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WATER CONSERVATION: PRACTICES AND POSSIBILITIES

by Darlene T. Burton

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PLANNING DIVISION
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ABSTRACT

This paper is the product of an extensive review of water conservation technology and practices from engineering, environmental and socio-economic perspectives. Its purpose is to provide guidance for the possible application of a water conservation strategy in Ontario, and, in particular, in the Great Lakes Basin region of Southern Ontario.

An attempt is made to evaluate sectors and activities where wastage of water resources presently occurs and the means whereby such wastage could be reduced so that water can be used more efficiently.

INTRODUCTION

Water conservation programs are most frequently associated with drought stricken areas. Ontario, in comparison to many of these areas, has an abundant supply of water. "Why then should residents of Ontario be concerned about conserving water"?

This paper will attempt to answer this question and will review methods by which water can be conserved in use sectors where wastage presently occurs. Also included in this report, is a short review of legislation, policy and programs relevant to water conservation. Emphasis is placed on probable institutional, economic and social factors likely to block or impede the success of conservation programs.

Water

Water is the essence of life. It is a major constituent of all living organisms and essential in many of the biochemical reactions on which life depends. Without water, life, as we know it, would not exist. It is one of our most basic requirements. Without it, man can only survive a few days.

Water is important as habitat for a diverse array of living organisms. It provides a fairly stable environment in which fluctuations in water availability and temperature are small relative to conditions in terrestrial ecosystems. Many organisms are adapted to life in aquatic ecosystems. In fact, it is in this environment that many scientists feel that life began.

Water has a number of unique physical and chemical characteristics which are the result of its atomic structure and bonding abilities. Besides its gas, liquid, and solid properties, water has high specific heat, high viscosity and thermal density properties which make it a unique substance.

The Hydrological Cycle

The hydrological cycle of the earth consists of global processes affecting the distribution and movement of water. These processes include movement from the atmosphere, inflow and temporary storage on land, and outflow to the primary reservoir, the oceans. The cycle consists of three principle phases: precipitation, evaporation, and surface and groundwater runoff.

The endless cycling of water maintains the freshwater environment and supplies the vast quantities of water necessary for life. The hydrological cycle is an important factor in modifying temperatures and provides a means of transport for many chemical nutrients.

A fundamental feature of the earth is an abundance of water, which covers about 71% of the earth's surface. Over 99% of the immense amount of water of the biosphere occurs in the oceans and polar ice deposits.(1) The amount of fresh water on earth is small in comparison to the water of the oceans. Fresh water is concentrated in the large, deep basins of several great lakes and about 20% is contained in Lake Baikal, in the USSR.(2) There are a large number of smaller lakes and reservoirs, however, the majority of these are located in temperate and sub-arctic regions of the Northern Hemisphere.

Distribution and Availability of Water

Canada is renowned for its vast water resources. Bordering on three oceans, Canada has the longest coastline of any country in the world. It also has numerous lakes, rivers and groundwater reserves.

Approximately 756,000 sq. kilometers of Canada's total surface area is covered by fresh water.(3) The Great Lakes shared by Canada and the United States constitute the largest surface reservoir of fresh

water in the world. The Great Lakes have a collective area of 245,240 Km^2 and a volume of 24,620 Km^3.(4)

Canada also has vast groundwater reserves. It is estimated that there is approximately thirty times more water stored in ground water reserves than there is stored in surface water reserves.(5)

MacNeil (1971) estimated that Canada has at least 4% of the world's known volume of freshwater which includes about 9% of the world's total river flow. These figures coupled with the country's small population give Canada an enormous per capita water supply of approximately 340,000 litres per day,. In light of these figures, it is no wonder that Canadians find it difficult to accept and act on predictions of an impending water crisis.

Water, however, is not as abundant or as available as we might like. Despite the apparent abundance of the resource, Canada has a serious water distribution problem. The mean discharge of all Canadian rivers is some 105,000 M^3/sec. Of this amount, 24,100 M^3/sec flows west to the Pacific, 33,400 m^3/sec flows east to the Atlantic, while the remainder, approximately 47,300 m^3/sec, flows north into James Bay and the Arctic Ocean. Thus, nearly 60% of the flow from Canada's river basins drains northward, while 90% of the population and most of the country's industry and agriculture are located in the south.(8)

Another problem affecting water distribution is temporal and seasonal variation in the hydrological cycle. Rainfall is not evenly distributed over land surfaces. The average annual precipitation for Canada is about 20 inches. Settled areas of the country receive approximately 29 inches per year, while many unsettled areas receive less than 16 inches per year. The Northwest Territories receives only 10 inches per year, the Yukon 13 inches, and some unsettled areas of the Prairie Provinces approximately 15.5 inches per year.(9)

Average annual surface runoff is often as high as 100 inches in some parts of British Columbia, but can be as low as 5 inches per year in dry parts of the Prairies and Northwest Territories. As a result of these regional variations, some areas of the country experience severe droughts, while other regions must cope with annual flooding.(10)

Regional variation also exists with respect to the distribution of groundwater supplies. The Atlantic Provinces consist mainly of impervious metamorphic and igneous rock formations which tend to limit groundwater supplies. Most of the Great Lakes - St. Lawrence Lowlands area have abundant groundwater supplies, and high levels of groundwater use, while the Canadian Shield region has limited supplies due to impervious bedrock and permafrost which prevent groundwater storage. In the Prairies most water supplies are found in glacial till, however, yields from these soils are often poor. In Western Alberta and British Columbia, much of the groundwater potential is still unknown because of the regions more variable geology.

Actually, groundwater evaluations are, at best, approximations. At this time, no accurate measure of the extent, character or distribution of Canada's water resources exists. More research is needed to investigate both the extent and distribution of Canada's groundwater reserves. It can be assumed, however, that for the most part, groundwater supplies are only significant on a local scale due to the presence of glacial till, permafrost and impermeable rock formations.

In conclusion, although Canada has an abundant supply of water, its distribution in time and space limit its availability for use. This is important to remember because the value of any given water supply is dependent on its availability to potential users.

This Historical Significance of Water

Besides being important for its life sustaining qualities, water has played an important role in Canada's history and development. Since the country's early days as a new frontier, Canada's oceans, lakes and rivers have greatly affected the character of the country's settlements and economic development patterns.

Early water resource development focused on domestic, agricultural and transportation uses. Water was an important source of power from which grist and saw mills were run. In the late 1800's, hydro electric development began. Originally, private firms built hydro electric plants to serve local industries and small communities. However, as the demand for hydro power grew, the small private firms were replaced by large public utilities which supplied power to increasingly larger areas.

Early settlements were almost always located on waterways because of the importance of these waterways as transportation routes. During these early days of water resource development, conflicts over water supply were rare because of the abundance of the resource and the comparatively small level of demand by users.

In 1909, the Boundary Waters Treaty was signed between Canada and the United States. This treaty established the International Joint Commission (I.J.C.). The IJC is concerned with the use, by either country, of boundary waters, and has a mandate to respond to requests to study and advise both countries on problems of mutual concern.

World War I saw a steady increase in the use of hydro electricity for chemical production and metal refining. By the Second World War, population and industry had begun to grow exponentially as did their respective demands for water. This period marked the end of low cost, readily available water development projects.

The early patterns of settlement and industrialization, based on water availability, continue to persist today. Despite technological advances, most Canadian settlements and industries are still centered around water. In combination with energy and raw materials, it is an elementary determinant of economic growth and the quality of life.

Today, water is important for drinking, dilution, cooling, cleaning, waste disposal, irrigation, transportation, production, power and heat. Water is an important solvent and catalyst in science and industry. It is an essential part of habitat for many plants and animals, and, is thus linked to the success of the fishing and and trapping industry. Water has become very significant in recent years as the center of the majority of our recreation activities like swimming, skating, and boating, as well as being important for cottagers and the tourist industry. Recently, researchers have attempted to estimate the monetary value of the recreational use of water. Recognition of this value has resulted in more water use conflicts than ever before. These conflicts occur because recreational uses of water are often incompatible with uses that impair water quality.

In conclusion, water plays an important role in Canada's economy because so many of our settlements and industries are water dependent. In fact, water has been called "a prime determinant of economic growth and the quality of life."(12)

Loss of Canada's water reserves would seriously alter the very character of the country.

Water Uses in Canada

Canadians use and waste a lot of water. Per capita, our water consumption is among the world's highest. In 1980, an estimated 173,900 million litres per day of fresh water were used to fill Canada's demand. This equal to about 7,100 litres per day per person.(13)

Water use can be classified as either withdrawal or non-withdrawal uses, and then further classified into consumptive uses or non-consumptive uses. Withdrawal uses remove water from its natural course although the water may eventually be returned to the waterway from which it was taken. Non-withdrawal uses are those uses made of water not removed from the natural course of the waterway.

A consumptive use is a use that results in a loss of water. This "lost" water is unavailable for use, and is not returned to the water source from which it was taken. Consumption is the result of transpiration and assimilation by living organisms, incorporation into industrial products, leakages and evaporation. Non-consumptive uses are those where no water is lost.

The largest withdrawal users in Canada are thermal generating stations. They are responsible for approximately 43% of the total withdrawals. With a projected growth rate of 5.5%, their water requirements are expected to increase from 48 billion litres a day to one hundred and forty three billion litres per day by the year 2000.(14)

Water serves two main functions in thermal generating stations. In the form of steam, water is used to drive turbines. It is also used as a coolant because of its ability to absorb heat. The use of water as a coolant is one of the major causes of consumption in thermal generating stations. This is because the heated water evaporates quickly as it is released to the outside environment. Despite this fact, overall consumption in thermal generation remains low relative to other water uses. Nuclear power plants use even more water than thermal generating plants. Conversion to nuclear power will mean even more significant increases in water requirements.

In 1980, agriculture was responsible for 48% of all consumption in Canada. Agricultural use was approximately 4.4 billion litres per day in 1980, and is expected to increase to 6.6 billion litres per day by the

year 2000.[15] The major agricultural uses of water are irrigation of crops and stock watering. Continued expansion of irrigation in Canada may place additional strain on water resources especially in the western provinces.

Mining is another large consumer of water. Approximately 40% of the water is used in deep well extraction of petroleum and gas.[16] As this water cannot be recirculated, it is considered to be consumed.

Manufacturing has the second highest withdrawal rate, but has a relatively low consumption rate. Water has many uses in industrial processes. It is used as a coolant and a medium in which processing takes place. It can be incorporated into finished products as well as being used for diluting and cleaning. In 1980, manufacturing accounted for 38,156 million litres per day total withdrawals. Consumption was approximately 1,567 million litres per day.[17] Recirculation of water in mining and manufacturing sectors has and will continue to help limit demands in these sectors.

Rural domestic and municipal water use is expected to increase from its present rate of 12,410 million litres per day in response to changing population sizes.[18] As people move to the western provinces, increases in population may strain already limited supplies in some regions. Rural domestic and municipal water uses include commercial, residential, and public uses of water. Bathing, laundry, dishwashing, toilets, drinking, cooking and cleaning are classified as residential water uses. Also, in this category, are many of the outdoor water uses associated with private homes and apartments, i.e. swimming pools, car washing, lawn and garden watering.

Commercial uses include supplies to stores, garages, commercial car washes, restaurant, hotels, etc. Public uses include watering public lawns, gardens, parks and golf courses. Also in this category are, public swimming pools, public buildings, fountains, and fire fighting.

Besides the withdrawal uses of water discussed above, there are many important non-withdrawal uses. Navigation, fish, and wildlife habitat, recreation, and hydro electric generation are the four major non-withdrawal uses of water in Canada.

In 1973, the value of all fish landed in inland waters was approximately 19 million dollars.(19) However, this figure cannot convey the true value of the fishery because of the many indirect benefits. These indirect benefits include tourism growth, and money paid by fishermen for licenses, gear, boats, guides, lodge rentals, etc. Like the fishery, wildlife has similar indirect benefits which are often under-estimated. Both of these industries play an important role in the Canadian economy.

In the previous section, the growing significance of water based recreational activities was elaborated. It is important to remember, that not only is the recreational use of water economically important, it is also socially and psychologically essential.

Navigation is another major water use in Canada. It may take the form of commercial shipping or recreational boating. Although we are not as dependent on navigation as a means of transportation as we once were, it still remains one of the most economical means of transporting bulk goods.

The last major non-withdrawal use that will be discussed here is hydro-electric power development. Hydro-power is the major source of electricity. The availability of cheap water power has had a strong influence on industrial development in this country. Hydro-electric plants require large amounts of water, but do not remove the water from its natural course. Although they consume little water hydro-electric plants are often controversial because they regulate the level of stream flow.

This section has attempted to review some of the major withdrawal and non-withdrawal uses of water in Canada. While many of these uses are compatible, some are not. In order to protect those uses sensitive to impact from other uses, there is a movement today toward sustainable multi-use resource development projects so that water development projects take other uses of the resource into consideration when planning projects.

Water use in Ontario and the Great Lakes Region

The Province of Ontario, and in particular, the Great Lakes region, is the center of approximately 40% of Canada's economic activity.(20) The Great Lakes contain almost 1/5 of the world's fresh water and are one of the world's most important inland waterways. The Great Lakes are found on the Canadian-American border and are shared by the two countries. They border on 8 states and 2 Canadian provinces, Quebec and Ontario.

The economy of the region is centered around industry, forestry, agriculture, mining, commercial and sport fishing, recreation, and tourism. The Great Lakes Basin has a number of advantages over other regions which have helped encourage its development. The major reason is that water is plentiful and readily available for industries. Navigation has been greatly enhanced by the Great Lakes St. Lawrence Seaway which allows ships to travel from the Great Lakes to the Atlantic. Power is also readily available in the region and is relatively inexpensive. The region is central in Canada and located close to markets in both Canada and the United States.

In 1977, at the request of the Canadian and American governments, the IJC set up the International Great Lakes Diversions and Consumptive Uses Board which was asked to report on existing and probable patterns of consumptive uses of Great Lakes water and existing diversions. The results of this study were published under the title Great Lakes Diversions and Consumptive Uses, in 1981.

The study showed that based on 1980 data, manufacturing, thermal power and municipal uses accounted for the major share of consumptive use in the Great Lakes Region. This is expected to increase from approximately 80% of total consumption in 1983 to 93% in 2035.

In 1980, the consumption rate for the U.S. was 14,200 million litres per day while Canada consumed about 1,900 million litres per day. Thus the U.S. is consuming water from the Great Lakes at a rate more than seven times that of Canada. Canada was responsible for only 27% of the 1980 withdrawals and 13% of the total consumption.(22)

The study predicted volumes of water to be used in each sector up to the year 2035. It is not expected that increased consumption will be detrimental to water supply at the predicted rates of increase, however, it may lead to a lowering of lake levels and outflow volumes. The study concluded, that if consumption continues to increase, there could be a 8.6% decrease in the mean flow of the St. Lawrence River with impacts occurring on shipping, hydro electric power generation, cottages, docks, beaches and water quality.(24) In an effort to avoid these negative impacts, it is necessary to monitor changing lake levels and the impacts of these changes, as well as to consider the possibility of reducing consumption, an activity known as "water conservation."

Canadian Water Management

Control of Canada's water resources is shared by all three levels of government: federal, provincial and municipal. Development of policy is dependent on federal-provincial cooperation. To promote cooperation between the three levels of government, the federal government delegates powers to the provinces who in turn assign some of their responsibilities to municipal and local governments.(25)

The major federal statute concerned with water management is the Canada Water Act which organizes intergovernmental relations, and policy formation, and co-ordinates federal and provincial activities. The Canada Water Act provides for the management of the water resources of Canada including research, planning, and the implementation of programs relating to the conservation, development and utilization of Canada's water resources.

Other pieces of relevant legislation are: the Navigable Waters Protection Act, which protects shipping lanes; the International Rivers Improvement Act, which protects stream flow in international rivers; the Fisheries Act, which protects fish habitat; the National Parks Act, which gives Parks Canada jurisdiction over waterways within National Parks; the International Boundary Waters Treaty, which protects boundary waters from diversion; and finally, the Northern Inland Waters Act, designed to protect the waters north of 60° latitude.

In Canada, provincial governments coordinate local activities, provide provincial funding, and enforce standards of quality and adequacy. Municipal governments have authority to raise and spend funds, but the provinces retain the power to approve and influence local activities. Municipal governments have jurisdiction over sewage treatment, land-use planning, and water supply systems. The municipalities in all provinces collect user fees from all those using public sewage collection and treatment facilities. Water and sewage charges are usually collected together, however, rate structures are varied among municipalities.

Most provinces have come to recognize the interrelationships between water quality and water quantity. This fact is recognized in Ontario's Official Policy on Water Management. The amount and physical characteristics of available water are important aspects of water quality.(26)

Provincial policy states that all reasonable and practical measures should be taken to conserve surface and groundwater reserves in order to maximize its availability for existing and potential beneficial uses. The province wants to ensure a fair sharing of water resources to protect the various water uses.

The major involvement of the Ministry of the Environment in this field is based on the water-taking permit system authorized by Sec. 37 of the Ontario Water Resources Act. The Ministry controls all surface and groundwaters in Ontario. It constructs, acquires, provides, operates and maintains waterworks, making water supplies available to municipalities and industry.

Besides the Ontario Water Resources Act, another piece of important water management legislation in Ontario, is the Conservation Authorities Act which allows the Conservation Authorities to develop, manage, restore and conserve the natural resources of a watershed area.

In conclusion, water quantity management in Ontario involves a combination of common law, federal and provincial statutes as well as municipal bylaws.

Definition of Water Conservation

Early in the twentieth century, when the conservation movement first began, conservation was defined simply as the wise use of resources for the greatest good of the greatest number of people over the longest period of time.(27) Although this sounds commendable, the problem with this definition is that it is difficult to get people with different interests to agree on what should be considered a wise use or which uses will yield the greatest benefits for most people.

In 1981, the World Conservation Strategy was published by the IUCN, UNEP, and the WWF. This report emphasized the importance of sustainability in their definition of renewable resource conservation.(28)

Water is considered to be an renewable resource because water supplies are renewed continuously through the hydrological cycle. Using this concept, water conservation can be defined as the management of man's water resources so that they yield the great sustainable benefit to present and future generations.

The 1979-1980 edition of the Canada Water Year Book listed two criteria against which a particular water management practice could be evaluated to determine whether or not it constitutes conservation. "The practice must conserve a given supply of water by either a reduction in water uses or loss, and, secondly, it must result in a net increase in social welfare. This definition limits conservation to beneficial reductions in water use or loss."(29)

For the purpose of this paper, the three definitions given here will be combined. Water conservation will be defined as a beneficial reduction in water use or loss so that the benefits from a particular water supply are sustainable.

Characteristics of Water that Contribute to its Waste

Water has a number of characteristics that contribute to its being wasted. Water supplies show regional and temporal variation. They are subject to scarcity and depend upon rational management.

People's belief that water is limitless is one of the main reasons for not conserving water. As a result of this belief, past water management practices have been dominated by supply side solutions. In the past, as water demands grew, people continued to look for new

supplies rather than make an attempt to control demand. On the whole, supply-side solutions to water management problems tend to be more economically, socially and environmentally disruptive than their alternative, which is to take a demand management approach. As well as believing that water is limitless, many people consider it a free good, something that we should not have to pay for. As a result of this belief, water is often supplied equally to both essential and non-essential users at very low prices. Usually, the cost to users includes only the cost of treatment and delivery. No commodity charge is placed on the water itself. This is due to inconsistencies in evaluating water in economic terms. It is difficult to put a dollar value on water. The value of water depends on its potential uses, and availability for use, as well as scarcity. Economic principles show that when an object is under-valued, it tends to be over-used. Because water is considered a free good, people are often resistant to attempts to implement water pricing schemes. Governments end up subsidizing uneconomic projects so that people can continue to have the free water they feel they are entitled to, and this increase in supply in turn contributes to further growth in demand.

A number of researchers have attempted to establish a more realistic dollar value for water. One approach that has been taken is to estimate the value of production in water dependent industries. Another approach is to estimate the cost of installing and operating equipment, or policies, that could reduce the amount of water wasted.

The final characteristic which contributes to water wastage is that it is a common property resource. This means that water belongs to no one individual or group of individuals. As a result, an individual user lacks the incentive to conserve water or preserve its quality because the benefits or costs of that user's actions, whatever they may be, are shared by everyone, not just the individual user. This is the main reason why the government controls our water resources. As the government accepts ownership of the country's water resources, it also

accepts the responsibility to manage both water quality and quantity for the benefit of all Canadians.

Why Should we Conserve Water?

The greatest obstacle to water conservation as a viable alternative to supply-side solutions is the fact that water is taken for granted. We should never let this happen because fresh water is a vital resource for which no substitute exists; water is essential for life.

Although Canada has abundant water supplies, these supplies are not limitless. Canada's water supplies are distributed unevenly throughout the country. Water shortages and floods are both common occurrence in this country. Droughts are particularly common in the southern regions of the Prairie provinces and the British Columbia Interior. Less severe water shortages are common in parts of the Northwest Territories.

The impacts of water shortages caused by drought can be substantial. They include reduced agricultural and industrial outputs, water restrictions on industries and municipalities, reduced energy production and decreases in recreational opportunities. Droughts may have serious social, economic and environmental impacts. These impacts can be particularly serious in areas where drought is uncommon. Water conservation programs can help alleviate drought and the impacts caused by water shortages, and may reduce the chance of a drought occurring.

Today in Canada, there are six major river basins where there are supply demand imbalances. In these basins, the present or forecasted future demands for water exceed present and predicted supplies. These basis are the Okanaga, Milk, North Saskatchewan, South Saskatchewan, Red-Assiniboine and Southern Ontario Basins.[29] It is believed that conservation programs in these areas could manage increasing demands to help keep them in line with supply.

Southern Ontario is not usually associated with water shortages because of the presence of the Great Lakes. However, even in this water-rich region, the availability of water is limited by regional and temporal variation distribution and pollution problems.

Technological and population growth have placed an additional strain on water resources. Technology has resulted in the public's being supplied with ever increasing amounts of water, as well as increasing the volume of goods requiring water as part of the production process. It is important that we remember that although water is renewable if available in sufficient quantities, it is a limiting factor for growth.

Even in situations where water is still plentiful, the cost of increasing water supplies is straining the financial resources of many communities. Engineering solutions to water supply problems are often very expensive, and are usually associated with large-scale disruption of the natural environment. Conservation programs could postpone or even eliminate the need for engineering solutions.

Although advances in technology have solved water supply problems in the past, we realise now that we can no longer depend on the "technological fix"; the belief that technology will solve any problems caused by resource shortages.

Canadians are becoming more concerned about the environment and the scarcity of resources. We have become more conscious of the role and benefits of water. However, we are still a long way from becoming a "conserver society." Every day in Canada, enormous amounts of energy and resources are wasted. Water is only one example, but it is a particularly good one because the knowledge and technology to eliminate a significant amount of water wastage is available, but is not being used.

We need to develop a conserver ethic. But it is believed by many people that this will not occur until Canadians find themselves in the midst of a serious water crisis or have some incentive to conserve.

This situation parallels that which took place in the early 70's as a result of the world energy crisis.(30)

One of the most important water management problems in Southern Ontario is the problem of conflicting water uses. Sometimes this problem is just a matter of unsatisfactory water allocation. At other times, it occurs in cases where one user has impaired water quality, so that although water may be present physically, its poor quality limits its availability for other users.

Water quality is an important consideration in any conservation program. Changes in water quantity affect water quality, and, likewise a change in quality may affect the quantity of water available for a specific use. Attempts to conserve water that do not address the water quality requirements of potential water users may be a waste of time, energy and resources, if the quality of the water being conserved has been seriously impaired.

Conservation programs can reduce the volume of polluted water being returned to waterways, thus increasing the availability of high quality water for other uses and reducing water treatment costs. Quality is an important incentive for conserving water intended for drinking or recreation. As people have come to realize the social and economic values of high quality water, we have seen more attempts to protect and conserve recreational waterways, and the surrounding areas for specific uses. Reservoirs which supply tap water to municipalities are also protected from uses which would impair water quality, as are the head waters supplying the reservoirs.

Besides reducing user conflicts, conservation makes more efficient use of energy and resources. Water wastage can be viewed in terms of energy wasted. Energy requirements for distribution, maintenance of suitable pressure, and treatment, as well as that used in the construction process, are enormous. Heating of water in the home is

the largest use of residential energy next to space heating. The cost of heating water is substantial. Reducing water uses reduces the amount of energy required to supply and heat water; thereby reducing the cost to water users.

A number of authors, including Foster and Sewell (1981), have predicted an impending water crisis in the near future. Some of their reasons for this prediction have already been discussed, i.e. conflicting water uses and deteriorating water quality. In their book Water: the Emerging Crisis in Canada, they also cited continuing pressure from the United States for water export from Canada as a contributing cause of the impending crises.(31)

The Canadian government has been under continuing pressure to export Canadian Water to the water-short areas of the United States. Several massive water transfer projects have been proposed which would result in serious environmental and social impacts in Canada. The largest of all the diversion proposals is NAWAPPA (North American Water and Power Alliance). It calls for diversion of water from Alaska and the Canadian North to the Western and Southwestern United States. In Canada, this project would result in severe impacts across the country, but particularly in the Rocky Mountain trench, the Great Lakes, James and Hudson Bays.(32)

Water conservation could help us avoid large projects like NAWAPA and their associated impacts. These projects should not only be avoided for environmental and social reasons. Our past experience with such projects shows that often-times they aren't even economical, i.e. Columbia River Treaty.(33)

Whether the United States really even needs Canadian water is another question that has been asked recently. It has been suggested that if the Western United States practiced water conservation to a greater degree, thus using their water more efficiently, they would not need Canadian imports.

To date, the Canadian Government has opposed large-scale water transfers, however, it is up to Canadians to see that the decision to protect Canada's water resources from export survives any change in government. One way to insure the protection of our water resources is to educate people to respect the limitation of the resources we have, and to use them wisely.

A successful water conservation strategy requires a lot of planning research and baseline data. It is necessary to predict future demands and the multitude of factors affecting demand. Conservation programs must anticipate a changing environment. A good conservation program allows us to anticipate change so that we can adapt to it, and the negative impact brought on by the change will be minimized.

In conclusion, conservation programs can reduce water consumption, and reduce the amount of energy needed to distribute, treat and heat water. Conservation programs help avoid the development of new supplies, and save money. They reduce user conflicts, insure that essential uses are met first, alleviate, and sometimes avoid water shortages, and droughts. They may also help cut down on water pollution, and will help preserve water quality.

Now is the right time to start planning for, and implementing conservation programs. Much of the technology, and many of the policies which could contribute to a successful water conservation program require implementation well in advance of an impending crisis to be effective. Water conservation will help us avoid a water crisis, but only if we come to accept such programs as part of our everyday lives.

Voluntary vs Mandatory Programs

A decision on whether a program should be voluntary or mandatory must consider how effective the program will be under each of these conditions, the necessity of the program, and the timeframe in which the program must show results.

Under crisis conditions, a mandatory program is a must. Enforcement of conservation measures helps insure their effectiveness. The mandatory program can be expected to show almost immediate results. Voluntary programs are often not as effective as mandatory ones, but may be desirable when implemented jointly with a mandatory program, or when conservation is desired in the long term rather than in a short-term crisis situation.

The decision whether or not a program should be voluntary or mandatory must also consider the particular conservation techniques being implemented. Some techniques lend themselves to voluntary programs, while others are best implemented under mandatory programs. Changes in rate structures are usually part of mandatory programs. They can be uniformally enforced and show fairly predictable results within short periods of time. Consumer education is a technique found in many voluntary programs. If people want to learn about conservation the information is available. Education is usually considered a long term approach to conservation, but its effects may be longer lived than those of many of the mandatory programs because education results in people's attitudes being changed. Voluntary programs may be advisable in situations where public resistance to mandatory programs is expected. When you provide the public with some incentive to conserve, the individual has a choice whether or not to take advantage of the incentive. This helps make the program more acceptable.

Two Types of Water Conservation

It is important to discuss water conservation programs in the context of timing. There are two timeframes for such programs. First, and probably the most significant for the majority of people, is long-term conservation, or general demand reduction. Long-term conservation programs usually attempt to achieve permanent changes in the use of water, and people's attitudes toward water resources.

The second type of program is short-term conservation, which is usually a contingency or emergency program meant to help a region cope with a drought or low-flow conditions. These programs are characterized by an acute need to save water, while permanent water conservation programs are usually a result of the desire to avoid increasing energy costs, and the need for capital expenditures, rather than the immediate reduction of water use.

Drought conservation measures are difficult to plan ahead as rapid action is required to cope with variable circumstances. In these cases, there is often significant conflict between environmental and economic objectives. Measures taken during droughts are more likely to result in negative impacts. These programs often require difficult choices to be made concerning domestic and industrial rationing and altering water flows on which recreational use and special habitat depend. Some of the desirable actions may be in conflict with existing law and policy which should always be flexible enough to accommodate emergency situations.

Permanent water conservation measures may be beneficial to all water users in the long run, and are not usually associated with serious environmental, economic and social impacts. Permanent conservation measures can help avoid the need for short term conservation programs. They reduce the probability of a crisis situation occurring. Permanent conservation can often be accomplished by voluntary means through education and information programs which make the idea more acceptable to the public. On the other hand, drought or contingency plans often require government action, and are usually mandatory programs.

Demand Management

Water demand reduction is an often neglected component of supply/demand management. Demand reduction is the process of inducing water users to reduce consumption so that water use does not exceed

currently available supplies. Solutions to water supply problems which focus on reducing demand are often cheaper and less environmentally damaging than traditional engineering solutions which have dominated the water management scene in the past. Engineering solutions focused on system expansion, finding new sources and technology to solve water supply problems, and did not consider the limitations of water supply.

Water demand reduction, or conservation, can be brought about in the long or short-term through voluntary and mandatory programs. These programs can limit the number of water using developments, schedule water use among users, increase the efficiency of water use, control water use through metering and pricing, and educate people to respect the limitations of the resource.

Conservation is possible in every water use sector to a varying degree and should be promoted by every level of government. Cooperation is the key to a successful program.

Actions to be Taken by Government

Long-term conservation programs can be adequately dealt with by provincial and federal governments while short-term contingency plans and programs are often best developed and enacted by municipal or local governments. This is because the short term program is often developed as a means to cope with a localized water supply problem. Contingency plans to remedy these problems are best looked at by local government because of the variable nature of the problem, and because water supply systems and billing are municipal concerns.

At the level of municipal government, it is possible to institute a number of very effective conservation measures. Municipalities and local governments should make conservation a part of their overall policy. An effective way to manage water resources on a local level is to practice watershed management. This principle is based

on the fact that the whole watershed contributes to the quality and quantity of water found in streams, rivers and lakes within the basin.

Municipalities should carefully assess both their ground and surface water supplies. Predictions of future growth are useful in estimating future demands on these supplies. In many cases, communities should consider developing contingency plans for water conservation, not only as a means of coping with drought, but also as a measure to be taken in cases where water quality could be seriously impaired by any number of possible pollution sources. Communities should begin implementing conservation in their landscaping and design. Stormwater can be reclaimed and wetland areas can be maintained. As has been done in many of the watershed areas of Southern Ontario, water conservation can go hand in hand with related activities such as erosion control, and prevention of stream sedimentation.

Municipalities may be able to restrict water-using developments that would stress their supplies and could encourage new development to implement conservation in industrial processes. They can encourage retrofitting and the use of water saving devices. Inspectors from the municipality could conduct leakage monitoring programs. Changes in billing schedules may also be used to promote conservation.

Municipalities should promote citizen awareness of conservation and the need to conserve water supplies. It is on the local level that education is particularly effective because people who are affected by their sense of commitment are receptive to the idea of working together for a common goal. If a mandatory conservation program becomes necessary, municipal government can implement local ordinances to limit water used.

Federal and Provincial governments can encourage government at all levels to consider conservation. They can arrange grant and loan programs to support municipal programs, and can provide municipalities with technical assistance. They can collect data, develop technology, and sponsor or conduct research. They can sponsor information and education programs, and can sponsor conservation exhibits which could travel to communities, or could be set up by the community itself. Grants from federal or provincial governments can create incentives for the manufacturers of water saving devices, or for homeowners and industries to retrofit, or use, new water conserving devices.

Finally, provincial governments can have their building and plumbing codes amended to accommodate situations where municipalities would like to enforce conservation through these measures, but are unable to do so without provincial support.

The next section will deal with a number of activities or water use sectors where water can be conserved.

Information and Education

Ultimately, both man's attitude and behavior towards the environment, and our limited resource base, must change if the achievement of conservation is to be assured. Lack of a conservation ethic, and ignorance of the benefits of conservation, prevent realization of the urgency for, and the relevance of, conservation.

The first step in the implementating of any conservation program is to seek public acceptance of the program. A program that provides for information and education is more likely to gain public understanding, acceptance and cooperation. Programs that open up dialogue between the general public and decision-makers pave the way for public involvement. They enlighten decision-makers as to the public's views, and may contribute to improved decision-making.

In order to encourage people to conserve, you must provide some incentive. Means of providing incentives to conserve can be classified as extrinsic or intrinsic. Providing economic incentives is considered an example of extrinsic motivation. Education programs which foster conservation values are considered intrinsic motivation.(34) Both types of motivation provide a means through which the value of conservation can be demonstrated. People are made more aware of both the need for, and the benefits of, water conservation. It is important that people realize that the benefits of conservation are environmental and social as well as economic.

Education and information programs are important not only in the short term crisis situation. They help foster a long-term commitment to the conservation ideal. Public information, community communication, and the development of personal commitment have been called the keys to a successful conservation program.(35)

Information and education programs often focus their efforts on specific target groups in society. Programs have been designed to reach children, residential consumers, decision-makers, builders, and industrialists to name a few. However, no matter which of these groups a program is designed to impact, the general objectives of the program remain the same; to make people aware of the need for conservation, and the possible solutions.

Some of the major components found in past information and education programs are:

- Water bill inserts
- newsletters, brochures, and flyers.
- newspaper, radio and television ads.
- newspaper articles.
- radio and television programs and interviews.
- sprinkler hose tags, used as reminders.

- questionnaires used for survey purposes are useful to get people thinking about conservation and their own water use habits.
- citizen working groups and public meetings help promote citizen involvement and commitment.
- manuals for homeowners, builders and industries on how to conserve.
- conservation kits, which provide information and easy to install devices for residential water users.
- mini-fair on conservation devices.
- education programs for school children.
- slide show presentations.
- arrangements with public libraries to have conservation references on hand for public use.

There are many examples of successful education and information programs. One example is the 1976 media coverage and publicity campaigns conducted in Marin County, California. This campaign successfully reduced water demand by 25-30% of the average annual demand. This amount was further increased when information and education programs were used in cooperation with other conservation methods.(36)

In most cases, it is difficult to evaluate the impacts of information and education programs because they are rarely used alone, and most often complement other conservation measures. This is the case in the Municipality of Waterloo in Southern Ontario, where information and education are only one segment of their extensive water conservation program. Waterloo has used many of the previously discussed components in their program. They have emphasized the importance of implementing their program in phases so that time is allowed for public acceptance and feedback. It is also felt that implementing their program in phases has helped the municipality maintain the public's interest in the program.(37)

In conclusion, information and education programs are very important components of an effective water conservation program. However, they are most effective when they compliment other conservation measures in an integrated, or holistic, approach.

Metering and Pricing

Metering and pricing are two important means of demand reduction. Substantial water savings have followed the installation of meters in many areas of Canada and the United States. Studies have shown that savings in water use can be as high as 50%.(38) Metering water use can help determine the effectiveness of conservation measures, and makes it possible to predict per-capita consumption trends and system losses. Accurate records of water consumption allow for a more equitable distribution of water costs. The major disadvantages of metering are the added expense of installing, reading and servicing meters.

The effect of metering on the level of water use has been the subject of some controversy. Metering by itself need have no effect on water use.(39) The impact of metering on water use depends not on metering itself, but on the price structure used to charge users for the water used.(40)

Metering water use makes it possible to consider various forms of water pricing as a means of providing incentives to conserve. In the past, because water was considered a free good, the price charged for water was not a price attributed to the resource itself. The price of water usually only covered supply and servicing costs of the supplier. Supply costs included the planning and construction costs of the works needed to supply the water to consumers, while servicing costs included operating costs, maintaining offices and staff, meter purchases, installation, reading and servicing, as well as line maintenance. The costs of supplying and servicing large industries were not much higher than the cost of supplying residential users. Thus, even though large

industries were using large amounts of water, the cost of supplying the water per unit of water used was less than the cost for residential users. Given this argument, low water rates for industries using large amounts of water appeared valid. Low water rates were often used as a means of providing economic incentive for further industrial development.

Today, this line of reasoning is being abandoned. It is now believed that more equitable water pricing could help encourage conservation, and could provide revenue for capital expenditures that result from increasing demand.

Demand for water varies in elasticity depending on the particular use it is intended for. Because the demand for many essential uses of water is inelastic, it is believed that the price charged for water has only a small effect on water consumption. The actual structure of the rates rather than the price charged is the significant factor in inducing consumers to change water use patterns.(41) Rate structures can be altered to create a direct economic incentive for consumers. Rate structure changes are an effective and an economic means of alleviating water supply problems. Conservation minded rate structures can be a major component of a water conservation program, however, not all rate structures encourage conservation. Of the six that will be discussed here, only three are considered to be conservation measures.

The six major types of rate structures used by water suppliers are: flat rates, uniform rates, peak demand rates, excess use charges, decreasing block rates, and increasing block rates.

Under a flat rate schedule, a fixed amount is charged for water services for a specific period of time regardless of the amount of water used. Flat rates are usually used in situations where water use is un-metered. They tend to encourage excess use because consumers reason that the more water they use, the more they are getting for their money.

Today, the number of utilities using un-metered flat rates is declining. Two major objections have been raised against their use. Flat rates lead to the waste and careless use of water. Wasteful use of water can lead to unnecessary capital expenditure because demand forecasts are in excess of what is actually needed. The second objection to flat rates is that they do not provide an equitable method of distributing water costs based on the amount of water used. Flat rates are based on servicing and supply costs rather than water use. Customers using large amounts of water are favored at the expense of those who use only small quantities.

Despite the overwhelming disadvantages of flat rate schedules, there are also some advantages to their use which made them popular in the past. They encouraged development, and they were easy to understand and administer. As well, they helped suppliers avoid some of the additional costs incurred by other rate structures which require metering.

Uniform water rates involve a constant charge per unit of water used. This rate schedule is also fairly easy to administer. However, because the rate does not vary with the amount of water used, this rate structure does not benefit users decreasing their water use nor is there an incentive to conserve.

Peak demand rates are a form of marginal cost pricing which penalizes users during times of peak demand when water use is heaviest, and the supply system is likely to be stressed. This rate structure aims to reduce elastic demand. Uses that are elastic such as lawn and garden irrigation are usually affected while inelastic uses such as water used for drinking, bathing and flushing toilets is not significantly affected.

In a peak demand rate schedule, higher rates are charged for amounts of water used in excess of the off peak time. Peak demand rates can be effective in altering water use patterns so that the stress to the supply system is alleviated. However, it is often difficult to implement

because of the resources required to collect the detailed data base on typical versus peak demand use for each consumer.

Excess-use charges are based on the idea that people have a right to a certain amount of water, but after this amount is surpassed, excess users should be penalized. This structure often uses typical winter rates as the basis for allowable or non-penalized use. Excess use charges tend to discriminate against those who use very little water in the winter, and, are thus, likely to exceed the amounts allowable in the summer. This especially true for golf courses, swimming pools and cottages.(42)

Under decreasing block rates, users are charged successively less per unit for each additional unit of water consumed. This structure encourages water use by providing lower rates as the quantity of water use increases. Although the marginal costs of maintaining water works may decrease, as water supplies diminish the utility is faced with the high costs of increasing water supplies through the development of new sources. Unless the utility can find some method by which this cost can be absorbed by consumers, the utility may find itself in a financial crisis. Because of the financial burden on utilities when supply increases are necessary, the popularity of the decreasing block rate has declined.

Increasing block rates charge more per unit of water used with each additional unit of water used. This structure encourages conservation, but low water users may be subsidized by larger users to the point that low water users may not be paying for the cost of supplying the service. One solution to this problem is to practice price discrimination. The rate structure can be adjusted so that it distinguishes between types of users. Residential users may be charged a different rate than industrial users.(43)

Of all the schedules discussed here, the three most effective in encouraging conservation are: the peak demand rate, the excess use charge, and the increasing block rate. There is some evidence to indicate that once affected by a conservation rate schedule, water consumption is relatively insensitive to decreases in marginal rates. In the case of Boulder, Colorado, the shift toward reduced water demand and use was permanent, and did not return to its original level during the six years after metering ended.(44)

A number of Canadian studies have also looked at changes in water rate schedules. In Toronto, it was found that flat and declining block rates contribute to wasteful water use, with little incentive for water conservation, which resulted in misleading water requirement forecasts. The study concluded that incorporation of increasing block rates would result in decreased water demand and reduced requirements for capital expenditures.(45) In Calgary, surveys showed that customers on a flat rate system used almost twice as much water as customers on a metered system. Waterloo, Ontario, is an example of one of the most extensive conservation efforts in Canada to date. It is a good example of a multi-faceted approach to water conservation which included changes in the rate structures used in customer billing. In Waterloo, water use was reduced by 14%. In this case, conservation helped postpone expensive capital expenditures necessary to augment their limited groundwater supplies.(46)

These studies demonstrate the significant impact that changes in rate structures can have on water use. Through the use of peak demand rates, excess-use charges, and increasing block rates, a direct economic incentive to conserve is given to the consumer. Communities using other rate structures, but wishing to implement a conservation program, should consider a change in rate structure an effective and economic means of encouraging conservation.

The possibilities for changes in rate structures need not be limited to the six discussed here. Other possibilities could include schedules that charge different rates for consumptive and non consumptive uses or those that charge for any impairment of water quality.

Residential Retrofitting

The majority of household plumbing fixtures and appliances in use today use a significant amount of water in excess of the minimum considered adequate to carry out their function. The toilet and the shower are the two major water consumers in the home. Toilets use approximately 4 gallons per flush and showers use about 3.6 - 6.4 gallons of water per minute. Household faucets range from 3.6 to 6.4 gallons of water per minute, but the amount of water wasted through running tap water varies greatly, depending on use habits.(47)

Many new and improved plumbing fixtures and appliances have been designed to replace older, inefficient models. However, replacement of the older fixtures and appliances is slow because replacement is often not economical. Retrofit programs attempt to modify existing fixtures without replacing them, so that water demand is reduced. Besides reducing demands, retrofit programs result in reduced sewage treatment plant loading, thereby delaying the need for expansion.(48)

Some of the retrofit devices that have been used include:

- Toilet tank reservoir devices like bricks, plastic bottles, and dams which displace water in the toilet tank so that less is used for each flush. Other reservoir devices, like the aqua-saver, used in the Municipality of Waterloo Conservation Program, are mechanical devices which limit water flow.(49)

- Shower flow restricters which restrict the amount of water coming through the shower faucet.(50)

- Faucet aerators can be installed on all household faucets. They mix the water with air so that, although water flow is reduced, pressure is maintained.(51)

Many of these devices can be supplied to homeowners inexpensively. An effective way to do this is to supply the devices in a conservation kit as part of an information and education program. These devices are easy to install and use. They have been reported to be able to reduce residential water consumption by approximately 20%. It has been found, however, that the retrofit devices work much more efficiently, and are more likely to be installed, if the program offer consumers the opportunity to have the devices installed for them by trained personnel.(52)

Conservation in New Structures

The best way of conserving water in residential plumbing fixtures and appliances is at the design and manufacturing stages. Fixtures designed to conserve water are generally capable of far greater conservation than those fixtures that are retrofitted. The first step in promoting the use of conserving fixtures and appliances is to ensure that these devices are available to the consumer. If their use is not legally required, then the decision whether or not to employ the new device in their home is left to the individual. Despite interest or concern on the part of the individual, their decision often comes down to a question of money cost.

Generally, it is more economical to install conservation devices in new structures rather than to replace already existing devices in old structures. By ensuring that all new structures are water efficient to begin with, you can ensure a gradual end to the less efficient retrofitting methods of conservation.

The simplest and most direct method of implementing conservation in new structures is to amend plumbing codes so that the use of low water consuming fixtures becomes mandatory. This method has been employed in many areas of the United States where municipalities have passed local ordinances requiring new structures to be fitted with low water using toilets (2.8 gallons per flush), low-flow shower heads (1.6 - 3.2 gallons per minute) and flow-restricting faucets (2.4 gallons per minute).

Alternatives to standard household plumbing devices are produced and supplied in Southern Ontario by Crane, Mansfield, Willis, and Plumbing Mart, among others. However, although these devices are available locally, there is no legislation enforcing their use nor is there significant economic incentive for the consumer to install these devices. It is difficult to legislate the use of conservation devices in Ontario because plumbing regulations are under provincial jurisdiction while conservation tends to be more of a local issue.(54) So far, the province has been resistant to the idea of local amendments to provincial legislation that would allow municipalities the flexibility needed to respond to local problems.

In the Municipality of Waterloo, subdivision agreements which would ask for a commitment from the developer to install conservation devices before the development was approved, were rejected as a means of implementing conservation in new structures because the agreements were not backed by legislation and would be difficult to enforce.(55) The approach, finally proposed by the Municipality of Waterloo, was to provide builders with a monetary incentive to install low water consuming fixtures in new buildings. This incentive could be supplied in the form of a rebate from the regional lot levy, and could be given out to water efficient industries and consumers who renovate their homes, as well as builder and developers.(56)

Any such program would have to include an information and education component which would highlight the advantages of conservation, as well as the types of devices that are available.(57) Some of the more popular water saving fixtures and appliances are:

a) Toilets.
   - Shallow trap toilets.
   - Self-contained chemical and bacterial toilets.
   - Pressurized flush toilets.
   - Oil flush toilets.
   - Vacuum toilets.

b) Showers.
   - Aerated faucet.
   - Pressure-reducing valves.

c) Lavatory and Sink Faucets.
   - Instant hot water aids.
   - Flow restricters.

d) Water conserving clothes and dishwashers.

e) Grey-water reuse systems. (Water from baths, clothes and dish-washing, is recycled and used for flushing toilets.)

For more information on the types of appliances available locally, see Tables 2, and 3 in, Guidelines to Encourage Water Conservation in New Structures, by Howard-Ferreira and Robinson.

Conservation in Agriculture

Agriculture can be a large consumptive user of water and is often very inefficient. It can be enhanced through ensuring that sufficient quantities of freshwater continue to be available, and improving water-

use efficiency. Some of the conservation measures that can be employed in agricultural settings include measures to reduce water losses in the storage, transmission, and delivery of water. Irrigation canals should be lined, and storage and distribution systems checked for leaks. Crops should be planted that are compatible with soil types, and water availability. In areas with limited water supplies, crops requiring less water could be planted. Minimum tillage farming and greater use of mulches can also help minimise water loss. Efficient irrigation methods, like drip irrigation, can be implemented. User habits can be changed; farmers can irrigate at night when water is less likely to evaporate. There are also opportunities for water reuse within the system. Grey-water, or treated sewage outflow, can be used to irrigate crops. Incentives for demand management such as water metering, seasonal pricing, and increasing block rates can also be used to encourage conservation in agriculture.

Before most of these measures could be implemented, it is important that education and information programs be used to foster a conservation ethic among the agricultural community. This should be an easier task to accomplish in this sector than in many others because the success of agriculture is so closely linked to adequate water supply and is subject to annual and seasonal fluctuations. As a result, water is less likely to be taken for granted by people working in this sector.

Conservation in Industry

Industry is the second largest water user in the Great Lakes Region, the major source of water being the Great Lakes themselves. Because of the abundance of water in the region, and its being supplied to industry cheaply, water quantity is not considered a problem, or an incentive for conservation, although it should be. Instead, the major incentives for industrial conservation appears to be efforts to maintain water quality, and monetary savings. Compliance with water quality regulations, and economic incentives, have already caused many industries to consider water conservation.(58)

Currently, industry recycles far greater quantities of water than any other use sector. The Great Lakes Basin Commission noted that the manufacturing sector has the least potential for conservation of any use sector because many industries are already practicing conservation through recycling to minimize costs.

In many industries, opportunities for recycling of water exist, however, each industry and plant site must be evaluated independently to ensure that the most appropriate system for that particular plant is devised. This is important because water quality requirements are variable and are industry specific. Each recycling opportunity reduces water requirements, and the pollution load on waste treatment facilities. A plant may be able to use municipal or plant waste water for certain processes such as cooling, waste transport, or equipment washdown, if water quality requirements are met. Besides recycling, other possibilities for conservation in industry exist, including the use of dry cooling towers, and a reduction in the amounts of water used in processing. Conservation in industry can help alleviate stress on municipal supplies.

In Attleboro, Mass., a major manufacturer used recycling and employee education to reduce its water consumption by 58%.(60) Another example of the possible saving in industrial water use is National Coupling Ltd., in Kitchener. In the past, clean cooling water was discharged directly into the storm sewer. Recently, however, the company investigated ways of reducing the volume of water used in their cooling process and by altering the water levels, obtained a savings of 4000 gallons per day, or 50% of previous use.(61)

In conclusion, although significant water savings are possible in industrial operations, many industries are already practicing conservation because of water quality requirements, and the monetary savings which result from reduced water supply, treatment, and energy costs.

Concluding Remarks

In conclusion, I would like to review, briefly, some of the major points covered in this paper. Water is essential to life. It is a unique substance for which there is no substitute. Water is continually cycled in the biosphere through the stages of the hydrological cycle. Water has played, and will continue to play, a significant role in the development of this country's settlements and economic base. Water is a prime determinant of our quality of life.

Canada appears to be water rich, and as a result, Canadians tend to take their country's water resources for granted. However, although Canada has enormous supplies of freshwater compared to many other countries, water supplies are not evenly distributed throughout the country. Water is limited by temporal and regional variation. In many water use sectors, water is used inefficiently and a great deal of wastage occurs. The loss, or wastage, of water can be lessened through the practice of water conservation - the beneficial reduction of water use or loss so that the benefits from a particular water supply are sustainable.

We may be on the verge of a water crisis. We should conserve to ensure that essential uses of water are adequately met, to reduce user competition for limited resources, to reduce the costs of physically augmenting water supply and treatment facilities, and to reduce energy costs. Water conservation can be considered a form of demand management. Instead of responding to growing demand by physically augmenting present water supplies, conservation acts to reduce demand so that present supplies adequately meet present and future needs. There are two main types of conservation programs. First, there are those that are short-term contingency programs and second, there are those programs that are long-term and permanent. These programs may be voluntary or mandatory depending on the needs of the particular situation. Action to promote conservation is possible at all three levels of government.

Municipal governments are probably the most appropriate level for the planning and implementation of local contingency plans. Provincial and federal governments should support local governments, however, their major role should be in research and education.

Today, an enormous amount of conservation technology is readily available. This technology could be used to conserve enormous amounts of water in almost every use sector. However, for a number of reasons, this technology is not being used to its full potential.

In order to promote conservation, two things are required. These are: 1) a change in our attitude toward water resources; and 2) incentives to conserve. These two ingredients are essential to the success of any conservation program. To avoid continued reliance on physical supply augmentation, and crisis management, we should begin to think about water conservation now. In order to avoid a possible water crisis, we must begin now to promote a long-term commitment toward conservation.

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