitivity analysis for rural communities that have a high density of individual services and hydrogeological studies to geo-reference well locations for addition to database.</p> <p>Future consent for subdivision development approvals based upon adjacent developments, and assessment of cumulative impacts on groundwater quality and quantity.</p> <p>Promotion of Best Management Practices (BMP) for O.Reg. 459 communal water supply systems.</p> <p>Promotion of testing and inspection of communal water supply systems not regulated under O.Reg. 459 or O.Reg. 505.</p> <p>New development involving municipal services should ensure that any water wells are properly abandoned as per O.Reg. 903.</p> <p>Municipalities need to review the use of engineering standards to assist in the protection of groundwater including programs and standards such as Stormwater Management standards, road design and maintenance standards.</p>
			GMS - Commercial and Industrial Land Use	<p>Same education as homeowners on individual services; promotion to not dispose of non-human waste in septic systems.</p> <p>Require Phase 1 ESA and if necessary Phase 2 ESA, for new development and redevelopment or renovation to identify and assess any potential historic problems and require appropriate mitigation measures.</p> <p>Require new high risk land uses to submit plans and protocols that protect groundwater, and submit monitoring plan to ensure protection. Determination of high risk land use may be performed by screening the risk of site development to groundwater and be based on type of chemicals handled and aquifer vulnerability. Consider an investment (capital) to be made on or before start-up of operations for environmental clean-up/protection.</p> <p>Encourage use of BMPs for storage and handling of chemicals and hazardous materials, with a primary focus on those facilities located on groundwater recharge and vulnerable areas in unserved portions of the Study Area.</p> <p>Municipalities should identify sources of potential contamination that they are responsible for such as former "dumps" and investigate impacts.</p>
			GMS - Agriculture	<p>Promotion of BMPs and Environmental Farm Plans (EMP).</p> <p>Promote conversion of underground fuel storage tanks into above ground tanks.</p> <p>Develop policies to implement the Nutrient Management Act and its regulations. Require evidence that any associated works have been designed in accordance with the Act.</p> <p>Quantify the actual effects of more significant farming activities on groundwater.</p>
			GMS - Areas on Private Services Adjacent to Separate Serviced Municipalities	<p>Request adjacent separate municipalities on communal services to require new high risk land uses to submit plans and protocols that protect groundwater and submit monitoring plan to ensure protection.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			GMS - Road Salt Practices	Encourage BMPs involving road salt application in the municipalities to optimize application rates and investigate alternatives to road salt. Use of setback guidelines for heavily salted roads to prevent new residences in areas of road salt application.
			GMS - Ecological and Habitat Areas	In areas mapped as high infiltration regions, encourage maintaining natural cover. Control new land development involving large areas of impervious surfaces such as paving. Where infiltration to groundwater is significantly restricted, encourage artificial recharge. Encourage BMPs for existing commercial/industrial and agricultural land uses in these areas. Control/limit development on individual services. Encourage use of alternate septic treatment systems.
			GMS - Groundwater Monitoring Network	Design and implement a groundwater monitoring network across the Study Area or individual municipalities, to cover rural, commercial/industrial and agricultural land uses. Monitor both groundwater levels and quality and evaluate trends over time and integrate with data from communal wells, test wells, Health Units and the Provincial Groundwater Monitoring Network.
			GMS - Data Management/GIS Management	Continuous updating of environmental and groundwater quality related database information presented in this study and preparation of interpreted maps on both a regional and more local scale. There may be a valid role for the County level or the Conservation Authorities to the agent for retention and management of this information due to their large jurisdictions. Sampling of wells and water analysis program in areas of interest can be a relatively inexpensive but highly effective way to determine the nature and degree of effects on groundwater from existing development. Municipalities require that all wells drilled for hydrogeology studies be geo-referenced for addition to the database. Use of watershed and subwatershed plans as a next step and as a means to bring the level of detail to a higher degree of accuracy. These studies could identify sensitive areas that need protection from overdevelopment.
			GMS - Community Awareness and Education	Build community links and encourage information sharing. This could be done through adding programs to the Landowner Resource Centre. Groups such as Federation of Ontario Naturalists, Ontario Federation of Agriculture and local Land Trusts are three examples of groups that can contribute to groundwater protection. Create educational workshops/events and/or attend public events (e.g. fairs) to inform students and others about groundwater (e.g. groundwater festivals). Municipalities should work cooperatively to develop information related to groundwater protection for homeowners including: how to maintain a septic system and well; hazardous waste disposal; advantages of tree planting, stream stabilization; proper use of pesticides; etc. The Landowner Resource Centre, advertisements, bulk mailings, could be used to disseminate this information.
			Regional Water Budget - Recommendations	The results of the statistical analyses of the 2, 5, 10 and 50 year return period peak flows (Figures B.2.4-4a,b,c,d) showed a strong relationship between the size of drainage area and the magnitude of peak flow. The only station data predicting relatively high flows for its watershed size is the Rideau River gauge at Ottawa (02LA004). It is recommended that a detailed investigation on the reasons for these unusually high flows be completed. During the dry seasons, mainly in the summer and early fall, base flow provides most of the runoff in the streams. Any future reduction in infiltration into the groundwater due to changes in land use practices, or excessive groundwater withdrawal would further reduce the summer low flows in the streams. This is especially the case within the eight watercourses identified in Table B.3-1. There is a lack of information within the Study Area on the amount of infiltration. Further studies will be required to obtain a better understanding on the contribution of precipitation and base flow and interflow. Similarly, there is a need to obtain additional local data on evaporation by installing 2-3 additional pan evaporation gauges and investigate typical water holding capacities of local soils within the study area. It is suggested that one of the pan evaporating gauges be located within the Arnprior to Chalk River corridor where precipitation appears to be the lowest within the Study Area. Pan evaporation gauges would also be beneficial in western portions of the Mississippi River watershed, Rideau River watersheds, and in the western portions of Renfrew County. The Ottawa valley between Arnprior and Chalk River recorded lower precipitation than the rest of the Study Area. Generally, there is a lack of precipitation data for the western part of the Study Area, which made the interpolation of precipitation isohyets very difficult. It is recommended that additional precipitation data be collected for this area, particularly for the area between Arnprior and Chalk River, at least for a couple of years to establish some correlation of local precipitation with long term stations.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The study maps can be used to help assess the long-term effects of water takings at the subwatershed level. While the maps are not suitable for evaluating the effects of individual water takings, they could be used to identify areas where the total water takings are high relative to infiltration, and closer scrutiny of new water taking permits may be warranted. The maps could be used to establish threshold maximum water taking volumes by watershed. Any additional water taking beyond the maximum threshold could require additional investigations and scrutiny prior to approval. The threshold value would likely vary between watersheds; however, as a default pending further study, maximum total water takings that exceed 25% of the aquifer capability (recharge minus current extraction volumes) could be used. Numerical groundwater flow modelling at the subwatershed level or smaller would be required to establish a more rigorous threshold limit. A better estimate of recharge volumes could be produced by incorporating vertical hydraulic conductivity and gradients into the analysis.</p>
				<p>The Estimated Water Recharge map (Infiltration) in conjunction with the Aquifer Recharge / Discharge map and the Overburden Geology map could be used to identify areas that may be more prone to reduced water levels in the aquifer during periods of drought. This approach could be improved by conducting historical analysis by subwatershed of average monthly rainfall, evapotranspiration and stream flow records to identify "critical" drought parameters. Once these parameters are identified, a comparison of observed rainfall, evapotranspiration and stream flow data for the previous fall, winter and spring months with the "critical" data could provide an early warning of imminent droughts for the following summer. Water level data from the new Provincial Groundwater Monitoring network could be used to aid in the analysis if correlations between aquifer levels and precipitation can be developed.</p>
				<p>Studies suggested in both items 3 and 4 above should be regarded as high priority projects.</p>
			Hydrogeological and Aquifer Analysis - Recommendations	<p>Approximately 50% of the well records used in this Study Area not geo-referenced, but because of the scarcity of data in most parts of the Study Area, they were used in this analysis. It is recommended that the maps be updated once the MOE Water Well Record database has been fully geo-referenced so as to improve accuracy.</p>
				<p>Additional well data is needed in the north and western portions of the Study Area to improve aquifer and hydrogeological characterization. The data gaps could be reduced by installing monitoring wells in areas where data density is poor.</p>
				<p>More detailed mapping of recharge and discharge areas could be performed by incorporating the effects of vertical hydraulic conductivity and precipitation infiltration.</p>
				<p>The geology maps should be periodically updated once more up-to-date mapping becomes available from the Ontario Geological Survey (OGS) and / or the Geological Survey of Canada (GSC).</p>
				<p>Chemical data collected and compiled in this study could be further analysed using advanced statistical methods. The application of Piper plots, cluster analysis and / or principal component analysis may increase the understanding of the chemical characteristics of the groundwater in the different aquifers.</p>
				<p>The interrelationship between groundwater and sensitive surface water and wetland receptors should be further investigated. A detailed evaluation of potentially sensitive surface water features would require a compilation of all quality and quantity information from all municipal and provincial studies, and the generation of a surface water quality and quantity database. Direct measurements could be made of seepage / leakage and vertical gradients in sensitive areas. Indirect methods such as geophysical surveys could be performed in discharge areas. The potential recharge / discharge map and potential discharge map provided in this study can be used to select and prioritize waterbodies for additional investigation.</p>
				<p>Public health officials should be aware that across the Study Area, fifty percent of all groundwater samples exceeded 20 mg/L of sodium (the Medical Officer of Health "notification level"), and 5% exceeded the Ontario Drinking Water Standard (ODWS) health-related standard of 1.5 mg/L for fluoride.</p>
				<p>Municipalities and transportation authorities in the Study Area could consider development of environmental management initiatives aimed at improving surface water and groundwater quality within the region. Where possible, reductions in the application of road salt should be implemented, in order to reduce the levels of sodium and chloride in shallow aquifers and in surface water drainage.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Programs of post-development groundwater sampling could be designed to investigate the effects of development on groundwater quality in vulnerable aquifers and to track changes in aquifer groundwater quality with time. The presence of nitrate in groundwater (pre or post development) is indicative of vulnerable aquifers and may indicate a need for improved protection of the groundwater supply.
			Surface Water Analysis - Recommendations	<p>The following recommendations are provided with regard to surface water within the Study Area, although surface water quality relates more to land use (effluent discharges and run-off) than to groundwater quality.</p> <p>Surface water analysis data should be revisited every 5 years to check trends over time, including during the drier summer months when the stream contains mostly baseflow.</p> <p>It is suggested that the Conservation Authority (or other agencies) undertake a systematic analysis of subwatershed surface water quality data, from upstream to downstream to: a) identify and assess any reaches of a water course where the more significant impacts are occurring, and b) determine the need for and locations of additional strategic surface water sampling locations.</p> <p>Consideration should be given to the use of electrical conductance and temperature surveys to quickly assess water quality over large areas. Such surveys have been used successfully in the South Nation River.</p>
			Groundwater Use - Recommendations	<p>The following recommendations are made:</p> <p>Accurate estimation of actual water usage through the existing Permit to Take Water (PTTW) records is difficult. Effort should be made to monitor the actual water used by the large water takers so that a more realistic accounting of the water demand can be determined. Information should be gathered on the fate of the groundwater for each use: what percentage is returned to the groundwater system, surface water system, and taken away by evapotranspiration.</p> <p>Consideration should be given to preserving groundwater recharge areas that contribute to baseflow to sensitive environmental features. Site development studies should include an evaluation of the ecological effects of a decrease in recharge in these areas. If the decrease is deemed significant, the loss of recharge should be augmented by other means.</p> <p>In areas where water shortages are a concern, water conservation measures should be encouraged, whether through voluntary or regulatory programs. As an example, the installation of water meters in communities supplied by municipal system usually reduces water demand.</p> <p>Monitoring wells should be installed in select areas to record groundwater levels and assess groundwater quality over time. Wherever possible, multi-level monitoring wells should be installed to produce information on vertical flow. The data can be collected to assess long-term trends in aquifer storage and to act as an early warning system for aquifer over pumping. Wells should be placed in all overburden and bedrock aquifers identified in this study. Priority can be given to installing wells near communities that rely on private wells. Some of the wells that were installed through the new Provincial Groundwater Monitoring Network may meet these needs.</p> <p>The inventory of O. Reg 459 and O. Reg 505 systems should be updated as new information becomes available. The "potential" systems identified in this study should be confirmed with local agencies such as the Health Unit and the MOE.</p>
			Aquifer Vulnerability Analysis -	<p>The following recommendations are made to enhance the accuracy and usefulness of the aquifer vulnerability mapping.</p> <p>It is recommended that an evaluation of aquifer vulnerability mapping methodologies be performed in order to quantify the effect that the methodology has on the outcome of the mapping exercise. Possible improvements to the mapping methodology include determining aquifer vulnerability in terms of expected contaminant travel time. Incorporating the hydraulic conductivity of the lithological materials and the vertical groundwater flow gradients can enhance the accuracy of the map. The accuracy of the map can also be further enhanced by incorporating borehole data from geotechnical and hydrogeological investigations, as this data is often more accurate than the water well logs that were predominantly used in this study.</p> <p>Any future aquifer vulnerability mapping should take into account the uncertainty with the data that was used as input into the evaluation. A map showing the uncertainty in the estimated aquifer vulnerability should accompany any future aquifer vulnerability map.</p> <p>Aquifer vulnerability maps could be created that target specific aquifers. For example, an aquifer vulnerability map could be created of the bedrock aquifer. Confidence interval maps should be generated for aquifer-specific vulnerability maps.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Individual municipalities could improve the accuracy of the aquifer vulnerability map by performing smaller scale (finer detail) aquifer mapping and incorporating additional local scale information.
				The aquifer vulnerability map should be periodically updated as new borehole and water well information becomes available.
			Land Use and Contaminant Inventory -	As noted previously, this contaminant inventory has been derived from data sources that outline potential and known contaminant sources. The data sets are however subject to a number of significant limitations.
				In terms of the potential contaminant sources, data limitations include issues such as the lack of geo-referenced information for location (e.g. fuel storage and spills databases) and uncertainty associated with the completeness of the data (e.g. uncertainty surrounding the final status of spills). Once recommendation resulting from this analysis is that the MOE spills database be updated with information concerning the final status of the spill (e.g., clean-up complete or ongoing monitoring). If, through this process, it is discovered that appropriate management or mitigation has not been documented, appropriate action should be taken to correct the situation to protect the groundwater resources.
				There is however, a broader issue in that any such methodology for identifying potential contaminant source will necessarily cast a wide net. Even through the process of assigning risks and an overall 'level of concern', many of the sites identified as having a high concern will in reality pose a minimal threat to groundwater resources due to site specific considerations such as low actual chemical usage and / or proper waste handling practices. Nevertheless, any one of these potential contaminant sources could pose a tangible threat to groundwater in the event of accidental releases of chemical products or wastes, or through poor management / housekeeping practices.
				Another limitation of the available data is the relative lack of information concerning historic land uses / activities which may have introduced contaminants to the environment. This could include former industrial or commercial sites which have either changed land use entirely, or no longer include site operations that would be identified as high risk.
				With these limitations in mind and considering the overall groundwater management objectives of the study, two broad recommendations are offered (as detailed below)
				1) Focus on prevention
				It is intuitive that preventing discharges to the environment that could result in groundwater contamination would be far preferable to simply reacting to environmental occurrences after the fact. The procedures and regulatory mechanisms for responding to such occurrences are generally well established, however, there is room for improvement in many cases at the facility level (i.e. spill response procedures customized for individual facilities). On the other hand, the adoption of proactive prevention planning is often lacking. Improvements in these areas could be facilitated through consideration of the following strategies:
				Compliance promotion and education - There are a number of existing regulatory requirements geared towards pollution prevention and spill response that have beneficial impacts in terms of groundwater management. These requirements however are not always complied with, often due to lack of knowledge or understanding at the facility level. Compliance could be improved through education programs, such as information sessions for businesses considered to be higher risk and / or located within sensitive groundwater areas or specific wellhead protection areas. Achieving full compliance would reduce the potential for groundwater impacts.
				Regulations or programs in this category include the following:
				Municipal sewer use bylaws - Any facilities discharging liquid waste streams to municipal sewers (storm or sanitary) are obligated to meet the requirements of their municipality's sewer use bylaw. These bylaws are typically based upon an MOE model sewer use bylaw. More recent versions of the model bylaw include requirements that qualifying facilities to submit a 'waste survey report' to the municipality, which details waste types and quantities. Requirements for occurrence reporting and remedial actions are also stipulated. As noted, these requirements are enshrined in more recent versions of the model bylaw. It is recommended that any municipalities using an older bylaw update it accordingly. Further, it is recommended that municipalities ensure that resources are in place to ensure that compliance is maintained.
				Fire Code requirements - Facilities where flammable or combustible liquids are stored or used are regulated by Part IV of the Ontario Fire Code. Qualifying facilities are required to meet certain standards in terms of containment, spill response and reporting, and remediation of spills. This includes the requirement to have written spill response procedures in place.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Liquid Fuels Code requirements - Similarly, facilities storing motive fuels (e.g. gasoline, diesel) or fuels for appliances (e.g. heating oil) are regulated by the Liquid Fuels Code. Such facilities are required to meet minimum standards pertaining to containment, spill response and reporting, and remediation.</p> <p>Requirements for private sewage disposal - Private sewage systems as regulated by Part 8 of the Building Code and private sewage works as regulated by Section 53 of the Ontario Water Resources Act are subject to minimum standards in terms of design and operation. Sewage works must obtain and comply with Certificates of Approval that typically provide for conditions such as the reporting of any unusual discharges.</p> <p>Requirements for the disposal of subject waste - The disposal of subject waste (liquid industrial waste and hazardous waste) is controlled by Regulation 347/558 under the Ontario Environmental Protection Act. The regulation includes provisions for the testing / classification of wastes, registration of waste generators and the tracking of all wastes generated.</p> <p>Requirements of the Canadian Environmental Protection Act (CEPA) - Qualifying facilities are required to participate in various CEPA mandated programs such as the National Pollutant Release Inventory (NPRI), and / or prepare spill response plans and pollution prevention plans.</p> <p>Promotion of environmental stewardship - The promotion of 'groundwater friendly' practices can be encouraged through voluntary programs that foster environmental stewardship. Such programs would encourage facility owners / managers to inform themselves about the potential impacts to the greatest extent possible. Such a program would require central coordination and sufficient resources to cover organization, and the development and delivery of outreach programs. Participation could be encouraged through marketing initiatives that promote a positive image towards participants.</p> <p>Adoption of mandatory pollution prevention planning - Making the preparation and adoption of pollution prevention plans mandatory for higher risk facilities could also be considered. It may be possible for municipalities to adopt such requirements as part of their sewer use bylaws, or for the issuing of building permits. For example, the City of Toronto has recently enacted such requirements as part of their sewer use bylaw. This type of program could also be considered on a voluntary basis, perhaps using tax incentives or some other means to encourage participation.</p> <p>2) Identify and manage current and future problems</p> <p>As noted herein, there are a number of ongoing soil and / or groundwater contamination issues associated with various sites within the Study Area. In addition, spills to the environment that could result in groundwater contamination are commonly reported to the MOE. These issues are tracked by the MOE (or various Federal departments in the case of Federal lands), who ensure that appropriate remediation or management techniques are implemented. Improvements in regulatory compliance would help ensure that such occurrences are reported and managed. Notwithstanding this, it is possible that there are other instances of subsurface contamination within the Study Area that are not being appropriately managed, either because they have not been discovered or reported, or their existence is the result of historic releases and the types of investigations that would reveal their presence have not been completed.</p> <p>In order to ensure that there is an appropriate level of awareness concerning existing contaminant issues and other sites where historic contamination may be an issue, the following recommendations are offered for consideration:</p> <p>The database presented herein should be maintained and expanded upon. Entries which are no longer relevant due to remediation or other factors, should be removed from the list. Other entries would be added or their status updated as new information becomes available. For example, the City of Ottawa are in Phase I of their Old Landfill Management Strategy, to identify all former disposal sites within the amalgamated municipality and prioritize them in terms of potential risk. As information from this study is obtained, it could be added to the data base.</p> <p>In order to identify sites where historic land use activities may have resulted in contamination issues, a detailed review of historic industrial activity within the Study Area could be completed. This would focus on historic activity prior to approximately 1980 at sites where industries known to be problematic from a contamination standpoint operated. This exercise was completed previously on behalf of the former City of Ottawa (Intera, 1988) and subsequently expanded to include the amalgamated City of Ottawa under a Hazardous Land Use Inventory. These could form the starting point for a broader study.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Agricultural Land Use - Recommendations	<p>Agricultural Land: It is recommended that an up-to-date satellite inventory of agricultural land be maintained for the Study Area. It should be more accurate than that currently available (i.e. classifications should be free of errors) and it should differentiate between major individual crops (e.g. corn, soybeans, etc.).</p> <p>Pesticides: It is recommended that more information be collected on pesticide use and groundwater contamination in areas where aquifer vulnerability is high. A network of monitoring wells could be established in these areas. Emphasis should be placed on the use of pesticides with above average leaching potential or toxicity.</p> <p>Nitrogen: Consideration could be given to establishing a network of groundwater monitoring wells in specific locations and representative areas from which nitrate concentrations in the upper aquifer can be monitored in both agricultural and non-agricultural areas. Multi-level wells should be used where appropriate. These wells should be located away from local potential sources of nitrate such as septic tanks and manure piles. Results will enable a clearer picture to emerge as to the actual contribution of agricultural activities to nitrate contamination of groundwater.</p> <p>Micro-organisms: A portion of well water sampling could be implemented across the agricultural portions of the Study Area to identify any wells contaminated with coliform and <i>E. coli</i> bacteria, in order to assess if the observed contamination is actually associated with the agricultural activities. Incidences of contamination would be followed up with an investigation of sources and the condition of wells, and recommendations for corrective action provided.</p>
			Groundwater Protection and Management - Recommendations	This section provides recommendations for municipalities in the Study Area to consider in moving forward to implement a groundwater management and protection strategy.
			Groundwater Protection and Management - Recommendations for Senior Government	<p>The Province is currently revising the <i>Provincial Policy Statement</i> (PPS) under the Planning Act. When the revised PPS is produced, all municipalities will be required to ensure that their Official Plans have regard to the Policy Statement. The province should be encouraged to require that Groundwater Protection be incorporated into Official Plans.</p> <p>The Province should be requested to enact a "Greening" amendment to Section 41 of the <i>Planning Act of Ontario</i> to include a provision to permit municipalities to require environmental protection measures to protect sensitive features and areas, including groundwater.</p> <p>The <i>Canadian Council of Ministers of the Environment</i> produced a document entitled from Source to Tap: the multi-barrier approach to safe drinking water. This document is to be followed by a technical document to assist communities in designing a multi-barrier approach to drinking water protection, when combined with other sources. The Toolkit developed in British Columbia municipalities has a number of methods on how to proceed through the development of a protection plan. The province should encourage the completion of this Source to Tap Guideline and seek to have it build upon the work done by the province of British Columbia. Once this document is available it should be consulted when developing planning policy or when examining an overall municipal strategy to gain insights from this national organization.</p> <p>The Province of Ontario needs to take the work done through special venues such as the O'Connor Inquiry and move forward to continue to assist in filling the data gaps and to make the appropriate regulations to allow municipalities more power to ensure that development does not negatively impact groundwater resources. The standard for data is established and must now be refined, monitored and furthered for use in each municipal jurisdiction. The work done by the province in the case of the Oak Ridges Moraine is an example of the role the province can play in setting the groundwork for the municipalities. The province should continue to work towards the implementation of the guidelines / regulations for source protection.</p>
			Groundwater Protection and Management - General Recommendations for	This section describes recommendations that the municipalities within the Study Area could consider implementing as part of a groundwater resource management and protection strategy. The recommendations cover aspects of groundwater management that are within a municipality's control to implement or to encourage others to implement. It is not intended that each municipality adopt all recommendations but rather that they choose the most appropriate to their circumstances.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>A municipality's primary vehicle for groundwater management is through its planning and management of new land uses within the community. Through Official Plan Policy and subsequently through zoning and site plan control, municipalities can identify areas where groundwater requires protection, stipulate the type of development that is acceptable or not acceptable in these areas and require proof from those within to develop that there will be no significant impact on the groundwater resource. Policies can be restrictive or flexible depending on the desires of the municipality. For existing land uses, municipalities have less legislative control and must rely more on education and awareness of the community. Also important for groundwater (management and incorporated into the recommendations) is the need to maintain and continually update the information database on which decisions are based.</p> <p>The implementation of any recommendation of this study will require joint action among the partners. One tool to bring life to the report is an Implementation Committee. One approach that could be considered is that the municipalities and the Conservation Authorities each appoint a person to a committee charged with bringing forward the recommendations of this study.</p> <p>For the purposes of organizing the recommended strategies for the protection of groundwater, they have been divided into broad categories that relate to type of land use and / or activity. These broad categories are as follows: General Planning Policy; Small Scale Development, consisting of individually serviced units; Larger Scale Development, consisting of new multi-lot / multi-lot developments; Commercial and Industrial Land Use; Agriculture; Areas on Private Services adjacent to Separate Serviced Municipalities; Road Salting Practices; Ecological and Habitat Areas; Groundwater Monitoring Network; Data Management / GIS Management; Community Awareness and Education.</p> <p>Recommended strategies for groundwater management and protection related to each of these categories are discussed in Table I.7.2-1. This table briefly describes the recommended strategy, its rationale, who is responsible for implementation, the timing of implementation. The study team recognized that the fact that the majority of Renfrew County is not included in a Conservation Authority. In this instance, the Ministry of Natural Resources has some responsibility but it is limited. It appears that the County will have to assume a greater role, particularly in the planning aspects, since there is a great deal of delegated authority.</p> <p>Lastly, the province is in the process of developing a watershed-source protection framework to address the recommendations made in Commissioner Dennis O'Connor's report on the Walkerton Inquiry. The legislative teeth for this framework will likely reside in amendments to the <i>Ontario Water Resources Act</i> and the <i>Environmental Protection Act</i>. A draft framework was released in April 2003 entitled "Protecting Ontario's Drinking Water: Toward a Watershed Based Source Protection Planning Framework". It is recommended that the design of groundwater source management strategies for the Study Area consider this document and its watershed-based approach once the document is in its final form.</p>
			Groundwater Protection and Management - Recommendations for Specific Municipalities	<p>This section highlights specific recommendations for each of the municipalities within the study area. It should be read in conjunction with the previous recommendation sections.</p> <p>City of Ottawa - The City of Ottawa is developing its first Official Plan since amalgamation. The draft Official Plan (January 2003) contains provisions for a limited amount of rural growth. The plan contains a number of policies directed at environmental conservation and improvement. The overall objectives of the plan make it clear that the protection of the environment is very important to the City. There is limited direction in the current draft related directly to groundwater protection.</p> <p>City of Ottawa - The Official Plan could make use of the results of this study, as well as the individual Wellhead Protection Studies, in developing a policy to require examination of these results as a condition of making application for new development. The objective would be to identify areas where sensitive groundwater may exist and to examine the impact new development could have. This could be combined with the other information in this report to direct development away from sensitive groundwater areas. The type of information provide in Appendix H relating to agriculture is another example of where a new development should take into account features such as those identified around the Agriculture and Agri-Food Canada Site in the former City of Nepean where contamination of the groundwater is possible.</p>

## Table A-1

### Previous Study Recommendations

### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
				City of Ottawa - The proposed Official Plan encourages growth of the Rural Villages based primarily upon individual wells. This study should be used as a basis for the evaluation of the demands such growth would place upon the local aquifers and maintenance of the database would provide a starting point for the type of cumulative impact analysis that may be important should the City continue to rely upon individual private wells to provide water for rural development. This could be added to the policies found in the Plan dealing with the types of studies required to support development in the rural area.
				City of Ottawa - The conclusions and recommendations from the various Wellhead Protection Studies should be incorporated into the City's Official Plan and Zoning By-law.
				City of Ottawa - In 2001 / 2002 the City of Ottawa prepared a framework for developing their comprehensive Groundwater Management Strategy. This strategy was developed to address a broad range of issues brought forward by an internal stakeholder session, the unique aspects of the City in terms of groundwater use and physical setting, and a review of experience in other jurisdictions. The City of Ottawa strategy has three key focus areas: private well water supply, communal well water supply and other non-residential land uses that have the potential to impact drinking water supplies. Eight common strategy elements were identified and specific tasks with program ideas and challenges were developed for each of the three focus areas. This Groundwater Study, as well as the separate Wellhead Protection Studies, significantly advances a number of the tasks and provides a technical basis to move the strategy forward.
				City of Ottawa - The City is also proceeding with: 1) a review of the rural subdivision and severance approvals process from the perspectives of hydrogeological study requirements and cumulative effects assessment; 2) identifying the types of studies that will be required for approval of new private communal groundwater systems, including the determination of groundwater capture zones and definition of appropriate wellhead protection area; 3) undertaking a pilot program for well certification including three inspections and a water chemistry analysis prior to occupancy; 4) City staff participate in the provincial level Regulation Groundwater Managers Group to share information and monitor / lobby the provincial government activities related to groundwater.
				County of Renfrew - The County of Renfrew adopted its first Official Plan in March, 2002. The Official Plan contains policies related to the hierarchy of servicing from the Provincial Policy Statement. The County does allow communal services for new development. The Plan also contains policies related to new rural development being permitted on the basis of hydrogeological studies and nitrate impact assessment studies.
				County of Renfrew - The Plan could benefit from the inclusion of a reference to this study and the requirement for an examination of proposed development in light of the conclusions related to the vulnerable aquifers. Development should be approved only where the aquifers can sustain the development for the long term. This would be particularly beneficial in areas where there are no Official Plans.
				County of Renfrew - The Plan also makes reference to the minimum lot areas for rural development as being one acre (0.4 hectares). The results of this study indicate that the majority of the areas have highly vulnerable areas. Given this case, it may be appropriate to look at increasing this minimum to one hectare and allowing for smaller lots only where the density can be justified in terms of potential impact upon the groundwater.
				County of Renfrew - The conclusions and recommendations from the three Wellhead Protection Studies carried out in the County (Killaloe, Beachburg and Haley Townsite) should be incorporated into the County's Official Plan. In areas where there are local Official Plans they should be similarly amended and the Zoning By-laws should be amended to implement the policy.
				County of Renfrew - Consideration should be given to setting up a groundwater monitoring network in selected areas and aquifers within the County. In Renfrew County, there have been no wells set up through the MOE's Provincial Groundwater Monitoring Network (PGMN) initiative that commenced in 2002. Most of the County is characterized by the highly variable Precambrian bedrock aquifer system associated with the Algonquin Highlands physiographic region, and current development is sparsely populated and rural; in view of these factors, the establishment of a portion of a groundwater monitoring network in these areas is not considered to have a high priority. There are other areas of potential interest for establishing an aquifer monitoring program such as the Petawawa Sand Plain where overburden wells in the sand are common, specifically in the Petawawa area and in Killaloe, Hagarty & Richards; in these areas consideration should be given to defining locations representative of more concentrated rural residential development and of agricultural activity. T

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				County of Renfrew - The other area of possible interest for groundwater and aquifer monitoring is in the Ottawa Valley Clay Plain strip where water is mainly derived from the bedrock; much of this areas is agricultural and it may be instructive to monitor both water levels and quality.
				Lanark County - Lanark County does not have an Official Plan at this time and there are no plans to develop one in the near future. The County does not participate to any extent in the development approval or review process, except from the roads standpoint.
				Lanark County - Should the County propose to develop an Official Plan this study can form the basis for the chapters dealing with the natural environment and the protection of water resources.
				North Frontenac Township - The Township is currently preparing a new Official Plan. This plan has been prepared for the Township and has been reviewed by the Ministry of Municipal Affairs and Housing (MMAH), the public and technical agencies. The Township is hoping to have the plan adopted by the end of April or early May 2003.
				North Frontenac Township - The Official Plan proposed to permit development by both plan of subdivision and by consent. The focus appears to be on the assurance that drinking water will meet the requirements of the Safe Drinking Water Act. The plan does not propose to limit the number of consents from any particular property.
				North Frontenac Township - The Township is in a position to amend the document to include a reference to the Appendices found in this study. For example, the Vulnerability Map could be added as an additional Schedule or as an Appendix. Reference could be added in the text to identify the study and ask that new development in areas of high vulnerability address the issue of potential groundwater contamination that could result from the proposed development. The requirement for a review or study by a qualified hydrogeologist would be appropriate as a measure to assist in the protection of groundwater, including the provision of any site-specific recommendations for well construction, lot sizing and positioning of the well and septic systems on a lot. This could be applied to be the required information for review of consents and plans of subdivision.
				North Frontenac Township - The contaminant mapping is another example of a map that could be referenced in the Official Plan. The Township could require that any application for development includes an appropriate statement or study related to the review of potential sources of contamination. A typical clause could reflect the need for a Phase 1 Environmental Site Assessment to either accompany an application or be provided as a condition of the approval. This type of condition could also apply to consents or subdivisions.
				North Frontenac Township - Should the Township include these types of requirements for studies, the Mississippi Valley Conservation as a review agency, will be able to add the information to the database that has been developed for this study.
				North Frontenac Township - The broad scale aquifer vulnerability mapping done as part of this study identifies all of the land as highly vulnerable. However, there may be localized areas of low to moderate vulnerability that have not been identified. The municipality could undertake a more specific study to identify any such areas, which may be better suited to development on private services.
				Central Frontenac Township - The Township adopted a new Official Plan in 2002. This plan has a general description of new development having to provide sufficient information for approval under the Building Code. New lots need to demonstrate that the water supply on adjacent properties is verified and subdivisions require servicing options reports to review the water supply and sewage disposal issues.
				Central Frontenac Township - At this time the issue of water quality has arisen around Sharbot Lake where iron content is naturally high in some locations. This non-health related issue, which is associated with the natural groundwater quality in the area, has been addressed through the use of individual treatment systems. This type of information is valuable for inclusion in the database, but does not appear to require any specific policies other than those presently in place in the Official Plan.
				Central Frontenac Township - The Official Plan is very new and the Township is not in a position to amend the document in the short term. This Study can serve as an advisory document that staff can use to identify the potential for consent or subdivision applications to impact on highly vulnerable areas. The Township is then able to use the existing policies to ask for the appropriate studies to support the development proposal.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Central Frontenac Township - The broad scale aquifer vulnerability mapping done as part of this study identifies all of the land area as highly vulnerable. However, there may be localized areas of low to moderate vulnerability that have not been identified. The municipality could undertake a more specific study to identify any such areas, which may be better suited to development on private services.
				Township of Lanark Highlands - The Township's Official Plan recognizes that lands throughout the Township will be serviced by individual systems. There is a policy that requires a water supply assessment report to demonstrate that there is an adequate supply and that consideration will be given to the cumulative impact of development. A water budget for users may be required.
				Township of Lanark Highlands - This policy is an excellent start to protecting the resource. The information found in this study will assist in determining the baseline for studies that are submitted. The requirement for the water supply assessment to meet a minimum standard would also be beneficial in the long term.
				Township of Lanark Highlands - The Township could also work with the Conservation Authority, or some other agency, to co-ordinate the submission of studies and ensure that the format is compatible with the database that has been developed for this study.
				Township of Lanark Highlands - The Township could amend its Plan to recognize this study and to direct development to areas that may not be as vulnerable.
				Addington Highlands Township - The Township is in the process of developing their Official Plan. The Township website includes a comment sheet for residents to completed to provide their input on the vision that is found on the website.
				Addington Highlands Township - The broad scale aquifer vulnerability mapping done as part of this study identifies all of the land area as highly vulnerable. However, there may be localized areas of low to moderate vulnerability that have not been identified. The municipality could undertake a more specific study to identify any such areas, which may be better suited to development on private services.
				Addington Highlands Township - In this instance the Township is also able to examine its overall objectives as they relate to environmental protection. Examples of the policies from Oxford County or Waterloo Region are excellent examples for the overall approach to protecting the groundwater resource that have been adopted. Such an overall approach supports the inclusion of detailed studies prior to development proposals being reviewed.
				Addington Highlands Township - In this instance it would appear to be appropriate to note in the Official Plan that the information from this Study is available to a prospective developer. The Plan can then set out a series of expectations for work to be done to support a development application. This type of work can start with an assessment of the area and any known problems. This can then be taken forward by doing a site-specific assessment to determine the characteristics of the groundwater and the potential for development to adversely affect its quality or quantity. If the Township requests such information it will make it clear that there is both an interest in protecting the groundwater and in setting the standard for all applicants to follow. Such a standard is easier to justify, and to demonstrate that the requirement will be equally applied, once it is in an Official Plan.
				Addington Highlands Township - The general policy recommendations found in this report can be applied to the development of the Official Plan and the various appendices from the report can be added as schedules to the Official Plan to demonstrate areas of potential concern, such as the vulnerability of the aquifer, potential agricultural conflicts, and interference with recharge areas.
			Groundwater Protection and Management - Recommendations for Conservation Authorities and Partners	Mississippi Valley Conservation Authority - The primary function of the MVCA relates to flood protection and to the provision of comments to the local municipalities regarding development. The MVCA also has an educational program for students at the Mill of Kintail.
				Mississippi Valley Conservation Authority - The MVCA has been a partner with the RVCA and South Nation Conservation (SNC) in providing comments on environmental matters to the City of Ottawa and in undertaking the septic approval function for the City of Ottawa. The MVCA provides a similar Planning Act review service to the other members of the Authority throughout the watershed.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Mississippi Valley Conservation Authority - The MVCA has been the lead for this project and may be a logical agency to maintain the database that has been created. Any study that is completed in the Study Area should be required to be completed in a manner that will facilitate updating of the database. This will be the only means to keep this information relevant. The MVCA, or any other agency that hosts this information, could look to make this information available to landowners, consultants and researchers for a fee in order to recover their costs.
				Mississippi Valley Conservation Authority - In MVCA, Golder Associates was retained in 2002 to determine target locations for establishing a groundwater monitoring network under the PGMN program within the MVCA watershed. Nine (9) potential areas with ten (10) were identified, of which PGWMN locations have been set up in four newly drilled wells. The MVCA is proceeding to complete the coverage of the watershed area by making arrangements for the final locations and then drilling and instrumenting monitoring wells in the remaining five (5) areas.
				Rideau Valley Conservation Authority - The RVCA has established a wide range of services related to environmental protection, and has staff with technical expertise in hydrogeology, hydrology and management of septic effluent. For example, the RVCA is involved with the City of Ottawa through a Memorandum of Understanding to review applications for development on private services. One of the significant objectives is the protection of the review is the protection of groundwater resources and long term reliability of the water supply from wells. The service includes review of Hydrogeological and Terrain Analysis reports for rural development and the natural hazards issues as set out in the <i>Provincial Policy Statement</i> .
				Rideau Valley Conservation Authority - The RVCA has participated in the development of resources such as the Landowner Resource Centre and in the distribution of various documents related to topics such as safe operation and maintenance of septic systems. The RVCA is also involved in a number of educational programs and runs a number of facilities throughout the watershed. The RVCA implements a Rural Clean Water Program in partnership with rural landowners. This program assists in protecting surface water and groundwater.
				Rideau Valley Conservation Authority - The RVCA can use the information presented in this study together with their experience, to assist in assessing the need for additional studies to enhance the protection of groundwater and surface water where development is proposed, and can use the results to assist in the prioritization of sub-watershed studies.
				Rideau Valley Conservation Authority - The RVCA, the MVCA, and the SNC have a long history of working together to provide services related to planning approvals. This association provides an excellent resource for the area municipalities and to individual landowners. This may be through the Landowner Resource Centre, coordinated by RVCA as is currently done, or through each of the Conservation Authorities. The objective is to increase the awareness of individuals to wide land use as a part of the stewardship approach. The RVCA could continue to work with its partners in providing the following: Written materials on how to maintain wells, septic systems, stream courses, etc.; Workshops on maintenance of wells and septic systems; Audit kits for homeowners to evaluate water consumption and conservation; Audit kits for homeowners to evaluate the use of household cleaners, herbicides, pesticides, fungicides, etc.; Continue to work with the school boards in developing curricula and in providing locations for outdoor education; and Continue to work with the agricultural community to provide resources on best management practices.
				Rideau Valley Conservation Authority - The RVCA is engaged in a number of monitoring programs, including groundwater. The Authority is actively developing a watershed-based information management system. The Authority should consider using the data from this report and updating the information as data becomes available for future groundwater management purposes.
				Rideau Valley Conservation Authority - In the RVCA, there have been 15 groundwater monitoring wells drilled and / or instrumented as part of the PGWMN, with distribution throughout the watershed. The well locations and aquifers were selected by the RVCA. This represents the implementation of a reasonably comprehensive network, and future installations at additional locations would depend on the results from ongoing monitoring and budget availability.
				Health Units - The Health Units participate with the municipalities in reviewing development applications. The Health Units also provide a function related to monitoring existing conditions and investigating reports of water problems. The Association of Public Health Units has a website that provides links to all of the Health Units in the Study Area: <a href="http://www.alphaweb.org/">http://www.alphaweb.org/</a> . The website lists the types of programs that the Health Units provide. The programs under environmental health, and health promotion and information are the areas that can be related to groundwater.



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Health Units - The Health Units are normally involved only when a problem has arisen, however it is recommended that they be more involved in the development of groundwater related educational tools jointly with other partners.
				School Boards - The development of the new curriculum provides the opportunity to increase the understanding of the natural environment in the classroom. The MVCA has developed a detailed program that is available to schools. MVCA offers these programs at the Mill of Kintail Conservation Area located near Almonte. The main goal of the Conservation Education Programs is to instill conservation ethics and an appreciation for our natural and cultural resources, through hands-on experience. The information can be found at: <a href="http://www.mvc.on.ca/text/education.html">http://www.mvc.on.ca/text/education.html</a> . School boards should be encouraged to incorporate groundwater management into the curriculum.
				Ontario Federation of Agriculture - The Ontario Federation of Agriculture (OFA) continues to offer its members a wide range of services and programs. These range from well corrections to assistance with the development of Environmental Farm Plans. The OFA hosts an excellent website that provides detailed information on each of their program initiatives: <a href="http://www.ofa.on.ca/site/home.asp">http://www.ofa.on.ca/site/home.asp</a> .
				Ontario Federation of Agriculture - The following is an extract from the website that lists the programs related to water issues: Rural Water Testing Program; Rural Well Upgrading and Decommissioning Program; Prioritizing Water Users; and Water Quality.
				Ontario Federation of Agriculture - The OFA has taken numerous steps to raise the awareness of government and its members of the impacts that farming can have on the environment. It has taken positions on improving the environment and has developed a position paper on the environment. It can be found at: <a href="http://www.ofa.on.ca/policyissues/Catalog.pdf">http://www.ofa.on.ca/policyissues/Catalog.pdf</a> . This document outlines the objectives of OFA to reduce the impacts upon the environment from nitrates, phosphates, etc.
				Ontario Federation of Agriculture - When municipalities are developing strategic plans and Official Plans these type of objectives should be taken into consideration. The links between organizations such as the OFA and municipalities need to be built in the areas of policy development. The OFA should pursue this type of link to better represent the interests of the farm community and to have a better understanding of the issues described in Official Plans. This in turn will assist the municipality when examining issues such as water quality and in voluntary program development.
				Other Groups - Since the vast majority of rural residents in Eastern Ontario rely upon groundwater there are a number of volunteer based groups that have an interest in maintaining the environment. Each of these groups has an interest in some form of environmental protection, and each has very detailed knowledge of their specific location and area of interest. Some examples of groups that can provide information regarding water would include: Eastern Ontario Model Forest <a href="http://www.eomf.on.ca/">http://www.eomf.on.ca/</a> ; Ontario Field Naturalists <a href="http://www.ontarionature.org/index.php3">http://www.ontarionature.org/index.php3</a> ; Land Trusts <a href="http://www.carolinian.org/land_trusts.htm">http://www.carolinian.org/land_trusts.htm</a> .
				Other Groups - Municipal boards and advisory committees and the numerous local environmental groups are a few other examples of groups that have an interest in the natural environment. The existing province-wide municipal groups such as the Association of Municipalities of Ontario (and its subgroup RUMA) may also be a forum for bringing these ideas to the fore and to seek provincial assistance.
				Other Groups - It is recommended that a listing of all groups that have an interest in groundwater be compiled into a database. Simply cataloguing who these groups are and making a summary available would be a first step to information sharing. Each municipality will know what groups exist and the type of information they may have. The database will allow for both information dissemination and will provide a framework for any group wishing to undertake work in a particular location.
				Implementation Committee - The creation of an Implementation Committee is one means to further the recommendations of this study and to focus on the work throughout the Study Area. The Committee should be made up of all the study partners, plus municipalities that did not directly participate, plus the non-governmental organizations that provide services in source protection / management.
				Implementation Committee - A further recommendation is for this group to summarize any available or new information on issues such as groundwater quality or quantity and contaminants, and to provide this information, in an agreed upon form, to the host of the groundwater database. This could consist of maps with information or text that relates to an area. This is one simple means to involve a very large number of people and improve available information for relatively little cost.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Implementation Committee - This Committee should also form the core for the development of new literature for use by individuals. This should build on the work of the Landowner Resource Centre, City of Ottawa and others, and make the information available throughout the Study Area. The Committee can act jointly to leverage limited money to best advantage and can seek provincial assistance as a unified group.</p> <p>Implementation Committee - The development of best practices approach for municipalities and consultants should be initiated by the Committee. The development of a common approach to source protection would benefit all decision-makers and homeowners. This work should include review and recommendations for new and innovative technologies related to water use, water conservation and septic / sewage treatment.</p>
			Public Consultation - Recommendations	<p>Key recommendations from the study include: 1. The Public Communications program that was developed by the Management Team and the Landowner Resource Centre should be implemented; 2. Public involvement through the promotion of educational programs in schools, advertisements through media or volunteer programs implemented through provincial or municipal agencies should be encouraged.</p>
Report on the Well Discovery Pilot Project, Village of Merrickville-Wolford, Eastern Ontario	2002	RVCA (Leeds & Grenville)	Recommendations	<p>The Well Discovery Pilot Project was conducted to help evaluate how best to approach private water well owners for well geo-referencing and tagging. Previous sections of this report summarised the project's results in terms of the well information gained and the response to the public outreach. The need for more individual well owners to be more informed about their wells is evidenced by those results. Ideas on what worked in terms of the project's approach and methods to private well discovery and suggested solutions to potential barriers were discussed in the previous section "Lessons Learned". In this section the following recommendations are made to assist the Ministry of the Environment and Energy (MOEE) and partners in future private water well outreach programmes.</p>
			Communication Plan	<p>To ensure the interest and active involvement of the well owners in their wells, the provincial and local agencies and governments should consider: A long-term communication programme to provide public information concerning private wells which gives access to sound and regularly updated information in an understandable vocabulary; and Integrate groundwater issues for different education levels, in schools, in community health care centres and other public institutions, in order to raise general groundwater literacy and awareness amongst those who rely upon well water.</p> <p>For the local communications and public outreach, the designers and implementers should be: Familiar with any previous interaction the residents would have had with local government(s) regarding their wells and groundwater issues, such as requirements for well records to be included with new development site plans. Make sure field staff are aware of these requirements and / or issues and consider any inclusions in door-to-door script, etc.; Considering sponsoring groundwater education forums, water clinics, etc., before the door-to-door work; Distinguishing between owner and renter in materials and considering how to contact the rental property owners.</p> <p>Not all local agencies and governments have adequate funding and / or revenue sources to provide staff and resources for these types of communication and public outreach programmes. The province needs to consider providing for these resources for its lower tier government and agency partners.</p>
			Recording of Well Location	<p>Some discussion has occurred regarding the relative accuracy of various global positioning systems (GPS) units and the relative costs. There have also been discussions around the end-use of a well's location information and the required accuracy. If the geo-referencing information is to be used to find the well at some time in the future when all surface evidence may have been removed then sub-one metre accuracy is often required to initially map the well, and to find the well if the co-ordinates are known. For mapping purposes plus / minus 3 metres is sufficient. Acquiring a GPS unit to meet the latter requirement would not be difficult but meeting the former may be cost prohibited at present.</p>

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Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>It may be more helpful, at this point: To record the well location in two formats: one, with universal transverse mercator (UTM) via handheld GPS units, and two, by a sketch which would include the distance to the closest centimetre of the well from three fixed points, the corners of permanent structures, or road centre lines and / or utility poles (noting ID number of pole), survey monuments such as iron bars found on the corner of lots, etc. This sketch could be stored locally with a copy of the accompanying well record; and For new wells, provide training to well drillers on the type of sketch that is required on the well record, including information that will adequately locate the property and then locate the well on the property. (A preview of the current records will identify the areas of the province that may need this type of training more than others.) Standardising the sketch requirements and legend may also be helpful.</p> <p>Whatever the GPS unit selected, the data management capabilities of the unit and its associated software need to be taken into account in the project and fieldwork planning. GPS units are survey tools and as such their use requires quality assurance / quality control (QA/QC) protocols: Incorporate the use of standard QA/QC protocols into the daily schedule, including access to survey control monuments.</p>
			Matching Water Wells with Well Records	<p>Depending on the circumstances, such as the age of the well, the quality of the sketch on the well record, and the well ownership, the process of matching wells to well records can be a time consuming and therefore costly endeavour. As the well record is a positive link between the provincial government, whose regulations provide for the creation and archiving of the record, and the wells and well owners, the agencies involved should consider the reinforcement of these links by: Declaring a moratorium on the well record retrieval fee, encourage people to seek their well records, and promote their understanding of the information on the well record; Having the provincial agency, when people are retrieving their well record(s), collect such information as: the name of the owner of the well at the time of drilling and the year of drilling. This will help with the matching of wells and well records, particularly if the 911 address is recorded on the record when the match is made;</p> <p>As the well record is a positive link between the provincial government, whose regulations provide for the creation and archiving of the record, and the wells and well owners, the agencies involved should consider the reinforcement of these links by: Considering the promotion of well record matching, by promoting self-retrieval of the well record, in an area prior to conducting a well inventory so that the background information on the well may already have been obtained by the current well owner; and Avoid defacing the well record with messages that may infer that the well owner is not entitled to the record or the information on it (see examples in Appendix I). It is important that the MOEE have a consistent message in the public outreach.</p> <p>A well decommissioning project in Alberta (<a href="http://www.agric.gov.ab.ca/sustain">www.agric.gov.ab.ca/sustain</a>) involves the well drillers in the well discovery process. Involvement of local drillers may also help in the well record matching process.</p>
			Well Tagging	<p>The placement of an identifying code on the well was acceptable to the residents approached during this pilot project. The use of the municipal dog tags was instructive as to the type of wear and tear to which the tag will be subjected. On one return visit the field team observed a tag damaged in just one week of service. Well tags should be: Able to withstand exposure to landscaping equipment; Identifiable and readable by the resident, who can call in the identifier code to the agency noted on the tag; and For existing wells, able to be attached to metal and cement well covers.</p>
			Partnerships	<p>The partnerships between provincial and local governments and agencies are very helpful in the well outreach and inventory work. In order to foster good working relations in these endeavors there should be: A written formal agreement between partners, specifying roles, responsibilities, funding and information sharing, access and use; and An initial agreement at the project planning and design phase, and final agreements committed to prior to commencement of the public outreach part of the project.</p> <p>An understanding needs to be in place as to the mandate of the various players. Field crews may encounter a wide variety of situations. Given the nature of the work and the fact that some matters have a regulatory aspect, the desired response of the field crews should be addressed and pre-defined in the planning stage. Project planning and training should: Specify roles and responsibilities, such that the field crew are well aware of how far their responsibilities extend, what information to collect and when, and what circumstances require that they notify a field supervisor or project management to bring a particular matter to their attention. Project management should also be aware of the appropriate protocols to follow and the circumstances that would require contacting additional advisors and / or contract officials.</p>
			Project Follow-up	<p>Outreach to the residents is required for any type of "well location survey" involving existing wells. This outreach could be part of a general programme for encouraging an interest and active involvement of the residents in their well's life.</p>

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				<p>For example, the pilot project in Merrickville-Wolford, and the local well inventory, mark the beginning of local outreach. There was an expectation, stated explicitly by some of the residents, that the "well discovery" would be checking the quality of the water or providing some check of the well. This was not the case. However the need for well owner's to be better informed about their wells was evident. In this context, it is recommended that: The municipality follow-up the well inventory with the general distribution of a homeowner's guide to safe wells with a flyer which provides pointers on particular well situations to make the information package of more immediate and local interest; Cheerful reminders to be placed in the local newsletter and community newspapers in spring, summer and winter, reminding people to submit water samples for testing of bacteria, including a note saying from where the sample bottles can be obtained; and</p> <p>In this context, it is recommended that: A welcome package be given to new rural property owners which provides the homeowner's guide to safe wells and septic systems as well as a list of people / organizations to contact for further information. Agencies that could be involved in various aspects of this outreach could include local public health units, community health care centres, real estate agents, municipal committees, well drillers, churches, etc.</p> <p>Project follow-up with the residents should be encouraged. Following up with the public on various issues will enhance the credibility of the project work and the importance of the task. Different circumstances will be encountered in various locales and this will determine the exact nature of the follow-up required. For this reason, it is recommended that: Project planning and funding be sufficient to allow for follow-up visits during the fieldwork phase and time at the project's completion to allow return visits and the retrieval of more information where required. In the pilot project for example, residents expressed an interest in the results. Members of the local advisory committee have suggested that the page of neighbourhood results be delivered to each participant in that neighbourhood with a covering letter acknowledging the assistance of the residents in the study.</p>
Rideau Canal Management Plan - Working Towards a Shared	1995	RVCA & Cataraqui (out)	Guiding Principles	<p>The Rideau Canal must be seen as a whole: all elements make a contribution to its value.</p> <p>Stewardship - The long-term environmental health and protection of the heritage character of the Rideau Canal Corridor are dependent on the collective actions of watershed and Corridor residents, businesses, visitors and governments. Education programs and opportunities for public involvement in the protection of the Rideau Canal Corridor should foster pride, ownership and stewardship of its natural and heritage values.</p> <p>Partnerships - Co-ordinated activities between the public and governments are essential to achieve a common vision for the Rideau Canal Corridor. This requires: coordinated planning and management of activities; clear definition of roles and responsibilities; ongoing consultation and communication with staff and the public; co-operative research and monitoring efforts; identifying creative initiatives, e.g., land trusts, increased volunteer programming and partnership agreements; co-ordination of enforcement activities; partnerships with communities, stakeholders and the private sector.</p> <p>Historic - Development and use of the Rideau Canal Corridor should be in harmony with the Canal's character and traditions as a national historic site and symbol of Canada's identity. The heritage character of the Rideau Canal Corridor's rural and urban cultural landscapes should be protected and, where appropriate, enhanced. Heritage traditions unique to the Rideau Canal Corridor should be identified and retained. Cultural resources, including buildings, engineering works and archaeological resources, within the Rideau Canal Corridor should be evaluated, protected and, where appropriate, presented to the public.</p> <p>Natural - The protection of the Rideau Canal Corridor's natural environment should be viewed as an integral part of economic and social activities, not something to be traded off against them. This is the concept of sustainable use. An ecosystem approach to the development and use is fundamental to a healthy environment. The cumulative impact of development on the Rideau Canal Corridor's environment should be considered in any decision-making. The diversity and productivity of ecological communities should be maintained and, where necessary, restored. Resource harvesting and other economic activities dependent upon the Rideau Canal Corridor's natural resources should be managed to ensure sustainable use. The natural environment is an integral component of the Rideau Canal Corridor's cultural landscape.</p>

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				<p>Clean - The health of the Rideau Canal Corridor depends upon the health of two watersheds of which the Canal is a part. There should be no net deterioration in water quality. The water quality of the Canal should be suitable for fishing, swimming and other water-related activities without risk of illness or discomfort. The water should provide suitable habitat for a diversity of aquatic and upland ecosystems.</p>
				<p>Usable - Tourism and recreation are, and should continue to be, major sustainable uses of the Rideau Canal Corridor contributing significantly to the regional economy. Tourism and recreation should: contribute towards the Rideau Canal Corridor's social and economic well-being; have minimal impact on the Rideau Canal Corridor's natural and cultural resources; and benefit local residents and visitors. The Rideau Canal Corridor should support a mix of public and private uses through the provision of: facilities and services to meet the needs of residents and visitors; recreational opportunities which are in harmony with concerns for public safety, environmental quality and heritage conservation; learning opportunities to promote the values of heritage protection for maintaining quality of life; year round recreation, tourism and learning opportunities; and activities and related facilities and services that are within the financial reach of all income groups.</p>
				<p>Usable - Those facilities and services necessary to support appropriate recreational activities along the Rideau Canal Corridor should be provided by the private sector wherever possible. Water levels will be managed for through navigation while accommodating the needs of: natural resources to maintain the diversity and integrity of habitats and species; recreation; flood abatement; municipal water requirements; and where appropriate, hydro-electric power generation. Public facilities and services should be safe, secure and inviting; project a consistent high quality image; and environmentally friendly.</p>
				<p>Financially Sustainable - Protecting the Canal's historic and natural values benefits all Canadians. However, decreasing funds will require the Canal to recover a fair portion of the costs of providing services and facilities for personal use in order to keep the Canal in operation. The protection of the historic and natural features of the Canal is a public benefit and should be borne by all taxpayers. Users deriving a personal benefit from the operation of the Canal and the use of Canal lands and water will be required to pay a fair portion of the cost of the service. Cost recovery and fees will be guided by the following: Fairness: The cost of services should be borne by those who benefit from those services directly. Appropriateness: All services with user fees should support the Parks Canada mandate. Efficiency: User fees should be cost effective and reflect the willingness-to-pay of the public. Simplicity: Fees must be clearly and easily understood by the public. Benefit: User fees must reflect the value of the service for which they are paid. The Rideau Canal will ensure that services are provided in the most cost-effective manner possible.</p>
				<p>Diverse - The beauty of the Rideau Canal Corridor, which includes its natural and cultural environment, is enhanced by its diversity. Landforms, vegetation, building design and materials, farming and fishing and local traditions all create a precious variety that should be maintained. Protection of the Rideau Canal Corridor environment contributes towards protecting Canada's diversity. Recreational and learning activities within the natural and historic environments should provide diverse experiences for visitors and residents. Rideau Canal Corridor uses should be balanced between: protection and use; urban and rural; the old and the new; active and passive fees; free and user-pay; public and private; built and natural environments; large and small scale; and busy and quiet. The diverse cultural landscapes of the Rideau Canal Corridor should be valued and protected.</p>
				<p>Accessible - The Rideau Canal Corridor is for all to enjoy. Access is essential, whether it is to a picnic site at a lockstation, to the recreational pathways in Ottawa or onto Big Rideau Lake. Canadians have a right to expect the Canal to be protected and accessible, even if they never visit. Public access to the water should be available, while respecting the rights of private landowners. A range of safe, appropriate opportunities to experience the diversity of the Rideau Canal Corridor should be available to all. The Rideau Canal Corridor should be managed as a linear recreational and heritage system. The Rideau Canal Corridor should be promoted and presented as a distinct cultural tourism corridor.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Attractive - Much of the Rideau Canal Corridor is green, open space, renowned for its scenic beauty. Our responsibility is to retain these environmental qualities to pass on to our children. Development along the Rideau Canal Corridor should: be in harmony with the scenic and heritage qualities of the surrounding environment; not detract from vistas and views to and from the water; be designed and maintained to a high standard; and be sensitive to the diversity and integrity of the natural and cultural landscapes.
Rideau Canal Water Management Study	1994	RVCA & Cataraqui (out of study area)	Hydrometric Data Collection	The discharge rating relations for the control structures in the basin should be confirmed by field measurements under controlled conditions. There is information to suggest that the relations now in use by Parks Canada do not properly estimate discharge at all of the structures.
				Efforts should be made to extend the gauging of flows at Poonamalie and Chaffeys Locks by the Water Survey of Canada (WSC) to allow for year-round flow records.
				The discharge rating of power stations in the watershed is suspect and efforts to confirm or improve these data are recommended.
				The streamflow gauging station on the Tay River near Port Elmsley should be reestablished. Reliable flow measurement in the lower Cataraqui basin is required.
			Control Structure Improvements	The use of stop log structures for the control of the lakes results in abrupt changes in flows and levels once a log is removed when an otherwise minor adjustment is required. Modifications to these structures should be examined to allow for finer control of water levels
				Finer control of water levels in the lakes can also be achieved by more frequent manipulation of stop log positions at the control structures. Further studies are recommended to identify improvements to the control structures downstream from Smiths Falls which would allow the river reaches to be operated near the navigation season operating range through the non navigation season.
			River Reach Operations	In the fall, the draining of the reaches should be scheduled over an extended period of approximately 2 weeks to minimize trapping fish in isolated ponds.
				In late winter and spring, the reach levels should not be drained after passage of the ice flushing flows and the freshet peak. As the increasing flow is discharged, the water level should remain at the level reached, but not exceeding the navigation season level.
			Flow Forecasting	Parks Canada should arrange for sharing of flow forecasts with the CASs and Gananoque Light & Power (GL&P) to ensure consistency among the agencies. In particular, the RVCA is attempting to improve their existing flood forecasting procedures and may be able to provide instantaneous peak flow estimates which will compliment the weekly flow forecasts prepared by Parks Canada. GL&P are also actively involved in monthly flow forecasts for planning energy purchases from Ontario Hydro. The forecasts prepared by Parks Canada could compliment these estimates.
				Parks Canada should consider meteorologic network improvements to enable more coordination between the data collection process and the operations model package.
Flow forecasts should be compared annually with actual flow experienced to provide data for evaluating the forecasting procedures.				
Canal System Operations	Parks Canada & GL&P should formalize an arrangement for sharing simulation results and recommendations produced by the Rideau Canal operations model.			
	Parks Canada & GL&P should formalize an agreement on the operating policies to be used in the Cataraqui River basin. The operating policies alternatives presented in this report should be used as the basis of this agreement.			
Rideau Lakes Basin Carrying Capacities and Proposed Development Policies	1992	RVCA (Frontenac, Lanark and Leeds &	Proposed Planning Policy Directions	In this section, we propose for municipal consideration planning policy directions that would: ensure that lake capacity considerations are fully and equitably taken into account in planning and development decisions; reflect the environmental concerns of the permanent and seasonal residents of the municipalities; where appropriate, maximize consistency among the municipalities.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>These proposals are based on: our review of the planning policies of the seven study lakes municipalities in Section 5.1; our analysis of lake carrying capacities, summarized in Section 10.1; response to the 1990 shoreline resident survey, as described in Section 9 and Appendix 2.</p> <p>We should emphasize that on many planning matters, there is no need for uniformity among the municipalities. On issues such as lot size and frontage, which do not by themselves affect environmental quality, the preferences of individual municipalities and their residents should remain paramount.</p> <p>The policy directions are expressed in general form. It would be the responsibility of the municipalities and their planning consultants to translate agreed policy directions into official plan and zoning bylaw provisions, and to decide on the specific mechanisms to be used (land use designations, zoning bylaw provisions, site plan control, property standards bylaw provisions, etc.).</p> <p>The following policy directions are divided into two categories. The first set of proposals, dealing with water quality and its basin-wide ramifications, is recommended to all 12 municipalities with lake frontage within the Rideau Lakes basin. The second set is recommended to the seven study lakes municipalities only.</p>
			Basin-Wide Planning Policy Directions	<p>Water quality objectives would be established for each lake, and incorporated into the relevant official plan or plans. These objectives would be expressed as a maximum permissible predicted average summertime chlorophyll a concentrations in micrograms per litre. At its meeting of June 24, 1991, the study Steering Committee adopted the following recommendation: that "... as a water quality objective, ... there be no net decline in water quality (no net increase in phosphorus loading); and further, that the participating agencies give priority to improving water quality (reducing phosphorus loading) on those lakes where the predicted chlorophyll a value is above 9.0 µg/L. [As noted in Section 3.1, average summertime chlorophyll a concentrations above 9.0 µg/L can result in frequent deterioration of water quality for water contact recreation, and impairment of aesthetic quality.]</p> <p>As a basis for establishing water quality objectives that can be incorporated into planning documents, we propose that the Steering Committee's recommendation be interpreted as follows: the water quality objective for each water body would be the predicted present concentration of chlorophyll a, or 9.0 µg/L of chlorophyll a, whichever is less; the predicted present concentrations would be those given in this report, but would be subject to recalculation in accordance with any changes in the exogenous components of the lake trophic state model developed for this study (see Section 10.4.1); priority would be given to reducing phosphorus loads to those water bodies that have predicted present chlorophyll a concentrations greater than 9.0 µg/L.</p> <p>Applicants would be required to commission independent professional studies of trophic state impacts where deemed appropriate by municipalities.</p> <p>On lakes that have reached or exceeded their water quality objectives, or whose downstream lakes have reached or exceeded their objectives, applicants would be required to demonstrate that: in case of new development (the creation of new lots and the development of existing vacant lots), phosphorus loads to the lake would not exceed background loads previously existing; in case of redevelopment (extensions to and enlargements of existing buildings and the redevelopment of existing developed lots), phosphorus loads to the lake would be reduced from those previously existing.</p> <p>The following conditions would apply to new development and redevelopment near lakes and their tributaries: buildings (except marina buildings), campsites, and sewage systems would be set back at least 30 m from water; tile field fill would be installed with and regularly maintained to a phosphorus retention capability of at least 6 mg/100 g of soil; vegetation within the 30 m setback would be disturbed as little as possible consistent with passage, safety, and provision of views and ventilation; the soil mantle within the 30 m setback would not be altered; on landscape types with poorer phosphorus retention capabilities, setbacks of more than 30 m would be encouraged, and would be required on lakes that have reached or exceeded their objectives. These additional setbacks would be in accordance with the guidelines proposed in Section 5.3. Specific guidelines would be developed and incorporated in planning documents.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>These conditions would be applied as follows: To development lots created after adoption of these policies, without exception; To development on existing vacant lots and all types of redevelopment, wherever possible. On lots whose locations and dimensions make it impossible to meet the conditions, additional remedial measures (such as reestablishment of natural vegetation) to intercept and retain phosphorus would be required through site plan control; To existing developed lots not subject to planning and development approvals, by seeking the cooperation of landowners in achieving the objectives of these conditions by voluntarily relocating and upgrading their septic tank-tile field systems, renaturalizing their shorelines, etc.</p> <p>Any new development permitted would be permitted on the premise that it might be occupied on a year round basis. (We do not advocate, however, that in lake trophic state modelling, it should be assumed that all development will be occupied on a year round basis, as this won't happen). As a result, official plan and zoning bylaw provisions would no longer distinguish between seasonal and principal residences. Municipal concerns about the demands of lakeshore residents for year round services would be dealt with through limited services official plan designations and / or zoning. In our opinion, the current distinctions between principal and seasonal residents in planning documents: do not reflect the reality of life on our recreational lakes today; are easily flouted, or are bypassed after initial development approval through site-specific amendments; by maintaining a pretense of seasonal-only development in certain areas, may avoid proper consideration of the impacts of development on water quality, and may encourage a lower standard of development with possibly adverse water quality impacts.</p> <p>Shoreland residential development alternatives to single tier detached would be encouraged. This would be done by: providing standards in all official plans for cluster / backshore residential or residential-resort development on properties with lake frontage, with greater flexibility in lot sizes than currently stipulated for single detached residential, greater flexibility in resort unit densities where applicable, provisions for common shoreline depth and common areas as a percentage of total area, and requirements for associated recreational facilities, but with the specific policies to be at individual municipal discretion; contemplating the development of stand-alone municipal communal water or water and sewage systems.</p>
			Study Lakes Planning Policy Directions	<p>Municipalities wishing to contemplate larger scale new shoreline developments would consider specific policies designed to encourage proponents to redevelop areas currently considered "underdeveloped" by the market, such as campgrounds or cabin operations, rather than locate in undeveloped natural environments.</p> <p>Applicants would be required to commission independent professional studies of impacts upon the following where deemed appropriate by municipalities: wetlands; fish and wildlife habitat; other significant natural and cultural heritage features; boating.</p> <p>For shoreline residential development, lot frontage would be defined as a straight line that: links the point where one side lot line intersects the shoreline with a point on the second side lot line that is on or inland of the shoreline; and is perpendicular to the first side lot line at the shoreline.</p>
Rideau River Shoreline Classification Survey, Kars Bridge to Mooney's Bay, Summer	2002	RVCA (Ottawa)	What's Next	<p>Complete data by acquiring Municipal addresses and Tax roll #'s for properties surveyed in the 2002 study.</p> <p>Continue Shoreline Classification survey from Kars Bridge to Smith's Falls (Summer 2003).</p>
Rideau River State of the River R	2001	RVCA	Recommendations	<p>Work out agreements whereby the various organizations that perform research and monitoring provide information for selected indicators on an on-going basis, and arrange for the information to be organized and expressed in a manner that is consistent with the State of the Environment (SOE) reporting format. For example, rather than supplying a large database of raw data, organizations could provide a summary report, figure or table.</p> <p>Continue to investigate the use of individual wildlife species as indicators. Assessing the condition of key indicator species, or rare species populations found in the Rideau could help to pinpoint areas requiring protection.</p>



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Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Investigate the possible use of composite indices for future SOE reports. For example, the Canadian Council of Ministers of the Environment is currently developing a composite metals index, which might simplify comparisons between different periods, and between different systems.</p> <p>Establish a location at which data can be housed, and updated on an on-going basis. Recommend RVCA, as it already collects much of this data, and has a Geographic Information System (GIS) in which ecological and biogeographical information can be collected and analyzed.</p> <p>Expand the Rideau River SOE report to encompass the entire Rideau River watershed. Many of the issues that affect the health of the Rideau River are watershed issues.</p> <p>Coordinate timing of the Rideau SOE report to allow incorporation of data from other source reports (ex. Fisheries Assessment 5-year summaries; Canadian Census).</p>
			Priority research or monitoring projects:	<p>Shoreline characterization survey</p> <p>Increased research, monitoring of algae in shallow littoral zone areas (toxic algae, mat-forming algae), and associated concerns such as dissolved oxygen depletion during decay of algal mats and plants</p> <p>Research into changes in aquatic plant community in the lower Rideau (monitoring of plant growth in navigation channel; better reporting of composition of harvested plants)</p> <p>Research into effects of water level manipulations on fish spawning, and on overwintering of aquatic wildlife</p>
Rideau Valley Conservation Report	1968	RVCA	Land Use	<p>RVCA encourage the elimination of grazing from local woodlands and forests</p> <p>RVCA begin the purchase and assembly of consolidated blocks of land in its Precambrian Shield region into an Authority Forest, until as much as possible of areas described as "key" lands in this report are under RVCA control, and that the RVCA adopt this project as a high priority program.</p> <p>RVCA consider the purchase and assembly of forest conservation lands in its Limestone Plain region as a matter of lower priority, unless such lands complement other conservation projects.</p> <p>RVCA support the expansion of the Leeds and Grenville County Forest in the areas described in this report.</p> <p>RVCA provide a private lands' assistance program designed to assist in the establishment of grass waterways and streambank improvements.</p> <p>RVCA encourage the use of contour tillage in suitable areas described in this report.</p> <p>RVCA develop alternative land use and farm consolidation projects under the terms of ARDA.</p> <p>RVCA encourage member municipalities, either individually or preferably jointly, to adopt a planning program, including legislative controls, in order to realize the full potential of remaining recreationally valuable lands.</p> <p>RVCA prepare and register fill and construction regulations under the provisions of Section 26 of the Conservation Authorities Act, 1968; and that priority on the preparation of these regulations be given to the Ottawa urban area, Smith's Falls, Kemptville and Perth.</p> <p>RVCA co-operate with and encourage local municipalities and planning boards to have designated, as "Open Space", in official plans and zoning by-laws, the lands delineated under the RVCA's proposed fill and construction regulations.</p> <p>RVCA urge and co-operate with local municipalities to provide for building and structure-free set-back from lands subject to fill and construction regulations of the RVCA.</p> <p>RVCA urge municipalities to discourage, in general, urban development on slopes greater than approximately 22 %, or in Leda clay areas having a high probability of slope failure.</p> <p>RVCA refer to and encourage municipal use of the information on soil stability and characteristics contained in the pertinent County Soil Reports when making decisions on the best type of urban development for any particular area with the RVCA.</p> <p>RVCA examine in detail all aspects of proposed subdivisions to ensure that no flood, erosion or slump-vulnerable lands or areas with a high scenic or recreational value are built upon.</p> <p>RVCA co-operate with local municipalities and the National Capital Commission in a phased program of land acquisition along the Rideau River and its main tributaries, and along the smaller, deeply-incised streams in the area.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Water	<p>RVCA work with the Ontario Water Resources Commission to help control pollution.</p> <p>Three additional recording rain gauges be installed at Bobs Lake Dam, Richmonds and Jellyby.</p> <p>Recording stream gauges be installed on the Jock River at Richmond and on Kemptville Creek at Kemptville.</p> <p>Hydrologic gauge installations be undertaken within three years.</p> <p>RVCA acquire and reconstruct Allan's Dam, Bowes Dam, Haggart Island Dams, Pike Lake Dam and Bellamy Pond Dam.</p> <p>RVCA encourage the owners of private dams to repair and maintain the structures in a safe condition.</p> <p>RVCA work with the NCC to implement the plan for the Rideau River improvements at Ottawa.</p> <p>RVCA implement the watershed management plan for Kemptville Creek.</p> <p>RVCA clear the channel of the Jock River and construct the Ashton Marsh dam and removable weir at Richmond and at Heart's Desire.</p> <p>RVCA work with the Rideau Canal office to appraise the implications of the Bobs Lake Diversion.</p>
			Biology	<p>RVCA urge immediate establishment of adequate waste treatment plants at Smith's Falls and Kemptville.</p> <p>RVCA urge the separation of the sewers and storm water pipes in Perth and the adequate chlorination of the effluent from the lagoons.</p> <p>Additional samples of the water of the Rideau River above the Smith's Falls Locks near the swimming area be check to determine if the bacterial quality is satisfactory for swimming.</p> <p>RVCA examine the waste disposal site south of the Rideau River at Smith's Falls and bring to the attention of the OWRC any seepage or poor condition that may appear.</p> <p>RVCA see that a regular check is made of the effluent from the cheese factory at Concession II, Lot 15, Oxford Township; and if conditions are unsatisfactory, bring this matter to the attention of the OWRC.</p> <p>RVCA direct the attention of the Department of Lands and Forests to the fish kill of June 10, 1967, on the Rideau River below Kars.</p> <p>RVCA urge that the proposed impoundments near Augusta, Cranberry Lake and Ashton be managed for the benefit of wildfowl, by the methods described.</p> <p>RVCA consider the establishment of a small impoundment, for wildfowl purposes, above the Ashton impoundment.</p> <p>RVCA consider acquiring the Crosby Lake Marshes for wildfowl management in conjunction with recreation.</p> <p>RVCA alone or with the Department of Lands and Forests consider, as a long-term plan, the management of the Brassils Creek Marsh.</p> <p>RVCA support the plan of the Department of Lands and Forests for the acquisition, on a long-term basis, of a tract of land in one township which would eventually be managed for wildlife.</p> <p>RVCA plan, as a long-term project, a small dam on Kings Creek near Prospect.</p> <p>RVCA acquire the Kars Pond and the land to the south of it and manage this area for the production of wildfowl.</p> <p>RVCA alone or with the Department of Lands and Forests acquire and manage the Glen Elm Marsh and manage it for wildfowl.</p> <p>RVCA acquire and develop the small pond south of Portland and develop it for public access as an interesting natural area.</p> <p>RVCA make an agreement with the town of Perth concerning its lagoons, and acquire additional lands for wildfowl management in this area.</p> <p>RVCA consider the establishment of wildfowl refuges, in co-operation with the Department of Lands and Forests, along the parts of the Rideau River which are heavily hunted, and thus prolong the hunting season.</p> <p>RVCA co-operate with the South Nation Conservation Authority in acquiring the key areas for the control of water levels in the Mer Bleue.</p>
			Recreation	<p>RVCA continue to liaison with the NCC, the Eastern Ontario Development Council, the Department of Lands and Forests, and the Department of Tourism and Information, to ensure that all planning is done in terms of an integrated recreational facilities system.</p> <p>RVCA take measures to establish contacts with neighbouring Authorities in order to achieve regionally co-ordinated planning within the Conservation Authorities system.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>RVCA adopt a scheme of conservation area classification and zoning in keeping with that outlined in this report.</p> <p>RVCA undertake with the EODC a training seminar for private campground operators.</p> <p>RVCA make use of as many methods as possible for land acquisition and control including easements.</p> <p>RVCA concentrate for five years on land acquisition for open space rather than development.</p> <p>RVCA employ the services of competent landscape architectural firms for planning conservation areas.</p> <p>RVCA seek to have member townships move ahead with official plans, zoning by-laws and subdivision controls, in order to safeguard the aesthetic and economic values inherent in the landscape.</p> <p>RVCA attempt to define design standards that may be adopted throughout the RVCA, making use of appropriate building materials as much as possible. The services of an architect should be retained for this purpose.</p> <p>RVCA assume an active role in the planning of the Rideau Canal and Waterway and its future development, in keeping with the principles of good ecological, environmental, and historic site management.</p> <p>RVCA undertake the development of a recreation and parks system as outlined in this report.</p>
Rideau Valley Conservation Strategy	1992	RVCA	Program Strategies	<p>Watershed Planning - The Authority (Rideau Valley Conservation Authority) commits itself to coordinate the preparation of watershed management plans for the Rideau River and all tributary watersheds.</p> <p>Cooperative Resource Management - The Authority commits itself to developing partnerships with other government agencies, non-government organizations and community groups to achieve integrated resource management on a watershed basis.</p> <p>Conservation Awareness - The Authority commits itself to increasing public and political awareness of the importance of conservation throughout the watershed.</p>
Rural Wastewater Management Study - City of Ottawa	2004	M-R SPR & City of Ottawa (out of study area)	Recommendations	<p>Conventional and alternative on-site sewage systems should be regarded as viable and flexible permanent solutions to rural servicing challenges, provided appropriate management structures are in place.</p> <p>Public education initiatives should be included in the implementation of any City programs involving on-site servicing.</p> <p>The village characterization and servicing approaches developed in this document should be used, along with the problem and high risk areas identified, as background information for approvals processes, environmental assessments and / or detailed design stages.</p> <p>Communal (shared) systems should be considered: when site conditions restrict the use of individual systems; in existing problem areas where individual systems are proven to be impractical; for the development of two to five units in cases where the property, including the units, has single ownership; for institutions, such as schools and seniors' homes. In such cases an agreement must be entered into between the City and the proponent; in Public Service Areas as identified in Community Design Plan and / or Class Environmental Assessment processes.</p> <p>As per the recommendations of the Walkerton inquiry, rural water quality data should be coordinated on a watershed or sub-watershed basis, for purposes of source management and environmental protection.</p> <p>The technical review provided in this study should be used as a reference reflecting the current state of on-site servicing technology.</p> <p>The Ottawa Septic System Office of the Rideau Valley Conservation Authority should: be contracted out for long term contracts of at least five years; be required to provide annual accountability reporting.</p> <p>The risk model should be applied to the rural villages not included in this study (i.e. Cumberland, Manotick and Metcalfe); subsequently, the model should be applied to non-village areas.</p> <p>An On-site System Management Program should be implemented including: a re-inspection program, a septic tank pump-out program, septage management, database management and public industry education.</p> <p><i>Program Administration:</i> A re-inspection program should be administered by the Ottawa Septic System Office of the Rideau Valley Conservation Authority.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p><i>Re-inspection Program:</i> Implement a three component re-inspection program: <i>Component 1 - Visual (Risk-Based Prioritization).</i> Implement a visual re-inspection program commencing with high-risk areas (village prioritized by the Risk Assessment Model). Inspections are to be carried out by the Ottawa Septic System Office. <i>2005-2018 with 2,300 systems / year</i>; <i>Component 2 - Property Transfer.</i> Implement a voluntary comprehensive re-inspection program at time of property transfer to be conducted by the private sector. <i>(Commencing in 2006)</i>; <i>Component 3 - Regular Frequency.</i> Implement a comprehensive re-inspection program of new and replacement systems every 4 years. Inspections are to be carried out by the Ottawa Septic System Office. Mandate septic tank risers on all new and replacement systems (by-law required) as well as take Global Positioning System (GPS) coordinates of the tank and leaching bed lines. <i>(Commencing in 2009 with 600 systems / year)</i></p> <p><i>Septic Tank Pump-out Program:</i> Implement a mandatory septic tank pump-out program with a frequency of four years to be administered by the Ottawa Septic System Office. Haulers would be required to report septic tank pump-outs to the OSSO including: location, date, volume, type of tank (septic / holding), and disposal site. <i>(Commencing in 2006)</i></p> <p><i>Cost Recovery:</i> Recover program administrative costs (including education and enforcement) and Ottawa Septic System Office inspection costs through a 'water protection fee' levied on properties with on-site wastewater systems. Inspections conducted by the private sector at time of property transfer and tank pump-outs should be contracted directly between the homeowner and the service provider.</p> <p><i>Enforcement:</i> Enforcement of faulty on-site systems can only be carried out by the Ottawa Septic System Office under the authority of the Building Code Act. The re-inspection program should include a budget for time and legal expenses arising from enforcement of the Building Code Act. A by-law to establish the re-inspection program may include fines and other measures to enforce non-compliance of an order to have a tank pumped-out.</p> <p>The risk model assessments should be updated and calibrated as data from system inspections becomes available.</p> <p>The template for 'Lot Sizing Reference Guidelines' provided in this report should be considered as background information for the City in the refinement of its Official Plan and design approval process. The City should consider the possibility of issuing proponent (applicant) guidelines to improve the technical validity and consistency of development applications.</p> <p>It is recommended that a Rural Wastewater Steering Committee be formed to oversee and provide direction for the implementation of the Rural Wastewater Management Model.</p>
Sawmill Creek Subwatershed Study Update	2002	RVCA (City of Ottawa)	Water Management Strategy (WMS)	<p>Existing Stormwater Management (SWP) Ponds - Improvements to the existing Hunt Club ridge SWM pond and to the Transport Canada SWM facility.</p> <p>Control Sources of Storm-Sewer Pollution - Intensified monitoring of storm sewers outfalls coupled with investigative efforts in upstream pipes when problems are identified.</p> <p>Control Sources of Storm-Sewer Pollution - Continued public education efforts.</p> <p>Land Development Approval Reviews - Integrated review of development applications in the watershed to ensure compliance of the development proposals with the goals and objectives recommended in the Watershed Study.</p> <p>Flow Diversion and Constructed Wetland Facility - Construct high-flow diversion from the main stem of Sawmill Creek near Cahill Drive, to divert flow westward to available open land between rail corridor and Airport Parkway.</p> <p>Flow Diversion and Constructed Wetland Facility - Construct multi-cell wetland facility on this available land parcel. Wetland will receive flow from the flow diversion in the creek, as well as all flow from the Cahill tributary. Wetland outflow will be conveyed to main stem of Sawmill Creek upstream of the Airport Parkway off-ramp to Walkley Road.</p> <p>End-of-Creek Disinfection Facility - Construct a disinfection facility at the mouth of Sawmill Creek to control bacteria load released to the Rideau River during the summer months.</p>
			Valley Lands Management Strategy (VLMS) Recommendations	VLMS recommendations are described for the specific reaches within the watershed.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			VLMS - Reach 1 Recommendations	<p>Reach should be viewed as primarily a flow conveyance route that supports aquatic habitat; ravine must be kept structurally sound, to ensure it continues to safely convey drainage from upstream areas. The ravine should be left "as is", rather than be developed as a recreational area.</p> <p>Modify Bank Street culvert to remove blockage to upstream fish passage.</p> <p>Correct erosion of shale banks and old rip-rap. Geotechnical investigations are recommended to assess the extent of the erosion of shale banks and the extent of grouted rip-rap in the channel that is in need of repair, to identify the level of risk of adjacent property damage, and to implement the appropriate repair or rehabilitative works where required.</p> <p>Monitoring of sewer systems should continue and be intensified if possible.</p>
			VLMS - Reach 2 Recommendations	<p>Minimize further urban intrusions into and across this reach, given its value to wildlife and as urban greenspace. Control stormwater contamination.</p> <p>Conduct geotechnical evaluation of current slope conditions. Where safety risk is found, examine options for structural slope stabilization.</p> <p>Plant tree cover on the west side of creek, including west side of Airport Parkway.</p> <p>Beaver management could be considered as an option for improving aquatic habitat and water quality.</p> <p>Modify low-flow channel to improve aeration.</p> <p>Work towards establishing a continuous bicycle / pedestrian route alongside creek corridor, with route chosen and designed to preserve natural character of the ravine.</p>
			VLMS - Reaches 3 & 4 Recommendations	<p>Improve habitat conditions and strive for a more natural corridor.</p> <p>Given proximity of residential and shopping areas, work towards developing bicycle paths / walkways along reach, to provide connections to the north and south, and to the west of Airport Parkway.</p> <p>Revegetate where creek shading and cover is minimal.</p> <p>Modify channel to improve aquatic habitat via creation of riffles.</p> <p>Acquire property / easements for bicycle / pedestrian routes through vacant land west of Bank Street, ideally as part of creek re-alignment.</p>
			VLMS - Reach 5 Recommendations	<p>Minimize further intrusions into the creek valley.</p> <p>Not allow increase in peak flows entering the creek from upstream or from adjacent lands.</p> <p>Improve shading and tree cover alongside creek channel.</p> <p>Improve instream aquatic habitat.</p> <p>Promote public appreciation of creek's function and impact of local urban area and human use on the creek and corridor.</p> <p>Construct riffles to improve low-flow aquatic habitat and aeration.</p> <p>Plant trees and shrubs along western edge of creek to reduce water temperature fluctuations and generally reduce water temperature.</p> <p>New development must ensure no increase in downstream peak flows or erosive impulse, and must be designed to maintain annual and seasonal volumes of water-table recharge through specific site-design measures.</p> <p>Monitor all storm-sewer outfalls. For contaminated outfalls, investigative tributary storm drainage systems for illegal or improper connections.</p>
			VLMS - Reach 6 Recommendations	<p>Ensure that land-use changes do not adversely change watershed hydrology or runoff quality. Place emphasis on maintaining water-table recharge; preferred method is distributed site-by-site measures. NCC review of proposed changes in use of Federal lands should address these requirements and should again address the potential impact that loss of tree cover can have on runoff generation, infiltration, sediment transport and water quality.</p> <p>Construct riffles along the creek, to enhance aquatic habitat; Lester Road to Blossom Park Mall is the stretch most requiring remediation.</p> <p>Plant trees and shrubs along west side of creek downstream of Lester Road to help reduce local stream temperature and temperature fluctuations.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			VLMS - Reach 7 Recommendations	<p>New roadways and urban developments must be designed to ensure no increases in peak flows or erosive impulses downstream along creek.</p> <p>Monitor Transport Canada SWM pond, to determine need for improvement.</p> <p>Investigate any known sources of contaminants from the Airport.</p> <p>Minimize loss of forest cover with development.</p> <p>As for Reach 6. Emphasis on need to maintain water-table recharge in this headwaters area, and to ensure that new development does not increase flow rates or erosive impulses along the Cahill tributary.</p> <p>Investigate reported pollution &amp; potential pollution sources along Cahill tributary. Also, coordinate routine inspection and clean-out of debris.</p> <p>New development must ensure no increase in peak flow rates or erosive impulse downstream along the Cahill tributary, and ensure that water-table recharge will be maintained over each development site.</p>
Sawmill Creek Watershed Study, Study Report	1994	RVCA (Ottawa)	Water Management Strategy	<p>Improve the existing stormwater management ponds.</p> <p>Continue and intensify storm-sewer pollution source control.</p> <p>Implement a checking mechanism in the land development approval process to ensure that all new development site plans incorporate measures to: maintain water table recharge; control pollutants at source; minimize runoff volumes; ensure no increase in downstream peak flows or erosion rates.</p> <p>Construction of the creek re-alignment (between Cahill and Walkley) incorporating wetland and pool features to improve water quality and incorporate adequate live runoff storage to control downstream erosion.</p> <p>Construction of an end-of-creek summertime disinfection facility.</p>
			Valley Lands Management Strategy	<p>Reach 1 - General Recommendation - Reach should be viewed as primarily a flow conveyance route that supports aquatic habitat; ravine must be kept structurally sound, to ensure it continues to safely convey drainage from upstream areas. The ravine should be left "as is", rather than be developed as a recreational area.</p> <p>Reach 1 - Specific Recommendations - Modify Bank Street culvert to remove blockage to upstream fish passage; Correct erosion of shale banks and old rip-rap. Start with review options presented in earlier investigations. Continued erosion may pose a definite safety risk; Monitoring of sewer systems should continue and be intensified if possible.</p> <p>Reach 2 - General Recommendations - Minimize further urban intrusions into and across this reach, given its value to wildlife and as urban greenspace. Control stormwater contamination.</p> <p>Reach 2 - Specific Recommendations - Conduct geotechnical evaluation of current slope conditions. Where safety risk is found, examine options for structural slope stabilization; Plant tree cover on the west side of creek, including west side of Airport Parkway; Beaver management program should be initiated; Modify low-flow channel to improve aeration; Work towards establishing continuous bicycle / pedestrian route alongside creek corridor, with route chosen and designed to preserve natural character of the ravine.</p> <p>Reaches 3 &amp; 4 - General Recommendations - Improve habitat conditions and strive for a more natural corridor; Given proximity of residential and shopping areas, work towards developing bicycle paths / walkways along reach, to provide connections to the north and south, and to west of Airport Parkway.</p> <p>Reaches 3 &amp; 4 - Specific Recommendations - Revegetate where creek shading and cover is minimal; Modify channel to improve aquatic habitat via creation riffles; Acquire property / easements for bicycle / pedestrian routes through vacant land west of Bank, ideally as part of creek re-alignment.</p> <p>Reach 5 - General Recommendations - Minimize further intrusions into the creek valley; Not allow increase in peak flows entering the creek from upstream or from adjacent lands; Improve shading and tree cover alongside the creek channel; Improve instream aquatic habitat; Promote public appreciation of creek's function and impact of local urban area and human use on the creek and corridor.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Reach 5 - Specific Recommendations - Construct riffles improve low-flow aquatic habitat and aeration; Plant trees and shrubs along western edge of creek to reduce water temperature fluctuations and generally reduce water temperature; New development must ensure that no increase in downstream peak flows of erosive impulse, and must be designed to maintain annual and seasonal volumes of water-table recharge through specific site-design measures; Monitor all storm-sewer outfalls. For contaminated outfalls, investigate tributary storm drainage systems for illegal or improper connections.</p> <p>Reach 6 - General Recommendations - Ensure that no land-use changes do not adversely change watershed hydrology or runoff quality. Place emphasis on maintaining water-table recharge; preferred method is distributed site-by-site measures. National Capital Commission (NCC) review of proposed changes in use of Federal lands should address these requirements and should again address the potential impact that loss of tree cover can have on runoff generation, infiltration, sediment transport and water quality.</p> <p>Reach 6 - Specific Recommendations - Construct riffles along the creek, to enhance aquatic habitat; Lester Road to Blossom Park Mall is the stretch most requiring remediation; Plant trees and shrubs along west side of creek downstream of Lester Road to help reduce local stream temperature and temperature fluctuations; New roadways and urban developments must be designed to ensure no increases in peak flows or erosive impulses downstream along the creek; Monitor Transport Canada stormwater management pond, to determine need for improvement; Investigate any known sources of contaminants from the Airport.</p> <p>Reach 7 - General Recommendations - As for Reach 6; Emphasis on need to maintain water-table recharge in this headwaters area, and to ensure that new development does not increase flowrates or erosive impulses along the Cahill tributary.</p> <p>Reach 7 - Specific Recommendations - Investigate reported pollution &amp; potential pollution sources along Cahill tributary. Also, coordinate routine inspection and clean-out of debris; New developments must ensure no increases in peak flowrates or erosive impulse downstream along the Cahill tributary, and ensure that water-table recharge will be maintained over each development site.</p>
Shirley's Brook and Watts Creek Subwatershed Study	1999	MVCA (City of C	Public Sector (PS) Initiatives - Natural Area	<p>Natural Area Management Changes - The City of Kanata is to consider the recommended Official Plan policy changes in the development of their new Official Plan.</p> <p>Protection / Restoration of Aquatic Habitat - The City of Kanata is to ensure that developers are aware of the recommended aquatic development setbacks.</p> <p>Protection / Restoration of Aquatic Habitat - The City / MVCA should work with developers where proposed development lands include reaches of degraded aquatic habitat. For other priority areas, the City / MVCA should develop site specific action plans with the assistance of landowners and local interest / community groups. For federally owned lands, the NCC is to lead the initiative. These action plans will need to detail required in-stream works as well as cost estimates so that appropriate funding can be raised.</p> <p>Protection / Restoration of Terrestrial Habitat - The City of Kanata should embark on a program to secure the priority woodland / wetland areas. These lands may be secured through land dedication as lands are developed or if necessary, through purchase or means of securement. As there are presently no mechanisms to prevent the clearing of these areas by landowners, this initiative should be acted upon as soon as possible. As well, for those woodlands that are degraded, with landowner co-operation / incentives, these areas should be restored / enhanced. It is assumed that lands under federal ownership would be appropriately managed by the NCC.</p>
			PS Initiatives - Flood Management	<p>Revise / Update and Extend Flood Mapping - Update and extend floodplain mapping for both Shirley's Brook and Watts Creek.</p> <p>Hydraulic Structure Improvements - Hydraulic structure improvements should be undertaken as part of road structure upgrade works.</p> <p>Flood Policy Updates - The local and Region Official Plans are to be updated / amended to recognize changes to the floodplain once floodplain mapping is updated.</p>
			PS Initiatives - Erosion Management	<p>Erosion Prevention Works - The City / MVCA should work with developers to restore channels where proposed development lands include reaches susceptible to erosion. For other areas, the City / MVCA should develop site specific action plans with the assistance of landowners and local interest / community groups.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Policy Update to Reflect Meander Belt - The local and Region Official Plan are to be amended to incorporate the limits of the meander belt for areas identified within the Shirley's Brook / Watts Creek Subwatershed. These areas are to be designated as natural hazard lands and regulated appropriately through the Region, City and MVCA.
			PS Initiatives - Groundwater Quantity and Quality Management	Groundwater Policy Changes - The City of Kanata should consider the adoption of the groundwater management recommendations when updating their Official Plan.
			PS Initiatives - Agriculture and Rural Land Management	Farmer / Landowner Education - The MVCA is to promote agricultural and rural best management practices.
			PS Initiatives - Urban Storm Water Management	Existing Urban Storm Drainage System Inventory - City of Kanata to undertake an inventory of the "micro drainage" system for developed areas.
				Storm Sewer Outfall Water Quality Sampling - Region should initiate a water quality sampling program with City assistance.
				Identifying Opportunities to Retrofit Parks and Open Spaces - City to identify opportunities for retrofitting of parks and open spaces.
				Integrate Source Control Measures During Road / Sewer Reconstruction - City to ensure that these integration opportunities are pursued.
				Retrofit Buildings with Roof Leaders Connected to Storm / Sanitary Sewers - City to encourage retrofitting of buildings with roof leader connections to storm / sanitary sewers.
				Consider the Requirements for Oil / Grit Separators for Storm Sewers Draining Commercial Areas - City to advise an appropriate use of oil / grit separators.
			Municipal Maintenance Program Review - City to undertake a review of existing municipal maintenance program.	
			Community and Corporate Involvement	Encourage community and corporate involvement through public awareness building programs.
				Encourage communities to become involved in natural area restoration efforts with the assistance of local interest groups.
				Introduce land stewardship programs through the preparation of Conservation Farm Plans and landowners initiatives to incorporate agricultural / rural best management practices for soil conservation, chemical management, waste management, forestry and habitat management.
				Incorporate information on local watersheds and the methods of environmental rehabilitation in local school curricula.
			Implications for Developers - Natural Area Protection	No development is permitted in Natural Areas W3 and W5 (Stony Swamp), S26 and W17 (Shirley's Bay). These areas are currently protected through Official Plan designations.
				Appropriate setbacks for watercourses should be recognized based on the habitat type (see Figures 2.1a and 2.1b) as well as the criteria presented in Section 7.2.3.1 of the Subwatershed Study Report.
				The harmful alteration or destruction of fish habitat cannot occur without approval under the <i>Federal Fisheries Act</i> and the preparation of a fish compensation plan.
				Low order streams should be preserved, where possible, and not enclosed.
				For Type 3 (i.e. poor) habitat reaches (particularly the high priority areas presented in Table 7.1 of the Subwatershed Study Report), opportunities to restore these reaches as part of development proposals shall be investigated.
				High priority woodlands (Table 7.2 in the Subwatershed Study Report and Figures 2.2a and 2.2b) should be protected as much as possible.
				Environmental Impact Statements shall be prepared (an Individual EIS based on Region EIS Guidelines or as part of an EMP) in situations where natural heritage features located in the subwatersheds are potentially affected by development. These areas include: areas of fish habitat; significant wetlands; significant woodlands; significant valley lands; significant areas of natural and scientific interest; and adjacent lands to significant wetlands south and east of the Canadian Shield (Stony Swamp and Shirley's Bay)
				These natural areas are presented in Figures 2.2a and 2.2b.



## Table A-1

### Previous Study Recommendations

#### Proposed Mississippi-Rideau Source Water Protection Region

Previous Study	Date	Watershed Area	Topic	Recommendation
			Implications for Developers - Flood Control	<p>No development and no fill should be located in the 100 year flood plain (to be based on updated floodplain mapping). Development or fill within the regulated flood and fill lines is subject to approval by the MVCA and the City, and may require a hydrogeological report to determine proposed impacts and measures to eliminate any environmental hazard.</p> <p>Runoff from new developments should control post development peak flows for the 2 to 100 year event to pre-development levels. Where no flood lines are available, the 100 year flood line should be defined and development or fill should be kept outside the computed line.</p>
			Implications for Developers - Groundwater Protection	<p>A minimum lot size of 4 ha in areas underlain by Precambrian rock is recommended. Any reduction in size below the minimum is subject to a site specific groundwater study. A minimum lot size of 0.8 ha is recommended in the Nepean / March / Oxford Formation. Any reduction in size below the minimum is subject to a site specific groundwater study. Individual lot septic systems should be located downgradient with respect to water supply wells with a minimum distance separation of 60 m.</p>
			Implications for Developers - Urban Storm Water Management	<p>The use of stormwater management practices based on a hierarchy of source, conveyance and end-of-pipe measures are to be considered for all new urban development. Applicable practices have been summarized for each catchment area within the subwatershed area. Minimum levels of treatment and control requirements for water quality, streambank erosion and flood control have been established. Recommended targets are to be applied on a subwatershed-wide and catchment area level. Erosion and sediment guidelines for consideration during construction activities have been included for use on a subwatershed-wide basis. Site drainage and servicing guidelines have been developed including storage facility design criteria and end-of-pipe construction phasing alternatives.</p>
Shoreline Classification Project, 2003 Report	2004	RVCA (Lanark, Leeds & Grenville and Ottawa)	Recommendations	<p>The 2003 Study Area can be split into two distinct reaches. Becketts Landing splits these two stretches. Land use, terrestrial vegetation, and erosion show significant decreases upstream and downstream from this location.</p> <p>One could characterize the reach closer to Ottawa (Maps 1 to 13) as being heavily developed with relatively small, residential properties. Slope is lower and there is much more groomed grass cover than along the upper stretch. There are many properties below Becketts Landing that provide good habitat through diverse terrestrial and aquatic vegetation cover. However, clusters of residential properties fragment these examples of good habitat. This removes continuity in valuable wildlife corridors.</p> <p>Above Becketts Landing (Maps 16 to 38) the properties become larger, slopes increase and land uses change. Agricultural properties are concentrated into this reach.</p> <p>General recommendations, derived from the 2003 study results, are different for the above mentioned reaches, upstream and downstream from Becketts Landing. Closer to the City of Ottawa, river health initiatives should focus on residential properties, whereby landowners in this area are provided with further information about improving the ecological viability of their shoreline properties and the health of the Rideau River. Informing landowners and facilitating change in shoreline practices and attitudes will benefit both the watercourse and its shoreline landowners. The Landowner Resource Centre (LRC), accessible in Manotick and on the internet, offers extensive resources for ecological waterfront property management. The Lower Rideau Watershed Strategy (LRWS) Questionnaire results showed the use of available brochures and self help methods for naturalization as the most likely action to be taken by landowners (Billington 2003).</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Further upstream, the scale of river health initiatives needs to be much larger. The erosion problems associated with increased slopes and agricultural land uses reach across many properties. Livestock accessing the river for watering purposes, is another issue concentrated in this reach. Both the City of Ottawa and the Rideau Valley Clean Water Programs are designed to assist landowners with on-site erosion control and water quality projects. Grants and technical assistance are offered to qualifying landowners. The overall health of the watershed depends on programs such as these. Continued funding and implementation will give landowners the help they need to minimize land use impacts in water quality and increase shoreline habitat viability.
Shoreline Classification Project, 2004 Report	2005	RVCA (Lanark and Leeds & Grenville)	Recommendations	<p>Moving further upstream from the City of Ottawa one would certainly expect shoreline characteristics to change. The most significant differences identified in this report can be attributed to the presence of large, provincially significant wetlands (PSW) on the Rideau River and Kemptville Creek. With 102 of 408 properties falling within or partially within PSWs, their impact cannot be ignored. More PSW cover than the 2002 and 2003 study areas increased percent frontage of natural classification, emergent aquatic vegetation, natural environment land use and riparian canopy. All of these attributes are extremely important to watercourse health.</p> <p>In the 2003 report it was mentioned that two different courses of action should be taken for river health initiatives. The issues impacting properties on the Rideau River upstream from Becketts Landing stretched across many properties. Erosion there was caused by widespread agricultural lands and increased slopes. No such areas could be identified in 2004.</p> <p>Suggestions for the reach closer to the City of Ottawa involved providing landowners with the resources they need to make decisions that benefit the river. This holds true for the entire 2004 study area. Landowners need to be given opportunities to inform themselves about watercourse related issues. With a wealth of information offered at the LandOwner Resource Centre (LRC) acting as a base for the public to draw from, other programs may be used to educate the public. Programs like the Rideau Valley Conservation Authority's (RVCA) tree planting program and Rural Clean Water Program provide a chance for this. Further, the RVCA is looking to consult the public on community-based volunteer watershed monitoring in early 2005. This will be a great avenue for the public to learn about the issues and participate in watershed monitoring and rehabilitation. The data collected in this study may be used to identify areas of concern and / or possible monitoring locations.</p> <p>The identified PSWs in the 2004 study area are candidate sites for a RVCA wetland monitoring program. Using more intensive methods than those used in this study, water quality, habitat quality and biodiversity would be monitored. Parks Canada and the Ecological Monitoring and Assessment Network (EMAN) are currently developing a Wetland Monitoring Suite. This suite of protocols provides a relatively simple and cost effective methodology to monitor wetland health. The first field sampling took place for a program like this in the early fall of 2004. The RVCA, South Nation Conservation and the Ontario Ministry of the Environment collaborated on a pilot project for invertebrate sampling in wetlands. This initial data will help decision makers assess the feasibility of adopting the suite of wetland monitoring protocols.</p>
Soils and Hydrogeologic Investigation of PCE and Petroleum Contamination, Village of Manotick, Final Report	1994	RVCA (Ottawa)	Conclusions	Based on the results of work completed in this study and described in this report we offer the following conclusions: 1) The hydrogeologic setting of the Manotick study is comprised of five hydrostratigraphic units from surface to depths include: Upper Aquitard of low permeability till, silt and clay averaging 5 m thickness; Upper Aquifer of high permeability basal till (where present) and fractured upper Oxford Formation dolostone averaging 13 m thickness; Lower Aquitard of low permeability lower Oxford Formation and upper March Formation dolostone averaging 15 m thickness; Lower Aquifer of high permeability lower March Formation sandy dolostone and upper Nepean Formation sandstone averaging 6 m thickness; Deep Nepean Formation sandstone of moderate to high permeability averaging 40 m thickness. Groundwater flow within the aquitards is primarily vertical whereas groundwater flow in the aquifers is primarily horizontal and to the north. The Upper Aquifer discharges to the Rideau River and the Lower Aquifer likely discharges to the Rideau River. Groundwater flow in the Lower Aquifer near the River is less certain than in the Upper Aquifer.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 1 cont.) The potential exists for flow in the Lower Aquifer to occur below the River toward domestic wells on Long Island as well as to unserviced areas to the west. 2) Both the Upper and Lower Aquifers are used as water supplies for private wells and communal wells in the Manotick area. Approximately 20% of the wells abandoned in the Manotick serviced area intersect the Lower Aquifer. The Lower Aquifer is approximately 16 times more permeable than the Upper Aquifer.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 3) Both the Upper and Lower Aquifers are contaminated with perchloroethene (PCE) and benzene above drinking water guidelines. The deep Nepean Formation sandstone may also be contaminated although it has not been tested in this study. The PCE plumes are larger than the benzene plumes. The Upper Aquifer contains one large PCE plume with a source at 5545 Main Street, one small PCE plume with a tentative source at 5576 Main Street and one PCE anomaly near Home Hardware with a likely localized source. The Lower Aquifer contains the same large and small PCE plumes with two PCE anomalies located at 5641 Whitewood Avenue and 5598 Eastman Avenue. The two PCE anomalies in the Lower Aquifer likely have localized but unknown sources and are not thought to be related to either the large or small PCE plumes. Two benzene plumes exist in the Upper Aquifer with sources near 5549 Main Street and 5549 Ann Street and near 5521 and 5527 Main Street. One benzene plume exists in the Lower Aquifer from a source near 5547 and 5549 Main Street.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 4) PCE contaminated soil exists primarily in the area of 5545 Main Street, the former Manotick Cleaners. Low levels of PCE in soil were also detected near Quality Cleaners and Home Hardware in the Manotick Mews. 5) The available soil and groundwater data strongly suggest that PCE as dense non-aqueous phase liquid (DNAPL) exists in soil and bedrock in the immediate vicinity of the former Manotick Cleaners building. This DNAPL likely extends to depths of about 40 m. Petroleum as light non-aqueous phase liquid (LNAPL) was detected as floating product in overburden and bedrock wells at 5549 Main Street and is suspected, based on soil quality data, to exist at residual saturations at 5549 Ann Street and 5527 Main Street. 6) The available water quality data indicate that degradation of PCE is likely occurring in groundwater at Manotick, and that PCE, and not its potential degradation products is currently the contaminant of concern.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 7) Three-dimensional numerical simulation of migration of PCE in groundwater suggests that plume migration in the Upper and Lower Aquifers may reach steady-state conditions and the Rideau River by about 1993 and 2003, respectively. PCE discharge to the Rideau River is expected to result in insignificant concentration levels in the river water that are more than a million times lower than available standards for the protection of freshwater aquatic life. Sampling of the Rideau River water confirms these simulations with no detected levels of PCE found.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 8) Numerical simulations also suggest that the continued operation of private wells outside of the serviced area may result in PCE plume migration within the Lower Aquifer to private wells west of the serviced area and to Long Island. Simulations suggest PCE migration to Long Island may occur by 1998. There is uncertainty in this migration potential due to uncertainty in the vertical hydraulic properties of the Lower Aquifer below the Rideau River, hydraulic heads within the Lower Aquifer and the number, location and pumping rates of private wells intersecting the Lower Aquifer. Additional monitoring wells are required to reliably determine this potential for migration. 9) Simulations also show that continued operation of the heat pump extraction well at 5544 Dickenson Street is likely to result in migration of the PCE plume in the Lower Aquifer to the extraction well within five years and will also increase the potential for migration of the PCE plume to the Rideau River and below the Rideau River to Long Island.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 10) Available data indicate that the existing communal wells at Hillside Gardens are too distant from the existing and likely future PCE plumes for there to be any significant threat of contamination of these wells by PCE. However future development of additional communal wells at Hillside Gardens and at other locations in Long Island should be assessed for PCE contamination potential based on proposed location and pumping rate. 11) Numerical simulations show that the increased consumption of water resulting from piped supply will not significantly influence PCE plume migration. However the increased discharge to septic systems is expected to increase the frequency of septic system failures as breakouts and effluent discharges to drainage ditches.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 12) Based on a risk-based pathway assessment, PCE contaminated groundwater within the serviced area poses negligible risk to the Rideau River and to residents within the serviced area. Our risk assessment further shows that soil with PCE above 20 µg/g and 65 µg/g may pose a health risk to occupants of residential or commercial buildings, respectively, constructed above the contaminated soil. Comparison of the available soil quality data (maximum PCE concentration of 60 µg/g) to cleanup criteria indicates that active remediation of PCE contaminated soil is not required as there does not appear to be human health risks posed by identified soil contamination. However soil quality below the former Manotick Cleaners building has not been determined.</p>
				<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 13) At sites like Manotick, where DNAPL is assumed to be present in the subsurface, remediation should focus on direct removal of residual and pool DNAPL and / or interception of dissolved PCE plumes. Currently there are no proven technologies for direct removal of DNAPL from bedrock below the water table. Consequently the most appropriate active remedial method for PCE contaminated groundwater is interception of dissolved PCE plumes using a groundwater pump-and-treat system. Such a system would consist of a series of vertical pumping wells screened across the Lower Aquifer with collected groundwater treated at surface likely using an enhanced oxidation process. Although this is the most appropriate containment and treatment technology for the dissolved PCE plumes, uncertainty in the maximum depth of PCE contamination and in the potential for PCE migration within the Lower Aquifer to private wells in nonserviced areas, prevents detailed design of such a system at this time.</p>
			Recommendations	<p>Based on the results of work completed in this study and described in this report we offer the following conclusions: 14) Given the uncertainty in PCE plume migration potential in the Lower Aquifer, expansion of the existing monitoring well network is the most appropriate remedial action for the Manotick site at this time. This expanded monitoring well network will provide supplementary hydrogeologic data to refine the potential for PCE migration in the Lower Aquifer to private wells in surrounding nonserviced areas.</p>
				<p>In light of the above conclusions and the Ministry of the Environment and Energy (MOEE) terms of reference for this study. We make the following recommendations: 1) Soil quality testing of soil located below the former Manotick Cleaners building at 5545 Main Street should be completed to provide a more complete characterization of soil quality at Manotick. If such testing cannot be completed, then air quality testing of ambient indoor air within the building should be performed to ensure safe levels for occupants. Such testing should be completed at least once in summer and once in winter. 2) Supplementary drilling, testing, installation and sampling of seven bedrock multilevel monitoring wells is required to address issues of PCE migration in the Lower Aquifer, to define the maximum depth of PCE contamination in bedrock and to expand the permanent long-term monitoring well network.</p>
				<p>In light of the above conclusions and the MOEE terms of reference for this study. We make the following recommendations: 3) The long-term monitoring well network should include all intervals within the existing ten bedrock monitoring wells and within the proposed seven supplementary bedrock monitoring wells as well as operating heat pump extraction wells. Monitoring should include measurement of water levels and collection and analysis of groundwater samples for PCE, trichloroethene (TCE), dichloroethene (DCE) isomers and vinyl chloride (VC) on a semi-annual basis for five years. The monitoring program and PCE plume evolution should be reassessed at the end of this five year monitoring period.</p>
				<p>In light of the above conclusions and the MOEE terms of reference for this study. We make the following recommendations: 4) Detectable concentrations of PCE in bedrock monitoring wells installed near the edge or outside of the serviced area, would indicate PCE migration towards private wells in the unserviced area and trigger a contingency plan. This contingency plan includes repeat sampling, increased sampling frequency, implementation of quarterly sampling of potentially affected private wells, and assessment of implementation of more active remedial measures. Such active remedial measures would likely include a groundwater pump-and-treat system to intercept dissolved PCE plumes. 5) The groundwater-source heat pump extraction well at 5544 Dickenson should cease operation because it increases spreading of the PCE plume, loading of PCE to the Rideau River and the potential for migration of PCE within the Lower Aquifer to Long Island.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
Supplementary Bedrock Hydrogeologic Investigation of PCE Contamination, Village of Manotick, Final Report	1996	RVCA (Ottawa)	Conclusions and Recommendations	The results of the supplementary bedrock hydrogeologic investigations of perchloroethene (PCE) contamination described in this report indicate the following conclusions: 1) The bedrock hydrogeologic conceptualizations of groundwater flow and PCE transport developed in the 1994 study are generally supported by the results of the supplementary investigations. 2) The PCE plume in the Upper Aquifer decreased in size from 1993 to 1995, although the PCE concentrations in the source area (i.e. 5545 Main St.) remained relatively stable. The decrease in plume size may be due to PCE degradation and / or elimination of earlier plume spreading caused by pumping of former private wells in the serviced area. The PCE plume in the Upper Aquifer continues to discharge to the Rideau River with resultant insignificant PCE levels in the river.
				The results of the supplementary bedrock hydrogeologic investigations of PCE contamination described in this report indicate the following conclusions: 3) The front of the PCE plume in the Lower Aquifer decreased in width but increased in size and concentration reflecting plume movement from 1993 to 1995. The PCE concentrations in the source area of the Lower Aquifer decreased significantly from 1993 to 1995. The dramatic reduction of PCE concentrations in the Lower Aquifer suggests that PCE dense non-aqueous phase liquid (DNAPL) may not be present in the Lower Aquifer and that PCE was introduced to the Lower Aquifer by groundwater flow via deep open wells near the PCE source area. The front of the PCE plume in the Lower Aquifer has migrated to below the Rideau River. 4) The PCE plume does not appear to extend much deeper than about 40 m or significantly into the permeable underlying sandstone of the Nepean Formation. 5) PCE has not been detected in either the Upper Aquifer or the Lower Aquifer in monitoring wells constructed on Long Island.
				The results of the supplementary bedrock hydrogeologic investigations of PCE contamination described in this report indicate the following conclusions: 6) The available data indicate that there is no significant potential for PCE plume migration in the Upper or Lower Aquifers westward to non-serviced areas. 7) Water level data and numerical modeling of PCE plume migration in the Lower Aquifer indicate that there remains potential for PCE plume movement to private wells on Long Island within the next 2 to 3 years. The new data collected and generated in this supplementary hydrogeologic investigation raise this potential to probable from the possible described in the 1994 study report.
				In light of the above conclusions, we make the following recommendations: 1) Further hydrogeologic drilling and testing are unlikely to further resolve the inherent uncertainty in the potential for plume migration in the Lower Aquifer to non-serviced areas on Long Island. 2) The groundwater monitoring program outlined in the 1994 study report should be implemented such that the next sampling round is conducted May / June of this year.
Tay River Watershed Management	2002	RVCA (Frontenac, Lanark, and	Major Recommendations	Undertake a groundwater study to determine groundwater reserves, dynamics and vulnerability. Groundwater is a major source of drinking water in the Tay watershed.
				Develop and enforce policies to achieve the protection of surface and groundwater quality and groundwater recharge areas in all Official Plans and Zoning By-Laws (sedimentation, mandatory septic system inspection, sewage treatment facilities upgrades, mandatory setbacks from water for development, agriculture and forestry activities, nutrient management planning, Provincial Stormwater Management Practices Planning and Design manual, well upgrades and decommissioning programs (OFA), explore de-icing options to road salt).
				Create a watershed information repository which all watershed stakeholders may access.
				Develop a coordinated communication program to inform all watershed stakeholders about the recommendations of the Plan first of all, and then of stewardship practices, watershed dynamics, watershed events, and other communication vehicles to help protect watershed resources (pesticides, rural land use practices, living by water, shoreline naturalization).
				Develop and promote incentive stewardship programs to encourage farmers to apply best management practices (cattle fencing, erosion control, manure management, alternate watering systems, Environmental Farm Plans, conservation tillage, pesticide/fertilizer management).
				Conduct septic system surveys to ensure proper functioning of all units.
				Continue water quality monitoring of all potential point sources of surface and groundwater quality impairment such as landfill sites, farmlands, industrial sources, sewage lagoons, stormwater outflows.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Continue (and expand where possible) baseline water quality monitoring for surface water and groundwater. Baseline data for a minimum of 10 years will be helpful in establishing water quality trends.
				Consider investigative surface water and groundwater quality monitoring to determine sources and types of impairment if the situation is warranted (Potentially faulty septic systems around lakes, the Perth Sewage Treatment Facility, agricultural lands, businesses, stormwater outfalls).
				Provide a continuous public education program on the proper storage, use and disposal of hazardous material including the promotion of the provincial "Spills Hotline" number to report accidental spills and discharges of hazardous materials.
				Continue macroinvertebrate monitoring of watershed streams to complement baseline chemical water quality data.
				Undertake comprehensive Lake Management Plans for watershed lakes (starting with those which have a lake association) to protect water quality and fish and wildlife habitat, and to determine trends, sources of impairment, inappropriate land use practices, and undertake lakeshore capacity assessment studies.
				Develop a water budget analysis for the watershed identifying all water inputs, sources and outflows through monitoring and modeling.
				Monitor the amount and the movement of water through the watershed through the establishment of a network of flow meters, seepage meters and piezometers including upgrading the streamflow gauge at Perth to collect continuous data, and disseminate the information widely in the community.
				Undertake research to determine the instream aquatic needs in terms of water quantity and water quality in order to determine what constitutes a "healthy" system.
				Inventory, catalogue and maintain a repository of all water takings (including those not requiring a permit) on a watershed basis.
				Monitor the hydraulic effects of beaver dams in the watershed and prepare a Beaver Management Strategy.
				Identify all present water uses and their related operations including dam operations.
				Following preparation of the water budget, define management objectives and set policy for the allocation or "use" of water.
				Explore watershed management options to determine the best way to address water management issues on a watershed basis and thus overcome the perceived issues of poor communication, inadequate coordination and conflicting mandates among water management agencies now working in the watershed.
				Research and full public discussion of the value of water and the cost of water use in the watershed including land values on clean lakes, "free" water in the river, water treatment, cost of degraded ecosystems, cost of remedial actions, "cost" of water in light of climate change and increasing water takings.
				Prepare a Fisheries Habitat Management Plan including assessment of trends, spawning areas, population characteristics and conservation measures needed.
				Protect natural shorelines in all planning processes (setbacks, buffers and zoning) and in agricultural and forestry activities in order to re-establish degraded shorelines by planting native vegetation along the shores of all watercourses (including lakes). Support and participate in MAPLE and its volunteer efforts at shoreline rehabilitation.
				Create a riparian corridor in all planning documents and the means to protect in through conservation easements, private land stewardship and public acquisition.
				Undertake fish population assessment by seine netting and other means.
				Establish and/or support educational materials, a "Home Assist" program, Living by Water, LLGreen, ecoPerth, REAL, stewardship councils, MNR's Guardians of the Watershed program, watershed workshops and demonstration sites to allow landowners to use good stewardship practices and principles in designing and maintaining their private lands.
				Identify critical wildlife habitat areas and linkages in the landscape and devise a management plan to protect and enhance these areas.
				Evaluate all unevaluated wetlands in the watershed.
				Protect all wetlands in the watershed (including those in Canadian Shield area) through appropriate measures in municipal planning documents, private land stewardship incentives, land trusts, public acquisition and potentially through regulations under Section 28 of the <i>Conservation Authorities Act</i> .

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Assess forest resources in the watershed for stand conditions, habitat value, species and age composition, ecological features and significance to overall watershed health.</p> <p>Develop and distribute information regarding the introduction and control of invasive, non-native species to the watershed.</p> <p>Publish and distribute the Tay River Watershed Management Plan.</p> <p>Undertake monitoring and research to determine the assimilative capacity of the river.</p> <p>Establish a watershed monitoring network to collect information on all aspects of the watershed ecosystem.</p> <p>Establish and support the "Friends of the Tay Watershed" group.</p> <p>Encourage and support the establishment of lake associations on lakes which are already not established.</p> <p>Establish a Tay Watershed Discovery Centre in the Town of Perth to provide information and encourage understanding of the watershed, the resources and their protection.</p> <p>Celebrate the watershed through special events and publications.</p> <p>Encourage all agencies, municipalities, residents and interest groups to endorse the Tay River Watershed Management Plan and commit to its implementation as the community guide to protecting the health of the Tay watershed.</p> <p>Support municipalities with information, public support and agency effort to balance the needs for growth, development and protective management of the watershed within their jurisdictions.</p>
Township of North Grenville, Groundwater Management Study	2001	RVCA (Leeds & Grenville)	Conclusions and Recommendations	<p>Nitrate concentrations in groundwater are elevated throughout the study area. Nitrate concentrations in clean groundwater are generally below the detection limit. A concentration above 1 mg/L-N is generally indicative of an anthropogenic impact. A significant number of wells in the Study Area have nitrate concentrations above 1 mg/L-N, confirming an impact from an anthropogenic source.</p> <p>The highest concentrations of nitrate in groundwater occur on and adjacent to the former Valley Sanitation site. Nitrate concentrations in this area are elevated in both the overburden / shallow bedrock and deeper bedrock aquifers respectively.</p> <p>The highest level of impact to groundwater quality was observed at the Cranberry Hill Subdivision and adjacent areas. The impact in this area is considered to be related to individual wells and septic systems in this area. It is not considered to be related to the former operations at Valley Sanitation.</p> <p>A measurable impact on water quality is observed on Phase I of the Oxford Heights subdivision. This impact is considered to be directly related to former operations at Valley Sanitation. Nitrate concentrations appear to be relatively stable over the past ten year period with the majority of wells meeting the 10 mg/L-N drinking water standard. There is no immediate need for corrective action in this area.</p> <p>To ensure the long term protection of groundwater quality in Phase I Oxford Heights, it is recommended that the existing wells on Lots 23 and 25 be properly abandoned and replaced with wells constructed in accordance with the methodology detailed by Gorrell Resource Investigations (GRI) (Appendix "D"). The Township should request that the Ontario Ministry of the Environment (MOE) use their authority under the Environmental Protection and Water Resources Acts to ensure that this work is completed.</p> <p>Development on County Road 18, west of Sommerville Road has measurable water quality impact derived from the Valley Sanitation and / or Cranberry Hill subdivisions. The major problem in this area is bacteriological and therefore, the primary source of the problem is considered to be individual wells and / or septic systems in this area.</p> <p>It is recommended that the residents of Cranberry Hill Subdivision be advised of the issue of water quality in their area. Alternative sources of water supply could include individual well repair/replacement and extension of the municipal water distribution system. A public consultation process to decide the appropriate course of action should be initiated.</p> <p>It is recommended that all future wells in the Study Area be constructed in accordance with the minimum specifications for the Oxford Heights Subdivision as detailed by GRI (Appendix "D").</p> <p>On the basis of information available at this time, development of Phase II Oxford Heights cannot be supported. If consideration is to be given to the development in the future, the developer should conduct a hydrogeological investigation to ensure the long term protection of water quality both in the proposed and existing development.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Development of the proposed Henderson subdivision on private services can be considered subject to the review of a detailed site specific hydrogeological report. Development of this site should, however, consider the long term problem and solution for the adjacent Cranberry Hill subdivision.
United Counties of Leeds and Grenville, Groundwater Management Study	2001	RVCA (Leeds & Grenville) and out of study area	Major Recommendations	<p>The groundwater management strategies outlined should be implemented. These strategies do not have to be implemented all at once but there should be a coordinated approach to an implementation schedule.</p> <p>Various data sources were used throughout the groundwater management study to derive the results that have been presented as mapping, figures, tables and summary statistics throughout the study. Much of this data is being continually expanded and updated. It is recommended that a long term maintenance plan be implemented to maintain the currency of the study deliverables and to facilitate future updates of the groundwater management strategy. A suggested methodology is to use a GIS framework, as described in this report.</p> <p>The inventory of communal water well systems that supply potable water to multi-users should be updated regularly. Considering the age and incompleteness of the data available for use in this study, the existing database should be reviewed by personnel/agencies that are familiar with the local area.</p> <p>Consideration should be given to updating the database of potential contaminated sites on a regular basis. The database that is generated in this study is not exhaustive and will become outdated with time. The database could be expanded to include zoning information for land uses that may pose a risk to groundwater resources.</p> <p>The interrelationship between groundwater and sensitive surface water and wetland receptors should be further investigated. The results of this study identified several water bodies that are considered to have, or suspected to have, a significant base flow component. A detailed evaluation of potentially sensitive surface water features would require a compilation of all quality and quantity information from all municipal and provincial studies, and the generation of surface water quality and quantity database. Further field data collection using seepage meters and thermal data may be required. This database could be used by stakeholders in identifying surface water bodies that are sensitive to groundwater impacts, and may require the implementation of land use controls in their catchment areas.</p> <p>Aquifers vulnerable to contamination were mapped at a scale of 1:400,000. It is recommended that a more refined analysis be conducted, producing mapping at a 1:50,000 scale or larger. Additional data needed for input, beyond what was used in this study, would include non-georeferenced MOE Water Well Records, large-scale geological mapping, aerial photographs, and results from all terrain analysis reports. Additional studies may require collection of field data including pump tests and water quality analyses.</p> <p>It is recommended that delineation of wellhead protection areas be conducted for Westport and Landsdowne. The WHPA study would require collection of data through pump tests and field monitoring, followed by detailed numerical groundwater monitoring. A comprehensive study of the discontinuous esker complex that occurs from Kemptville south to the St. Lawrence River should be completed. This study would define the three dimensional extent of the complex and define the hydrogeological relationships between the esker complex, the adjacent sand plain and the underlying bedrock aquifer. This study would designate areas of the esker complex that should be managed to protect groundwater resources.</p> <p>Data from long-term monitoring of water levels in wells can be used to assess the long-term effects from groundwater usage and meteorological changes. Data collected via the Provincial Groundwater Monitoring Network can be used for this purpose.</p>
			GMS - Coordinated Approach to GW Management and Protection	Develop a United Counties of Leeds and Grenville Official Plan that would provide a coordinated and comprehensive set of groundwater management and protection policies. Under the authority of the <i>Planning Act</i> , lower tier municipalities would be required to amend their Official Plan policies to conform to the policies of the United Counties Official Plan.



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				If a United Counties Official Plan is not adopted, develop groundwater management and protection policies that would act as a guide to lower tier municipalities for inclusion in Official Plan and Zoning By-laws.
			GMS - Small Scale Development - Individual Services	Education program for existing owners of individual services that addresses routine inspection of wells and septic systems, promotes decommissioning of unused wells and replacement of dug wells with new drilled wells; promotes regular testing of wells for indicator bacteria; discourages the use of water softeners in general and promotes proper monitoring of existing water softeners. Digital geo-referenced data base of septic tank approvals. Minimum lot size of 1 ha or water quality testing of adjoining properties if there are less than 5 residences in 5 ha. Inspect the construction of all new potable water wells to ensure MOE well construction requirements are met under O. Reg. 903. Require proof of licensing for well contractor, well technician and plumber. It is estimated that 300 to 400 new wells are constructed per year in the United Counties.
			GMS - Large Scale Development	New development on full communal or municipal services. Promotion of BMP's for communal water supply systems regulated by the OWRA. Promotion of testing and inspection of communal water supply systems not regulated by the OWRA.
			GMS - Municipal Well Systems	Public education and awareness of WHPA's, BMP's, and water conservation. Signage designating WHPA's along roads. Promote decommissioning of unused or abandoned wells including a subsidy of \$500/well to owner. Define WHPA's around municipal wellfields. Spill response review. Installation of sentry wells in WHPA's in areas of existing land use concerns.
			GMS - Commercial and Industrial	Same education programs as homeowners on individual services; promotion to keep non-human waste from septic systems. Require new Category A land uses to submit plans and protocols that protect groundwater and monitoring plan to ensure protection.
			GMS - Agriculture	Promotion of BMP's and Environmental Farm Plans. Promotion, with financial assistance to convert underground fuel storage tanks into above ground tanks. Nutrient Management By-laws.
			GMS - Areas Adjacent to Separated Municipalities	Ask separated municipalities to require new Category A land uses to submit plans and protocols that protect groundwater and monitoring plan to ensure protection.
			GMS - Road Salt Practices	BMP's Study of Road Salt Application in the County to optimize application rates and investigate alternatives to road salt. Use of MTO Corridor Control Policy or existing setback guidelines for County Roads to prevent new residences in areas of road salt application.
			GMS - Data Management / GIS Management	Continuous update of environmental and groundwater quality related database information presented in this study. GIS system management.
Upper Poole Creek Subwatershed	2000	MVCA (City of C	Study Team Recommendations	Alternative 2 - Diversion of the cool baseflow currently being captured by the sewers of the existing Westridge subdivision to the Crossing Bridge sewer. This will prevent this water from being heated in the stormwater management pond and add to the cool water input to the downstream reach. Other options will achieve this but this is the most cost-effective and is supported by the developer. The estimated cost of this work is \$18,000. Alternative 9 - Installation of separate foundation drains in areas of future development to discharge cool water directly to the creek may be feasible in limited areas where the water table is close to the ground. The premium for constructing a "three-pipe" system as opposed to the normal "two-pipe" system (sanitary and storm sewer) is about \$75/m. This cost would be borne by the development proponent.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Alternative 10 - Construction of a baseflow by-pass for future phases of the Westridge development as in the earlier recommendation</p> <p>Alternative 11 - Grading of lots adjacent to the creek to direct roof runoff and rear yard runoff directly to the watercourse should be feasible in limited areas. There is effectively no additional cost for this measure.</p>
				<p>Alternative 13 - Various types of filter systems (sand filters, sand-peat filters, bio-retention filters, pervious pipe systems) can be used to reduce the requirement for a permanent pool to provide water quality treatment in an end-of-pipe stormwater management facility. Quality control can be provided if required in a dry pond. This approach will reduce the potential for discharge of heated water. Other types of systems relying on exfiltration will not be successful because of surficial soil and bedrock conditions. As indicated in section 7.2.5, the estimated cost of the modified "Etobicoke" system is \$80/m to \$100/m of the storm sewer system.</p>
				<p>Alternative 16 - Sedimentation and erosion control plans should be prepared and implemented for all new development to prevent runoff of sediment laden water into the creek. Implementation of such measures is mandatory. Hence there is no incremental cost for construction and maintenance of these devices. There is a potential cost to the municipality to more rigorously police the use of these measures. It is estimated that this might be equivalent to 2 hours of an inspector's time every two weeks per subdivision over the construction period. Given that there will be two main areas of construction within the Poole Creek watershed in the foreseeable future, this would cost of the order of \$1,500 to \$2,000 pre year.</p>
				<p>Alternative 17 - Buffers should be provided along the creek for all new development to a minimum of 30 m each side of the creek. There is no direct cost associated with this requirement.</p>
				<p>Alternative 18 - A monitoring program should be implemented by the proponents of development to measure flows, water quality, temperature and biological parameters. This will provide a mechanism to confirm that proposed actions are having the anticipated positive effect and to recognize if additional remedial actions are required to preserve the health of the watercourse. The estimated cost of such a program is \$4,000 to \$5,00 per year based upon installation and operation of a flow gauge; water quality and temperature sampling once every two weeks in the summer and once per month for the remainder of the year. This initial capital and installation costs would be about \$3,000.</p>
				<p>Alternative 19 - Environmental Impact Studies (EIS) should be completed for lands adjacent to provincially significant wetlands (e.g., Upper Poole Creek wetland) to identify appropriate buffers. This cost will be borne by the development proponent.</p>
				<p>Alternative 20 - Riparian cover should be increased along the watercourse (see the attached map for potential locations) to increase the amount of shading and help minimize solar heating of the water.</p>
				<p>Alternative 21 - Instream structures (such as Lunkers structures, point bars) should be introduced into the stream to provide fish habitat and cover (see the attached map for potential locations). Note this alternative would not be implemented if alternative 31 is implemented as part of the enhanced plan. The estimated cost per structure is \$2,500 for lunkers and \$600 for point bars.</p>
				<p>Alternative 23 - A control program for invasive plant species (such as glossy buckthorn) should be prepared and implemented. Such a program would be undertaken using volunteer efforts in a community based program.</p>
				<p>Alternative 29 - Some of the previously installed rehabilitation measures should be removed or modified since they are creating negative impacts on the cool / coldwater potential of the stream. Large pools have formed which are allowing extensive solar heating to occur because of the low flow through them during dry periods. Removal can be accomplished using volunteer efforts.</p>
				<p>Alternative 32 - Aquatic plantings or point bars should be introduced into the stream to improve the morphology of the watercourse. This would not be required if alternative 31 is implemented as part of the enhanced plan.</p>
				<p>Alternative 34 - The Township should encourage landowners adjacent to the creek to maintain a buffer of undisturbed vegetation immediately adjacent to the creek. This could be accomplished by an educational brochure describing the benefits. Preparation and distribution of such a brochure would potentially cost about \$1,000 to \$1,500.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Potential Enhancements	<p>Alternative 31 - Reconfiguration of the stream channel to a narrower meandering form more consistent with the low flows experienced during dry periods would have the greatest potential to achieve the goal of a robust coldwater system. Pools and riffles would be introduced to improve habitat and aeration. See the attached sketch. The cost of this work is estimated as between \$300,000 and \$500,000 depending upon the extent of the reach subject to reconfiguration.</p> <p>Alternative 27 - Pumping from bedrock wells adjacent to the reach of the creek upstream of the existing pond during low flow period could extend the cool / cold water stream system upstream provided alternative 31 (stream reconfiguration) was implemented. The estimated cost of implementing this option is about \$50,000 for up to 10 wells. Without the latter, any cool water introduced during summer periods would be heated above the critical temperature before reaching the Crossing Bridge.</p>
Urban Geology of Canada's National Capital Area	1998	M-R SPR & outside of study area (Ottawa)	Conclusions	<p>Based on the experience gained during the urban geology project in the National Capital area, there is a demand for geoscience information and this information is used by the private sector, government and the general public. New computer technology permits geoscientists to easily gather and process earth science data and deliver the information in convenient formats. Earth scientists should be aware of the needs of their clients and should provide documents that are adapted to a wider public than are traditional geological maps, graphics and data bases.</p> <p>Urban geology, like all environmental geology projects, requires the participation of earth scientists with varied backgrounds in order to include as many aspects of the physical environment as possible and to provide a comprehensive geological model of the study area. The participation of the private and public sector is also essential in urban geology projects since the information comes from many sources and must be integrated into a single data base before being released as a regional document.</p> <p>In order to properly answer the needs of clients of earth sciences information, scientists involved in urban geology must get together to discuss the approaches to be used when initiating new projects and to propose standards for the type of information and formats of documents that would be most appropriate to users of urban geology products. Even though there is an increased awareness by the general public of environmental issues and that environmental studies are becoming mandatory in new urban developments, governments are hesitant to initiate new urban geology projects due to decreasing resources. It is therefore important that all levels of government cooperate by contributing to urban geology projects, according to their own field of expertise, thus keeping the cost of the projects to a minimum.</p>
Urban Wells Study, City of Ottawa	2007	M-R SPR & outside of study area (Ottawa)	<p>Recommendations for an Approach to Urban Wells</p> <p>Scoping the City's Interest in Urban Wells</p>	<p>As noted in the outset of the report, the City has a broad interest to ensure the long-term health and vitality of its residents, businesses, and environment, particularly since the impacts arising from improper well usage are almost always experienced locally - through human health issues, ecosystem health issues, and financial expenditures to remedy these situations. While the City may exercise some degree of control over the matter of wells within the urban area, it is recognized that the City has limited resources and needs to focus its efforts on those particular wells which may be of greatest concern.</p> <p>Jurisdictional issues must also be considered since the Province of Ontario is responsible for the legislation related to wells. It is however recognized that municipalities can take a role in addressing well issues as long as their actions are in harmony with provincial statutes and regulations. Municipalities may also be empowered by the Province to take on a more significant role through a Memorandum of Understanding, as in the cases of North Grenville and Oxford.</p> <p>This section of the report helps the City focus on the wells of greatest concern, discusses initiatives to intervene, recommends a preferred initiative, and describes the implementation steps for the intervention.</p> <p>As described in Section 2.2, the full range of potential issues has been organized by considering the type of well (residential or non-residential) and the purpose of the well (potable or non-potable). In addition, dug wells and abandoned wells have also been identified as requiring special consideration.</p> <p>In order to scope the City's interest in urban wells, consideration has been given to public health, the environment, and economic factors, for each well type/purpose. The scoping exercise also considered what approaches (or lack thereof) municipalities are taking in similar situations with respect to the four categories of well applications (residential / non-residential, potable / non-potable). Table 5-1 summarizes the scoping of the City's interest in wells.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Based on the scoping exercise, the following suggestions emerge to help Ottawa frame its interest in wells: Urban wells for residential potable purposes are appropriate in the private service enclave areas where municipal services are not available (or are not expected to be available in the foreseeable future); in situations where Ottawa can exercise its authority, the City could permit these subject to a development agreement which ensures that the landowner is required to connect into municipal piped services when they become available; Urban wells for residential non-potable domestic purposes are not appropriate, and where Ottawa can exercise its authority these wells should not be developed; however, closed-loop ground source heat pump systems which are installed as a sustainable heating solution for multi-unit residential development can be permitted on a case-by-case basis subject to studies and a development agreement which ensures that the owner provides the necessary safeguards to protect the environment and limit the City's liability;</p> <p>Based on the scoping exercise, the following suggestions emerge to help Ottawa frame its interest in wells: Urban wells for non-residential potable purposes are not appropriate for private development, however, may be appropriate for low-risk public facilities or similar public applications on a case-by-case basis; and Urban wells for non-residential, non-potable purposes may be appropriate for both private development and public parks (or similar public applications) on a case-by-case basis, and in situations where Ottawa can exercise its authority, the City should permit private development subject to studies and a development agreement which ensures the owner provides the necessary safeguards to protect the environment and limit the City's liability.</p>
			Possible City Interventions for Wells	<p>Based on our research, discussions with other municipalities, and discussions with City staff, a range of interventions have been considered. These interventions have potential positive aspects, potential negative aspects, and may require any combination of mechanisms to implement. The interventions are: 1. Require the owner's well contractors to submit well records as a condition of development approval; 2. Require that a well be inspected by the City during construction and decommissioning (the inspectors would need to be certified as per Ontario Regulation 903); note that this could be similar in implementation to the existing inspection program in the former Township of Osgoode; 3. Prohibit the use of residential / potable wells within the urban area; 4. Require abandoned wells to be decommissioned as a condition of planning approvals; 5. Require connection to municipal services (if available) as a condition of planning approvals; 6. Perform critical reviews of all Permit to Take Water applications; 7. Control well usage and discharge through planning approvals or municipals by-laws;</p> <p>The interventions are: 8. Cap the number of severances allowed per private service neighbourhood; and, 9. Cap the number of non-potable wells allowed per privately serviced neighbourhood.</p> <p>Table 5-2 summarizes the above interventions and discusses their potential negative / positive aspects, and the mechanisms required to implement them. It also identifies whether the intervention could be initiated immediately, only partially (with follow-up changes need for full intervention), or requires significant changes before the intervention could be undertaken.</p>
			Recommendation	<p>The following subsections detail our recommendation for the City to intervene on matters related to urban wells. It includes a discussion of the rationale for our recommended approach and aspects related to implementation.</p>
			Recommended Intervention: Use the Development Approvals Process as the Principal Tool in a Broader Strategy	<p>In order to assess the interventions and identify a recommended intervention we have given consideration to: The City's jurisdiction (since it relates to its ability to intervene); Existing tools, practices, processes, or mechanisms already in place which support an intervention; Commonality of an intervention based on the municipality survey (which is considered indicative of a best practice); Weighing of the positive aspects against the negative aspects of the intervention; and Presumed effectiveness of the intervention.</p> <p>Based on our review of the interventions, our preliminary recommendation is for the City to utilize the development approval process to intervene on matters related to urban wells as the principal tool in a broader strategy. Our justifications for this preliminary recommendation, based on the above considerations, are described below.</p> <p>The City has existing jurisdiction over development approvals: The City is already responsible for a wide variety of development approvals and the Planning Act provides the City with broad authority to address environmental, land use, and servicing issues through development review. It should also be noted that addressing wells through the development approvals process does not require Provincial authorization.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>By using development approvals, the City is leveraging an existing mechanism: The development approval process at the City is long established, and both City staff and the public at-large are familiar with the City's development approval functions. As noted through interviews with City Staff, they are currently using the development approvals process to address well matters. Given that issues with urban well have been previously triggered by development approvals (variances, severances, building permit applications) then there is a rationale to utilize the development approvals process. By using development approvals, no significant change to the City's current practices are required and only relatively minor changes to various documents are needed to formally recognize a practice already in place.</p> <p>Wells addressed through development approvals is a common approach in other jurisdictions: Based on the municipal survey, the use of development applications to identify all types of wells (residential, non-residential, potable, non-potable, abandoned, etc.) and put in place appropriate safeguards was a very common finding. The municipal survey also indicated that there was very limited public objection to this approach.</p> <p>The positive aspects outweigh the negative aspects: The positive aspects - most notably ensuring that old wells are abandoned, new wells are constructed properly, environmental safeguards are in place, and formal acknowledgement to connect into future servicing - outweigh the primary negative aspect - that development approvals only address new construction.</p> <p>Incorporating wells in the development approvals process is expected to be an effective intervention: Based on a few past experiences at the City, addressing well matters through the development approvals has proven to be effective; it also appears to be effective at the other municipalities which were surveyed. Conditions imposed on a development approval helps to ensure that the onus for proper well commissioning, maintenance and abandonment is placed on the owner and well contractor. Through agreements or clauses registered on title, it also allows for the formal recognition by the owner that connection into full municipal services may be required at a later date. This covers many of the City's principal concerns related to wells in the urban area.</p>
			Steps to Implement the Recommended Approach	<p>Given that the City is already using the development approvals process as a trigger to address urban wells, and that Infrastructure Staff are circulated on applications involving wells, it is recommended that this practice continue in the short-term.</p> <p>Based on research of other municipal practices, existing city policies, and existing city practices, the following is needed to formally implement the recommended approach over time: Update the Official Plan's policies for servicing to reflect this approach; Update to the Infrastructure Master Plan and Environmental Master Plan (of Vision 2020) to reflect this approach; Update to any implementing or procedural by-laws related to development approval requirements; Update to the City's development manual (used internally by staff) to reflect the approach; and Update to development application forms to gather information about existing wells or proposed wells.</p>
			A Preliminary Decision Tree for Planning Approvals Involving Urban Wells	<p>To provide the City with an idea of the decision-making process for planning approvals involving urban wells, a decision tree has been developed. The process illustrated in the decision tree, the requirements for studies, conditions of approval, and what is deemed to be appropriate are based on the research and findings of this study.</p> <p>The decision tree is provided as Figure 5 on the following page. As a preliminary decision tree, this is also subject to refinement based on further internal discussions with staff before implementation of the initiative.</p>
Village of Constance Bay Groundwater Study	2006	MVCA (City of C	Recommendations for New Development - General Recommendations	<p>Wells and Septic Systems - New development within the Village should take into account the observed build-up of nitrates in the overburden sand aquifer and take measures to minimize additional nitrate loading; Increase enforcement of existing well construction regulations through municipal involvement in well inspection; Require more stringent well construction protocols. Consider increasing casing depth to provide greater protection to the water supply from groundwater contamination caused by septic systems; Identify and abandon unused wells prior to development. The municipality could require proof of proper abandonment of unused water wells, monitor wells or boreholes as a condition of development approval;</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Wells and Septic Systems - Require a hydrogeological assessment to City standards by a licensed professional of all new subdivision development prior to approval. Proponents wishing to proceed with new development by plan of subdivision should be made aware of the nitrate issues such that the required site-specific hydrogeological studies can take this into consideration. Additional details on the recommended scope of the hydrogeological assessments are presented in Section 8.1.2.2; For development approval by consent neighbouring wells should be sampled and favourable chemical testing results obtained. In general, the concentration of developments by consent should not be greater than 5 lots in a 5 hectare area, unless a hydrogeological assessment is performed; Require each development to identify a spare weeping tile bed; Development on marginal terrain should be conducted in phases, with proof of favourable operation of earlier phases being required prior to approving later phases.</p> <p>Non-Residential Fuel Storage Tanks - Use municipal powers related to development approvals and servicing to ensure that the provincial requirements are being followed; Municipalities could require proof of proper installation, registration, upgrading or removal of any storage tanks as a condition of development approval.</p> <p>Protection of Groundwater Recharge Areas - Limit the development of impervious surfaces to protect groundwater recharge; Establish land use controls on the storage and handling of hazardous chemicals in significant local and regional groundwater recharge areas. For example, the shallow bedrock area west of the Village of Constance Bay (See Figure 7) is identified as a regional recharge area for the bedrock aquifer. The entire Constance Bay peninsula is considered a local groundwater recharge area for the shallow sand aquifer.</p>
			Recommendations for New Development - Lot Sizing and Servicing	<p>Private wells, septic systems and grey water systems require careful consideration of land area requirements to ensure sustainability, particularly in dense development areas as exists along the shores and south eastern portions of Constance Bay, where there is potential for cumulative impacts and direct influence from adjacent lot services. The area required in support of sustainable servicing can vary significantly with aquifer characteristics, soil type, drainage patterns, proximity to surface waters or sensitive habitats, local building code requirements, etc. Cumulative nitrate impacts have been identified as a concern in the Village because of the relatively vulnerable aquifer and historical development on small lots. Reasonable access for maintenance must also be considered as part of the land area requirement in support of sustainable private services.</p> <p>Area Requirements for Wells - Area and separation requirements for wells are established primarily in consideration of potential for influence from surficial activities and in particular septic bed effluent. This is particularly critical in the Village of Constance Bay where the shallow aquifer is not isolated from the surface. When wells are deep and the aquifer is well protected from surficial activities (including proper well construction), requirements for area and separation are reduced. In the southwestern portion of the Village, clay soils exist at surface, and it is expected that the underlying bedrock aquifer that is used in this area is somewhat protected from surface contamination and septic system discharges. Therefore, from a well sensitivity perspective, smaller lot sizes are possible relative to the areas of the Village where the potable water aquifer is shallow and unprotected.</p> <p>Area Requirements for Septic Beds - A septic system is made up of the tank and leaching bed. The proper function of a well constructed leaching bed is dependent on the allowance of a sufficient area to properly dispose of effluent through infiltration into the underlying soil. Part 8 of the Ontario Building Code (OBC) addresses the site characterization requirements, design and construction of leaching beds. Where soil permeability is low or bedrock is near surface, or the water table is too close to ground surface, raised beds and mantles are required to distribute effluent over sufficient area for successful infiltration. General drainage and annual rainfall should be taken into consideration in very constrained situations. Often, an equal land area is required to be designated for use in the event of bed failure (referred to as 100% spare area). In the southwestern portion of the Village, clayey soils are present near surface, and therefore raised beds may be required.</p> <p>Area Requirements for Septic Beds - Septic systems require additional area (beyond the area of the leaching field) to reduce impacts on groundwater (mainly by dilution). In 1995, the Ministry of the Environment (MOE) published guidelines for servicing rural development (MOE, 1995, revised 1996). These guidelines provide a method that determines the required area to mitigate septic impacts on groundwater.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Area Requirements for Grey Water Systems - With increasing frequency, new development and system rehabilitation is making use of grey water disposal systems in order to reduce total loading to the septic bed and therefore the land area requirements for septic beds. Grey water systems may include disposal of water treatment process water (backwash) or other in-home water uses which do not need to be directed to the septic system. Use of grey water systems may also influence the land area and location of well and septic systems. The design of grey water systems (Class 2 systems) is covered under Part 8 of the Ontario Building Code. Permission and regulation of grey water systems is evolving, and local regulation should be reviewed to determine how such systems may influence total lot area requirements.</p>
				<p>These area requirements for sustainable services are only one factor in consideration of the establishment of a minimum lot size for land use planning purposes. The area required for services must be considered along with many other factors, including house footprint, other hard surface areas (most notably driveways, but also paved landscaped areas, etc.), regulatory set back requirements allowance of accessory facilities such as out buildings and swimming pools, etc. when considering specification of lot sizes in development planning. These latter factors in particular have changed substantially in recent years, and generally it can be stated that historical designations of minimum lot sizes (e.g. half acre or 0.2 ha) are no longer adequate to support both the land requirements for sustainable services and lot build out factors typical of current development trends.</p>
				<p>Recommendations for site-specific assessments are based on the recent study results, previous hydrogeological investigations, as well as the general understanding of well and septic systems planning. Overall, the site specific assessments should be consistent with the 1995 Ministry of the Environment (MOE) guidance manuals: Procedure D-5-4 <i>Technical Guideline for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment</i>; and Procedure D-5-5 <i>Technical Guidelines for Water Supply Assessment</i>. The City and proponent should agree on the scope of the impact study prior to initiation. The results of the impact study should be reviewed by the City prior to acceptance of the study findings.</p>
				<p>The impact assessment should have the following objectives: Description of the hydrogeology, soil texture, potable and non-potable aquifers, sensitive environmental features, mapped locations of adjacent wells and septic systems; Identification of spatial and seasonal variations in the local groundwater flow gradients and velocities in the shallow overburden and deeper bedrock aquifer. The study should specifically identify the direction of shallow groundwater flow relative to water wells on neighbouring properties; Description of the proposed water use, and confirmation that the water quality and quantity at the proposed development is sufficient to meet the perennial water needs of each lot. Estimate the recoverable on-site recharge and comment on the potential for aquifer mining; Evaluate the vulnerability of the water-supply aquifer to surface-derived contamination; Provision of well construction specifications;</p>
				<p>The impact assessment should have the following objectives: Assessment of the existing well water quality at all neighbouring wells, and properties upgradient and downgradient of the development. Water samples should be tested for general inorganic chemistry, nitrogen species and bacteria. Interviews with adjacent residents concerning the performance of their septic systems and water quality; Prediction of the potential interference on neighbouring wells from a quality and quantity perspective, and comment on the risk of impacts from adjacent properties; Assessment of the suitability of soil conditions and identify limiting factors (bedrock, water-table depth) on the property for sewage effluent disposal; Recommendations on minimum lot sizing, and the configuration of the septic bed relative to on-site and neighbouring water wells. Determine if more restrictive septic tile bed specifications are needed over and above Building Code requirements;</p>
				<p>The impact assessment should have the following objectives: Assessment of the potential for additional nitrate loading on the aquifer and to the neighbouring wells from the proposed development. The City should adopt a policy where all proposed developments that are located upgradient from an existing development, be required to demonstrate that no unacceptable additional loading will occur at the downgradient property boundary; Description of the uncertainty in the analysis.</p>
			Recommendations for New Development - Approach to Institutional / Commercial Development	<p>In terms of policy development for institutional and commercial development, municipalities can use the information regarding the land use risk in one of two ways. Under the conventional zoning approach, the municipality identifies the category or categories of uses that are prohibited or permitted within each of the zones. Alternatively, a performance zoning approach can be used where there is a recognition that blanket restrictions may be inappropriate for a particular area or may be beyond the required scope of protection.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>This latter approach is recommended for the Village of Constance Bay. Implementation of this approach would require that prior to the approval of new commercial or institutional land uses with the potential to contaminate groundwater, the City should require detailed management plans to minimize the risk to groundwater. Land uses that have been deemed as potentially representing an elevated risk to the groundwater are listed in Table 8.1. It is noted that this list is intended to be comprehensive, and therefore may include activities that would likely be unlikely to be proposed in the context of the Village of Constance Bay.</p>
				<p>Approval under a performance zoning approach could require the proponent to have some or all of the following elements in their proposal: Characterization of site aquifer characteristics, potential contaminant pathways and receptors, a presence of significant aquifer recharge zones. The potential risk to each receptor in terms of water quality and quantity impacts should be assessed; Design of engineered systems to ensure protection of the aquifer from chemical releases (e.g., double walled tanks, lined areas, corrosion protection, spill containment, leak detection). Ensure that provincial requirements for installation, registration, upgrading or removal of tanks are being followed; Limits to the development of large impervious surfaces in identified locally significant recharge areas to encourage artificial recharge (high infiltration and vulnerability areas shown on Figures 8 and 9);</p>
				<p>Approval under a performance zoning approach could require the proponent to have some or all of the following elements in their proposal: Development of hazardous material handling and spill management protocols; Groundwater monitoring system for early detection of impacts including the installation of sentry monitoring wells near contaminant sources and downgradient of land uses with potential risks; Spill response plan for handling unforeseen accidents within an area; Ecosystem enhancement, such as the development of new wetlands where existing ones are disturbed, or the re-establishment of natural recharge potential in areas where groundwater recharge has significantly deteriorated due to development; Bonding posted by the proponent to cover future environmental clean-up efforts.</p>
				<p>The requirements for the detailed management plans will be decided on a case by case basis depending on the risks associated with the land use as well as the surrounding areas.</p>
			General Recommendations for Existing Development	<p>Residents of the Village of Constance Bay should be notified of a potential widespread nitrate issue in the groundwater and encouraged to have their water tested for bacteria and nitrates (<i>A public meeting was held on February 4, 2006, at which time the results of the testing were presented. The Health Unit has also sent letters to the residents informing them of the potential water quality issues. Copies of the presentation and letter are provided in Appendix F</i>). The public should also be made aware of water treatment options for elevated nitrate concentrations, including reverse osmosis and distillation. Table 8.1 and Table 8.2 provide further information on water treatment options for a variety of water quality issues relevant to the Constance Bay area.</p>
				<p>Landowners should be educated on the sensitivity of the local aquifer to environmental threats.</p>
				<p>Promote proactive Best Management Practices (BMPs) and educate existing landowners of the sensitivity of the aquifers to environmental threats. Focus should be placed on commercial land uses that potentially handle or store hazardous material. Some of the key BMPs that should be promoted include waste management, spill protocols and fuel / chemical storage and management.</p>
				<p>Educate the general public and businesses on the need to protect groundwater.</p>
				<p>Develop incentive programs to reduce contamination risks such as funding abandonment of unused wells, removal of storage tanks, etc.</p>
				<p>Review road salting practices in an effort to minimize salt application quantities.</p>
				<p>Control of land practices in agricultural areas as it relates to nutrient management is primarily controlled by the Nutrient Management Act and associated regulations. Additional controls that the City can enact are limited. The City may best protect the groundwater resource by promoting BMPs in conjunction with other stakeholders such as the Ontario Federation of Agriculture, the Ontario Ministry of Agriculture and Food and Conservation Authorities. Particular BMPs that should be promoted include proper handling / storage of chemicals and fuels, controls on animal access to watercourses, milk house waste management, and the abandonment of unused wells.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommendations for Existing Development - Water Quality and Treatment	All of the water quality problems encountered during the sampling program are treatable. Table 8.2 provides instructions to private well owners about some of the common water quality problems experienced in the Village of Constance Bay. A summary of common treatment technologies for private well systems, also developed by the Ministry of Health, is reprinted as Table 8.3.
			Recommendations for Existing Development - Large Water Takings	Currently, no large water takings were identified in the Village of Constance Bay; however, it is recommended that the City develop a policy for any future large water taking permit applications. The City should ensure that the proponent has assessed, to the City's satisfaction, the risks that the taking has to water levels in the aquifer or sensitive receptors. A hydrogeologist should perform the evaluation. Aspects that should be evaluated include the risk of aquifer dewatering, reductions to base flow of surface water streams potential interference with neighbouring wells, record keeping protocols and adequacy of monitoring programs.
Village of Lanark, Communal	1990	MVCA (Lanark)	Conclusion	<p>The individual correction programme undertaken in 1980-81 has not resolved the problem of bacterial and chemical contamination. The extent of the bacteriological contamination varies with the time of year as demonstrated by the different results obtained in July 1987 and April 1990, when the number of unsafe and doubtful wells ranged from 18% to 51% depending on the time of year. The bacterial contamination has been attributed to the fact that not every one participated in the 1980 - 1981 individual correction programme.</p> <p>The chemical contamination by nitrate is attributable to the hydrogeological characteristics of the Village of Lanark. The formation of nitrate is a natural by-product of the chemical transformation of ammonia rich effluent discharged to tile-bed systems.</p> <p>The general contamination of all wells to various degrees is caused by the downward percolation of the septic tank effluent from the leaching bed to the underlying bedrock aquifer, which is largely recharged by direct infiltration and receiver limited lateral flow due to local topography. The overall density of septic tank systems exceed the capacity of the aquifer to dilute such an input of nitrate and to produce a drinking water with nitrate levels of less than 10 mg/l.</p> <p>It is interesting to note that the new subdivision on Affleck, Willis and Rothwell Streets already have nitrate levels over 8 mg/l in 5 of the 33 houses. This subdivision is recent and isolated from the rest of the village.</p> <p>The 1987 and 1990 well sampling programmes have clearly demonstrated that groundwater contamination is still prevalent in the Village of Lanark and that this situation cannot be resolved on an individual basis.</p>
Village of Lanark, Private Sewage and Water Systems	1979	MVCA (Lanark)	Remedial Measures	The following remedial measures are recommended for the purpose of upgrading individual water and sewage disposal systems, other than those designated as "satisfactory", and / or to abate health hazards and surface water contamination within and adjacent to the Village.
			Water Supply - Remedial Measures	In most cases, the evidence suggests that water of a quality designated as "doubtful" or "contaminated" is a direct result of a poorly-functioning septic tank, a poor or inadequate disposal field, the proximity of a substandard sewage system, or by contamination of surface waters. The following remedial measures should be undertaken or considered in such cases, as and when required, to ensure acceptable potable water quality.
			New Wells - Water Supply Remedial Measures	<p>New wells are generally recommended for those houses presently without their own source of potable water or where existing source are classified as "substandard", as defined above. It should be noted that the sanitary survey disclosed that a significant number of houses are provided with cisterns and are using rain water thus collected for washing and other non-potable purposes.</p> <p>Within the context of this recommendation, the installation of a new well and its cost includes the selection of an appropriate and approved location, drilling of the well with casing down to the water-bearing zone, and developing the well. The cost of pumping facilities are also included where either a) there is no pump now, or b) where an existing pump would not be suitable if the recommended remedial measures are implemented. The costs of property repair, such as the removal of drill cuttings, landscape repair and the like, are included only to the extent of returning the property to its original condition (i.e. new landscaping is not included where none existing previously). Excluded from all cost estimates are those for internal piping and plumbing facilities for well water service; the provision of such facilities being deemed to be the responsibility of the house owner.</p> <p>New wells drilled and developed under this recommendation are to be in accordance with the requirements of the Ontario Ministry of the Environment (MOE) and the Environmental Protection Act.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Existing Well Extension - Water Supply - Remedial Measures	<p>Previous studies indicate that there are a number of water-bearing zones in the limestone underlying most of the Village of Lanark. It is suspected that, in some cases, the upper or shallow aquifer may be locally contaminated. In such cases, it is recommended that existing wells be extended to tap water from a lower aquifer, and casing provided to seal off all access to the contaminated zone. Such well extension would generally require the removal of the existing casing, re-drilling of the well to a greater depth and installing a new casing. The upper portion of the well, from the land surface to a depth not less than 6.1 meters (20 feet), should be drilled 5.1 centimeters (2 inches) greater in diameter than the diameter of the finished well, and the annular space between the well casing and the bedrock filled with cement grout.</p> <p>In some cases, the cost of well extension as described above may be such as to justify the drilling of a new well.</p>
			Existing Casing Extension - Water Supply - Remedial Measures	<p>In places where infiltration of contaminated water through cracks and rock fissures is suspected, the extension of the casing down to the water bearing zone and grouting of the well may be recommended. Unless the existing casing and well is greater than 6 inches in diameter, thereby permitting a smaller diameter casing to be inserted to the full depth, this work will require removal of the existing casing, re-drilling, and insertion of a new casing down to the required depth.</p> <p>Grouting, as described in 3.1.2 above, will be required to seal cracks and fractures around the new casing. Where a smaller diameter casing is inserted into an existing larger diameter casing, the annular space between the two casings will also require grouting.</p>
			Sealing and Grouting of Wells - Water Supply - Remedial Measures	<p>This remedial work will be required for wellheads exposed to surface water infiltration. Wells located outside are generally provided with sealing caps, approximately 5 feet below ground surface. These caps may be cracked (in some cases plastic caps were used) or not fitted properly to the casing, thus permitting the contaminated surface water to infiltrate the well itself.</p> <p>The remedial work recommended includes excavating the wellhead, placing or replacing and sealing new caps and grouting as described above. In some cases, and although generally more costly, pressure grouting may be required. This involves filling the annular space between the outside of the casing and the inside of the drilled hole with a fluid mixture of cement and water of a consistency that can be forced through the grout pipes and placed as required.</p>
			Improvements to Surface Water Drainage - Water Supply - Remedial Measures	<p>In some cases, wellheads are located in depressions or where run-off drainage is such that surface water flooding and infiltration of the wells can occur. Where this is experienced, proper drainage ditches or drains, to direct the surface water away from the wellheads, will prevent this infiltration.</p>
			Water Filters - Water Supply - Remedial Measures	<p>Based on the chemical analysis of random samples, the water in the Village of Lanark generally contains high concentrations of iron and chlorides and, understandably for well water, has high hardness. None of these characteristics represent a danger to health although they may make the water somewhat unpalatable and perhaps aesthetically objectionable. Domestic water softeners are available and may, at the owners option and cost, be installed to reduce the hardness. In most cases involving well water, however, these units tend to be somewhat costly to install and operate relative to advantages obtained. The quality of water showing turbidity or containing undissolved iron (slightly rust coloured) can be improved, often very substantially by installing, at the taps, cartridges containing activated carbon or other filtering material. Such cartridges are readily and relatively inexpensively available from many manufacturers and / or suppliers of plumbing equipment.</p> <p>Removal or reduction of chlorides is best achieved by eliminating infiltration of surface waters containing chlorides (e.g. winter salting of roads). Removal or reduction of chlorides from other sources will require demineralization. However, on the basis of taste performance only, and not because of any toxic consideration, all house owners supplied with water containing more than 250 mg/L of total chlorides should be advised of the fact. Any decision favouring the installation of demineralization facilities, and any cost resulting therefrom should be the responsibility of the owner.</p>
			Disinfection of Water - Water Supply - Remedial Measures	<p>It is strongly recommended that all new wells, and all existing wells which are upgraded (deepened, casing extension, etc.) should be disinfected prior to being placed in or returned to service. Details of a relatively simple method of achieving this in private domestic wells are given in the pamphlet entitled "Is the Water Safe to Drink?", and which is available from the MOE.</p>

**Table A-1**

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Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Water from wells known or suspected of being contaminated by bacteria, and for which other remedial measures may not be indicated herein, could require some form of continuous disinfection. For individual domestic supplies, iodination appears to offer advantages in terms of low initial installation cost, low operating cost and a minimum need for attention by the owner. The requirements and recommendations of the Ministry of Health and / or Environment, as well as the manufacturer or supplier of iodination equipment should be determined in advance. Manufacturers of iodination systems include: Aquodine Ltd. and Iomech Ltd.</p> <p>Continuous disinfection by chlorination, involving the flow-proportioned metering of a chlorine solution (hypochlorite) ahead of the pressure tank (to ensure proper mixing and adequate contact time) may be employed. Such hypochlorination systems are generally more costly to install, and generally require more attention (e.g. solution make-up) on the part of the householder than the iodination systems. The addition of slightly more chlorine than actually required (referred to as super-chlorination) will ensure complete disinfection of the water supply but could result in a slight "chlorine" taste in the water leaving the taps. This may be overcome by installing a granular activated carbon filter downstream of the pressure tank on the feed line to all outlets. Manufacturers or suppliers of hypochlorinators include: Control and Metering Ltd. and Wallace and Tiernan. The requirements and recommendations of the Ministries of Health and / or Environment, as well as the manufacturers or suppliers of hypochlorination equipment should be determined in advance.</p> <p>Disinfection systems based on the use of ultraviolet light may also be used. For small domestic water supply systems, these devices while effective, could be quite costly to install and maintain.</p>
			Sewage Disposal - Remedial Measures	The following remedial measures are recommended for the purpose of upgrading existing sewage disposal systems and to ensure that nearby wells and surface waters are not contaminated.
			New Septic Tank - Sewage Disposal - Remedial Measures	New septic tanks, of approved design and materials of construction, are generally recommended where the present system is "substandard" or is "deteriorating" as defined above. The installation of all new septic tanks must be in accordance with the MOE and Ministry of Health (MOH) regulations and guidelines. In summary, these requirements include: the minimum working capacity is to be 600 imperial gallons (IG) (2.7 m <sup>3</sup> ); the tank is to be constructed of reinforced concrete, steel or fiberglass material. If steel is used, the interior and exterior surfaces of the tank must be treated with bitumen, epoxy, PVC or rubber sufficient to protect the surfaces from corrosion; the tank is located not less than: 5 ft. (2 m) from any building or structure, 10 ft. (3 m) from any property line, or 50 ft. (15 m) from any well, pond, lake, river, reservoir or the like.
			New Normal Distribution Field - Sewage Disposal - Remedial Measures	<p>New distribution fields are recommended as part of the septic systems where new tanks are installed and where there are no existing distribution fields or where the existing fields are inadequate under the new conditions.</p> <p>As in the case of new septic tanks, the distribution field design and installation shall be as per the MOE and the Department of Health requirements which can be summarized as follows: the minimum length of distribution piping shall be dictated by soil percolation time minimum size of the pipe shall be 3" dia. (4" dia. if syphon or pump used); the bottom of the distribution pipe bed shall be at least 1 m (3 ft.) above rock or groundwater; spacing between pipes shall be not less than 2 m (6 ft.); minimum separating distances from distribution field shall be 100 ft. (30 m) from any well or other natural body of water.</p>
			New Raised Distribution Fields - Sewage Disposal - Remedial Measures	<p>In places where 1 m (3 ft.) of acceptable soil is not available under the distribution pipe trenches due to rock elevations or high water table, a distribution field may be constructed of selected and approved material to form a mound sufficiently high to obtain the 1 m (3 ft.) required clearance. Where the distribution bed is constructed on rock which contains fissures and fractures (very common in the Village of Lanark), the area beneath the bed should be sealed with a minimum of 0.3 m (1 ft.) of clay. This will prevent short-circuiting of septic effluent and access to water bearing zone.</p> <p>The design and installation of raised distribution fields should be in accordance with MOE and Department of Health requirements.</p>
			Extension to Existing Distribution Fields - Sewage Disposal - Remedial Measures	In places where the existing distribution field appears to be inadequate or overloaded, additional weeping tile and trenches may be required to improve the distribution field performance. The total length of absorption trenches and tile or pipe shall be as indicated in the MOE, Septic Tank Systems publication and will depend on the total number of bedrooms in the house served and soil percolation test results.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Class 6 (Proprietary Aerobic) Systems - Sewage Disposal - Remedial Measures	Under the Sewage System Regulations of the Ontario Environmental Protection Act, a Class 6 sewage system is one, "in which sewage is treated in a proprietary aerobic sewage treatment plant". Suppliers of Class 6 (Proprietary Aerobic) Systems include: Waltec Industries, CMS Equipment Ltd. and Northern Purification Systems Ltd. Subject to approval and acceptance by the MOE, such Class 6 systems could provide advantages over conventional septic tanks in terms of site requirements and appearance, reliability of performance, ease of operation and freedom from maintenance. It should be noted, however, that under the above Regulations, all Class 6 systems are subject to a service contract between the owner and the manufacturer, his authorized agent or a third person licensed under the Act.
			Holding Tanks - Sewage Disposal - Remedial Measures	This type of sewage disposal would be recommended only in locations where area limitations do not permit the installation of a septic or Class 6 system. Holding tanks would be used only for storage of sewage which must be hauled regularly to disposal sites approved by the Department of Health. (The existing sewage Treatment Plant at the Town of Perth appears to be one logical receiving station for the Village of Lanark.) Design of the holding tank and hauling arrangements would be as described in the Ontario Regulation 229 under "The Environmental Protection Act". The working capacity of the holding tank shall not be less than 9000 l (2000 IG).
			Alternative "Group" Sewage System for Mill Street - Sewage Disposal - Remedial Measures	<p>Several houses along Mill Street and the west side of South Street have limited possibilities for the installation and successful operation of individual septic tanks or Class 6 systems. For example, houses 218 and 224A and adjacent houses along the south side of Mill Street are backed by a steep and generally rocky slope which would preclude effective distribution fields. Similarly, high groundwater levels and the proximity to the Clyde River suggest limitations to the effectiveness of distribution fields behind houses 187 west to and including 210A north of Mill and South Streets. Altogether approximately 19 houses in this immediate area could be subject to either individual or collective consideration, as deemed most appropriate. The houses falling within this category are designated with an asterisk (*) in the appended Summary of Data Sheets as well as having a note to this effect on the relevant data sheets.</p> <p>Because of the complications which could arise with respect to a group system, such as municipal ownership and operation, legal and financial agreements, land acquisition, sewage works approvals and others, prior consideration should be given to the separate and individual installation of i) a Class 6 (proprietary aerobic) system, ii) a Class 4 (septic tank) system, or iii) a Class 5 (holding tank) system.</p> <p>As an alternative, in the event that all of the above systems fail to meet requirements and regulations, it is proposed that those houses affected be connected to a group sewer discharging to an appropriately-designed septic tank and distribution field. The proposed arrangement is shown on Figure 6901-1 and involves a group sewer located north of Mill Street (and South Street if necessary) at the back of the properties. This would lead to a septic tank of appropriate size and design located near House 210A. Septic effluent would then be pumped to a distribution field located on the Trust Co. property southwest of Mill Street, north or south of the River Clyde. It must be emphasized, however, that any decision favouring such a "group" system rests with the Village which must own, operate and maintain such a system.</p>
Village of Merrickville-Wolford - Municipal Groundwater Management Study	2000	RVCA (Leeds & Grenville)	Groundwater Management Plan Recommendations	The Groundwater Management Plan consists of a series of action items that assist with managing the resource. Such management consists of short term and long term activities. Golder Associates has identified twelve (12) management activities that make up the Groundwater Management Plan. Details or clarification can be found in Section 4.0. The impetus of these recommendations is based on the conclusions of the report. The principal Groundwater Management Plan activities suggested for the Village of Merrickville-Wolford based on this study, and in no particular order, are summarized as follows:
			Completion of borehole geophysics on municipal water wells	Rationale: The water well records for the Village of Merrickville municipal water wells indicate that little is known about the geology and subsequently the source of groundwater in the village. The work performed in this study has led to conjecture on the source of the groundwater supply and recommended wellhead protection zone for the municipal wells. These theories can be further investigated and refined by performing borehole geophysical investigations on the municipal water supply wells.

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Implementation: Several methods can be employed but those most applicable to the municipal water wells are: Borehole televiewer - an ultrasonic transmitter-receiver is raised in the borehole and an ultrasonic beam traces the borehole wall. This method is used for tracing fractures; Temperature logger - this method measures the temperature in the borehole and allows for locating thermal anomalies caused by fluid flow. This allows for the highest production groundwater production zones to be identified; Resistivity logging - this method measures the electrical resistivity of the formation and the groundwater. This method would be able to determine groundwater production zones in the aquifers and identify groundwaters with high ion concentrations possibly indicating contributions by contaminated groundwater.</p> <p>Cost: The estimated cost for performing borehole geophysics would be dependent on the number of the municipal wells that are analyzed. The estimated cost per municipal well with the three (3) geophysical techniques recommended would be approximately \$10,000.</p>
			Public Awareness Program	<p>Rationale: Public awareness of water quality has never been more of an issue in Ontario than it has become in the past year. Public awareness should be the Village of Merrickville-Wolford's highest priority in terms of groundwater management options. The success of any groundwater management plan depends on the cooperation of the people working and living within the Village of Merrickville-Wolford. The people in the municipality need to understand how their actions can affect the quantity and quality of the water supply. Education is the key to ensuring awareness and is the foundation of a successful groundwater management plan.</p> <p>Implementation: The public awareness should incorporate the following suggestions and operatives: 1) It shall be the duty and responsibility of the village to issue a notice to all billing addresses and a notice to all permanent residences served by the system within seven days of any of the following: When any contaminant above the Ontario Drinking Water Objectives for health related parameters have been exceeded in samples from the municipal supply wells or the distribution system; Failure to comply with applicable testing procedures; Failure to comply with any treatment technique which has been prescribed; or, Failure to perform the prescribed monitoring as required; 2) Failure of any water samples from the municipal water supply wells or distribution system for bacteriological parameters will require an immediate "boil water notice"; 3) Post signs on roadways within the wellhead protection area with contact information in the case of an emergency or the release of a contaminant;</p> <p>Implementation: The public awareness should incorporate the following suggestions and operatives: 4) Distribute brochures in both wards with information regarding the groundwater resource, emergency response procedures, waste disposal, groundwater sampling methods, and septic tank maintenance. Information should be supplied to residents for whom to contact with questions or in case of emergencies; 5) Set-up a Water Resource Committee to provide education programs / meetings directed towards business owners, schools, and the community at large. These meetings, at least one per annum, would be used as educational seminars and public forums where issues and concerns can be brought to the public and committees attention.</p> <p>Cost: The cost of the public awareness program is estimated to range between \$5,000 and \$7,500 per year.</p>
			Well Abandonment / Decommissioning Survey	<p>Rationale: Since the Merrickville Ward of the Village of Merrickville-Wolford has been on municipal water supply, private wells within the ward have likely not been in use for a number of years. Wells that have not been decommissioned or improperly decommissioned may provide access points for contamination of groundwater supplies in the Village. All private wells not in use within the service areas of the distribution system should be decommissioned as per Regulation 903 of the Ontario Water Resources Act.</p> <p>Implementation: No official records of the well decommissioning were provided for this study so it was assumed that no records exist and that well abandonment was not completed. The village should perform a survey where employees of the village or a private contractor perform inspections of all wells within the Merrickville Ward.</p> <p>Cost: The cost of the well abandonment survey is estimated to range from \$5,000 to \$10,000. This cost does not include proper decommissioning of wells. The cost to decommission a well is estimated to range between \$2,000 and \$5,000 per well.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Municipal Well Number 3 Upgrading Review	<p>Rationale: The purpose of well number 3 is provide back up supply to the portion of the Village north of the Rideau River. Municipal water supply well number 3 has had a history of water quality problems and is located in an area with private individual septic systems. Adequate retention time for bacteriological treatment and end users in the area of well number 3 does not exist.</p> <p>Implementation: Upgrading is required at well number 3 for it to remain part of the municipal water supply. Alternatively, well number 3 could be abandoned and secure souce replacement could be provided by municipal wells south of the river. A) In the event of well decommissioning, the municipal well should be abandoned in accordance with Ontario Water Resources Act Regulation 903. To alleviate the threat of the loss of water supply to the north part of the Village in the event of damage to the primary watermain, a second watermain, as previously recommended by Totten Sims Hubicki (2000), could be constructed. An alternative effective solution would be to install a properly sized holding tank or water tower on the north side of the river. In times of need, a tanker truck, held on escrow bond by the village, could deliver water quickly and effctively to the holding tank or water tower. B) In the event of upgrading, consideration should be given to including well number 3 permanently in the circulation system, the provision of retention time holding tank and provision of sewage services to the north side of the Village.</p> <p>Cost: In consideration of item A) decommissioning the municipal well is estimated to cost between \$5,000 and \$10,000. Constructing a water tower to provide water to the north side of the Merrickville Ward would range between \$300,000 and \$400,000. A holding tank is estimated to cost between \$25,000 and \$50,000. If the Village considers construction of a second watermain, a feasibility study could be performed to provide a cost on the construction of a second watermain. The feasibility study is estimated to cost between \$7,500 and \$12,000. In consideration of item B) construction of a holding tank is estimated to cost between \$25,000 to \$50,000. Upgrading the well head to be permanently included in the treatment system between \$10,000 and \$25,000 and abandoning septic systems about \$5,000. Extension of the sewer line to the treatment system is estimated between \$300,000 and \$500,000.</p>
			Groundwater and surface water quality monitoring	<p>Rationale: The purpose of groundwater and surface water monitoring is to provide: a "snapshot" status of the groundwater resource; an evaluation of possible groundwater resource mining; and a sensitivity evaluation of the groundwater resource. Groundwater monitoring is one of the most common non-regulatory forms of groundwater protection and allows for groundwater chemical and physical characteristics to be measured. The monitoring program may be restricted to municipal water supply wells only or could be expanded to monitor known or possible up-gradient contamination sources such as the municipal landfill, industrial sites, underground storage tanks, or agricultural areas.</p> <p>Implementation: The Village could retain a consultant contractor to carry out the groundwater monitoring program once an appropriate groundwater monitoring program is established.</p> <p>Cost: The Village could perform an evaluation study to develop an appropriate groundwater monitoring program. The cost of the evaluation study is estimated to be between \$3,000 and \$5,000. The cost of the groundwater monitoring program is estimated to range between \$10,000 and \$25,000 per annum, depending on the number of monitoring stations. Installation of new monitoring locations could be in the order of \$3,000 to \$10,000 per location. A monitoring program should therefore consider existing infrastructure to a large degree.</p>
			Establish a Wellhead Protection Area (WHPA)	<p>Rationale: Wellhead Protection Areas (WHPA) consist of the protection of the groundwater in an area immediately around an individual well or well field (refer to section 4.1.7). The current study identifies a WHPA within the Village. The WHPA was defined on the basis of the groundwater numerical flow model. The WHPA includes an Exclusion Zone within a 330 m radius around the municipal wells. In this area, strict land use controls are implemented (e.g. no pesticide applications, road salt controls, modified fuel storage, emergency spill response). Beyond this Exclusion Zone, a Restricted Use Zone exists between 330 metres radius and 4.2 kilometres radius from the municipal wells. In the Restricted Use Zone, land uses and practices are regulated (e.g. contaminant source inventory, groundwater monitoring, road salt applications, special storage tank designs). The main protection considerations for WHPA are based on: the direct introduction of contaminants to the area from improper well casing, road runoffs, spills, and accidents; attenuation of microbial contaminants such as bacteria and viruses; and, dilution / attenuation of chemical contaminant incl</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Implementation: The wellhead protection areas for the Village were developed on the basis the hydrogeological investigations carried out in this study including pumping test analysis. Zoning by-laws would be required to be drafted to implement the WHPA. These should be preceded by public consultation and input.</p> <p>Cost: The cost of implementing the WHPA would depend on the zoning by-laws that are amended or established due to the incorporation of the WHPA. The cost of supplying information to residents and businesses regarding the WHPA can be integrated into the Public Awareness Program. The cost for implementation would range on the order of \$50,000 to \$100,000. The cost would include public consultation, drafting of by-laws, provision of contingency measures (such as spill kits) and funding for retrofits in the Exclusion Zone in closest proximity to the municipal wells.</p>
			Well Head Protection Area Refinement	<p>Rationale: The WHPA developed in this study identifies a large area for protection and could benefit from refinement. If a WHPA is too large, over protection can occur and can possibly result in extra costs for land unnecessarily designated as protected zones.</p> <p>Implementation: Refinement of the WHPA could be achieved by more detailed aquifer assessment through installation of additional monitoring wells and long-term geochemical and isotope geochemistry studies.</p> <p>Cost: Additional information regarding the hydrogeology of the Village, such as long-term groundwater levels, chemical variation and aquifer spatial variability could not be attained during this study. Therefore, it is recommended that the Village consider a supplemental aquifer evaluation to refine the proposed WHPA. The cost of performing a supplemental and more detailed evaluation, including a 3-D numerical groundwater flow model, is estimated to range between \$100,000 and \$200,000.</p>
			Official Planning Study	<p>Rationale: The Village has an Official Plan that requires updating to allow for zoning by-laws to be issued, refined or modified. The policies would reflect the information provided in this study regarding the groundwater resource and best management practices. Overburden is generally thin and sporadic in the Village and is therefore considered a sensitive site setting. The current official plan for Wolford Ward indicates 0.5 hectare lot sizes which are inadequate for private individual services.</p> <p>Implementation: A private planner with experience in groundwater management could be retained to perform the official planning study. Consideration in the official plan should be for a minimum lot size of 2 to 2.5 hectares unless a detailed hydrogeological study proves that a lower standard is justifiable.</p> <p>Cost: The cost of an official planning study would likely range from \$10,000 to \$15,000.</p>
			Contingency Plan	<p>Rationale: In the event of a spill of hazardous materials, the village should have an emergency response team at their disposal. The cost of replacing the groundwater resource in the event of contamination is far greater than the cost of having an emergency response team on retainer.</p> <p>Implementation: The Village could have a standing contract with a contractor to provide necessary services in case of an emergency such as an accidental chemical spill. The contractor should provide drilling equipment, on-site laboratory for volatile chemical analyses, and systems for extraction and treatment of contaminated groundwater. Having a standing contract with an emergency spill response contractor is more cost-effective in the long term than an urgent situation emergency response team. The Village could also require companies handling hazardous chemicals to draft emergency response plans. Such plans contain maps of the facility, a hazardous identification sheet, a notification procedure, a fire response plan, an evacuation plan and a spill prevention, control and countermeasure plan. The companies who handle hazardous wastes and the Village could enter a partnership where the costs for an emergency response team could be shared.</p> <p>Cost: The cost of having an emergency response team on stand-by for the Merrickville Ward would be between \$5,000 and \$10,000 per year.</p>
			Contaminant Survey and Inventory	<p>Rationale: A contaminant survey would provide the village with the information concerning possible contaminant threats to the groundwater resource.</p> <p>Implementation: A rudimentary contaminant survey was performed in this study. The village could retain a private consultant to perform a detailed contaminant survey and inventory which would rank the sites according to the chemicals on-site and the possibility of contaminants entering the groundwater supply. The village could acquire most of the necessary information by requiring facilities handling hazardous materials to prepare a chemical inventory.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Wolford Private Well Inspection	<p>Cost: A contaminant survey and inventory would range between \$5,000 and \$7,500.</p> <p>Rationale: This study has shown that the quality of a significant number of wells in the Wolford Ward of the village is compromised by the age of the wells and by improper installation. These wells pose threats to the potable water supply of residents in the vicinity of such wells and to the municipal wells.</p> <p>Implementation: A survey could be performed where a qualified consultant performs inspections of private wells in the Wolford Ward. The survey could be narrowed to inspect wells that are older than 10 years. The study should be focused by Village wide water quality survey for bacteriological and nitrogen cycle indicators. The Ministry of the Environment (MOE) well records would provide the estimate of the number of wells that would need to be inspected.</p> <p>Cost: The Ministry of the Environment (MOE) well records would require updating to provide a clearer estimate of the required number of wells. It is expected that the cost would be between \$20,000 and \$50,000. Cost to upgrade the wells, if required would be done by the well owner.</p>
			Increased Reservoir Capacity of Treated Groundwater	<p>Rationale: The Groundwater per Capita study (Totten Sims Hubicki, 2000) has determined that the size of the underground reservoir currently used by the Village is not large enough for the current service population.</p> <p>Implementation: The water reservoir should be replaced by a water storage capacity at least to the requirements outlined in the study by Totten Sims Hubicki (2000). This would allow for an increased volume of available treated water in case of a contamination threat to the municipal wells.</p> <p>Cost: The cost of installing a reservoir of sufficient size to meet the current water storage need for the village would be between \$500,000 and \$750,000.</p>
Village of North Gower Groundwater Study	2005	RVCA (City of Ottawa)	Recommendations for New Development - General Recommendations	<p>Wells and Septic Systems - Increase enforcement of existing well construction regulations through municipal involvement in well inspection; Require more stringent well construction protocols. It is recommended that wells be cased and grouted to a minimum depth of 12 m where the aquifer has been mapped as moderate to highly vulnerable (See Figure 8), unless detailed hydrogeological reports recommend otherwise; Identify and abandon unused wells prior to development. The municipality could require proof of proper abandonment of unused water wells, monitor wells or boreholes as a condition of development approval;</p> <p>Wells and Septic Systems - Require a hydrogeological assessment to City standards by a licensed professional of all new subdivision development prior to approval. The study should assess potential interference on neighbouring wells from a quality and quantity perspective and comment on risk of impacts from adjacent properties. Study should include sampling of nearby wells and recommend minimum lot sizes, the configuration of the septic bed relative to on-site and neighbouring water wells, and provide specifications for well construction; Determine if more restrictive septic tile bed specifications are needed over and above Building Code requirements through the undertaking of a detailed hydrogeological assessment; For development approval by consent, neighbouring wells should be sampled and favourable chemical testing results obtained. In general, the concentration of developments by consent should not be greater than 5 lots in a 5 hectare area; Require each development to identify a spare weeping tile bed; Development on marginal terrain should be conducted in phases, with proof of favourable operation of earlier phases being followed;</p> <p>Fuel Storage Tanks - Use municipal powers related to development approvals and servicing to ensure that the provincial requirements are being followed; Municipalities could require proof of proper installation, registration, upgrading or removal of any storage tanks as a condition of development approval.</p> <p>Protection of Groundwater Recharge Areas - Limit the development of impervious surfaces to protect groundwater recharge; Establish land use controls on the storage and handling of hazardous chemicals in significant local and regional groundwater recharge areas. For example, the shallow bedrock area west of the Village of North Gower (See Figure 7) is identified as a regional recharge area for the bedrock aquifer that is utilized by the Village residences.</p>



**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			<p>Recommendations for New Development - Lot Sizing and Servicing</p>	<p>Private wells, septic systems and grey water systems require careful consideration of land area requirements to ensure sustainability, particularly in dense development where there is potential for cumulative impacts and direct influence from adjacent lot services. The area required in support of sustainable servicing can vary significantly with aquifer characteristics, soil type, drainage patterns, proximity to surface waters or sensitive habitats, local building code requirements, etc. Reasonable access for maintenance must also be considered as part of the land area requirement in support of sustainable private services.</p> <p>Area Requirements for Wells - Area and separation requirements for wells are established primarily in consideration of potential for influence from surficial activities and in particular septic bed effluent. This is particularly critical when the aquifer is not isolated from the surface area, as it typical when wells are founded in shallow granular deposits or in shallow bedrock overlain by granular deposits. When wells are deep and the aquifer is well protected from surficial activities (including proper well construction), for instance by a deep layer of clay soils, requirements for area and separation are reduced.</p> <p>Area Requirements for Septic Beds - A septic system is made up of the tank and leaching bed. The proper function of a well constructed leaching bed is dependent on the allowance of a sufficient area to properly dispose of effluent through infiltration into the underlying soil. Part 8 of the Ontario Building Code (OBC) addresses the site characterization requirements, design and construction of leaching beds. Where soil permeability is low or bedrock is near surface, or the water table is too close to ground surface, raised beds and mantles are required to distribute effluent over sufficient area for successful infiltration. General drainage and annual rainfall should be taken into consideration in very constrained situations. Often, an equal land area is required to be designated for use in the event of bed failure (referred to as 100% spare area).</p> <p>Area Requirements for Septic Beds - Septic systems require additional area (beyond the area of the leaching field) to reduce impacts on groundwater (mainly by dilution). In 1995, the Ministry of the Environment (MOE) published guidelines for servicing rural development (MOE, 1995). These guidelines provide a method that determines the required area to mitigate septic impacts on groundwater. Appendix E describes this method and applies it to the North Gower area.</p> <p>Area Requirements for Grey Water Systems - With increasing frequency, new development and system rehabilitation is making use of grey water disposal systems in order to reduce total loading to the septic bed and therefore the land area requirements for septic beds. Grey water systems may include disposal of water treatment process water (backwash) or other in-home water uses which do not need to be directed to the septic system. Use of grey water systems may also influence the land area and location of well and septic systems. The design of grey water systems (Class 2 systems) is covered under Part 8 of the Ontario Building Code. Permission and regulation of grey water systems is evolving, and local regulation should be reviewed to determine how such systems may influence total lot area requirements.</p> <p>These area requirements for sustainable services are only one factor in consideration of the establishment of a minimum lot size for land use planning purposes. The area required for services must be considered along with many other factors, including house footprint, other hard surface areas (most notably driveways, but also paved landscaped areas, etc.), regulatory set back requirements allowance of accessory facilities such as out buildings and swimming pools, etc. when considering specification of lot sizes in development planning. These latter factors in particular have changed substantially in recent years, and generally it can be stated that historical designations of minimum lot sizes (e.g. half acre or 0.2 ha) are no longer adequate to support both the land requirements for sustainable services and lot build out factors typical of current development trends.</p> <p>The study area consists generally of two distinct soil regimes, each with characteristics that will affect lot area requirements to support sustainable servicing. Those area requirements must be added to other lot development factors in consideration of planning allowances for lot size. Specific recommendations for the various areas within the Village are presented in the following sections based on soil regime.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Marine Clay Soils: The relatively low nitrate concentrations measured in groundwater in this study (an average nitrate concentration of 0.5 mg/L) are reflective of the protection that the low permeability clay soils provide to the bedrock aquifer. As such, septic systems in areas of marine clays (the majority of the North Gower area) do not have a large potential for impacting on the bedrock aquifer. That is, the surficial clay soil zone where leaching bed effluent is directed is hydraulically separated from the bedrock aquifer ("system isolation") and as such no nitrate impact assessment is necessary under the Ministry of the Environment (MOE) system (See Appendix E). However, the low permeability soils result in constraints to efficient septic effluent disposal and generally development in the areas with clay soils will likely require either raised leaching beds (where percolation times are unacceptably high) or very large leaching bed areas, thus adding to lot area requirements. The reported septic system failures in the Shipman East subdivision (based entirely on marine clay soils) are reflective of the difficulty leaching systems have in such low permeability clay soils.</p>
				<p>Marine Clay Soils: Minimum lot sizes in clay soil areas should take into consideration provision of area for large (potentially raised) leaching beds plus at least 100% spare area in the event of bed failure. For large residences on clay soils, the required leaching bed size is in the order of 1500 m<sup>2</sup> (3000 m<sup>2</sup> with an allowance for a spare area). Adequate lot area is also required to provide adequate separation of the leaching bed areas (including the spare area) from on-site wells, lot drainage and other features. Given the history of bed failures, it is also prudent that leaching systems be sized larger than the minimum requirements as specified in the Ontario Building Code. Municipal authority for this provision should be discussed with the Ottawa Septic Office and Building Code officials.</p>
				<p>Marine Clay Soils: For new development areas on clay soils, we recommend that the City consider a minimum lot size of 0.8 ha in order to allow for proper sizing of septic beds, along with all other anticipated lot build out factors.</p>
				<p>Glacial Till and Drumlins: Testing of groundwater from existing development in till and drumlin areas generally indicates nitrate concentrations less than 1 mg/L. However, the highest nitrate concentration measured (7.88 mg/L) occurred at the Blair / Edward Kidd Subdivision. Testing was limited and these developments are not very old. Nitrate levels can in some situations build up over time in groundwater compared to background levels. This would be indicative of an imbalance in nitrate input and would provide a caution regarding long term sustainability. Additional testing in the future would be prudent in these existing subdivisions to assess for any trends in nitrate levels.</p>
				<p>Glacial Till and Drumlins: As detailed in Appendix E, in glacial till and drumlins areas, we recommend the City consider minimum lot sizes of 0.5 ha in areas with existing low background nitrate concentrations (e.g., less than 1 mg/L as N). In areas with higher background nitrate concentrations, we recommend the City consider minimum lot sizes of 1.0 ha.</p>
				<p>Site Specific Assessments: The recommendations provided above are based both on the evidence of local testing and investigations, as well as general understanding of well and septic system planning. Site specific assessments are recommended in all cases in order to reconfirm this general information and allow for the possibility that site specific conditions may vary. Also, the chosen minimum lot size should be larger size based on assessments of both proper well function needs and proper septic bed needs.</p>
				<p>Site Specific Assessments: The City may wish to specify minimum lot sizes as a planning tool and consider those sizes sufficient for well and septic system planning. Alternatively, the City may wish to permit consideration of alternate sizes (smaller) based on site specific technical assessments. In such cases, the scope and terms of the study required to consider and confirm smaller lot sizes should be established in advance of investigations.</p>
			Recommendations for New Development - Approach to Commercial / Industrial Development	<p>In terms of policy development and regulatory controls such as zoning, municipalities can use the information regarding the land use risk in one of two ways. Under the conventional zoning approach, the municipality identifies the category or categories of uses that are prohibited or permitted within each of the zones. Alternatively, a performance zoning approach can be used where there is a recognition that blanket restrictions may be inappropriate for a particular area or may be beyond the required scope of protection.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>This latter approach is recommended for the Village of North Gower. Implementation of this approach would require that prior to the approval of new land uses with the potential to contaminate groundwater, the City should require detailed management plans to minimize the risk to groundwater. Land uses that have been deemed as potentially representing an elevated risk to the groundwater are listed in Table 7.1. Approval under a performance zoning approach could require the proponent have some or all of the following elements in their proposal.</p> <p>Approval under a performance zoning approach could require the proponent to have some or all of the following elements in their proposal: Characterization of site aquifer characteristics, potential contaminant pathways and receptors, a presence of significant aquifer recharge zones. The potential risk to each receptor in terms of water quality and quantity impacts should be assessed; Design of engineered systems to ensure protection of the aquifer from chemical releases (e.g., double walled tanks, lined areas, corrosion protection, spill containment, leak detection). Ensure that provincial requirements for installation, registration, upgrading or removal of tanks are being followed; Limits to the development of large impervious surfaces in identified locally significant recharge areas to encourage artificial recharge (high infiltration and vulnerability areas shown on Figures 6 and 8);</p> <p>Approval under a performance zoning approach could require the proponent to have some or all of the following elements in their proposal: Development of hazardous material handling and spill management protocols; Groundwater monitoring system for early detection of impacts including the installation of sentry monitoring wells near contaminant sources and downgradient of land uses with potential risks; Spill response plan for handling unforeseen accidents within an area; Ecosystem enhancement, such as the development of new wetlands where existing ones are disturbed, or the re-establishment of natural recharge potential in areas where groundwater recharge has significantly deteriorated due to development; Bonding posted by the proponent to cover future environmental clean-up efforts.</p> <p>The requirements for the detailed management plans will be decided on a case by case basis depending on the risks associated with the land use as well as the surrounding areas.</p>
			General Recommendations for Existing Development	<p>Promote proactive Best Management Practices (BMPs) and educate existing landowners of the sensitivity of the aquifers to environmental threats. Focus should be placed on commercial land uses that potentially handle or store hazardous material. Some of the key BMPs that should be promoted include waste management, spill protocols and fuel / chemical storage and management.</p> <p>Educate the general public and businesses on the need to protect groundwater.</p> <p>Develop incentive programs to reduce contamination risks such as funding abandonment of unused wells, removal of storage tanks, etc.</p> <p>Review road salting practices in an effort to minimize salt application quantities.</p> <p>Control of land practices in agricultural areas as it relates to nutrient management is primarily controlled by the Nutrient Management Act and associated regulations. Additional controls that the City can enact are limited. The City may best protect the groundwater resource by promoting BMPs in conjunction with other stakeholders such as the Ontario Federation of Agriculture, the Ontario Ministry of Agriculture and Food and Conservation Authorities. Particular BMPs that should be promoted include proper handling / storage of chemicals and fuels, controls on animal access to watercourses, milk house waste management, and the abandonment of unused wells.</p>
			Recommendations for Existing Development - Water Quality and Treatment	<p>While not appearing as a widespread issue based on the 2004 water sampling results, exceedances of health related bacteriological parameters such as E. Coli and total coliforms are likely present, especially in areas where the aquifer has been mapped as high vulnerability. Therefore, private well owners are encouraged to have their water tested on a regular basis.</p>
				<p>All of the water quality problems encountered during the sampling program are treatable. Table 8.2 provides instructions to private well owners about some of the common water quality problems experienced in the Village of North Gower. A summary of common treatment technologies for private well systems, also developed by the Ministry of Health, is reprinted as Table 8.3.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Recommendations for Existing Development - Large Water Takings	The City should ensure that the proponent has assessed, to the City's satisfaction, the risks that the taking has to water levels in the aquifer or sensitive receptors such as Steven Creek. A hydrogeologist should perform the evaluation. Aspects that should be evaluated include the risk of aquifer dewatering, reductions to base flow of surface water streams, potential interference with neighbouring wells, record keeping protocols and adequacy of monitoring programs.
Village of Westport - Preliminary Groundwater Study	2003	RVCA (Leeds & Grenville)	Main Recommendations	<p>The interpretation and conclusions should be re-evaluated as new information becomes available.</p> <p>Gaps in the information as identified throughout the report should be filled in. Further information on the geology and hydrogeology in the area of recharge (southwest of the Village) would increase confidence in the hydrogeological interpretation provided in this study. The new well proposed by the municipality should be carefully logged to provide details on the geology, structure and hydrogeology encountered at this location. Cored well(s) may also be necessary.</p> <p>Testing should be conducted to determine the hydraulic conductivity and porosity of the aquifer.</p> <p>Following collection of the additional data (items listed above), a WHPA study should be completed for the Village of Westport.</p>
Village of Westport - Preliminary WHPA Study	2004	RVCA (Leeds & Grenville)	Main Recommendations	<p>The interpretation and conclusions should be re-evaluated as new information becomes available.</p> <p>Gaps in the information as identified throughout the report should be filled in. Further information on the geology and hydrogeology in the area of recharge (southwest of the Village) would increase the confidence in the hydrogeological interpretation provided in this study. Further information east of sewage lagoon would confirm the existence of groundwater high at the model boundary here. More information on the southwestern portion of the study area would help identify the hydraulic connection between the recharge area of the aquifer and Westport Sand Lake. The assumed low permeability bed of the wetlands should be confirmed. If a granular bed exists instead then the wetland could be a possible recharge source WHPAs.</p> <p>The WHPA study should be completed as per MOE's Technical Terms of Reference for Groundwater Studies. These tasks would include: intrinsic susceptibility, completion of contaminant source inventory, groundwater use assessment, and groundwater protection and management plan.</p>
Vulnerability Pilot Study - Almonte Municipal Water Supply Wells	2005	MVCA (Lanark)	Conclusions	<p>The 100 m radius Exclusion Zone, the 2 year Time-of-Travel (TOT) Pathogen Zone, the 5 year TOT Dense Non-Aqueous Phase Liquid (DNAPL) and Contaminant Zone, the 25 year TOT Secondary Protection Zone, and the Total Capture Zone were defined for Almonte Wells 3, 5, 6 and 7 &amp; 8 using traditional reverse particle tracking and the base case 3-D MODFLOW Model of the Almonte area. These TOT capture zones are very similar to, but not identical to the same base case TOT capture zones defined in the earlier INTERA Wellhead Protection Area (WHPA) Study.</p> <p>The results of our confidence assessment shows that the traditional reverse TOT capture zones are very sensitive to the assumed values of the Nepean Formation Aquifer hydraulic conductivity and porosity. Since these Model parameters can be highly variable and are difficult to reliably define at the large spatial scales of the Model, there remains uncertainty in the traditional reverse TOT capture zones that cannot be resolved with available data. The reverse TOT capture zones defined using the calibrated MODFLOW Model with base case parameter values remains our best estimate of traditional reverse TOT capture zones for Almonte Wells.</p> <p>Capture zones based on Surface to Well Advection Times (SWATs) were defined for Almonte Wells 3, 5, 6 and 7 &amp; 8 using grid-based forward particle tracking and the base case 3-D MODFLOW Model of Almonte. The resultant SWAT-based capture zones for Almonte Wells are much smaller than the traditional reverse TOT capture zones. For Wells 3 and 7 &amp; 8, the resultant forward SWATs are all greater than 25 years. The shortest forward SWATs for Wells 5 and 6 are in the range of 2 to 5 years.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The results of our confidence assessment of forward SWAT capture zones shows that the results are sensitive to assumptions concerning the material properties that describe vertical advection in both the unsaturated and saturated Bedrock Aquitard. Since these Model parameters can be highly variable and are difficult to reliably define at the large spatial scales of the Model, there remains uncertainty in the traditional forward SWAT capture zones that cannot be resolved with available data. The forward SWAT capture zones defined using the calibrated MODFLOW Model with base case parameter values remains our best estimate of traditional forward SWAT capture zones for Almonte Wells.</p> <p>The results of our SWAT modeling of capture zones for the Almonte Wells indicates that vertical advection through the unsaturated and saturated zones of the Bedrock Aquitard provides significant protection to Almonte municipal water supply wells. Based on a comparison of reverse TOTs and forward SWATs for Wells 3 and 7 &amp; 8, this additional vertical protection is estimated at 20 to 35 years. For Wells 5 and 6, a similar comparison suggests this additional protection is about 2 to 10 years.</p> <p>Reassessment of the five potential contaminant threats (sources) identified and retained in the earlier INTERA WHPA Study considering the results of SWAT modeling, indicates that three of these five potential contaminant sources should be retained for further consideration. The Ontario Clean Water Agency (OCWA) Sewage Treatment Ponds remains the most important of these three potential contaminant sources.</p>
Water and Wastewater Alternative Servicing Solutions Study - Village of Cumberland, City of Ottawa, Ontario	2003	RVCA (City of Ottawa)	Recommended Solutions	<p>The alternative water supply option scoring the best in the weighted performance review matrix is Option 3 - Extension of Central Water Service for the Entire Village. The alternative wastewater collection option scoring the best in the weighted performance review matrix is Option 2A - Extension of Central Wastewater Service for the core of the Village. These alternatives are therefore, the solutions that best address the problems identified in Phase 1 of the Class Environmental Assessment (EA), and that best meet the objective of the project: to provide a safe and reliable drinking water supply of adequate quality and quantity, as well as management of sewage in a way that is acceptable from both a health-related and environmental effects perspective. However, the findings of the public consultation (see Section 17.0) indicate that the majority of Cumberland residents consider the cost for central service alternatives to be unaffordable (without funding), and that they would only consider supporting central services if government funding was available.</p> <p>A project to extend central water and / or wastewater to the Village of Cumberland would be classified as a 'Schedule B' project under the Municipal Class EA process (Municipal Engineers Association (MEA), 2000). Therefore, Phases 3 and 4 of the Class EA process would not be required before implementation (Phase 5: completion of detailed design, tendering, and construction). The extension of services may, however, necessitate a Community Design Plan / Secondary Plan before implementation. Recognizing the importance of feedback received from the public, proceeding with the community planning exercise and the next phase of the EA is not recommended until such time that an adequate level of funding has been secured. Once an adequate level of funding has been secured, and following confirmation of the preferred solutions (through additional public consultation), implementation of the preferred solution(s) could proceed.</p> <p>It is important to recognize that the implementation of sewage solutions will not solve the defined water problem, and the implementation of water solutions would not solve the defined sewage problem. If funding becomes available in the future that is not sufficient to allow for the extension of both central water and wastewater services, the extension of the central water supply should be given priority over wastewater. This would be possible, according to the Provincial Policy Statement, although an amendment to the existing Cumberland Official Plan would be required.</p> <p>The source and timing of funding becoming available for either or both of the central service components is not known, and should not be counted on at this time. In the interim (which could be many years), Village residents should be encouraged to consider what can be done to improve the water supply and surface water quality in the Village. The City can also assist with the implementation of certain interim measures. Recommended interim measures are summarized in the following chart.</p>
			Education - Interim Measures	<p>Objective - Focused on protection and conservation of groundwater and surface water resources</p> <p>Lead Organization - City and Village Residents</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				Community Associations should be encouraged to engage in public education related to water and wastewater issues of the Village. The City currently coordinates seminars on well water and septic system care. At these seminars Village residents should be encouraged to periodically have their water tested at a private laboratory for nitrate and chloride, in addition to the routine bacteriological analysis service provided by the Province.
			Regulations and Enforcement - Interim Measures	<p>Objective - Enforcement of standards for septic systems and wells through inspection programs</p> <p>Lead Organization - City and Province</p> <p>Recommendations regarding regulation and enforcement of septic systems are expected as part of the City's Rural Wastewater Management Study that is currently underway. Mandatory septic system inspections could lead to improvements in the existing water supply and surface water situation, if inspections resulted in septic system upgrades. Enforcement of water well regulations is a provincial responsibility.</p>
			Private Service Upgrades - Interim Measures	<p>Objective - To improve existing private wells and septic systems</p> <p>Lead Organization - Village Residents</p> <p>The City currently has no authority or direct responsibility to conduct private work on private land. Private services are the responsibility of individual homeowners.</p> <p>It is considered that individual corrections (i.e., addition of ultra-violet (UV) treatment to water supplies; extensions of wells above ground to eliminate buried well heads; replacing poorly sealed wells; replacing failing septic systems with approved treatment units) can be effective in correcting many of the health-related issues, providing that the systems are regularly inspected and properly maintained by the owners.</p> <p>Individuals who are considering undertaking private individual corrections, should do so based on specific groundwater quality data (for their well) and individual septic system performance. If the available groundwater data are limited to bacteriological parameters, it is recommended that sampling for other septic indicator parameters be considered (for example nitrate, ammonia and chloride), in addition to the normal bacteriological parameters. Homeowners with satisfactory water supplies from existing wells or with appropriate in-home treatment units will not likely need, or want to repair or replace their wells. Homeowners that are uncertain regarding the performance of their septic system should have them inspected and assessed by qualified personnel.</p> <p>In terms of the reported water shortages in some wells in various parts of the Village, there are a variety of possible courses of action starting with checking the depth of pumps to ensure that they are set deep enough in the well to take advantage of the water storage volume available in the well bore. In the central growth area where water shortages are reported to occur more frequently a more detailed hydrogeological study should be undertaken, involving: a detailed house-by-house review of the water well records; measurement of current pump position versus total well depth and static water levels; and pumping tests of existing wells (or test wells) of varying depths to quantify available yields.</p>
			Environmental Management - Interim Measures	<p>Objective - To review road salting practices, storm water management and to consider implementation of groundwater and surface water monitoring programs</p> <p>Lead Organization - City</p> <p>The City could consider development and implementation of environmental management initiatives aimed at improving surface water and groundwater quality within the Village. Reductions in the application of road salt in Areas 1 and 2 may reduce the levels of sodium and chloride in the shallow bedrock aquifer. A groundwater monitoring program could be designed to track changes in aquifer groundwater quality with time, especially in Areas 1 and 2.</p>
			Land Use Planning - Interim Measures	<p>Objective - To evaluate future Village development on private services using the results of this study</p> <p>Lead Organization - City</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				It is recommended that potential development proposals be reviewed on a case-by-case basis with consideration of the groundwater quality issues identified in this study. As described in Section 15.6, the naturally poor water quality for non-health related parameters is generally expected to preclude approval of new development on individual wells in many areas of the Village.
			On-going Funding Review - Interim Measures	Objective - To look for sources of funding by continuing to review provincial and federal infrastructure programs Lead Organization - City, Province and Village Residents  Provincial and federal infrastructure funding programs should continue to be reviewed on an on-going basis in order to determine if funds are potentially available for the extension of central water and / or wastewater services to the Village of Cumberland.
Water Resources Study - City of Kanata Rural Area	1994	MVCA (City of Ottawa)	General	Development on terrain directly underlain by the Precambrian Formation should be restricted to minimum lot sizes of 4 ha.  Development on terrain underlain by the Nepean / March / Oxford Formations should be based on minimum lot sizes of 0.8 ha, with the exception of the areas immediately adjacent to the Ottawa River, where a minimum lot size of 2 ha is required. Development on terrain underlain by the Gull River / Rockcliffe Formations should be based on minimum lot sizes of 2 ha. Lot sizes of 1.2 ha could be considered if development was restricted to homes with a maximum water demand of 2,000 L/day, which would create impact equivalent to a luxury home with a demand of 3,000 L/day on a 2 ha lot. Development in areas with more than 5 m of protective (low permeability) overburden could accommodate lot sizes of 0.8 ha or less. However until the suitability of smaller lot sizes is confirmed through site-specific hydrogeologic study a lot size of 0.8 ha is recommended. Development on overburden aquifers such as exist in Dunrobin area should not be allowed unless supported by site-specific hydrogeologic study to confirm availability and protection of such aquifers from surface (septic system) contamination. No development on wetlands in accordance with provincial policy.
			Well Construction	In assessing the suitability of development plans, recommended plans would include individual lots with septic systems located downgradient with respect to groundwater flow of water supply wells and minimum separation distances of 60 m between any septic system and well. The City should subsequently ensure that developments are constructed according to plans. Well installation and well grouting be inspected by the municipality as part of the building approval process. Areas with salty water at depth, the location of fresh water and quality of the aquifer be verified. Any existing wells within the proposed subdivision be tested and abandoned properly if the water supply is salty. That groundwater source heat pumps only be considered after careful evaluation of its impact.  Areas of low yielding limestone aquifers, consideration be given to drilling of wells by cable tool drilling methods. Cable tool drilling methods allow for the development of small waterbearing zones, which often are plugged by conventional air rotary drilling methods.
			Private Sewage Disposal	City of Kanata is encouraged to promote the implementation of these systems (alternate systems which treat sewage prior discharge) as they are demonstrated to be useful and appropriate. Regular inspection of septic system performance, preferably in the spring time during high water tables, is also recommended. Such inspection should typically be completed on a five year cycle. Homeowners with failing systems should be required to bring their systems up to standard within a specified time period set by the municipality.
			Hydrogeologically Sensitive Areas	Areas where overburden thickness is less than 5 m can be considered hydrogeologically sensitive areas. Short flow paths to the aquifer exist with little buffer. Road salting impact had detrimentally affected groundwater resources. Such impact is expected to increase with development and should be avoided. Road salt impact could be minimized by encouraging plowing and sanding of roadways and use of alternative deicing compounds.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Other widespread inputs from pollutants from agricultural activity may also occur. Evidence of such impact, in present subdivisions, was not observed during this study. However, in less developed areas near barn yards, some impact was observed, as nitrate and bacteria contamination. In planning of future development, existing water quality should be addressed at the subdivision stage.</p> <p>Point source contamination may also occur from selected industrial and commercial activity in the City of Kanata. Very little commercial development is present in the City of Kanata rural area. What present is limited to gas stations along the major roadways through the rural area. Given the general sensitivity of the groundwater resource in the City of Kanata, it is recommended that future industrial and commercial activity with potential to contaminate groundwater not be located upgradient of existing and future domestic wells.</p>
Wellhead Protection Area Study - Almonte, Ontario	2003	MVCA (Lanark)	Main Recommendations	<p>The action plan for groundwater source protection developed in this study be implemented.</p> <p>The integrity of the clay liners of the OCWA municipal sewage treatment lagoons should be investigated and confirmed.</p> <p>Collection of additional geologic and hydrogeologic data, possibly in association with installation of sentinel wells, in the WHPA's situated northeast of municipal wells 3, 7 and 8 and south of municipal wells 5 and 6 be undertaken.</p>
			Recommended Action Plan	<p>The Town's new Official Plan incorporate policies for groundwater source protection, as outlined in this report.</p> <p>The zoning by-law be amended as soon as possible, to regulate land use in and around the WHPA's. Particular concern should be given to the scope of uses permitted in the Highway Commercial, Shopping Centre and General Industrial Zones in the capture zones for municipal wells 3, 7 and 8; and in the Institutional, General Industrial and Rural Zones in the capture zone for wells 5 and 6 to prohibit uses that are listed in Categories A-C. In assessing permitted uses, aquifer vulnerability should be considered. For municipal wells 3, 7 and 8 that have low aquifer vulnerability, the WHPA Sensitivity ratings should be decreased by one value (e.g., WHPA Sensitivity 1 becomes WHPA Sensitivity 2, etc.). Municipal wells 5 and 6 which have high and medium aquifer vulnerability should have unchanged WHPA Sensitivity ratings.</p> <p>The Site Plan Control By-law be amended to apply site plan control to all development in a WHPA.</p> <p>Any future development within a WHPA should only be permitted based on an impact assessment that verifies that the risk of the development to the municipal water supply is acceptable.</p> <p>A nutrient management plan be required for all intensive livestock operations in or near a WHPA.</p> <p>A program of public education be implemented following the suggested strategy described in this report.</p> <p>A program for regular septic tank pump-out and reinspection be instituted, for any systems located within the 2 year capture zones.</p> <p>A restricted haulage route by-law be adopted to prevent the haulage of hazardous materials through WHPA's.</p> <p>A program for data maintenance and monitoring be instituted, including inspection/verification of the integrity of the municipal wells and well casing seals, on a regular basis.</p> <p>A program for sentinel well monitoring be instituted. Such sentinel wells should be installed upgradient within the WHPA's and would provide advanced warning of changes in groundwater quality that may affect municipal well water quality, and also provide important calibration targets for refinement of the numerical groundwater flow model and capture zones.</p>
Wellhead Protection Study - Carp Communal Wells, City of Ottawa	2003	MVCA (City of Ottawa)	Recommended Wellhead Protection Area Strategy	<p>The Wellhead Protection Area (WHPA) for the Carp wells extends to the northeast and south of the water supply wells. To the northeast, the WHPA terminates along the bedrock outcrop associated with the Carp Ridge. To the south, the sand and gravel deposit is located beneath the overlying silty clay deposit and the WHPA extends to just south of March Road and west of Carp Road. The "window" in the clay deposit along Rivington Street is partly within the WHPA.</p> <p>The inventory of potential sources of groundwater contamination identified that five low to high relative risk sites (for causing groundwater contamination) are located within, or very close proximity to the Carp communal wells WHPA. The cumulative risks associated with these sites are indicated to be high.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Although this study indicated the presence of a very limited number of potential sources of contamination to the overburden aquifer groundwater within the WHPA, the aquifer is highly vulnerable where the protective layer of silty clay is absent. Due to the vulnerable nature of the overburden aquifer, environmental management of the WHPA is essential in order to maintain protection of the aquifer and quality of the groundwater supply.</p>
			Regulatory Groundwater Protection Measures	<p>The City of Ottawa has several tools available to regulate groundwater protection. The primary planning tool is the Official Plan. The draft Official Plan makes reference to the benefits of wellhead protection, but only implements it after a site-specific study. This study will provide the technical basis for Carp, with currently has a communal (City) well water supply.</p> <p>It is recommended that the City should consider amending the Official Plan to make reference to this study and to require that its recommended WHPA be implemented through any Community Design Plan which is undertaken for the Village of Carp. On January 9, 2003, a report was submitted to the Planning and Development Committee of Council that identified the village of Carp as a priority for a Community Design Plan. A Community Design Plan would provide an opportunity to conduct a comprehensive review of the issues the village is facing. A Community Design Plan for the Village of Carp should incorporate the wellhead protection area identified in this report.</p> <p>The second tool which the City has at its disposal is the implementation through the Zoning By-law. It is recommended that the City should consider the implementation of the WHPA identified through this study in the upcoming zoning by-law review and that the area be shown as a constraint area within which all development be subject to specific development criteria (to protect the overburden aquifer).</p> <p>The Zoning By-law could adopt a specific general provision section which outlines the limitations on uses, and any specific development criteria which would be applied to the lands within the constraint. These limits would be notwithstanding any uses which may be permitted within a specific zone or any development standard which may apply elsewhere within a zone. For example, the section could prohibit the development of retail gasoline outlets, fuel storage facilities, petrochemical facilities, fertilizer plants or specialized farms (intensive livestock or feedlots), dry cleaners and any other uses which could potentially cause harm to the communal well water supply. The zoning by-law could also limit the types of material which are permitted to be stored outside. The City should consider such Zoning By-law restrictions within the 10 year Time of Travel (ToT) capture zone, both within and outside the Village boundary. Although it is not entirely located within the defined WHPA, the zoning by-law provisions should also be imposed on the area where the "window" in the clay deposit has been identified.</p> <p>The City should consider a Zoning By-law provision (applicable to the entire WHPA; the 25 year ToT capture zone) that would require all fuel or chemical storage tanks (including pesticides) to be double-walled tanks (or equivalent protective design) and that they be designed to have proper containment systems. Containment should also be required for areas where pesticide spraying equipment is filled.</p> <p>Regarding dry cleaners and other commercial and industrial operations that regularly produce dense non-aqueous phase liquid (DNAPL) chemical waste, the City should consider prohibiting their operation in all areas of the City that rely on groundwater for the supply of drinking water (not only within the WHPAs), unless alternative water supplies are readily available and can be easily implemented if a groundwater supply aquifer has to be abandoned. Such prohibition would be relevant to Carp.</p> <p>As described in Section 3.3, Amendment 51 to the Township of West Carleton Official Plan included a defined WHPA within the Village boundary of Carp. The current study has defined a WHPA which is different and, 1) takes in additional lands in the northeastern part of Carp; 2) excludes lands in the northwest and west parts of the Village, and; 3) includes lands to the south, outside of the Village boundaries.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Therefore, the following additional suggestions regarding the WHPA strategy are provided: For those residents in the northeast part of the village, who chose to remain on their individual well, there is not a need (from a potential aquifer contamination perspective) for them to abandon their well and connect to the communal supply because: a - private wells are generally cased full depth through the overburden and completed in the underlying bedrock, and b - the wells themselves do not represent a conduit of significance, in view of the overall vulnerable nature of the sand deposit in this part of Carp; If appropriate to do so, the City should consider reviewing and modifying (i.e., possibly be made less restrictive) land use constraints imposed through the current by-law on lands within the Village boundary that are outside of the WHPA defined by this study;</p> <p>Therefore, the following additional suggestions regarding the WHPA strategy are provided: The lands within the WHPA to the south of the Village are used for agricultural and residential (along Carp Road) purposes, and generally consist of a silty clay layer that overlies, and provides natural protection for, the sand and gravel deposit (overburden supply aquifer). The City should consider undertaking field visits and interviews with the owners of all farming and residential properties to determine if there are any man-made holes through the clay (such as abandoned wells, improperly sealed well casings) that could serve as a conduit for potential surface or near-surface contaminant sources to supply aquifer. If such man-made holes were to be found, appropriate mitigation measures could be taken by the City, with the co-operation of the property owner(s).</p>
			Groundwater Investigations - Non-Regulatory Groundwater Protection Measures	<p>The City should consider undertaking subsurface investigations at sites that were identified to represent the greatest relative potential risk to contaminate the overburden aquifer within the WHPA. Based on the cumulative risk assessment of each identified site, the Agri-West Corporation site is indicated to be the site with the highest relative potential risk to contaminate the overburden aquifer. Based on the relative potential risk associated with historical activities at the Carp flour mill site, it could be considered for investigation. The City should consider as the highest priority the investigation of these sites, related to historic and current activities (see 6.2.4 regarding the existing groundwater monitors located between these sites and the communal wells).</p> <p>Prior to undertaking any field investigations, the target site(s) should first be examined in greater detail than possible in this study to further assess the potential contaminant sources. Based on all available information the details for each site investigated (if warranted) would be finalized.</p> <p>The installation of groundwater monitors for site investigations could serve as part of a sentinel groundwater monitoring network (see Section 6.2.4), and may provide some useful hydraulic information if installed as multilevel piezometers extending into the coarse sand and gravel deposit.</p> <p>Sewer system inspections is another "investigation" type of issue for the City to consider. Potential deterioration of the Carp sewer system, could, over time, lead to impacts on the supply aquifer in the highly vulnerable portion of the WHPA. The City should consider reviewing the sewer inspection / maintenance schedule to ensure a low risk of groundwater contamination by the sewer system.</p> <p>In view of the known presence of the window along Rivington Street, the Technical Advisory Group brought forward the potential for a discontinuity in the clay deposit beneath the Carp River and the connection of the Carp River to the aquifer. Previous interpretation of the geology and hydrogeology had concluded that the clay was continuous beneath the river. The effects of a potential discontinuity were checked as part of the uncertainty analysis simulations. In order to investigate this matter further, it would be necessary to carry out a field investigation program to determine the continuity of the clay beneath the Carp River, specifically within the reach of the river within the WHPA east of Carp Road. This could involve for example, a geophysical survey (during the drier summer period) and a series of confirmatory boreholes adjacent to the river channel edge.</p>
			Drainage Studies - Non-Regulatory Groundwater Protection Measures	<p>Surface water from the area of bedrock outcrop, northeast of the WHPA may contribute water to the Carp water supply wells by draining into the WHPA. The City should therefore consider a study to examine the areas that transmit surface water to areas of high groundwater recharge within the WHPA, and should consider extending the WHPAs to include those drainage areas.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Education and Assistance Programs - Non-Regulatory Groundwater Protection Measures	<p>Specific education programs concerning Wellhead Protection could be directed towards the farming community, the business community and the general public.</p> <p>Although the potential risks to the communal wells posed by current agricultural operations are considered to be almost negligible, it is recommended that the City should consider a program of education and awareness that would focus on farms and landowners within the WHPAs so that they clearly understand the risks posed by abandoned wells, fuels, pesticides and manure. If necessary, the City could work with agencies such as the Resource Centre, and the Conservation Authorities to continue to grant programs to assist rural residents to upgrade existing fuel tanks, upgrade existing manure handling facilities, create environmental farm plans and to monitor existing wells and septic systems (surface water quality should also be considered with respect to education and grant programs).</p> <p>The City should consider developing an aquifer protection education program that targets business operations within the WHPA. That education program could encompass a variety of related topics, including the proper handling and management of industrial chemicals, emergency preparedness and legal issues (liabilities) related to adverse impacts.</p> <p>It is recommended that the City maintain contact with the Provincial Smart Growth Panel for Eastern Ontario. The City should consider recommending that the Panel investigate rural development issues and make recommendations to assist in the protection of groundwater including funding of projects to ensure its protection.</p> <p>The City should consider working with all of the local school boards, particularly with the local school (Huntley Centennial), to develop programs to assist the students in learning about the water cycle and the importance of groundwater in Carp in particular. As one example, the Grade 4 curriculum includes a study of the earth and the various natural cycles and this could fit in with this part of the program.</p> <p>The City should consider the continuation of its association with the Conservation Authorities and the Landowner Resource Centre in providing a resource for the rural residents. The current programs offered through the Centre are oriented towards surface water protection, but it would be possible to expand these programs to include groundwater protection as well. Services such as well testing and septic system inspections (for rural residents) could be included in a program.</p> <p>Examples of various programs which are currently offered are: Green Acres - Ottawa's Rural Reforestation Program; Gaining Ground Grant Program to reduce Erosion; Ontario Rural Wastewater Centre; Ontario Living By Water Project; Ottawa's Rural Clean Water Program; Rideau Valley Clean Water Grants Program; Watershed Watch Program; Wetland Habitat Fund.</p> <p>It is recommended that the City consider promoting the use of the Ministry of the Environment (MOE) video "Groundwater the Hidden Resource" as an excellent primer for people to understand groundwater.</p> <p>The City should consider erecting signage indicating the boundaries of the WHPAs (on main transportation routes) in order to raise public awareness. Spill reporting information could be included on the signs.</p>
			Groundwater Monitoring Program - Non-Regulatory Groundwater Protection Measures	<p>The City should consider the installation of a groundwater monitoring network specific to and within the Carp WHPA. The monitoring network would be an important component of a "multi-barrier" system of drinking water protection. The purpose of the monitoring network would be to collect data related to groundwater quality and hydraulic head data, in order to assess the quality of the raw water supply (in the overburden aquifer), to provide sentinel wells for "early warning" of potential problems, and to refine the groundwater model.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The monitoring network could consist of "fences" of multilevel groundwater piezometers, located at specific ToT intervals (e.g. the 50 day and 2 year ToT, and the 10 year ToT). Priority should be given to installation of monitors within the areas of high groundwater recharge. A suggested monitoring frequency would be semi-annually to start. The frequency of monitoring could then be adjusted depending on the findings of the initial monitoring and considering monitor locations (ToT intervals). The chemical analysis should initially include a broad suite of organic and inorganic parameters related to the drinking water quality standards; selection of the subsequent analytical parameter list would depend on the findings and the nature of the potential contaminant sources in the particular WHPA. Development of trigger mechanisms for action on behalf of the City, based on the concentration of each parameter and the trend in its concentration over time, should be considered.</p> <p>It is understood that it has been recommended to the City that the existing monitoring well located between the Agri-West Corporation site and the communal wells and between the Carp flour mill and the communal wells be replaced by monitors that are screened through the full thickness of the overburden aquifer. In terms of monitoring for the presence of potential contaminants, this is not considered the most appropriate approach. Rather, it is suggested that a multi-level monitor installations with discrete sampling intervals across the aquifer thickness be installed.</p> <p>The City should investigate if funds are available from the Provincial Groundwater Monitoring Network program for the purpose of installing the Carp WHPA groundwater monitoring network.</p>
			Implementation of Wellhead Protection Strategy - Non-Regulatory Groundwater Protection Measures	<p>The City should consider the following in order to implement the Wellhead Protection strategy. This list of "next steps" is not in order or importance.</p> <ul style="list-style-type: none"> <li>Develop a schedule for implementation of the Wellhead Protection strategy</li> <li>Prepare a public consultation plan</li> <li>Develop appropriate WHPA regulations</li> <li>Prepare emergency response procedures</li> <li>Prioritise and initiate subsurface investigations and drainage investigations</li> <li>Develop a groundwater monitoring program</li> <li>Develop and deliver education and assistance programs</li> <li>Develop a schedule for regular review of the status of the WHPA, including updates on groundwater quality, and possible updates to the groundwater model</li> <li>Develop contingency plans for alternative water supplies</li> </ul>
Wellhead Protection Study, King's Park Subdivision, Village of Richmond	1996	RVCA (City of Ottawa)	200-Day Travel Time Zone - Recommendations	<p>The results of our wellhead protection area delineation are shown on Figure 30542-1. This figure displays both the 200-day and 2500-day travel time zones for the 99th percentile. We have established the 200-day travel time to protect the aquifer from pathogens such as viruses and bacteria. After 200-days of travel in ground water, most if not all bacteria and viruses should die-off. Our principle for protecting the 200-day travel time zone is prevent any type of land use that could introduce pathogens to the ground water and also, to prevent any other type of contamination from occurring within this zone. There are several land use activities that we recommend keeping out of the 200-day travel time zone as summarized below: septic systems; sludge manure application; feedlots; kennels; manure storage.</p> <p>During our site reconnaissance, we did not note the presence of these land use activities within the 200-day wellhead protection zone with the exception of the sewage pumping station and agricultural land use. Since the area is fairly well developed for residential land use and the residences are connected to public sewer, there does not appear to be a significant risk for future land use activities of the nature described in the list above. We do not recommend any future development within the 200-day travel time zone. Fertilizer, manure of sludge spreading should be discontinued within the 200-day travel time zone. The only type of land use we advocate on any vacant land within the 200-day travel time zone is timber management and passive recreation (walking, hiking).</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			2500-Day Travel Time Zone - Recommendations	<p>We established the 2500-day wellhead protection zone based on an estimate of the time required to respond, investigate and remediate an accidental spill of contaminants such as chemicals or petroleum outside that zone. The area between the 200-day travel time zone and the 2500-day travel time zone is capable of supporting low density residential development and carefully controlled farming and timber management. We discourage commercial development within the 2500-day travel time zone since commercial operations tend to store potential contamination sources such as chemicals and petroleum and can also produce hazardous waste. We also recommend that salt and sand / salt stockpiles on bare ground be banned from the 2500-day travel time zone.</p> <p>Where petroleum or chemical storage pre-exists within the 2500-day travel time zone, we recommend engineered structures to minimize the potential for a spill. Engineered structures may include, for example, double walled tanks, interstitial monitoring for underground storage tanks, low level alarms, high level alarms, and berms around potential contamination sources. The goal of engineered structures is to passively prevent a spill from reaching bare ground, surface water or ground water. If passive engineered structures are not feasible due to physical site constraints or space limitations, then we recommend using active spill response measures to prevent the release of potential contamination sources such as chemicals or petroleum to bare ground within the 2500-day travel time zone. Active measures might include, for example, sand bags, absorbent pads, booms and other objects that will help to contain a spill before it reaches bare ground. A drawback to active spill response measures are that they require human intervention.</p> <p>Other land use restrictions we recommend between the 200-day and 2500-day travel time zone include limiting the density of farm animals since the soil has a limited capacity to absorb the nitrogen produced in animal manure. There are guidelines for aquifer protection ordinances that limit the number of animals per acre based on average rates of manure production and nitrogen content per type of animal. We can provide information at your request if this is anticipated to be a problem.</p> <p>The Ministry of the Environment and Energy (MOEE) provides "Guidelines for Sewage Sludge Utilization on Agricultural Lands", dated as revised on January, 1986. These guidelines are useful for sludge spreading on lands that are proximal to the communal well system. Although these guidelines require a minimum separation distance of 90 meters (300 feet) between sludge spreading and water wells, we recommend keeping all sludge spreading outside the 200-day travel time zone.</p> <p>Agricultural practices within the 2500-day travel time zone should minimize the application of fertilizer and use bio-degradable pesticides with a half-life in unsaturated soil of 30 days or less.</p>
			Managing the Wellhead Protection Area - Recommendations	<p>Step 4 of our wellhead protection process involves managing the wellhead protection area. We offer a few suggestions above for land uses that are not amenable in the protection area. Implementing land management can be accomplished through public education, land use zoning, and ground water monitoring.</p> <p>The easiest but most expensive method to control land use within the protection zone is to acquire a fee interest in the land, buy the development rights or purchase the property. Other methods for land use protection include zoning ordinances. Some towns have been reluctant to adopt zoning boundaries that do not conform to property line boundaries or that can't be described easily by Village maps.</p> <p>Since most of the land is developed in the wellhead protection area, the best resource protection would be public education to minimize the risk of spills and releases within the sensitive areas. In particular, residences and businesses should be informed about the importance of disposing of household and commercial chemicals and petroleum products in a manner that is safe for the environment.</p> <p>We recommend that the Regional Municipality of Ottawa-Carleton (RMOC) take a survey of agricultural practices before discussing land management recommendations with land owners. A survey might include the type and amount of fertilizer, pesticides and herbicides that are added to agricultural land within the 2500-day travel time zone.</p>
			Monitoring the Wellhead Protection Area - Recommendations	<p>Ground water monitoring near the communal well system is a last resort method for detecting contamination in the ground water before it reaches the water supply wells and the distribution system. As a last resort, it is beneficial to collect water quality samples from observation wells that are located near the boundary of the 200-day travel time zone. Water quality samples can be tested on a regular basis for parameters that could be found in the ground water near the site such as Coliform Bacteria, Nitrate-Nitrogen, Petroleum Hydrocarbons, Pesticides, Herbicides, Chloride and Hardness.</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
			Areas Outside the Wellhead Protection Area - Recommendations	The zone of contribution to the communal well system is larger than the 2500-day travel time zone. However, it is difficult to manage land use in the entire watershed area that recharges the wells. Therefore, we have chosen the more practical protection zones based on the 200-day and 2500-day travel times. We have not studied areas outside the 2500-day travel time zone. While we have no specific recommendations for those areas outside the 2500-day travel time zone, we do recommend that land owners, Village officials, and the RMOC work together to manage sludge spreading and waste disposal, control development density and control commercial and industrial development so that the risk of ground water contamination is minimized if not eliminated. We recommend that impact studies be performed on any proposed commercial or industrial land use to check for potential effects on water quality and water quantity at the communal well system.
			Recommendations Summary	In summary, we recommend the following actions to follow up this Wellhead Protection Study: 1) Work with Village Officials to establish procedures for evaluating the impacts of new development on groundwater quality and quantity; 2) Restrict land use activities within the 200- and 2500-day travel time zones to those identified in this report; 3) Educate the commercial businesses identified in Table 1 to institute engineered structures for the prevention of chemical and petroleum spills to the bare ground and ground water; 4) Survey agricultural practices and work with land owners as a team to minimize fertilizer, pesticide and herbicide use; 5) Install monitoring wells and implement a water quality testing program to check for contaminant migration before it reaches the communal wells.
Wellhead Protection Study - Munster Hamlet and Kings Park Communal Wells, City of Ottawa	2003	RVCA (City of Ottawa)	Recommended Wellhead Protection Strategy	<p>The Wellhead Protection Area (WHPA) for the Munster wells extends some 9 km to the northwest of the water supply wells and is some 2.8 km wide. The WHPA terminates at a large wetland area.</p> <p>The WHPA for the Kings Park wells is comprised of two arms, on either side of the Jock River. It extends to the west-northwest for some 14 km, is typically about 2 to 3 km wide, and terminates at a large wetland area (same one as for the Munster capture zone). It also extends some 9 km to the south, with a maximum width of about 2 km, and terminates under another wetland area.</p> <p>The large wetland area to the west-northwest of the Munster and Kings Park wells is crossed by the Highway 7 corridor.</p> <p>The inventory of potential sources of groundwater contamination indicates that sites with low to high risk of causing groundwater contamination are located within or in close proximity to the Munster and Kings Park communal wells WHPAs.</p> <p>Many of the high risk sites are located within the villages (Munster and Richmond) and are therefore in relative close proximity (short Time of Travel (ToT)) to the communal supply wells.</p> <p>The sites with the greatest potential risk to contaminate the Nepean sandstone aquifers are the closed landfills / dumps, the scrap yard and the dry cleaner. The high degree of risk associated with these sites is due to the possibility of dense non-aqueous phase liquid (DNAPL) disposal or spills.</p> <p>The retail gasoline outlets, automotive repair shops, active farming operations, and other commercial operations and historical land uses within the WHPAs also present potential for contamination of groundwater. However, the low aquifer vulnerability of the Nepean aquifer indicates that the overall (cumulative) risks associated with these sites should be low.</p> <p>The Nepean sandstone aquifer, the main supply aquifer for the Munster and Kings Park communal wells, is indicated to be naturally protected by a significant thickness of overlying bedrock of moderate hydraulic conductivity, and also in some areas by low and moderate hydraulic conductivity overburden. However, environmental management of the WHPA is essential in order to maintain protection of the aquifer and quality of the groundwater supply. It is important to distinguish that the following Wellhead Protection strategy is for the deep sandstone aquifer that supplies these communal wells, and not for the shallower aquifers that supply individual wells in the area.</p>
			Regulatory Groundwater Protection Measures	The City of Ottawa has several tools available to regulate groundwater protection. The primary planning tool is the Official Plan. The draft Official Plan makes reference to the benefits of wellhead protection, but only implements it after a site-specific study. This study will provide the technical basis for Munster and Kings Park, with currently has a communal (City) well water supply.

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>It is recommended that the City should consider amending the Official Plan to make reference to this study and to require that its recommended WHPA be implemented through any Community Design Plan which is undertaken for the Village of Richmond or Munster Hamlet. A Community Design Plan would provide an opportunity to conduct a comprehensive review of the issues the village is facing. Any Community Design Plan undertaken for Richmond or Munster Hamlet should incorporate the wellhead protection area identified in this report.</p> <p>The second tool which the City has at its disposal is the implementation through the Zoning By-law. It is recommended that the City should consider the implementation of the WHPAs identified through this study in the upcoming zoning by-law review and that the area be shown as a constraint area within which all development be subject to specific development criteria (to protect the Nepean sandstone aquifer).</p> <p>The Zoning By-law could adopt a specific general provision section which outlines the limitations on uses, and any specific development criteria which would be applied to the lands within the constraint. These limits would be notwithstanding any uses which may be permitted within a specific zone or any development standard which may apply elsewhere within a zone. For example, the section could prohibit the development of retail gasoline outlets, fuel storage facilities, petrochemical facilities, fertilizer plants or specialized farms (intensive livestock or feedlots), dry cleaners and any other uses which could potentially cause harm to the communal well water supply. The zoning by-law could also limit the types of material which are permitted to be stored outside. The City should consider such Zoning By-law restrictions within the 2-year Time of Travel (ToT) capture zone.</p> <p>The City should consider a Zoning By-law provision (applicable to the entire WHPA; the 25 year ToT capture zone) that would require all fuel or chemical storage tanks (including pesticides) to be double-walled tanks (or equivalent protective design) and that they be designed to have proper containment systems. Containment should also be required for areas where pesticide spraying equipment is filled.</p> <p>Regarding dry cleaners and other commercial and industrial operations that regularly produce dense non-aqueous phase liquid (DNAPL) chemical waste, the City should consider prohibiting their operation in all areas of the City that rely on groundwater for the supply of drinking water (not only within the WHPAs), unless alternative water supplies are readily available and can be easily implemented if a groundwater supply aquifer has to be abandoned. Such prohibition would be relevant to Munster and Richmond.</p> <p>As described in Section 3.3, Amendment 51 to the Township of West Carleton Official Plan included a defined WHPA within the Village boundary of Carp. The current study has defined a WHPA which is different and, 1) takes in additional lands in the northeastern part of Carp; 2) excludes lands in the northwest and west parts of the Village, and; 3) includes lands to the south, outside of the Village boundaries.</p>
			Groundwater Investigations - Non-Regulatory Groundwater Protection Measures	<p>The City should consider undertaking subsurface investigations at or in the immediate vicinity of the sites that were identified to represent the greatest potential risk to contaminate the Nepean sandstone aquifer. The sites that should be given the highest priority are those sites within the WHPAs where DNAPLs may be present (i.e. the one identified dry cleaner and the two identified closed landfills within the Kings Park WHPA). Other high risk sites that are outside of the WHPAs or where DNAPL use is not suspected would be lower priority at this time. Sites where industrial chemicals are used and where septic systems and / or dry wells may be in use should also be priorities for field investigations (ten such sites were identified by the institutional, commercial and industrial (ICI) field survey).</p> <p>Prior to undertaking any field investigations, all information related to the target sites should be examined in greater detail than possible in this study, to identify specific potential contaminants of concern and to develop site specific conceptual models and a detailed site investigation plan (if warranted). A detailed review of the contaminant inventory information collected for this study (ICI survey results in Appendix F), supplemented by additional data collection (e.g. site specific sampling from water wells, septic systems and dry wells) could be undertaken in order to further prioritise sites for intrusive field investigations. Sites where groundwater quality information already exists (e.g. the Munster Lagoons) may not require further investigation.</p>

**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>In most cases, groundwater investigations would not need to extend to the Nepean sandstone. Generally, the most relevant information concerning groundwater quality will be obtained in the overburden and in the shallow bedrock, particularly if groundwater monitors can be installed fairly close to suspected contaminant source areas. However, monitors that are installed to the Nepean sandstone for site investigations could serve as part of a sentinel groundwater monitoring network (see Section 6.2.4). The installation of multilevel piezometers, to evaluate vertical gradients and to determine / monitor groundwater quality with depth, would be recommended at confirmed sites of groundwater contamination.</p> <p>A City of Ottawa study (by Golder Associates) that is currently underway is evaluating and prioritising for investigation, all former landfills within the City of Ottawa. The results of that study should be reviewed in order to help prioritise the investigation of the closed landfills that were identified within or in close proximity to the Munster and Kings Park WHPAs.</p> <p>The results of sensitivity simulations suggest that the extent of the Munster and Kings Park capture zones and / or the "two-arm" capture zone configuration in Kings Park are mostly sensitive to: i) effective porosity values into the Nepean formation layers; ii) hydraulic conductivity (K) contrasts in the Nepean formation layers; and iii) K variations into the Upper Paleozoic formations layer. Detailed investigations would be required to reduce the uncertainty level associated with these parameters.</p> <p>Detailed investigations would be required in order to determine the degree of influence, if any, that fault zones may have with respect to groundwater flow and the extent of the Kings Park capture zone arms. Also, in order to better evaluate the potential effects of the Jock River on the Kings Park supply wells and capture zones, the Jock River flow regime and seasonal surface water and groundwater levels would need to be assessed in the Kings Park area.</p>
			Drainage Studies - Non-Regulatory Groundwater Protection Measures	Wetlands are important recharge features within the WHPAs. The City should therefore consider initiating a study to examine the areas that transmit surface water to the wetlands within the WHPA, and should consider extending the WHPAs to include those drainage areas.
			Education and Assistance Programs - Non-Regulatory Groundwater Protection Measures	Specific education programs concerning Wellhead Protection could be directed towards the farming community, the business community and the general public.
				<p>Although the potential risks posed by agricultural operations to shallow groundwater and on-site shallow wells is, in general, far greater than the potential to cause impacts on the communal wells, based on the findings of the agricultural land use survey, it is recommended that the City should consider a program of education and awareness that would focus on farms and landowners within the WHPAs so that they clearly understand the risks posed by abandoned wells, fuel, pesticides and manure. Some pesticides are DNAPLs, therefore the proper handling of pesticides should be highlighted. If possible, the City should gather additional information regarding farm operations and provide direct feedback regarding farming operations and practices.</p> <p>Specific farming locations / operations may also be selected for groundwater investigations in order to determine what, if any, impacts these operations are having on shallow groundwater or the Nepean aquifer. If there is evidence of a groundwater contamination problem, and possible impact on the communal wells, the City could work with agencies such as the Resource Centre, and the Conservation Authorities to continue grant programs to assist rural residents to upgrade existing fuel tanks, upgrade existing manure handling facilities, create environmental farm plans and to monitor existing wells and septic systems (surface water quality should also be considered with respect to education and grant programs).</p> <p>The City should consider developing an education program that targets business operations within the WHPAs. That education program would focus on the proper handling and management of industrial chemicals, issues related to septic system and dry well disposal of chemicals, disposal of chemicals in sewers, emergency preparedness and legal issues (liabilities) related to adverse impacts.</p> <p>It is recommended that the City maintain contact with the Provincial Smart Growth Panel for Eastern Ontario. The City should consider recommending that the Panel investigate rural development issues and make recommendations to assist in the protection of groundwater, including funding of projects to ensure its protection.</p>



**Table A-1**

**Previous Study Recommendations  
Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>The City should consider working with all of the local school boards, particularly with the local schools: St. Philip Elementary (Richmond); Munster Elementary; and South Carleton Secondary, to develop programs to assist the students in learning about the water cycle and the importance of groundwater to Richmond and Munster in particular. As one example, the Grade 4 curriculum includes a study of the earth and the various natural cycles and this could fit in with this part of the program.</p> <p>The City should consider the continuation of its association with the Conservation Authorities and the Landowner Resource Centre in providing a resource for the rural residents. The current programs offered through the Centre are oriented towards surface water protection, but it would be possible to expand these programs to include groundwater protection as well. Services such as well testing and septic system inspections could be included in a program.</p> <p>Examples of various programs which are currently offered are: Green Acres - Ottawa's Rural Reforestation Program; Gaining Ground Grant Program to reduce Erosion; Ontario Rural Wastewater Centre; Ontario Living By Water Project; Ottawa's Rural Clean Water Program; Rideau Valley Clean Water Grants Program; Watershed Watch Program; Wetland Habitat Fund.</p> <p>It is recommended that the City consider promoting the use of the Ministry of the Environment (MOE) video "Groundwater the Hidden Resource" as an excellent primer for people to understand groundwater.</p> <p>The City should consider erecting signage indicating the boundaries of the WHPAs (on main transportation routes) in order to raise public awareness. Particular attention should be directed to the area where Highway 7, a major transportation corridor, crosses the wetland recharge area for the communal wells. Spill reporting information could be included on the signs.</p>
			Groundwater Monitoring Program - Non-Regulatory Groundwater Protection Measures	<p>The City should consider the installation of a groundwater monitoring network specific to and within the Munster and Kings Park WHPAs. The monitoring network would be an important component of a "multi-barrier" system of drinking water protection. The purpose of the monitoring network would be to collect data related to groundwater quality and hydraulic head data, in order to assess the quality of the raw water supply (in the Nepean aquifer), to provide sentinel wells for "early warning" of potential problems, and to refine the groundwater model.</p> <p>The monitoring network could consist of "fences" of multilevel groundwater piezometers, located at specific ToT intervals (e.g. the 50 day and 1 year ToT, and possibly also extended out to the 10 year ToT). A suggested monitoring frequency would be semi-annually to start. The frequency of monitoring could then be adjusted depending on the findings of the initial monitoring and considering monitor locations (ToT intervals). The chemical analysis should initially include a broad suite of organic and inorganic parameters related to the drinking water quality standards; selection of the subsequent analytical parameter list would depend on the findings and the nature of the potential contaminant sources in the particular WHPA. Development of trigger mechanisms for action on behalf of the City, based on the concentration of each parameter and the trend in its concentration over time, should be considered.</p> <p>The installation of groundwater monitors (as required in the draft Certificate of Approval (C of A) for the Kings Park water works) could serve as part of this sentinel groundwater monitoring network, and may provide some useful hydraulic information (if installed within the two WHPA areas as multilevel piezometers extending to the Nepean sandstone aquifer). The current study does not indicate that surface water from the Jock River contributes to the Nepean supply aquifer, and as such this is not a consideration with respect to finalizing the location and design of these monitor installations.</p> <p>The City should investigate if funds are available from the Provincial Groundwater Monitoring Network program for the purpose of installing the WHPA groundwater monitoring network.</p>
			Implementation of Wellhead Protection Strategy - Non-Regulatory Groundwater Protection Measures	<p>The City should consider the following in order to implement the Wellhead Protection strategy. This list of "next steps" is not in order or importance.</p> <p>Develop a schedule for implementation of the Wellhead Protection strategy</p> <p>Prepare a public consultation plan</p> <p>Develop appropriate WHPA regulations</p>

**Table A-1**

**Previous Study Recommendations**

**Proposed Mississippi-Rideau Source Water Protection Region**

Previous Study	Date	Watershed Area	Topic	Recommendation
				<p>Prepare emergency response procedures</p> <p>Prioritise and initiate subsurface investigations and drainage investigations</p> <p>Develop a groundwater monitoring program</p> <p>Develop and deliver education and assistance programs</p> <p>Develop a schedule for regular review of the status of the WHPA, including updates on groundwater quality, and possible updates to the groundwater model</p> <p>Develop contingency plans for alternative water supplies</p>
Westport Water Works - First Engineers' Report for Water Works	2001	RVCA (Leeds & Grenville)	Summary and Recommendations	Numerous recommendations, which can be found throughout this report, are summarized here for convenience. Recommendations regarding non-compliance with the Drinking Water Protection Regulation 459/00 (DWPR) are listed first, followed by other recommendations. Recommendations are prefaced by the Section number which generated them.
			Recommendations to comply with Drinking Water Protection Regulation 459/00	<p>3.a - Flow records indicate that the firm capacity of the Westport wells system is approximately 56% of the maximum day demand recorded over the past three years. Draw down tests are recommended to establish the maximum available capacity in the two wells. Future upgrading of well capacity is recommended. It is noted that this recommendation had been supported by Ministry of the Environment (MOE) staff in recent reports.</p> <p>4.a - Potential sources for bacterial contamination of the water supply have been identified. The following work is recommended to minimize this potential: regrading and improvements to the parking areas in the vicinity of Well #1 is recommended to prevent ponding in this area; cracks and distortions in the elevated tank should be repaired and sealed as recommended in Misco's May 9, 2000 report (Appendix C). On completion of this work the tank will need repainting; pump tests (see also recommendation 3.1) should be carried out to determine the area of influence around each well. The Village should enact appropriate policies and by-laws to control development within this area (i.e. a well head protection plan); a visual (camera) inspection of the interior of the wells, and in particular the ends of the well casings, should be undertaken to confirm the bedrock / casing depth and grouting and sealing of the well annuli.</p> <p>6.a - New drinking water regulations require daily grab samples for turbidity, or continuous monitoring and recording. Most water agencies find it less costly to install continuous monitoring and that is recommended.</p> <p>8.a - A site specific water quality program is provided in Chapter 8. Immediate implementation is recommended.</p>
			Other Recommendations	<p>2.a - The Village of Westport has recently been issued a permit to take water which permits less than what is currently used. The Village is advised to continue its efforts to have this permit revised.</p> <p>2.a - At the time of construction, no Certificate of Approval was issued for the Westport Water System. This will be corrected with the issuance of new Certificates under the Province's drinking water protection program.</p> <p>4.b - It has been observed that the raw water quality of Well #1, which operates primarily in a stand by mode during the summer, is of lower quality than Well #2. A test program which incorporates more frequent use or cycling of Well #1, particularly during the summer, should be initiated to determine if this might result in an improvement.</p> <p>5.a - The single observed exceedance of the Interim Maximum Acceptable Concentration (IMAC) for arsenic appears to be an anomaly. Nevertheless, increased sampling for arsenic should be undertaken to monitor arsenic levels.</p> <p>6.b - Preparation of a formal operations manual, in conformance with MOE guidelines, is recommended. The manual should include contingency planning.</p> <p>7.a - A holding tank is required on the eye wash station to supply room temperature water.</p>

**Notes:**