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APPLICATION OF ENVIRONMENTAL DAMAGE ASSESSMENT AND RESOURCE VALUATION PROCESSES IN ATLANTIC CANADA

CASE STUDY: CANADA

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FOREWORD

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APPLICATION OF ENVIRONMENTAL DAMAGE ASSESSMENT AND RESOURCE VALUATION PROCESSES IN ATLANTIC CANADA

by

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Executive Summary

Environmental damage assessment (EDA) is a management tool under development in Canada that works to identify, quantify and value environmental injuries. The goal of EDA is to support restoration of the affected ecosystem or natural resource to its "pre-incident" condition. A step-wise process is employed for completing an environmental damage assessment, beginning with identification and determination of the source and extent of the injury, followed by restoration planning, then implementation of the restoration plan.

While EDA is still in its infancy in Canada, and there is a pressing need to establish protocols for data collection and analysis, this approach has shown considerable promise as an ecosystem restoration tool. So far, Environment Canada has used EDA in cases involving the release of hazardous substances into freshwater and coastal ecosystems.

The Canadian legislative framework provides opportunities for the application of EDA in the assignment and recommendation of appropriate compensation for environmental damage as determined through the EDA process. The *Canadian Environmental Protection Act*, the *Fisheries Act*, the *Migratory Birds Convention Act*, the *Canada Wildlife Act*, the *Canadian Shipping Act* and the *Arctic Waters Pollution Prevention Act* all provide opportunities for the use of EDA in Canada.

The 1999 revision of the *Canadian Environmental Protection Act* provided for the creation of the Environmental Damages Fund. The Environmental Damages Fund (EDF) is a special holding or trust account of Environment Canada (monitored by the Treasury Board of Canada) for managing monies collected via court orders, awards, out-of-court settlements, and other legal judgements. The Fund is used

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to channel resources in support of remediation and restoration activities identified through the EDA process (and often stipulated in the negotiated compensation agreement or court decision).

It was a series of freshwater fish kill events on Prince Edward Island during the summer of 1999 that stimulated Environment Canada - Atlantic Region's original efforts in developing environmental damage assessment (EDA) protocols and processes. A summary of this first experience is provided in Appendix A. From that initial experience, lessons were learned about the importance of co-ordinating data collection to support a successful environmental damage assessment. As such, the Environment Canada EDA team recommended the development of data collection and analysis protocols.

Practical experience with damage assessment (in Canada and the United States) indicates that such protocols are essential to success. Protocols serve three main purposes: 1) they ensure data collection links the hazardous release to environmental damages, 2) they guide data collection immediately after a release (as the data is time sensitive), and 3) they provide the needed clarity of the roles and responsibilities of the multiple parties (including government responders, responsible parties, community responders) involved in an emergency response.

Protocol development has proceeded in the Atlantic Region of Canada since 1999. Preliminary protocol work has been completed to address two specific cases: 1) small scale petroleum spills in coastal environments, and 2) hazardous releases into freshwater environments.

A simplified approach for quantifying and valuing the environmental injuries resulting from small-scale coastal petroleum spills has been drafted. The approach relies on existing emergency response procedures for data collection and pre-assessment techniques, but avoids having to proceed with detailed (and often costly) field investigations. The advantage of using a simplified approach comes at the expense of some precision and accuracy in measuring and valuing damages. It is important to note that such a trade-off may not be acceptable where highly sensitive areas or highly valued ecosystem components (such as endangered species and spaces) are impacted. As well, it is important to keep in mind that the proposed simplified quantification and valuation approach should be used as a *starting point* for discussion and negotiation of suitable compensation, fines or court awards, rather than a definitive estimate of total injury and economic costs.

A draft protocol for water, sediment, macro-invertebrate and fish sampling and analysis has been drafted for cases involving a hazardous release into freshwater environments. The Economic Valuation component of this draft protocol document (an important component of the whole EDA process) is still under development. The draft protocol document for primary data collection is a compilation of existing sampling procedures, and is arranged to reflect the order that data collection should follow at the field site.

Given the success of the preliminary work on EDA thus far, it is likely that this type of analysis will be used more frequently in the future. It may be desirable for protocol development to continue, and to be promoted as a valuable environmental management tool in Canada and elsewhere. The need for EDA protocol is especially great in regions where cross-jurisdictional environmental emergencies may occur. Currently available draft protocol approaches may provide the reader with guidance on how to apply environmental damage assessment in various contexts.

Ecosystem studied: Freshwater and coastal ecosystems

Valuation method(s) used: Benefits transfer, travel cost method, restoration cost method

Main lessons learned: Co-ordinating data collection through the use of accepted protocols is essential for supporting the scientific basis of suspected "cause-effect" pathways, determining the temporal and spatial

extent of impacts from hazardous releases, and selecting the appropriate economic valuation methods to use for estimating suitable compensation.

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1. Introduction

Environment Canada and other government departments (at both the federal and provincial levels) are trustees of Canada's environment and natural resources. These agencies use many tools to fulfil their responsibilities as trustees. Increasingly, these tools involve influencing people's behaviour in such a way that prevents them from causing environmental damage.

Enforcement of environmental laws and regulations is a common approach taken in response to such problems. Environment Canada, under the authority of legislation like the *Canadian Environmental Protection Act*, has the ability to recover monetary damages from parties responsible for damage or injury to natural resources or the environment[4]. In the past, however, our ability to link financially-based court judgements (e.g. fines) to the repair of environmental damage has been hampered by a lack of accepted methods to assign costs to these damages. The development and implementation of a new approach - environmental damage assessment (EDA) - in Canada is working to address that very issue. EDA allows practitioners to quantify environmental damage, determine economic and social costs associated with the damage. EDA results can then be used to recommend a suitable compensation amount in any given instance.

While it is true that EDA is still in its infancy in Canada, and there is a pressing need to establish protocols for data collection and analysis, this approach has shown considerable promise as an ecosystem restoration tool. So far, Environment Canada has been successful in the use of EDA in cases involving releases of hazardous substances into freshwater and coastal ecosystems.

This paper explores EDA from the perspective of its development in Canada and describes the recently developed data collection and analysis protocols available to support the physical damage assessment and economic valuation. The role of valuation in environmental damage assessment, and the ways that EDA can support both formal and informal enforcement processes are also described. The application of EDA to an actual event (a fish kill) by Environment Canada is also described and some concluding observations regarding the success of the EDA experience in Atlantic Canada are then offered. Finally, recommendations for future work and improvements to EDA protocol development are presented.

2. How Environmental Damage Assessment works

The goal of completing a damage assessment is to restore injured ecosystems or specific natural resources to their pre-incident condition. To achieve this goal, two broad questions are asked:

- What natural resources have been injured and what is the loss to the public?
- How can the environment be restored and what type and scale of restoration is appropriate?

A step-wise process is employed to address these questions, beginning with a pre-assessment of environmental injury, followed by restoration planning, then implementation of the restoration plan.

[4] Campbell, Erin. "Rationale for Applying Fines, Penalties and Court Awards to the Environmental Damages Fund", Applying Environmental Damage Assessment and Restoration Tools in the Atlantic Region. Chapter 5 of unpublished report, prepared for Environment Canada - Atlantic Region. 1998.

Step 1 Pre-Assessment: Injury is assessed by examining the resources placed at risk during an incident, defining the nature of the resources' exposure to contamination, and recording any direct observations of resource injury. If injuries are expected to continue, and feasible restoration alternatives exist to address those injuries, Trustees proceed to conduct a full damage assessment.

Step 2 Restoration Planning: Two closely co-ordinated activities take place during this phase: injury assessment, to determine the nature and extent of injuries to the environment and ecosystem services; and restoration method selection, to select a preferred action or series of actions from a reasonable range of restoration alternatives. Trustees work closely with the Responsible Parties to ensure the restoration plan is technically feasible and cost effective.

Step 3 Restoration Implementation: The restoration plan is undertaken as promptly as possible. All restoration efforts provide for monitoring; important for measuring progress and incorporating necessary changes to ensure the restoration effort's overall success. In many cases, the Responsible Parties assume responsibility for implementing the restoration with Trustee supervision.

On observing or receiving a report of an incident, the first step in the pre-EDA process is to obtain as many of the important details as possible, specifically:

- when and where the event occurred (characterise the environmental setting);
- possible source of the contaminant and the extent of the contamination;
- identify the product involved;
- volume released to the environment, and its physical and chemical properties, and
- potentially impacted components of the ecosystem (i.e. species).

Based on the information received, investigators decide whether a full EDA process is triggered, requiring additional and more detailed site assessments for evaluation of appropriate remedial measures. Environmental data used for the damage assessment must be gathered in a manner that is timely, accurate, comprehensive and scientifically defensible.

The expertise of personnel collecting environmental data and conducting assessments must be demonstrable to all stakeholders especially when seeking financial penalties and compensatory awards related to environmental injury and restoration from courts. Assessments should follow well-defined protocols. While methods and protocols exist for determining biological effects, economic value and the like, a synthesis of procedures supporting EDA would be tremendously useful for simplification. In so doing, it becomes necessary to draw from the existing methods to construct a robust EDA methodology which requires a slight shift from exploratory science, to the applied science needed for decision-making. Available methods and procedures are included in the bibliography for the reader's reference.

Ecosystem restoration is an important component of the complete EDA process. Restoration is intended to replace the damaged ecosystem component, or provide support to enhance natural recovery. Restoration ensures that the services provided to the environment, the economy and the community are restored, offsetting the imposed costs of the polluting event.

3. The Context for Environmental Damage Assessment in Canada

3.1 Legislative Impetus

The Canadian legislative framework provides opportunities for the application of EDA in the assignment and recommendation of appropriate compensation for environmental damage as determined through the EDA process. The *Canadian Environmental Protection Act*, the *Fisheries Act*, the *Migratory Birds Convention Act*, the *Canada Wildlife Act*, the *Canadian Shipping Act* and the *Arctic Waters Pollution Prevention Act* all provide opportunities for the use of EDA in quantifying and assessing the dollar value of environmental damage resulting from a polluting activity, and for recovering funds from the polluter to repair these damages.

3.2 EDA and Environment Canada

Environmental Damage Assessment is a potentially powerful tool for Environment Canada and other departments with resource management / protection mandates. It can act as a deterrent to polluters because they know they can be held accountable to pay for cleaning up damages they cause. Diligence and pollution prevention is thus encouraged. Environment Canada manages the funds obtained through EDA via the Environmental Damages Fund.

The Environmental Damages Fund (EDF) was established in 1995 as a special holding or trust account of Environment Canada (monitored by the Treasury Board of Canada) for managing funds collected via court orders, awards, out-of-court settlements, and other legal judgements[5]. This Fund has some similarities to the Oil Spill Liability Trust Fund set up in the United States in support of the national Natural Resource Damage Assessment process. The Fund is used in support of remediation and restoration activities identified through the EDA process; and often stipulated in the negotiated compensation agreement or court decision. The Fund is also used to support relevant environmental damages research and development.

Between 1998 and 2001, approximately $325,000 (all amounts in $Canadian) was contributed to the Environmental Damages Fund. These contributions were derived from proceeds associated with charges laid under the Canadian Environmental Protection Act, Section 36(3) of the Fisheries Act, and Section 32 or 35 of the Fisheries Act. Thus far, $115,000 has been disbursed from the Fund to support nine restoration projects in Atlantic Canada. The total value of those same projects amounts to more than $1.2 million (including cash and in-kind support), demonstrating the importance of partnerships in achieving a higher level of environmental clean-up than the Environmental Damages Fund (EDF) alone could achieve.

4. Environmental Damage Assessment: An Atlantic Canada Perspective

Each year in the Atlantic Region of Canada (which consists of the provinces of Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador), approximately 2,500 spills or releases of petroleum and chemicals are reported through a pollution reporting network. Spills or hazardous releases can involve a wide variety of products with a similarly broad range of chemical and physical properties. Once released, these products can result in contamination of the air, soil or water.

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5 Campbell, Erin. 1998. "Rationale for Applying Fines, Penalties and Court Awards to the Environmental Damages Fund", Applying Environmental Damage Assessment and Restoration Tools in the Atlantic Region. (Dartmouth, Nova Scotia: Environment Canada Atlantic Region).

Those entering water can cause lethal and sub-lethal effects on the marine and aquatic flora and fauna. For example, each year approximately 15 to 20 fish kills are reported in this region which result from spills or releases of contaminants, chronic effluent discharges, physical damage, alteration of habitat, or natural causes.

Of the oil and hazardous material spills reported to Environment Canada-Atlantic Region, nearly 60% are considered small spills of less than 10,000 litres. Numerous small spills in the coastal environment may account for the largest volume of petroleum entering the environment. While a considerable source of pollution, small spills receive much less public attention in comparison to the high profile (and infrequent) large spills. However, it was a series of freshwater fish kill events on Prince Edward Island during the summer of 1999, that stimulated the Atlantic Region's original efforts in developing environmental damage assessment (EDA) protocols and processes.

The Atlantic Region's first EDA (refer to Appendix A for a brief summary) relied upon Environment Canada's Enforcement Division's toxicological analysis of fish tissue to ascertain the source of the pollutant, and its collection of thousands of fish carcasses to estimate the scale and extent of the fish kill event. These data sources supported the first EDA valuation, which estimated the cost of restoring the lost fish population and compensating the community for lost recreational services provided by the closed fishery.

From that initial experience, lessons were learned about the importance of co-ordinating data collection to support not only the "cause-effect" pathways, but also the temporal and spatial extent of impact from a hazardous release, and the appropriate economic valuation methods to use for estimating suitable compensation.

It is important to note that the assessment process depends on the availability of technical expertise to evaluate the toxicity of spilled substances, to conduct site surveys, to collect chemical, biological and environmental data, to assess damage, and to assign monetary value to damaged resources. An environmental damage assessment team has responsibility for planning and conducting damage assessments in the event of a spill of hazardous substances. Depending on the magnitude and complexity of a spill, a broad range of expertise can be drawn regionally from within Environment Canada, the community, and from other agencies. Environment Canada's regional Environmental Emergencies program staff are the core members of the team – they are available and prepared to undertake spill site surveys and damage assessments during an emergency response. These Environment Canada staff are (along with staff from other agencies with spill response responsibilities) all members of the Regional Environmental Emergencies Team.

A key recommendation from the EDA team was for the development of protocols to assist field staff in collecting the right information at the scene, and to use that data appropriately for quantifying ecosystem injury and the economic value of ecosystem losses. It was also recommended that future environmental damage assessments broaden their analytical scope beyond recreational fish species, and that they represent (as much as possible) an ecosystem perspective.

5. The Importance of Environmental Damage Assessment Protocols

5.1 The Need for EDA Protocols

As mentioned, environmental damage assessment (EDA) is a new tool for Canada. At this point, the EDA practitioner is faced with more questions than answers. Given this uncertainty, there is clear need to develop protocols on how assessments are designed and implemented. Developing these protocols will contribute to the success of EDA in Canada and enhance ecosystem restoration efforts. It is the authors'

belief that initial experiences in Atlantic Canada with the development of protocols and their application to fish kill events and small scale oil spills will advance EDA development at the national level.

Practical experience with damage assessment (in Canada and the United States) indicates that national protocols are essential to success. Protocols serve three purposes:

1. They ensure that data is collected which can link a hazardous release to environmental damages. The magnitude of the damages must also be identified and evidence obtained which can support the claim of damage in a court of law.

2. Data collection linking the hazardous release to damages is time sensitive; data gathering opportunities are lost as time passes. If data gathering is incomplete or if the data is of poor quality, then the EDA process is jeopardised. Protocols are therefore required to guide data collection immediately after a release.

3. From an operational perspective, EDAs are complex. Multiple players from a variety of disciplines must interact in a linked chain to produce evidence of ecosystem damage and appropriately scaled restoration options. Overlapping jurisdictions (inter-provincial and international) and mandates further test successful integration. Consequently, there is a need to have a good understanding of the roles and responsibilities in an EDA situation.

5.2 Protocol Development in Atlantic Canada

5.2.1 Small Scale Petroleum Spills in Coastal Environments (Summarised from Clement, 2001)

Clement (2001) proposes a simplified approach for valuing the environmental injuries resulting from small-scale coastal petroleum spills. The approach relies on existing emergency response procedures for data collection and pre-assessment techniques as noted earlier, but avoids having to proceed with detailed (and often costly) field investigations.

There are several reasons supporting Clement's proposal. Key among them are the disproportionately high assessment costs associated with quantifying and valuing injuries from small petroleum spills. A comprehensive EDA requires extensive data collection, modelling and in-depth socio-economic analysis; with a price tag that may exceed the compensatory amount recommended in the final analysis - making comprehensive EDAs of small scale spills economically inefficient. The advantage of using a simplified approach comes at the expense of some precision and accuracy in measuring and valuing damages. As Clement notes, such a trade-off may not be acceptable where highly sensitive areas or highly valued ecosystem components (such as endangered species and spaces) are impacted.

The simplified valuation approach proposed in the draft protocol sums three components: ecological costs, service flow costs, assessment costs. Ecological costs include the expense of restoring, replacing or rehabilitating the environmental injury, and are based upon the type of shoreline, its relative sensitivity to disturbance, total area affected, and the type of petroleum spilled. Service flow costs address the direct human-use values lost as a result of a spill. Assessment costs are all the reasonable expenditures undertaken to perform the EDA (Clement, 2001).

Clement also states that the proposed simplified quantification and valuation approach should be used as a *starting point* for discussion and negotiation of suitable compensation, fine or court award, rather than a definitive estimate of total injury and economic costs.

If this approach is unacceptable to the public or the alleged Responsible Party, then the alternative is to undertake a comprehensive environmental damage assessment (EDA) which would be much more complex, detailed and expensive to undertake. As well, a comprehensive, scientifically and ecologically rigorous approach may also result in a substantially greater estimate of ecological costs, especially if surveys of the public's willingness-to-accept compensation are employed - which can raise the ceiling on compensation estimates.

To test the simplified EDA approach, Clement applied his model to a small scale gasoline spill that occurred in a Nova Scotian cove (Clement, 2001). The 670 m^2 of impacted shoreline was classified as a "high response priority" by the Regional Environmental Emergencies Team, and was comprised of man-made structures, cobble beach and mixed-sediment beach. Using the equations developed to enable a simplified EDA (which relied heavily on the benefits transfer economic valuation technique), Clement estimated that the restoration costs of the injury were nearly $29,000. Data from a national survey on the importance of nature to Canadians, was used to estimate the lost recreational values associated with an impaired coastal environment frequented by walking enthusiasts. Recreational service flow costs were estimated at $1300 for the period the coastline was oiled. The assessment costs associated with the field investigations, data analysis and completion of the EDA amounted to $4,750. In total, the small scale gasoline spill in the cove was estimated to cost nearly $35,000.

The simplified EDA approach was applied to a case that had already been through the Canadian justice system, and a decision had already been made as to the fine and penalty for the gasoline spill. At that time, the fine was determined according to case law and precedent. The judge in this case fined the Responsible Party $10,000 (less than a third of the estimated environmental damage costs), most of which was directed to the Environmental Damages Fund.

This example illustrates two important points: 1) EDAs are better at reflecting the significance and scale of ecosystem injury than case law precedents, and thereby act as a market-based pollution deterrent in legal proceedings; and 2) conducting a comprehensive EDA with extensive ephemeral data collection would not have been an economically efficient undertaking in this case.

5.2.2 Hazardous Chemical Releases into Freshwater Environments (Summarised from Sawyer, Hundert and MacDonald, 2001)

A series of fish kill events on Prince Edward Island during the summer of 1999, stimulated Environment Canada's first efforts in developing environmental damage assessment protocols. Since those initial efforts, and now broadening the scope of EDA to reflect an ecosystem approach, a draft protocol document has been prepared by the Southeast Environmental Association to co-ordinate detail field investigations and data collection after a hazardous chemical release. Keenan and Boyce (2001) have prepared the draft protocol for water, sediment, macro-invertebrate and fish sampling and analysis. The Economic Valuation Protocols (an important component of the whole EDA process) are still under development[6].

The Southeast Environmental Association's draft protocol document is a compilation of existing sampling procedures, and is arranged to reflect the order that data collection should follow at the field site. The protocol provides a material and equipment list for the field teams, and explains how the collected information will be used later throughout the EDA process.

[6] During the fall/winter of 2001, the Southeast Environmental Association will develop a protocol document guiding the translation of biophysical data into the economic valuation analysis for supporting compensation recommendations with the assistance of Environment Canada-Atlantic Region.

For example, the field sampling protocol includes instructions for completing a stream macro-invertebrate (bottom dwellers) population assessment. The status of a stream's bottom-dwelling community helps define the extent and duration of a hazardous release's impact upon the freshwater environment (Keenan and Boyce, 2001). The time window for completing such an analysis is very narrow. Having protocols in place to guide a proper assessment improves the overall quality of the damage assessment completed in the freshwater environment.

6. Additional Thoughts on Environmental Damage Assessment

Given the success of the preliminary work on EDA thus far, it is likely that this type of analysis will be used more frequently in the future. Environmental damage assessment (EDA) as a tool, serves a useful purpose in developing information important in speaking to sentence in legal proceedings. It is desirable for protocol development to continue, and to be promoted as a valuable tool in Canada and elsewhere. The need for EDA protocol is especially great in regions where cross-jurisdictional environmental emergencies may occur, like in the Great Lakes of Canada, or the Gulf of Maine. Currently available draft protocol approaches may provide the reader with guidance on how to apply such techniques to similar contaminant events.

It has also been the Canadian experience, that the physical sciences are more established and accepted in the Canadian justice system in comparison to the economics of damage valuation. Economic valuation is a new tool being used in Canada, and practitioners and stakeholders will need to become more familiar with its potential uses and applications in all aspects of environmental protection.

Appendix A: Fish Kill EDA Case Study

An environmental damage assessment (EDA) case study from the Atlantic Canada experience is used to illustrate the importance of community involvement in the EDA process, as well as the role of multi-disciplinary partnership, access to EDA protocols, ecosystem restoration, and valuation in determining compensation.

A.1 Background to the Fish Kill Event

In 1999, a significant rainfall event washed chemical laden soil from a large potato field into the Valleyfield River of Prince Edward Island, Canada. Immediately, dead fish were reported in the river by the Montague Watershed Enhancement Co-op, the local watershed enhancement association. This fish kill, principally of brook trout, precipitated an environmental damage assessment.

The fish kill was caused by the high concentration of a pesticide in the river. The implicated chemical, a pesticide used to control leaf eating insects on potato plants, has been shown in past studies to be extremely toxic to aquatic life. The sub-lethal effects of this particular pesticide (increased vulnerability to illness, impaired growth and reproductive maturity) are also of concern.

At least twenty five hundred brook trout were killed as a result of this incident. The recreational fishery was closed, which imposed costs upon the local community and economy. Both the Regional Environmental Emergency Team (federal and provincial agencies), and community partners worked together to assess the cause of the kill, minimise its impact, and collect preliminary data useful in quantifying damages.

A.2 Scope of Environmental Damage

Damage to the aquatic ecosystem in this case, specifically the brook trout stocks (recreational fish), were assessed in the EDA that followed. There are several other aquatic species inhabiting the affected river as well, including Atlantic Salmon, rainbow trout, stickleback and many species of macro invertebrates. The primary focus of the EDA was the quantification of fish mortality through the collection of carcasses. A secondary EDA compared the remaining live population of brook trout to historical population trends, the difference being the environmental loss / damage caused by the incident.

A.3 Duration of Environmental Damage and Restoration Options

Electrofishing surveys (enumeration method that involves shocking a stretch of river with a mild electric current to stun – not kill – the fish) indicated that the young of the year were most heavily impacted. This portion of the population plays two important roles: 1) they are the future spawners, and 2) they are a food source for larger fish. The loss of this size class will have a significant future impact on the population. Fortunately, a portion of the Valleyfield River system was not impacted by the incident, and so the remnant population from that section of the river have an opportunity to eventually redistribute and take advantage of the unused habitat. Natural regeneration may take several years to bring fish stock back to levels experienced prior to the 1999 fish kill.

Restocking with hatchery-raised brook trout is another restoration option. Restocking works best when it is possible to re-introduce offspring from the river's own healthy brood stock. While it takes two years to raise releasable fish to the river system, the probability of restoration success can be realised several years earlier than allowing natural regeneration of the stock. Restoration success is also influenced by fishing pressure upon the stock, water quality and the quality of the habitat and spawning substrate.

A.4 Economic Costs of the Valleyfield River Fish Kill

Using available data and standard valuation methodologies (replacement cost, willingness to pay, and market value of expended resources), an economic valuation of the Valleyfield River fish kill attempted to place a minimum monetary value on the ecosystem losses, the lost service flows to the community, and actual damage assessment and restoration expenditures. Because of limited data and uncertainty, economic, environmental and social losses are believed to amount to considerably more than are reported here. The following sections provide details of the economic valuation calculations that were completed in 1999 when future fishing seasons were still uncertain.

A.4.1 Restoration of Trout Population (Replacement)

Assuming a restoration plan that depended upon restocking, the replacement cost method was used to estimate a minimum value of ecosystem losses. The calculations relied upon the observed fish loss estimates, and market prices for hatchery raised trout. Ecosystem costs in the first year after the fish kill amounted to approximately $1,800. If one expects that only a fraction of dead fish were actually collected and included in the analysis (very likely), then the replacement value of brook trout will be much higher than the value reported here.

In addition to purchasing and releasing an appropriate number of hatchery-raised fish, ecosystem restoration costs also include the costs to maintain a fish stock monitoring program. An ecosystem restoration program will require monitoring of stock progress, and will likely require additional fish releases to ensure the population structure is rebuilt. Monitoring and future stocking activity were estimated to cost approximately $7,800 over the life of a conservative re-stocking program. In total, restoration of the trout population (and ecosystem functions of this river) will require a minimum investment of $9,600 in the year following the incident.

A.4.2 Expenditures - The Costs of Investigation and Enforcement

The total cost of the fish kill included the cost of people's professional and volunteer time, and all out-of-pocket costs such as travel, laboratory analysis, purchase of investigation materials, and disposal of dead fish. All costs, except for the cost of time, are determined using reported expenditures (private sector and public sector expenditures are reported separately).

The private sector (volunteers, non-governmental organisations) incurred expenses of $6,100 in response to the fish kill event. The public sector incurred $9,200 in response expenditures, for a total of $15,300.

A.4.3 Lost Service Flows - A Closed Recreational Fishery

The lost opportunity for recreational fishing imposed costs upon the surrounding watershed communities. The cost (or lost recreational value) is measured using consumer surplus estimates

associated with the recreational fishery on the Valleyfield River. To test the sensitivity of two controlling variables (the number of participants in the recreational fishery, and the number of days the fishery may be closed), a range of lost service flow estimates were generated and are presented here.

At the time of the original economic analysis, it was unclear whether or not the Valleyfield River's recreational fishery would reopen the following spring. If the recreational fishery were to open in the spring of 2000, the community would experience a loss of between $10,700 and $14,200 over the closed season days experienced in 1999. If the recreational fishery was to remain closed the following year, additional losses of $28,600 to $38,200 over those two years would be expected. However, when spring came in 2000, the Valleyfield River was reopened for recreational fishing.

A.4.4 Total Estimated Cost of the Fish Kill

Based upon the results of the environmental damage assessment, recreational fishery statistics for this particular watershed, and reported expenditures for the investigation and enforcement action, it has been determined that **at least** $35,600 to $39,000 in ecosystem, service flow and expenditure losses were incurred as a result of the fish kill event in the Valleyfield River.

Given the limitations of data and the simplifying assumptions of the analysis, it is probable that the true total cost of this fish kill is actually much *greater* than that reported here. As a result of the case, funds were made available to the Southeast Environmental Association through the Environmental Damages Fund for restoration of the fish population in the Valleyfield River system during the summer of 2001.

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