MEASURING SUSTAINABLE DEVELOPMENT

APPLICATION OF THE GENUINE PROGRESS INDEX TO NOVA SCOTIA

The GPI Water Quality Accounts

NOVA SCOTIA'S WATER RESOURCE VALUES AND THE DAMAGE COSTS OF DECLINING WATER RESOURCES AND WATER QUALITY

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GPI *Atlantic*

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FORWARD

Limitations of the GDP as a Measure of Progress

The most commonly used measure of economic and social well-being is the Gross Domestic Product (GDP). Yet, in recent years there has been increasingly widespread acknowledgment by leading economists of the shortcomings of the GDP as a comprehensive measure of progress. Indeed, as an aggregation of the market value of all goods and services, the GDP was not intended, even by its architects, as a composite index of economic welfare and prosperity.

Using GDP levels and growth rates to measure progress takes no account of the value of unpaid work, free time, and environmental assets. It does not allow policy makers to distinguish the costs and benefits of different economic activities, and it masks changes in income distribution. Such fundamental omissions and limitations render the GDP an inadequate measure of social and economic well-being.

It should be noted that these are not flaws of the GDP per se, but of its use as a benchmark of economic and social health, prosperity and welfare. Nobel Prize winner, Simon Kuznets, who designed the Gross National Product, never endorsed its modern use as an overall measure of progress. As early as 1934, Kuznets warned the U.S. Congress:

> *The welfare of a nation can scarcely be inferred from a measurement of national income* (Cobb et al. 1995).

As the GNP began increasingly to be used as a measure of general social well-being and progress after the Second World War, Kuznets' reservations about the limitations of the system he helped create grew stronger, and he argued that the whole system of national accounting needed to be fundamentally rethought. In 1962 he wrote:

> *Distinctions must be kept in mind between quantity and quality of growth, between its costs and return, and between the short and the long run¼.Goals for 'more' growth should specify more growth of what and for what.*[1]

When the GDP is misused in this way, it frequently sends misleading and inaccurate signals to policy makers that can result in the depletion of vital resources and investment in economic activities that carry hidden social and environmental costs. What we count and measure is a sign of what we value. By focusing on quantitative material growth as our primary measure of

[1] Kuznets, Simon, *The New Republic,* Oct. 20, 1962, (cited in Cobb et al. 1995)

progress, we under-value the human, community and social values and environmental quality which are the true basis of long-term well-being, prosperity and wealth.

The flaws inherent in the misuse of the GDP as a measure of progress include the following:

1) The GDP is a current income approach that fails to value natural and human resources as capital assets subject to depletion and depreciation. As such it cannot send early warning signals to policy makers indicating the need for re-investment in natural and human capital. For example, the GDPs of Newfoundland and Nova Scotia registered massive fish exports as economic growth, but the depletion of fish stocks appeared nowhere in the accounts. Similarly, the more trees we cut down and the more quickly we cut them down, the faster the economy will grow. In this report, we examine how the current failure to account for water as a valuable natural capital asset can keep the depletion and degradation of our water resources off the policy agenda.

2) Secondly, the GDP is a quantitative measure only and fails to account for qualitative changes, both in the mix of economic activity and in the quality of our goods and services, including ecosystem services[2]. This failure can send perverse messages to policy makers. The *Exxon Valdez*, for example, contributed far more to the U.S. GDP by spilling its oil, than if it had delivered its oil safely to port, because all the clean-up costs, legal costs, media activity, and damage repair made a huge contribution to the economic growth statistics.

   Thus, water pollution and bottled water sales are literally "better for the economy," according to our economic growth statistics, than free, clean water, simply because more money is spent on the former. This incongruity extends to ordinary household purchases. There is no recorded relationship, for example, between the cost of consumer durables as capital investments on the one hand and the quality of services they provide on the other, leading to the paradox that the quicker things wear out and have to be replaced, the better for the GDP.

   In sum, this failure to account for qualitative changes means that increases in crime, divorce, gambling, road accidents, natural disasters, disease, obesity, mental illness and toxic pollution all make the GDP grow, simply because they produce additional economic activity. More prisons, security guards, burglar alarms, casinos, accident costs, dieting pills, anti-depressants, lawyers, oil spill and pollution clean-ups, and the costs of setting up new

[2] The Canadian System of National Accounts (CSNA) as a whole does provide information on shifts in the mix of economic activity by sector, industry, commodity and province. This, therefore, applies only to the use of GDP as a measure of progress, since industry and commodity shifts registered in the CSNA are rarely if ever invoked as signals of changes in societal well-being and prosperity.

households after family breakups, all add to the GDP and are thus conventionally counted as "progress".

This anomaly led Robert Kennedy to remark 30 years ago:

> *Too much and too long, we have surrendered community excellence and community values in the mere accumulation of material things....The (GDP) counts air pollution and cigarette advertising and ambulances to clear our highways of carnage. Yet the gross national product does not allow for the health of our children, the quality of their education, or the joy of their play. It measures neither our wit nor our courage; neither our wisdom nor our learning; neither our compassion nor our devotion to our country. It measures everything, in short, except that which makes life worthwhile* (Kennedy 1993).

3) Thirdly, because it excludes most non-monetary production, the GDP records shifts in productive activity from the household and non-market sectors to the market economy as economic growth, even though total production may remain unchanged. Thus, paid child care, hired domestic help and restaurant food preparation all add to the GDP, while the economic values of parenting, unpaid housework, home food preparation and all forms of volunteer work remain invisible in the economic accounts.

4) Market productivity gains may result in greater output *or* increased leisure, but the GDP counts only the former. Longer paid working hours add to GDP growth by increasing output and spending, but free time is not valued in our measures of progress, so its loss counts nowhere in our accounting system. Given this imbalance, it is not surprising that the substantial economic productivity gains of the last 50 years have manifested in increased output, incomes and spending, while there has been no real increase in leisure time.

   Omitting the value of unpaid work and free time from our measures of progress has important implications for the changing role of women in the economy, who have entered the paid workforce in growing numbers without a corresponding decline in their share of unpaid work. Indeed, as the "value of leisure time" module in the GPI demonstrates, women have experienced an increase in their total work-load and an absolute loss of leisure time.

   The failure to value leisure time is directly related to natural resource and environmental health and well-being. Blind economic growth and material gain have been the major forces fueling ecological degradation, including the depletion and deterioration of vital water resources. Re-examining work patterns in industrialized nations to value increased leisure rather than income growth alone as a key to well-being, can make a vital contribution to ecological health and stability.[3]

5) Finally, because it does not account for income distribution, GDP growth may mask growing inequality. GDP may rise substantially, as it has in recent years, even while most people are getting poorer and experiencing an actual decline in real wages and disposable income. The benefits of what experts refer to as "strong" and " robust" economic growth, based on GDP measurements, may be distributed very unequally. The trend towards rising inequality in a period of strong economic growth has been even more pronounced in the United States than in Canada (Cobb et al. 1995a, Messinger 1997) [4].

These shortcomings and others led to a recent joint declaration by 400 leading economists, including Nobel Laureates:

> *Since the GDP measures only the quantity of market activity without accounting for the social and ecological costs involved, it is both inadequate and misleading as a measure of true prosperity....New indicators of progress are urgently needed to guide our society....The Genuine Progress Index (GPI) is an important step in this direction* [5].

3 [3]For an outstanding exposition of this relationship, see Anders Hayden, *Sharing the Work, Sparing the Planet: Work Time, Consumption, and Ecology,* Between the Lines, Toronto, 1999.

[4] Messinger demonstrates that the absolute decline in the original U.S. Genuine Progress Index since the early 1970s is largely due to growing disparities in income distribution in that country. Rising inequality is registered in column B of the original GPI as an adjustment to personal consumption based on the share of national income received by the poorest 20 percent of households.

[5] Signatories include Robert Dorfman, Professor Emeritus, Harvard University, Robert Heilbroner, Professor Emeritus, New School for Social Research, Herbert Simon, Nobel Laureate, 1978, Partha Dasgupta, Oxford University, Robert Eisner, former president, American Economics Association, Mohan Munasinghe, Chief, Environmental Policy and Research Division, World Bank, Stephen Marglin and Juliet Schor, Harvard University, Don Paarlberg, Professor Emeritus, Purdue University, Emile Van Lennep, former Secretary General, OECD, Maurice Strong, Chair, Ontario Hydro and Secretary General, Rio Earth Summit, and Daniel Goeudevert, former Chairman and President, Volkswagen AG. Full text and signatory list available from *Redefining Progress*, One Kearny St., San Francisco, CA. 94108.

The Development of Expanded Accounts

Fortunately, considerable progress has been made in the last 20 years by the World Bank, OECD,
United Nations, World Resources Institute and other international organizations, by national statistical agencies, including Statistics Canada, and by leading research institutes and distinguished economists, in developing expanded economic accounts which include critical social and environmental variables. The new internationally accepted guidelines in *The System of National Accounts 1993* suggest that natural resources be incorporated into national balance sheet accounts and that governments develop a "satellite system for integrated environmental and economic accounting," and a satellite account to measure the value of unpaid household work.

Accordingly, Statistics Canada, in December, 1997, released its new *Canadian System of Environmental and Resource Accounts (CSERA),* which consist of natural resource accounts linked to the national balance sheets, material and energy flow accounts linked to the input-output tables, and environmental protection expenditure accounts. Statistics Canada has sponsored an international conference on the measurement of unpaid work, has produced its own extensive valuations of household work, and is developing a *Total Work Accounts System (TWAS)* which includes both paid and unpaid work (Statistics Canada 1997a; Stone and Chicha 1996). Every six years an extensive time use survey is now part of Statistics Canada's General Social Survey. Other agencies are also moving in this direction. Human Resources Development Canada, for example, has recently issued an Index of Social Health for all the provinces and for the country as a whole.

Some composite indices, like the Measure of Economic Welfare (MEW), the Index of Sustainable Economic Welfare (ISEW), the Genuine Progress Index (GPI), and the Index of Economic Well-being (IEW), incorporate up to 26 social and environmental indicators, including unpaid work, income distribution, changes in free time and valuations of natural capital and the durability of consumer goods (Messinger 1997, Cobb et al. 1995a, Osberg and Sharpe 1998, GPI Atlantic 1998) [6]. These indices also distinguish direct contributions to economic welfare from defensive and intermediate expenditures, and from economic activities that produce an actual decline in well-being. There have been continuing improvements in

[6] Messinger compares the MEW and the original GPI and replicates the models for Canada. On the original GPI (Genuine Progress Indicator), see Cobb et al. 1995a. See also GPI Atlantic, *Measuring Sustainable Development: Application of the Genuine Progress Index to Nova Scotia*, January, 1998, and *Project Profile*, March, 2000. This and other GPI materials are available on the GPI Atlantic web site: www.gpiatlantic.org

methodologies and data sources in recent years, and excellent models are now available for application.

In fact, the current interest in social indicators and comprehensive measures of progress owes a strong debt to the pioneers in this field of the late 1960s and early 1970s, who recognized the limitations of the GDP and sought to go beyond them. Nordhaus and Tobin's Measure of Economic Welfare and similar efforts to expand the definition of national wealth led to the development of new measurement instruments which today form the basis of recent efforts in this field.

At that time, in the early 1970s, the pioneers' understanding of the potential importance of time use surveys and environmental quality indicators was not matched by the availability of data in these fields. The early recognition of the importance of valuing natural resources, for example, initiated the process of gathering data that did not exist at the time. The work of Andrew Harvey and others in constructing the first standard time use surveys, the development of state of the environment reporting in the same era, and the emergence of other important social indicator measurement tools, have now produced and made available the actual databases that make the Genuine Progress Index possible.

For the first time, 10 and 20-year time series for social and environmental indicators can actually be created. In short, the construction of an actual policy-relevant GPI at this time should not be seen as a "new" phenomenon, but as a natural evolution of earlier work in the field. The basic principle linking and integrating the components of these expanded accounts is the view of "sustainable development", which reflects a concern (a) to live within the limits of the world's and the community's resources, and (b) to ensure the long-term prosperity and well-being of future generations.

According to Statistics Canada, "sustainable development implies that all people have the right to a healthy, productive environment and the economic and social benefits that come with it", and therefore includes in its definition of sustainability the objective of "equity, both among members of the present generation and between the present and future generations." (Statistics Canada 1997a). The new accounts also use cost-benefit analysis that includes environmental and social benefits and costs, and an investment-oriented balance sheet approach that includes natural and social capital assets, to provide a more comprehensive view of progress than is possible with the current-income approach of the GDP.

The current emphasis on "growth" is replaced, in the new accounting systems, by a concern with "development," as defined by former World Bank economist, Herman Daly:

> ***Growth** refers to the quantitative increase in the scale of the physical dimension of the economy, the rate of flow of matter and energy through the economy, and the stock of human bodies and artifacts, while **development** refers to the qualitative improvement in the structure, design, and composition of physical stocks and flows, that result from greater knowledge, both of technique and of purpose* (Daily 1994).

Values, Approach, Methods, and Data Sources in the Nova Scotia GPI

In essence, the fundamental approach of the Nova Scotia Genuine Progress Index is to assess the economic value of our social and environmental assets and to calculate their depreciation or depletion as costs. Maintenance of these capital assets is seen as providing the basis for economic prosperity. As such, the Nova Scotia GPI is a step towards fuller cost accounting than is possible by valuations of produced capital alone.

Any index is ultimately normative, since it measures progress towards defined social goals, and all asset values can therefore be seen as measurable or quantifiable proxies for underlying non-market social values such as security, health, equity, and environmental quality [7]. In the case of this particular component of the GPI, the normative value or goal that serves as the standard for measuring genuine progress is the availability and high quality of Nova Scotia's water resources, including surface water, ground water and coastal waters. Improvements in drinking and recreational water quality are indicators of success in moving towards that goal and in strengthening an important ecological and social asset. Conversely, higher rates of shellfish and beach closures due to bacteriological contamination, increased acidification of rivers and lakes, declining fish populations, higher rates of erosion due to coastal wetland loss, and increased eutrophication of lakes signify a depreciation of that natural capital and an erosion of its value.

The Nova Scotia GPI uses existing data sources in its valuations, and applies the most practical and policy-relevant methodologies already developed by the World Resources Institute, the OECD, the World Bank, national statistical agencies and other established research bodies. In particular, the Nova Scotia GPI will rely on published data from Statistics Canada, Environment Canada, and other government sources where ever possible, to ensure accessibility and ease of replication by other jurisdictions.

[7] For the Nova Scotia GPI, these norms are defined in *Measuring Sustainable Development: What the Genuine Progress Index Can Do For Nova Scotia*, pages 12-15: presentation to the N.S. Government Inter-Departmental Consultation, March 3, 1998, World Trade and Convention Centre, Halifax. Available on the GPI web site at *www.gpiatlantic.org*

Due to the paucity of integrated data on water quality, this particular study uses published and unpublished data from a wide range of sources, including Environment Canada, Statistics Canada, Health Canada, and the federal Department of Fisheries and Oceans, the NS Department of Environment, NS Department of Natural Resources, NS Department of Municipal Affairs, NS Department of Transportation and Public Works, Halifax Regional Municipality, Halifax Regional Water Commission, the Soil and Conservation Society of Metro Halifax, the North American Commission for Environmental Cooperation, and a variety of academic and independent research studies. Other jurisdictions wishing to replicate this study will have to search their own provincial and municipal records to obtain the data required for several important indicators.

For more information on the background, purposes, indicators, policy applications and proposed methodologies of the Nova Scotia GPI, please see the GPI Atlantic web site at www.gpiatlantic.org

The Nova Scotia GPI is designed as a pilot project for Canada, and to that end has received invaluable assistance from Statistics Canada in data access, consultation on methodologies and analysis, advice and review of draft reports, and staff support. Start-up funding for the Nova Scotia GPI was provided by the Nova Scotia Department of Economic Development and ACOA, through the Canada – Nova Scotia Cooperation Agreement on Economic Diversification. Core funding for this particular component of the GPI was provided by the Science Horizons Internship program and Environment Canada, with additional funding from Halifax Regional Municipality and the Halifax Regional Water Commission, and in-kind support from the NS Department of Environment and the Clean Nova Scotia Foundation.

A primary goal of the project is to provide a data bank that can contribute to the Nova Scotia government's existing outcome measures. The reports and data will therefore be presented to Nova Scotia policy makers stressing the areas of policy relevance. Conclusions will emphasize the most important data requirements needed to update and maintain the index over time. Eventually the data should be usable to evaluate the impacts of alternative policy scenarios and investment strategies on overall progress towards sustainable development in the province. In order to demonstrate the applicability of the GPI approach at the micro-level, in evaluating particular investments from a full-cost accounting perspective, this study contains an appendix applying the GPI methods to the proposed Halifax Harbour sewage treatment plan.

What the GPI is Not

Just as the GDP has been misused as a measure of progress, there are also several potential misinterpretations of the GPI and misuses of the data it presents. These will be discussed in detail as the separate modules are presented. But it may be helpful to list some of the major issues at the start.

The GPI is not intended to replace the GDP. The GDP will undoubtedly continue to function for the purpose for which it was intended as a gross aggregate of final market production. It is not, therefore, that the GDP itself is flawed. It is the *use* of the GDP as a comprehensive measure of overall progress that is being challenged, and it is this need that the GPI attempts to address.

Identifying omissions from our measures of progress does not imply that the GDP itself should be changed to include these assets. The purpose of the GPI reports, therefore, is not to suggest that unpaid work should be included in the GDP, or that the costs of crime and water pollution be subtracted from the GDP. Nor do the GPI natural resource accounts and environmental quality valuations recommend the creation of a “green GDP”, or “net domestic product” which subtracts defensive expenditures on environmental protection. This can be done, but it is not the purpose of the GPI.

Rather than suggesting changes to the GDP, the GPI in effect adopts a qualitatively different approach. While the GDP is a current income statement, the GPI presents a balance sheet of social, economic and environmental assets and liabilities and reports the long-term flows or trends that cause our assets to appreciate or decline in value. It is only our current obsession with short-term GDP growth trends that is misplaced. The GPI seeks to “put the GDP in its place” rather than to abolish or change it.

The GPI assesses the economic value of social and environmental assets by imputing market values to the services provided by our stock of human, social and environmental capital. But this imputation of market values is not an end in itself. It is a temporary measure, necessary only as long as financial structures, such as prices, taxes and monetary incentives, continue to provide the primary cues for the actual behaviour of businesses, consumers and governments.

Monetization is only a tool to communicate with the world of conventional economics, not a view that reduces profound human, social and environmental values to monetary terms. It is a necessary step, given the dominance of the materialist ethic, to overcome the tendency to undervalue the services of unpaid labour, natural resources and other “free” assets; to make their contribution to prosperity clearly visible; and to bring these social and environmental assets more fully into the policy arena. Monetization also serves to demonstrate the linkages and connections between non-market and market factors, such as the reality that depletion of a natural resource will eventually produce an actual loss of value in the market economy.

In order to separate ends from means, the first two GPI reports on the value of unpaid work, presented time use valuations first as the basis of the secondary, and dependent, monetary valuations. In the third GPI report, on costs of crime, crime rates were presented first as the basis of the secondary, dependent monetary valuation of the costs of crime. Similarly, in the natural resource and environmental accounts being released this year, physical accounts will always precede and form the basis for the subsequent monetary accounts. In the present report, likewise, physical and qualitative indicators of water quality are presented before economic costs and valuations.

As the grip of market statistics on the policy arena is gradually loosened, the desired direction for the GPI is to return to the direct use of time, environmental quality and social indicators in decision making. This will also allow for greater accuracy and precision than relying on derivative economic values.

While the assignment of monetary values to non-market assets may appear absurd and even objectionable, we do accept court awards for grief and suffering and insurance company premiums on life and limbs as necessary measures to compensate actual human losses. We pay higher rents for dwellings with aesthetically pleasing views and we sell our time, labour and intelligence often to the highest bidder. Similarly, in a world where “everything has its price”, monetizing social and environmental variables assigns them greater value and provides a more accurate measure of progress than excluding them from our central wealth accounts.

Ultimately, however, it must be acknowledged that money is a poor tool for assessing the non-timber values of a forest, the costs of pollution or global warming, the value of caring work, the quality of education, or the fear, pain and suffering of a crime victim. A materialist criterion cannot adequately assign value to the non-material values that give life meaning.

Eventually, therefore, the Genuine Progress Index itself should give way to multi-dimensional policy analysis across a number of data bases. New Zealand economist Marilyn Waring suggests a central triad of indicators – time use studies, qualitative environmental assessments, and market statistics – as a comprehensive basis for assessing well-being and progress (Waring 1998).

In the meantime, and only so long as market statistics dominate our economic thinking and our policy and planning processes, the GPI can provide a useful tool for communication between the market and non-market sectors. By pointing to important linkages between the sectors, the GPI itself can provide a means to move beyond monetary assessments towards a more inclusive and integrated policy and planning framework.

The Genuine Progress Index is not designed to be a final product, but it is a significant step in the direction of more comprehensive measures of progress than are currently in use. The GPI itself should be seen as a work in progress subject to continuous revision, improvement in methodologies, and inclusion of additional variables. It will continue to evolve in form and content with further research, the development of new methods of measurement, and the availability of improved data sources. Given these caveats, all interpretations and viewpoints expressed in this and other reports are designed to raise important issues for debate and discussion rather than as definitive or final conclusions or prescriptions.

For example, the GPI researchers have wrestled long and hard with definitions of "defensive expenditures" and the degree to which these might be interpreted negatively in measures of progress as surrogate values for damage incurred or as positive investments in environmental restoration. In other words, are *more* defensive expenditures a sign of progress or not? Or do the indicators of genuine progress themselves need to be based squarely on the physical indicators themselves, and separated entirely from the secondary economic valuations?

Similarly, much more work needs to be done on separating resource stock accounts from flow data, like harvesting rates, and on distinguishing *relative* progress towards greater sustainability, which refers to changes in human activity, from a more absolute standard of sustainability based on nature's own balance and capacity to support human activity. Rather than offering any pretense or definitive answer to these challenging questions, GPI Atlantic hopes that its natural resource and environmental quality accounts stimulate further productive debate among researchers that will allow for ever greater clarity and accuracy in future updates of the GPI work. In sum, GPI Atlantic is not wedded to any particular method of measurement, but seeks to improve its accounting methodologies over time in accord with the constructive feedback its work receives.

Finally, it must be stated that the economic valuations are not precise. Any attempt to move beyond simple quantitative market statistics to the valuation of goods and services that are not exchanged for money in the market economy will produce considerable uncertainty. In the GPI report on the economic value of unpaid household work, for example, six different valuation methods were compared, each producing different aggregates. In the GPI *Cost of Crime* report, a range of cost estimates was presented from the most conservative measurements to more comprehensive estimates that included costs of unreported crimes; retail “shrinkage”; losses of unpaid production; and suffering of crime victims.

This problem of precision is accentuated further in the natural resource accounts, with attempts to value ecological services and the non-market functions of natural assets. For example, there is no doubt that water bodies, wetlands, and forest watersheds provide vitally important functions to human society, including waste and nutrient cycling; erosion, flood and storm control; recreation; water filtration and purification; and food production, and that these functions have vital economic value. But these functions have so long been accepted as "free," that any diminution of functional capacity has gone unrecorded in standard accounting procedures that track only market transactions in which money is exchanged.

How then, are such functions to be valued? Clearly a reduced natural nutrient or waste cycling capacity in a water body, as a result of nutrient or waste overload, will have to be replaced by waste treatment upgrades that compensate for the loss of "free" ecological services, if water quality is to be maintained. In this report, we have used the capital costs of engineering upgrades as a surrogate value for the cost of lost nutrient cycling capacity. In the pages that follow, there are many such difficult valuation choices, and GPI Atlantic has opted for the more conservative estimate in such cases. In other cases, where previous scientific studies have suggested a range of values, there are places where a mid-range value has been adopted in this study. But these few examples suffice to demonstrate that any economic assessment of natural resource values, or costs of natural capital depreciation, cannot pretend to be precise.

What the GPI Can Contribute

Despite all these major qualifications it is finally important not to throw the baby out with the bath water! The GPI is in its earliest stages of development, but it is still considerably *more* accurate to assign explicit economic value to unpaid production, natural capital and other social and environmental assets than to assign them an arbitrary value of zero, as is currently the case in our conventional economic accounting system. And it is far *more* precise to recognize natural resource depletion, and crime, sickness and pollution costs as economic liabilities rather than to count them as contributions to a more “robust” economy and to social progress, as is presently done.

While it is very important to improve on the precision and methodologies of natural resource accounting and of social and environmental valuations, the current lack of precision should not be taken as an excuse for any delay in incorporating these mechanisms into our accounting systems. Efforts to value social and environmental assets, using the best available methodologies and data sources, still provide far greater accuracy and precision than continued reliance on an accounting system and measure of progress that gives *no* value to these assets and counts their depletion as gain.

In the long run, the GPI is intended as one step towards greater "full cost accounting" both in our core national and provincial accounts, and as the basis for taxation and financial policy that will ultimately enable market prices themselves to reflect the full values and costs of embodied resources. The transition from externalized to internalized costs, from non-market to market valuations, and from fixed to variable pricing mechanisms are the three core principles of full cost accounting. For example, this study suggests that water pricing according to volume can be far more effective in encouraging resource conservation than flat annual rates. Incorporation of natural resource valuations into our core economic accounts is, therefore, the first essential step in improving the efficiency of market mechanisms so that they reflect the full range of social, economic and environmental benefits and costs of both production and consumption processes.

The Nova Scotia Genuine Progress Index is not an isolated effort, but part of a global movement to overcome the recognized flaws in our current measures of progress, and to ensure a more sustainable future for our children, and for the planet. Indeed, as we have seen, the new System of National Accounts, Canada’s own international commitments, and the considerable advances of recent years in developing expanded measures of progress, require that further efforts be made to integrate social, economic and environmental variables in our accounting mechanisms. The costs of continuing to ignore our social and environmental assets are too great. We have learned the hard way that measuring our progress in strictly materialist terms, and without reference to our natural environment, which is the source of all life and of human survival, ultimately undermines well-being and prosperity.

In sum, and with all its limitations, the GPI is a substantial step towards measuring sustainable development more precisely than prevailing accounts are able to do. It is itself a work in progress designed to help lay the foundations for the new economy of the 21st century, an economy that will genuinely reflect the social, spiritual, environmental and human values of our society.

Nova Scotia GPI: Release of Natural Resource Accounts, 2000-2001

This particular report is the first full release of data for the Nova Scotia GPI natural resource and environmental accounts, on which research has been ongoing for the past two years. In the coming weeks and months, GPI Atlantic will also release its greenhouse gas accounts; an ecological footprint analysis; resource accounts for forests, fisheries, and soils and agriculture; the GPI air quality component; and the first stage of a sustainable transportation analysis that applies full-cost accounting principles to alternative modes of transportation. All these reports are nearing completion and will be released before the end of the year 2000, if funding permits. In the spring of 2001, GPI Atlantic will release its solid waste component.

This release of data on the health of Nova Scotia's natural resources, and on the province's environmental quality, follows the release of several social accounts. These included full reports on the economic value of civic and voluntary work and on the economic value of unpaid housework and child care, released in July and November, 1998, with voluntary work updates released in February, 1999 and February, 2000. Those two studies measured important economic assets that are hidden and unvalued in our current accounting system, and demonstrated that unpaid voluntary work and household production provide critically important services to society that are an essential precondition for a healthy market economy. The studies also showed that any deterioration in these sectors directly affects the standard of living and quality of life and has serious repercussions for the market economy.

The third GPI data release, in April, 1999, laid the groundwork for these natural resource accounts, by challenging the conventional economic growth paradigm, in which "more" is always assumed to be "better." GPI Atlantic's *Cost of Crime* report showed clearly that growth in and of itself does not necessarily signify an improvement in well-being, and that this simplistic, prevailing assumption can mislead policy makers and skew the policy agenda. The contrast between the *Cost of Crime* report and the first two reports on the value of unpaid work, is therefore a useful illustration of Simon Kuznets' dictum that "goals for 'more' growth should specify of what and for what".

While higher crime rates produce more spending on prisons, police, burglar alarms, and theft insurance, all of which make the GDP grow, crime clearly diminishes the quality of life and diverts precious economic resources from health, education, and other activities that enhance human and social welfare. In the GPI, "less" is frequently "better." Unlike the signals emanating from the GDP, in which growth of any kind signifies "progress" and a "stronger" and more "robust" economy, the GPI counts *less* pollution, crime, sickness, fossil fuel combustion, and natural resource depletion as signs of genuine progress.

In the last six months, GPI Atlantic has also released the first two indicator sets of its population health component, an assessment of *Women's Health in Atlantic Canada,* and a report on *The Costs of Obesity in Nova Scotia,* which demonstrated that obesity costs the Nova Scotia health care system $120 million a year in direct costs, and a further $140 million annually in lost productivity. In October, 2000 , GPI Atlantic will release a study on *The Costs of Tobacco in Nova Scotia.* Though sickness produces more spending on doctors, hospitals and drugs, all of which make the GDP grow, the GPI recognizes *less* sickness, and improved population health as a core indicator of genuine progress.

While the next few months will see GPI Atlantic focusing primarily on the release of its natural resource and environmental accounts, there will be ongoing work by GPI researchers in the coming months on other social and economic components of the Genuine Progress Index, including income distribution, employment and work hours, the value of leisure time, and on other health indicators. If funding permits, and if research proceeds on schedule, there will be further data releases in these areas in the coming months and in the early part of 2001.

The previous GPI data releases to date help establish a context for this present report on water quality, and for the other natural resource accounts that follow. Just as crime signifies the deterioration of a social capital asset (a peaceful and secure society), so a decline in water quality signifies the deterioration or depreciation of an environmental asset. The Genuine Progress Index treats natural, social and human capital in a way that is similar to the way the conventional accounts assess the value of produced capital. From that perspective, the environmental assets considered in this module are healthy, diverse, and good quality water resources.

If water quality declines, and these capital assets deteriorate in value, then renewed investment in natural resource conservation is required in the same way that a factory owner must consider the repair or replacement of old or malfunctioning machinery. The only major caveat to this analogy is that, unlike manufactured capital which always depreciates over time, there is no *inherent* reason for natural capital to depreciate in value, because it has the capacity for self-renewal. If used sustainably, the quality and value of natural capital can actually be maintained *without* additional investment. That is a big "if," but the distinction must be borne in mind to overcome the dangerous prevalent assumption that accepts the decline in environmental quality as "inevitable." Natural capital assets can, in effect, provide a range of ecological services indefinitely, and even renew and replenish themselves, provided that depletion rates are within an ecologically sustainable range.

The need for re-investment in natural capital therefore literally signifies the *cost* of previous unsustainable use, and of human activities that have previously failed to respect and understand the natural limits, cycles and balance that exist in the natural world. Unlike manufactured capital depreciation, which represents a drawing down on *past* and *present* resources, natural capital depreciation *also* represents a drawing down on *future* resources, of favouring present consumption over the welfare of future generations.

For example, the marine environment and freshwater rivers and lakes are *inherently* capable of providing as stable a level of fish stocks for future generations as at any time in the past. The 80% decline in Atlantic salmon returns, described in this report, is therefore not only a present cost of unsustainable resource use and human excess, but also a cost that will be borne by our children and for many generations to come. The "re-investment" that future generations will have to make in forest and water restoration, and in other forms of natural resource conservation, to ensure their own survival, is therefore a cost that they will bear as the price of actions by past and present generations.

While the depreciation metaphor is useful to illustrate the concept of natural capital, this crucial distinction between manufactured and natural capital must always be kept in mind. Since produced capital depreciation is inevitable, further investment in manufactured capital can potentially *add* real value that enhances well-being and improves the standard of living and quality of life of future generations. By contrast, natural capital depreciation that requires further investment *always* signifies a prior *cost* incurred through previous excess or unsustainable use. Unsustainable human activity in effect defers investment costs to future generations, because ecologically sustainable use would allow the resource to regenerate naturally without further investment.

This brief overview established the context of this present report in the framework of past and ongoing work on the Genuine Progress Index. Altogether the Nova Scotia GPI will consist of 22 components[8]. These are listed in Appendix I. By the end of the year 2001, enough components of the GPI will be complete for any jurisdiction to adopt the index as an actual policy tool and strategy for sustainable development.

GPI Atlantic will also continue to cooperate and work closely with other parallel efforts in Canada and throughout the world, including the new joint indicators initiative by the National Round Table on the Environment and the Economy and Environment Canada, the ongoing development of resource satellite accounts, total work accounts and the Index of Social Health at Statistics Canada, the Index of Economic Well-being developed by the Centre for Living Standards, the exploration of new health indicators by Health Canada, the ongoing pioneering work of Redefining Progress in the USA, the Alberta GPI project beginning this fall, the outstanding community indicators work in Newfoundland, the Quality of Life Indicators Project currently being launched by the Canadian Policy Research Network, and many other similar initiatives that share the goals and aspirations of GPI Atlantic.

As work develops, GPI Atlantic would welcome a formal national consultation to discuss the GPI results and their implications as well as the results of similar indicator projects, to review the methodologies and measurement tools in detail, to identify core indicators that can serve as annual benchmarks of progress, to make specific recommendations to fill data gaps necessary to maintain the index over time, and to explore the potential for aggregating particular indicator sets

In consultation with Statistics Canada and in the interests of policy relevance, it has been decided to adopt a sectoral "bottom up" approach to the Nova Scotia GPI, presenting as

[8] The components of the Nova Scotia GPI are described in detail in the GPI Atlantic profile entitled *Measuring Sustainable Development,* (updated March, 2000), available on the GPI Atlantic web site at *www.gpiatlantic.org*

comprehensive a portrait as possible of each of the 22 components that comprise the Index. Wherever possible, as mentioned earlier, monetary values will be imputed in order to demonstrate linkages between the market and non-market sectors of the economy.

When this sectoral development is complete, aggregation will present a major challenge, and it is now anticipated that the final GPI will more likely consist of several sets of sub-indices, corresponding to the five-fold division of components listed in the Appendix, rather than as a single aggregated "bottom line" index. Challenges will include the elimination of double-counting, the consideration of appropriate weighting mechanisms, and the identification of core indicators that will allow a more integrated Genuine Progress Index to assess progress towards overall sustainable development in the province. The construction of this more composite index will require intensive consultations with Statistics Canada staff, other government officials, and independent experts, and is not a task GPI Atlantic plans to undertake alone.

While the initial construction of the index is complex and time-consuming, as these first reports demonstrate, the goal is that the final index be easy to maintain and update in future years, that the design enable ready comparability with other jurisdictions, and that results are presented with a view to practical policy relevance and application. Each report describes in detail the methodologies used to derive results, so that other provinces can more easily replicate the measurements. Each report also describes the data requirements necessary to maintain the index and points to existing data gaps, and each report also emphasizes major policy implications indicated by the findings. Upon completion, the Nova Scotia GPI should not be regarded as a final and rigid formula, but as a work in progress that will be constantly modified and refined to reflect improved methodologies and new approaches and data sources.

That is the basic framework for this first data release of the Nova Scotia GPI natural resource accounts – the water quality account for the province. The more detailed background documents for the project, the completed modules of the index to date, including summaries and press releases, a current GPI newsletter, and a summary of this report are available to the public on the GPI web site at *www.gpiatlantic.org* Information on upcoming reports and data releases will be posted on that web site as it becomes available.

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List of Acronyms

AO - aesthetic objectives

ASF - Atlantic Salmon Foundation

BOD - biological(biochemical) oxygen demand

CEC - Commission for Environmental Cooperation

CCME - Canadian Council of Ministers of the Environment

GCDWQ - Guidelines for Canadian Drinking Water Quality

GPI - Genuine Progress Index

HRM - Halifax Regional Municipality

IMAC - interim maximum acceptable concentration

MAC - maximum acceptable concentration

NSDOE - Nova Scotia Department of Environment

NSDNR - Nova Scotia Department of Natural Resources

NSDTPW - Nova Scotia Department of Transportation and Public Works

SWCSMH - Soil and Water Conservation Society of Metro Halifax

TSS - total suspended solids

WRI - World Resources Institute

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Executive Summary

The Earth's ecosystems are the source of all human goods and services, with water capital a key component of life itself. Unfortunately, we often take water availability and water quality for granted. But Canada's water supply is not exempt from potential shortages and degradation that have already afflicted parts of the world. David Schindler, one of the world's leading water experts, has warned that Canada's current levels of pollution, habitat destruction and climate warming "will compromise Canada's freshwater supplies so dramatically in the next 50 years that freshwater fisheries could disappear and drinking-water supplies will be in a state of crisis"(Nikiforuk 2000).

Current trends in water use and pollution threaten freshwater quality and availability, and the ecosystem health on which the human economy ultimately depends. Without a firm commitment to pollution prevention and control, and without the recognition of water values in our core benchmarks of progress, future generations may face a potentially irreversible crisis in a resource on which human survival and all other life forms depend. For this reason, an assessment of our water resources is one of the 22 central components of the Genuine Progress Index (GPI), enabling us to measure our progress in sustaining and improving the quality of this vital source of natural capital.

The GPI Natural Capital and Environmental Accounts aim to broaden our economic accounts to include natural resources and environmental assets. Natural assets or resources can be considered as natural capital. Just as we consider manufactured capital an asset in conventional economic indicators like the GDP, so we must account for the natural capital assets that are intrinsic to our very livelihood.

The GDP and related market statistics currently give no value to our natural capital assets. On the contrary, they actually record their depletion as gain, because they only count their "use value" when incorporated into industrial production and sold at the market price. Therefore, in our conventional accounts, the more trees, water and fish we consume, the faster the economy grows. The more pollution we have and the more we spend on clean-up, the more the GDP will grow. When GDP growth rates are misused as a measure of well-being and prosperity, they actually send the wrong message to policy-makers and the public about the health of our environment.

By contrast, the Genuine Progress Index recognizes that water resources have a wide range of social, economic and ecological values. Because these values are dependent on clean, healthy water, investment is also necessary to maintain and protect this vital natural asset. In the GPI, pollution is treated as a cost, not a gain, to the economy and society.

The Nova Scotia GPI Water Quality Account includes three main sections. Part I is a compilation of water quality indicators for the province, including drinking water quality, surface water quality, recreational water quality, wetlands, estuaries and coastal areas, and contaminated areas. Because resource benefits cannot always be accurately reflected monetarily, this first part of the GPI water quality account focuses only on physical indicators of key water quality issues.

Part II is a quantitative assessment of the economic value of Nova Scotia's water resources and water quality, including the costs due to losses in water-related ecosystem services and declines in water quality. Part two presents data on the value of water-related ecosystem services, defensive expenditures, pollution abatement costs, damage costs, restoration costs, and health costs. The study assesses the costs of halting the degradation of Nova Scotia’s water capital and of protecting the flow of services from the province's water resources.

Part III is a detailed case study of the economic, environmental and social costs and benefits of wastewater treatment for Halifax Harbour, that demonstrates the utility of the GPI "full-cost accounting" approach to micro-level assessments of alternative investment options.

The development of comprehensive accounts should not be seen as a costly and draining exercise. Indeed, according to the U.S. Panel on Integrated Environmental and Economic Accounting, investing in more complete, accurate and timely data will yield a high economic return.

> “An investment in comprehensive economic accounts would benefit the nation because... better information allows both the public and private sectors to make better decisions.” (Nordhaus and Kokkelenberg 1999)

Better physical and economic accounts including improved data on the interaction between the economy and the natural environment would help:

- refine regulatory tools, conservation policies and pollution control investments;
- improve the management of public lands by revealing the hidden subsidies to leasers that result from under-valuing the true worth of forests, rangelands and waters;
- structure tax penalties and financial incentives that would be passed on as more realistic prices that reflect the actual preservation or depletion of natural wealth; and
- assess the costs and benefits of measures to slow greenhouse warming.

The study marks the first ever assessment in Canada of the full value of a province's water resources, and pulls together vast quantities of published and unpublished information from a wide range of federal, provincial and municipal sources.[9] The GPI water quality study is the first in a series of natural resource accounts to be released in the coming months by GPI Atlantic, as part of the Nova Scotia Genuine Progress Index, a new measure of well-being and sustainable development.

Results from this GPI Water Quality Account show that more Nova Scotians have clean and healthy drinking water than they did 15 years ago, but the quality of the province's rivers, lakes and coastal waters has declined. The province's water resources provide a wealth of benefits to Nova Scotia worth more than $11 billion a year, including drinking and industrial water supply, recreation, waste treatment, food production, nutrient cycling, erosion control, and other vital ecosystem services.

The study found a 3.2 percentage point improvement from 1987 to 1998 in municipal water samples that were free from coliform bacteria; a 33% improvement in the percentage of Nova Scotia's population with drinking water conforming to national health guidelines; and a 17% improvement in water complying with aesthetic objectives. Two municipal water supplies still have lead above the maximum acceptable concentration, and 3% of municipal water samples showed the presence of coliform bacteria that could cause health problems.

Still, more than one third of Nova Scotians don't trust their drinking water and spend an estimated $265 a year per household on bottled water and water filtration systems, injecting $32.8 million a year into the provincial economy. In the GPI, unlike measures of progress based on the GDP, this infusion of spending is not regarded as economic gain nor as a signal of well-being. Rather, if more Nova Scotians trusted their drinking water, they would realize major savings.

But while drinking water quality has actually improved, the province's wetlands, rivers, lakes, and coastal waters are in decline, causing hidden damage to the economy, and threatening the well-being of future generations. Nova Scotia's rivers have suffered more from acid rain than any other province, and only 20% of the province's former salmon rivers still have healthy fish stocks. Atlantic salmon are extinct in 22% of NS rivers, 31% have only "remnant" populations,

[9] Databases and information in GPI Water study are from: Environment Canada, Department of Fisheries and Oceans, Statistics Canada, Health Canada, NS Department of Environment, NS Department of Natural Resources, NS Department of Transportation and Public Works, NS Department of Municipal Affairs, Halifax Regional Municipality, Halifax Regional Water Commission, Soil and Conservation Society of Metro Halifax, North American Commission for Environmental Cooperation, and a variety of academic and independent research studies.

and another 25% have depleted stocks. In 1999, only 22 of Nova Scotia's 72 salmon rivers were still open to recreational salmon angling.

Since 1985, the number of brook trout caught in the province has dropped by half, likely because of previous over-fishing, acid rain, and sedimentation of stream beds due to logging, agriculture and development. The GPI report estimated a loss to Nova Scotia of $22 million over 10 years due to the decline in recreational fishing. As well, the closing of the commercial salmon fishery has cost the federal government another $1 million to buy back licenses.

Along the coast, the number of shellfish closures, due mostly to bacteriological contamination, has more than doubled in the last 15 years, at an annual estimated cost of $8 million a year in lost revenues. In the last four years alone, the closed shellfish area has increased by 38%.

Metro lakes are faring no better, with nearly one-quarter "aging" and dying rapidly due to high concentrations of phosphorus, nitrogen and other nutrients that come from fertilizer run-off, and from households, agriculture and forestry. Four metro lakes are already classified as "eutrophic," meaning that nutrient levels are so high that dissolved oxygen levels have been significantly reduced, and another seven are "mesotrophic," with intermediate levels of nutrients and oxygen. When oxygen is depleted, fish and other aquatic organisms die.

But the highest costs are the most hidden ones, with wetland loss due to development costing Nova Scotia an estimated $2.3 billion a year in lost ecological services. Wetlands are among the most productive ecosystems in the world. They perform a host of incredibly valuable functions, including waste and nutrient cycling; protection against erosion, floods and storms; water purification; and food production. They are one of the richest known wildlife habitats and an essential link in the food chain.

If we lose the benefits of natural, functioning ecosystems, not only do we lose habitat and species diversity, we also have to cope with the loss in ecosystem services by investing in expensive waste treatment and water purification plants, and engineering projects to control erosion and flood damage. Currently the loss of wetland services is invisible in our economic accounts, and we count the cost of expenditures to compensate for these lost services as a gain to the economy. This is bad accounting. We have to recognize, appreciate and *value* nature's vital and irreplaceable life-support services.

The GPI report notes that Nova Scotia has lost 62% of its saltwater wetlands and 17% of its freshwater wetlands since colonization, and it urges immediate conservation measures to prevent further loss.

The GPI report also estimates that Nova Scotia's uncut forested watersheds provide $2,750 per hectare in services per year protecting water supply, -- filtering and intercepting water, controlling run-off, and removing air pollutants. The estimate is based on what it would cost to replace those services with man-made water filtration plants and storm-water retention systems if the forests were clear-cut.

One positive trend noted in the GPI report is a significant reduction in contaminants in pulp and paper mill effluent as a result of federal government regulations implemented in 1992, with all five major Nova Scotia mills now averaging 99% compliance with federal standards. The GPI report recommends further regulation including lowering acceptable carbon dioxide levels below 100 mg/litre using aeration or pH adjustment, in order to reduce contaminants that still cause stress to fish.

The GPI study also details the value of Nova Scotia's water resources for recreation ($150 million a year); investments needed for improvements in wastewater disposal ($532 million) and municipal water supply upgrades ($136 million); water pollution abatement and control expenditures ($180 million); contaminated well claims ($548,000 a year); and a range of other water resource values and pollution costs.

The GPI report has 15 recommendations to the province to protect and conserve the value of Nova Scotia's water resources, including greater source control to reduce toxic discharges to harbours, rivers and lakes; investments in wetland restoration, watershed protection, sewage and water supply upgrades, and salmon habitat restoration; and the explicit recognition of water resource values and pollution costs in the province's core economic accounts.

At a time of budget cuts, we need to keep in mind the investments necessary to maintain our water resources. If water values are not protected, and if adequate investment in sewage treatment, pollution control and conservation are not made, then damage costs and water intake costs will definitely increase, and future generations will be faced with significant costs.

Following earlier cuts, the Nova Scotia Department of Environment has had its 2000-2001 slashed by 16% to $13.1 million from $15.6 million the previous year, making essential inspection, monitoring and enforcement more difficult. The GPI report contains a section, referring to the Walkerton tragedy, that details the costs of inadequate monitoring and enforcement of drinking water quality, and warns that "disinvestment in environmental protection produces major costs to society and the economy."

The GPI Water Quality account is the first in a suite of GPI natural resource accounts to be released later this year, on which GPI Atlantic researchers have been working for more than two years. In the coming months, GPI Atlantic will release its greenhouse gas account for Nova Scotia; an ecological footprint analysis for the province; natural capital accounts for forests, fisheries, and soils and agriculture; an air quality component, and a full-cost accounting analysis of different modes of transportation in Nova Scotia.

GPI reports to date have focused on social components of the Genuine Progress Index, including the value of voluntary work, the value of unpaid household work, the cost of crime in Nova Scotia, and several population health indicators. Work is also currently proceeding on other social and economic indicators in the GPI.

Funding for the GPI Water Quality Account was provided by Environment Canada, Halifax Regional Municipality, and the Halifax Regional Water Commission, with in-kind support from the Nova Scotia Department of Environment and the Clean Nova Scotia Foundation.

SUMMARY OF RESULTS

PART I: WATER QUALITY CRITERIA AND INDICATORS

Water Pollution Releases and Transfers in Nova Scotia	The total water pollutants released and transferred increased by 16.5%, from 708,981 kg in 1996 to 826,061 in 1997 (CEC 1999).
Percent of Nova Scotia's Population on Municipal Water Supplies that Conform to the Guidelines for Canadian Drinking Water Quality (GCDWQ) for Aesthetic and Health Standards	Using 1996 water quality data, 14 municipal water supplies (18%) of a total of 78 province-wide, serving 65% of the total municipal population in the province, did not meet one or more aesthetic objectives of the GCDWQ. In terms of health-related criteria, 8 of the 78 municipal water supplies (10%), serving 16% of the total municipal population in the province did not comply with one or two of MACs; 6 supplies exceeded the MAC for turbidity, and 2 supplies exceeded the criteria for lead. The percent of Nova Scotia's population served by municipal water supplies that comply with the aesthetic objectives and health-related criteria of the GCDWQ increased by 16.7% and by 33% respectively, between 1986 and 1996.
Percent of Nova Scotia's Municipal Water Supply Samples that Conform to the GCDWQ for Bacteriological Content	In terms of bacteriological content, water quality has improved with a 3.2 percentage point increase in municipal samples detecting zero coliforms from 1987 to 1998.
Percent of Nova Scotia's Population on Municipal Water Supplies Meeting the GCDWQ Interim Maximum Acceptable Concentration for Trihalomethane Compounds	The percent of Nova Scotia's population served by municipal water supplies with THMs above present IMAC was about 38.7% in 1989. This percentage decreased to an average of 20% between 1990 and 1994. Most recently, average preliminary results from testing in September 1999, January 2000, and Spring 2000 indicate that approximately 14% of the municipal population served by municipal water supplies may be affected by THM levels above the IMAC of 100 micrograms/litre.

Area of Land Under Water Supply Watershed Protection Strategies	31% of water supplies are either designated as Protected Water Areas or have a comprehensive water supply protection strategy in place. The GPI goal is the designation of protected water areas for 100% of the province's water supply watersheds.
Pesticide Concentrations in Private Wells in Agricultural Areas	There is no comprehensive programme for monitoring private well water quality in the province. A 1989 study in King's County indicated that of the 102 wells sampled, zero exceeded maximum acceptable concentrations (MACs) for pesticides tested. Atrazine and its degradation products were detected most frequently in 33 (32.4%) of the wells tested. Eight wells (19%) had more than one pesticide detected, with a maximum total pesticide concentration in one well of 2.19 micrograms/litre. Presently, there is no guideline for total pesticides in the GCDWQ.
Private Wells with Nitrate Concentrations Above the GCDWQ	In 1985, a province-wide study found approximately 7% of the wells on record had nitrate levels above MAC of 10 mg/L. (Note: the study indicates that the database tended to include wells sampled only when there was a suspected problem in the well's water quality.)
Contamination of Private Wells from Road Salt	The annual number of well claims to the NSDTPW for private wells contaminated by road salt runoff increased from 13 in 1989 to 34 in 1999.
Acid Deposition Affecting Rivers and Lakes in Nova Scotia	A study of 202 of lakes in Eastern Canada, reporting on sampling since the early 1980s, indicates that: • 33% have reduced levels of acidity; • 56% have shown no change; and, • 11% have become more acidic. However, the least improvement has occurred in Atlantic Canada. Atlantic salmon, an indicator species, are extinct in 22% of Nova Scotia's rivers; 25% of the province's rivers have depleted stocks; 31% of rivers have remnant populations; and, 20% of Nova Scotia's rivers have experienced no significant effect.

	The problem of acidic deposition is amplified in Atlantic Canada because our ecosystems are very sensitive to acid inputs. The critical load for much of the region is less than 8 kg/hectare/year, while the critical load target for reductions is set at less than 12 kg/hectare/year. Projections indicate that the Atlantic region will continue to receive deposition greater than 8 kg/hectare/year even after the legislated emission reductions are complete.
Wild Atlantic Salmon Population Trends	Over the past thirty years, Atlantic salmon returning each year to spawn in their natal rivers in eastern North America have declined by 75%, or from 1.5 million to only about 350,000; Canada's wild Atlantic salmon runs have declined by 80% during the past 25 years. In 1998, only 21 of the 71 Canadian index Atlantic salmon rivers met their minimum spawning targets. Nova Scotia's rivers have experienced the greatest impact in Canada in terms of the percentage of fish habitat affected by acid rain. In 1999, only 22 of Nova Scotia's 72 salmon rivers were open to recreational salmon angling. A recent study undertaken in New Brunswick discovered that nonylphenols, which are found in pesticides, urban runoff and sewage effluents, many plastics, and industrial and domestic detergents have caused gender 'confusion' and developmental irregularities in Atlantic salmon. In addition, increased sediment loads to rivers due to agriculture, forestry activities, and development have negatively affected aquatic habitat and fish populations.
Brook Trout Populations	Since 1985, the number of brook trout caught in the province has declined from 2.6 million to 1.3 million (50% decrease)
Wastewater Contaminant Contribution from Pulp and Paper Mills	In 1992, the federal government amended the Pulp and Paper Effluent Regulations under the authority of the Fisheries Act. As a result, both TSS and BOD in the effluent of pulp and paper

	mills have dramatically decreased since 1995. All five mills in Nova Scotia have significantly decreased TSS and BOD levels. Mill effluent compliance in relation to the LC50 standard has increased from 58.7%, in 1995, to 98.7% in 1998. However, meeting this goal does not mean that mill effluents are 100% contaminant-free, nor does it ensure that there are no cumulative or chronic impacts on the ecosystem. There is evidence that fish still exhibit signs of distress when exposed to effluent from an oxygen activated sludge treatment plant when levels of carbon dioxide are greater than 100 mg/litre. Mills using these treatment systems have carbon dioxide levels of 48 to 251 mg/litre in their effluent.
Trends in Beach Closures due to High Bacterial and Parasitic Levels	Beach closure data and information records have not been consistently maintained in Nova Scotia. Limited information has been collected by informally surveying the Nova Scotia Department of Environment district offices. Thus, no trends in closures are available at this time. However, closures do occur each year in the province.
Eutrophication of Lakes	Lake sampling, in 1991, of 51 lakes in the Halifax-Dartmouth Metro area indicated that four lakes were eutrophic (7.8%), nine lakes were mesotrophic (17.6%), and the remainder were all oligotrophic (74.5%). Nine lakes in King's County were monitored between 1993 and 1999 for trophic state indicators (i.e. total phosphorus, chlorophyll, and transparency). Results indicated a slight increase in nutrient concentrations over time, but all lakes either remained oligotrophic or were approaching mesotrophic conditions. There is no comprehensive water quality database which addresses the trophic status of lakes throughout the province. Site-specific or region-specific surveys have been undertaken where significant development pressures have been identified This is currently a significant data gap because we are unable to make a comprehensive assessment of the trophic status trends of Nova Scotia's lakes.

Recreational Fishing Trends	The number of recreational fish caught has dramatically and steadily declined since 1975, with the most dramatic decline in the 1990s. Between 1975 and 1995, the total number of recreational fish retained declined by nearly 5 million fish, or about 70%. The total recreational catch declined by nearly 1.7 million fish, or 45%, between 1990 and 1995 alone. The angler effort (i.e. the number of days spent fishing per year), has also declined from 1.5 million days, in 1980, to 1.2 million in 1995, the lowest number in two decades. Total recreational fishing expenditures were approximately $24 million to $25 million from 1975 to 1990, followed by a decline of $5.5 million between 1990 and 1995.
Areas closed to shellfishing	Nova Scotia has the highest number of closed shellfishing areas in all the Atlantic provinces, accounting for about half the Maritime regional total. The number of shellfish closures has more than doubled in the last 15 years. The area closed has increased by 264 sq. km. over the past 4 years, a 38% increase in a very short period of time.
Area of Wetland Lost since Colonization	Approximately 17% of Nova Scotia's freshwater wetlands, and 62% of the province's saltwater wetlands have disappeared. Overall, 20.5% of original area covered by freshwater and saltwater wetlands has been lost since colonization in Nova Scotia; a loss of about 75,000 hectares.
Area of Wetland Restored or Rehabilitated in Nova Scotia	Several agencies in Nova Scotia have participated in wetland restoration projects, including Ducks Unlimited, Canadian Wildlife Service, Nova Scotia Natural Resources and Eastern Habitat Joint Venture Data on wetland restoration are available in files at the NSDNR but there are no resources to pull the information together at this time. However, the latest inventory of wetlands in the province includes restored wetlands.

Number and Area of Contaminated Sites in Nova Scotia	There are a total of 375 contaminated sites in Nova Scotia. Of this total, 72 have been re-classified as medium low, medium, and high risk sites based on the CCME scoring system Of the 72 sites, high risk contaminated areas account for 4% of contaminated areas (23 hectares); medium risk sites account for 83% of contaminated areas (473 hectares); and, medium low risk sites account for 13% (73 hectares).

Part II: WATER VALUES AND THE COSTS OF WATER POLLUTION AND WATER QUALITY DECLINE

WATER VALUES	
Preliminary Estimate of Nova Scotia's Water Resource Values	**Nova Scotia's wetlands contribute at least $7.9 billion in valuable ecological services each year, plus up to $22.8 million or an average of at least $12.5 million in additional economic value. The province's lakes and rivers contribute at least $3.1 billion per year more in ecosystem services**. The estimates are based on preliminary information only, and therefore are only a starting point for assigning economic value to the ecological goods and services provided by the world's ecosystems.
Water-based Value of a Forested Watershed	Based on replacement values, the estimated net benefit of a restored watershed is at least **$2,587/hectare/year**[10]**.** In addition, the estimated value of a forested watershed in terms of the forest's interception of water and control of runoff is at least **$86/hectare/year** [11]**;** and the estimated value of a forested watershed for its removal of air pollutants is **$75/hectare/year.**
Water-Based Recreation Value	The total expenditure on water-based recreational activity in Nova Scotia, by Canadians, is estimated at **$106.2 million per year.** The additional economic value, based on "willingness to pay" estimates, for water-based recreation above the total expenditures is **$43.8 million/year. Thus, the total direct expenditures plus the economic value that is placed on the enjoyment of participating in water-based recreation by Canadians is estimated at $150 million per year in Nova Scotia.** This does not include expenditures by foreign tourists.

[10] This is a conservative estimate because it includes the capital costs of replacing this lost forest function through construction of a filtration plant. It does not include the on-going costs of operating the filtration plant, an estimated US$300 million per year.

[11] This is a conservative estimate because it includes only the capital cost of replacing this lost forest function, but not the operating and maintenance costs for the man-made retention structures.

DEFENSIVE EXPENDITURES	
Cost to Improve Municipal Wastewater Disposal	**$444.8 million (1997$)** is needed for identified sewage system projects due to deficiencies (including HRM and Industrial Cape Breton). This cost is a crude surrogate measure of the costs of untreated wastewater disposal to the Nova Scotia environment. In other words, this is the necessary investment to stop further degradation as well as restoration of the respective water resources. If investments are made, the benefits of lowered contaminant additions such as improved shellfishery, beaches, aesthetics, and an improved marine environment, will be realized.
Cost to Improve Domestic Wastewater Disposal	**$86.9 million (1997$**) is the estimated cost to develop wastewater treatment facilities to improve wastewater disposal and reduce impacts on aquatic ecosystems. This estimate represents a surrogate value for the negative impacts of insufficient on-site sewage systems in Nova Scotia. In other words, this is the investment needed to prevent a further decline in the value of our water resources, and to reverse damage already incurred.
Government Pollution Abatement and Control (PAC) Expenditure	**On average, $106 million/year was spent by municipalities in Nova Scotia on water-related PAC expenditures, and $27.8 million/year was spent by the Nova Scotia provincial government on water-related PAC expenditures.** Nova Scotia's government expenditures on PAC increased by $15.4 million between 1991 and 1994. Most of the increase in expenditures occurred at the local level. Municipal government expenditures on PAC increased by approximately $30.6 million, whereas provincial government PAC expenditures declined by $15.2 million.

Pollution Abatement and Control (PAC) Expenditures in the Business Sector	On average, the business sector in Nova Scotia spent an average of $51.0 million/year, in 1995 and 1996, on PAC; **$46.3 million** on water-related PAC, and $4.6 million on air-related PAC. • 69% spent on end-of-the-pipe processes, • 13% on environmental monitoring, • 8% on reclamation and decommissioning, and • 5% on PAC integrated processes.
Percent Contribution by the Public and Business Sector in PAC	• local government contributed over half of all PAC expenditures (59%; $116.5 million), • industry contributed approximately 26% ($51 million), and • provincial government contributed 15% ($30.5 million).
Prevention and Protection Expenditures in the Business Sector	**The business sector in Nova Scotia spent an average of $7.6 million/year on prevention and protection expenditures. However, there is a declining trend in expenditures.** Expenditures declined by $4.1 million, or 42% between 1995 and 1996.
Inspection, Monitoring and Enforcement Expenditure	**The total annual expenditure can be estimated at approximately $4.8 million. However, the annual amount is dependent on the Department of Environment's budget.**
WATER INTAKE COSTS	
Industrial Water Intake Treatment Expenditure	**Nova Scotia industry spends an average of $3.2 million/year on water intake treatment costs.**
Municipal Water Supply Expenditure	**The total estimated municipal expenditure on Nova Scotia's drinking water is approximately $8.1 million/year, including:** $7.5 million per year for drinking water treatment, $214,770 per year for water monitoring and analysis, and $322,160 per year for watershed protection, in Nova Scotia.
Costs to Improve Municipal and On-site Water Supply	The estimated cost for upgrades for municipal water supplies is **$114.5 million,** and a further 14 on-site communities require water supply improvements at an estimated cost of over **$21.2 million (1997$); a total of $135.7 million.**

Private Defensive Expenditures for Drinking Water	Nova Scotians spend an estimated **$4.2 million/year on home water filtration for drinking;** residents who drink bottled water regularly spend an estimated **$28 million/year** on bottled water; **a total of $32.8 million (1997$) per year, 1.6% of total annual food expenditure.**

DAMAGE COSTS DUE TO WATER QUALITY DECLINE AND RESOURCE LOSS	
MARKET-RELATED IMPACTS	
Cost of Well Claims due to Road Salt Contamination	The total cost paid by the provincial government for well claims due to salt contamination averages about **$548,000 per year**.
Cost of Shellfishery Closures	**As of August 1999, the economic cost of closed shellfish areas is estimated at $8.0 million/year. The cumulative total economic losses over the time period 1940 to 1994 is estimated at $155 million.**
NON-MARKET IMPACTS	
Cost of Beach Closures	The five year cumulative cost of the, so-far incomplete, list of beach closures in the province can be estimated at **$103,000 for closures that have occurred over the past 5 years. In addition, the cost of closures that are reportedly annual occurrences is estimated at $56,000 per year.**
Historical Value of Atlantic Salmon Fishing in Nova Scotia	**The total value of the salmon recreational catch was approximately $3.1 million per year in the 1980s.** The total cost to the Federal government to buy back the commercial licences was **$1 million**.
Recreational fishing in Nova Scotia	**It is estimated that over the past decade there may well have been a loss of $22 million in revenues in Nova Scotia due to a decline in recreational fishing.**

RESTORATION COSTS	
Restoration of salmon rivers	**The cost of mitigating acidification in the southwestern region of Nova Scotia is $227.5 million to $250.3 million.** Presently, there is no estimate for the area of acidified salmon habitat in other regions of Nova Scotia, which means that this estimate is only a percentage of the total restoration cost. **In Nova Scotia, it is estimated that as a result of 718,068 volunteer hours, approximately $8.6 million is contributed to the restoration of the acidified Atlantic salmon habitat, per year.** **Thus, the tallied restoration cost, which is not yet complete, is estimated at about $238.9 million in liming costs, and approximately $8.6 million per year in volunteer hours.**
Costs due to Wetland Loss	**The 50-year cumulative cost of lost ecosystem services due to wetland losses since colonization, is at least $77 billion (1997$).** **The on-going total annual cost of lost ecosystem services due to loss of Nova Scotia's wetlands is at least $2.3 billion per year.**
HEALTH IMPACTS	
Cost of Water-Related/Water-Borne Illness	The average annual cost of giardia and campylobacter in Nova Scotia is **$3 million per year**.

Water Quality Account - 1st Data Release

A) WATER VALUES (IF WATER RESOURCES ARE ECOLOGICALLY SOUND)	
Lakes and rivers	at least **$3.1 billion/year** in ecosystem services
Wetlands - freshwater and saltwater	1) at least **$7.9 billion/year** in ecosystem services
	2) a minimum of **$12.5 million** in economic value
Forested Watershed Water-based Value	1) at least **$2,587/hectare/year** for water filtration
	2) at least **$75/hectare/year** for removal of air pollutants
	3) at least **$86/hectare/ year** for interception of water and control of runoff
	Total: $2,748/hectare/year
Water-based Recreation	**$150 million/year**
Historical Atlantic Salmon Recreational Fishing	**$3.1 million/year**
TOTAL VALUES	**Total water ecosystem values $11.2 billion/year** (excludes the economic value for wetlands based on WTP, $12.5 million, and the Atlantic Salmon recreational fishing value, $3.1 million per year because of possible double-counting with the water-based recreation value.
	Total forested watershed water-based value $2,748/ha/year (here for reference, but not included in the total above)
B) DEFENSIVE EXPENDITURES	
- TO AVOID CONTAMINATION OF WATER	
Investment Necessary for Improvements for Wastewater Disposal	**$531.7 million**

Pollution Abatement and Control (PAC)	**$180 million/year**
Prevention and Protection	**$7.6 million/year**
Inspection, Monitoring and Enforcement	**$4.8 million/year** (depending on NSDOE total budget; e.g. declined between 1998/9 and 1999/2000)
TOTAL	**$192.4 million/year, plus necessary capital investment of $531.7 million**
C) WATER INTAKE COSTS	
INCREASE WHEN A (WATER VALUES) OR B (DEFENSIVE EXP.) DECREASE	
Municipal Water Supply	**$8.1 million/year** in operating costs (provincial expenditure for treatment, monitoring and protection, based on HRM's expenditure; necessary investment for upgrades $114.5 million in capital costs)
Household Water Filtering and Bottled Water	at least **$32.8 million/year**
Industrial Water Intake	**$3.2 million/year**
Domestic On-Site Community Water Supply	**unknown**, however, a capital investment of at least $21.2 million is needed for upgrades
TOTAL	**$44.1 million/year in operating costs, plus a necessary capital investment of $126.7 million**
D) COSTS INCURRED DUE TO A LOSS IN WATER RESOURCE VALUE AND WATER QUALITY DECLINE	
1) DAMAGE COSTS	
Contaminated Well Claims	**$548,000/year**

Shellfishery Closures	**$8 million/year; plus cumulative cost of $155 million** 1940 to1994
Beach Closures	at least **$56,000 per year; plus $103,000** over the past 5 years
Atlantic Salmon Fishing	**$1 million**
Recreational Fishing	**$2.2 million/year**
Wetlands	**$2.3 billion/year, plus cumulative loss of $77 billion**
TOTAL	**$2.31 billion/year, plus $77.18 billion in cumulative losses over 50 years due to wetland losses**
2) RESTORATION COSTS	
Atlantic Salmon Rivers	**$8.6 million/year, plus $238.9 million** for southwestern region
3) HEALTH COSTS	
Water-Related Illness	at least **$3 million/year**
ALL COSTS DUE TO DECLINE IN WATER VALUES AND/OR INSUFFICIENT INVESTMENT IN DEFENSIVE EXPENDITURES	**$2.32 billion/year IN DAMAGE, RESTORATION AND HEALTH COSTS;**

1 INTRODUCTION

1.1 The GPI Water Quality Account

Natural and social scientists have attempted to measure the effects of human activities on our environmental assets using physical measures such as the monitoring of major environmental indicators (e.g. air quality, water quality). Less attention has been given to measuring the economic value and social contribution of natural resources and environmental assets [12].

> "The slow development of economic measures is due to two major factors. First, economic accounts generally record and measure activities that pass through the marketplace, while most of the activities that raise environmental concerns - from air pollution to appreciation of pristine wildernesses - take place outside the market. Second, the paucity of data and difficulties of valuation for most environmentally related activities make constructing economic measures much more difficult than is the case for market-related activities. The end result is that most nations produce detailed national economic accounts accompanied by vast quantities of useful data for market-related activities and little or no comparable data for non-market environmental activities". (Nordhaus and Kokkelenberg 1999)

Thus, according to the U.S. Committee on National Statistics, the idea of broadening our physical and economic accounts to include natural resources and environmental assets is intuitive and straightforward.

> " Natural resources such as petroleum, minerals, clean water, and fertile soils are assets of the economy in much the same way as are computers, homes, and trucks. An important part of the economic picture is therefore missing if natural assets are omitted in creating the national balance sheet. Likewise, consuming stocks of valuable subsoil assets such as fossil fuel or water or cutting first-growth forests is just as much a drawdown on the national wealth as is consuming aboveground stocks of wheat, cutting commercially managed forests, or driving a truck." (Nordhaus and Kokkelenberg 1999)

[12] For a history of national accounting, augmenting of national accounts, and environmental accounting studies completed to date, see Nordhaus and Kokkelenberg (1999).

Besides being intuitively-driven, the need to broaden the physical and economic accounts of our environmental assets is also based on the earth's ability to sustain life and on the ability of humans to derive benefits and products from the earth's ecosystems.

> "Ecosystems sustain us. They are Earth's primary producers - solar-powered factories that yield the most basic necessities: food, fiber, water - and all at an efficiency unmatched by human technology. Ecosystems also provide essential functions - services like air and water purification, climate control, nutrient cycling, and soil production - that we can't replace at any reasonable price. Harvesting the bounty of ecosystems roots our economies and provides us employment... In every respect, human development and human security are closely linked to the productivity of ecosystems. Our future rests squarely on their continued viability". (WRI 2000)

At the same time, the World Resources Institute's (2000) most recent report on people and ecosystems states that nearly every measure we currently use to assess the health of ecosystems indicates that we are "drawing on them more than ever and degrading them at an accelerating pace".

Water quality generally encompasses three main categories: drinking water, recreational water, and aquatic habitat. These all relate to the health of aquatic ecosystems and to the health of living organisms, including humans, that depend on their resources. The Nova Scotia GPI Water Quality Account includes three main sections. Part I is a compilation of water quality indicators for the province including drinking water quality, surface water quality, recreational water quality, the health of wetlands, estuaries and coastal areas, and the number and area of contaminated areas. Part II is a quantitative assessment of the values of water resources and water quality, including the costs due to losses in water-related ecosystem services and declines in water quality. Part III is a detailed case study of the economic, environmental and social costs and benefits of wastewater treatment for the Halifax Regional Municipality, based on the Halifax Harbour Solutions Plan.

Thus, parts one and two are part of the macro-assessment of water quality for the Nova Scotia G.P.I. Part three is a micro-level application demonstrating the utility of the G.P.I. full-cost accounting approach in assessing specific policy options.

The development of comprehensive accounts should not be seen as a costly and draining exercise. Indeed, according to the U.S. Panel on Integrated Environmental and Economic Accounting, investing in more complete, accurate and timely data will yield a high economic return.

> "An investment in comprehensive economic accounts would benefit the nation because... better information allows both the public and private sectors to make better decisions." (Nordhaus and Kokkelenberg 1999)

Better physical and economic accounts including improved data on the interaction between the economy and the natural environment would help:

- refine regulatory tools, conservation policies and pollution control investments;
- improve the management of public lands through the identification of hidden subsidies to leasers that result from under-valuing the true worth of forests, rangelands and waters;
- structure tax penalties and financial incentives that would be passed on as more realistic prices that reflect the actual preservation or depletion of natural wealth; and
- assess the costs and benefits of measures to slow greenhouse warming.

> "Economists have developed a new view on the role of data collection, in which data are valuable because they allow better decisions to be made by both the public and private sectors... For example, it is estimated that reducing uncertainties about the costs and damages of climate change by half over the next two decades would be worth more than [US]$20 billion." (Nordhaus and Kokkelenberg 1999)

1.2 The Importance of Water

Water, though one of the most important resources and components of our environment, is often taken for granted, especially in North America. However, water management issues are not limited to countries with scarce supplies. For example, the over-exploitation of surface and groundwater resources has resulted in soil salinization and waterlogging in the United States as well as Central Asia (MacDonald 1999). In addition, water pollution and human-induced environmental changes have restricted water use worldwide, including Canada.

Most recently, Dr. David Schindler, one of the world's leading water experts, has warned that Canada's current levels of pollution, habitat destruction and climate warming "will compromise Canada's freshwater supplies so dramatically in the next 50 years that freshwater fisheries could disappear and drinking-water supplies will be in a state of crisis"(Nikiforuk 2000). He predicts that the combined effect of climate change, acid rain, human and livestock wastes, increased ultraviolet radiation, airborne toxins and biological invaders will result in an unprecedented degradation of Canada's freshwater supplies and ecosystems[13]. Schindler emphasizes the need

[13] Dr. Schindler is a water ecologist at the University of Alberta. These findings will be published this fall in the *Canadian Journal of Fisheries and Aquatic Sciences*.

for increased funding for freshwater research and a national water strategy to avoid an ecological crisis. He blames the ongoing decline of national water supplies on Canada's "cavalier attitude" towards water, government cutbacks, and a "turf war" between federal and provincial politicians. John Smol, another prominent Canadian freshwater ecologist agrees with Schindler's findings.

Water is essential to the well-being of humans and all living organisms. While it may seem to be abundant on Earth, a recent report by the World Commission on Water, notes that only 0.08% is readily available for human use (Mittelstaedt 2000).

> "Water is continuously cycled between the planet's surface and atmosphere through evaporation and precipitation, powered by the sun. It is the fresh water that falls on land as rain or snow, or that has been accumulated and stored over eons as groundwater, that people depend on to meet most human needs.... That supply, although replenished daily (but not evenly distributed in time or space), is both limited and vulnerable to human actions and abuse. Freshwater resources around the world have been overused, polluted, fought over, and squandered with little regard for the human and ecological consequences." (Gleick 1998)

We are beginning to incur the costs of our actions. Water shortages are becoming more frequent, and groundwater overdraft has increased to unsustainable levels worldwide. The World Commission on Water predicts that water use will increase 40% over the next 20 years due to industrial, agricultural and urban demands (Mittelstaedt 2000). Because many sources of water have been degraded, the Commission recommends that:

- governments stop subsidizing water-supply systems in order to promote water conservation behaviour and promote the development of new technologies;
- polluters bear the full costs of the effects of effluents; and,
- countries must more than double their investment in infrastructure (e.g. sewage treatment and water pipes) to meet the growing need for water.

De Villiers (2000) suggests that Canadian water policy should seek to achieve the following:

- water should be priced to mandate thrifty use (i.e. price it to encourage conservation);
- users should be obliged to maintain water that passes through their systems in as pristine a state as possible and should be penalized for not doing so; and,
- unsustainable withdrawals from water systems should be prohibited.

> "It is obvious that under current trends the arithmetic does not add up. Already our aquatic ecosystems are severely stressed... [T]he predicted increase in water

> use would impose intolerable stresses on the environment, leading not only to loss of biodiversity, but also to a vicious circle in which the stresses on the ecosystem could no longer provide the services for plants and for people." The World Commission on Water 2000 report, *A Water Secure World: Vision for Water, Life and the Environment*; cited in Mittelstaedt 2000).

According to de Villiers (2000),

> " ... only about one-third of all the precipitation falling on land goes back to the oceans via rivers and groundwater runoff, which is the renewable aspect of our water resources, the dynamic part of long-term water reserves. This is the human community's usable freshwater supply: about 44, 800 cubic kilometres a year."

Canada has 5.6% of the world's renewable freshwater, but currently accords low policy priority to the preservation and stewardship of this precious resource. In addition, Canada has extensive coastal regions along three different oceans. Three of our coastal provincial capitals still have no sewage treatment facilities: Halifax, St. John's and Victoria.

> "In many parts of the world, the overwhelming water issue is that there is simply not enough clean water for basic sanitation and drinking. But in Canada, there are essentially three issues facing water policy-makers: pollution, supply management (drought and flood controls, and sustainability of use), and water exports." (de Villiers 2000)

Globally, the per capita water demand has dramatically increased, and rates of extinction of organisms dependent on freshwater are greater than ever before (Gleick 1998). Throughout Canada, the United States, and Mexico, an estimated 20% of amphibians and fishes, 36% of crayfishes, and 55% of mussels are threatened or already extinct (Allan and Flecker 1993). In Canada, three reptile species, one amphibian species, and 13 freshwater fish species are currently threatened or endangered species (Gleick 1998).

At a global level, water shortages are increasing. In the next several decades two-thirds of the world's population could face severe shortages[14]. In Canada, privatization and bulk water sales have become national issues. Canada holds 5.6 % of the world's renewable supply of freshwater, and as the world's population is demanding increasing amounts of water, investors are proposing to export water for profit. This is a contentious issue because water has historically been viewed as a public good. Currently, Canada's freshwater is publicly owned and controlled, but according

[14] Council of Canadians. 2000. "Water Exports: Turning off the privatization tap". *Canadian Perspectives.* Winter. 10.

to the Council of Canadians, private companies are seeking control over water treatment, and delivery and sewage treatment.

In some cases privatization of water services has led to a decline in access to water for low-income people (e.g. England, Wales). At first glance, it may seem that exports of water would help people in areas of scare supplies, but the cost would maintain water services as a luxury item in these regions, and poor people would likely not have access to the imported supplies. In addition, the effects of bulk water exports on the ecology of freshwater ecosystems could be detrimental, and in some areas, water levels are already falling. The Great Lakes, water levels are at all time lows and this is affecting the region's economy, particularly in tourism and real estate values.

Current relevant statistics (de Villiers 2000) show that:

- "Between 1972 and 1991, Canada's water withdrawal increased by 80%, while the population grew by only three percent."
- "18% of Canada's urban population lives in municipalities that do not provide sewage treatment."
- "Canada has diverted more water than any other nation on Earth."
- "Canadians pay on average $28 a month for water, about one-quarter the amount Europeans pay for their water, and use twice as much."
- "During the summer, about half of all treated water is sprayed on lawns."
- "In 1994, Canadian households paying for water by volume used 39% less than those paying a flat rate."

> "The real costs of pollution (environmental degradation and its effects on human health and well-being) are nowhere acknowledged in the ledgers of corporate Canada and are consequently left to be picked up by the taxpayer. It is instructive to see the contortions through which corporations will go in order to avoid defining the cost to taxpayers of corporate pollution as a "subsidy" and their equally vigorous efforts to label as a 'tax' any political effort to make them pay their share." (de Villiers 2000)

Pricing for conservation is important because communities in Canada that charge a flat annual rate use proportionately more water than communities where water is measured and volume charges are applied. De Villiers (2000) says that this does not make manufacturing more expensive, nor does it penalize the poor. New technologies use less water, so that appropriate pricing of water would benefit efficient and conservation-conscious factories. Secondly, in most countries it is the rich that benefit most from the hidden subsidies embedded in flat rate charges, because they use the most water. Thirdly, multi-tier systems can be implemented such as the current system in Southern France. That system allocates a very low subsidized price for basic uses like sanitation and drinking (e.g. 50 litres per person), a higher charge for showering and watering the garden, and a very high charge for uses beyond these needs such as filling up a swimming pool.

After water pricing, de Villier's second recommendation is to insist that all users restore water to its pristine state after use. That is, they either do not change it or else they pay for its restoration. This will make municipalities responsible for sewage treatment, hold industry responsible for water effluent, and regulate agricultural and forestry uses of pesticides, herbicides, and fertilizers.

In short, current trends in water use and pollution threaten freshwater quantity and availability, water quality, and ecosystem health on which the human economy ultimately depends. Unless the issue is seriously addressed at this historical juncture, and included in core benchmarks of progress, future generations may face a potentially irreversible crisis in a resource on which human survival and all other life forms depend. For this reason, an assessment of our water resources is one of the 20 central components of the Genuine Progress Index, enabling us to measure our progress in sustaining and improving the quality of this vital source of natural capital.

1.3 Freshwater and Marine Biodiversity

Anthony Ricciardi, a Dalhousie University researcher, has found that freshwater species in North America are going extinct at a rate as rapid as that found in the world's rainforests (Shiers 2000). He blames the extinction rates of fishes, amphibians (i.e. frogs, salamanders), mussels, snails and crayfish, on human activities such as dam construction, pesticide and herbicide runoff, and the introduction of foreign species into lakes, rivers, and streams. If current trends continue unabated, his research shows that 625 species will go extinct over the next century; a rate of loss five times greater than land animals, and three times that of coastal marine mammals such as whales. These losses may have a further detrimental affect on other species and on the entire ecosystems as food chains breakdown.

> "Every species has a role in keeping the ecosystem productive, but in many cases we don't know what it is. Conservation campaigns haven't focused on freshwater animals, which are often considered common and mundane. Mussels and the like may suffer from bad public relations ... because they aren't as photogenic as 'feathered and furry critters'. At the same time, they may be ignored simply because of their location. Underwater, it's out of sight, out of mind. It's easier to

> see a change in the terrestrial system ...like the loss of a forest or plant, than what's happening underwater."

According to a recent article in the journal *Science*, land use change (e.g. development, agriculture, forest practices) and biotic change (e.g. introduction of new species to an ecosystem), are the greatest global changes causing losses in freshwater biodiversity (Weymiller 2000). The researchers found that freshwater ecosystems are very sensitive to poor land-use practices because they accumulate all the silt and excess nutrients from runoff. This runoff damages aquatic habitat and wildlife. In addition, aquatic systems are easily disturbed by the introduction of an exotic species because they have evolved as fairly isolated habitats in relation to land systems.

Similar to soils, freshwater and marine sediments are some of the least known habitats, yet are believed to contain greater species diversity than terrestrial areas (Freckman et al. 1997). Approximately 175,000 species have been identified in these environments, but, it is estimated that 98% of these species are still unknown (Palmer et al. 1997, Wall 1999). Aquatic sediments and their organisms provide many important functions. They store significant amounts of carbon as organic matter and as the result of nutrient cycling of carbon and nitrogen (e.g. decomposition); create new biomass; mix and redistribute organic matter; and produce biological nitrogen. According to Palmer et al. (1997),

> "These 'unseen' habitats harbour biota that are central to fundamental ecological processes at local and global scales. Degradation of freshwater sediments will limit the availability and quality of surface water, disrupt global biogeochemical cycles, destroy habitats for many unique species, and alter our climate and the flux of gases globally."

Freckman et al. (1997) add that,

> " ... the functioning and linkages among these habitats may be essential to sustaining life on earth, yet we are only beginning to realize the extent of the interdependence of biotic interactions in sub-surface activities. We do not know if human activities such as groundwater contamination, pollution, salinization, channelization, and dam building that are destroying the biodiversity in these habitats will alter ecosystem processes and the provision of essential ecosystem services."

It has been found, through a multinational experimental research project, that a decrease in species richness in terrestrial ecosystems results in a decrease in ecological productivity (Schulze 1999).

1.4 Pressures on Marine and Coastal Areas

Approximately 60% of the global population lives within roughly 100 kilometres of the shore. As a result, coastal areas have often been used as dumping grounds for sewage, garbage and toxic wastes. Much of the remaining non-coastal pollution is concentrated along rivers and other waterways. Pollution and poor land use practices within these watersheds affect downstream marine habitats because sediments and pollutants are ultimately washed into coastal waters.

Pressures on marine ecosystems include coastal population density and continued population growth, accompanied by increased consumer demand for marine products, increased waste disposal, rapid alteration of coastal habitats, uncontrolled industrial pollution and inadequate institutional structures for managing marine resources.

The direct factors (pressures) leading to the loss of marine biodiversity are:

- habitat loss
- intense overexploitation
- pollution and sedimentation
- species introduction
- climate change

Coastal ecosystems contain some of the richest biodiversity, but they are increasingly being threatened by development-related activities. About 34% of the world's coasts are at high potential risk of degradation, and another 17% are at moderate risk. According to the WRI (2000), most of the coastal ecosystems potentially threatened by development are located within northern temperate and northern equatorial zones.

1.5 Canada's Trend Toward Environmental Deregulation and Budget Cutbacks

According to David Schindler, warm spells are melting glaciers, thereby affecting the reliability of water supplies in western Canada; rising temperatures have increased the evaporation rates of lakes in Ontario by 30%; shipping has been adversely affected by falling water levels; wetlands are threatened; and the ability of lakes and rivers to dilute our wastes has declined and will continue to decline (Nikiforuk 2000). In addition, Schindler's research shows that pollution, habitat destruction, overfishing and climate warming have all contributed to the near disappearance of sports fishing across southern Canada.

> "All of these events are occurring at a time when funding for Canadian freshwater research, once the envy of the world, has reached all-time lows due to federal and provincial cutbacks.... The question [is] what agencies today are doing science to protect the public interest? Ontario's Dorset laboratory, once a world leader in acid-rain research, has been so severely cut that it can't even afford to have someone answer the phone." (Nikiforuk 2000)

1.5.1 The Lessons of Walkerton

Government cutbacks in environmental protection, monitoring, regulation and enforcement, occurring all across Canada, has produced fatal results in the recent deadly disaster of E. coli-contaminated water in Walkerton, Ontario. According to Gary Gallon, previously the Senior Policy Advisor to the Ontario Minister of the Environment and President of the Ontario section of the Canadian Environment Industry Association from 1993 to 1996, a decision to substantially reduce the role of environmental protection and conservation was buried within the Progressive Conservative's "Common Sense Revolution".

> "The Harris government and his Premier's Office decisions and actions regarding environmental protection and conservation went way beyond the "Common Sense Revolution". They would ultimately contribute to the creation of conditions that led to the Walkerton E.coli 0157:H7 disaster. They would result in more pollution from factory farms,... reduced water quality surveillance by the Ontario Ministry of Environment... [,and] less qualified and underfunded Public Utilities Commission officials fumbling the ball for safe drinking water..." (Gallon 2000)

The Ontario government has cut the budget of the Ministry of Environment by more than 30%[15], accompanied by cuts in regulations and the elimination of environmental watchdog bodies. These cuts have included: a 65.5% cut to the environment programme and standards branch related to water and air quality; a 70% cut to programmes focused on the improvement of recreational and drinking water quality; a 42.4% cut in the MOE's operating budget; the elimination of more than 900 MOE abatement, regional and enforcement staff, cutting environmental assessment powers; the exemption of private sector operations from environmental assessment; a 67% reduction in environmental enforcement fines; a red tape commission that recommended up to 50% reduction in environmental regulations; and downloading to underfunded and undertrained municipalities and officials. Currently, the Harris government is increasing its total budget for the year 2000 but has not increased the budget for the MOE, instead further reducing it, yet again.

The local impacts and costs of the Walkerton tragedy include (Gallon 2000, Mackie and Alphonso 2000):

- at least 7 deaths and another 4 suspected deaths
- up to 2,000 serious illnesses
- hospital costs to treat E.coli victims, including 962 hospital visits and air lifts
- psychological and physical trauma and stress
- loss of revenues as businesses are avoided by the public
- tourist revenue losses due to avoidance of the region by Canadian, American and other foreign tourists
- $1 billion lawsuit on behalf of the injured families
- Commission of Inquiry and other legal expenses
- closed Walkerton schools
- $300,000 in emergency funding to bus students to nearby schools
- cost of bottled water to the residents over six to eight weeks
- repairs to Walkerton's drinking water supply and infrastructure
- decline in property prices
- clean up of cattle and pig factory farms and feedlots.

Examples of other disasters that have occurred during the time of these budget cuts and staff downsizing include:

1) The 1996 Cryptosporidia bacterial contamination of Collingwood's drinking water which was also related to contamination from animal feces, after the Ontario MOE delayed a request to fund the upgrade of Collingwood's water treatment system. The incurred costs included:

[15] Both the MOE and the MNR budgets were cut more than twice the rate targeted for other ministries (15%).

- serious illness
- hospital costs and loss of work and leisure time
- cost of bottled water to residents
- cost of repairs and clean up

2) The 1997 Plastimet plastics toxic fire in Hamilton, Ontario, which occurred after provincial orders to clean up the Plastimet operations were not enforced by the government as a result of the lack of qualified staff in the regional office. The incurred costs included:

- evacuation of hundreds of families
- dioxin pollution of their yards and gardens
- immediate illness and long-term health effects
- air pollution and soil contamination
- fire-fighting costs
- repairs and clean up costs
- property damages
- losses in real estate values

Finally, Ontario's declining environmental record has been documented and brought to light by Environment Canada's National Pollutant Release Inventory (NPRI) and the Commission for Environmental Cooperation (CEC). The CEC's latest report cites Ontario as the third largest polluter in North America based on 1997 data of 63 states and provinces; in 1996 it was the fourth largest polluter (CEC 1999, CEC 2000).

The lesson from Walkerton is that disinvestment in environmental protection produces major costs to society and the economy. Paradoxically, these costs have contributed to Ontario's GDP and economic growth rate, because our conventional accounting systems make no distinction between economic activity that creates benefit and that which results from harmful action that signifies a decline in the quality of life. Thus, pollution, like some, sickness and natural disasters, is mis-counted as a contribution to the economic prosperity and well being, because the GDP simply aggregates *all* spending, and GDP growth, in turn, is currently taken as the primary indicator of "progress." A second lesson from Walkerton, therefore, is that so long as economic growth rates continue to be misused as measures of progress, more Walkerton's are likely, because governments have no built-in incentive to invest in environmental protection so long as that protection appears merely as a "cost" on their balance sheets.

By contrast, the Genuine Progress Index counts pollution as a cost, and environmental protection as an *investment* in natural wealth that will yield long-term economic benefits. Provincial governments need strong environmental research, monitoring, education and enforcement programmes. In order to fulfil this mandate, provincial departments of environment need adequate funding and personnel to implement good environment policies. Downsizing and budget cuts directed at environmental programmes will cost dearly in the long-term, possibly with disastrous results. Until social and environmental benefits and costs are included in our core measures of progress, necessary investments in environmental protection are unlikely, and more Walkertons can be expected.

Nova Scotia is not exempt from this danger. The Nova Scotia Department of Environment has drawn up new draft regulations to ensure consistent weekly testing of municipal water supplies, and to ensure a good path of communication between the department, the municipality and test results from labs. However, the N.S. government has recently directed budget cuts to the department, and amalgamated it with the labour department. These measures come after prior governments have already directed budget cuts at environmental programmes. This apparent "cost-saving" may put more stress on a small staff, and hamper efforts to enforce the new regulations and maintain a healthy environment, and produce sensuous long-term costs.

1.6 GPI Qualitative Indicators, Expenditure Accounts and Damage Costs

To remedy the serious flaws of our current accounting system, based on GDP, the Genuine Progress Index adopts a very different model of the human economy than that taught in almost all economic texts. The deluded model that is the basis of conventional economic thinking sees the human economy as an isolated system of one-way flows, in which firms produce and households consume. Earlier GPI reports on the economic value of unpaid work have already challenged the flawed model by demonstrating that households *produce* as well as consume, and that the value of unpaid household production is therefore ignored in our conventional accounting systems, with serious social consequences. However, the conventional model is even more seriously flawed because it ignores the vital flow of natural resource and ecosystem services from the environment to the human economy and the potentially deleterious flow of human waste into the environment. Instead of seeing the human economy as an isolated system, the Genuine Progress Index is based on a more realistic model that understands the human economy as a sub-system of an encompassing ecosystem on which it is dependent for life-supporting services and into which it discharges the waste products of its economic activity.

The flows of heat, energy and matter from the ecosystem allow the human economy to function and are thus accorded specific *value* in the Genuine Progress Index. Because the conventional economic model ignores these ecosystem services because they are "free", it also mistakenly regards them as limitless and value-less and it therefore actually counts their depletion as economic gain. Similarly, the Genuine Progress Index counts waste discharges from the human economy that exceed the natural absorptive and assimilative capacity of the environment as explicit *costs*. Again, because it ignores the existence of the encompassing ecosystem, the conventional economic model mistakenly regards that assimilative capacity as “free” limitless and value-less, and thus counts pollution costs as economic gain.

The Genuine Progress Index should therefore be understood as the fundamental challenge to the conventional model of the human economy the underlies current national accounting practices, policy making and even economics textbooks and courses. So long as this flawed model remains the basis of our economic thinking, it is literally safer to put non-economists in charge of our finance and economic development departments. Adoption of the Genuine Progress Index as a more accurate measure of well-being and sustainable development can also help initiate the shift to a more accurate model of the human economy that corresponds to reality. Because of the imminent change of natural resource depletion and waste overload, the well-being of future generations and the avoidance of more Walkertons literally depends on this shift occurring without delay. Nova Scotia has an opportunity to take a lead in this process and to demonstrate a path towards a more sustainable future.

The GPI water quality account is the first in a series of natural resource accounts to be released this year, and therefore marks a significant step in the development of the Nova Scotia Genuine Progress Index. In the coming months, GPI Atlantic will also release its greenhouse gas accounts, its ecological footprint analysis, and its forests, soils, and fisheries accounts, its air quality component and a first-stage transportation account. The GPI solid waste component will be released in the spring of 2001.

Because we depend on water for life and production, an assessment of our water resources is one of the 20 central components of the Genuine Progress Index, enabling us to measure our progress in sustaining and improving the quality of this vital source of natural capital. The U.S. GPI notes that although water is one of the world’s most precious environmental assets,

> “ the national income accounts provide neither an inventory of the quantity or quality of water resources nor an account for the cost of damage to water quality”.

The U.S. GPI 1998 update estimated the annual cost of damage to water quality and damage from siltation at $50.1 billion in 1997 (1992$US; Anielski and Rowe 1999). This amount includes the estimated point source damage to recreation aesthetics, ecology, property values, and household and industrial water supplies since 1972; and an estimate by The Conservation Foundation of the damage of erosion. The U.S. GPI estimate did not include government defensive expenditures. The U.S. GPI also provided a separate and additional estimate of $350 billion for the cost of wetland loss.

The GPI for Nova Scotia adopts a somewhat different approach from the U.S. model including costs incurred by government and the use of physical indicators. The Nova Scotia GPI water quality accounts include qualitative indicators, defensive expenditures for abatement, monitoring, treatment and control of water pollution, and some of the damage costs due to water pollution and/or water quality decline. The following report is only a starting point for monitoring the genuine progress of our water resources and values based on the very limited data, time-frame and funding available. At the end of the report there is a list of policy-relevant recommendations and recommendations for improvement of data sources, for example funding is needed for long-term monitoring programmes.

PART I: WATER QUALITY CRITERIA AND INDICATORS

Water is essential for human health; about 2.5 litres per person each day, in fact, are necessary for survival and health (Health Canada 1997). In addition, we use water for physical health, to relax and enjoy, and as a source of food such as fish and shellfish. Lakes, rivers, wetlands and coastal areas provide habitat for thousands of organisms from bacteria and fungi to amphibians, fish, birds and mammals. Some contaminants are found naturally in water (e.g. some water may have arsenic present). However, most current aquatic and human health hazards result from contaminants released to the environment by humans. These include pesticides and other organic compounds, metals, fluoride, radionuclides, microorganisms, nutrients (nitrates, phosphates), and other substances.

There are many sources of water pollutants (Environment Canada 2000). Substances in the air, such as toxic chemicals and lead, are collected in the rain that falls. Water collects substances as it runs across natural and man-made surfaces, producing runoff. In urban areas water runoff increases the concentration of substances such as nutrients, sediments, petroleum products and road salts, worsening the quality of lakes and rivers. Additionally, industrial, farming, and forestry activities can also significantly affect water quality in rivers, lakes, and groundwater. Farming and forestry can increase the concentrations of nutrients, pesticides, and suspended sediments, thereby increasing water temperatures; industrial activity can increase concentrations of metals and toxic chemicals, and add suspended sediments, thereby increasing water temperatures and lowering dissolved oxygen levels. These effects can have serious and often fatal results in aquatic ecosystems, and make the water unsuitable for other uses.

Water quality is defined by its chemical, physical and biological content. However, the characteristics of water change over seasons and over geographic regions. In Canada, we have developed water quality guidelines for drinking water, recreational water, and for the protection of aquatic life [16].

The following criteria and indicators are a first attempt to provide a relatively comprehensive portrait of the different elements of resources. Unfortunately there are currently not enough readily available data and information to construct a definitive physical account of water quality for the province. GPI Atlantic hopes that future development of this account and improvements in data sources, methodologies and measuring instruments will produce ever more accurate

[16] Canadian drinking water guidelines can be found at: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/dwguide.htm For recreational water quality guidelines see: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/recwater.htm. Guidelines for the protection of aquatic life and for agricultural water uses (irrigation and livestock water) are at: http://www.ec.gc.ca/ceqg-rcqe/water.htm

assessments of the state of our water resources. It is also GPI Atlantic's hope that other jurisdictions will find this template useful as a starting point for their own water resource accounts.

2 WATER POLLUTANT RELEASES AND TRANSFERS IN NOVA SCOTIA

In 1997, Nova Scotia was ranked as having relatively low industrial pollutant releases and transfers; number 52 among 63 states and provinces[17] (CEC 2000). The same report notes that, Nova Scotia reduced its overall pollutant releases and transfers by 9.2% between 1995 and 1997, but estimates that they have increased by 7.9% since then (1997-1999; CEC 2000).

In 1996, 43,272 kg of pollutants were discharged to Nova Scotia surface waters[18] (0.1% of the North American total), and 343,551 kg of pollutants were released on-site to land in the province[19] (0.2% of North American total) (CEC 1999). In 1997, pollutants discharged to surface waters rose by 4.6% (1,992 kg), to 45,264 kg, and pollutants discharged on-site to land decreased by 10.3% (35,360 kg), to 308,191 kg. Total off-site transfers (including pollutants transferred for treatment prior to disposal, or shipped for disposal off-site), increased by 46.7%, from 322,158 kg in 1996 to 472,606 kg in 1997 (CEC 1999, CEC 2000).

If we assume that the surface water discharges, on-site land releases, and off-site transfers are all pollutant releases that can measurably affect surface and ground water quality, then the total water pollutants increased by 16.5%, from 708,981 kg in 1996 to 826,061 in 1997. At the same time, Nova Scotia's total pollutant releases and transfers within Nova Scotia decreased by about 4% as a result of a decrease in air emissions as well as the decrease in on-site land releases.

In summary, the results from the CEC's Taking Stock 1996 and 1997 publications show an increase in water-related pollutants over the two years. The increase in off-site transfers may mean that more pollutants were potentially being treated prior to treatment and/or disposed of in a safe manner. While CEC reports are a good indication of the pollutants released and transferred by industry, the data do not include non-point sources (e.g. agricultural and forestry runoff, cars, trucks and aircraft), some small sources like gasoline service stations, nor do they report on all substances of concern.

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[17] Releases are the on-site discharge of a pollutant to the environment at the site of the reporting facility, including emissions to air, discharges to surface waters, releases to land, and deep-well underground injection. Transfers are off-site shipments of a listed pollutant in waste sent for treatment prior to disposal, including wastes sent to municipal sewage treatment plants, or for disposal at an off-site facility. Only the quantity of the listed chemical is reported to the pollutant release and transfer register (PRTR).

[18] Surface water discharges are the amount of discharge, spills, and leaks to each water body, including direct discharges to streams, rivers, lakes, oceans and other bodies of water. These are releases from contained sources such as industrial process outflows, as well as discharges due to runoff from a facility's boundaries.

[19] On-site land releases are the amount of pollutants released to landfills, land treatment/application, spills, leaks, including the disposal of wastes in landfills in which wastes are buried, application farming whereby a waste is applied to or incorporated into soil for biological degradation, and disposal in surface impoundments which are uncovered holding areas used to evaporate or settle waste materials.

3 DRINKING WATER

Water quality and its impact on social well-being are evaluated primarily on the basis of Canadian standard drinking water indicators of quality. Nova Scotia's water supplies are examined for compliance to the Guidelines for Canadian Drinking Water Quality in terms of aesthetic objectives and general health-related criteria, as well as bacteriological content, and THM (trihalomethane compounds) levels. Global environmental change, water pollution and water overuse are increasing the economic value of water. For instance, the U.S. is now pressuring Canada to export water, and climate change is predicted to have a negative impact on the availability of freshwater. As a result, the protection and health of drinking water resources are becoming even more important locally as well as on an international scale.

About 57% of Nova Scotia's total population is dependent on municipal water supplies. In total there are 78 municipal water supplies serving 535,950 people. The remaining 43% of the province's population is reliant on individual systems, mostly private wells. The quality and availability of drinking water is a key element to measure as an indicator of progress. If our water capital depreciates or water resources are degraded, then our genuine progress has decreased. Future research and water quality account updates should consider comparisons of Nova Scotia water quality with the water quality of other provinces.

3.1 Percentage of Nova Scotia's Population on Municipal Water Supplies that Conform to the Guidelines for Canadian Drinking Water Quality (GCDWQ) for Aesthetic and Health Standards

Canada's drinking water guidelines are revised and updated on an on-going basis by the Federal-Provincial Subcommittee on Drinking Water. The Guidelines for Canadian Drinking Water Quality (GCDWQ) outline maximum acceptable concentrations (MAC) and aesthetic objectives for the physical, microbiological, chemical and radiological parameters of drinking water supplies.

MACs indicate the highest concentration of a substance in drinking water that is considered safe for human use based on lifelong consumption, and exposures to contaminants above the MAC may have an unacceptable health impact. Aesthetic objectives (AO) apply to substances or characteristics of drinking water "that may affect its acceptance by consumers or interfere with practices for supplying good water" (Health Canada 1997b)[20]. The guidelines are reviewed each year to ensure that the latest technology and knowledge of health impacts are applied. The latest Guidelines for Canadian Drinking Water Quality (GCDWQ) were published in April 1999.

[20] If a concentration is well above an AO there is also a possibility of a health risk.

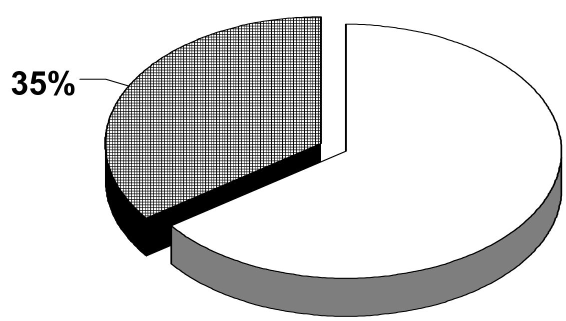
Evaluating whether or not our drinking water supplies comply with the guidelines is an important indicator of the quality of municipal drinking water.

1996 data from the Nova Scotia Drinking Water Systems Database are evaluated using the most recent GCDWQ (Health Canada 1999). According to the database, there are 78 municipal water supplies serving 535,950 people in the province (57% of the province's total population). This population estimate is used in the following analysis.

Results:
In 1996, one or more of the treated samples for 14 municipal water supplies (18%) of a total of 78 province-wide, did not meet one or more aesthetic objectives of the Guidelines for Canadian Drinking Water Quality (GCDWQ). These 14, however, served 65% of the province's population. The aesthetic substances or characteristics found to be above the guidelines included pH, manganese, colour, and iron, in their order of occurrences.

Using the population from the 1996 database, 35% of Nova Scotia's population were served by the 64 municipal water supplies that had all samples in compliance with the aesthetic objectives of the GCDWQ, and 65% of the provincial population on the other 14 municipal water systems were served by supplies that had one or all samples not in compliance with one or more aesthetic objectives (pH, manganese, colour and/or iron) in 1996 (Figure 1). Since 1996, one of the main

Figure 1. Percent Population with Municipal Water Supplies Conforming to the Aesthetic Objectives of the GCDWQ, in 1996

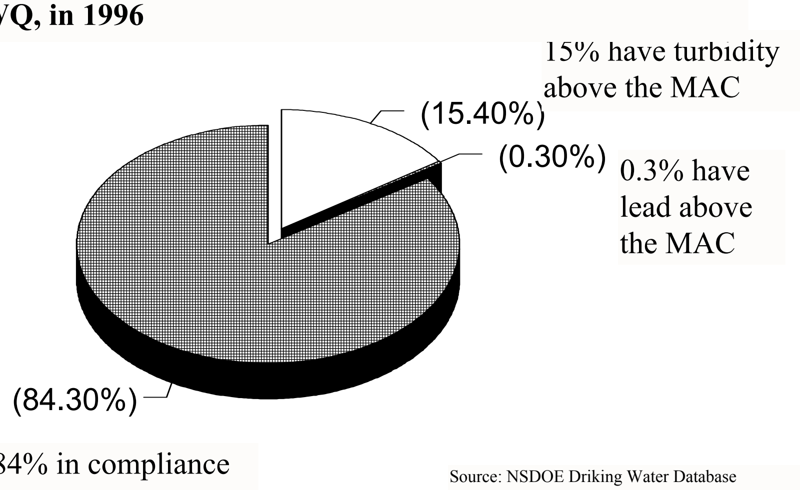


Source: NSDOE Drinking Water Database

municipalities among the 14, namely Dartmouth, has now built a new water treatment plant[21]. Manganese and iron can create undesirable tasting water; pH levels below 6.5 can cause corrosion of pipes, and pH levels above 8.5 can increase scaling problems.

In terms of health-related criteria, 6 of the 78 municipal water supplies (9%) exceeded the criteria for the maximum acceptable concentration (MAC) of turbidity; 2 of the total 78 supplies exceeded the criteria for lead. Using the population recorded in the Nova Scotia 1996 database, 84% of the population's supplies conformed to the MAC guidelines for health related criteria, and 16% of the population were served by water supplies that did not comply with one or two of the maximum acceptable concentrations (MACs) for health-related criteria (Figure 2).

Figure 2. Percentage of Population with Municipal Water Supplies with Compliance and without Compliance to the GCDWQ, in 1996



Source: NSDOE Driking Water Database

Most of the non-conforming supplies (6 of the 7) were above the MAC for turbidity[22]. Turbidity is a measure of the presence of suspended solid material, and qualifies as an undesirable aesthetic characteristic[23] as well as a health-related MAC because suspended solids can shelter micro-organisms from the action of disinfectants and can be an indicator of inadequate treatment of water (McGhee 1991). Two of the seven supplies had samples indicating levels of lead above the MAC for one of their water supplies. One also had turbidity levels above the MAC. These supplies had treated samples 0.013 mg/litre and 0.017 mg/litre, respectively, above the MAC guideline. The MAC for lead is set at 0.010 mg/litre. Although lead occurs naturally in the

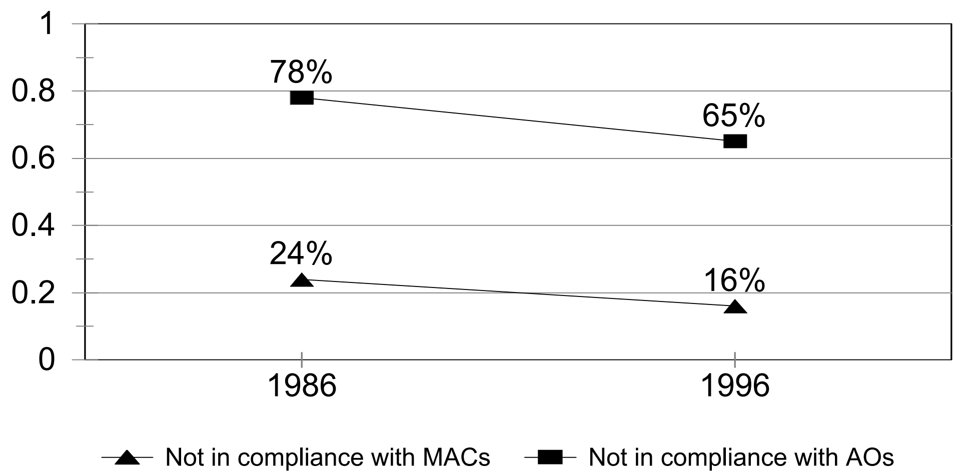
[21] Personal communication, Nova Scotia Department of Environment.
[22] MAC = 1 nephelometric turbidity unit (NTU)
[23] All municipal water supplies met the aesthetic objective for turbidity which is set at 5.0 NTU.

environment, it enters drinking water primarily as a result of corrosion of materials containing lead in the distribution system. It is present in raw water as a result of atmospheric deposition, and can increase in communities with acidic water supplies (Health Canada 1997b). Lead is a serious health concern and has been shown to retard mental development among children.

It should be noted that the data presented here is from 1996, and that changes in the quality of drinking water may have occurred since then. Data on the drinking water of municipalities has recently been transferred to an electronic database. Information can be requested through the NSDOE, however, the information has not yet been evaluated as public information by the Nova Scotia government.

Due to time constraints, this initial GPI water quality account only considers the conformity in drinking water guidelines of the latest available year (1996) in detail. However, for comparison, the 1996 results are compared with results from the same database for the year 1986[24]. The percent of Nova Scotia's population served by municipal water supplies that comply to the aesthetic objectives of the GCDWQ has increased by 17%, since 1986 (Figure 3). Similarly, the data indicate an improving trend for compliance with the health-related criteria, with, compliance having increased by 33%.

Figure 3. Percentage of Population on Municipal Water Supplies with Samples not in Compliance with the GCDWQ in 1986, 1996



Source: NSDOE Drinking Water Database

[24] 1986 was chosen arbitrarily for a 10-year comparison. The 1999 guidelines are used for evaluating compliance and the 1996 population was used for the 1986 calculations.

3.2 Percentage of Nova Scotia's Municipal Water Supply Samples that Conform to the GCDWQ for Bacteriological Content

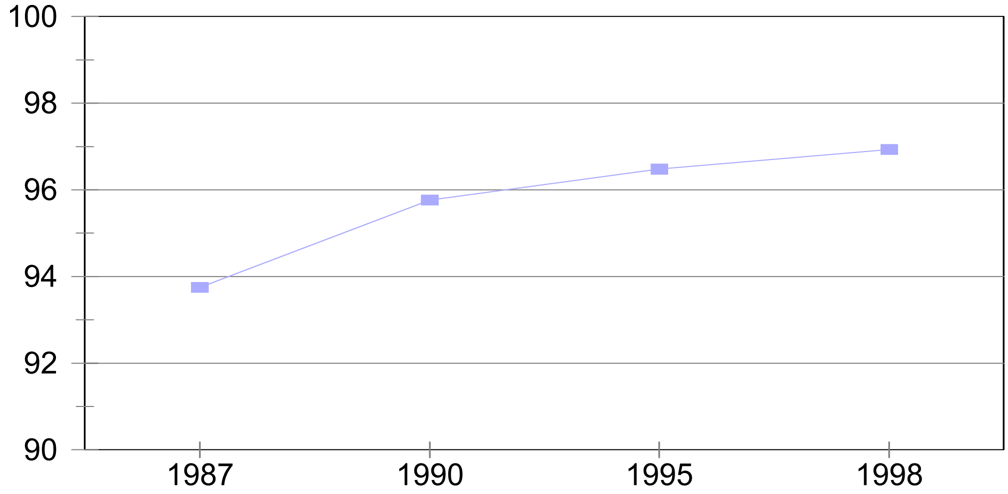
Bacterial content in water is indicated by the presence or absence of indicator bacteria called coliform organisms. The presence of coliform bacteria is indicative of the presence of more problematic bacteria that have the potential to cause disease or illness. Therefore, if a drinking water supply is free of bacterial indicators, it is probable that the water is also free of other more dangerous bacteria. The maximum acceptable concentration (MAC) for coliforms in drinking water is set at zero organisms detectable per 100 ml, and none of which should be *Escherichia coli* or thermotolerant coliforms (Health Canada 1999). In other words, a negative test (i.e. zero presence) for coliform organisms indicates a positive result and good water quality, with no detectable presence of bacteria.

> "Samples are analyzed for total coliform and fecal coliform bacteria which are indicators of sewage and the potential occurrence of disease causing organisms such as hepatitis a and salmonella (Health Canada 1997b)."

The most common microbial pathogens found in untreated water are bacteria such as Campylobacter, E. coli, Salmonella, Shigella, and Staphylococcus aureus. These cause a range of water-borne diseases, including gastroenteritis, fatal kidney failure, typhoid fever, and skin, ear and eye infections. Outbreaks of these diseases are rare in Canada, but the recent deaths and sickness in Walkerton, Ontario, indicate that this rarity is no cause for complacency.

The percentage of municipal water samples testing negative for bacteria increased between 1987 and 1998 (Figure 4). In 1987, 93.8% tested negative, and in 1998, 97% of samples tested negative. This trend indicates that water quality has improved, with a 3.2 percentage point increase in provincial samples detecting zero coliforms. Further information on municipalities with positive coliform bacterial samples are available through the NSDOE.

Figure 4. Percent of Municipal Samples meeting the GCDWQ MAC for Coliforms



Source: NSDOE Drinking Water Database

3.3 Percentage of Nova Scotia's Population on Municipal Water Supplies Meeting the GCDWQ Interim Maximum Acceptable Concentration for Trihalomethane Compounds

Trihalomethane compounds (THMs) are created when chlorine reacts with organic material in water. This occurs most often in surface water supplies. Chlorination, a common method of treatment in the Maritimes, is used to disinfect drinking water in order to kill micro-organisms such as bacteria and viruses that can cause serious illnesses and deaths in some cases. Chlorination has been an important factor in the virtual elimination of typhoid fever, cholera and many other waterborne diseases. On the other hand, trihalomethane compounds are suspected to increase the chance of bladder cancer by 1.3% after exposure to high THMs over at least 25 years. This increased risk is very slight but it does cause a health concern, and accordingly, THMs in drinking water should be monitored as an important indicator of the quality of municipal waters.

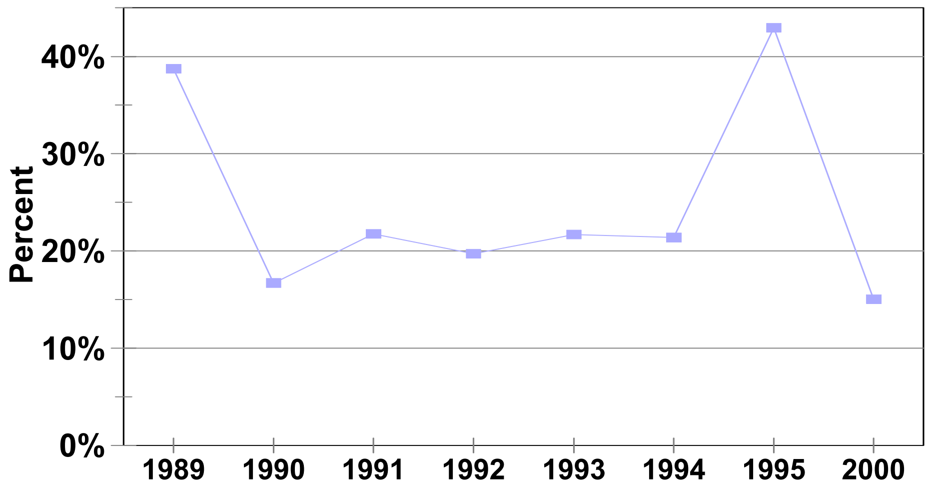
Monitoring for THMs in Nova Scotia's municipal supplies began in 1989 and continued until 1995. At that time, those supplies with high THMs were advised to take corrective action to rectify the THM problem. THM monitoring is continuing for water supplies that have historically had high THM levels. Currently, quarterly testing is underway to determine which municipal water supplies still have THMs above the interim maximum acceptable concentration (IMAC) of 100 µg/L (Health Canada 1999). Prior to 1993, the MAC for THMs was 350 µg/L. Provincial comparisons are not possible at this time, but should be included in subsequent accounts.

Trends:

THM data was collected between 1989 and 1995 for 72 municipal water supplies in Nova Scotia. With the exception of 1990, 20% to 29% of municipal water supplies have reported THM levels above the most recent guideline of 100 micrograms/litre. In 1993, the MAC was lowered to 100 micrograms/litre because of its status as a suspected carcinogen. The interim MAC is set as a new goal towards which municipalities are working.

The percent of Nova Scotia's population served by municipal water supplies with THMs above the 1999 IMAC was about 38.7% in 1989 (Figure 5). This percentage decreased to an average of 20% between 1990 and 1994, and increased in 1995 to 42.9% because a large urban population centre (Dartmouth) was above the IMAC. Dartmouth has since built a new state-of-the-art water treatment plant that has corrected its water quality problems. Most recently, average results from testing in September 1999, January 2000, and Spring 2000 indicate that approximately 14% of the population served by municipal water supplies may be affected by THM levels above the IMAC of 100 micrograms/litre. These numbers represent an average of three sampling periods, but are considered preliminary because a full result, according to the GCDWQ, is an average of four samples taken over the course of one year. Therefore, the percentage of municipalities with THMs above the guideline level may be further reduced. The final quarter sample, and full annual average will be released by the Nova Scotia Department of Environment in late July 2000. The names of the municipalities with higher than acceptable THM levels will be made public upon release of the new NSDOE data.

Figure 5. Municipal Population Water Supplies with THMs above the IMAC (%)



Source: NSDOE Drinking Water Database

3.4 Area of Land Under Water Supply Watershed Protection Strategies

Water supply watersheds are often at risk of contamination from everyday land-use activities in surrounding and nearby communities. For instance, several forestry activities and other clearing of surface vegetation can have an effect on water table levels, and increase sedimentation in surface waters. Thus, water supply watersheds need a set of protective measures to mitigate the impact of other uses of the watershed. Legislation (Nova Scotia Environment Act) is currently in place which enables communities to designate their watershed as protected. This designation restricts activities within an area which may adversely affect the community water supply.

In 1998 , the State of the Nova Scotia Environment report (NSDOE 1998) noted that 31% of water supplies were either designated as Protected Water Areas or had a comprehensive water supply protection strategy in place. No additional designations or strategies have been implemented since that time. The purchase of land around a watershed by a municipality is one option for protection, and designation is another. The GPI goal is the designation of protected water areas for 100% of the province’s water supply watersheds.

4 GROUNDWATER

According to Environment Canada (1999), 55% of Nova Scotia's population is reliant on groundwater for municipal, domestic and rural uses; 43% of Nova Scotians obtain their drinking water from private wells (NSDOE 1998). Groundwater exists everywhere under the surface of land. Because it is less visible than surface water (lakes, rivers and streams), humans have tended to pay less attention to its health. More recently, reports on contamination of groundwater by leaking gasoline storage tanks, dry cleaning solvents, chemical leakage from landfill or industrial waste disposal sites, road salt, septic systems, and fertilizers and pesticide, have caused concern among Canadians.

According to Environment Canada (1999), contamination of groundwater in Canada is a serious problem due to major sources of contaminants from industrial and agricultural sources as well as domestic household sources. It is important to take preventative measures because groundwater is very expensive and very difficult (sometimes impossible) to clean up. Additionally, groundwater moves slowly, and thus problems can take a long time to show up. Several preventative measures can be implemented, including the replacement of leaking tanks with ones that do not corrode; locating landfills in areas where leachates will not contaminate groundwater; and by restricting access to groundwater recharge areas.

There are several indicators of groundwater availability and quality. Availability can be measured by analyzing historical trends of groundwater levels up to the present day. Nova Scotia's Department of Environment began an Observation Well Programme in 1964. Most recently, 10 of these sites have had data loggers installed[25]. However, the data has not yet been summarized. Therefore, future work should consider compiling the data available both from the Observation Well Programme and from the on-going data collection at the 10 sites with data loggers.

4.1 Private Well Water

There are approximately 140,000 wells in Nova Scotia, from which about 43% of residents obtain their drinking water. Runoff from agriculture, forestry, and lawn-care often contains high levels of nutrients, particularly nitrogen and phosphorus as well as pesticides, that can end up in a private water supply. Nutrients are present in industrial and domestic fertilizers, improperly stored manure piles, and natural soil. High nitrates in drinking water can cause problems during

[25] Sites with data loggers as of October 1999 are: Charleston, Greenwood, Kentville Industrial Park, U. Canard, Wolfville, Lawrencetown, Truro 420, Fraser Brook, Monastery, and Sydney Watershed.

infancy (e.g. blue-baby syndrome). Because Nova Scotia has a large agriculture and forestry industry, and a significant rate of dependance upon groundwater, monitoring well water for pesticides and nitrate levels is important for identifying potential non-point sources of groundwater pollution.

4.1.1 Pesticide Concentrations in Private Wells in Agricultural Areas

Pesticides in well water present a health risk to rural communities in Nova Scotia, especially those communities that are heavily dependent upon the forestry and agricultural industries. Pesticides enter the water cycle through agricultural crop runoff, forestry runoff, or infiltration through the soils to the water table. Many pesticides have been linked to serious illnesses like cancer, and to reproductive impacts on both humans and wildlife, as well as to blue-baby syndrome in infants. Monitoring pesticide concentrations in groundwater provides an indication of the health of the resource and its potential use as a drinking water source or irrigation supply. Pesticides are persistent chemicals that do not break down easily and therefore accumulate in the environment over time.

The King's County Farm Well Water Quality study, conducted in 1989, examined nitrate and pesticide detections in the region's rural well water supply (Moerman and Briggins 1994). Unfortunately, time series data are not yet available for this indicator. Therefore, a better source of monitoring and data records is important because these data have implications for other agricultural areas in Nova Scotia, including Colchester, Cumberland, Hants and Annapolis counties, for which data are not available.

Results:

None of the wells sampled by Moerman and Briggins (1994) exceeded maximum acceptable concentrations (MACs) for pesticides tested. Atrazine and its degradation products were detected more frequently than any other control product, appearing in 33 (32.4%) of 102 randomly selected wells tested for pest control products. The MAC for atrazine is set at 0.005 milligrams/litre.

19% of the wells sampled (8 wells) had more than one pesticide detected, with a maximum total pesticide concentration in one well of 2.19 micrograms/litre. Presently, there is no guideline for total pesticides in the GCDWQ (Health Canada 1999).

4.1.2 Private Wells with Nitrate Concentrations Above the GCDWQ

Data were reviewed from the same well water studies used in the previous indicator, with tests conducted in King's County in 1989 (Moerman and Briggins 1994) and a groundwater study conducted in 1985 (McLeod and Fulton 1985). In general, wells with pesticide detections also had elevated nitrate concentrations, with 71% of the wells with pesticides registering nitrate concentrations greater than 5 mg/L. There are other regions of Nova Scotia with high concentrations of agricultural activity, but insufficient data are available for those regions (e.g. Colchester, Cumberland, Hants and Annapolis counties). The results of the Kings County studies and other previous work have implications for these agricultural areas.

Trends:

In 1985, a province-wide study examined well water quality to determine the extent of nitrate contamination in Nova Scotia (McLeod and Fulton). Only towns with at least six samples available were included in the study. As a result, samples for 3,594 wells (3.6% of the provincial total) were analyzed. Approximately 7% of the wells had nitrate levels above the maximum acceptable concentration (MAC: 10 mg/L; Health Canada 1999). However, the study notes that the database tended to include wells sampled only when there was a problem suspected with the quality of well water. Therefore, the data presented may be biased towards problem areas. The greatest percentage of wells containing high nitrate concentrations were found in Kings, Colchester, Digby and Shelburne counties (Table 1). High levels of nitrates in Shelburne and Digby counties may be due to septic system effluent.

Table 1: Percentages of Samples with Nitrates in Nova Scotian Counties, 1985

County	Greater than 10 mg/L nitrates
Kings	29%
Colchester	15%
Shelburne	11%
Digby	11%

Source: McLeod and Fulton 1985

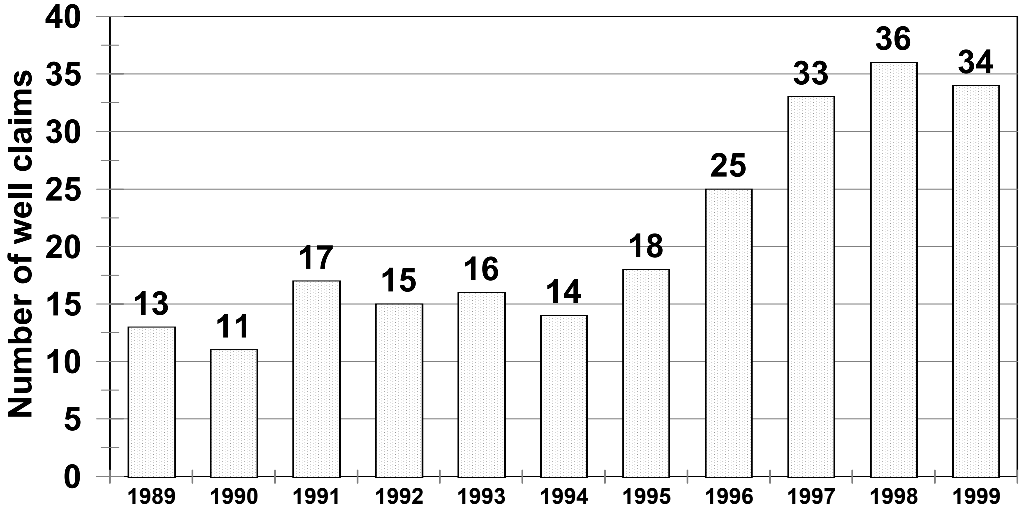
In 1989, a random survey of farm wells in Kings County reported that 13% of the 237 wells sampled had nitrates above the MAC guideline of 10 mg/L (Moerman and Briggins 1994). The highest level was 46 mg/L. These results cannot be readily compared to the results from the 1985 samples analyzed in Kings County, because the former study was based on available data and the latter study was based on a random survey. Many of the wells sampled in 1989 are currently being sampled again as part of an on-going study in King's County. However, the data are not yet available[26].

4.2 Contamination of Private Wells from Road Salt

According to the NSDOE (1998), the Nova Scotia Department of Transportation and Public Works (DTPW) applies nearly a quarter of a million tonnes of salt each winter[27] in its standard road maintenance. The DOE's report notes that studies in Ontario and Maine indicate that 20% of road-side wells exhibit salt contamination where highways are heavily salted. The annual number of well claims due to road salt contamination in Nova Scotia has risen since the early 1990s (Figure 6). The number of well claims were estimated from *The State of the Nova Scotia Environment* (1998) for the years 1989 to 1995, and data on well claims between 1996 and 1999 were obtained from the DTPW[28]. The trend in Figure 6 demonstrates an increase in the number of claims to the NS DTPW for private wells contaminated by road salt runoff. According to the NSDOE (1998), there are two key regulations: 1) In areas where wells have been contaminated, the DTPW is switching to the use of sand rather than salt. 2) Well construction regulations now require new wells to be located at least 20 feet from the road right-of-way.

[26] Personal communication, Nova Scotia Department of Environment.
[27] Or about 230 tonnes of salt per road kilometre.
[28] The number of claims for the fiscal year 1999 is reserved because at the time data were received from the NS DTPW the fiscal year claims were not yet finalized.

Figure 6. Number of Annual Well Claims Due to Road Salt Contamination



Source: NSDTPW; NSDOE 1998

5 SURFACE WATER QUALITY

Surface water quality is important for healthy aquatic ecosystems, recreation, wildlife habitat, and human health. Aquatic life is intrinsically important for its biological diversity. Additionally, because humans are dependent on water, they are dependent on aquatic ecosystems. Most of the water we consume and use for industrial purposes originates from lakes and rivers. Therefore, if these systems deteriorate in quality they can become unsuitable for drinking water, recreational use, industry and/or agriculture.

Healthy aquatic ecosystems are defined as "those where human disturbances have not impaired the natural functioning (e.g. nutrient cycling) nor appreciably altered the structure (e.g. species composition) of the system" (Environment Canada 2000). This section considers the trends in acidification of Nova Scotia's rivers, trends in Atlantic salmon populations, and wastewater effluent from pulp and paper mills as key indicators of surface water quality. Future research should also consider the effects of other pollutants that are affecting Nova Scotia's lakes and rivers. For example, common loons in Nova Scotia currently have the highest blood mercury concentrations of any loon population in North America (Nocera and Taylor 1998), and trends in this key indicator species or their prey might become a core genuine progress indicator in the future to assess whether efforts to cut mercury levels are reducing pollutant deposition in Nova Scotia lakes.

5.1 Acid Deposition Affecting Rivers and Lakes in Nova Scotia

Two common air pollutants, sulphur dioxide and nitrogen oxides are the major cause of acid rain, namely acid deposition. The main sources of these pollutants are coal-fired power plants, nickel and copper smelters, and motor vehicles. Both pollutants can stay in the air for days and can travel up to thousands of kilometres. They reach land or water surfaces through precipitation (i.e. rain, snow and fog) adversely affecting soil, water, plants, and buildings. They can also be converted to fine particles; Suspended in the air they form a major part of smog pollution. Most acid rain falls in the eastern part of Canada because the largest sources of sulphur dioxide and nitrogen oxides are found in the eastern part of North America and because the winds that can carry the pollutants generally flow in a easterly direction (Environment Canada 1999c).

In 1985, Canada and the seven eastern provinces implemented a programme to cut sulphur dioxide emissions within eastern Canada by half by 1994, within eastern Canada (Environment Canada 1999b). By 1994, emissions in the region had been cut by 54% from the 1980 levels. Since 1994, emissions have continued to decrease in some provinces, while increasing in others. In 1991, the United States and Canada signed the Canada-U.S. Air Quality Agreement (Environment Canada 1999b), which resulted in the U.S. decreasing its sulphur dioxide emissions by 26% from 1980 levels. As a result, levels of sulphate in the rain and snow have fallen considerably, and further reductions over the next 10 years are planned.

According to Environment Canada (1999c), the current Canada-US programme is a "good first step", but the U.S. and Canadian commitments to reductions by the year 2010 will still leave an area of about 800,000 square kilometres of central Ontario, southern Quebec and Atlantic Canada receiving more sulphate than its natural systems can tolerate. Additionally, recovery is occurring very slowly in many locations. Environment Canada (1999b) reports than of 202 lakes studied in Eastern Canada since the early 1980s:

- 33% have reduced levels of acidity (approx. 67 lakes);
- 56% have shown no change (approx. 113 lakes); and,
- 11% have become more acidic (approx. 22 lakes).

However, the least improvement has been seen in Atlantic Canada. This is a result of two problems: 1) although sulphate in rainfall has decreased because of the decrease in sulphur dioxide emissions, there has not been a general decline in the acidity of rain because there has been parallel decrease in airborne calcium and magnesium salts that normally help neutralize acids; and, 2) the ability of water bodies to neutralize acids has also declined.

> "Surprisingly, and disappointingly, despite cutting SO2 [sulphur dioxide] emissions in half in eastern Canada, rain is still acidic. That is because calcium and magnesium salts have also decreased more or less in tandem with the reduction in sulphur dioxide emissions. As a result, there has been some decrease in acidity, but not as much as expected." (Environment Canada 1999b)

The acidity of rain is determined by the presence of acid-forming substances such as sulphate and the availability of acid-neutralizing substances such as calcium and magnesium salts that are concentrated in precipitation. The reasons for the decrease in calcium and magnesium that has occurred, is not yet understood.

Another contributing factor that has not been directly addressed through targeted reductions is nitrate deposition. Environment Canada (1999c) reports that if nitrate deposition continues at its present levels it will erode the benefits gained through the reductions in sulphur dioxide emissions. Nitrogen oxides also contribute to ground-level ozone/smog, so reductions in these pollutants will help air quality too.

The problem of acidic deposition is amplified in Atlantic Canada because the majority of our ecosystems are very sensitive to acid inputs, and because very little improvement has been observed in this region. The critical load for much of the region is < 8 kg/hectare/year, while the critical load target for reductions is set at <12 kg/hectare/year. Projections indicate that the

Atlantic region will continue to receive deposition greater than 8 kg/hectare/year even after the legislated emission reductions (Beattie and Keddy 1994).

Acidified rivers and lakes are limited in their ability to support aquatic life and recreational uses. Most species of plants and animals have a small range of pH tolerance as habitat requirements. As more Nova Scotia rivers and lakes are affected by acidification, habitat for several species of fish and amphibians, and potential water uses are diminished.

> "Lakes [and rivers] that are acidified cannot support the same variety of life as healthy lakes. As a lake becomes more acidic, crayfish and clam populations are the first to disappear, then various types of fish. Many types of plankton - minute organisms that form the basis of the lake's food chain - are also affected. As fish stocks dwindle, so do populations of loons and other water birds that feed on them. The lakes, however, do not become totally dead. Some life forms actually benefit from the increased acidity [e.g. lake-bottom plants and blackfly larvae]." (Environment Canada 1999b)

The acidity of water is measured using a pH scale, ranging from zero (maximum acidity) to 14 (maximum alkalinity). The middle of the scale (7) is neutral, and acidity increases along the scale form 7 to zero. The pH scale is logarithmic, meaning that a difference of one unit represents a ten-fold change. Normal rain has a pH of 5.6, which is slightly acidic because of the carbon dioxide in the earth's atmosphere. The effects of acidity on aquatic life are shown in Table 2.

Table 2. The Effects on Aquatic Ecosystems as Water Becomes More Acidic

Water pH	Effects on Aquatic Ecosystems
6.0	- crustaceans, insects and some plankton species begin to disappear
5.0	- major changes in plankton community - less desirable moss and plankton species invade - progressive loss of some fish populations; the more highly valued species are generally the most sensitive to acidity (e.g. salmon)
less than 5.0	- water is largely devoid of fish - bottom is covered with undecayed material - nearshore areas may be dominated by mosses - terrestrial animals, dependent on aquatic ecosystems are affected: e.g. loss in sources of food; reproductive success of birds declines; Source: Env. Canada 1999b

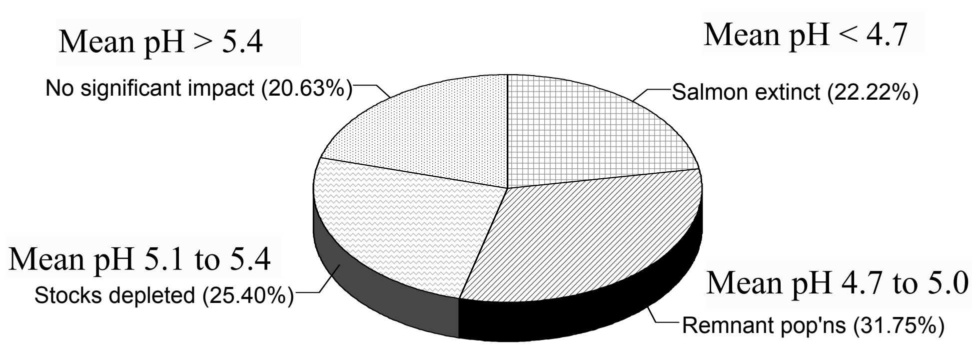
Trends:

Atlantic salmon are a good indicator species for the water quality of Nova Scotia's rivers, because they are sensitive to acidity. They have difficulty reproducing in water with a pH less than 5.6, and a pH of 5.0 is toxic to them. According to Watt and Hinks (1999), one-third of salmon productivity in Nova Scotia has been lost as a result of the acidification of the province's rivers.

Currently, salmon are extinct in 14 rivers with a mean annual pH of less than 4.7. Twenty rivers have a mean annual pH of 4.7 to 5.0, with only remnant populations of salmon in tributaries; and 16 rivers have mean annual pH values of 5.1 to 5.4, where some salmon stocks are depleted in tributaries. As a result, Atlantic salmon are extinct in 22% of Nova Scotia's rivers; 25% of the province's rivers now have remnant depleted stocks; 32% of rivers have only remnant populations; and, 21% of Nova Scotia's rivers have experienced no significant effect (Watt and Hinks 1999; Figure 7).

Recently, a 1999 study, published in the scientific journal *Nature*, noted that rates of acidic

Figure 7: Nova Scotia Salmon Rivers
Mean pH of 68 Rivers & Salmon habitat



Source:Watt and Hinks 1999

deposition from the atmosphere (i.e. acid rain) decreased throughout the 1980s and 1990s, but found that reduced emissions do not immediately cause improvement in aquatic ecosystems (Stoddard et al. 1999). The study concluded that it is possible that the acid-neutralizing chemicals found in rocks and soils have been depleted due to many years of acid rain deposition in several areas of eastern North America, and that the ability of rivers and lakes to recover has therefore been eroded over time.

5.2 Wild Atlantic Salmon Population Trends

> "Thirty years ago, about one and half million small and large Atlantic salmon (*Salmo salar*) returned each year to spawn in their natal rivers in eastern North America. Today, only about 350,000 do so. That's a reduction of more than 75%." (Anderson et al. 2000)

Wild Atlantic salmon is no longer a commercial species in the Maritimes; the last commercial fishery was closed in 1985 (Taylor 1999). The Department of Fisheries and Oceans revealed in 1998 that only 21 of the 71 Canadian Atlantic salmon rivers met their minimum spawning targets. As a direct result of the decline in wild populations, recreational salmon fishing is greatly restricted. In 1999, only 22 of Nova Scotia's 72 salmon rivers were open to recreational salmon angling. In 1999, the U.S. Department of Interior proposed that wild salmon populations in parts of Maine be classified as endangered under the Endangered Species Act (Anderson 2000). Similarly, the Canadian Department of Fisheries and Oceans has submitted a request to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that salmon populations in the Bay of Fundy be listed as endangered.

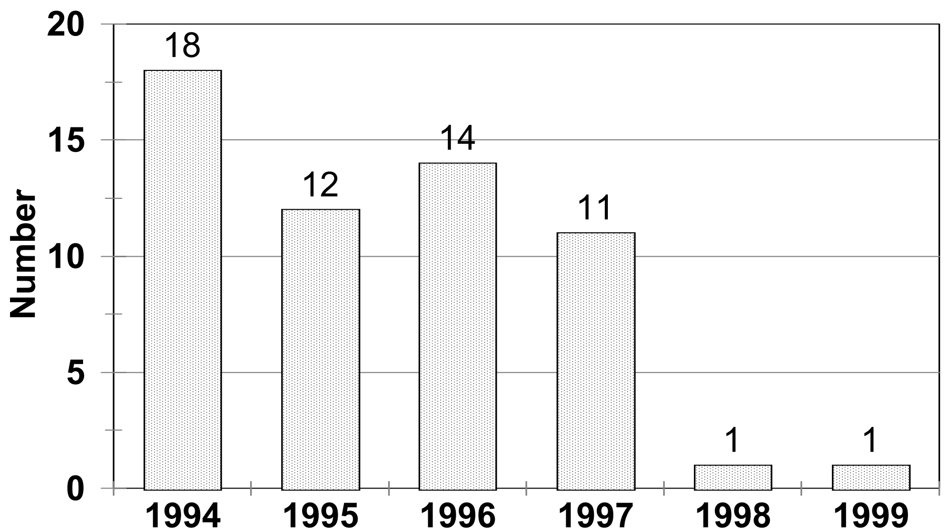
Nova Scotia's rivers have experienced the greatest impact in Canada in terms of the percentage of fish habitat affected by acid rain (i.e. acidification; Watt et al. 2000). Several primary freshwater fish species are sensitive to water quality changes. However the best historical data are available for the most sensitive species, Atlantic salmon. Watt et al.(2000) have estimated that the acidification of salmon rivers is responsible for a 33% decline in Atlantic Salmon in Nova Scotia, with a combination of other factors responsible for the remainder of the decline. Other anthropogenic (human-based) causes of the Atlantic salmon's decline include past commercial overfishing, and possibly the effects of the warming of the ocean's waters due to climate change. The continuing decline of Atlantic salmon is also thought to be a result of several additional factors including: depletion of the salmon's food source by commercial fisheries (e.g. capelin); exposure of juvenile salmon to the "endocrine disrupter" nonylphenol, which leads to mortality later in the saltwater phase of the salmon life cycle; interaction between escaped aquaculture salmon (e.g. disease); and continuing ocean perturbations involving temperature (Anderson et al. 2000)

Trends:

According to the Atlantic Salmon Federation, "Canada's wild Atlantic salmon runs have declined by 80% during the past 25 years," (ASF 2000). The low numbers of large salmon returning to spawn is demonstrated in Figures 8-11. The U.S. Fish and Wildlife Service and the U.S. National Marine Fisheries Service recently issued a report claiming that wild Atlantic salmon are now in danger of extinction despite conservation efforts. The report stated that escapes from salmon fish farms (i.e. aquaculture); water withdrawal; and catch and release recreational fishing are all threats to the well-being of wild Atlantic salmon populations.

Figure 8 to 11. Returns of Large Wild Atlantic Salmon to Nova Scotia Rivers[29]

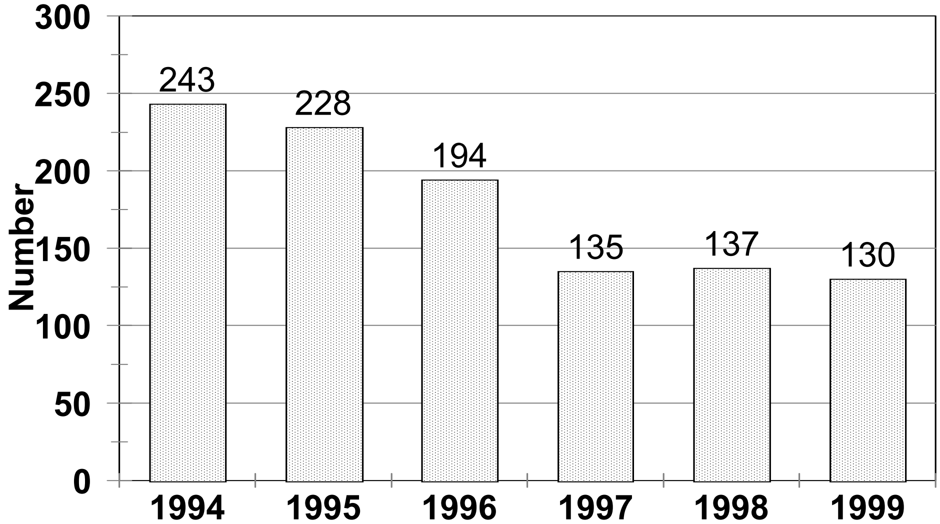
Figure 8. Liscomb River
Large Salmon Returns, 1994 to 1999



Source: DFO Final 1999 Cumulative Counts

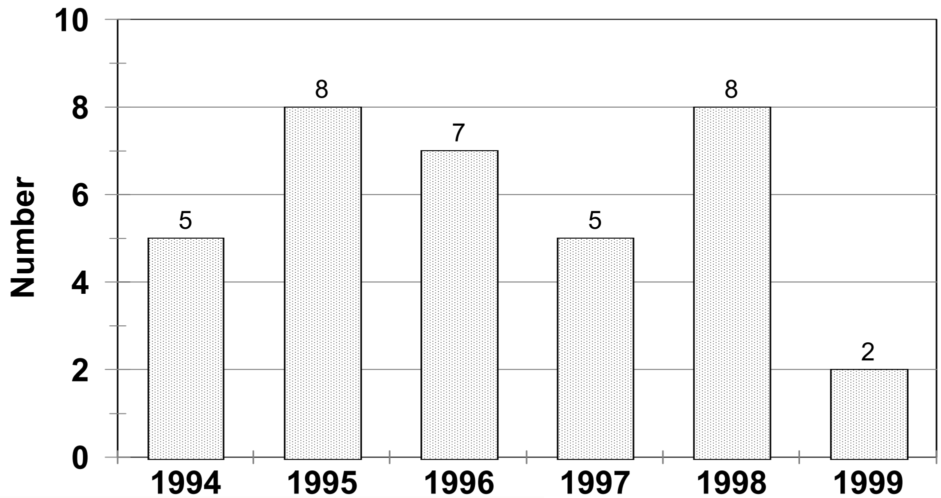
[29] Large Atlantic salmon are salmon that have spent 2 years at sea. The large salmon are necessary for spawning.

Figure 9. LaHave River
Large Salmon Returns 1994 to 1999



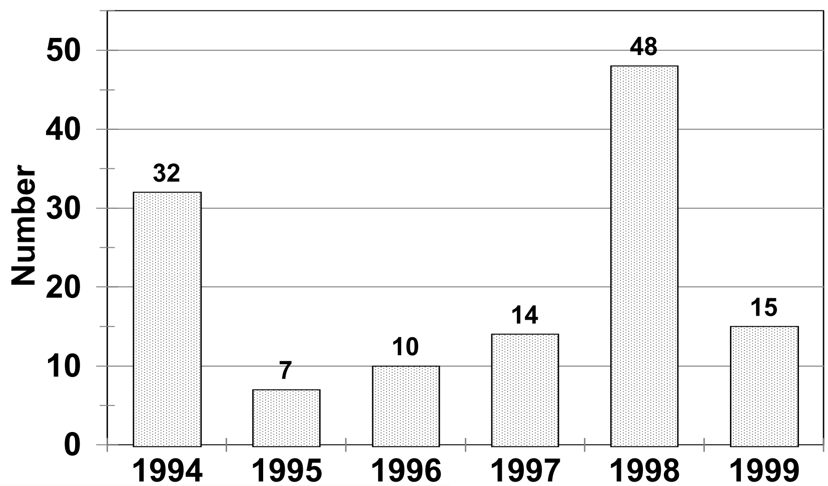
Source: DFO Final 1999 Cumulative Counts

Figure 10. Grand River
Large Salmon Returns1994 to 1999



Source: DFO Final 1999 Cumulative Counts

Figure 11. Sackville River
Large Salmon Returns, 1994 to 1999



Source: DFO Final 1999 Cumulative Counts

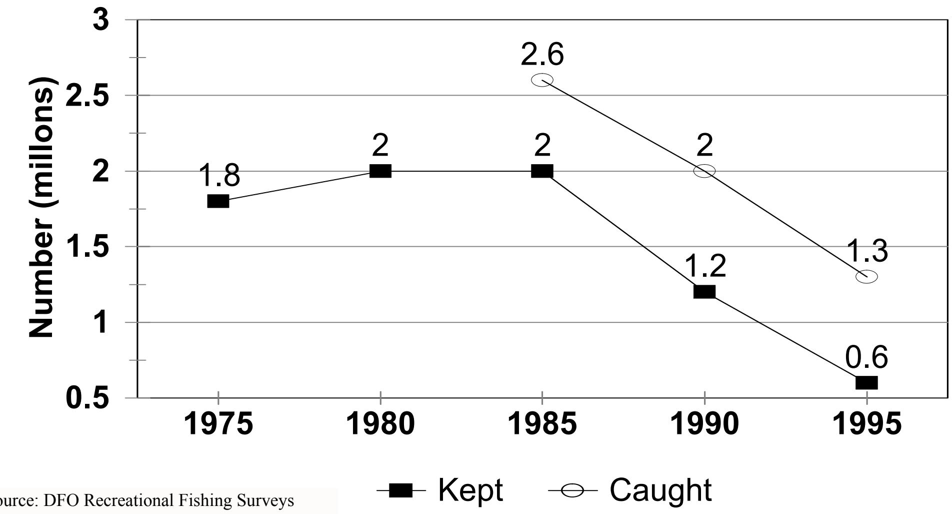
A recent study undertaken in New Brunswick discovered that nonylphenols, which are found in pesticides, urban runoff and sewage effluents, many plastics, and industrial and domestic detergents, have caused gender 'confusion' and developmental irregularities in Atlantic salmon (Fairchild et al. 1999). In addition, increased sediment loads to rivers due to agriculture, forestry activities, and development have several effects on aquatic habitat and fish populations. Increasing the amount of suspended sediment can affect feeding practices and food sources, irritate gills of fish (which can cause death), and destroy protective mucous covering the eyes and scales of fish, thereby leaving them more susceptible to disease and infection. Furthermore, suspended sediment can carry toxic agricultural and industrial compounds such as nonylphenols which cause abnormalities in fish. Sediment particles can also stress fish by increasing the water temperature, because particles absorb warmth from the sun. Finally, the settling of sediments can bury and suffocate fish eggs in spawning beds[30]. Therefore, there is a need for long-term monitoring of sedimentation and siltation, as well as the state of fish habitat.

5.3 Brook Trout Populations

[30] The description of the effects of suspended and settling sediment in aquatic habitat is summarized from Environment Canada's website, Fresh Water: Sediment - Fisheries/Aquatic habitat; http://www.ec.gc.ca/water/en/nature/sedim/e_fish.htm

Recreational brook trout catches are used here as an indicator of brook trout populations in Nova Scotia. The annual catches recorded by the DFO have declined dramatically in tandem with salmon declines[31]. This decline may be a result of over-fishing as well as the result of the acidification of rivers. Since 1985, the number of brook trout caught in the province has declined by 50% from 2.6 million to 1.3 million (Figure 12).

Figure 12. Recreational Brook Trout Caught and Retained in NS, 1975-1995



Source: DFO Recreational Fishing Surveys

[31] DFO Recreational Fishing Surveys: http://www.dfo-mpo.gc.ca/communic/statistics

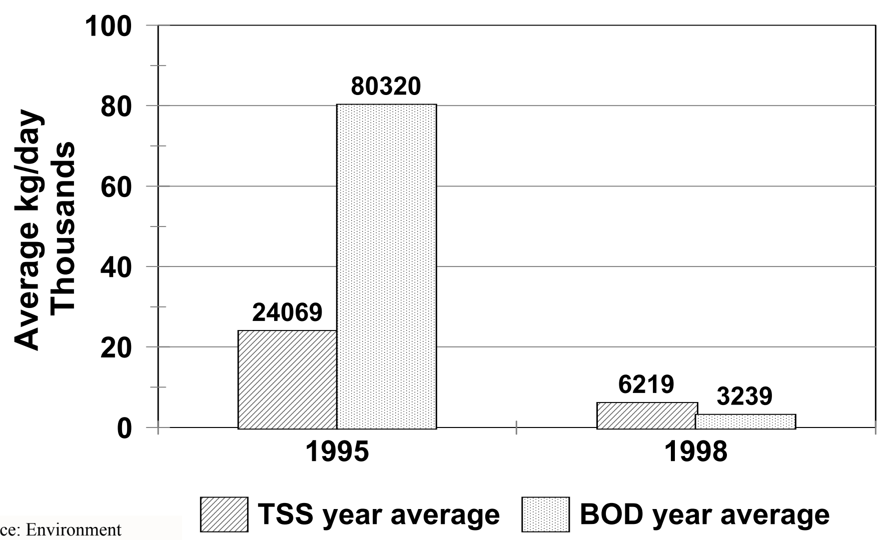
5.4 Wastewater Contaminant Contribution from Pulp and Paper Mills

In 1992, the federal government amended the Pulp and Paper Effluent Regulations under the authority of the Fisheries Act. These amendments included changes in effluent limits as well as a required environmental effects monitoring programme for each pulp and paper mill in Canada. Waste water effluent from mill processes has caused concern because it contained many hazardous chemicals. Pulp and paper effluent data are available for 1995 and 1998 before and after the amendments were fully implemented. Thus, the first Environmental Effect Monitoring cycle was undertaken in 1998[32]. The next cycle will be completed in 2001.

Trends:

Total suspended solids (TSS) and biological oxygen demand (BOD)[33] are reported as the annual average kilograms of contaminant load per day. Both TSS and BOD in the effluent of pulp and paper mills have dramatically decreased since 1995 as a result of improved regulations and the subsequent investment in pollution control (Figure 13). All five major mills in Nova Scotia have significantly decreased TSS and BOD levels.

Figure 13. TSS and BOD in Pulp & Paper Mill Effluent (NS) 1995, 1998

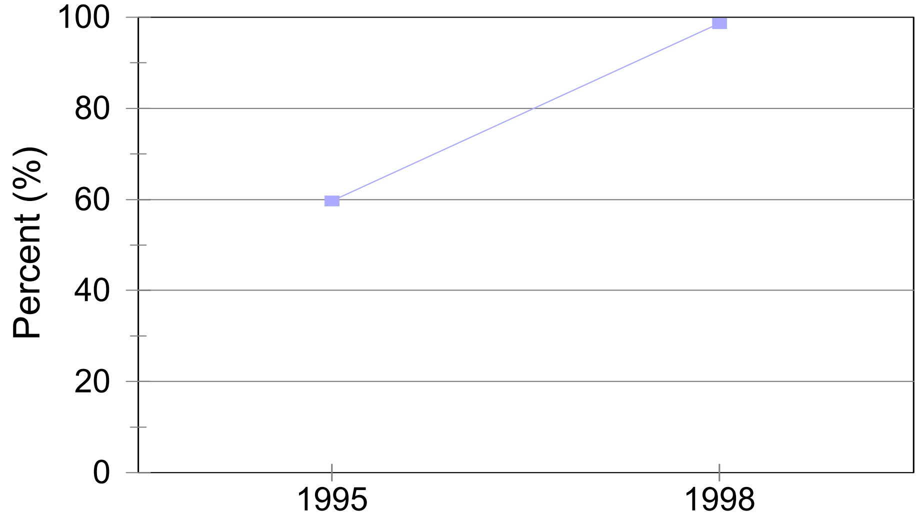


Source: Environment

[32] Data were provided by Environment Canada.
[33] See glossary for definitions.

Trout lethality is also reported and is defined according to the LC50 standard, i.e. a minimum of 50% survival rate of fish exposed to a lethal concentration (LC) dose of effluent over 96 hours. If more than 50% of the fish exposed to mill effluent die within 96 hours of exposure, the effluent is non-compliant. Mill effluent compliance in relation to the LC50 standard has increased from 58.7% in 1995 to 98.7% in 1998 (Figure 14). The changes under the Fisheries Act provided an incentive (i.e. a potential fine) to change aspects of pulp and paper processing. These results signify the effectiveness of regulations for pollution prevention and should promote the use of regulatory legislation for improving water quality.

Figure 14. NS Pulp & Paper Mills
Mill Effluent Compliance* 1995,1998



*According to LC50 (trout lethality) standard

Source: Environment Canada

However, meeting the LC50 goal does not mean that mill effluents are 100% contaminant-free, nor does it ensure that they have no cumulative or chronic impacts on the ecosystem. For example, a recent study showed that rainbow trout exposed to effluent from an oxygen activated sludge treatment plant exhibited signs of distress (e.g. erratic swimming, gasping at the surface, and paralysis) during the first hours of exposure (O'Connor et al. 2000). The cause of the distress of the rainbow trout was elevated levels of carbon dioxide of greater than 100 mg/litre. A survey of mills using oxygen activated sludge treatment systems showed that carbon dioxide levels in effluents ranged from 48 to 251 mg/litre[34]. Therefore, further regulations should call for lowered carbon dioxide levels below 100 mg/litre by using aeration or pH adjustment. The total maximum loading of all pollutants for each watershed should also be considered in future regulatory mechanisms.

[34] According to O'Connor et al (2000), a carbon dioxide concentration of 250 mg/L is lethal to rainbow trout.

6 RECREATIONAL WATER QUALITY

Recreational water use in Nova Scotia is an important sector of the tourism industry as well as an important attribute and indicator of quality of life for those who live here. There are many sources of contaminants that can limit recreational uses, such as sewage, industrial effluents, agricultural runoff (including manure, fertilizers and pesticides), urban storm runoff, oil and gasoline spills, and pollution from boaters. Microbiological contamination from untreated or poorly treated sewage can lead to gastrointestinal illnesses and chemical pollutants like PCBs have been linked to cancerous lesions in marine mammals.

The following indicators of recreational water quality are considered here: restrictions on recreation users due to beach closures; changes in the opportunities for recreational fishing since 1975; and the eutrophication levels of lakes in the Halifax Metro area and Kings County.

6.1 Trends in Beach Closures due to High Bacterial and Parasitic Levels

Beach closures occur mostly in the summer months when air and water temperatures increase, resulting in conditions conducive to bacterial growth. The subsequent increase in evaporation rates results in lower water levels, while beach use soars. Some beaches in Nova Scotia are located near municipal or domestic wastewater treatment facilities or raw sewer outfalls. These effluent sources and summer climatic conditions increase the bacterial content of the surrounding water.

The Guidelines for Canadian Recreational Water Quality stipulate a maximum allowable concentration (MAC) of 2000 E. coli/litre (Health Canada 1992). Above that MAC, contamination becomes a public health concern. When bacterial counts rise above the MAC, the swimming area is closed until the bacterial level is in compliance. Beach closures are an indicator of the prevalence of water-related public health issues and can be a measure of potential lost recreational and tourism opportunities. Studies on the willingness-to-pay and travel costs of beach users in Ontario indicate that the benefits due to surface water quality improvements are worth over $70/year (1997$) per household that participate in beach activities.

Trends:

Beach closure data and information records have not been consistently maintained in Nova Scotia. Limited data have been collected for this survey by informally surveying the Nova Scotia Department of Environment district offices. Closures have been recorded from personal interviews, and thus only the most recent closures have been reported (Table 3). As a result, interpretation of trends over the long-term is not possible since the data are incomplete.

Table 3: Recent Beach Closures Reported for Parts of Nova Scotia

Location	Beach Name	Closed	Length of Closure	Suspected Cause
Lake Milo	Lake Milo	Summer 1994	1 month	Bird nesting site, and poor water circulation
	Lake Milo	Summer 1999	1 month	
Chester	Bayswater Beach	August 1998	2 months	Seasonal freshwater pool became stagnant
Chester	n/a	Summer 1999	3 months	n/a
Pictou	n/a	1998,1999	3 months/year	n/a
Pugwash	Pugwash Beach	Every summer	3 months	Located near outfall from mal-functioning sewage treatment plant
Amherst	Blair Lake	1998	2 weeks	Unknown
Florence	Florence Beach	1998	3 months	n/a
Big Pond	Big Pond Beach	1995	3 months	n/a
N. Sydney	Groves Point	Throughout summers	Undetermined	Near sewer outfall
N. Sydney	Indian Point	Throughout summers	Undetermined	Near sewer outfall

Complications: Lack of reporting and consistent data. If data were available, correlations of beach closures with regional incidence of “contact” water-borne disease would be possible, illustrating the strong links to public health issues. In addition, the losses in recreational days and consequent economic costs could be calculated. A clear data gap exists here of inadequate reporting of recreational water quality. Future data collection and research should be undertaken to adequately monitor the frequency and the costs of beach closures.

6.2 Participation in water-based activities

Trends in participation in water-based activities can reveal changes in the opportunity for recreational uses that reflect the water quality of lakes, rivers and coastal areas. Additionally, the level of recreational activities may reveal public perceptions of water quality in a certain area or region. The Department of Fisheries and Oceans maintains an on-line database for Recreational

Fishing Surveys across Canada[35], including national and provincial data, which is used in the following indicator of recreational fishing trends in Nova Scotia.

6.2.1 Recreational Fishing Trends

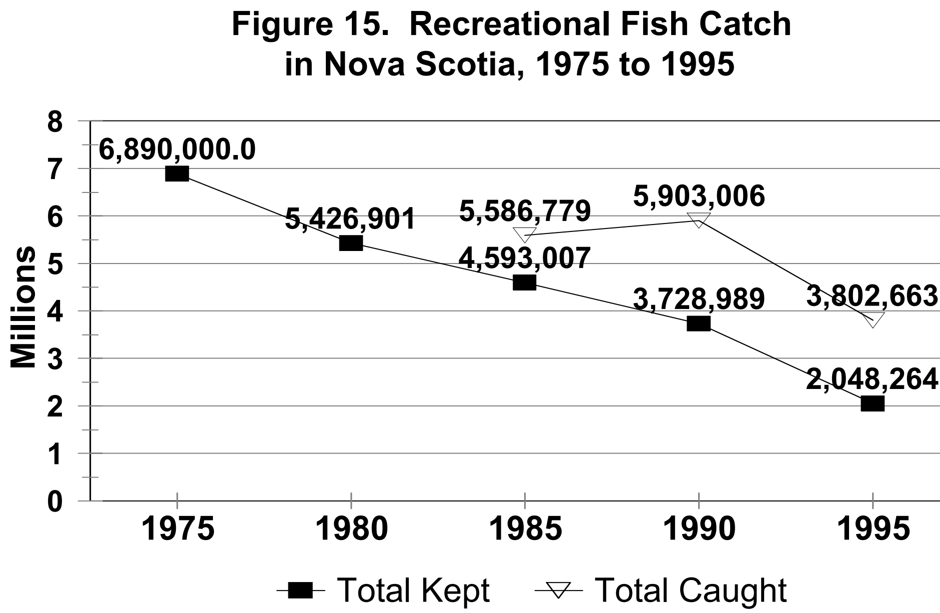
According to the DFO Recreational Fishing Survey water quality is the number one factor determining the choice of fishing destination in Nova Scotia for residents and visitors (Table 4). Other important factors include: lack of pollutants in fish, presence of favourite species, lack of angler crowding, and the natural beauty of the area. All five top-ranked factors reflect a preference for an experience that emphasizes a pristine environment. In other words, environmental conservation and investment in the natural capital of Nova Scotia's wild areas is essential for this economic sector.

Table 4. The Top Five Factors For Choice of Destination for Recreational Fishing

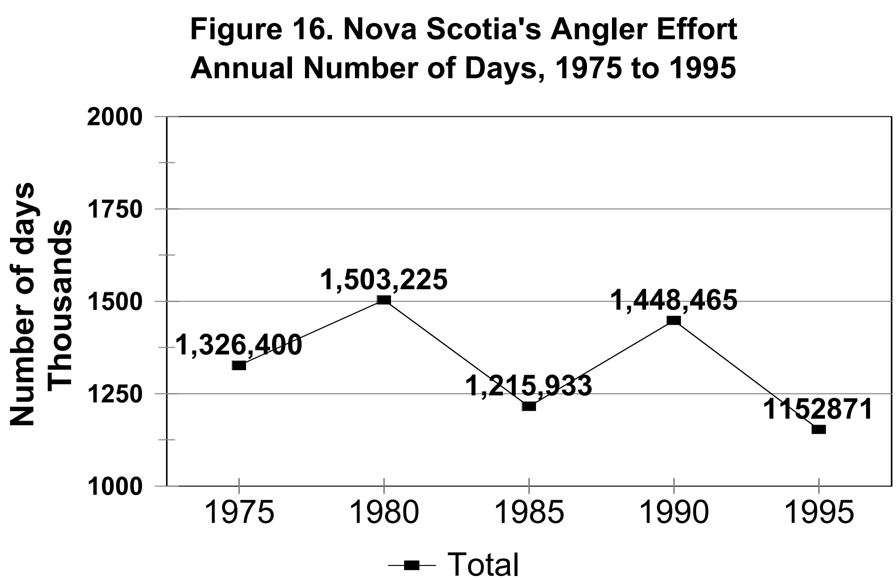
Factor	Ranking
Water Quality	1
Lack of Pollutants in Fish	2
Presence of Favourite Species	3
Lack of Angler Crowding	4
Natural Beauty of the Area	5

According to the same survey, anglers in Nova Scotia indicated an improvement in recreational fishing quality from 1990 to 1995. However, their perception does not concur with the actual trend in recreational fishing opportunities. The number of recreational fish caught has dramatically and steadily declined since 1975, with the most dramatic decline in the 1990s (Figure 15). Between 1975 and 1995, the total number of recreational fish retained declined by about 5 million fish or 70%. Anglers today are catching less than a third as many fish as they did 20 years ago. The total recreational catch declined by approximately 2 million fish between 1990 and 1995.

[35] http://www.dfo-mpo.gc.ca/communic/statistics



Source: DFO Recreational Fishing Survey 1975, 1980, 1985, 1990, 1995

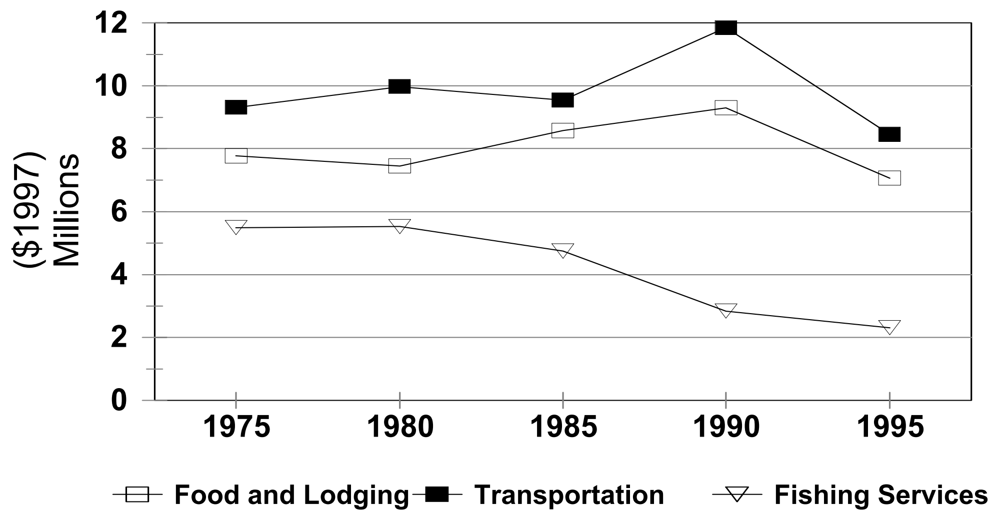


Source: DFO Recreational Fishing Survey 1975, 1980, 1985, 1990, 1995

The angler effort (i.e. the number of days spent fishing per year), has also declined since 1980, though not steadily, with 1.5 million days in 1980, 1.2 million days in 1985, and 1.4 million days in 1990 (Figure 16). In 1995, the DFO Recreational Fishing Survey reported the lowest number of anglers in two decades (1.18 million).

Angler expenditures on food, lodging, and transportation in Nova Scotia follow similar decreasing trends with food, lodging and transportation expenditures roughly paralleling angler effort trends, and fishing services expenditures mirroring the decline in fish catch. With the most dramatic drops in both angler efforts and fish catch occurring in the 1990's, the most recent period has also seen the largest economic losses with a 22% decline in total recreational fishing expenditures between 1990 and 1995 alone (Figure 17).

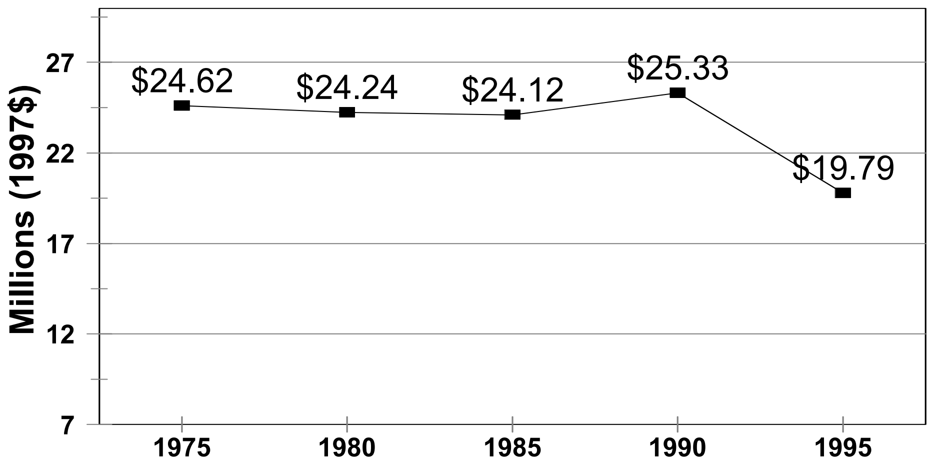
Figure 17. Recreational Anglers' Expenditures in Nova Scotia 1975-1995



Source: DFO Recreational Fishing Survey 1975, 1980, 1985, 1990, 1995

Thus, as a result of a decline in the number of fish caught and retained, and a decrease in fishing days between 1990 and 1995, expenditures on transportation fell by about $3.8 million, and expenditures on food and lodging fell by about $3 million. Between 1975 and 1995, expenditures on fishing gear declined by more than 50%. Total recreational fishing expenditures, converted to 1997 dollars (i.e. constant dollars), indicate annual expenditures of approximately $24 million to $25 million from 1975 to 1990, followed by a decline of $5.5 million between 1990 and 1995 (Figure 18).

Figure 18. Total Recreational Fishing Expenditures in Nova Scotia1975-1995



Source: DFO Recreational Fishing Survey 1975, 1980, 1985, 1990, 1995

The declining trend in Nova Scotia's recreational fishing is demonstrated by the steady decrease in the number of brook trout kept in Figure 12 and in the total recreational fish catch in Figure 15. However, the economic result of the decline in the quality and quantity of fishing did not surface until the mid 1990s. The loss in economic value is shown in Figure 18 with a decrease in total expenditures of $5.5 million (1997$). This may have occurred because of a gradual realization of the declining quality of recreational fishing in Nova Scotia that eventually cumulated in a major economic loss in 1995, and a decrease of approximately 300,000 days of angling activity.

In short, a dramatic decline in recreational fishing in the 1990s has occurred. The consequent economic loss may be due to the depreciation of Nova Scotia's natural capital. This illustrates that a disinvestment or loss in natural capital (i.e. freshwater and coastal ecosystems) can produce significant and direct financial loss to the Nova Scotia economy.

6.3 Eutrophication of Lakes

Eutrophication is a natural process that takes place over geological time, turning lakes into bogs, and eventually converting the bog to land. Human activities are introducing extremely high concentrations of nutrients such as phosphorus and nitrogen in many aquatic areas, which is artificially speeding up the process of eutrophication. When nutrients are added to water, they cause plant life to flourish, which can change the dynamic within the water body with respect to wildlife habitat (i.e. can choke a lake with plant life). When the plant life dies, the decomposition of the organic matter utilizes the available dissolved oxygen, depleting oxygen for fish and other aquatic organisms. Sources of nutrient loadings that contribute to accelerated eutrophication include fertilizer runoff (chemical and manure), sewage, and nutrients suspended in soil/sediment resulting from the activity of households, agriculture and forestry.

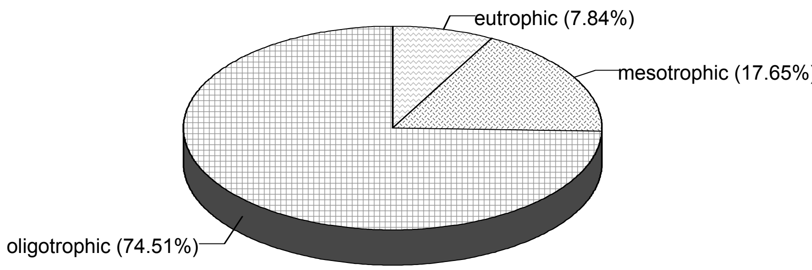
The trophic status of lakes is based upon their level of biological productivity, which is highly dependent on the nutrient "richness" of the water itself. Lakes and ponds become un-naturally eutrophic when they receive large supplies of nutrients to their waters through anthropogenic sources, sending the natural aging process of lakes into "fast-forward". Lakes are, therefore, classified as: 1) oligotrophic when they are low in nutrients, low in plant biomass, and maintain high oxygen levels in deep water; 2) mesotrophic with intermediate levels of nutrients, plants and oxygen; and, 3) eutrophic when nutrient levels are high, plant biomass is high, and a significant reduction in oxygen levels in deep water is observed during the summer. According to Michael et al. (1998), eutrophication of lakes is mostly caused by non-point pollution from development, silviculture and agriculture. Eutrophication results in poor water clarity and reduced oxygen availability in the water, and often causes a change in the biological community such as declines in fish species.

Results:

In 1974, Environment Canada sampled six Halifax Metro lakes, which were re-sampled by the Soil and Water Conservation Society of Metro Halifax in 1990, for nutrient load modeling and to assess stages of eutrophication (SWCSMH 1991). Over this time period, which is extremely short in the context of the natural life of lakes, the trophic status index increased for five of the six lakes.

In 1991, the Department of Fisheries and Oceans sampled 51 lakes in the Halifax-Dartmouth Metro area (Keizer et al. 1993). The results indicated that four lakes were eutrophic (7.8%), nine lakes were mesotrophic (17.6%), and the remainder were all oligotrophic (74.5%; Figure 19). Keizer et al. (1993) state that their results only provide a one-time sample. However, they point out that lakes in this area are all naturally oligotrophic, and that human activities have already increased phosphorus levels sufficiently to cause a significant change in the trophic status of nearly one-quarter of Metro lakes. In other words, if this trend continues unabated, Metro lakes will be in danger of not supporting recreational use and diverse fish populations.

Figure 19. Trophic Status for 51 Lakes in Halifax Metro Area



Source: Keizer et al. 1993

Table 5. Eutrophic Lakes in Halifax/Dartmouth Metro Area

Eutrophic Lakes
Oathill
Bissett
Settle
First

Nine lakes in King's County were monitored between 1993 and 1999, by volunteers, for trophic state indicators (i.e. total phosphorus, chlorophyll, and transparency)[36]. Results indicated a slight increase in nutrient concentrations (i.e. total phosphorus) over time, but all lakes either remained oligotrophic or were approaching mesotrophic conditions[37].

[36] King's County Volunteer Lake Monitoring Programme
[37] D. Taylor, NSDOE; pers. comm.

However, there is no comprehensive water quality database which addresses the trophic status of lakes for other areas of the province. Only site-specific or region-specific surveys have been undertaken as in the above studies where substantial development pressures have been identified This is currently a significant data gap because we are unable to make a broader assessment of the trophic status trends of Nova Scotia's lakes.

The increase of nutrient loadings is economically and socially significant given the importance of recreation and overall water quality. Recreational users want clean shorelines, clear water and desirable fish species (Keizer et al. 1993). Water clarity and quality pertaining to the trophic status of lakes also has an economic effect on property values. In Orange County, Florida, researchers found that the degree of eutrophication had an impact on lakefront property values (Feather 1992). The study concluded that each unit increase in the trophic state index results in a US$1,549 (1983 U.S. dollars) decline in the parcel selling price. A similar study in Maine, found that a one metre improvement in water clarity increased property values by US$34/ foot of water frontage to US$81/ foot of water frontage.

7 WETLANDS, ESTUARIES AND COASTAL AREAS

7.1 Areas closed to shellfishing

Disposal of untreated sewage into our marine waterways has many negative environmental effects on aquatic habitats and marine resources. Filter feeding organisms like oysters, mussels and soft shell clams live within our estuaries and along the mud flats of Nova Scotia. If the surrounding waters are contaminated with high bacterial levels (often attributed to untreated sewage disposal), the shellfish tissue itself becomes contaminated.

Consumption of shellfish from contaminated areas can cause serious illness, generating public health issues. Shellfish area closures in Nova Scotia are sadly common. These closed areas were once used for market, recreational and subsistence harvest. Closure of shellfish beds due to bacterial contamination creates serious negative impacts and costs to the environment, the community, and the economy.

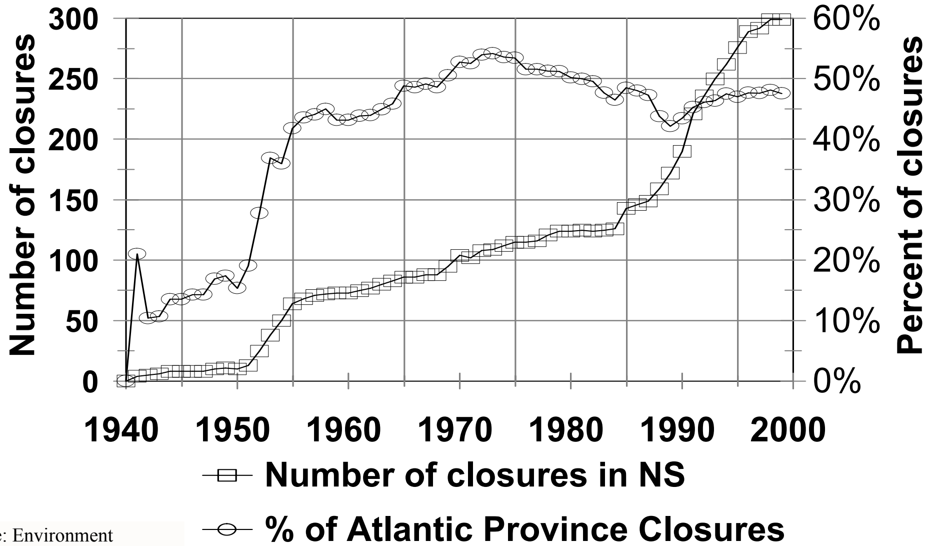
The State of the Nova Scotia Environment Report (1998) shows that Nova Scotia has the highest number of closed shellfishing areas in the Atlantic provinces, accounting for about half the region's total. However, the report does not record the relative size of the closures. The most recent data collected by Environment Canada (1999) assess the total *size* of shellfish beds closed annually to shellfishing. From the perspective of sustainable development, the indicator "goal" is zero closed areas, the same as the "pre-impact" condition of the resource.

Results:

According to the Nova Scotia Department of Environment, the number of shellfish closures has increased steadily since the 1940s (Figure 20). The number of shellfish closures has more than doubled in the last 15 years alone. In addition, the number of closures has increased since 1995, from 276 closures to 299 in 1999. In the most recent data, Nova Scotia still has the highest percentage of Atlantic Canada shellfish closures.

Currently, Nova Scotia accounts for about 47% of the total number of closed areas in Atlantic Canada. *The State of the Nova Scotia Environment* (1998) reported that 700 sq. km. were closed to shellfish harvesting in 1995. According to Environment Canada, this area has increased by 264 sq. km. (1999) over the past 4 years alone, a 38% increase in a very short period of time. This indicates that although the number of closures has not changed dramatically, the actual area closed (sq. km) has significantly increased. An increasing trend in closures signifies a decline in water quality in estuaries and coastal areas.

Figure 20. Shellfish Closures in Nova Scotia, 1940 to Present



Source: Environment Canada

This is an example of how the depreciation of natural capital can produce direct economic losses. Unfortunately, our conventional economic accounting system cannot elucidate this connection because the value of natural capital is not acknowledged and its depreciation, therefore, remains invisible. Even as a potential contribution to GDP, foregone revenues from shellfish harvesting are not recognized because our conventional accounts contain no benchmarks of sustainable resource use that allow current harvest levels to be assessed against original or potential stock levels. Integrated environmental-economic accounting, as proposed in the Genuine Progress Index, is essential if policy-makers are to understand the intimate connection between natural wealth and economic wealth, and to act wisely to protect and enhance both.

Another effect of the decrease in shellfisheries and other commercial species like Atlantic salmon has been to expand investment in aquaculture, which is a man-made replacement of natural stocks. Aquaculture comes at a cost, both monetarily and environmentally. It costs to set up an aquaculture business and maintain an aquatic environment for the fish, and it costs the environment because the high density of fish populations creates a high demand on the local environment, and because diseases contracted by the farmed fish can be spread to wild stocks by escapees.

7.2 Area of Wetland Lost since Colonization

Wetlands perform a variety of important ecological functions. Wetlands provide important habitats and landscapes that require recognition, protection, and enhancement of their value. With regard to water resources, wetlands provide important treatment functions to improve the quality of water. For example, wetlands have the ability to store large volumes of water, to filter water, and to release water slowly and they therefore provide important flood protection functions.

According to the U.S. GPI report (Anielski and Rowe 1999),

> "Wetlands contain some of the most productive habitat in the world. Yet their value is not represented in economic accounts because the benefits - such as regulating and purifying water and providing habitat for fish and waterfowl - are generally 'public goods,' for which there is no overt price. When a farmer drains and fills a marsh, the GDP rises by the increased output of the farm. However, the loss of services from the wetland goes uncounted. The GPI rectifies this by estimating the value of the services that are given up when wetlands acreage is converted to other purposes."

The U.S. GPI account estimates the value of ecological services lost due to the accumulated loss of wetlands in the U.S.A. at roughly $349.9 billion.

Much of Canada's wetlands have been lost, especially in and around urban centers. Nova Scotia has lost large tracts of salt marsh to the dyking activities of the original Acadian settlers who converted salt marshes to productive agricultural land. The loss of wetlands, however, brings the loss of the important ecological functions they perform, which in turn, protect and enhance our water resources. In addition, wetlands provide important bird habitat for local and migratory populations. Saltwater wetlands along the Nova Scotia coast, where heavy wave and wind action work to erode the shore line, provide vital protection from erosion processes, and help store and prevent the loss of valuable nutrients and minerals.

The most important wetland functions include (Bowron et al. 1999, de Groot 1992):

- flood prevention;
- shoreline protection and erosion prevention;
- storm control;
- water purification;
- storage and recycling of human waste;
- spawning and nursery habitat for commercial and non-commercial fish and shellfish;
- sanctuary, breeding and nursery habitat for terrestrial, near-shore, and migratory birds;

- feeding habitat for terrestrial wildlife;
- nutrient cycling, production and storage;
- waste treatment;
- recreation;
- food production; and,
- education and science uses.

The point here is not to discount or diminish the value of the output provided by farms or other economic activities performed on areas converted from wetlands. These outputs are already recorded in the GDP and have assigned value. The point of the GPI is simply to provide a more accurate and comprehensive picture, by *also* recording the foregone economic value of the lost wetland functions and the potential cost of replacing the valuable services once provided by these wetlands. The same logic would apply if this productive farmland were then converted to urban development. A realistic and comprehensive assessment and valuation would not record *only* the benefit and value of the new urban outputs, but would balance that against the lost and foregone value provided by the farm. By adopting a cost-benefit approach to accounting that includes social and environmental valuations, the Genuine Progress Index can help remedy some of the serious flaws in our present reliance on a current income accounting system that is limited to a narrow range of tradable market values alone. This assessment of the value of lost wetland functions should be understood in that context.

Trends:

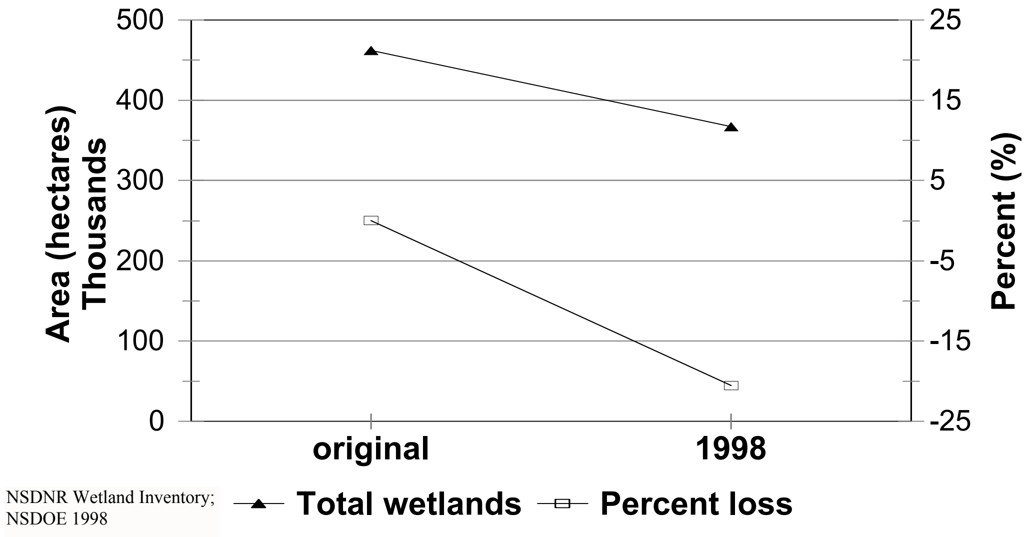
The State of the Nova Scotia Environment (1998) estimated that losses of freshwater wetland habitat in Atlantic Canada since settlement range from 16 to 18% (pg.25). A wetland inventory has been updated since the release of The State of the Nova Scotia Environment in 1998. Using the new inventory, and assuming that a mid range of 17% of freshwater wetland area has been lost in Nova Scotia, the original area of freshwater wetlands in Nova Scotia was 429,483 hectares. Additionally, a 62% loss in the provincial area of saltwater wetlands has been estimated by the Department of Natural Resources.

Overall, approximately 20.5% of original fresh and salt wetlands have been lost since colonization, approximately 75,000 ha, in total across Nova Scotia (Figure 21). According to the estimates from the 1984 and 1998 inventories there has been an increase in wetland area. However, the Nova Scotia Department of Natural Resources indicates this is a reflection of the change in the method of inventory and that a recorded increase in area was anticipated because of increased accuracy in reporting[38]. Therefore, only the latest and most accurate inventory is included here.

[38] Personal communication, Wetlands and Coastal Habitats Programme, Nova Scotia Department of Natural Resources.

There is no current source for an estimate of the rate of shoreline erosion due to the loss in saltwater wetlands. This is an important data gap that needs to be filled, because there are several

Figure 21. Losses in Total Wetlands Area (ha) & Percent loss



direct and indirect economic costs associated with shoreline erosion such as a decline in property values and loss of habitat. However, it is very likely that the rate of erosion along Nova Scotia's shorelines is accelerating due to the loss of wetlands.

7.3 Area of Wetland Restored or Rehabilitated in Nova Scotia

Several agencies in Nova Scotia have participated in wetland restoration projects, including Ducks Unlimited, the Canadian Wildlife Service, the Nova Scotia Department of Natural Resources, and Eastern Habitat Joint Venture. Often, the thrust of restoration initiatives is to recreate viable habitat. However, the role of wetlands in performing important ecological functions beyond habitat provision is also recognized, and the success of habitat restoration depends directly on the ability of the wetland to perform those ecological functions on which species rely.

Wetland restoration has proven to be a cost effective means of purifying water runoff, regulating water flow and temperature, and providing habitat for a range of terrestrial and aquatic species. Communities can benefit from wetland restoration because of increased tourism and recreation opportunities, educational and scientific study visits, storm control and shoreline stabilization, improved water quality and waste treatment, enhancement of biological diversity, protection of wildlife, sediment stabilization, and community pride (Bowron et al. 1999).

Raw data on wetland restoration are available in files at the Nova Scotia Department of Natural Resources (NSDNR) and at Ducks Unlimited, but the NSDNR has indicated that there is no staff or time to pull this information together. However, Figure 21 accounts for the latest inventory of wetlands in the province, and this includes restored wetlands.

8 CONTAMINATED AREAS

8.1 Number and Area of Contaminated Sites in Nova Scotia

All contaminated sites have the potential to impact water resources negatively, including groundwater sources, streams and rivers. Contaminated sites can vary in size, and are generally created when waste is improperly disposed. Contaminated sites in Nova Scotia have been identified by the N.S. Department of Environment. Information on each site was collected through Phase I site assessment visits in 1992 and 1993. Sites were assessed according to location, type of contaminant, qualitative assessment of contaminant level, and the potential for water contamination.

Sites included in this re-classified database had been previously identified and classified as medium to high risk sites in a study conducted in late 1980s. Sites previously identified as “low” risk are not included in this re-classified database. The new database was developed to help establish priorities for contaminated site clean-up efforts. Time series trend data are not possible, but the magnitude of the problem is important in itself.

Results:

There are a total of 375 contaminated sites in Nova Scotia. Of this total, 72 have been re-classified as medium low, medium, and high risk sites based on a scoring system (CCME 1992). Thus, the other 303 sites remain classified as low risk sites. The 72 reclassified sites are categorized based on the level of risk, be it high, medium, or medium low. The site risk category is based on: a) the characteristics of the contaminant such as the degree of hazard, and quantity; b) the risk and/or actual exposure of the contamination to groundwater, surface water, and direct contact by humans and wildlife; and, c) the risk regarding human and wildlife health, including the impact on drinking water supplies and land use. Based on these criteria, 2.8% of the sites are classified as high risk (Class 1), 61.4% are medium risk, and 35.7% are medium low risk (Figure 22).

When the area (ha) of each site is considered, medium risk sites account for 83.1% (473 hectares) of contaminated areas, high risk sites account for 4% (23 hectares) of contaminated areas, and medium low risk sites for 12.8% (73 hectares; Figure 23). The names and locations of sites are available through the NSDOE.

Figure 22. Number of Contaminated Sites in Nova Scotia

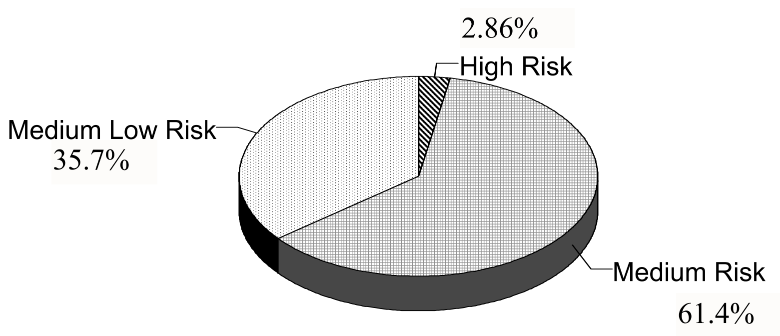
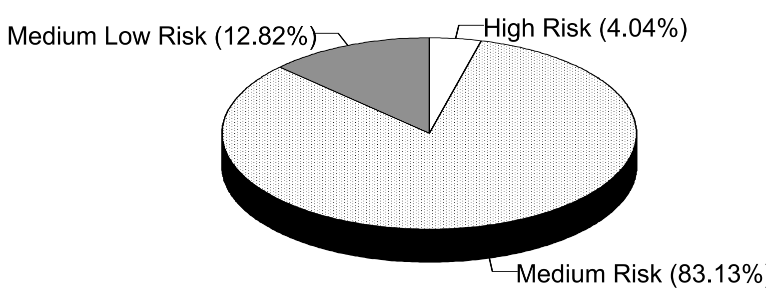


Figure 23. Area of Contaminated Sites in Nova Scotia



Class 1 (High Risk) = 2 sites
Class 2 (Medium Risk) = 43 sites
Class 3 (Medium Low Risk) = 25 sites
Total Contaminated sites = 72 sites
(2 sites are unclassified)

Source: NSDOE Contaminated Sites database

Part II: WATER VALUES AND THE COSTS OF WATER POLLUTION AND WATER QUALITY DECLINE

The overall economic value of water resources and water quality for Nova Scotia is considered in the following section. The real economic value of clean water is infinite to human society and all living organisms, as we are dependent on water for life itself. In an industrial-based society we rely heavily on all our natural assets including water not only for our basic personal daily needs (i.e. drinking, bathing etc.), but also for our manufactured economy. In addition, most of our wastes are disposed either directly into water bodies or into terrestrial areas in ways that frequently affect the nearby water resources. Aquatic ecosystems are also important for marine life and diversity which, in turn, affect the health of human society. Consequently, human society is completely dependent on the earth's water resources, while its activities often pollute, degrade, and/or deplete them.

Water resources, therefore, have many social, economic and ecological values. Because the value of water resources is dependent on clean, healthy water, investment is necessary to maintain and protect this natural asset just as it would be to maintain the value of manufactured capital assets. Natural assets or resources can be referred to as natural capital. Just as we consider manufactured capital an asset in our economic indicators (i.e. GDP), so we must account for the natural capital assets that are intrinsic to our very livelihood. The GDP and related market statistics currently give no value to our natural capital assets. On the contrary, these conventional accounts actually record natural resource depletion as gain, because they only count their "use value" when incorporated into industrial production and sold at the market price. This is simply bad accounting - like a factory owner selling off machinery and counting it as profit. By contrast, the GPI assesses the values of water resources and water quality as natural capital assets that provide valuable services for human society and for ecosystems.

To maintain and protect our natural water assets (i.e. capital), it is necessary, from the GPI perspective, to invest in "defensive" and "avoidance" expenditures as defined below. The cost-effectiveness of these expenditures can be assessed by quantifying the costs of a decline in water ecosystem services, and by the costs of a decline in water quality. Some costs can be directly quantified using market-related proxies like the effect of water quality decline on property values for example. Indirect market-related measurement techniques also exist, for some cost estimates like the effect of water quality decline on recreational opportunities (e.g. swimming) and wilderness areas. Non-market techniques such as willingness-to-pay (WTP) are also helpful in estimating non-use values like existence and option values.

The full value of our natural capital assets can only be maintained when these impacts and costs are "internalized," or included in market prices. Therefore, the GPI employs the "polluter pays" philosophy in its accounts. For example, when water bodies are used as waste repositories, the user is responsible for controlling pollution to the full extent required, for restoring damaged environmental resources, and for compensating those suffering damage.[39] To the extent that industrial users pass on their pollution prevention and environmental restoration expenses to consumers, as is the norm, market prices should reflect the actual costs of water use and pollution. The "polluter pays" principle, and the notion that resource use and pollution should reflect their true costs in market prices form the basis of the GPI water quality account. Full-cost accounting for water resources and water quality seeks to assess the full costs of human activities to water resources, the investment necessary to maintain and protect natural water capital, and the market and non-market impacts that result from this human activity.

GPI water quality account was developed with available data in mind, and in an attempt to include all possible "costs" and values. The overall valuation of water resources in Nova Scotia is based on extrapolations from the benefits identified in previous studies. Defensive, avoidance, market-related and non-market values are also included in the analysis.

Defensive environmental expenditures are costs being incurred, or costs that should be incurred, to halt pollutant additions to water resources. Once asset depreciation has occurred, defensive expenditures are necessary, even if regrettable. For example, if a society is less peaceful, and experiences more crime, then more prisons may be needed even though they are a cost of crime and a defensive (or regrettable) expenditure. Similarly, if water quality deteriorates and water capital depreciation occurs, then defensive spending is required both to prevent the situation from getting worse and to try to restore resource value.

Defensive expenditures should not reflect a gain in well being, as the use of the GDP to measure progress implies, until the value of the capital asset is restored. Currently prisons and pollution clean-up contribute to GDP, and the consequent economic growth is misinterpreted as improved prosperity. In the GPI, which registers crime and pollution as costs rather than gain, defensive expenditures on prisons and pollution clean up are seen as proxies for damage already incurred. *If* that defensive spending is real investment in social or natural capital, it will yield a future flow of services that will then register as gains rather than costs to human society. For example, a successful prisoner rehabilitation program or harbour clean-up may contribute to a more peaceful society or improved water quality that will produce benefits like less crime and less shellfish closures. In short, essential defensive expenditures can be *both* "costs" of prior harmful action *and* potential investments in the future.

In sum, most defensive expenditures are counted as costs in the GPI, because they would not be necessary if damage had not occurred or if resource use were fully sustainable, nor do they directly improve well being. At the same time, this accounting procedure does not imply that such expenditures are unnecessary or should not be taken, and they *may* potentially be positive

[39] Tietenberg, Tom. 1994. *Environmental Economics and Policy*. (New York, USA: Harper Collins College Publishers) pg. 406.

investments. The gains are then recorded as the investments bear fruit and when a restored environment yields improved ecosystem services that tend towards pre-damage levels. Preventive expenditures, in particular, that actually prevent environmental degradation from occurring, are defensive expenditures that are treated in the GPI as positive investments and contributions to well-being.

The United Nations defines defensive expenditures in relation to the environment as:

> "The actual environmental protection costs involved in preventing or neutralizing a decrease in environmental quality, as well as the actual expenditures that are necessary to compensate for or repair the negative impacts of an actually deteriorated environment."[40]

Similarly, Statistics Canada defines defensive expenditures (or regrettable expenditures) as those "undertaken to maintain a given level of welfare or to defend against a decline in welfare."[41] Therefore, a genuine index of progress should only increase when net well-being improves. The GDP currently does not make this distinction, with financial compensations for environmental degradation being added to the economic growth statistics and here misinterpreted as an indicator of improved economic well-being.

There is clearly some ambiguity in determining whether defensive expenditures should be interpreted as productive investments in natural and human capital contributing to a net future gain, or instead, as financial compensations for past incurred costs. The U.S. GPI[42] is based on the latter assumption, whereas, a study by Jarrett (1994) regarded defensive expenditures as productive investment and positive indicators that government was responding to environmental degradation due to human activities[43].

Here, defensive expenditures include preventative, remediative, and avoidance costs are calculated. In the Nova Scotia GPI preventive and remediative costs are seen *both* as proxies for actual damage costs *and* also as potentially positive investments that will eventually result in a *flow* of improved services. Avoidance expenditures are "actual or imputed costs for preventing

[40] United Nations. 1993. *Handbook of National Accounting: Integrated Environmental and Economic Accounts.* U.N. Department of Economic and Social Information and Policy Analysis. Statistics Division.

[41] Statistics Canada. 1997. *Econnections: Linking the Environment and the Economy*. Catalogue No. 16-505-GPE.

[42] Cobb, C., Halstead, T., and Rowe, J. 1995. *The Genuine Progress Indicator: Summary of Data and Methodology*. Redefining Progress. San Francisco.

[43] Jerrett, M.L.B. 1994. *Environmental Assessment of Policy Through Budgetary Analysis: Conceptual Framework and Methods*. Environmental Assessment Review Office.

environmental deterioration by alternative production and consumption processes, or by the reduction of or abstention from economic activities."[44] Avoidance costs do not necessarily result in a flow of improved or restored services. In addition to assessments of defensive expenditures actual damage costs are also determined. These costs are recognized as decreases in *stock* (i.e. natural capital) values.

Not all goods and services with economic value are traded in the money economy. For example, voluntary work, unpaid household work, ecological services, the recreation value of beaches and forests-- all have great economic value. Because they are regarded as "free" from a market perspective, their value to the economy and society is frequently overlooked and ignored. But, without such "free" services and goods, our standard of living and quality of life would decline dramatically. Indeed, some valuable non-market services are essential to life itself. Relying solely on market statistics to assess economic value can therefore send very misleading and even dangerous signals to policy makers. Therefore, the GPI assigns explicit value to the non-market services provided by our water resources.

The costs of degradation/depreciation are included as market-related, non-market, health, and unquantified values. Market-related impacts are measurable market-based values like property value decline or foregone revenues form closed shellfisheries, and can therefore serve as surrogate values for the true full value of the impact. Non-market values and related impacts are specific values calculated for recreation, wetlands, lakes and rivers, using surrogate valuation methods such as replacement cost estimates for lost ecological services, household willingness-to-pay (i.e. contingent valuation), and travel cost models (i.e. how much users will pay to visit a specified location).

Because benefits cannot always be accurately reflected monetarily, all GPI components begin with a set of physical accounts that reflect actual trends in resource use and sustainable harvest. The first part of the GPI water quality account therefore focuses on physical indicators of several water quality issues. In the following sections, the data available for defensive expenditures, pollution abatement costs, damage costs, restoration costs, and health costs are presented. Some of these expenditures have the goal of stopping the degradation of Nova Scotia's water capital, and others protect the existing flow of services from our water resources. All costs and benefits are reported in 1997 dollars using appropriate conversions from the Nova Scotia consumer price index, and currency exchanges are based on the time of data collection.

[44] Nordhaus, W.D., and Kokkelenberg, E.C. (eds.). 1999. *Nature's Numbers: expanding the U.S. national economic accounts to include the environment*., Panel on Integrated Environmental and Economic Accounting, Committee on National Statistics, and Commission on Behavioral and Social Sciences and Education, National Research Council, National Academy of Sciences, Washington, D.C.

9 WATER VALUES

9.1 Lakes and Rivers

Based on estimates by Costanza et al. (1997) the replacement value of ecosystem services and natural capital, Nova Scotia's lakes and rivers contribute at least $3.1 billion per year ($12,187/ha/year)[45], including water supply, water regulation, waste treatment, food production, habitat, and recreation. These estimates per hectare only begin to place a true value on the ecological goods and services provided by the world's ecosystems.

Though monetization is universally recognized as an inadequate means to assess the value of ecosystem services that support life on earth, it is also recognized that *lack* of such valuation has become dangerous. While these services are regarded as "free" and taken for granted there is no incentive for conservation or sustainable use built into an economic accounting system that sets the agenda for the policy arena. So long as resource depletion is counted as gain in our economic accounts and measures of progress, environmentally responsible policy initiatives will be blunted. While monetization is *not* a desirable tool for environmental assessment and valuation, it is temporarily necessary in a world where decision-making is dominated by budgetary considerations. If a service does not have a dollar value, it literally gets no attention. If sustainable resource use cannot be encouraged through education, awareness, and ethical codes alone, then monetary valuation allows tax policy and financial incentives to be shaped to reduce costs for environmentally responsible behaviour and to set penalties for activities that pollute, deplete or damage the environment.

Monetary estimates of the value of ecosystem services are necessarily crude, because these services are not traded in the market place. But it is far more accurate to attempt such a valuation than to assign our natural wealth an arbitrary value of zero in our economic accounts, as is currently the case. The inclusion of social and environmental benefits and costs in our economic accounts and decision-making process certainly corresponds far more closely to reality than the current pretense that such benefits and costs do not exist. Therefore the economic valuations by Costanza and his team of international scientists are a convenient starting point for recognition of the values of ecosystems in providing life-sustaining functions for all life, including human society. These global estimates must now be expanded and developed at the

[45] These estimates are calculated based on estimates, for the value of the ecological goods and services provided by wetlands, lakes and rivers. The area data is from the Department of Natural Resources 1995 GIS forest inventory database. The Costanza et al. estimates were converted to 1997 Canadian dollars. The value calculated for lakes includes the following services: water supply, water regulation, waste treatment, food production, and recreation. The value estimated for wetlands includes the following services: gas regulation, disturbance regulation, water regulation, water supply, waste treatment, habitat, food production, raw materials, recreation and cultural.

national, regional, and local level to reflect the full value of ecosystem services in each jurisdiction. In the meantime, the Nova Scotia GPI estimates can only extrapolate from the global ones to assess the value provided by the provinces lakes and rivers.

9.2 Value of a Forested Watershed for Water Supply

Many municipalities have engaged in a process to protect water supply watersheds. Protection may involve the direct purchase of watershed lands or the design of a community stewardship plan[46]. This is an additional defensive expenditure incurred by the municipalities of Nova Scotia to protect drinking water supplies. Forested watersheds protect the quality of drinking water supplies; control runoff, especially stormwater runoff, and remove air quality pollutants that can harm water bodies through rain deposition, as well as human health. Trees, plants and soil in forests work together to reduce stormwater runoff in urban areas. Stormwater flow is reduced when forests in the surrounding watershed, as well as urban green areas, intercept rainwater--storing, evaporating and slowing the water that must be managed in urban centres. Without heavily forested areas, containment facilities must be constructed to manage the increased flow of water.

The annual cost of watershed protection in the Halifax Regional Municipality is $3/1000 m^3, (HRWC estimate; pers. comm.). Extrapolated to Nova Scotia's annual municipal water use, the cost of watershed protection in Nova Scotia is estimated at $368,544 per year. However, each municipality will incur different costs depending on its particular needs and strategy. For example, the direct purchase of lands will be considerably more costly than the provincial estimate given here.

A classic example of the cost-effectiveness of watershed restoration and protection, to protect a municipality's water supply and the integrity of its water quality, is New York City's purchase of the complete 4,144 square kilometer watershed in the Catskill Mountains that supplies the city's water (Parlange 1999). By the early 1990s, the city recognized that the development of villages, dairy farms and other human enterprises in the watershed was affecting the quality of its water supply. It compared the costs of a new filtration plant (US$8 billion in capital costs plus an annual operating cost of $300 million), to the cost of watershed restoration. City planners found that restoring the integrity of the watershed would cost less than US$2 billion, while, the filtration plant would cost almost US$11 billion just in the first ten years.
In other words, "the hard work of the watershed's forest and soils could save the city as much as US$9 billion over ten years" (Parlange 1999). On a per hectare basis, the

[46]Nova Scotia DOE. 1995. *Nova Scotia Designation of a Protected Water Area*. Halifax, Nova Scotia: Water Resources Branch; Nova Scotia DOE. 1992. *Designing Strategies for Water Supply Watershed Management in Nova Scotia*. Province of Nova Scotia.

watershed purchase and restoration cost is about $4,826/ha, with projected savings worth an estimated $21,718/ha over the first ten years. Therefore, the estimated net benefit is $16,892/ha over the first ten years.

In 1997, New York City began its watershed conservation programme. It bought strips of land adjacent to streams and reservoirs, cleaned up aging septic tank systems, and implemented tighter environmental controls on residents and businesses in the area. The benefits of the restoration option were recognized because the services provided by the natural ecosystem were explicitly valued. Once the watershed was restored, operation and maintenance would cost the municipality almost nothing. This is an excellent example of how clean, natural environments provide direct economic value in providing the services we depend upon for life-support.

Parlange (1999) offers a solution for smaller municipalities that may have trouble financing watershed protection. She reports on a debt-free alternative where,

> "investors could buy a contract called a 'security' from the city in exchange for the right to a proportion of the savings the city generates by not having to build a filtration plant. In [this] case, a $2 billion investment would earn half of the $9 billion savings, or $4.5 billion... a modest $100 investment would earn you $22.50 each year."

Another example of the benefits from a healthy, forested watershed have been illustrated by a regional ecosystem analysis of the United States' Chesapeake Bay region, which includes the greater Baltimore-Washington D.C. area[47]. Using Geographic Information System (GIS) technology, the analysis measured the changing structure of the watershed's landscape and tree cover (American Forests 1999)[48]. The study found that the southeastern watershed has dramatically changed since 1973. Heavily forested areas (high vegetation cover with 50% or greater tree canopy cover) declined from 55% to 38%, and average tree cover declined from 51% to 39%.

The forest and average tree loss resulted in a 19% increase in water runoff. The cost of intercepting the increased water runoff with man-made stormwater retention ponds and other engineered systems is estimated at US$1.08 billion (1999$; US$2/cubic ft. storage). **Therefore, the analysis concludes that the watershed's stormwater retention capacity value decreased from $5.7 billion in 1973 to $4.7 billion, in 1997, a loss of $1 billion[49].**

[47] http://www.americanforests.org/ufc/uea/chesapea/chspkbyanl/index.html

[48] American Forests developed CITYgreen® software to help communities analyze the value of local trees and vegetation as part of urban infrastructure. CITYgreen® is an application of ArcView for Windows.

[49] Stormwater runoff calculations use formulas from the Urban Hydrology of Small Watersheds model (TR-55) developed by the U.S. Natural Resources Conservation Service.

Additionally, the lost tree canopy would have removed about 4.2 million kg (9.3 million pounds) of pollutants from the atmosphere each year, worth an additional estimated US$24 million per year in lost services[50]. The existing tree cover saves the region US$1.08 billion per year, and removes 34 million pounds of pollutants, an additional savings valued at US$88 million per year. 27 year ago, in 1973, the watershed's forests would have removed 43 million pounds (19.5 million kg) of pollutants, worth an estimated $112 million per year.

Watersheds clearly have inherent non-monetary value for protection of wildlife habitat and ecosystem integrity. Additionally they have direct and indirect economic and social value. Forest cover and watershed restoration affect water supplies, stormwater management, and air pollution. **Using the example from the Catskill watershed in New York, the estimated net benefit of a restored watershed is US$16,892/hectare[51]. The estimated value of a forested watershed for the Chesapeake Bay watershed is US$2,237/hectare (per construction cycle[52]), in terms of the forest's interception of water and control of runoff, plus US$49/hectare/year for its removal of air pollutants.**

GPI Atlantic recommends that a similar regional ecosystem analysis be undertaken for all major watersheds in Nova Scotia, to estimate the change in forest cover and its effect on water interception, pollutant removal, and stormwater runoff. These external costs should be internalized as costs to the municipality, to the developers and to the forestry industry when considering urban and commercial development, clearing of land, and clearcutting of forests.

[50] The UFORE model for Air Pollution, developed by David Nowak of the U.S. Forest Service, estimates the amount of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide deposited in tree canopies, as well as the amount of carbon sequestered. It is based on data collected in 50 U.S. cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each U.S. state.

[51] This is a conservative estimate because it does not include the on-going costs of operating the filtration plant after the initial 10 year period, an estimated US$300 million per year.

[52] This is a conservative estimate because it does not include the operating and maintenance costs for the man-made retention structures.

9.3 Water-Based Recreation Value

According to a 1996 survey, "*The Importance of Nature to Canadians*", published by Environment Canada, 630,000 Nova Scotians (85.2% of the total population) participated in nature-related activities in Nova Scotia (DuWors et al. 1999). A second publication by Environment Canada has estimated the economic benefits of nature-related activities for the residents of Nova Scotia (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000). In 1996, the residents of Nova Scotia spent $249.7 million (1997$) on nature-related activities (i.e. direct economic value), which was the greatest revenue among the Maritime provinces. In addition, Nova Scotian residents place an additional economic value of $65.1 million (1997$) on the enjoyment they derive from these activities, over and above their expenditures. Therefore, the overall economic value of nature-related activities by Nova Scotia residents, within Nova Scotia, can be estimated at $314.8 million per year.

Using the same data from the 1996 survey, 316,900 Canadians participated in water-based recreational activities in Nova Scotia[53]. These Canadians took 3.9 million trips for water-based activities in Nova Scotia (2.8 million same-day and 1.1 million overnight trips), for a total of 5.2 million days spent on such activities in Nova Scotia[54]. The average daily expenditure per person, from the 1996 survey, is $20.40 (1997$) on recreational activity in Nova Scotia (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000)[55].

Therefore, based on expenditures of $20.40 per day, the total expenditure on water-based recreational activity in Nova Scotia, by Canadians, is estimated at $106.2 million per year. This value indicates a direct economic value provided by natural areas and the maintenance of high water quality, and demonstrates the importance of preserving natural water capital, especially given the burgeoning tourism industry in the province. An additional economic value based on the enjoyment value placed on water-based recreation is derived from the $65.1 million explained above. **Therefore, the estimated economic value) for water-based recreation above the total expenditures is $43.8 million based on willingness-to-pay (WTP) estimates. Thus, the total direct economic value plus the additional value that is placed on the enjoyment of participating in water-based recreation is estimated at $150 million per year.**

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[53] Special data request by personal communication. March 23, 2000. Michel Villeneuve and Elaine DuWors, Environment Canada.; based on data from: DuWors, E., Villeneuve, M., Filion, F.L., and Burke, D. 1999. *The Importance of Nature to Canadians: A Statistical Compendium for Drainage Basins within Province or Territory in 1996.* Special Report #17. Environmental Economics Branch. Environment Canada. Ottawa.

[54] Personal communication. March 23, 2000. Michel Villeneuve and Elaine DuWors, Environment Canada.; based on data from: DuWors, E., Villeneuve, M., Filion, F.L., and Burke, D. 1999. The Importance of Nature to Canadians: A Statistical Compendium for Drainage Basins within Province or Territory in 1996. Special Report #17. Environmental Economics Branch. Environment Canada. Ottawa.

[55] The expenditures included are: accomodation, transportation, food, equipment, and other items.

9.4 Wetland Values

The total cost in lost ecosystem services due to cumulative wetland losses across Nova Scotia since colonization, and estimated over the past 50 years, is at least $77 billion (1997$). The remaining wetlands contribute a value of at least $7.9 billion per year in ecosystem services and values. See section 12.2.4 for a description of these wetland functions and services. In addition between $2.3 million and $22.8 million or an average of at least $12.5 million can be estimated as the additional economic value of wetlands for Nova Scotian residents, based on willingness to pay (WTP) estimates.

10 DEFENSIVE EXPENDITURES (Regrettable expenditures)

Defensive environmental expenditures are costs being incurred or costs that should be incurred to halt pollutant additions to water resources, and to restore degraded or polluted water resources.

10.1 Cost to Improve Municipal Wastewater Disposal

In Nova Scotia, municipalities operate 103 wastewater treatment plants. 37 municipalities use sewage settling lagoons for treatment, 16 have drying beds for sludge disposal, and 14 use some form of tertiary treatment. Studies conducted in 1996 and 1997 revealed that several municipalities in Nova Scotia require upgrades to wastewater treatment facilities to ensure they meet with effluent quality guidelines[56]. These costs are engineering cost estimates. Investment in appropriate technology will improve resultant effluent quality. These investment costs are defensive expenditures to prevent pollutant additions, and can act as crude and conservative surrogate measures of how much the disposal of untreated wastewater costs the Nova Scotia environment on an annual basis (assuming investment has not yet been made).

If these investments are made, the benefits of lowered contaminant additions can be realized, offsetting the impacts of insufficient wastewater treatment prior to disposal such as closed shellfisheries, beaches and aesthetic degradation. Costs not accounted for by failure to invest in wastewater treatment upgrades include damage to benthic and other marine habitats, disruption of nutrient and food cycles, and disruption of natural ecosystem functioning. In other words true environmental damage costs from inadequate sewage treatment likely far exceed the engineering cost estimates for wastewater treatment upgrades.

Required Engineering Costs Estimate:

The 1996 *Nova Scotia Municipal Infrastructure Needs Assessment*[57] estimated that $535 million was needed for identified sewage system projects due to deficiencies. This included $400 million for Halifax Harbour and $80 million for Industrial Cape Breton. Now, the Halifax Harbour estimate has been reduced to $315 million, so the estimate will have decreased to **$444.8 million (1997$)**. This cost is a crude surrogate measure of the costs of untreated wastewater disposal to

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[56] Department of Municipal Affairs. 1996-1997. “Province-Wide Summary of Deficiencies”, *Municipal Affairs Infrastructure Inventory.*

[57] ABL Environmental Consultants Ltd. March 21, 1996 report, *Municipal Infrastructure Needs Assessment: Final Report on Database Creation, Use and Documentation.* Nova Scotia Dept. of Municipal Affairs.

the Nova Scotia environment. In other words, this is the necessary investment to halt the degradation of the respective water resources.

If investments are made, the benefits of lowered contaminant additions, such as improved shellfisheries, beaches and aesthetics, and an improved marine environment will be realized. These improvements will also be reflected in the improved reputation of Halifax and Industrial Cape Breton as aesthetic relocation cities for businesses and families, and will also be reflected in increased tourism revenues, shellfish harvesting, and beach water quality. Other benefits will accrue to benthic and other marine habitats, nutrient and food cycles, and natural ecosystem functioning. For example, the accompanying case study of the costs and benefits of sewage treatment for the Halifax Harbour estimated a net benefit of $860 million to $1.4 billion as a result of the impacts of the project (Wilson 2000).

10.2 Cost to Improve Domestic Wastewater Disposal

Studies conducted in 1996 and 1997 revealed that there were a number of un-serviced communities in Nova Scotia with serious on-site sewage disposal problems[58]. The study provided estimates of what it would cost to develop wastewater treatment facilities for these communities, to improve wastewater disposal, and to reduce the associated impacts. The engineering cost estimates provide a conservative surrogate value for the negative impacts of insufficient on-site sewage systems in Nova Scotia. Costs not accounted for include: changed trophic status of nearby surface waters, increased public health risk, risk of groundwater pollution, and aesthetic problems. Therefore, actual environmental damage costs from failure to make needed investments likely far exceed the engineering costs given below.

Required Engineering Cost Estimate:

Of the 92 communities with on-site problems, 63 require provision of sewerage. The estimated cost to develop wastewater treatment facilities to improve wastewater disposal and reduce impacts on aquatic ecosystems is **$86.9 million (1997$)**. This estimate represents a surrogate value for the negative impacts of insufficient on-site sewage systems in Nova Scotia. In other words, this is the investment needed to prevent a further decline in the value (i.e. degradation) of our water resources and to restore a measure of water quality. As mentioned above, the environmental costs are not included.

[58] Department of Municipal Affairs. 1996-1997. *Community On-site Sewage System Inventory.*

10.3 Environmental Protection Expenditures

> "Environmental protection expenditures consist of expenditures undertaken with the intention of preventing, reducing and remedying environmental degradation or preserving the environment. They include expenditures for pollution abatement and control (PAC) and expenditures for restoring wildlife and habitat, along with expenditures for environmental monitoring, environmental assessments and audits, and expenditures for reclamation and decommissioning of sites."
> (Statistics Canada 1998)

Statistics Canada's new Canadian System of Environmental and Resource Accounts, released in December 1997, has, as one of its three core components, a set of Environmental Protection Expenditure Accounts (EPEA), which detail business and government expenditures on pollution control and abatement (Statistics Canada 1997, Statistics Canada 1997a). In its description of the EPEA, Statistic Canada notes that these pollution abatement and control expenditures are defensive expenditures that could be used to calculate a "net" or "green" GDP.

10.4 Government Pollution Abatement and Control (PAC) Expenditure

Pollution abatement and control (PAC) refers to the technology applied or measure taken to reduce or mitigate specific pollution. Provincial and municipal pollution abatement and control (PAC) expenditures are reported by Statistics Canada, by province, for 1991 to 1994 (Statistics Canada 1996).

Nova Scotia's government expenditures on PAC increased by $15.4 million between 1991 and 1994 ($154.4 million to $169.7 million; 1997$). Most of the increase in expenditures occurred at the local level. Municipal government expenditures on PAC increased by approximately $30.6 million (114.1 million to $144.7 million), whereas provincial government PAC expenditures declined by $15.2 million, between 1991 and 1994 ($40.3 million to $25.1 million).

On average, $116.5 million/year was spent by municipalities in Nova Scotia on PAC expenditures, and $30.5 million/year was spent by the Nova Scotia provincial government on PAC expenditures. **Using the percent of PAC expenditures spent by the business sector on water-related PAC (91%) [48], $106.0 million/year was spent by municipalities, and $27.8 million/year was spent by the Nova Scotia provincial government.** It is evident from these

[48] See Section 10.5; Statistics Canada 1999.

trends that more of the financial burden has been placed on local governments as provincial budgets for pollution abatement and control have declined.

10.5 Pollution Abatement and Control (PAC) Expenditures in the Business Sector

Statistics Canada surveyed the business sector nationally and by province to determine how much was spent on pollution abatement and control (PAC; Statistics Canada 1998, 1999). The data provided represents expenditures for the years 1995 and 1996, and here is reported in 1997 dollars. Statistics Canada has released the 1997-1998 national data as part of the Human Activity and the Environment 2000 publication.

In 1995, Nova Scotia's business sector spent a total of $37.8 million (1997$) in capital expenditures, and $10.6 million (1997$) in operating expenditures on PAC, totaling $48.4 million. Of the total expenditure, 90.7% was spent on surface water, and soil and groundwater PAC, and 9% was spent on air PAC. Therefore, in 1995, the business sector in Nova Scotia spent a total of $43.9 million on water-related PAC expenditures, and $4.4 million on air-related PAC expenditures. 69% of business pollution abatement and control (PAC) expenses were spent on end-of-the-pipe processes, 13% on environmental monitoring, 8% on reclamation and decommissioning, and 5% on PAC integrated processes.

Box 1. Categories of Pollution Abatement and Control Expenditures

Expenditures on end-of-pipe processes for PAC: purpose is to abate or to control undesirable substances emitted during normal production activities; end-of-pipe processes do not affect the production process itself.

Environmental monitoring: includes expenditures related to equipment, supplies, labour and purchased services required for the monitoring of pollutant emissions that would affect air, water or soil quality.

Site reclamation and decommissioning: includes expenditures to clean up environmental damage and expenditures related to the closure of a site.

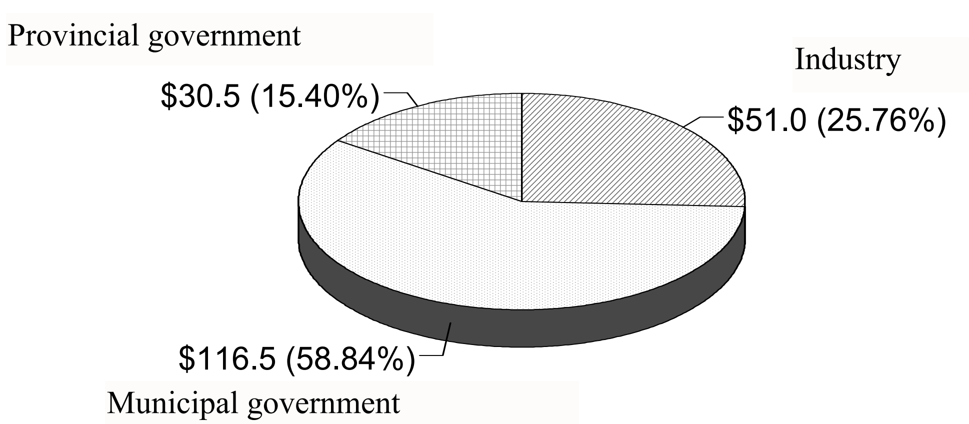
Expenditures on integrated processes for PAC: lead to a new or significantly modified production process in order to prevent or reduce waste generated.

In 1996, the total PAC expenditure by the business sector was $53.5 million (1997$): $25.8 million in capital expenditures, and $27.7 million in operating expenditures (Statistics Canada 1999). $48.7 million (1997$) was spent on water-related expenditures, and $4.8 million (1997$) was spent on air-related expenditures. **Thus, there was an overall increase of $5.1 million/year on PAC expenditures, including a $4.8 million increase in water-related PAC expenditures. On average, however, the business sector in Nova Scotia spent an average of $51.0 million/year, between 1995 and 1996, on pollution abatement and control expenditures; $46.3 million/year on water-related PAC expenditures, and $4.6 million/year on air-related PAC expenditures.**

10.6 Percent Contribution by the Public and Business Sector in PAC

Using the average annual expenditures spent by the province, municipalities, and industry on PAC in Nova Scotia, results show that local government contributed over half of all PAC expenditures (59%; $116.5 million), industry contributed approximately 26% ($51 million), and the provincial government contributed 15% ($30.5 million; Figure 24).

Figure 24. PAC Expenditures by the Public and Business Sectors



10.7 Prevention and Protection Expenditures in the Business Sector

Nova Scotia's business sector expenditures on environmental assessments and audits, and on habitat protection, are available for 1995 and 1996 from Statistics Canada (1998, 1999). From the GPI perspective, preventive expenditures are **positive contributions to well-being** because they improve and protect water resources and the environment, and prevent damage being incurred.

The total prevention and protection expenditures spent by Nova Scotia's business sector are directly reported for Nova Scotia for the years 1995 and1996. In 1995, $9.7 million was spent on prevention and protection by the business sector; and, in 1996, $5.6 million. **Therefore, the business sector in Nova Scotia spent an average of $7.6 million/year on prevention and protection expenditures, with a declining trend in expenditures evident in 1996.** Specifically, expenditures declined by $4.1 million between 1995 and 1996. The declining trend in prevention and protection expenditures demonstrates a worrying lack of investment in preventive measures. This is significant given the increasing pressures on the environment from human and industrial activities, and the likelihood of future damage costs that will exceed modest preventive investments now.

Box 2. Categories of Prevention and Protection Expenditures

Environmental assessments and audits: includes expenditures for reviews of current operations for compliance with regulations, and expenditures to evaluate the environmental impact of proposed projects.

Wildlife and habitat protection: includes expenditures made to protect wildlife and habitat from the effects of economic activity, or to restore stocks that have been adversely affected by such activity.

Source: Statistics Canada 1998

10.8 Inspection, Monitoring and Enforcement Expenditure

Each year, provincial governments expend resources to enforce, through soft and hard tactics, the laws and regulations put in place to protect water resources. Laws and regulations deal with water quality issues and pollution permitting. Violators can be fined and taken to court, or they may be acquitted of the charges. It is also possible that the governing agency (the Nova Scotia Department of Environment) is unable to enforce legislation due to lack of human and financial resources, political will, or changing priorities and programme mandates. Therefore, a decline in enforcement, fines and prosecutions may appear as an improvement in our accounting system, but actually is a deferred investment

The amount expended by the Nova Scotia Department of the Environment in water resource protection is reflected in prosecution, inspection, monitoring, and environmental protection costs. This can be conservatively estimated at 50% of the inspection, monitoring and enforcement budget (i.e. assuming 50% of personnel dedicated to water). In addition, there are prosecutorial summary records reporting the fines paid. Using an overall average estimate of the cost of a trial from the Public Prosecution Office, a conservative estimate of the trial costs can be calculated.

The resulting total estimated costs of inspection, monitoring and enforcement expenditure are highly conservative, as several costs are not counted. For instance, we are not including other provincial government expenditures such as those by the Departments of Natural Resources and Fisheries and Aquaculture, nor are we including federal level intervention (e.g. DFO), or municipal by-law expenses. The provincial NSDOE is primarily responsible for managing provincial fresh water resources, but the other departments and jurisdictions also have a role in monitoring and enforcing pollution control and water resource protection. If data become available from other agencies, they will be included in future updates of this study.

An average trial cost at the Public Prosecution Office is $94.23 (personal comm.)[34]. Although this seems low, this includes all prosecutions, and many defendants plead guilty, thus incurring minimal costs. Prosecution summaries from the Department of Environment are available from 1985 through 1999. **The average prosecutorial cost over the past decade was $83,450 per year (1997$).** The highest costs were in 1991 and 1992, when $129,434 and $130,715 (1997$) were respectively incurred.

In 1998/1999, the Nova Scotia Department of Environment's total budget was $15.3 million (1997$)[35],with 62% of that budget spent on monitoring and enforcement ($9.5 million). **Thus, if we assume that approximately 50% of the latter amount were expenditures related to water quality, then $4.75 million was spent on water-related monitoring and enforcement in the 1998/1999 fiscal year. Thus, the total annual expenditure can be estimated at approximately $4.8 million, though, the annual amount will be dependent on the Department of Environment's budget in any given year.**

[34] Personal communication with the Public Prosecution Office, Halifax, Nova Scotia.
[35] http://www.gov.ns.ca/envi/dept/ecs/bus_plan.htm

11 WATER INTAKE COSTS

11.1 Industrial Water Intake Treatment Expenditure

Industries use water as a process input for cooling and other purposes. Often, industry itself must first treat the incoming water so that it is suitable for use. Water treatment processes for industrial purposes are generally site specific, and possibly process-specific to serve the needs of that industry. If water quality improved, less treatment would be required, thereby resulting in a savings to the industry or facility. If water quality deteriorates, greater industry costs are incurred, perhaps to the point where the process or industry is no longer viable.

Statistics Canada collected data in 1981, 1986, and 1991 for the "Water Use in Canadian Industry" report series (Tate and Scharf 1985, Tate and Scharf 1992, pers. comm.)[36]. Currently, the 1996 data are the most recent available. The surveys of Canadian industrial water use are conducted every five years, (based on the mini-Census of Canada year). Due to the confidentiality restrictions imposed on these surveys, data can be released only as aggregates in the form of summary tables.

In these reports, industrial intake water treatment was recorded by province and by industry type, and the costs incurred for intake treatment were reported. Because data were collected over time, they may also serve as an indicator of intake water quality. However, these interpretations may not be reliable because it is difficult to discern if a change in costs is due to a change in water quality, a change in industry water quality requirements or a tighter business environment (e.g. recession in 1991) that makes capital investments more likely to be deferred.

The highest cost (in constant 1997$), for water intake treatment by Nova Scotia's industry sector was in 1981, $6.5 million (1997$), in comparison to 1986, 1991, and 1996 (Table 6). The lowest costs were in 1996, at just under $1.3 million. On average, 322.8 million cubic metres of water are drawn annually by industry in the province, according to the water use surveys (Tate and Scharf 1985, Tate and Scharf 1992, pers. comm.)[36]. **Therefore based on the reported costs for 1981, 1986, 1991, and 1996, Nova Scotia industry spends an average of $3.2 million/year on water intake treatment costs.**

[36] 1991 and 1996 survey tables were obtained from the Environmental Economics Branch, Environment Canada. Hull, Quebec.

Table 6: Industrial Intake Treatment Costs 1981, 1986, 1991, and 1996

Year	Intake treatment costs (1997$)	Intake treatment costs (current$)	Water Intake Treatment Costs (1997$)/1000 m^3
1981	$6,450,830	$3,644,536	$23.89
1986	$1,985,301	$1,471,593	$3.45
1991	$3,052,000	$2,808,870	$12.18
1996	$1,287,388	$1,262,145	$6.61
Average	$3,196,296	$2,297,000	$11.53

Thus, between 1981 and 1996, total intake treatment costs by industry declined by $5.2 million (1997$), with major fluctuations, and the cost per unit decreased by $17.28/1000 m^3 (Table 6). This trend probably signifies a high initial cost for water treatment technology, with fluctuating costs thereafter. The variations in cost may also be a result of the following : 1) a decrease in the costs of water treatment technology; 2) a shift in industry types within the province regarding the extent of water treatment required; and/or, 3) a change in business climate due to recessionary pressures, leading industry to defer investments.

The cost per unit for intake treatment was high in 1981 ($23.89/1000 m^3), relative to the cost per unit in the other years (Table 6). **Using the costs and water intake reported by Nova Scotia industry between 1981 and 1996, the average cost of water intake treatment per 1000 cubic metres was $11.53/1000 m^3**.

11.2 Municipal Water Supply Expenditure

Municipalities throughout Nova Scotia treat the water they distribute prior to consumption. Generally, water is filtered and then chlorinated, although some communities are seeking treatment alternatives due to site specific quality problems. Municipal water treatment is a defensive expenditure, because without treatment water-borne illnesses will occur. Treatment prevents the exposure of municipal residents to potential water quality problems.

In the future, estimates of Nova Scotia municipal drinking water treatment expenditures can be obtained by sampling a number of municipalities of various sizes and sources for the costs of treatment, monitoring and analysis, and water supply protection. Here, we use the Halifax

Regional Water Commission's average estimated costs. The total treatment costs are indicative of the cost of water quality problems, which are not entirely pollutant problems. Some aspects of water quality that require treatment for human consumption are quite natural, like the presence of algae, arsenic, and parasites. However, the costs expended on treatment are for the protection of human health against water pollution, and therefore can be considered as full defensive expenditures.

The total municipal demand was determined using the Nova Scotia Drinking Water Database[37]. Most of the extraction rates for municipal water supplies in the province are provided in the database. A small number of supplies with missing data were estimated using the provincial average water use per person[38]. The total municipal water extraction is 294.2 million litres/day, serving a population of 436,010.

According to the Halifax Regional Water Commission (HRWC), the cost of watershed protection, water treatment, and water quality monitoring and analysis is $75/1000 cubic metres ($m^3$) [39]. The breakdown is: $70/1000$m^3$ for treatment, $2/1000$m^3$ for water quality monitoring, and $3/1000$m^3$ for watershed protection. Based on the HRWC estimated water treatment cost ($70/1000 cubic metres), and the annual municipal water extraction (294,200 m^3/day)[40], the total expenditure required for Nova Scotia's municipal drinking water supply was calculated.

The estimated annual expenditure for treatment of drinking water is $7.5 million per year ($1997), plus an additional $214,770 per year (1997$) for water monitoring and analysis, and $322,160 per year (1997$) for watershed protection, in Nova Scotia. Thus, the total estimated municipal expenditure on Nova Scotia's drinking water is $8.1 million/year. This estimate reflects the annual operating costs; it does not include the capital costs.

Although treatment costs are not 100% due to pollutant problems, all municipal expenditures on treating drinking water are for the protection of human health, prevention of water-borne illnesses, and public well-being. Future research and analysis should consider whether drinking water quality sources in Nova Scotia have declined, resulting in a need for increased treatment processes and/or increased expenditures to provide good drinking water.

11.3 Costs to Improve Municipal and On-site Water Supply

[37] Nova Scotia Department of Environment, *Nova Scotia Drinking Water Database*, Last revised May 14, 1999. Halifax, Nova Scotia.

[38] Provincial average water use per person was based on the reported water extraction and the respective population served.

[39] (personal communication, 2000)

[40] Calculated from the Nova Scotia Department of Environment Drinking Water Database.

The costs required to improve municipal and on-site water supplies, such as the construction of filtration plants may be an indicator of watershed deterioration. As the example from New York City demonstrates (see section 9.2), a healthy forest can maintain watershed quality at almost no cost. From that perspective, filtration is a “regrettable” expenditure that has become necessary due to poor watershed management, including urban sprawl development, clearing of land, and poor forestry and agricultural practices. Improvement costs are further defensive costs to prevent public health problems.

Of the 71 water treatment facilities in Nova Scotia, 42 provide water filtration as a means of treatment (ABL Environmental Consultants 1996). This is one of the major deficiencies cited across the province, because water supplies are more vulnerable to contamination (e.g. THMs) in the absence of filtering. **The estimated cost for upgrades for municipal water supplies is $114.5 million (1997$), and a further 14 on-site communities require water supply improvements at an estimated cost of over $21.2 million (1997$); for a total of $135.7 million.**

11.4 Private Defensive Expenditures for Drinking Water

Consumers may purchase bottled water, water filters or purifiers for their homes to avoid what they perceive as poor quality or unsatisfactory drinking water. Using Statistics Canada's 1994 data from *Households and the Environment*[41], the percentage of Nova Scotia's households that use water filters or purifiers for drinking water and the percentage of households that purchase bottled water can be determined.

Assuming that a family would opt for a low cost solution to filter water (i.e. activated carbon filters and Brita type water filters), the amount of activated carbon water filters a household of 2.6 persons would purchase in one year was estimated (i.e. one filter's life span = 1 month). Using the market cost for an activated carbon filter (approx. $6.00), the total amount expended by Nova Scotian households to avoid poor quality water through the use of filters was estimated.

An estimated 16.3% of Nova Scotians spend at least **$4.2 million/year on home water filtration for drinking water**. This calculation is based on an estimated total of 359,308 households[42] in the province, and data from Statistics Canada indicating that 16.3% of Nova Scotian households use water filters or purifiers in their home[42]. This is a very conservative estimate as it assumes that all of these households are using a basic Brita-type water filter that costs approximately $6.00/filter and must be replaced every month. This amount is underestimated because the households using a water softener, filter, or ozone purifier at the point of water entry to the home were also reported in the total number using water filtering devices, and these devices are considerably more expensive than a typical carbon water filter system.

In addition, 18.1% of Nova Scotian households purchase bottled water[42]. As the average Nova Scotia household consists of 2.6 persons, an estimated 169,090 people in Nova Scotia consume bottled water. 75% of the daily water intake required by humans (2.4 litres) is obtained through drinking water, and 25% through the consumption of food (Environment Canada 2000). If we assume that among Nova Scotians who purchase bottled water, 50% of the daily water intake through drinking is from purchased bottled water, then the 169,090 residents who drink bottled water regularly spend an estimated **$28 million/year on bottled water (1997$), based on an average of $0.50 per litre**.

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[41] Statistics Canada. 1994. *Households and the Environment 1994*. Cat. No. 11-526-XPB.; www.statcan.ca/english/Pgdb/Land/Environment/envir01a.htm; Population data ...People/Population/demo02.htm

[42] The average Nova Scotia household has 2.6 persons; from, Statistics Canada. 1997. *Detailed Average Food Expenditure and Quantities per Household*. IPS 62F0023. The Nova Scotia population reported for June 1999 by the Nova Scotia Department of Finance (942,652) was used in the estimate.

The cost to purchase water filters and the cost to purchase drinking water provide a conservative total estimate of **Nova Scotian's personal avoidance expenditures for clean drinking water at a total of $32.8 million (1997$) per year.** Assuming that those who filter their drinking water do so as an alternative to buying bottled water, the proportions mean that more than one-third of Nova Scotians do not trust the quality of drinking water coming out of their taps, and spend money trying to improve it. **As a result Nova Scotian households spend 1.6% of their total annual food expenditure compensating for what they perceive to be poor drinking water quality[43].**

[43] Statistics Canada. 1997. *Detailed Average Food Expenditure and Quantities per Household*. IPS 62F0023.

12 DAMAGE COSTS DUE TO WATER QUALITY DECLINE AND RESOURCE LOSS

12.1 Market-related Impacts

12.1.1 Cost of Well Claims due to Road Salt Contamination

When groundwater becomes contaminated, it is often necessary to develop new and safer drinking water wells in the area to supply surrounding users. The cost to develop a new well in a rural community, where municipal service connection is not possible, is a cost to Nova Scotians, and can act as a surrogate value of groundwater contamination.

The State of the Nova Scotia Environment (1998) estimates that the number of new wells constructed each year is approximately 2500-3000[44]. The number of wells that were developed to replace contaminated sources and the consequent costs incurred are not currently recorded. Information on the number of wells re-drilled in Nova Scotia each year due to some form of groundwater contamination could in the future be included in the WELLOGS database through the Nova Scotia Department of Environment.

Information on the number of wells contaminated in Nova Scotia due to road salt and the remediation costs are available. These records are kept by the Nova Scotia Department of Transportation and Public Works as a result of claims made to the department.

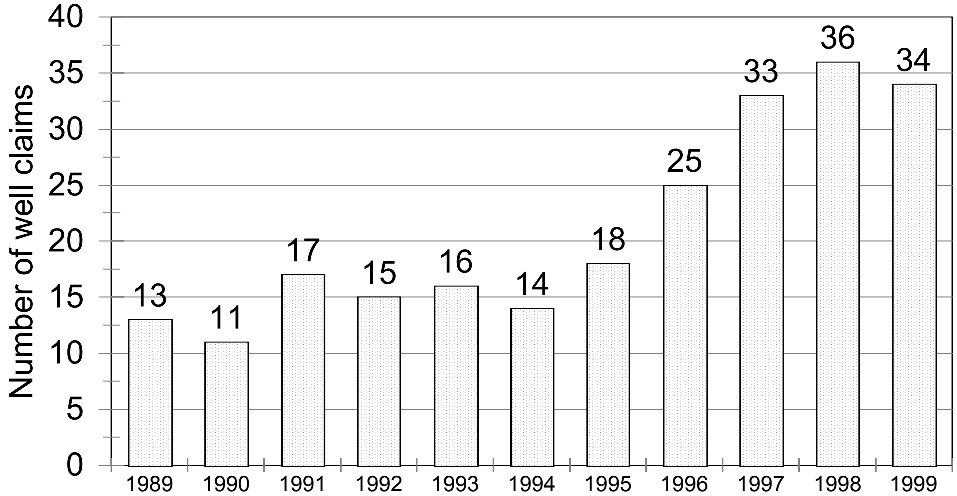
Estimates of the costs of well remediation due to contamination does not include the other costs of groundwater pollution, such as the cost of pollution to surface waters that subsequently are contaminated through sub-surface water flows, nor the costs to wildlife and the many natural water-dependant processes.

Results:

Using the number of well claims and the costs of remediation for wells contaminated due to road salt, the annual public cost and the cost per well claim was calculated. The number of claims due to salt contamination increased from 25 in the fiscal year 1996/1997 to 34 in the fiscal year 1999/2000 (Figure 25). The average cost per well claim between 1996 and 1999, was approximately $15,900 (1997$) based on the costs per year and the total number of claims. **The total cost paid by the provincial government for well claims due to salt contamination is, on average, about $548,000 (1997$) per year, based on the claims made between 1996 and 1999 (Figure 26).**

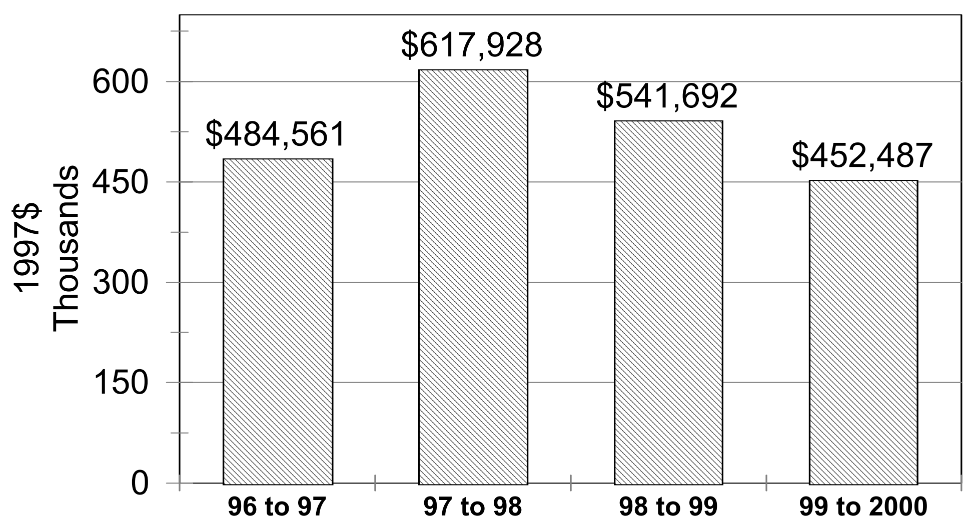
[44] NSDOE. 1998. *The State of the Nova Scotia Environment 1998*. page 16.

Figure 25. Number of Annual Well Claims due to Road Salt Contamination



Source: NSDTPW; NSDOE 1998

Figure 26. Annual Cost of Well Claims Due to Salt Contamination, 1996-1999



Source: NSDTPW

12.1.2 Cost of Shellfishery Closures

Filter feeding organisms like oysters, mussels and soft shell clams live within our estuaries and along the mud flats. If the surrounding waters are contaminated with high bacterial levels, the shellfish tissue itself becomes contaminated. Consumption of shellfish from bacteriologically contaminated areas can cause illness, and in severe cases even death.

Unfortunately, shellfish area closures in Nova Scotia are common. These closed areas were once used for market, recreational and subsistence harvest. Closure of shellfish beds due to bacterial contamination creates serious negative impacts that cost the environment, the community, and the economy. Data have been maintained on the number of areas closed to shellfishing over the past several decades. This record reveals that the locations closed to shellfishing are growing in number, preventing local communities and the economy as a whole from generating benefits from that resource (see Section 7.1).

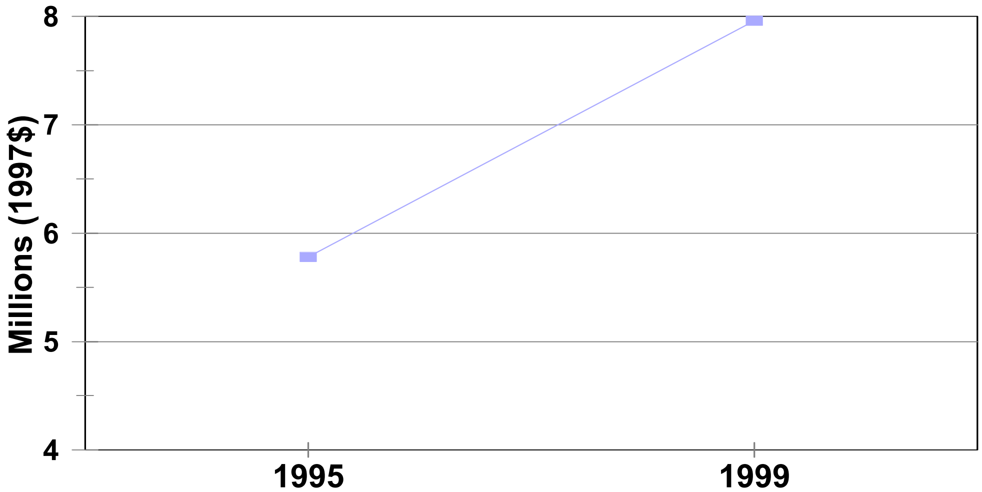
Results:

The State of the Nova Scotia Environment (1998) reported that 700 km^2 was closed to shellfish harvesting, in 1995. Based on an average value of the annual market landing of shellfish per square kilometre of open shellfisheries, the economic cost of foregone revenues from the area closed as of 1995 was estimated at $5.8 million per year. Calculations are based on the average landed value of Nova Scotia's shellfisheries for the years 1989 to 1992, per square kilometre of open shellfishing area ($8259.53/$km^2$; 1997$).

Since 1995, the area closed to shellfishing has increased by 37.6%. In 1999, the area closed totaled 963.6 km^2, paralleled by an increase in economic losses of $2.2 million (Figure 27), in less than five years. **As of August 1999, the economic cost of foregone revenues from closed shellfish areas is estimated at $8.0 million/year.**

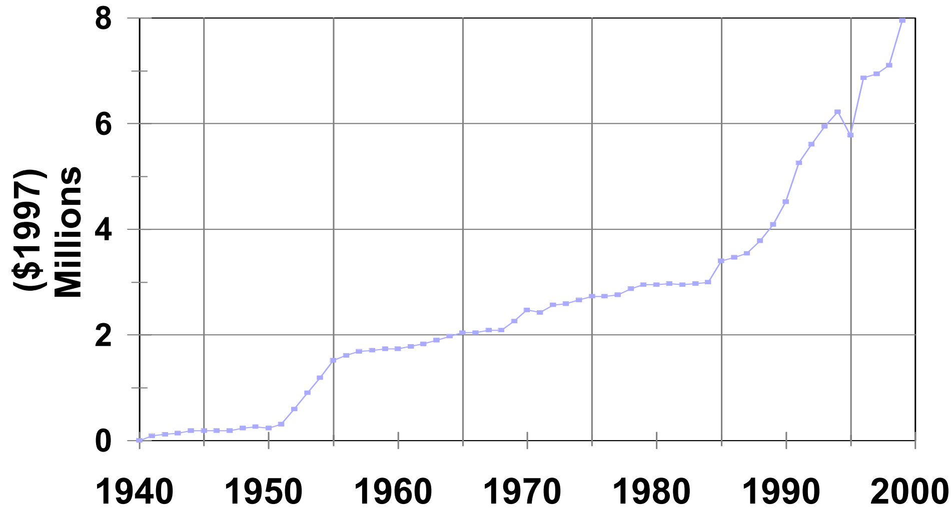
From 1940 to 1994, there are no data on the area of closed shellfisheries; only the number of closures are reported. Therefore, the annual area closed was calculated using an estimated average area of 2.9 km^2 per closed shellfishery (based on closures reported 1995 to1999), multiplied by the number of closures per year. The estimated area of closures was then used to estimate the annual cost of closure for each year from 1940 to 1994. Although this is not a precise estimate, it does provide a picture of the annual losses over the time period from 1940 to 1994 (Figure 28). **The cumulative total economic losses over this time period (1940 to 1994) is estimated at $155 million.**

Figure 27. Estimated Cost of Shellfish Closures*, in Nova Scotia; 1995, 1999



* Annual cost

Figure 28. Estimated Cost of Shellfish Closures* in Nova Scotia,1940 to 1999



*Annual cost

12.2 Non-Market Values and Related Impacts

12.2.1 Cost of Beach Closures

Every year, recreational beach and swimming areas are closed due to the presence of high levels of bacteria. The closure of beaches is significant because, for Nova Scotia residents, Canadian and non-Canadian tourists, Nova Scotia is "Canada's Ocean Playground"[45]. The Guidelines for Canadian Recreational Water Quality stipulate a maximum allowable concentration of 2000 E.coli/litre (Health Canada 1992).

Section 6.1 above, lists some of the more recent beach closures due to bacterial counts above the maximum allowable concentration (MAC). The average daily expenditure by Nova Scotia residents participating in outdoor activities in natural areas is $25.50[46]. **Using this daily average, the cost of the very incomplete list of beach closures in the province can be estimated at $103,000 for certain closures that have occurred over the past 5 years, plus the cost of some closures that are reportedly annual occurrences, estimated at $56,000 per year.** This is a very conservative estimate based on only 10 visitors and beach users per day. The number of users may be much higher, but without specific statistics we have opted for a very conservative estimate. Insufficient records and information on the rate of closures and the impact on beach users in Nova Scotia demonstrate that this indicator needs to be far better monitored, especially given the economic importance of tourism and natural areas in the province.

12.2.2 Historical Value of Atlantic Salmon Fishing in Nova Scotia

Like beach closures, some recreational fishing opportunities are now also closed, resulting in a loss of direct and indirect benefits. Atlantic salmon has been an important recreational and symbolic fish species in Nova Scotia. Unfortunately, Nova Scotia has suffered the greatest adverse impacts of any area in North America in terms of the percentage of fish habitat lost due to acid rain (Watt and Hinks 1999).

Wild Atlantic salmon is no longer a commercial species in the Maritimes with the last commercial fishery closed in 1985 (Taylor 1999). The Department of Fisheries and Oceans revealed in 1998 that only 21 of the 71 Canadian Atlantic salmon index rivers met their minimum spawning targets. As a direct result of the decline in wild populations, recreational salmon fishing is greatly restricted. In 1999, only 22 of Nova Scotia's 72 salmon rivers were open to recreational salmon angling. To place a value on the lost recreational benefits from the

[45] The saying " Nova Scotia - Canada's Ocean Playground" is on Nova Scotia's car license plates.
[46] (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000)

acidification of Nova Scotia salmon rivers, one can estimate the associated decline in Atlantic salmon population in those rivers.

According to the DFO *Survey of Recreational Fishing in Canada* (1995), the average expenditure per angler in Canada is $617.85 per year (1997$) and the average days spent fishing per angler in Nova Scotia is 21 days. Therefore, an average expenditure per angler per day was estimated at $29.42 (1997$) [47]. This amount was used to calculate the annual value of salmon fishing in the province (i.e. average number of rod days multiplied by average expenditure/angler/day).

The historical average value of the Atlantic salmon recreational catch in Nova Scotia was an estimated $2 million per year (1997$) between 1980 and 1988. This average is based on historical sport catch statistics from Department of Fisheries and Oceans publications[48]. The average annual number of rod days between 1980 and 1988 was approximately 71,000 per year. An additional willingness to pay per day by anglers in Nova Scotia is estimated at $15.75 (1997$) by the DFO 1995 *Survey of Recreational Fishing*[57]. Therefore, the additional economic value, above direct expenditures, that anglers place on recreational fishing in relation to the historical salmon catch is estimated at $1.1 million. **The total value of the salmon recreational catch was, therefore, approximately $3.1 million per year in the 1980s.**

In addition, the commercial salmon fishery was closed in the mid-1980s. The total cost to the Federal government to buy back the licences was $1 million (1997$). Future work should also consider the total losses due to the loss of a commercial Atlantic salmon fishery.

[47] Department of Fisheries and Oceans. 1995. *Survey of Recreational Fishing in Canada*. http://www.dfo-mpo.gc.ca/communic/statistics/recfsh95/content2.htm

[48] Swetnam and O'Neil 1984, O'Neil et al.1986, O'Neil et al.1987, O'Neil et al.1989, O'Neil et al.1991.

12.2.3 Recreational fishing in Nova Scotia

Trends in recreational fishing expenditures are provided in section 6.2.1, in Part I of this report. Total expenditures were relatively steady through the 1970s and 1980s. However, between 1990 and 1995, total recreational fishing expenditures declined. In the year 1990, the DFO survey indicated that just over $25 million was spent in Nova Scotia, but in the 1995 survey, under $20 million was spent in the province. The difference in expenditures from the 1990 survey to the 1995 survey was $5.5 million. If we assume that between 1990 and 1995, the total expenditures declined each year by about 1 million, and a further $1.5 million in the year 1995, then the cumulative loss over these five years may be estimated at $15.5 million. Furthermore, if we assume that the spending has remained the same over the second half of the decade, then it can be estimated that for each year since 1995 there has been an additional loss of $5.5 million relative to the expenditures of 1990. **Therefore, it may be estimated that over the past decade there may well have been a loss of $22 million in revenues in Nova Scotia due to the decline in recreational fishing.**

12.2.4 Wetland Valuation and the Costs due to Wetland Loss

The location of wetlands (i.e. between land and water) makes them among the most productive of the world's ecosystems. They play a major role in food production and services including flood prevention, shoreline protection, water purification, and recreation. Their natural values encompass habitat for breeding, feeding and resting grounds for fish, migratory birds and other animals.

Coastal marshes export mineral and organic nutrients that support biological production in adjacent estuarine and coastal waters. Estuaries and coastal waters serve as important nursery grounds for coastal fish and shellfish. For example, about two-thirds of fish caught around the world hatch in tidal areas (Wagenaar Hummelinck 1984). Estuaries play a significant role in normal functioning of nutrient cycles due to their high rate of mineralization, and they can recycle large amounts of organic human waste without negative side effects. Each of these ecological functions though conventionally regarded as "free", has value to the human economy and society.

Evaluation of wetland functions and characterization of these functions has been outlined in literature from studies around the world (de Groot 1992, Thibodeau et al. 1981)[49]. Wetland functions can be valued using replacement cost methods (in cases where new technology could conceivably replace natural wetland functions); damage cost estimates; estimates of the loss in

[49] See also: Farber, S.C. 1987. "The value of coastal wetlands for the protection of property against hurricane wind damage". *Journal of Environmental Economics and Management*. Vol 14: 143-151.

productivity; valuations of the loss in ecosystem services such as water supply; and willingness to pay (WTP) valuations.

Although drained freshwater wetlands have contributed to the economy through agricultural production, the ecosystem processes have not been replaced. In fact, the drainage and change in land-use have incurred damage costs, such as reduced water filtration and increased sedimentation in addition to lost wetland services. For example, wetlands have been drained, aided by subsidies, in the Midwest of the U.S. in order to increase cropland. However this conversion has resulted in reduced water filtration and increased sedimentation of rivers and streams in their drainage basins. Ultimately this loss in wetlands has led to poor water quality (Lant and Tobin 1989). Additionally, the value of the restored wetlands was found to be greater than the agricultural value of the converted lands[50].

The most important wetland functions include (Bowron et al. 1999, de Groot 1992):

- flood prevention;
- shoreline protection and erosion prevention;
- storm control;
- water purification;
- storage and recycling of human waste;
- spawning and nursery habitat for commercial and non-commercial fish and shellfish;
- sanctuary, breeding and nursery habitat for terrestrial, near-shore, and migratory birds;
- feeding habitat for terrestrial wildlife;
- nutrient cycling, production and storage;
- waste treatment;
- recreation;
- food production; and,
- education and science uses.

Anielski and Rowe (1999) determined the economic cost of the loss of wetlands in the United States as one of 26 components of the U.S. Genuine Progress Indicator. They estimated that wetland acreage in the U.S. declined from an original 395 million acres in the 1780s to about 259 million acres in 1950; with a further average loss of 462,000 acres per year from 1950 to 1975; 294,000 acres per year from 1976 to 1984; and 121,000 acres per year subsequently. Using conservative estimates of the value of services from one acre of wetland, they estimate the cumulative cost of the loss of U.S. wetlands in 1997 at about US$350 billion[51]. GPI Atlantic recognizes that a proper wetland account should have separate stock and flow accounts,

[50] The value of the wetlands per acre ranged from $8 to $1,035 greater than the agricultural value per acre.

[51] Anielski and Rowe (1999) use per acre value ranging from US$328 to US$19,543 (1992$).

however, the lack of information available on restoration makes it difficult to estimate a flow account at this time.

12.2.5 The Economic Value of Coastal Wetlands

There are several examples of coastal or saltwater wetland valuation. The Dutch Wadden Sea coastal wetlands have been estimated to contribute over US$6,200/ha/year in direct and indirect values[52] (de Groot 1992). In comparison to other calculations for wetlands this estimate is moderate. For example, US$10,000/ha/year (1974$) is the estimated monetary contribution of wetland services for several estuaries along the east coast of the U.S.(Gosselink et al. 1974), US$28,000/ha/year (1981$) was estimated for the Charles River Basin in Massachusetts (Thibodeau and Ostro 1981), and US$72,000/ha/year (1988$) was estimated for the Atlantic Spartina Marsh (Hair 1988).

Therefore, coastal wetlands are worth between $6,200 and $72,000/ha/year. Taking the second lowest estimate ($10,000/ha/year), which is a close geographic match, we can calculate the cost of the losses in wetland services across Nova Scotia since colonization. US$10,000 (1974$) was converted to 1997 Canadian dollars to give an annual value of $35,376/hectare/year (1997$).

Approximately 19,958 hectares of saltwater marshes have been dyked for agricultural purposes or lost to other types of development in Nova Scotia since colonization[53]. **This equals a cumulative loss of $23.8 billion (1997$) in foregone wetland services over the past 50 years, assuming that 50% of the total 19,958 hectares of saltwater wetlands were converted by 1950, another 25% by 1975, and the remaining 25% by 1990.** This is a conservative estimate because many coastal wetlands may have been dyked or lost prior to this time period. However, we do not know the exact time period for the loss of each wetland.

Since 1990, the total cost incurred as a result of the loss of 19,958 hectares of saltwater wetlands is an estimated $706 million/year in wetland services. Presently, there are 21,442 ha of saltwater wetlands remaining, providing an estimated $440.2 million/year, in wetland services to Nova Scotia.

[52] Includes the following values: flood prevention, storage and recycling of organic matter and nutrients, nursery and migratory habitat, nature protection, and spiritual and historical information. Direct values were determined based on economic production, and indirect values were determined using shadow pricing techniques.

[53] Personal communication. Wetlands and Coastal Habitats Programme. Nova Scotia Department of Natural Resources.

12.2.6 The Economic Value of Freshwater Wetlands

Costanza et al. (1997) estimate the annual value of wetlands to be at least US$14,785/ hectare/year (1994$)[54]. This estimate equals $21,206/hectare/year in 1997 Canadian dollars. Their wetland value estimate includes the value of gas regulation, disturbance regulation, water regulation, water supply, waste treatment, habitat/refuge, food production, recreation, and cultural importance[55]. **The remaining freshwater wetlands (354,637 ha) in Nova Scotia[56] are worth at least $7.5 billion per year in ecosystem services.**

Based on the same proportions of saltwater wetland loss used in section 6.3.7.1 (i.e. 50% of total since 1950, additional 25% since 1975, and remaining 25% since 1990), **the cumulative cost in lost services**, **over the past 50 years, of the losses in freshwater wetlands since colonization, is estimated to be at least $53.3 billion (1997$) in Nova Scotia, and the on-going annual cost of foregone services of the total freshwater wetlands lost in Nova Scotia** (74,845.5 hectares; see wetland section in Part I) **is $1.6 billion/year**.

12.2.7 Overall Wetland Losses and Wetland Values

The total cost in cumulative wetland losses across Nova Scotia since colonization, estimated over the past 50 years is, therefore, at least $77 billion (1997$). The on-going total annual cost of foregone services from Nova Scotia's lost wetlands is at least $2.3 billion per year, and the remaining wetlands contribute a value of at least $7.9 billion in ecosystem services per year. The conversion of wetlands to agricultural use does result in economic and social gains, however, the true costs in the loss of wetland services as well as other externalized costs

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[54] Various methods were used by Costanza et al. (1997), to estimate both the market and non-market components of the ecosystem services. Estimates were derived from previous studies, using unit values based on either: 1) the sum of consumer and producer surplus; 2) the net rent (or producer surplus); or 3) price times quantity as a proxy for the economic value of the service. All estimates are a starting point in valuation, with only some wetland functions quantified and the overall values are therefore interpreted as a minimum value of ecosystem services.

[55] Ecosystem service values (US$1994/ha/yr): climate regulation (regulation of atmospheric chemical composition, e.g. CO_2/O_2 balance), $133; disturbance regulation (e.g. storm protection, flood control), $4,539; water regulation (hydrological flows, e.g. provision of water for agricultural and industrial processes), $15; water supply (storage and retention of water), $3,800; waste treatment (recovery of mobile nutrients and removal or breakdown of excess nutrient compounds), $4,177; habitat/refuge (resident and transient populations), $304; food production (that portion of gross primary production extractable as food), $256; recreation (provision of recreational opportunities), $574; and cultural uses (provision of opportunities for non-commercial uses), $881. The value of raw materials (portion of gross primary production extractable as raw materials), $106, was not included (Costanza et al. 1997).

[56] Personal communication. Wetlands and Coastal Habitats Programme. Nova Scotia Department of Natural Resources.

such as increased sediment and water runoff need to be considered in land-use planning. Information on the impacts of agriculture will be included in the GPI Soils and Agriculture Account for Nova Scotia to be released later this year.

12.2.8 Willingness to Pay for Wetland Conservation and Restoration

A 1989 study asked a stratified sample of residents of communities near the Minudie Dykelands in Nova Scotia what amount they are willing-to-pay (WTP) for a hypothetical conversion of the Minudie Dykelands area into a freshwater marsh (Stokoe et al. 1989). In this survey, 80% of the surveyed residents (i.e. non-users) supported the conservation of wetlands in general. The average WTP, in a one-time payment, ranged from $2.50 to $25.00 ($3.03 to $30.25; 1997$). Using these amounts extrapolated to the population of Nova Scotia (i.e. 80% of 942,652 people, June 1999 Nova Scotia population), **$2.3 million to $22.8 million, or an average of at least $12.5 million can be estimated as the additional economic value of wetlands for Nova Scotian residents**.

Similar studies have been undertaken across the United States indicating a range of willingness to pay for ecological values (Lant and Tobin 1989, Hoehn and Loomis 1993, Beran 1995, De Zoysa 1995, Wilson and Carpenter 1999). Unfortunately, willingness to pay (WTP) as a tool to identify the value of complex systems such as wetlands has shortcomings. According to Costanza et al. (1989),

> "the economic value of ecosystems is connected to their physical, chemical, and biological role in the overall system, *whether the public fully recognizes that role or not*. Standard economics has too often operated on the assumption that the only appropriate measures of value are the current public's subjective preferences. This yields appropriate values only if the current public is fully informed."

Thus, the first problem with "willingness to pay" estimates is that the public is not fully informed about the true contribution of ecosystems to their well-being. Secondly, the general public has a very difficult time attaching an economic value to ecosystem services, because they do not use them directly and visibly to further their interests and they are highly unlikely to recognize the full range of services provided (Wilson and Carpenter 1999). In that case, WTP may be a useful tool to estimate what people are willing to pay for a restoration project, for example, but not to reflect the true economic value of ecosystem services. At the same time, contingent valuation will more closely reflect true values over time as ecosystem goods and services are increasingly likely to be in the forefront of the public mind, as the quality of our environment declines and as individual interests are seen to be dependent on ecosystem health. (World Resources Institute, 2000). The best approach is to derive estimates for ecosystem values that a fully informed public would be likely to produce if it were to analyze the structure and function of ecosystems.

13 RESTORATION COSTS

From the perspective of the Genuine Progress Index, the actual costs of damage are seen as a decrease in stock values. For example the costs of restoration can serve as a proxy for the depreciation of natural capital. As a second step, however, the same restoration efforts are recognized as positive investment, because the resulting flow of improved services will contribute to future environmental quality. Thus, within an accounting framework, restoration is similar to fixing the mess we've already made, or preventing a situation from deteriorating further. In that sense, it is a "defensive expenditure" that does not directly improve net well being, but rather compensates for past damage and prevents further decline. On the other hand, restoration does provide benefits over the long term and particularly for future generations in enhanced ecosystem service flows, and it prevents further losses in ecosystem functioning and goods and services. Restoration therefore constitutes an investment in future well being.

Initial expenditure is like the clean-up that follows an oil spill. As such, it is a cost imposed upon present generations by those of the past for activities that depleted ecosystem integrity. The benefits from the restored habitat will accrue over many future years. These expenditures are, therefore, also considered **investments in "Genuine Progress**", though the benefits show up only gradually in the accounting framework, as ecosystem services are restored.

13.1 Restoration of salmon rivers

An estimate of restoration cost is available for aquatic ecosystems affected by acid rain. Phillips and Forster (1987) compiled estimates of the economic impacts of acid rain in Canada. Estimates of the cost of lime treatment to reduce aquatic acidification in Eastern Canada were taken from studies by Forster (1985), Kelso and Minns (1986), and from the U.S. - Canada Memorandum of Intent (1983). The annual cost per hectare of lime treatment ranged from $100 (1983) to $120 (1985). In constant dollars, the estimate per hectare cost ranged from $156 to $171.60 (1997$).

The estimated restoration costs are used here to estimate the damage costs of acidified salmon habitat and associated drainage basins in southwestern Nova Scotia. The pH threshold for salmon habitat is ≥ 5.4 units. Therefore, the total aquatic area in the Southern Uplands of Nova Scotia with pH <5.4 was determined at 14,586 sq. km[34]. **Using the estimated costs for restoration through lime treatment, the cost of mitigating acidification in the southwestern region of Nova Scotia is $227.5 million to $250.3 million.** Presently, there is no estimate for

[34] Personal communication. Walton Watt, Atlantic salmon and acid rain researcher.

the area of acidified salmon habitat in other regions of Nova Scotia, which means that this estimate is only a small percentage of the total restoration cost for the province.

A second cost regarding the restoration of salmon habitat has been calculated by the Atlantic Salmon Federation[35]. The Federation estimated the number of days volunteered by anglers belonging to organized groups who participated in salmon restoration work. **In Nova Scotia, it is estimated that as a result of 718,068 volunteer hours, approximately $8.6 million is contributed to the restoration of the acidified Atlantic salmon habitat per year.**

Thus, the tallied restoration cost, which is not complete as of yet, is estimated at about $238.9 million in liming costs, and approximately $8.6 million per year in volunteer hours.

[35] http:/www.asf.ca/Communications

14 HEALTH IMPACTS

14.1 Cost of Water-Related/Water-Borne Illness

Incidence of water-borne (i.e. bacteriological, parasitic) and water-related (i.e. chemical toxins) diseases is significantly lower with the treatment of municipal water. However, despite increased access to treated water, people continue to contract water-borne diseases (e.g. *Giardia*) and water-related problems (e.g. swimmer's itch) through direct consumption from domestic wells, treated sources, recreational water contact, and the consumption of foods irrigated with contaminated water.

Water-borne disease is reported to the provincial department of health, whereas water-related complaints are not communicable, and are therefore not mandatory to report. The incidence of water-borne diseases over time can be studied using available data. The incidence of water-related illness, such as afflictions from high nutrient consumption, is more difficult to identify and quantify, mainly because it is virtually impossible to ascribe environmentally-caused illnesses to a particular source, since toxin accumulations are cumulative and synergistic.

The *Statistical Report on the Health of Canadians* reports a national rate of 15.8 cases of *Giardia*/ 100,000 persons, and a rate of 3.9 cases of E. coli/100,000 persons in Nova Scotia (Statistics Canada 1999a). The Nova Scotia Department of Health also keeps a record of the annual number of cases of *Giardia* and *Campylobacter*. However, public health specialists have reported that cases of water-borne and food-borne illness are often not reported. They estimate that as few as 1%-10% of the total cases are reported (Statistics Canada 1999a).

Giardia (*Giardia lambia*) are one-celled organisms or protozoa that infect the intestinal tract of humans. Cysts enter the water supply when human or animal feces contaminated with the organism are nearby. Giardia outbreaks are rare but do occur when contaminated water does not receive adequate treatment (Health Canada 1997b). Campylobacter are bacteria found on raw meat, clams, and shellfish, as well as in human and animal feces. They are also found in water, with the highest levels in summer and fall. Heavy rainfall and runoff from farms has been found to increase counts in river systems. Illness can result from water-borne or food-borne Campylobacter (Health Canada 1997b).

Results:

The economic costs of water-borne illness in Nova Scotia were calculated using Health Canada's *Economic Burden of Illness* estimates (Health Canada 1997c). The total number of cases of notifiable diseases for Canada were summed and used to calculate the average direct cost (i.e. drugs, physicians, hospitals, research), and the indirect costs (i.e. short-term disability), per case of an infectious and parasitic diseases.

Direct costs per case are $7,675, indirect costs per case are $3,724 (short-term disability only), and therefore, total costs per case are $12,083 (1997$). Based on these estimated costs, reported cases of *Giardia* cost, on average, $1.5 million/year; and, reported cases of *Campylobacter* cost an average of $3.1 million/year in Nova Scotia. Because *Campylobacter* can also be contracted through food sources, only 50% of the cost, $1.5 million, is included in the average annual cost of water-borne illness in this report. **Therefore, the average annual cost of Giardia and Campylobacter in Nova Scotia is $3 million per year.**

Future work should determine the percent of cancer and other diseases in Nova Scotia ascribed to toxins in water, and calculate the costs using Health Canada's *Economic Burden of Illness* (Health Canada 1997c).

WATER QUALITY ACCOUNT - 1st Data Release

A) WATER VALUES (IF WATER RESOURCES ARE ECOLOGICALLY SOUND)	
Lakes and rivers	at least **$3.1 billion/year** in ecosystem services
Wetlands - freshwater and saltwater	1) at least **$7.9 billion/year** in ecosystem services
	2) a minimum of **$12.5 million** in economic value
Forested Watershed Water-based Value	1) at least **$2,587/hectare/year** for water filtration
	2) at least **$75/hectare/year** for removal of air pollutants
	3) at least **$86/hectare/ year** for interception of water and control of runoff
	Total: $2,748/hectare/year
Water-based Recreation	**$150 million/year**
Historical Atlantic Salmon Recreational Fishing	**$3.1 million/year**
TOTAL VALUES	**Total water ecosystem values $11.2 billion/year** (excludes the economic value for wetlands based on WTP, $12.5 million, and the Atlantic Salmon recreational fishing value, $3.1 million per year because of possible double-counting with the water-based recreation value.
	Total forested watershed water-based value $2,748/ha/year (here for reference, but not included in the total above)
B) DEFENSIVE EXPENDITURES	
- TO AVOID CONTAMINATION OF WATER	
Investment Necessary for Improvements for Wastewater Disposal	**$531.7 million**
Pollution Abatement and Control (PAC)	**$180 million/year**

Prevention and Protection	**$7.6 million/year**
Inspection, Monitoring and Enforcement	**$4.8 million/year** (depending on NSDOE total budget; e.g. declined between 1998/9 and 1999/2000)
TOTAL	**$192.4 million/year, plus necessary capital investment of $531.7 million**
C) WATER INTAKE COSTS	
INCREASES WHEN A (WATER VALUES) OR B (DEFENSIVE EXP.) DECREASE	
Municipal Water Supply	**$8.1 million/year** in operating costs (a provincial extrapolation for treatment, monitoring and protection, based on HRM's expenditure; necessary investment for upgrades $114.5 million in capital costs)
Household Water Filtering and Bottled Water	at least **$32.8 million/year**
Industrial Water Intake	**$3.2 million/year**
Domestic On-Site Community Water Supply	**unknown**, however, a capital investment of at least $21.2 million is needed for upgrades
TOTAL	**$44.1 million/year in operating costs, plus a necessary capital investment of $126.7 million**
D) COSTS INCURRED DUE TO A LOSS IN WATER RESOURCE VALUE AND WATER QUALITY DECLINE	
1) DAMAGE COSTS	
Contaminated Well Claims	**$548,000/year**
Shellfishery Closures	**$8 million/year; plus cumulative cost of $155 million** 1940 to1994
Beach Closures	at least **$56,000 per year; plus $103,000** over the past 5 years
Atlantic Salmon Fishing	**$1 million**

Recreational Fishing	**$2.2 million/year**
Wetlands	**$2.3 billion/year, plus cumulative loss of $77 billion**
TOTAL	**$2.31 billion/year, plus $77.18 billion in cumulative losses over 50 years in wetland losses**
2) RESTORATION COSTS	
Atlantic Salmon Rivers	**$8.6 million/year, plus $238.9 million** for southwestern region
3) HEALTH COSTS	
Water-Related Illness	at least **$3 million/year**
ALL COSTS DUE TO DECLINE IN WATER VALUES AND/OR INSUFFICIENT INVESTMENT IN DEFENSIVE EXPENDITURES	**$2.32 billion/year IN DAMAGE, RESTORATION AND HEALTH COSTS;**

RECOMMENDATIONS

1) The value of our water resources should be explicitly recognized in our core provincial and national accounting systems, and the deterioration of water quality should be counted as depreciation in the value of this natural asset.

2) Water conservation and pollution prevention should be built into all governmental, industrial and residential construction and development projects, with the price of that construction reflecting its true costs in maintenance of water quality.

3) To encourage conservation and responsible consumption, water should be priced according to volume consumed rather than as a flat or fixed rate.

4) Source control should be introduced to reduce toxic discharges to Halifax Harbour along with implementation of the proposed sewage treatment plan. Source control should also be used to protect the quality of harbours, rivers, lakes and other water bodies throughout the province.

5) Restoration efforts, including the upgrading of municipal water supplies, wetland conservation, lime treatment to mitigate acidification of salmon habitat, and other improvements in water quality described in this report, should be regarded not as simple costs in budgetary decisions, but as long-term investments to restore the value of a precious natural capital asset, and the protection of water supplies. Restoration efforts should include:

> **a) wetland restoration**
>
> **b) watershed planning including the protection of water supply through wetland and forest protection (e.g. wetlands will improve the quality of water supply)**
>
> **c) upgrades to sewage treatment to protect water resources, recreation, fish habitat, and water supply**
>
> **d) upgrades to municipal water supplies and/or watershed restoration (e.g. New York City opted for watershed restoration instead of building a filtration plant)**
>
> **e) lime treatment to mitigate acidification of salmon habitat.**

6) Increase regulation for pulp and paper mill effluent that will lower carbon dioxide levels below 100 mg/litre using aeration or pH adjustment.

7) Improve record-keeping of beach closures to assess costs of contaminated water to recreation users and tourism.

8) There is currently a lack of long-term monitoring trend data. In particular, comprehensive data and monitoring programmes are needed for:

a) rivers (e.g. pH, sedimentation/siltation, temperature)

b) lakes (e.g. eutrophication, contaminants, sedimentation/siltation).

9) Lobby for increased controls on sulphur dioxide and nitrous oxide emissions at the federal level. These emissions are detrimentally affecting Nova Scotia's rivers, lakes and forests resulting in environmental damage and economic losses.

10) Planning for restoration and protection of coastal areas is necessary for prevention of coastal erosion, and the protection of shellfisheries, marine habitat, and property.

11) Create database and implement comprehensive monitoring for private well water quality, especially in agricultural regions.

12) Legislate and implement regulations against the use of nonylphenols and other endocrine disrupters in pesticides, industrial products, and household products.

13) Regional ecosystem analysis should be used for all major watersheds to estimate the change in forest cover and its affect on water interception, pollutant removal, stormwater runoff, and the ability to supply good water quality. The external costs associated with the loss of forest cover should be internalized in cost estimates and prices in land-use planning for urban and commercial development, clearing of land, and timber harvesting.

14) Future research and water quality account updates should consider comparisons of Nova Scotia water quality with the water quality of other provinces. Future updates should also consider separate stock and flow accounts for water resources and usage, and further clarify the role of defensive expenditures in the accounts.

15) Current data gaps and specific data needs are specified throughout this report. Filling some of these data needs and processing previously un-analyzed data (such as wetland restoration efforts) will assist greatly in future assessments of the state of Nova Scotia's water resources.

GLOSSARY

Accounts and accounting: The purpose of accounting is to provide economic information about a household, organization, or government. Accounts generally divided into "income accounts," which record receipts and outlays during a given period such as a year, and "asset accounts," which provide a snapshot of the assets, liabilities, and net worth of an entity at a given date. People are most familiar with the income accounts and balance sheets of businesses, but the same concepts apply equally well to individuals, governments, and nations.

Acid Rain: Rainfall with a pH of less than 7.0. One source is the combining of rain and sulphur dioxide emissions, which are a by-product of combustion of fossil fuels. Also referred to as acid deposition and wet deposition.

Aeration: Any active or passive process by which intimate contact between air and liquid is assured, generally by spraying liquid in the air, bubbling air through water, or mechanical agitation of the liquid to promote surface absorption of air.

Aerobic: Characterizing organisms able to live only in the presence of air or free oxygen, and conditions that exist only in the presence of air or free oxygen. Contrast with anaerobic.

Aerobic processes: aerobic bacteria use oxygen to decompose organic matter, resulting in mostly organic cell mass and heat. Contrast with anaerobic processes

Air pollutants: Substances in the air that could, at high enough concentrations, harm human beings, animals, vegetation, or material. Air pollutants may thus include forms of matter of almost any natural or artificial composition capable of being airborne. They may consist of solid particles, liquid droplets, or combinations of these.

Air quality standards: Levels of air pollutants, prescribed by regulations, that may not be exceeded during a specified time in a defined area.

Algae: Simple rootless plants that grow in sunlit waters in relative proportion to the amounts of nutrients available, and provide food for fish and small aquatic animals.. Algae are photosynthetic microorganisms that can produce oxygen and organic mass from inorganic chemicals. When nutrient levels are elevated due to agricultural and urban run-off, they can affect water quality adversely by lowering the dissolved oxygen in the water.

Algae blooms: Rapid growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment.

Anaerobic processes: anaerobic bacteria use electron acceptors rather than oxygen to decompose organic matter, resulting in more end products such as methane, ammonia, and hydrogen sulfide than aerobic processes.

Aquatic ecosystem: Basic ecological unit composed of living and nonliving elements interacting in an aqueous environment.

Aquifer: The underground layer of water-soaked sand and rock that acts as a water source for a well; described as artesian (confined) or water table (unconfined).

Avoidance costs: Actual or imputed costs for preventing environmental deterioration by alternative production and consumption processes, or by the reduction of or abstention from economic activities.

Benthic community: All the plant and animals living on or closely associated with the bottom of a body of water.

Bioaccumulation: A term used to describe a process that occurs when levels of toxic substances increase in an organism over time, due to continued exposure. Sequestration of metals or chemicals in living tissue, such as PCBs in fatty tissue, increases over time with continued exposure.

Biodiversity: Range of genetic differences, species differences, and ecosystem differences in a given area.

Biological (Biochemical) Oxygen Demand (BOD) : The amount of dissolved oxygen required for the bacterial decomposition of organic waste in water. When bacteria come in contact with organic material they will utilize it as a food source. The amount of oxygen used in this process is called the biological or biochemical oxygen demand. It is considered to be a measure of the organic content of waste, and represents the amount of oxygen required to stabilize waste in a natural environment.

Biomagnification (biological magnification): A cumulative increase in the concentrations of a persistent substance in successively higher levels of the food chain.

Biomass: Total living weight (generally in dry weight) of all organisms in a particular area or habitat. It is sometimes expressed as weight per unit area of land or per unit volume of water.

Biosphere: Thin stratum of the earth's surface and upper water layer containing the total mass of living organisms that process and recycle the energy and nutrients available from the environment.

Capital: In classical and neoclassical economic theory, one of the triad of productive inputs (land, labour, capital). Capital consists of durable goods that are in turn used in production. The major components of capital are equipment, structures, and inventory.

Capital accumulation (environmental accounting): Environmentally adjusted concept of capital formation that accounts for additions to and subtractions from natural capital. The concept may also include discoveries or transfers (from the environment into the economic system) of natural resources, and the effects of disasters and natural growth**.**

Capital consumption: The wearing away of capital stock due to physical destruction or erosion through the ravages of time and through the use of the asset in production, plus the complete withdrawal of capital assets from capital stock (scrappage). Depreciation is more general, in that it is the fall in the price of a capital asset as it ages. Depreciation includes capital consumption, and it also includes revaluation, which consists of pure inflation and obsolescence.

Carbon dioxide (CO2): Colourless, odourless, and nonpoisonous gas that results from fossil fuel combustion and is normally a part of ambient air. It is also produced in the respiration of living organisms (plants and animals) and considered to be the main greenhouse gas contributing to climate change.

Carcinogen: Cancer-causing chemicals, substances or radiation.

Coliform bacteria: A group of bacteria used as an indicator of sanitary quality in water. Exposure to these organisms in drinking water causes diseases such as cholera.

Combined sewers: A sewer that carries both sewage and storm water runoff.

Consumer surplus: Difference between the amount a consumer would be willing to pay for a commodity and the amount he or she actually pays.

Contaminant: Any physical, chemical, biological, or radiological substance or matter that has an adverse affect on air, water, or soil.

Contaminated Sediments: Particles of matter on the bottoms of water bodies that contain toxic contaminants.

Contingent valuation: Method of valuation used in cost-benefit analysis and environmental accounting. It is conditional (contingent) on the construction of hypothetical markets, and is one method of estimating the willingness to pay for potential environmental benefits or for the avoidance of their loss.

Conservation: The continuing protection and management of natural resources in accordance with principles that assure their optimum long-term economic and social benefits.

Consumptive use: the difference between the total quantity of water withdrawn from a source for any use and the quantity of water returned to the source; e.g., the release of water into the atmosphere; the consumption of water by humans, animals, and plants; and the incorporation of water into the products of industrial or food processing.

Cost: Measure of what must be given up to acquire or achieve something.

Cost-benefit analysis: Assessment of the direct economic and social costs and benefits of a proposed program for the purpose of program selection. The cost-benefit ratio is determined by dividing the projected benefits of the program by the projected costs.

Defensive environmental costs: Actual environmental protection costs incurred in preventing or neutralizing a decrease in environmental quality, as well as the expenditures necessary to compensate for or repair the negative effects (damage) of environmental deterioration. Such costs include expenditures required to mitigate environment-related health and other welfare effects on human beings.

Depletion: Loss of water from surface water reservoirs or groundwater aquifers at a rate greater than that of recharge.

Depletion costs: Monetary value of the quantitative depletion (beyond replenishment or regeneration) of natural assets by economic activities. Depletion of natural resources results from their use as raw materials in production or directly in final (household) consumption.

Dioxin: Any of a family of compounds known chemically as dibenzo-p-dioxins. Concern about them arises from their potential toxicity and contamination in commercial products.

Discharge: In the simplest form, discharge means outflow of water. The use of this term is not restricted as to course or location, and it can be used to describe the flow of water from a pipe or from a drainage basin.

Discounting (of natural assets): Determining the present value (net worth) of assets by applying a discount rate to the expected net benefits from future uses of those assets. The discount rate reflects the social preferences for current (as compared with future) uses.

Dissolved oxygen (DO): The amount of oxygen freely available in water (not chemically combined), and necessary for aquatic life and the oxidation of organic materials. Oxygen dissolved in water, wastewater, or other liquid, is usually expressed in milligrams per litre, parts per million, or percent of saturation.

Dissolved solids (DS): Very small pieces of organic and inorganic material contained in water. Excessive amounts make water unfit to drink or limit its use in industrial processes.

Domestic use: The quantity of water used for household purposes such as washing, food preparation, and bathing.

Drought: A continuous and lengthy period during which no significant precipitation is recorded.

Ecosystem: A system formed by the interaction of a group of organisms and their environment.

Effluent: The sewage or industrial liquid waste that is released into natural water by sewage treatment plants, industry, or septic tanks.

Emission standard: Maximum amount of polluting discharge legally allowed from a single source, mobile or stationary.

Environmental accounting: In national accounting, physical and monetary accounts of environmental assets and the costs of their depletion and degradation. In corporate accounting, the term usually refers to environmental auditing, but may also include the costing of environmental impacts caused by the corporation.

Environmental costs: Costs connected with the actual or potential deterioration of natural assets due to economic, social, or political activities. Such costs can be viewed from two different perspectives: (1) as costs caused, that is, costs associated with economic units actually or potentially causing environmental deterioration by their own activities, or (2) as costs borne, that is, costs incurred by economic units independently of whether they have actually caused the environmental impacts.

Environmental damages: Harm caused to the environment by natural or human activities. They are frequently measured in dollars, but some damages may be unmeasurable.

Environmental degradation: Deterioration in environmental quality from ambient concentrations of pollutants and other activities and processes, such as improper land use and natural disasters.

Environmental externalities: Economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism. As a consequence of negative externalities, private costs of production tend to be lower than “social” costs. It is the aim of the “polluter/user pays” principle to prompt households and enterprises to internalize externalities in their plans and budgets.

Environmental functions: Environmental services, including spatial functions, waste disposal, natural resource supply, and life support.

Environmental protection: Any activity to maintain or restore the quality of environmental media by preventing the emission of pollutants or reducing the presence of polluting substances. It may consist of (1) changes in characteristics of goods and services, (2) changes in consumption patterns, (3) changes in production techniques, (4) treatment or disposal of residuals in separate environmental protection facilities, (5) recycling, and (6) prevention of degradation of the landscape and ecosystems.

Environmental restoration: Reactive environmental protection. It includes: (1) reduction or neutralization of residuals; (2) changes in the spatial distribution of residuals; (3) support for environmental assimilation; and (4) restoration of ecosystems, landscape, and so forth.

Environmental services: Qualitative functions of natural non-produced assets of land, water, and air (including related ecosystems) and their biota. There are three basic types of environmental services: (1) disposal services, which reflect the functions of the natural environment as an absorptive sink for residuals; (2) productive services, which reflect the economic functions of providing natural-resource inputs and space for production and consumption; and (3) consumer or consumption services, which provide for physiological as well as recreational and related needs of human beings.

Estuary: Regions of interaction between rivers and nearshore ocean waters, where tidal action and river flow create a mixing of fresh water and saltwater. These areas may include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

Eutrophic lake: Shallow, murky bodies of water that have excessive concentrations of plant nutrients causing excessive algal production.

Eutrophication: The natural process by which lakes and ponds become enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants.

Existence value: Value of knowing that a particular species, habitat, or ecosystem does and will continue to exist. Such value is independent of any use the valuer may or may not make of the resource.

Externality: Activity that affects others for better or worse, without those others paying or being compensated for the activity. Externalities exist when private costs or benefits do not equal social costs or benefits.

Flow vs. Stock: A flow variable is one that has a time dimension or that flows over time (like a stream); a stock variable is one that measures a quantity at a point in time (like the water in a lake).

Freshwater: Water that generally contains less than 1000 milligrams per litre of dissolved solids such as salts, metals, nutrients, etc.

Fungi: Multicellular, nonphotosynthetic microorganisms.

Gross Domestic Product (GDP): The most important item in the National Income and Product Accounts (NIPA). GDP measures the nation's total output of goods and services and the total income of the nation generated by that output. It measures the sum of the dollar values of consumption, gross investment, government purchases of goods and services, and net exports produced within a nation during a given year, where these transactions are valued at market prices. It also represents the incomes earned as wages, profits, and interest, as well as indirect taxes. In addition to the totals for the nation, the NIPA provide a rich array of data on output and incomes in different industries and regions, as well as a record of international transactions.

Groundwater: The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells and springs.

Groundwater recharge: The inflow to an aquifer.

Hazardous materials: Anything that poses a substantive present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Heavy metals: Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Land degradation: Reduction or loss of the biological or economic productivity and complexity of rain-fed crop land, irrigated crop land, range, pasture, forest, or woodlands resulting from natural processes; land uses; or other human activities and habitation patterns, such as land contamination, soil erosion, and destruction of the vegetation cover.

Leaching: The removal of soluble organic and inorganic substances from the topsoil downward by the action of percolating water.

Marginal cost: Increase in total cost required to produce 1 extra unit of output (or reduction in total cost from producing 1 less unit).

Marginal value: Dollar value of one additional unit of product.

Market valuation: (1) Market price valuation applied in national accounts; (2) value of natural resources and of their depletion and degradation, imputed in environmental accounting and estimated on the basis of expected market returns.

Natural assets: Assets of the natural environment. They consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets, and air.

Natural resources: Natural assets that can be used for economic production or consumption.

Net present value: Present value of an investment, found by discounting all current and future streams of income by an appropriate rate of interest.

Nonmarket: Economic activity that produces goods and services not distributed by markets.

Non-renewable resources: Natural resources that can be used up completely or else used up to such a degree that it is economically impractical to obtain any more of them; e.g., coal, crude oil, and metal ores.

Nutrient: As a pollutant, any element or compound, such as phosphorus or nitrogen, that fuels abnormally high organic growth in aquatic ecosystems (e.g. eutrophication of a lake).

Oligotrophic lake: Deep, clear lakes with low nutrient supplies. They contain little organic matter and have a high dissolved oxygen level.

Organic: (1) Referring to or derived from living organisms. (2) In chemistry, any compound containing carbon.

Ozonation: a water purification method that involves the use of ozone to destroy microbial pathogens.

Parts per million (PPM): The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages.

Pathogenic microorganisms: Microorganisms that can cause disease in other organisms or in humans, animals, and plants.

Pathogens: Disease-causing agents such as bacteria, viruses and parasites.

PCBs: Polychlorinated biphenyls, a class of persistent organic chemicals that bioaccumulate.

Percolation: The movement of water downward through the subsurface to the zone of saturation.

Pesticide: A substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended to regulate plant or leaf growth. Pesticides can accumulate in the food chain and/or contaminate the environment if misused.

Physical accounting: Natural-resource and environmental accounting of stocks and changes in stocks in physical (nonmonetary) units, for example, weight, area, or number. Qualitative measures, expressed in terms of quality classes, types of uses, or ecosystem characteristics, may supplement quantitative measures. The combined changes in asset quality and quantity are called “volume changes.”

Plankton: Tiny plants and animals that live in water.

Pollution: (1) Presence of substances and heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects; (2) activity that generates pollutants.

Pollution abatement: Technology applied or measure taken to reduce pollution and/or its impacts on the environment. The most commonly used technologies are scrubbers, noise mufflers, filters, incinerators, wastewater treatment facilities, and comporting of wastes.

Precipitation: Water falling, in a liquid or solid state, from the atmosphere to a land or water surface.

Protozoa: Single-celled animals that reproduce by binary fission.

Public good: A commodity whose benefits may be provided to all people (in a nation or town) at no more cost than that required to provide it for one person. The benefits of the good are indivisible, and people cannot be excluded from using it.

Receiving waters: A river, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged.

Recharge: The processes involved in the addition of water to the zone of saturation; also the amount of water added.

Recyclable: Refers to such products as paper, glass, plastic, used oil, and metals that can be reprocessed instead of being disposed of as waste.

Renewable Resource: Natural resource (e.g., tree biomass, fresh water, fish) whose supply can essentially never be exhausted, usually because it is continuously produced.

Reservoir: A pond, lake, or basin (natural or artificial) that stores, regulates, or controls water.

Restoration: The renewing or repairing of a natural system so that its functions, and its qualities are comparable to its original, unaltered state.

Restoration costs: Actual and imputed expenditures for activities aimed at the restoration of depleted or degraded natural systems, partly or completely counteracting the (accumulated) environmental impacts of economic activities.

Runoff: The amount of precipitation appearing in surface streams, rivers, and lakes; defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

Salinity: The concentration of salt in a body of water.

Sediment: Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice, and gravity.

Sewage: The waste and wastewater produced by residential and commercial establishments and discharged into sewers.

Sewage system: Pipelines or conduits, pumping stations force mains, and all other structures, devices, and facilities used for collecting or conducting wastes to a point for treatment or disposal.

Sewer: A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream.

Sewerage: The entire system of sewage collection, treatment, and disposal.

Sludge: A semi-solid residue from any of a number of air or water treatment processes.

Solvent: Substances (usually liquid) capable of dissolving or dispersing one or more other substances.

Storm sewer: A system of pipes (separate from sanitary sewers) that carry only water runoff from building and land surfaces.

Surface water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors that are directly influenced by surface water.

Suspended sediment: Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.

Suspended solids (SS): Defined in waste management, these are small particles of solid pollutants that resist separation by conventional methods. Suspended solids (along with biological oxygen demand) are a measurement of water quality and an indicator of treatment plant efficiency.

Sustainability: (1) Use of the biosphere by present generations while maintaining its potential yield (benefit) for future generations; (2) non-declining trends of economic growth and development that might be impaired by natural-resource depletion and environmental degradation.

Toxic: Harmful to living organisms.

Transboundary pollution: Pollution that originates in one country but, by crossing the border through pathways of water or air, is able to cause damage to the environment in another country.

Travel cost: A method of assessing willingness to pay using cost data associated with movement to an environmental recreation area.

Trihalomethanes (THM's): A family of chemical by-products generated by water chlorination.

Urban runoff: Storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.

Valuation of natural assets: Methods of applying a monetary value to natural assets in environmental accounting that include (1) market valuation; (2) direct nonmarket valuation, such as assessment of the willingness to pay for environmental services (contingent valuation); and (3) indirect nonmarket valuation, for example, costing of environmental damage or of compliance with environmental standards.

Wastewater: Water that carries wastes from homes, businesses, and industries; a mixture of water and dissolved or suspended solids.

Wastewater treatment plant: A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

Water (H_2O): An odourless, tasteless, colourless liquid formed by a combination of hydrogen and oxygen; forms streams, lakes, and seas, and is a major constituent of all living matter.

Water conservation: The care, preservation, protection, and wise use of water.

Water contamination: Impairment of water quality to a degree that reduces the usability of the water for ordinary purposes or creates a hazard to public health through poisoning or the spread of diseases.

Water pollution: Generally, the presence in water of enough harmful or objectionable material to damage the water's quality.

Water quality: A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water quality guidelines: Specific levels of water quality that, if reached, are expected to render a body of water suitable for its designated use. The criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Watershed: The land area that drains into a stream.

Water table: The top of the zone of saturation.

Well: A pit, hole, or shaft sunk into the earth to tap an underground source of water.

Wetlands: Lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. Other common names for wetlands are bogs, ponds, estuaries, and marshes.

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Appendix I

The Nova Scotia Genuine Progress Index: List of Components

Time Use:

* Economic Value of Civic and Voluntary Work
* Economic Value of Unpaid Housework and Childcare
* Costs of Underemployment
* Value of Leisure Time

Natural Capital:

* Soils and Agriculture
* Forests
* Marine Environment/Fisheries
* Nonrenewable Subsoil Assets

Environment:

* Greenhouse Gas Emissions
* Sustainable Transportation
* Ecological Footprint Analysis
* Air Quality
* Water Quality
* Solid Waste

Socioeconomic:

* Income Distribution
* Debt, External Borrowing, and Capital Movements
* Valuations of Durability
* Composite Livelihood Security Index

Social Capital:

* Health Care
* Educational Attainment
* Costs of Crime
* Human Freedom Index

Appendix II

Part III: Case Study: The Costs and Benefits of Sewage Treatment and Source Control for Halifax Harbour