THE IMPORTANCE OF WATERSHED MANAGEMENT

IN PROTECTING ONTARIO'S DRINKING

WATER SUPPLIES

APPENDICES

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PREPARED BY: CONSERVATION ONTARIO

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APPENDIX A—DECISION SUPPORT TOOLS TO EVALUATE WATERSHED ALTERNATIVES

The intention of this appendix is to briefly describe some of the tools which are commonly used to evaluate various watershed management activities mentioned in Chapter 3. These tools are useful in dealing with water supply, water quality, flooding and various environmental issues.

A.1 Water Quality Models

Rural Water Quality Model

The Grand River Simulation Model, GRSM, is a continuous simulation river water quality model. The model was developed to predict dissolved oxygen (DO) variations throughout a river and to identify periods of dissolved oxygen violation (times when DO levels fall below Provincial water quality objectives). The model incorporates an aquatic plant model, which is capable of simulating the growth of various shallow rooted aquatic plant types typical of the Grand River watershed. The model requires input data or stream flow, point sources such as sewage treatment plants, non-point sources such as agricultural and urban runoff, and various process rate coefficients.

The original model was developed in the 1970s by the Ontario Ministry of the Environment as part of the Grand River Basin Water Management Study. The model has been upgraded by the Grand River Conservation Authority from 1995 to 1998.

The GRSM model was used to predict water quality (DO minimums) of the river system for various water management scenarios that were investigated as part of the study. The scenarios were partly based on projections of population growth, and associated STP discharges to the river system. A 20-year projection of water quality was obtained from the GRSM with various assumptions regarding the operating of STP effluent and rural diffuse source inputs.

Reference: Technical Report 30: *Water Quality Simulation Models and Modelling Strategy for the Grand River Basin.*

Agricultural Area Water Quality Models

The Agricultural Nonpoint Source Pollution Model (AGNPS) was developed by the United States Department of Agriculture in 1986 to obtain estimates of runoff quality from rural lands. Its primary emphasis is on nutrients, pesticides and sediments. The objective of the model is to compare the effects of pollution control practices that could be incorporated into the management of watersheds. It is a distributed model that simulates agricultural watersheds for a single storm event assuming uniform precipitation patterns. Watersheds modelled by AGNPS must be divided into homogeneous square working areas called cells. Subdivision of main cells into smaller sub-cells gives flexibility to account for heterogeneity in the watershed. The hydrology is calculated by the Soil Conservation Service curve number approach. The Universal Soil Loss Equation is used for predicting soil erosion in five different particle sizes, namely, sand, silt, clay, small aggregates and large aggregates. The pollutant transport portion is subdivided into one part handling soluble pollutants and another part for sediment-based pollutants.

The Grand River Conservation Authority has established two pilot study areas (Canagagigue Creek and Lower Conestogo River) to evaluate the use of AGNPS in watershed nutrient management planning. A tool is needed to predict the change in the water quality of a river in response to implementation of agricultural best management practices. This information is needed to predict the change in the water quality of a river in response to implementation of agricultural best management practices. This information may then be used by an in-stream water quality model (GRSM) that assimilates nutrients from both non-point sources (modelled by AGNPS) and point sources such as wastewater treatment plants.

A.2 Watershed Quality Models

GAWSER Hydrologic Model

The Guelph All Weather Sequential Events Runoff model was developed by the University of Guelph in the mid 1970's and was refined in the late 1980's to predict streamflow from rainfall, snowmelt or combined rainfall/snowmelt events. Streamflow can be modelled for long periods of time (years) making it useful for water balance studies. The model also has the ability to simulate sediment loading, pollution wash off and water temperature. Runoff amounts are determined through the use of the Green Ampt approximations for infiltration. The model accounts for a full water budget, runoff, infiltration, evaporation, interflow and deep groundwater percolation.

The runoff response is determined using the area/time method to distribute runoff with time. The unit hydrographs are then routed through the river channel by using the Muskingum-Cunge method of channel routing. Reservoir routing is represented by the Puls routing method with controlled releases.

The GAWSER hydrologic model has been successfully applied in the Grand River watershed and in other watersheds throughout Ontario. It has been used in generating design flood flows, assessing the effect of land use change and providing input to river water quality models such as GRSM. It has also been used in water budget analysis to address drought, and water allocation problems.

Reference: Schroeter & Associates. 1996. GAWSER: Guelph All-Weather Sequential-Events Runoff Model, Version 6.5, Training Guide and Reference Manual. Submitted to the Ontario Ministry of Natural Resources and the Grand River Conservation Authority.

Hydrological Simulation Program (HSPF)

The Hydrological Simulation Program—Fortran (HSPF) simulates for extended periods of time the hydrologic, and associated water quality processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. HSPF uses continuous rainfall and other meteorologic records to compute streamflow hydrographs and pollutographs. HSPF simulates interception soil moisture surface runoff, interflow, base flow, snowpack depth and water content, snowmelt, evapotranspiration, groundwater recharge, dissolved oxygen, biochemical oxygen demand (BOD), temperature, pesticides, conservatives, fecal coliforms, sediment detachment and transport, sediment routing by particle size, channel routing, reservoir routing, constituent routing, pH, ammonia, nitrite-nitrate, organic nitrogen, orthophosphate, organic phosphorus, phytoplankton, and zooplankton. The Program can simulate one or many pervious or impervious unit areas discharging to one or many river reaches or reservoirs. Frequency-duration analysis can be done for any time series. Any time step from 1 minute to 1 day that divides equally into 1 day can be used. Any period from a few minutes to hundreds of years may be simulated. HSPF is generally used to assess the effects of land-use change, reservoir operations, point or nonpoint source treatment alternatives, flow diversions, etc. Separate programs are available for data preprocessing and for postprocessing for statistical and graphic output of any constituent at any time step for any length of time.

Reference: U.S. Geological Survey, June 11, 1997. HSPF Readme File, HSPEF—Version 11. Hydrologic Analysis Software Support Team. Reston, VA.

A.3 Water Budget Modelling

The foundation of modern Hydrology is the Hydrologic Cycle. The Hydrologic Cycle is characterized by the Hydraulic Budget or Water Budget equation. The hydrologic budget for a watershed can be written for a selected time period as:

$$P - R - G - Et = \triangle S$$

Where P = Precipitation on the watershed in a given time period

R = Net surface runoff for the selected time period

G = Net groundwater flow for a selected time period

Et = Evapotranspiration for a selected time period

$\triangle S$ = Change in storage (surface and groundwater) of the volume of water on and in the watershed during the selected time period

Introducing water users (such as municipal or industrial water taking) into the equation, the equation now becomes:

$$P - R - G - Et - \text{Water Use} = \triangle S$$

This can be simplified into:

Water available - Water use = $\triangle S$ or net water available to support natural environmental functions and potential water use.

The Grand River Conservation Authority is currently developing a watershed wide water budget. Once completed, the water budget will address questions related to water takings, with respect to the sustainability of the taking, as well as the possible ecological impacts of such takings. The water budget will also identify basins whose streamflows are naturally sensitive to droughts. Once identified, a drought contingency plan may be developed to deal with expected reductions in streamflow. In addition, a complete water budget will increase the general understanding of the watershed, therefore facilitating a more effective management of the resource.

Determining the water availability component consists of employing a computational procedure to estimate available water. Currently, in Phase 1, the Grand River Conservation Authority is utilizing the deterministic hydrologic model, GAWSER, to estimate streamflow for a 40-year simulation period. Making use of output generated from the modelling exercise, a mass balance approach is applied, as shown in Equation 2, to estimate available water for a given subcatchment. Phase 2 will integrate a finite difference groundwater model, MODFLOW, into the estimation of water availability. By gaining a better understanding into groundwater movement throughout the watershed, regional and local groundwater discharges, which have the ability to dramatically alter the water availability estimate, would be identified.

While the existing water budget is useful in understanding the existing hydrologic processes of the watershed, future water budgets are essential to effective long-term management of the watershed. By projecting possible future scenarios such as, long term climate change, land use change, population increases and agricultural intensification onto the existing water availability and water use, a future water budget can be produced, and with it, the ability to manage the watershed in a proactive sense.

Reference: Bedient, Philip, B., Huber, Wayne, C. 1992. *Hydrology and Floodplain Analysis.* Addison-Wesley Publishing. Reading, Massachusetts.

A.4 Groundwater Model

MODFLOW (Modular three dimensional finite difference groundwater flow model)

There are a variety of groundwater models available to analyze regional groundwater systems as described in Chapter 3.

This appendix briefly describes an industry standard “MODFLOW”, a groundwater flow model developed by the U.S. Geological Survey in 1989 for the computer simulation of groundwater flow. MODFLOW is used to simulate groundwater systems for water supply, contaminant remediation and mine dewatering. It was used in the Waterloo-Wellington area to model regional groundwater flow for the Mill Creek and Blair-Bechtel watersheds and is presently being incorporated into the Water Budget Model for the entire Grand River watershed (Appendix A.3).

The model has a modular structure that allows it to be easily modified to adapt the code for a particular application. Many new capabilities have been added to the original model. The latest update is called MODFLOW-2000 in order to distinguish it from earlier versions. MODFLOW-2000 simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic (restricted to having the principal directions aligned with the grid axes), and the storage coefficient may be heterogeneous. Specified head and specified flux boundaries can be simulated as can a head dependent flux across the model's outer boundary that allows water to be supplied to a boundary block in a modelled area at a rate proportional to the current head difference between a "source" of water outside the modelled area and the boundary block. MODFLOW is currently the most used numerical model in the U.S. Geological Survey for groundwater flow problems. In addition to simulating groundwater flow, the scope of MODFLOW—2000 has been expanded to incorporate related capabilities such as solute transport and parameter estimated.

The groundwater flow equation is solved using the finite difference approximation. The flow region is subdivided into blocks in which the medium properties are assumed to be uniform. In plan view the blocks are made from a grid of mutually perpendicular lines that may be variably spaced. Model layers can have varying thickness. A flow equation is written for each block, called a cell. Several solvers are provided for solving the resulting matrix problem; the user can choose the best solver for the particular problem. Flow rate and cumulative volume balances from each type of inflow and outflow are computed for each time step.

Reference: McDonald, Michael G. and Arlen W. Harbaugh. (1988). Chapter A1. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, in *Techniques of Water-Resources Investigation of the United States Geological Survey*

A.5 Geographical Information System

The use of geographical information system (GIS) has grown dramatically in recent years. A Geographical Information System is a moderately sophisticated, yet robust tool employed to support the capture, management, modelling and display of geographically referenced data. One of its main uses is mapping the location of features. For example, the Grand River Conservation Authority has mapped the watershed natural hazards by combining data layers including floodlines, steep slopes, wetlands, streams and topography. This natural hazard mapping is then useful for municipal planning throughout the watershed.

Similarly, in groundwater mapping, the Grand River Conservation Authority has used GIS to map groundwater recharge areas and aquifer systems. These mapped areas give an understanding of the system and enable groundwater protection areas to be established. Beyond mapping the locations, GIS also provides a mechanism to monitor change with time. For example, by combining soil/geologic data layers with land use data layers, the impact of land use upon runoff during a storm event for flood concerns and during a season for water supply concerns can be determined.

At the Grand River Conservation Authority (GRCA), GIS technology is used extensively throughout the organization. GRCA's committed goal for using the technology is to maintain an integrated, watershed-based tool for resource management that meets the evolving needs of the GRCA and its partners. The objective, in terms of using this technology, remains improved business performance. GIS technology has enabled the GRCA to do things unimaginable only a few years ago. Not only does the GRCA have good data, but the data is also being used on a daily basis to make better decisions. In addition, the GRCA has committed to keeping the GIS data current. It is this commitment that enables the GRCA to utilize its GIS technology in support of on-going decision-making.

APPENDIX B - RISK MANAGEMENT

Risk assessments for water supply questions utilize technical information to characterize the magnitude of human health risk. This is accomplished using descriptions of physical features and management practices within the watershed and factual information defining the health effects of human exposure to contaminants arising from within the watershed.

The schematic in Figure B-1 demonstrates the principles implicit in risk assessment and management. Figure B-1 depicts the simple situation of a feedlot, a downgradient water supply well, and a water treatment system prior to delivery of the water to consumers. This illustrates the three elements of a problem that are relevant to risk assessment:

1. **A Source Exists -** a source of contamination, in this situation arising from a confined livestock facility;
2. **One or More Pathways Exist -** a series of pathways exist by which the contaminants may migrate to the well. The pathways in this case involve surface flow and subsurface movement. Various biological, chemical, and/or transport processes act on the water contaminants during migration and affect their fate;
3. **One or More Water Consumers Exist -** one or more water consumers use the well as a drinking water source, and may experience human health impacts from contamination.

These three elements - source, migration pathway(s) between the source and the consumer, and human receptor - must all exist for there to be a risk of human health exposure.

In this simple example, responses to reduce the human health risk might include:

Option I: land use controls to preclude the land use activity;

Option II: divert the surface water flow by recontouring the surface drainage pathway or install sewer pipes that intercept the surface flows;

Option III: Upgrade the water treatment facility;

Option IV: Use an alternative water supply from outside the watershed.

The simple example of Figure B-1 is easily expanded in scope and scale to the level of the watershed. At a larger scale, there will typically be a larger number of potential management options; for example:

Option V: allow continued use of the land as an animal feedlot but require effluent treatment on the surface water runoff from the feedlot,

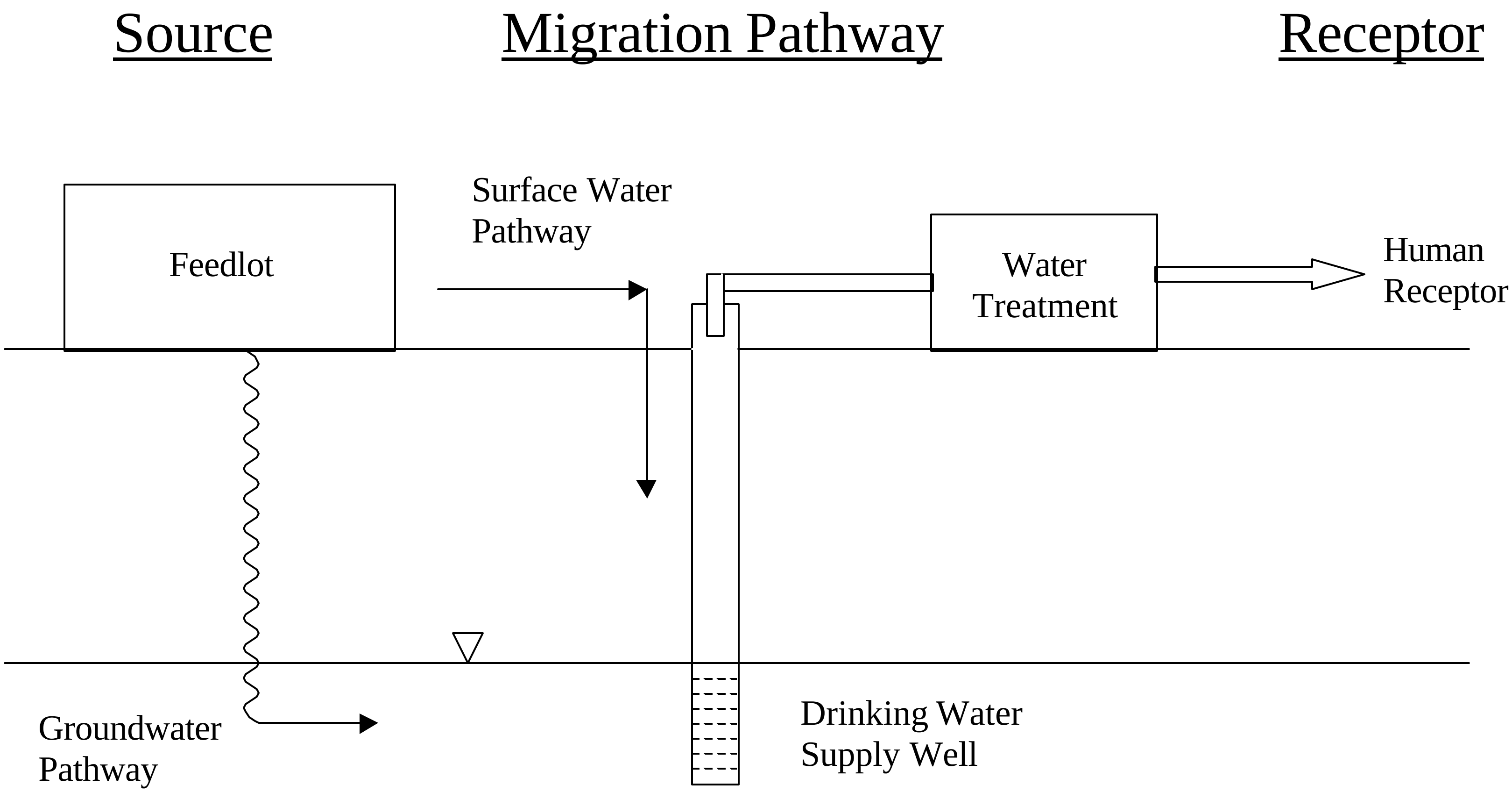
Option VI: overland surface drainage using measures such as infiltration beds or trenches that infiltrate surface drainage to the groundwater. The groundwater pathway to the receptor, being much longer in time, may have the ability to eliminate contaminants,

Option VII: adopt agricultural practices such as grassed swales to reduce particulate concentrations in the feedlot runoff; and,

Option VIII: institute a system of real time water quality monitoring that allows the timely issue of boil water alerts to consumers if the situation warrants.

The above list is not intended to be all encompassing. The intent is to suggest a progression of possible options, each of which reduces the consumer's risk of exposure to contaminants in combinations of one or more, provide effective protection of the water supply. Risk assessment methodologies are used in watershed planning to examine the merits of such measures by predicting the impact they have on the severity, duration, and frequency of human exposure to contaminants.

Figure B—1: SCHEMATIC DESCRIPTION OF RISK ASSESSMENT PROCESS



Schematic Depiction of Risk Assessment Process

APPENDIX C—FEDERAL AND PROVINCIAL WATER QUALITY LEGISLATION

TABLE C—1: Key Federal Water Quality Legislation

Key Federal Water Quality Legislation	Administering Agency	Purpose
Canada Water Act	Environment Canada	Provides the framework for joint federal-provincial management of Canada's water resources.
Canadian Environmental Protection Act, 2000	Environment Canada	Provides pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.
International River Improvements Act	Environment Canada	Provides for licensing of activities that may alter the flow of rivers flowing into the United States
International Boundary Waters Treaty Act	Department of Foreign Affairs and International Trade	Outlines principles and guidelines for the management of boundary and transboundary waters by Canada and the United States, with the primary objective of preventing or resolving disputes regarding the water quality and quantity of shared water resources. The Treaty establishes the *International Joint Commission* (IJC), an independent bi-national body with a regulatory, investigative and adjudicative role. In its regulatory capacity, the IJC's approval is required for any works in boundary waters and certain transboundary waters that may affect levels or flows at the boundary. Its investigative role is initiated by the submission of a reference from one or both governments; and it has not yet arbitrated a dispute.
Fisheries Act	Department of Fisheries and Oceans (DFO) Environment Canada administers the pollution prevention provisions of the Act.	Regulates the harvesting of fish, protects fish habitat, prevents pollution of fishery waters, and ensures safe human use of fish.
Canada Shipping Act	Transport Canada	Provides for the Governor in Council to make regulations with respect to prohibiting the discharge from ships of pollutants and prescribing substances and classes of substances that are pollutants.
Navigable Waters Protection Act	Transport Canada	Ensures public access to, and efficient use of, our waterways.
Related Agreements/Guidelines		
Great Lakes Water Quality Agreement	Environment Canada	Restores and maintains the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem and includes a number of objectives and guidelines to achieve these goals.
The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem, 1994	Environment Canada/DFO/Agriculture and Agri-Food Canada/Health Canada Ontario Ministry of the Environment/Ontario Ministry of Agriculture and Agri-Food, Ontario Ministry of Natural Resources	Renews and strengthens planning co-operation and co-ordination in implementing actions to restore and protect the ecosystem, to prevent and control pollution in to the ecosystem and to conserve species, populations, and habitats in the Grand Lakes Basin.
Federal Drinking Water Guidelines	Department of Health	Identifies substances that have been found in drinking water and are known, or suspected to be harmful and establishes the Maximum Acceptable Concentration of the substance that can be permitted in water used for drinking. To date, guidelines have been established for microbiological, radiological and more than 85 physical chemical parameters.
Federal Water Policy	Environment Canada, 1987	Provides a statement of the federal government's philosophy and goals for the nation's freshwater resource and of the proposed ways of achieving them. Its recognizes that water is, at present, Canada's most undervalued and neglected natural resource – the underlying philosophy is that Canadians must start to view water as a key to environmental health and as a scarce commodity having real value.

Table C—2: Key Provincial Water Quality Legislation

Key Provincial Water Quality Legislation	Administering Agency	Purpose
Ontario Water Resources Act	Ministry of the Environment	Provides for the conservation, protection and wise use and management of Ontario's surface and groundwater.
Environmental Assessment Act	Ministry of the Environment	Provides protection, conservation and wise management of the environment. This act applies to government and municipal activities as well as commercial or business activities. An environmental assessment must be performed for a proposed area of undertaking. The Ministry of the Environment along with the Environmental Assessment Board may approve or deny the proposal to allow the undertaking to proceed.
Environmental Protection Act	Ministry of the Environment	Provides protection and conservation for the natural environment. There are points on general provisions, motors and motor vehicles, water, waste management, vehicle permits (hauling waste), abandoned motor vehicles, sewage system, litter, spills and control and stop orders. In order to deal with the many aspects of this act and assist the Ministry of the Environment, there are provincial officers (to enforce), an appeal board and an environmental council.
Pesticides Act	Ministry of the Environment	Ensures the safe use, management and storage of pesticides.
Conservation Authorities Act	Ministry of Natural Resources/Conservation Authorities	Permits Conservation Authorities to establish and undertake a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals in the areas over which they have jurisdiction. Permits Conservation Authorities to administer the Fill, Construction and Alteration to Waterways Regulation that prohibits construction in floodplains and wetlands, filling in scheduled areas, and the alternation of waterways.
Lakes and Rivers Improvement Act	Ministry of Natural Resources	Ensures flow and water level characteristics of lakes and rivers are not altered to the point of disadvantaging other water users.
Aggregate Resources Act	Ministry of Natural Resources	Provides for the management of aggregate resources, controls and regulates aggregate operations, rehabilitates land that has been excavated, and minimizes adverse impacts on the environment when performing aggregate operations. There are statutes on licences, permits, abandoned pits and quarries, rehabilitation, offences and penalties and areas without municipal organization.
Planning Act	Ministry of Municipal Affairs and Housing	Sets ground rules for land use planning in Ontario and establishes how lands may be controlled and who may control them. The Act allows the province to manage broad provincial interests such as the protection of farmland, floodplains or wetlands and empowers municipalities to create zoning bylaws to control the use of land and regulate the location, type and dimensions of buildings and structures.
Municipal Act		Outlines the powers and authority of Ontario's municipalities. Local municipalities are authorized to provide water and sewage under the Act. Municipalities derive all of their powers through statutory delegation of the provinces.
Public Utilities Act		Permits a local municipality to acquire, establish, maintain and operate waterworks. It may also acquire by purchase or otherwise and may enter on and expropriate land, waters and water privileges and the right to divert any lake, river, pond, spring or stream of water, within or without the municipality, as may be considered necessary for waterworks purposes, or for protecting the waterworks or preserving the purity of the water supply.
Drainage Act	Ministry of Agriculture, Food and Rural Affairs	Provides for the establishment of municipal drains which may allow landowners to obtain an outlet for land drainage.
Agriculture Code of Practice (Certificate of Compliance)	Ministry of Agriculture, Food and Rural Affairs, Ministry of Municipal Affairs and Housing, Ministry of Environment	Provides guidelines for livestock operations to minimize land, water and air pollution potential.

APPENDIX D—INFORMATION REQUIRED FOR GOOD DECISION MAKING

Effective decision-making within the framework of watershed management requires an understanding of the current state of the natural environment, societal values and economic influences. Watershed management projects typically begin with an information collection and assessment stage. This information base allows stakeholders to have a common understanding of physical features, processes and community issues that exist in the watershed. This allows for the beginning of discussions concerning trade-offs and opportunities as the watershed management plan is developed.

Where information is dated, incomplete or missing coverage, of questionable quality or inaccessible, the information gaps are filled. Where it is impractical or impossible to fill these information gaps within the existing time and financial limits of the project, decisions are made and qualified on the basis of 'best available information'.

Raw data is converted or analyzed so that it is useful for decision-making. For example, a table of total phosphorus concentrations as a measure of water quality is of little use to most stakeholders unless it is compared to some standard i.e., 0.03 mg/l as the upper limit for aquatic life or a long term average.

Natural Environment Information

Natural environment features and processes can be categorized many different ways i.e., abiotic or biotic, water based or terrestrial, landforms or flora or fauna. These features and processes are often evaluated or ranked, i.e., impaired or unimpaired. Methods of data gathering range from in-field sample collection and analysis, interpretation of mapping, aerial photography, satellite imagery, use of existing statistical information or some combination of these (Mitchell, 1989).

Water information is typically divided between quantity and quality. Quantity information is best presented as a water budget, which is a comprehensive description and measure of surface and groundwater supply and use. Water budgets are essential for water allocation decisions (GRCA and CVC, 2000). Water quality is generally expressed as long term average concentrations of specific parameters compared to some standard, as number of exceedances over time, or as annual loadings.

Baseline water quantity and quality monitoring networks provide this information. These networks are necessary over a long term to capture extreme events, and at a scale capable of providing subwatershed specific information. Conservation authorities currently operate a climate and streamflow monitoring network for flood forecasting and warning in partnership with the provincial and federal governments, and assist with monitoring of the Provincial Water Quality Monitoring Network. These networks provide long-term baseline information but in most cases are often enhanced with additional conservation authority operated stations to provide the required density for watershed management decisions.

Given the complexity of natural environment features, ‘indicators’ have become popular as surrogate measures of broader system or subsystem health. Examples include the presence of certain benthic invertebrate species as an indicator of good water quality (Hilsenhoff, 1987), and the presence of certain vegetation species as an indicator of woodland disturbance (Oldham, M.J., et. al., 1995). E.Coli. itself is considered an indicator for the presence of pathogens in water.

Societal Values Information

Understanding the value society places on a resource, including water, is important for selecting protection or enhancement strategies as part of a watershed plan. A plan will be more effective if strategies address resources considered a priority by stakeholders.

Public involvement through steering committees, task groups, surveys, questionnaires and public meetings are some of the most common methods of gathering information about societal values. The public are generally asked to rank resources or resource issues as a means of conveying relative importance. This information can then be used by organizations to design implementation strategies.

The Maitland Watershed Partnerships (MWP), including the Maitland Valley Conservation Authority, recently conducted a community mail out survey and interview process to rank the importance of issues such as manure management, soil erosion, drinking water protection, herbicide use, septic maintenance and stream protection. Results indicated highest priority for protection of rivers and streams from hazardous wastes followed by drinking water protection from herbicides and faulty septic systems (KAYAK, 2000). This information will be used by the MWP to design a best management practices implementation program for the watershed.

Most conservation authorities and watershed management agencies conduct periodic reviews of societal values through community surveys, open houses or public workshops.

Economic Information

Economic information is the least developed and least used piece of information for watershed management. In most cases, decision makers can readily assess implementation costs of a management decision. This can be summarized in terms of staff wages, materials and administration. Benefits from effective watershed management can rarely be described in this fashion. The value of clean drinking water, clean rivers and lakes and healthy forests and wildlife is difficult if not impossible to assess. In many cases, decisions are weighed between generalized motherhood values supporting implementation, and precise financial figures demonstrating costs.

Ideally, resources themselves or certain environmental conditions would be assessed economic value. This would permit a fair economic comparison of watershed management benefits and costs. While some work has been attempted in this field (contingent valuation studies), methods and results have not yet been broadly accepted as credible information for watershed management decision-making. However, decision makers are very aware of the value and weight this economic information can carry in decision-making. Further research is required to refine economic assessments for watershed management.

The Current State of Information for Watershed Management

Conceptually, there is a lack of long term, watershed scale baseline water information to support decision-making. The Conservation Authorities, as part of the current provincial Water Resources Information Project (WRIP), have made a list of the information that should be developed across the province to support watershed management and decision-making with respect to water. The Grand River Conservation Authority is documenting the steps it has undertaken to make the required data useful, including overcoming data sharing and accessibility barriers, pooling several sources, straightening out varying formats, cleaning the data and filling in gaps, compiling into a useable database, and linking to analytical tools. While the provincial concern is centred around information sharing, database structures, standards, database integration and information management systems, the Conservation Authorities are most concerned that much of the baseline, in-field information gathering is lacking and must be addressed first.

Federal and provincial baseline monitoring networks have been subjected to a series of financial cuts during the past ten years. Impacts include a reduction in the actual number of monitoring stations, a reduction in parameters being monitored, delays in the distribution of monitoring information and increasing maintenance costs and user fees. The ability of watershed managers to predict extreme events (flood, drought) or understand trends in surface and groundwater quality has been seriously compromised as a result.

Baseline monitoring networks need to be restored and enhanced beyond their previous capabilities. This enhancement will allow for prediction of extreme events, better understanding of water quality trends as well as development of water budgets, water allocation criteria, flood protection, enhanced state-of-the-watershed reporting, targeting of areas for rehabilitation, program evaluation and many other initiatives.

The Conservation Authorities' recommendations for province-wide information improvement include updating soils maps, correcting geology maps, updating well logs, implementing a provincial groundwater monitoring network, developing a biological and chemical assessment network, cleaning existing climate data sets, enhancing the climate and streamflow monitoring networks, updating the Ontario Base Mapping, ground truthing remotely sensed data (Landsat), and quantifying the benefits of watershed management in general and “best management practices” in particular.

APPENDIX E—CASE STUDIES IN WATERSHED MANAGEMENT

United States

Boston and New York City

Both Boston and New York City have identified watershed planning and management as core components of their long-term water supply strategies and have acknowledged this link through funding commitments. This is because development and changing land near the upland surface water reservoirs, which serve as the cities' water supply source, are causing concern about the negative implications of this development on water quality. A concurrent shift in philosophy from that of "water development" (e.g., more diversions) to "water management" (e.g., demand management, supply protection) has been encouraged by strong watershed citizens' groups.

There are also strong financial reasons for both cities to pursue protection of existing water sources. Neither city provides water filtration because the upland sources are of such good quality. They are attempting to demonstrate that watershed management can forestall the need for filtration while saving Boston approximately $150 million and New York City between $3-8 billion.

New York City has been particularly aggressive in taking steps to improve water quality. It has strengthened water quality monitoring efforts and embarked on a widespread watershed protection program. It has identified specific potential threats to water quality and has developed long-term strategies (such as revised watershed regulations and land acquisition) to deal with these concerns. New partnerships have been created with upstream watershed communities to further the city's water quality goals. One notable example is the Watershed Agricultural Program which encourages upstream farmers to undertake whole farm plans and best management practices with the assistance of a team of professionals and financial incentives paid for by the city and supplemented by available state, federal and local funding. A Watershed Memorandum of Agreement has been signed to strengthen cooperative efforts among stakeholders (Ashendorff, Principe, Seeley, LaDuca, Beckhardt, Faber, and Mantus, 1997).

Platt and Morrill (1997) observed that water managers have been shifting their planning focus away from their long-standing reliance upon supply augmentation towards more efficient management of existing sources. This trend has occurred, in part, in response to fiscal and environmental constraints upon the development of new or expanded external sources and as a response to federal mandates imposed by the Environmental Protection Agency under the Safe Drinking Water Act and the Clean Water Act.

Willamette River, Oregon

In a recent five-year study of the Willamette River in Oregon, it was concluded that water quantity and water quality "can no longer be considered separate issues" and that "water management requires a coordinated whole-basin approach" (Leland, Anderson, and Sterling, 1997). The Willamette River is about 300 km long with eleven storage reservoirs and two re-regulating reservoirs on six of the thirteen major tributary rivers.

The population of the river basin is expected to grow at a rapid rate with more than 500,000 additional people living in the basin by 2015. The responsibility for water management extends among 21 state agencies, 18 federal agencies and 6 regional organizations.

The Willamette River Basin Water Quality Study was undertaken to gather information about the river and to develop tools for its management. Through this study, it was determined that water quality and river health was deteriorating and that without strengthened river basin planning and management, river health would continue to deteriorate in the face of rapidly expanding populations. It was suggested that river health needed to be valued equally with economic gain when management decisions will affect riparian or aquatic habitats. A number of short and long-term recommendations for action were put forward to enhance the quality of the river's water and habitat while at the same time providing a clean and plentiful water supply for the future. Three key recommendations were:

- Price resource use to fund purchase of critical land areas or to fund stream-side restoration projects.
- Develop a comprehensive project review process that integrates and co-ordinates agency project reviews and that considers quality and quantity issues together, effects on groundwater and surface water in the basin and their interrelationships, and cumulative effects on river health
- Explore market incentives to improve water quality (such as making discharges and water rights "tradable" or developing fees for water use), and reduce wastewater disposal and use of pesticides and other chemicals.

The need to monitor and track river health and to undertake studies and develop models to further explain the relationship between various land uses and pollutant levels in the river was emphasized.

Spokane County, Washington

In the above cases, emphasis was on the protection of surface water. In Spokane County, Washington, a US Geological Study undertaken in the mid-1970s showed that contamination of the groundwater aquifer was taking place (Dobratz, Wubben, and Maxwell, 1986).

Rapid urbanization in the area caused the US Environmental Protection Agency to create the Spokane-Rathdrum sole source aquifer in 1978. A Memorandum of Understanding was developed by the EPA with other federal agencies to review activities in the area to ensure that they did not further degrade the aquifer. Subsequent studies to determine how the aquifer functions, to identify potential contamination problems, and to develop the best combination of preventive measures were carried out by the county. Based on this research, committees of technicians and local citizens worked together to develop a regional water quality management plan to protect the aquifer. Components of the plan included a comprehensive land use plan, a comprehensive wastewater management plan, a coordinated water system plan, stormwater and spill control, and solid and hazardous water disposal.

It is interesting to note that with this case study, the researchers observed that while county commissioners worked closely with local citizens' groups in formulating policies and programs, it was not easy to obtain support for preventive action programs unless the problem was dramatically visible. The reduced level of grant funds available from the federal government had shifted the bulk of the financial responsibility to the local level. Therefore, capital-intensive protection programs for water resources will create property assessments and monthly user charges that will be significantly greater in future years. It was concluded that more intense and innovative programs of public awareness and project financing were needed to develop effective protective efforts and offset rising expenses.

AWWA Watershed Survey

In a study undertaken by the American Water Works Association (AWWA) Research Foundation, it was concluded that watershed protection programs can play a strong role in maintaining or enhancing water quality and in providing cost-effective options to the application of advanced water treatment methods. This study included a literature review and analysis of the results of a national survey of watershed management programs conducted by water utilities and state regulatory agencies and 24 case studies of successful watershed management programs (Robbins, Glicker, Bloem, and Niss, 1991).

The results of the water utility survey were based on 272 watersheds. These watersheds were analyzed for the relation between land use and specific water quality concerns. The most frequently cited concerns by water utilities were nutrient loading and pesticide runoff from agricultural activities, followed by bacteriological and viral contamination associated with septic tanks and sewage discharge, turbidity effects from agricultural cropland runoff and bacteriological contamination form recreational land use.

The survey asked respondents to rate a list of typical control measures used to protect the quality of surface water relative to their applicability and effectiveness. The results of the ratings are listed below.

Table E—1:Water Utility Managers' Ratings Of The Effectiveness Of Watershed Controls

Ranking	Watershed Control	Systems Using This Control	Average Rating
1.	Land ownership	25	4.0
2.	Reservoir use restrictions	53	4.0
3.	Watershed entry restrictions	38	3.8
4.	Reservoir buffer strips	35	3.7
5.	Industrial-municipal discharge permits	34	3.7
6.	Sanitary sewers	37	3.5
7.	Hazardous material controls	13	3.5
8.	Septic tank permits	42	3.5
9.	Formal agreements with landowners	16	3.5
10.	Zoning restrictions	29	3.4
11.	Streamside buffer strips	29	3.4
12.	Prohibited land uses	23	3.4
13.	Legal action	28	3.3
14.	Use of best management practices	32	3.3
15.	Stormwater collection treatment	19	3.2
16.	Regulation of construction practices	38	3.2
17.	Ambient water quality criteria	44	3.1
18.	Transfer of development rights	8	3.1
19.	Wildlife control	18	3.0
20.	Informal agreements with landowners	18	2.6

On the basis of the survey questionnaires or through referrals from contacts in the water management industry, the researchers examined 24 effective watershed management programs and practices used by water utilities to provide a foundation for recommendations for effective source water protection.

Despite differences in system size and source characteristics, a common element was the general process used to strengthen watershed protection. This process contains six steps:

1. Watershed inventory (physical characteristics, land use, ownership, water quality)
2. Identification of contaminants of concern and sources of these contaminants
3. Goal setting for a watershed management program
4. Selection of appropriate control measures to protect water quality
5. Implementation through necessary legal, financial and institutional arrangements

6. Monitoring and evaluation

Monitoring and evaluation were considered of critical importance because they supply feedback on whether changes are needed in the program goals, watershed control measures or program implementation.

The study suggested that a mix of structural and non-structural controls can be effective. These can be divided into four broad categories based on land use: 1) general measures that apply to most or all watersheds, 2) control measures for agricultural land, 3) control measures for forest management, and 4) control measures for urban development. It was concluded that water treatment and in-reservoir practices were not substitutes for effective watershed management. In most cases, a combination of watershed management, in-lake or in-reservoir management, and water treatment was used to achieve the desired level of water quality. Controlling contaminants at the source was considered to be the most fundamental way to prevent degradation of water quality in water-supply reservoirs and finished water. Non-structural solutions such as land use controls were favoured over structural solutions such as detention basins since they require financial and institutional commitment for long-term maintenance.

It was observed that a well-evaluated, carefully planned watershed management program is of *"no value if it is not properly carried out. Effective watershed management must therefore include a commitment by water system managers to provide the necessary financial resources, staff, institutional arrangements, and public education to successfully implement the program"*.

For watersheds composed of several political jurisdictions, regional planning agencies were seen to play an important role in facilitating coordination among agencies and agreements to control future development. In some instances, state regulations were enacted to provide minimum statewide standards. Thought to be one of the premier examples of a comprehensive statewide attempt to regulate land use activities in water supply watersheds, the North Carolina law is designed to overcome the jurisdictional conflicts that occur when a community's water supply is located outside its planning and zoning jurisdiction. The law requires local governments to adopt land use plans, ordinances and regulations that are at least as stringent as the minimum state requirements.

Public involvement is critical since public awareness of watershed issues affects the acceptability of mandatory controls, the effectiveness of voluntary controls, and the degree of support received. Water quality monitoring is essential for proper water management. The specific water quality variables that should be targeted in a watershed monitoring program are a function of the natural and human sources of contamination.

It was noted that wholesale application of a program that was successful in one drainage basin may not be appropriate for another, because watersheds are extremely varied in terms of natural environmental features, land use, ownership, and institutional controls. However, the management tools such as watershed models and geographic information systems provide an ever increasingly important role in future watershed planning efforts.

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APPENDIX F—WATERSHED MANAGEMENT IN THE UNITED STATES, UNITED KINGDOM, FRANCE, AUSTRALIA, AND NEW ZEALAND

United States

Managing water resources on a watershed basis is not a new concept in the United States. As early as 1908, the U.S. Inland Waterways Commission reported to Congress that each river system, from its headwaters to its mouth, is an integrated system and must be treated as such (U.S. EPA, 1998b).

The Water Quality Act (1965) requires that states develop water quality standards for interstate waters. As a result, river basin compacts were formed to protect systems such as the Delaware and the Colorado Rivers (U.S. EPA, 1998b).

In 1972, the Federal Water Pollution Control Act *"established as a national goal, the restoration and maintenance of the physical, chemical and biological integrity of the Nation's waters"* (U.S. EPA, 1998). The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act. The national goal spelled out in the CWA was to eliminate all discharge of pollutants into navigable water by 1985. The CWA established a very broad framework of planning, research, financial assistance, and permit systems to further the national objective and goals.

The law gave EPA the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit under the National Pollutant Discharge Elimination System (NPDES) is obtained.

The 1977 amendments focused on toxic pollutants. In 1987, the CWA was re-authorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants (POTW's) under the Construction Grants Program. While CWA provides for the delegation by EPA of many regulatory, administration, and enforcement aspects of the law to state governments, in states with the authority to implement CWA programs, EPA still retains oversight responsibilities.

There is currently a fundamental shift occurring in water management within the U.S. This shift is a moving away from water development (i.e., structural improvements or diversions) to a stewardship ideal (i.e., watershed protection schemes). According to Platt and Morrill (1997), the American system of public water supply is at a turning point:

"The politics of scarcity is giving way to the politics of sustainability. The myth of unlimited sources of new supply, like the myth of national water scarcity, is yielding to the reality that existing supplies must be managed, protected, and wisely allocated. Recognition is also spreading that water supply management in not an isolated, single-purpose enterprise but is part of the larger context of multiple purpose water resource and land management."

Leading this shift is the U.S. Environmental Protection Agency (EPA), who has developed a framework known as the Watershed Protection Approach (WPA). The WPA does not compete with existing clean water programs, but provides a framework within which existing federal, state and local programs are integrated (U.S. EPA, 1998b).

The WPA is based on four elements:

- All priority problems in a watershed should be identified and addressed – problems posing the greatest risk to human health, ecological resources, desirable uses of the water, or a combination of these.
- All parties with a stake or interest in a specific watershed should participate in the analysis of problems and the creation and implementation of solutions.
- Actions taken in a watershed should draw on the full range of methods and tools available, integrating them into a coordinated, multi-organizational attack on the problems.

- Stakeholders should agree on measures of success early and monitor progress throughout the life of the project (U.S. EPA, 1998a).

The WPA builds on CWA Section 303(d) and the Total Maximum Daily Load (TMDL) process. Section 303(d) of the CWA requires states to submit lists of water quality limited water bodies every two years and to develop TMDLs for their water quality limited waters (U.S. EPA, 2000a).

"technology-based effluent limitations or other legally required pollution control mechanisms are not sufficient or stringent enough to implement the water quality standards applicable to such waters." (U.S. EPA, 1999).

TMDLs are defined as the maximum pollutant load a waterbody can assimilate without violating set state water quality standards (Department of Environmental Protection, 2000). This calculated maximum must take into account both point and non-point sources as well as any naturally occurring background conditions. The completed TDMLs must take into account seasonal variations and margin of safety, in addition, the EPA must approve each TDML. In the case of the EPA not approving the submitted TDML, the EPA will establish one itself (U.S. EPA, 1999).

Once the TMDL is set and approved for a specific watercourse, and the pollutant reduction required to meet the TMDL is established, implementation of control actions should proceed. Implementation is the responsibility of the state, or where the EPA established the TDML, the EPA's responsibility. For controlling point sources, the NPDES process can be used to lower effluent concentrations. In the case of non-point sources, both state and local laws may be used to authorize the implementation of non-point source controls, such as Best Management Practices, or land use zoning.

Currently the TMDL process does not specify how discharges must attain the load reduction, however, the EPA is drafting regulations that would require states to submit an implementation plan with the TDML during the approval process. This, however, is meeting with opposition from states who object to federal interference in what they see as a local issue.

Implementation of Section 303(d) was primarily focused on point source pollution. In recent years, non-point source contributions to water quality degradation has become better understood and the EPA and state implementation now includes non-point source pollution problems (U.S. EPA, 1999). By requiring that TMDLs include all sources of pollution, point, non-point and background, the EPA is subtly compelling state and local organizations to adopt the watershed approach in water management.

Although Section 303(d) and the TDML process is a cornerstone of the WPA, several other programs can be integrated as well. Various EPA programs such as the Non-point Source (NPS) Program, Wellhead Protection (WHP) Program and the Sole Source Aquifer (SSA) Program can also be integral parts of any Watershed Protection Approach.

The following is a brief description of these programs.

- **Non-point Source Program—**is a pollution abatement, and resource remediation program designed specifically for controlling and reducing pollution due to non-point sources. Under the 1987 Amendments to the CWA, states were required to conduct statewide assessments of waterbodies and identify those that were either in violation of state water quality objectives, or were likely to violate the water quality objectives some time in the future, because of non-point source pollution. In addition, the states were obligated to develop non-point source management programs, which would address those impaired or threatened waters. Once the EPA has approved the management plan, the states were eligible to receive annual grants from the EPA to assist in implementing the management plan (U.S. EPA. 1998a).

- **Wellhead Protection Program—** is a pollution prevention and management program used for protection of underground water supplies. WHP Programs must be submitted to the EPA for approval, and must contain delineation of the capture zone, an inventory of any source contaminants as well as a source management plan. (U.S. EPA. 2000c)

- **Sole Source Aquifer Program—**is a designation rather than a program. Groundwater aquifers are designated Sole Source if the aquifer is the communities primary source of water, and if contaminated, developing an alternate supply would be extremely expensive. Once identified, any development that occurs within the designated area, which is set to receive federal financial aid, must be reviewed by the EPA to ensure that the development will not endanger the aquifer (U.S. EPA. 2000b)

While the CWA and the WPA are in place to ensure clean surface waters, for all uses, the Safe Drinking Water Act (SDWA) is in place solely to ensure safe and clean drinking water. One aspect to ensuring safe drinking water is to have relatively clean raw water supplies, as a complement to the traditional treatment approach. Realizing the importance of protecting source waters, the EPA is beginning to implement Source Water Protection (SWP) programs.

An EPA goal is to have 60 % of the population, which is served by communal water systems, receive their water from systems with Source Water Protection Programs in place under both WHP and watershed protection programs, by 2005 (U.S. EPA. 1998a). As a first step to realize that goal, an Amendment to the SDWA was made in 1996. This Amendment requires that all states develop and submit to the EPA, Source Water Assessment Programs (SWAP) to analyze and identify existing and potential threats to public water systems.

A state SWAP must:

- Set forth the state's strategic approach to conducting the assessments
- Delineate the boundaries of the areas providing source waters for each public water system
- Identify the origins of regulated and certain unregulated contaminants in the delineated area to determine the susceptibility of public water systems to such contaminants (U.S. EPA. 1998a)

Delineating watershed boundaries and identifying potential and existing problem areas are logical first steps to developing a fully integrated source protection plan. With the development of SWAPs and eventually full SWP programs, the EPA is looking to further integrate the multitude of programs the EPA oversees:

"…. development of state SWAPs and SWP Programs offers a unique opportunity to integrate not only drinking water programs, but also to integrate drinking water, clean water, coastal, solid and hazardous waste, agricultural and other environmental programs…." (U.S. EPA. 1998a).

This wide integration could be made possible under the framework provided by the WPA. The EPA seems to be headed in a direction that will focus federal, state and local government programs and efforts on environmental and public health management within the boundary of a specific watershed.

United Kingdom

The United Kingdom first entered into integrated water management in 1974, with the creation of the Regional Water Authorities. These organizations were not delineated by political boundaries but rather by boundaries of groups of river basins, and were concerned with all aspects of water management other than sewers, local drainage committees and management of the canal system (Morrison, 1995).

With the Water Act of 1989, the Regional Water Authorities were privatized and the National Rivers Authority and the Office of Water were created (Morrison, 1995).

The National Rivers Authority was short-lived. In 1996 the Environment Agency was created, which incorporated the functions of the National Rivers Authority, Her Majesty's Inspectorate of Pollution, and Local Waste Regulatory Authorities.

With the creation of the Environment Agency, the United Kingdom created a statewide organization whose primary aim is:

"…. to protect and enhance the environment and make a contribution towards the delivery of sustainable development through the integrated management of air, land and water." (Environment Agency, 2000a).

The Environment Agency has the following responsibilities:

- Flood Defense
- Water Quality
- Water Resources (Abstractions)
- Navigation
- Fisheries
- Conservation and Regulation
- Process Industries Regulation (PIR)
- Radioactive Substance Regulation (RSR)
- Non-Radioactive Waste Management and Producer Responsibility
- Contaminated Land and Land Quality (Environment Agency, 2000a)

With the above responsibilities falling under one umbrella organization, the Environment Agency is in the unique position to develop and implement fully integrated management plans for air, land and water.

The Environment Agency employs a process known as Catchment Management Planning, which takes advantage of waters natural boundaries in the planning process, and applies it to each of its river catchment basins. This process was designed with the thought of managing water uses, which interact and may conflict with each other, for the overall benefit of the water environment and its users (Butler, 1996).

The Catchment Management Plans (CMPs) are undertaken to:

- focus attention of the water environment of a specific river catchment;
- involve all interested parties in planning for the future well being of the river catchment;
- agree on a vision for the catchment which helps to guide all activities over the next 10 – 20 years;
- establish an integrated strategy and action plan for managing and improving the catchment over the next 5 years;
- identify specific actions, to which the Environment Agency is committed, for inclusion in its business plans (Butler, 1996).

A successor to the CMPs has since been introduced, the Local Environment Agency Plans (LEAPs). These plans provide coverage for all catchments in England and Wales. Like CMPs, LEAP areas are defined by a catchment boundary, or a group of subcatchment boundaries.

The primary goals of LEAPs are to:

- promote openness and accountability;
- develop liaison and partnership with key groups;
- educate the public on local environmental issues which are identified by the Environment Agency;
- prioritize issues and establish an action plan for managing and improving the local area over the next 5 years (Environment Agency, 1997).

The major difference between LEAPs and CMPs is the level of local involvement in the generation of the plan. The general public and key shareholders both have the opportunity to influence which issues are targeted, as well as voice opinions on the proposals and recommended actions. All environmental planning now starts at this local level. Throughout the United Kingdom, 26 local plans have been completed to date, all developed with collaboration with the public, and public representatives (Environment Agency, 2000b).

The Environment Agency also interacts with the local level in selecting areas to receive funding for flood defense works. Since the funds for flood defense are raised from local levies, council taxes, or drainage rates, Regional Flood Defense Committees (RFDCs) must approve where the funding will be spent. RFCDs comprise various local authority members, in order to safeguard the proper usage of levy funding (CIWEM, 1998).

The Environment Agency reports primarily the Department of Environment, Transport and the Regions (DETR) (CIWEM, 1998). However, the majority of its funding comes from flood defense levies - 36% and charging schemes (producer of pollution pays) - 37%, with remainder coming from the DETR - 16.2 %, the Ministry of Agriculture, Fisheries and Food (MAFF)—5.1 % and the National Assembly of Wales (NAW) - 1.9% (Environment Agency, 2000a).

The water supply industry in the United Kingdom is highly privatized. Private industry treats and distributes potable water, as well as processes sewage. The private industry also owns and maintains all water distribution and sewerage infrastructure.

The water industry follows regulations set by the DETR, which are enforced by the Drinking Water Inspectorate (DWI) who reports directly to the DETR. As well as enforcing the Water Quality Regulations, the DWI also investigates all incidents of below quality drinking water (DWI, 2000).

France

In France, management of surface and groundwater is considered to be a "national common heritage". Water Policy is defined by the State. Dialogue on water policy is institutionalized at three levels:

National Level:

The National Water Committee, chaired by a Member of Parliament, is composed of representatives of the National Assembly, the Senate, institutions and national federations. It provides input on the trends of the national water policy and on drafts of legislative and regulatory texts.

River Basin Level:

Under the Water Law, 1964, the French national territory is divided into six large "river basins" administered by a Water Agency, a public body established under State supervision. It is with these Water Agencies that France has implemented a watershed-based water management system. The Water Agencies report directly to the Ministry of Environment and Ministry of Economy and Finance. The primary roles of the Water Agency are to conduct research on water issues, participate in the financial management of the water resource, and active involvement in water resource issues.

The Water Agencies oversee a system of pollution (polluter pays) and resource (user) fees. These fees are paid by the consumer/user. Using these monies, the agencies provide grants, subsidies and loans to promote water-related activities that are deemed to be in the "common interest" of basin citizens (Morrison, 1995).

In 1992, a new Water Law was passed. Four major innovations are contained in this law which:

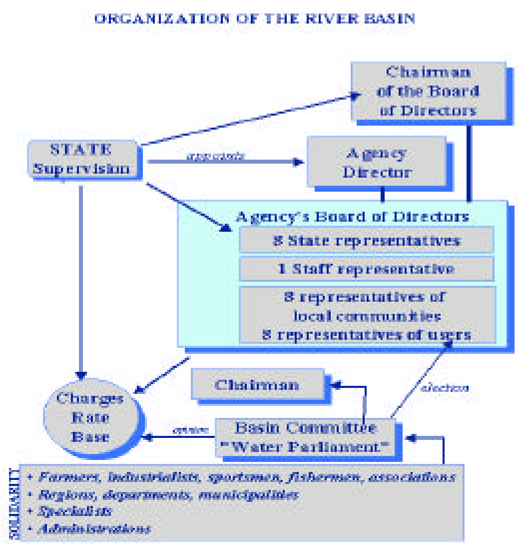
- recognizes the intrinsic value of water beyond its economic value;
- appreciates the water resource as a unique entity requiring a global management;
- requires planning documents for each hydrological basin (the Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) and the Schéma d'Aménagement et de Gestion des Eaux (SAGE);
- increases the power of the local governments with regard to the maintenance and development of the aquatic environment (Barnier, 1993).

Water Agencies are founded on the "user-polluter-pays" principle. The Agency levies charges on water withdrawals and discharges from all users who affect water quality and modify the water regime. The rates applied for calculating charges are determined for each Agency with the agreement of the River Basin Committee. The Agencies provide grants, subsidies and loans to promote water-related activities that are deemed to be in the "common interest" of basin citizens.

Basin Committees oversee the actions of the Water Agencies, also called Basin Authorities. The Basin Committees range in size from 61 to 114 members, comprising elected representatives of the State, water users, socio-professionals and State agencies. The River Basin Committee, chaired by a local elected official, prepares and adopts a Masterplan for Water Development and Management (SDAGE) after consulting with Regional, General and Local Councils. SDAGEs define the objectives for water quantity and quality as well as the developments and improvements to be undertaken to attain them. They define the limits of the sub-basins corresponding to hydrographic units.

The River Basin Committee advises the Water Agency on: 1) the rates and bases of water charges levied for water withdrawals and discharges, 2) the priorities for the Agency's 5-year action programmes, and 3) methods to aid investments and the smooth running of private and public wastewater treatment plants.

Composition of River Basin Committees



Tributary/Sub-Basin Level

At the tributary or subbasin level, a Water Development and Management Scheme (SAGE) is prepared to define objectives for the utilization, development and quantitative and qualitative protection of surface and groundwater resources, and aquatic ecosystems, as well as for the preservation of wetlands. SAGEs must meet the general guidelines set in the SDAGEs.

A Local Water Commission prepares and monitors the implementation of the SAGE. The Commission is composed of representatives from local communities (50%), users (25%) and State representatives (25%).

To help attain the objectives determined by the SAGE, local communities can associate themselves with a "Local Water Community". The " Local Water Community " can be entrusted with the study, the completion and operation of all constructions, installations or equipment of an urgent or general character, aiming at:

- developing a basin or part of a hydrographic basin;

- developing and maintaining a watercourse that is not managed by the State, including accesses;
- water supply;
- controlling stormwater and run-off;
- protecting against floods and the sea;
- controlling pollution;
- protecting and preserving surface and groundwater;
- protecting and restoring sites, aquatic ecosystems and wetlands as well as bordering woodlands;
- developing hydraulic works for civil defence.

The development of watercourses within the framework provided by the SDAGEs and SAGEs must be designed:

- taking the whole basin into account and considering the river and its tributaries from their sources to their mouths;
- contemplating that all water uses be quantitatively and qualitatively satisfied, together with the resulting requirements;
- studying the impacts on the environment and integrating the protection of aquatic ecosystems and the prevention of harmful effects regarding the conservation of natural media;
- ending in a multipurpose design and a consistent management of the various installations and equipment.

Water law enforcement

The Prefect of the region where the River Basin Committee is located, manages and coordinates the State's policy as it concerns water law enforcement and water resources management. This helps maintain the unity and coherence of State decentralized actions in this field, in the regions and departments involved.

The decentralized, departmental or regional State administrations—Regional Directorates of Industry and Research (DRIRE), Departmental Directorates of Agriculture and Public Works (DDAF and DDE) - examine, within their respective responsibilities, all applications for:

- concessions for the use of watercourses and falls, in particular for micro power stations;
- development of rivers, lakes and water bodies;
- extraction of materials and gravel;
- water withdrawal for various uses;
- wastewater discharges, spreading of sludge and liquid manure;
- opening of dumping sites;
- operation of establishments classified as dangerous or insalubrious.

The installations, constructions or activities that can be dangerous for health and safety, have serious impacts on water resources and aquatic ecosystems, are harmful to the free flow of water, or increase the risk of flooding, are subject to administrative authorization. Authorization is given after a public inquiry and can be cancelled or modified, without compensation:

- for sanitary reasons, and to protect the drinking water supply of populations in particular;
- to prevent or stop flooding or in the case of a menace to public safety;

- in the case of a major menace to the media when they are subject to critical hydraulic conditions not in keeping with their preservation;
- when installations are abandoned or not regularly maintained.

Installations subject to authorization or declaration for the withdrawal of surface water or discharges and for the pumping of groundwater must be fitted with appropriate systems for measurement or assessment. Their operators or owners are obliged to install and verify the perfect operation of the system and store the corresponding data in a location that is accessible to the administrative authority. The administration can take the necessary steps for limiting or temporarily suspending water use, when it is confronted with a threat or with the consequences of accidents, drought, floods or the risk of water scarcity. When necessary, specific measures can be taken in highly sensitive areas. In case of accidents presenting a danger to civil safety, water quality, supply or conservation, the administration can force the authorities in charge to take measures and, if they do not comply, can intervene, when necessary, at the expense of the authorities concerned.

France has a water police who are responsible for policing waterways and monitoring the application of the regulations concerning abstraction, discharge permits, and the conservation and management of water resources. In addition, the water police monitor wastes for conformity with regulations (Morrison, 1995).

Water quality objectives

Quality objectives have been defined for the main watercourses in France. Their preparation, based on the 1978 order of the Ministry for the Environment, in compliance with the 1964 water law, helps define and orientate the actions necessary for protecting watercourses. Departmental maps showing quality objectives have been adopted in most departments, on the basis of a wide consultation of local partners.

The Water Agencies, together with the National Fund for Rural Water Supply, contribute to the implementation of consistent programmes for urban, industrial or agricultural pollution control and for the rehabilitation of rivers.

Water supply

In France, the organization of potable water supply services, waste and storm water collection and treatment is under the responsibility of municipalities or groups of communities (Syndicate). There are 15,244 water supply services and 11,992 sanitation services for 36,763 communities. Local communities may entrust the management of their water supply services to a specialized private company or directly manage them by way of a Water Authority.

There are two types of contracts for private services: concession and affermage. A concession contract places the maintenance of the entire water system, including the government owned distribution/collection system, under the private firm's responsibility. Under an affermage contract, the private firm is only responsible for supplying, collecting, and billing. General maintenance and repairing falls under the responsibility of the commune. The maintenance work is usually financed via a surtax added onto the water bill. The private firm collects this surtax and transfers it to the commune. In both cases, the entire system is returned to the commune at the end of the contract (Morrison, 1995).

The duration of a concession agreement may vary from 20 to 50 years, depending on the amount of investments to be made, water consumption and price, while an "affermage" contract lasts from 5 to 20 years. This approach guarantees performance standards with precise contractual obligations and fairly distributes the risks to be taken among the partners.

In France today, the majority of potable water supply, as compared to the number of users covered, is implemented through delegated management (75%). The part of sanitation services entrusted to private companies is rapidly increasing (> 35%).

Where the community or Syndicate directly manages water supply, it takes complete charge of investments for and operation of water supply services, of the relations with users, invoicing and recovery, generally through a municipal collector. The staff of the water authority is composed of municipal agents with a civil servant status. Today, except in some medium and large towns that have set up their own technical municipal services, water authorities are found in small rural communities.

Other options for water management are available to communities. For instance, communities can decide to operate potable water production and intakes by themselves as water authorities and delegate water supply to private companies.

1) In case of a concession, the private partner finds the necessary funds that are not covered by public assistance. In the other cases (affermage, public authorities, leases), municipalities or groups of communities must gather the funds necessary to build and rehabilitate the installations they own. To avoid a sudden increase in water price, that the user could find unbearable, municipalities can benefit from various kinds of public assistance. They include aids from: 1) the Water Agency, 2) the National Fund for Rural Water Supply (FNDAE), an "urban-rural area solidarity" fund which aims at compensating investment overcosts that villages have to bear because houses are scattered and the areas are not densely populated, and 3) regions and departments that support the investment efforts of rural communities with subsidies or loan interest rebates from their own budgets.

Australia

Australia is a commonwealth consisting of six states and two territories. Within the Commonwealth Government, the Department of Primary Industries and Energy (DPIE) and the Department of Environment, Sport and Territories (DEST) are the main agencies responsible for environmental and resource management. Their role is mainly policy development, leadership and facilitation.

The states are autonomous in the areas of natural resources and environmental management. Thus, the administration of water and the environment varies from state to state.

In Australia, catchment management has been a focus since the 1790's when water shortages were experienced. Later in the 1930's, catchments emerged as a significant focus of land and water management to protect urban water supplies. Recent emphasis has been on integrated land and water resource management for multiple purposes. Australian catchment management is moving towards a collaborative rather than a top-down government directive approach. (Hooper, 1999)

In the 1980's, it was recognized that there was a need to address concerns about the state of the nation's water resources in an integrated fashion. In 1994, the Council of Australian Governments (COAG) endorsed a comprehensive strategic framework (Water Reform Framework) for the efficient and sustainable reform of the Australian water industry. To manage and report on the establishment of goals for, and the progress of implementation of the framework the Agricultural and Resource Management Council of Australia and New Zealand established an inter-governmental Task Force. Ten "deliverables", representing elements of the framework were identified:

- Full cost recovery pricing;
- Comprehensive water allocation systems;
- Trading in water entitlements;
- Effective performance monitoring;
- Integrated natural resource management;
- Institutional separation;
- Devolution of irrigation management;
- Public education and consultation;
- Stormwater and waste water re-use;

- Groundwater management.

The States and Territories are undertaking measures to implement integrated catchment management to implement the Water Reform Framework.

The Water Reform Framework provides a blueprint for action. The National Strategy for Ecologically Sustainable Development (ESD) provides an effective basis for addressing sustainability issues. Specific objectives of the strategy are:

- to develop water management policies which are based on an integrated approach to the development and management of water resources (including catchment management, public participation, water allocations to maintain aquatic and riparian environments, and nutrient management);
- to develop and implement the most effective mix of water resource management mechanisms (including pricing, regulation, monitoring, institutional arrangements and property rights).

Australia recognizes local responsibility for resource management. The recognition of the inter-relatedness of role and responsibilities means that cooperative action by all relevant parties is seen as the appropriate basis for implementation.

"*Sustainable natural resource management requires a partnership between the community and all levels of government, in which each partner contributes appropriately in terms of skills and resources in line with its responsibilities and interests".*
(page 4, <www.dist.gov.au/SCIENCE/pmsec/14meet/inwater/app1form.html>)

The Landcare program, which promotes partnerships between the community, industry and government in the management of natural resources is an important aspect of implementation.

One example of a partnership to further wise management of water resources is the Murray-Darling Basin Initiative. This Initiative is a partnership between the governments of the Commonwealth, New South Wales, Victoria, South Australia, Queensland, the Australian Capital Territory and the community. The purpose of the Agreement is to promote and coordinate effective planning and management for the equitable, efficient and sustainable use of the water, land and other environmental resources of the Murray-Darling Basin. The Initiative is the largest integrated catchment management program in the world, covering the watersheds of the Murray and Darling rivers, an area of over one million square kilometres.

The Commission is the executive arm of the Murray-Darling Basin Ministerial Council. It is responsible for managing the River Murray and the Menindee Lakes system of the lower Darling River, and advising the Ministerial Council on matters related to the use of the water, land and other environmental resources of the Murray-Darling Basin.

This Initiative seeks to achieve:

- improvement in, and maintenance of, water quality for all beneficial uses—agriculture, environmental, urban, industrial, and recreational;
- control of existing land degradation, prevention of further land degradation and, where possible, the rehabilitation of land resources to ensure the sustainable utilization of these resources;
- conservation of the natural environment of the Basin and the preservation of sensitive ecosystems.

Two major programs include the Basin Sustainability Program aimed at gathering information and developing partnerships and strategic long-range plans to support decision-making and implementation, and the Water Business Program that includes management, flow regulation and protection of infrastructure investments.

New Zealand

New Zealand has a long history of integrated watershed management. Between 1986 and 1991, a new public bureaucracy was set up to manage freshwater resources. At the national level, two agencies have key roles: the Ministry for the Environment (MfE) and the Department of Conservation (DoC). The MfE is primarily a policy advisory and reporting agency, with a limited regulatory role. DoC is a heritage management agency, with specific “hands on” responsibilities for managing the large public conservation estate. Under the Conservation Act (1987) the DoC has the power to take action against polluters who damage aquatic habitats.

At the sub-national level, a two-tiered system of directly elected regional councils and local authorities (city and district councils, and unitary authorities) undertake environmental functions. Under the Resource Management Act, (1991), 12 elected regional councils, defined on the basis of major water catchments, undertake environmental planning. The Resource Management Act provides a statutory framework for a relatively integrated approach by replacing a large number of separate and sometimes inconsistent and overlapping statutes concerned with the use of natural resources. The purpose of the Act is to promote “the sustainable management of natural and physical resources” and takes into consideration the values of the indigenous Maori people. It encourages public accountability and participation. Decision-making is decentralized within a hierarchical planning framework. This hierarchy is based on the assumption that decisions should be made as close as possible to the appropriate level of community of interest where the effects and benefits arise.

The RMA: Functions by levels of government

Central Government

- Overview role;
- Develop national policy statement and national environmental standards;
- National aspects of coastal management.

Regional Councils

- Integrated management of regional resources;
- Water and soil management;
- Regional aspects of coastal management;
- Manage geothermal resources;
- National hazards mitigation;
- Regional aspects of hazardous substance use;
- Air pollution control.

Territorial Local Authorities

- Control effects of land use and subdivision;
- Noise control;
- Controls for natural hazards avoidance and mitigation;
- Local control of hazardous substances use.

Specific objectives and policies relating to water pollution, water abstractions, works on beds and margins of water bodies, land management, and methods for implementing these are formulated in regional plans. The documents provide the basis for evaluating and making decisions on resource consent applications and to monitor policy effectiveness. Councils are required to be cognizant of cumulative and interactive effects and cross-boundary issues, and have a duty to consider alternatives and assess their benefits and costs in carrying out their functions. Their plans are binding on district councils and stakeholder user groups. Application of adaptive approaches based on consultation, collaboration and consensus building amongst stakeholder groups is also strongly encouraged by many regional and district councils in carrying out their responsibilities under the Act.

From a procedural stance, the New Zealand system provides a sound framework for resources planning. However, there are some challenges:

- Regional Councils receive little guidance or technical assistance from central government. Agencies at the national level are hamstrung by lack of resources.
- Water resources planning practices traditionally focus on a supply-oriented biophysical approach rather than a conservation approach of balancing demand with availability and promoting efficient water use.
- In the absence of national standards for water quality and because of lack of adequate information to prescribe appropriate numeric standards, regional councils have to rely on more discretionary qualitative standards in regional policy statements and plans.
- Responsibility for riparian land is fragmented between regional councils, territorial local authorities and DoC. Close collaboration is necessary to implement land management policies.
- Three issues are not addressed in the RMA: lack of provision for “user pays” charges in the RMA; the merits of using effects based rules to control point source discharges; and the difficulties of regulating non-point source discharges.
- A full range of monitoring is not currently being carried out. Local councils are dependent on local rate and charging regimes to fund their activities thus one constraint on most regional councils is lack of sufficient resources to undertake adequately the resource monitoring function – even though it is a requirement of the Act (Memon, 1997).

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