Reclaiming Free Flow

An Information Guide on Removing Small Abandoned Dams

Part I of the
Humphreys Mill Dam
Decommissioning Project

Project Coordinator:
Sentinelles Petitcodiac Riverkeeper

Project Sponsors:
Environment Canada's Habitat Stewardship Program
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Sentinelles Petitcodiac Riverkeeper

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DISCLAIMER

While realizing that every dam and waterway has its specific characteristics, this guide serves as a general framework to help readers in the process of assessing the removal of small abandoned dams. The information written is therefore not intended to be a comprehensive analysis of all dam decommissioning or dam safety requirements. For those purposes, readers should consult with appropriate experts in the field as well as with governmental agencies responsible for the regulation of dams.

The authors are therefore not legally responsible for any decisions made based on this guide. The contents are the sole responsibility of the Sentinelles Petitcodiac Riverkeeper, and the findings and recommendations contained herein do not necessarily reflect those of other individuals and organizations listed in this Information Guide.

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INTRODUCTION

The Importance of Healthy Rivers in Our Communities

Historically, rivers[1] have always been at the center of the communities in which they flowed, providing food and water and acting as transportation routes. With time, this was taken for granted and our relationship to rivers started to change. Instead of only appreciating and making use of rivers in their natural state, many took advantage of their constant and sometimes powerful flow, to turn water wheels to grind grain, and later, to propel turbines to provide energy for industries. In addition, rivers have been for a long time, and some are still, used for dumping and getting rid of waste.

Fortunately, our relationship and understanding of rivers is evolving, as we humans realize how much damage can result from our actions, such as the clogging of rivers with dams. Many people who make use of rivers for recreational activities appreciate the natural qualities of a river and are part of, or forming new groups with river protection and restoration goals in mind. Many more feel that a healthy river free flowing in their community enhances their overall quality of life.

This Information Guide gives an overview of the process involved in removing dams and is intended to be used as a framework for removing small abandoned dams in the Inner Bay of Fundy region. Because of the wide range of functions and purposes of dams, this guide limits itself to small dams that have been abandoned and no longer serve a purpose.

[1] The term river is used generally in this guide and includes all waterways like small brooks, streams and creeks.

It is also important to note that this guide is adapted for the removal of small abandoned dams to be targeted for removal or alteration only, and does not give information or advice on the upgrading or repairing of dam structures.

The objective of this guide is therefore to raise awareness on the subject of dam removal, and at the same time, offer general guidelines that can help concerned citizens take action and solve the issues around small abandoned dams that clog their river, impede natural fish passage and pose a threat to public safety.

In itself, the physical removal of the actual dam structure is a process that is relatively simple. But there are a number of issues that need to be addressed prior to considering or initiating a dam removal project. Good planning should be at the center of every project to ensure that the impacts of released sediments and stream bank erosion, for instance can be brought to their lowest.

In fact, each removal project has its unique characteristics, and while one project brings forward complex issues that are difficult and take time to solve, others can be simple and easy to deal with, therefore needing less resources and requiring the use of only certain sections of this guide.

This is not the first guide written on dam removal. In fact, many other resources, such as scientific reports and individual case studies have been written on the subject. We sincerely hope that this information guide will help point the way in providing general knowledge and will lead readers into consulting experts in the field and other resources required to the specific needs of some more or less complex dam removal projects.

SECTION 1

An Overview of Dams

1.1 Types of Dams

A dam is a barrier that obstructs the natural flow of water, creating a body of water behind its structure called an impoundment or reservoir. Dams come in all shapes and sizes and are built using diverse methods and materials such as wood, steel, concrete, and compacted rocks and earth.

Dam categories:
Storage
Diversion
Flood Control

Dams can serve multiple functions that can be grouped in three categories being storage, diversion and flood control. Storage dams can serve as a water supply, can provide hydroelectric power generation, create a drinking water supply and serve as water recreation areas. Diversion dams are used to divert water to other areas for irrigation, augment water supplies or else used for other industrial needs.

Flood control dams are designed to minimize the effects of sudden high water flows caused by heavy rain or snow melt events, by retaining considerable amounts of water in the impoundment. In the case of the Inner Bay of Fundy, many flood control dams or systems, such as causeway-dams or aboiteaux were originally designed and built to act as tidal barriers to protect agricultural lands from the incoming seawater.

Dams create obstacles to natural fish passage

In all cases dams create obstacles to natural fish passage, which are partial (gate management systems in place), complete (no fish passage management or fishway available) or artificially engineered (fish ladders or fish tank transport systems in place). Dams also come in different sizes; from very small dams such as is the case on the Humphreys Brook in Moncton, to very large dams such as the Mactaquac Dam on the Saint John River.

1.2 Social Progress and the Damming of Rivers

During the last century, dams played an important role in the growth of our communities. The damming of waterways meant that water could be contained, thereby controlling its flow to run water wheels, move logs down river, power saw mills, produce energy, store water for irrigation and drinking water needs and control floods. Dams also allowed for transportation by way of navigation on designated stretches of rivers that were once inaccessible. Back in those days, the benefits of dams were never questioned. As well as being the solution to the growing industrial needs of societies, and later an effective method for producing electricity, their construction provided work to many people, sometimes for periods lasting many years on larger dam projects.

During the last century, the damming of rivers contributed to socio-economic progress

In certain cases, dams also played an important role in creating recreational areas, by turning small and inaccessible streams into lakes for activities such as boating and skating. Fishing ponds with fish brought in from hatcheries were also created for sport fishing.

The ecological effects associated with dams, and the loss of natural characteristics of rivers such as rapids, pools, fish migration, and wetlands were for a long time considered minimal in comparison to the benefits they procured to society.

1.3 Reconsidering the Value of Dams

All over the world, citizens and governments have begun to reconsider the value of dams versus their impacts on the environment. While the damming of rivers brought considerable benefits to society, with time it became clear that dams had caused harm on entire lengths of rivers, depleting fisheries and degrading ecosystems.

The value of dams is being reconsidered by citizens and governments

During the last few decades, a new trend has emerged, as more than 500 dams have been removed in the United States alone, in order to restore fish passage and the ecological integrity of thousands of kilometre stretches of rivers. One of the most active states engaged in decommissioning abandoned dams in the United States is the State of Maine. In the summer of 1999, a dam removal project which received international attention was completed at the Edwards Dam on the Kennebec River, while another removal project was completed in the summer of 2000 on the East Machias River.

More than 500 dams have been removed in the U.S. alone

Most of these dams were built more than 50 years ago or as far back as the mid-1800 s. Some of them have long since been abandoned, while others had long ago outlived the use they were designed to deliver and were providing marginal or no benefits to their owners. In fact, many dams targeted for removal are often a burden to their owners because of the high costs of maintaining them and the public safety threats that they pose.

Except in the provinces of British Columbia and Ontario, where their Departments of Natural Resources have developed strategies and province-wide audits to assess the state of dams, which have led to decommissioning projects being implemented on the Finlayson Dam (ON) and the Thedosia Dam (BC), other jurisdictions of Canada have made little progress in this area.

On a broader perspective, the World Commission on Dams, following public resistance to larger dam building projects around the globe, organized a forum with experts from around the world to examine the value of dams and their impacts on the environment and on society. Their final report entitled Dams and Development — A New Framework for Decision Making was published in November 2000. The report provides ample evidence that large dams have not produced as many benefits as their supporters claim, especially if impacts on people and nature are taken into consideration.

Large dams have not produced as many benefits as their supporters claim

Some of these large dams are responsible for causing great environmental damage, including the extinction of many fish and other aquatic species, the loss of forestlands, wetlands and farmlands. In some cases this has resulted in the relocation of millions of people, denying them access to natural resources and causing social, economic hardships and poverty.

1.4 Ecological Impacts of Dams on River Systems

Fish and other species have difficulty adapting to the ecological impacts of dams

Dams alter and block the natural flow of rivers, creating impoundments of water behind the structure. Consequently, these can have considerable impacts on river biota immediately at the dam site and far upstream and downstream from the dam. These impacts extend to the floodplains, estuaries and headwaters of the river system. Fish and other species have difficulty adapting to the ecological impacts of dams. The new conditions make the system altogether different from its natural state, and with time usually lead to an accelerated decline in the river s biota.

Under normal conditions, a healthy stream is well aerated with a rich supply of oxygen created by water flowing rapidly from pools and riffles over gravel bars, boulders and logs. The natural occurrence of dissolved oxygen is crucial to the survival of fish and other aquatic organisms.

Impoundments contribute to the reduction of dissolved oxygen in rivers

Impoundments contribute to the reduction of dissolved oxygen through water temperature increases and euthrophication. Dissolved oxygen levels decrease with temperature increases. The accumulation of nutrients caused by the artificial impoundment can also lead to excessive plant growth, which in turn decreases oxygen as a result of decomposition.

Areas downstream from the impoundment are deprived of the valuable supply of nutrients, organic debris and coarse materials that are trapped behind the structure or deposited in areas of reduced flow. These

materials replenish habitats downstream and are essential to the survival of estuarine and coastal marine species. The volume of water itself is also reduced. As the impoundment s area expands, evaporation increases, resulting in less water flowing downstream.

Since there is no effective way to allow for the natural transfer of sediments from the impoundment to downstream sections of the stream, sediments accumulate over the years in the impoundments behind the dam structure. These sediments contain valuable nutrients but may also have accumulated contaminants over the years such as toxic chemicals and heavy metals that could have adverse effects on aquatic organisms and riverine ecosystems as a whole if released unchecked. Furthermore, dams and the impoundment it creates can have a considerable effect on surrounding terrestrial species since these rely on riparian habitats and riverine resources.

Over the years, sediments accumulate in the impoundments created by dams

Perhaps the worst effect of dams is the obstruction to fish passage. While some dams are equipped with a fish ladder, most of these devices do not always function properly and consequently, hinders the natural migration of fish. Even if there is fish passage, conditions in the impoundment such as temperature or salinity may be drastically different than the downstream conditions, which in turn reduce the survival of fish.

Fish ladders often do not function properly

Another obvious effect of transforming a section of a river into and impoundment, therefore causing changes in flow rates and patterns, are the long-term changes to downstream channels, riparian zones and floodplains, as well as the species and the community that depend on them.

SECTION 2

Exploring the Concept of Dam Removal

2.1 Changing Perspectives on Dams

Although people have been removing dams for as long as they ve been building them, it was mainly because it made financial sense. Considering that the average life expectancy of a dam is 50 years, and since most dams were built a long time ago, many of these dams can no longer serve their intended purpose because of their aging condition or because societal needs have since changed. As time goes by, more and more of these structures are starting to deteriorate, and owners are being forced to upgrade, repair or remove them.

Many aging dams no longer serve their intended purpose

After proceeding with a cost-benefit analysis, the owners often realize that the financial investment required to fix a dam actually exceeds the costs associated with the removal of the structure. These high costs, along with the low financial profits, are often deciding factors for owners to proceed with the removal.

In the past, dam removal was not always viewed as a reasonable approach to river restoration. In fact, before the scientific community advanced the understanding of riverine ecosystems and made that knowledge available to the public, most people thought that the ecological impacts of damming rivers were minimal.

As more and more people became aware and recognized the value of healthy rivers in their community, this perception was changed. Many have come to the conclusion that the harm that some dams cause to a river is often greater than the actual benefits they were meant to provide to society. In addition, a growing number of communities are realizing that the older the structures are, the more they pose an increasing threat to

The harm done by some dams is often greater than the benefits they provide

public safety. Nowadays, dam removal is not only considered as being cost-effective, but also as an ecologically sound practice for restoring riverine ecosystems. In fact, individuals or groups that value the return of natural flowing conditions in their watershed s streams and rivers are identifying more and more dams for removal.

Nowadays, dam removal is viewed as a sensible river restoration option

Although the removal of dams only recently became viewed as a sensible river restoration tool, there are already numerous dam removal success stories. Experience in North America and in Europe shows that the removal of dams has brought back many rivers to their original healthy free-flowing state. In the United States alone, more than 500 dams have been removed from waterways, and at least 100 or more are targeted for removal in the coming decade. Some of these projects have been well documented in the American Rivers publication entitled Dam Removal Success Stories . Some of these success stories, such as the Edwards Dam Removal Project in Augusta, Maine have received considerable media attention and have contributed to the education of the public on dam removal issues in North America.

2.2 Understanding the Process of Dam Removal

To be considered safe and effective, dam removal must follow a pre-determined process

The process of removing a dam is mainly about (a) identifying and working within a defined **framework** or **process**, (b) doing initial research by undertaking a **preliminary assessment** of the structure and the river system, (c) identifying and addressing **stakeholder** issues, (d) assembling a **team of experts** and preparing the **detailed plans** (water management, sediment management, stream restoration and fish rescue/recovery), (e) **removing** the structure and **restoring** the stream and its habitat, and finally (f) **monitoring** the effects of the removal on the river s hydrology, ecology and the nearby infrastructure.

Since each dam and the river it blocks have their own specific characteristics, it is not always possible to rely on past removal cases to evaluate the outcomes of each removal project. For this reason, all of the issues, especially the most critical ones must be addressed before the deconstruction phase takes place. All possible risks associated with the eventual removal must be brought to their lowest probability of causing harm to the river or the community in which it flows.

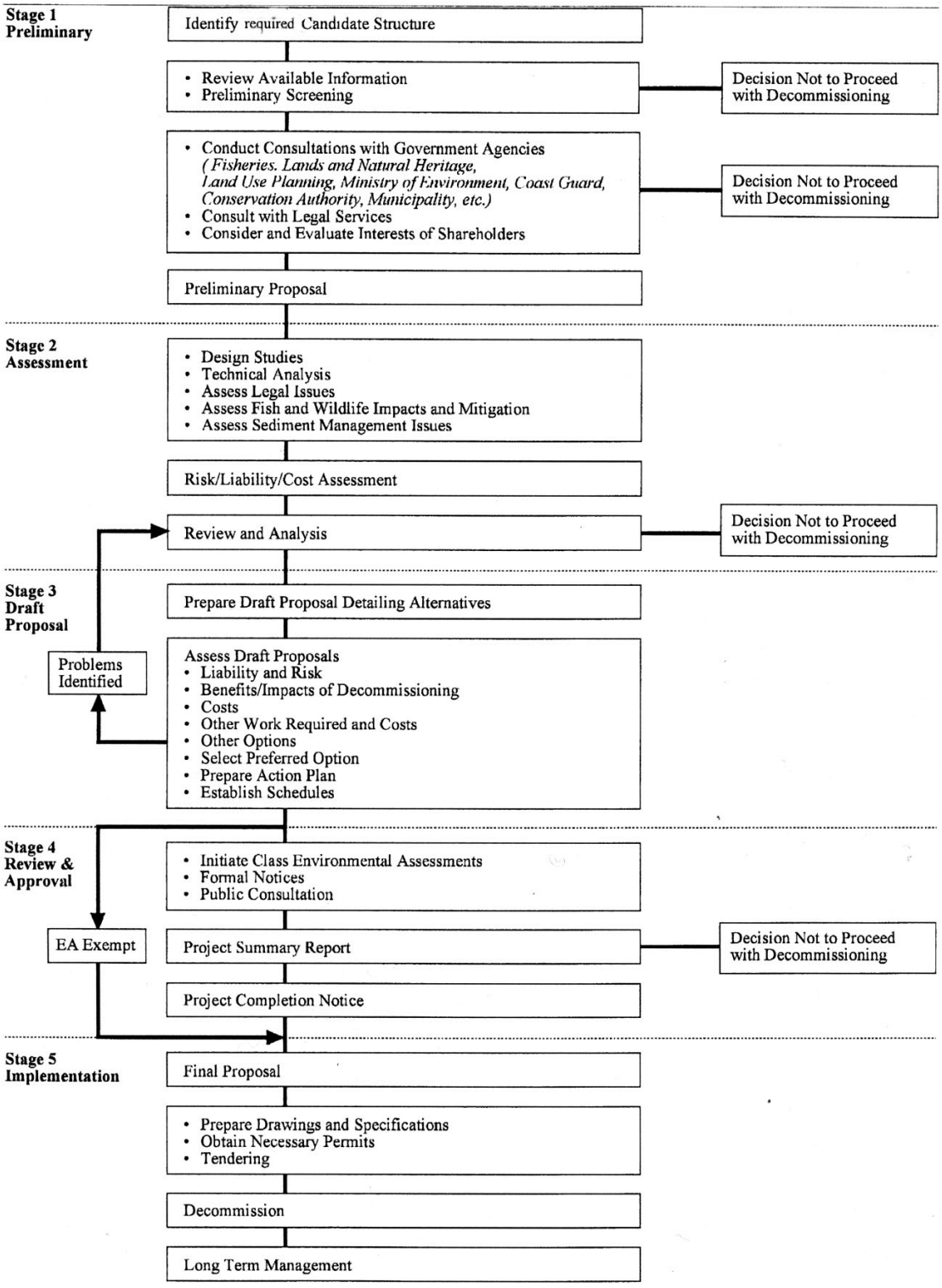
Each dam and the river it blocks have their own specific characteristics

Although strategies and physical removal techniques tend to vary from one project to another, the following procedures are generally involved in the removal of the structure: (1) drawing down the impoundment by breaching the dam, (2) dealing with sediments behind the structure by potentially removing it, (3) deconstructing the structure with the proper equipment, and (4) minimizing the impacts of erosion and sediment deposit downstream.

Removing the structure is the most critical phase in the project, mainly because of possible adverse effects to the environment with sediment releases downstream. This removal process should be thoroughly understood, and each step should be studied and pre-planned before proceeding with a project to remove a dam. Furthermore, safety should always be at the forefront, especially if heavy equipment is operated in or around flowing water. The following chart, presented as Table 1, outlines a Dam Removal process developed by the Ontario Department of Natural Resources. The process proposed in this chart is similar to other frameworks used in other dam removal projects in North America, and constitutes a good model for the purposes of this Information Guide.

The dam removal process should be thoroughly understood before proceeding

Table1 — Flow Chart (From The Process of Decommissioning Dams in Ontario)



2.3 Dams that Don t Make Sense

With their campaign to remove dams entitled Rivers Unplugged , American Rivers, an organization dedicated to the protection and restoration of rivers in the United States, advocates the removal of Dams that Don t Make Sense . That term is used to identify those dams that no longer serve a purpose or where the costs outweigh the benefits.

It doesn t make sense to keep rivers blocked with dams that no longer serve a purpose

With the efficiency and value of dams being questioned both from an ecological and economical point of view, individuals, environmental groups and now government agencies are identifying appropriate candidates for decommissioning, and challenging the relicensing of dams that don t make sense.

Another organization active in the restoration and protection of rivers in Canada is British Columbia s Outdoor Recreation Council (ORC). In the year 2000 the ORC, with assistance provided by British Columbia s Fisheries Renewal Program, initiated a project to systematically review and identify marginal or outdated dams that could be decommissioned or dismantled in that province.

In BC, more and more resources are allocated for habitat enhancement, which includes the removal of dams

Since the Fisheries Renewal BC was established, significant new resources for habitat enhancement have now been made available in British Columbia, including $20 million from the federal government for the Pacific Salmon Endowment Fund, and $140 million over four years under the Pacific Salmon Treaty for its recently created restoration and enhancement endowment funds.

The ORC produced a detailed report in 2001, which evaluated options as well as opportunities associated with the range of dam management strategies that were available for river recovery in British Columbia. There are approximately 2500 dam structures in British Columbia that are officially known to provincial agencies. Of these, approximately 400 dams

have been classified as having high or very high hazards where loss of life or property may occur should the dams fail.

The report includes a component on the identification and systematic evaluation of nearly 100 dam candidates from around that province. This audit was carried out in order to explore the range of issues and options associated with dam management and to encourage further government action or initiatives towards addressing some of these outstanding issues. A "primary candidate list" of nearly 40 dam structures was created based on an evaluation of operation, institutional, and biological concerns.

In BC, many dams are being evaluated and 40 of them are considered primary candidates for alteration or removal

Based on a series of criteria developed by American Rivers and the ORC in British Columbia, many Dams that Don t Make Sense have now been targeted for removal. The following criteria are part of the original assessment used by American Rivers and ORC to begin considering candidates for removal, or identifying candidates where owners may have difficulties in justifying their continued existence.

- **Structural safety** — as dam structures age and weaken, some dams become unsafe to operate.
- **Reservoir siltation** — siltation will reduce the dam s ability to store water and produce electricity.
- **Marginal benefits** — poor design, inefficient turbines, or changing societal needs have made some old dams obsolete.
- **Economic costs** — Marginal dams cost money to maintain while providing little or no benefit to society.
- **Ecological damage** — the damage caused to fish and other river-dependant species makes some dams difficult if not impossible to justify from any perspective.

A series of criteria are used to categorize dams as Dams that Don t Make Sense

For any or all of the above reasons owners have abandoned dams, leaving others with the burden of removing them. These abandoned structures pose a threat to public safety and continue to damage the ecosystem in which they are situated.

2.4 The Case for Small Abandoned Dams

Many abandoned dams were built more than 50 or even 100 years ago

Out there blocking our rivers, sometimes deep in the forests and other times right in the middle of our communities, sits a large number of small abandoned dams that have outlived their intended purpose. These dams were built at times more than 50 or even 100 years ago and in many cases, their owners cannot be identified. The existence of these sleeping barriers is often unknown by government authorities and they are therefore never inspected or regulated.

Small dams are generally considered to be less than 15 metres high, and creating an impoundment of less than 30 hectares

While there is no clear or standard size definition for small abandoned dams, they are generally considered to be less than 15 meters high. Distinguishing small dams from larger ones is also based on the size of the impoundment it creates (generally less than 30 hectares), although a small dam can hold huge quantities of water that can cover large areas of land, depending on the morphodynamic features of the river. By pushing the definition a little further, small is a relative term, as the size of a dam can also be based on the sum of the impacts it has on the riverine ecosystem in which it is situated.

Abandoned dams pose a threat to public safety and in failing, they can destroy property

Because of their aging condition, these small abandoned dams can sometimes break by themselves, creating sudden flooding and erosion downstream. Accumulated sediments that may in some cases be toxic can be released downstream, impacting fish habitats in the process. These unsafe abandoned dams can also be a threat to public safety, either by people falling from the structures, falling into the currents created by the falls, or in the sudden release of large volumes of water in the event of failure. Furthermore, unsafe and aging abandoned dams can result in the destruction of property during flooding resulting from dam failure.

Many of these abandoned dams are ownerless, meaning that their owners cannot be traced either because they have since died, closed their mill or other businesses related to the operation of the dam. In many cases as well, title to the dam may be unclear, with the adjacent land ownership having changed many times since the dam was built, and the present-day landowner at times unknowingly inheriting the structure. As a result, the responsibility for removing or repairing these dams often falls on provincial and federal authorities, who often have yet to dedicate resources to remove the abandoned structures.

Removing small abandoned dams usually creates less controversy

However because of their reduced size and because they often only provide marginal or no benefits, the removal of small dams usually involves less controversy. Issues related to their removal are usually easier to address, simply because fewer people are affected by the outcome. Removing small abandoned dams represents less planning and implications than large dams, which can take years only to make the decision on decommissioning. Even though they need serious considerations, technical issues associated with the removal of these dams are also easier to manage. These are some of the reasons why this Information Guide focuses on small abandoned dams.

2.5 The Implications of Dam Removal

As mentioned earlier, the decision to remove a dam should be closely evaluated, based on the dam s specific characteristics and functions. In fact, dam removal is often not considered an option for a majority of large dams now operating in rivers across the world. Even if they significantly affect the ecological integrity of certain river ecosystems, some of these structures allow for fish passage and other measures to mitigate the effects on the surrounding riverine and terrestrial habitats.

Generally, the benefits they provide, such as electricity and fresh drinking water storage are considered necessary by the businesses that operate and the people living in their vicinity. Until there are alternatives to the functions they provide, some dams still make sense at this point, providing energy and supplying fresh drinking water to growing populations.

Until there are alternatives to the functions they provide, many dams still make sense at this point

As you will read in the next sections of this Information Guide, there are a series of issues to be considered before taking on a project to remove a dam. Addressing these issues is key to defining the general parameters of the project, and will help in determining which areas need more attention.

Even if the dam meets each one of the preliminary criteria for decommissioning (i.e. abandoned, marginal or no benefits, public safety, etc.), removing it can be a complex undertaking. For instance, if the dam sits in a river near an industrial area, or was used for industrial purposes, it can mean a greater probability of sediment contamination, and higher costs associated with the project s assessment and the eventual removal of the dam.

Large amounts of accumulated sediment may mean higher sediment removal costs

Another important factor is the actual amount of sediment that has accumulated behind the dam, which can mean higher dredging or sediment removal costs, along with greater risks associated with sediment being transported downstream. For these reasons and others that will be addressed in this Information Guide, dam removal should be researched and planned with care. Omissions in the planning process, especially during the actual deconstruction phase, could lead to negative environmental impacts on the ecosystem being targeted for restoration.

Aside from ecological considerations, the project s degree of complexity is dependent on the specific location of the dam, as well as which impacts its removal will have on the nearby community. The draining of an impoundment and the removal of a dam can affect the community in a

number of ways, including the possible erosion of downstream infrastructures, which may have been constructed after the dam was built.

For these reasons, dam removal projects that are undertaken on streams or rivers located in the middle of communities tend to have a degree of complexity greater than those situated in remote areas. This Information Guide, prepared in the context of the Humphreys Mill abandoned dam assessment, located at the center of an urbanized community, will therefore explore a number of additional issues which would otherwise not have been considered in more remote abandoned dam scenarios.

SECTION 3

Carrying Out a Preliminary Assessment

Overview

The process of removing a dam usually involves the assessment of many factors such as the collection of data on the dam, an assessment of the river system and the review of stakeholder issues. Preliminary answers to all of these factors are required before the decision to initiate the removal of the dam takes place. The main stakeholders, who comprise the dam owner, river conservation groups, area residents and the relevant government agencies, must be involved in the process from the beginning. Local area citizens affected by the removal are usually involved via public consultations, and in many cases, are the ones who initiate the removal process. This section gives an overview of the list of preliminary assessments needing to be undertaken to assist the decision-making process of removing small abandoned dams.

3.1 Getting to Know the Dam

To assist the decision-making process of removing a dam, it is important to begin gathering some basic background information on the specific structure. First, the dam and the river should be identified by its name. Its owner, if known, should be approached and identified. The dam should also be eventually presented on a map, so that others can find it easily. Photos should be taken of the stream, the dam and the nearby infrastructure so that it can be documented and better presented.

To assist the decision process, basic information on the structure, must be gathered

Information on the dam s structure, its history, its former use and the purpose it serves today (if any) should then be gathered, to identify the year it was built, the materials and methods used to build the dam, and to know if any repairs or modifications were made to the dam since it was constructed. If available, plans of the dam and safety inspection reports should also be obtained to help in the assessment.

The dam s structure should also be inspected by a qualified engineer, to obtain a preliminary assessment of its condition and identify possible structural problems present at the dam such as cracks, the condition of its abutments and any water seepage problems. These directly affect both the safety and the function of the dam and definitely affect the overall cost and feasibility of its future repair or removal.

To evaluate its condition, the dam s structure should be inspected by a qualified engineer

Signs of environmental impacts of the dam s presence should also be noted. Understanding the effects of factors such as sudden changes in water levels, water quality and water temperature, stream bank erosion, stranded or dead fish, vegetation and algae accumulation and sediment buildup will be an important factor in determining whether removal is the best option.

The following worksheet (Table 2), largely inspired from the American Rivers Guide to Removing Dams, should serve as a good tool to begin gathering the basic information needed in order to jump-start the dam removal assessment.

Table 2 — Knowing Your Dam

Step 1 - Identifying the Dam

1. What is the dam called?
2. In which river is it located?
3. Is there a name for the created impoundment (pond, reservoir)?
4. What are the nearest roads, highways, municipalities?
5. The specific location of the dam should be indicated on a map.

Step 2 — Inspecting the dam structure

Important notes:

- Don t forget to obtain permission to access the dam site.
- Asking the help of an expert (i.e. a qualified engineer) and taking pictures and notes can be very helpful

1. Are there adequate warning signs for indicating the dam upstream?
2. Are there adequate warning signs near the structure?
3. Are there any visible cracks in the dam structure?
4. Are there chunks that appear to have fallen from the structure?
5. Is there any water leaking through the structure?
6. Are there animal burrows in earthen sections of the dam?
7. Are there trees or bush growing on the dam?

Other observations like debris, logs, concrete or rock blocking spillways and gate operation problems should be noted.

Step 3 — Observing the effects of the dam on the river and nearby area

1. Are there large and/or sudden changes in water levels?
2. Are there differences in water clarity above and below the dam?
3. Are there differences in water temperature above and below the dam?
4. Are there excessive amounts of vegetation and/or algae in the impoundment?
5. Is there an obvious build-up of sediment above the dam?
6. Are fish and/or mussels stranded above or below the dam?
7. Are waterfowl or shorebird nests flooded above or below the dam?
8. Are fish eggs or amphibian eggs exposed above or below the dam?
9. Are fish spawning beds, like gravel bars exposed above or below the dam?

Step 4 — Finding out more about the dam s type, functions and history

1. When was the dam first built?
2. Has it been rebuilt during its lifetime? If yes when, why and how many times?
3. How was it built, what materials were used and how did it work?
4. What function did it originally serve? What function does it serve now?
5. How has the operation of the dam changed over time. Has it been modified in any way, has it been raised or lowered?
6. Do authorities at the municipal, provincial and federal level know of the existence of this dam?
7. If yes, do they have concerns about it?
8. Has it ever been regulated and/or inspected?
9. If yes, when, and is there a report available?
10. Are there safety concerns associated with the presence of this dam?

3.2 Issues to Consider

Those involved in the decision-making process quickly realize that removing dams implies that many interrelated concerns and priorities need to be taken into consideration. Issues, such as the health of the river and the fish and wildlife it holds, the people and properties that live nearby, the impoundment created by the dam, sediment accumulation, public safety and sources of financing, are to be carefully considered before taking the decision to proceed with the removal. Solving all of the issues relevant to dam removal or reaching consensus with all stakeholders often means that compromises will have to be made in terms of according more priority to certain issues over others.

Many issues should be carefully considered before taking the decision to proceed with the removal

The issues relevant to the removal of small abandoned dams can be grouped in four main categories:

- **Environmental issues** generally relate to the natural resources of the area. Dam removal requires a full understanding of the impacts on upstream and downstream flow and habitat, its effect on fish populations and wildlife, and the impacts on passage and movement of fish and other species. Sediment movement potential should also be evaluated, along with impacts on water quality, especially in the short-term period following the removal. Effects on riparian and wetland areas also need careful consideration. Finally, the location of the dam within the river basin is an important factor in determining the ecological benefits of removal.

— **Economic issues** generally relate to comparing the costs and benefits associated with either repairing abandoned dams to make them safe or else removing them. Even though we are dealing with small abandoned dams, some of them may still provide benefits in terms of recreation. An evaluation should be done to verify if the overall price to be paid to maintain these benefits is reasonable, in

terms of the resulting environmental impacts and in comparison with the immediate or future repairs and maintenance costs required. Economic considerations may also involve liability issues, long-term versus short-term costs and benefits, questions about who should pay for each option and the availability of funding.

— **Engineering issues** relate both to the physical structure of the dam and the natural environment that is affected by its presence. Handling the various engineering and technical issues that may arise in a project can be dealt with in many ways, with each having their own resulting impacts. Each option put forward should be therefore be evaluated in terms of its overall financial cost and resulting environmental impacts. The restoration plans of the riverine ecosystem following the removal of the dam should also be at the forefront when considering an option.

- **Societal issues** take into consideration the place that the dam holds in the community. Removing a dam usually consists in the drainage or the decommissioning of an impoundment. This changes the characteristics of a river and consequently, the use that the community members can make of it. Concerns about public safety, aesthetics, and loss of heritage and alterations of recreational activities are common societal issues that need to be addressed. Although the idea of removing a dam can be challenged by many at the start of the process, favorable attitudes towards removal often prevails once the community is well informed about the benefits of a free-flowing river.

On the following pages, Table 3 presents a list of questions relating to issues in all of the above-mentioned categories. It is important to understand that these issues are interrelated to one another and can be part of more than one category. This is why we present them in this manner.

Table 3 — Issues Related Questions

Questions to Consider	Environmental	Economic	Engineering	Societal
What are the dam characteristics: size, type, and overall condition?			x	
When was the dam built? Is that the original dam?			x	
When was the last time that the dam was inspected?			x	
What is the safety condition of the dam?			x	x
What are the costs to keep the dam safe (repairs, insurance, operation and maintenance, periodic dredging, permitting)?		x	x	x
Is there anyone claiming ownership of the abandoned dam? If not, who owns the land on which it is situated?		x		x
Originally, what was the dam used for? What purpose does it serve now?		x		x
Does the impoundment contribute directly to the local economy?	x	x		x
What is the history of the immediate area when the dam was built? What historical aspects of the dam and its surrounding community and industries could be represented through a series of interpretive displays or plaques?		x		x
Would an interpretive and/or recreational project be supported by the local residents and by the town officials?		X		x
Is there an interest in the community to participate in the project? Who will maintain the site after it is created?		X		x
What is the community s understanding of the dam and the river?				X
What is the community s attitude toward the dam and the river?				X
Who are the stakeholders in the decision to remove the dam?		X		x
What people or groups benefit from the dam (including individuals, businesses and organizations)? How do they benefit (e.g., economically, quality of life)?		X		x
What are the total costs of the project? Are there funds available for the costs of dam removal and site restoration?	X	x		x

Questions to Consider	Environmental	Economic	Engineering	Societal
Does the impoundment have positive aesthetic qualities? Negative?	X			x
How many homes or businesses are located on the impoundment?		X		x
Does the dam currently serve an important flood control function?			X	x
What would happen if the dam would fail by itself? What would be the impacts on the environment and properties below the dam? Who would be responsible?	x	x	x	x
Are there liability concerns during the dam removal process?		x	x	x
What are the impacts of removal on the area s infrastructures?		x	x	x
What kind of protection wall will be needed to avoid erosion?		x	x	
How does the dam existence and removal affect flooding conditions in the area? What happens during a heavy rainfall?		x	x	
Are there any properties below the dam that could be affected by the removal?		x	x	x
Who will own the land that is under the impoundment?		x		x
Is there going to be an effect to the value of the properties around the impoundment? Will it go up?		x		x
Would there be increased public access with dam removal? Would owners of the surrounding land want or approve of the increased access?		x		x
What are the current economic benefits from the recreational use of the impoundment? Would the restored river provide more recreational opportunities?		x		x
Could restoration of the lands through dam removal help to revitalize a riverfront area?	x	x	x	x
What are the impacts of removal on the storm drains around the dam?		x	x	
Is there access to both sides of the dam for the necessary equipment needed to remove the dam?		x	x	
What is the condition of the ecosystem upstream and downstream of the dam?	x			

Questions to Consider	Environmental	Economic	Engineering	Societal
How much does the community value the current species and habitat?	x			x
What types of industries were there in the immediate and surrounding area when the impoundment was created? What types of industries exist around the site today?	x	x		
What kind of pollutants would they have produced that could have entered the impoundment?	x			
What is the quality of the habitat in the impoundment? Upstream? Downstream?	x			
What species of fish did the stream carry before the dam was installed?	x			
What species live in or near the water (fish, birds, mammals, insects, reptiles, etc.) above the dam? Below the dam?	x			
What species would benefit or be harmed by dam removal (for example birds, fish, mussels, amphibians, reptiles, aquatic invertebrates). Any endangered species?	x	x		
What impacts would removal have on the passage and movement of fish and other species?	x	x		
Are any of the species that live in or near the river officially endangered?	x	x		
What is the capacity to regenerate the salmon habitat in that section of the river? Is there a possibility to create a project for salmon reintroduction and involve people in the surrounding community?	x	x		x
What are the benefits to the environment and wildlife associated with the removal of the dam?	x			
Would the addition or change of species through dam removal help the local economy (more, fewer, different fish for example)?	x	x		x
What critical life stages for fish and wildlife would need to be taken into account in timing and planning the dam removal?	x		x	
What measures can be taken to minimize the impacts on fish and wildlife during removal?	x		x	
What are the impacts of removal on upstream and downstream flow and habitat?	x			

Questions to Consider	Environmental	Economic	Engineering	Societal
When the dam is removed, what will the brook look like? Width, depth, path of the channel, will there be pools, riffles, rapids, and waterfalls?	x			x
Does the banks downstream need to be stabilized?	x	x	x	x
How many acres will be affected by the removal of the dam?	x	x		x
How much land will be exposed? How will the area look like after the dam is removed? Will it create a wetland, grassland?	x	x	x	x
Will the banks need to be seeded or planted with trees or will there be a natural growth of vegetation after the dam removal?	x		x	x
Once stabilized, will the banks be stable enough to support any overflow or sudden heavy rainfall?	x	x	x	x
Will the floodplain and flood hazard areas if any, change with the removal of the structure?	x	x	x	x
Will the draining of the impoundment have an effect on groundwater levels? Are there any wells that have been created after the impoundment that could be affected?	x	x	x	x
How much sediment has accumulated since the dam was built? How was it estimated?	x		x	
Is it the original sediment? Has it been dredged or disturbed before?	x		x	
What type of sediment is in the impoundment? What is the particle size? Is it contaminated? Who is responsible for the contamination?	x		x	
If the dam is not removed, what will happen to the sediment accumulation? Will it have to be dredged eventually? What are the costs associated with dredging?	x	x	x	
How will the sediments in the impoundment react after removal of the dam and once the brook starts flowing again?	x		x	
Will there be removal of some or all of the accumulated sediments?	x	x	x	
Will the river create its own natural path or will it need to be dredged to a specific path and angle?		x	x	

Questions to Consider	Environmental	Economic	Engineering	Societal
How does dredging affect fish/wildlife habitat?	x		x	
After the removal, how much sediment would potentially be released downstream? Can it be avoided? What will be the impacts on the stream and the watershed? Where will it end up?	x		x	
Is there a way to minimize the travel of sediments with screens or gates?	x		x	
Where can we dispose the sediment after it is removed, even in the case where it s contaminated?	x	x	x	
Is there an accumulation of debris in the impoundment? What lies underwater and in the accumulated sediments? Who will be responsible for removing the debris?	x	x	x	

3.3 The Dam Owner s Responsibility & Liability

When they can be identified, owners of abandoned dams may be federal or provincial agencies, local authorities, public utilities, private business owners or individuals. Legal responsibilities can be an important factor influencing the owner s decision to proceed with the removal of dams. In fact, dam owners are responsible for the maintenance and repair of the dam so that these do not become a hazard to public safety, or a potential risk for properties upstream and downstream from the dam. Dealing with measures of maintenance can be very costly to the owner, especially in the case of an abandoned dam where no income is generated by the structure.

Legal responsibilities can be an important factor influencing the owner s decision to proceed with the removal of dams

Dam owners should also do their outmost to avoid injury to people that venture near the area of the dam by posting signs, installing warning devices or fencing the area to restrict its access. Even if these precautions are taken, the owner can be held liable if injury to people and property occurs as a result of the dam s presence, its malfunction or its failure due to inadequate maintenance or the lack of other safety precautions.

3.4 The Citizen s Role

Citizens living in the vicinity of an abandoned dam are often the ones questioning the value of this dam and thus providing the spark that initiates the decision-making process about keeping or removing the structure. Concerns about public safety are the most common trigger for questioning the continued existence of a dam, although the health of the river, recreational and economic issues are also on top of the list.

Concerns about public safety are the most common trigger for questioning the continued existence of a dam

Getting people involved and establishing local support for removal at the beginning of the process is important, as citizens can provide a much needed voice for the river, especially at the stage where decisions involve weighing economic factors against ecological issues affecting the river s overall health.

By getting involved, individuals can also actively participate in the process and therefore enable a better-informed decision process. Some of the things they can do include the identification of safety and environmental problems associated with the existence of the dam, educating others about the ecological impacts, participate in the organization of public meetings and envisioning the future use of the area, like creating public parks and nature trails.

A public meeting will serve as a good start in getting feedback from the community affected by the decision to remove the dam.

3.5 The Importance of an Education Campaign

An education campaign can play a large role in determining the outcome of each decision

Even if all the facts to justify dam removal are in place, and that removal seems to be the best option for the river, the dam owner and the community, it doesn t necessarily mean that the dam will come out. It is therefore important that each project to remove a dam be supported by a campaign to inform stakeholders, key players and members of the community affected by the removal.

In each project, the fate of the dam and the river will be determined by a series of decisions. An education campaign can play a large role in determining the outcome of each decision. A successful campaign starts with a clearly defined strategy and a detailed set of communication goals. The strategy and goals should also be general enough to adapt to various situations as the campaign moves forward.

An open and honest approach is to be favored when dealing with all of the various stakeholders. In these situations, it is often better to stick with the facts, in the sense that one exaggeration or false statement may seriously damage the credibility of the project for the remainder of the decision making process.

Citizens or groups can enter the decision process at any stage, but the idea is for the education campaign to be part of the process from the very beginning, so that future interventions are pro-active instead of re-active. At the start of the process, for instance, there is more opportunity to clear up some of the fundamental misconceptions about dam removal. It also leaves more time to address the larger scope of issues and encourages serious consideration of dam removal as a viable option.

Public safety considerations, fish passage and economic factors are the most commonly used motives for restoring rivers through dam removal. The key approach is to put forward these motives and if possible, associate them with economic factors, as they are the most persuasive. Fortunately, many issues already have an economic component attached to them and can be used to favor removal.

As much as possible, the various issues should be associated with economic factors

Once the education campaign plan is laid out with specific activities, clear goals and timelines, it should be put into action and verified periodically to check the progress. Adjustments should be made to the strategy and the communication tools as necessary.

Communicating with residents upstream and downstream of the dam should be established early in the process, especially the people that own the land and residents around or near the impoundment. Prepare yourself and your group by reading-up on the subject of dam removal. Table 3 provides answers to questions that are most frequently asked by concerned citizens when faced with the removal of a dam in their area.

Material can be prepared and information can be communicated by way of private and public meetings, public places like the library, public events, and local organizations through letters, mail-outs, local radio stations through talk shows, public television, newspaper articles and letters to the editor.

Dam removal can trigger strong emotional reactions in certain persons. Provide members of the community with factual information about the various issues and the advantages of a free-flowing river, and avoid telling them what to think. In addition, encourage the people in favor of removing the dam to publicly voice their support for a healthy river.

People in favor of removing the dam should be encouraged to publicly voice their support for a healthy river

Visual images are extremely useful for convincing people about the merits of a free-flowing river. Photos of the dam and the river upstream and downstream can be used to show the impacts on the environment like sedimentation, poor water quality, excessive vegetation, algae growth and other problems. An amateur video can also be shown to compare the impacts of the dam with the beauty of the river further upstream.

As an example, a video produced collaboratively in the United States by the River Alliance of Wisconsin, the National Park Service, Trout Unlimited and American Rivers shows case studies of three communities where dams have been removed. By showing before-and-after footage and testimonials from local officials and citizens, this video can effectively reduce the fear of unknown outcomes in communities undergoing the dam repair or removal decision.

Visual images are extremely useful for convincing people about the merits of a free-flowing river

Another way of convincing members of the community of the value of removing a dam is to get them out on the river and directly showing them healthier stretches of the river. It can be a revealing experience to see the difference between a healthy part of the river and the area affected by the presence of the dam.

Table 4 - Answers to Frequently Asked Questions

(Taken from — Dam Removal, a citizen s guide to restoring rivers, by Trout Unlimited and River Alliance of Wisconsin)

1. Won t the river turn into a trickle of water that a person could jump across?

An easy way to predict the river s width and flow after a dam removal is to look at the river 1) before it reaches the impoundment and 2) just downstream of the dam. Unless the geology or topography changes substantially in the restored stretch of river, it is unlikely that the restored river segment will be significantly wider or narrower than already found at these portions of the river.

2. Won t we have more flooding problems?

This is a legitimate concern only if the dam if the dam technically provides flood control. Most small dams do not. If, according to qualified personnel, the dam does not provide flood control, this needs to be explained to the community. Many dams actually increase the risk of flooding, due to serious disrepair and/or misoperation during storm events.

3. Won t we be left with stinking mud flats?

Logic dictates that sediments are exposed when the impoundment is drawn down during dam removal. Depending on the time of year and type of sediments, there may be an odor of decomposing silt and vegetation for a short period of time (typically ranging from a few days to a few weeks). Years of experience shows that these newly exposed lands will revegetate (green up) within weeks during growing seasons, thanks to the many plant seeds that have accumulated in the rich sediment over the years. Once exposed to sunlight and oxygen the plants grow very quickly and the sediments dry up in the process. Of course, if the exposed land is subject to dense shade, tidal action or other significant water level fluctuations, this area may not revegetate as much or as quickly.

4. Who will own the new land?

Dam removal usually results in exposing land that was previously underwater. Land ownership questions can usually be answered by referring to deeds and titles for the waterfront properties and the dam property. Failing to address this concern early in the process can unnecessarily cause alarm in the community. Avoid this problem by answering the question of land ownership as early as possible.

5. Won t wildlife habitat be lost, causing wildlife to suffer?

The habitat created by the dam will change with dam removal. Consult your state natural resources agency for site-specific information and predicted changes. Historical records can sometimes provide a good indicator of what the restored habitat might look like. Healthy rivers are the lifeblood of healthy wildlife habitats. Dams alter the natural physical, biological and chemical functions of a river. This results in degraded conditions for a variety of aquatic and terrestrial species.

6. Will property values plummet?

This is usually a factor when there are private homes on the impoundment. Of course, this is a very site-specific issue, but there are several cases where predicted decreases in property value never occurred. Studies are underway to better document these effects. Because this impact is best measured over time and has several variables involved (e.g., area real estate market, characteristics of the property), it is best to look at property values at other former dam sites with similar community attributes. These could be in your state or elsewhere.

7. Who will pay for the dam s removal?

This varies with the site. Sometimes the dam owner pays (e.g., an individual, taxpayers, a business). Sometimes private funds are acquired. Some states (provinces) also provide funding for dam removal. One of the most effective ways to promote dam removal is to help identify funds for the removal. Consult your state (provincial) dam safety official for information specific to your community or situation. Helping people in your community to understand the costs associated with keeping and removing the dam can be among your most valuable efforts. Understand what is not included in most cost

estimates. If professional estimates have not been made, you will need to find a way to gather them.

8. Doesn t the dam have historical value?

This concern points out the need to look cumulatively at the dam s impacts to determine which dams have a true historical value that is greater than the environmental value of restoring the river. Historical issues can become a significant issue, especially if they arise near the end of the decision-making process. With the vast number of dams in many states across the U.S., very few are considered true historic sites. At some dam removal sites, communities honor a dam s past contributions with interpretive displays and other information. If historical issues are likely to become an issue, early involvement with historical societies and preservation offices are recommended.

9. Won t the dam removal introduce exotic or diseased species?

Dams sometimes act as barriers, protecting upstream areas from invading species. This is a site-specific issue that needs to be addressed by the appropriate state (provincial) or federal natural resources agency. In many cases, mitigation measures have been designed to restrict unwanted species.

10. Won t the best fishing spots be lost if the dam is removed?

Often, anglers like to fish right below the dam and oppose removal because they ll lose a good fishing opportunity. But the fish aren t there because it s good habitat, they re usually stacked up trying to get upstream. Dam removal improves the health of the river and aquatic habitat, usually to such an extent that local anglers can look forward to improved angling opportunities, and along a much longer stretch of river. In some cases, removing a dam will restore a warm water fishery to a more rare cold water fishery that supports trout or salmon. In many cases, dam removal will allow a wide variety of warm water, cool water and cold water species to seasonally occupy the same stretch of river, thus providing greater fishing variety.

3.6 The Costs of Removing Dams

As mentioned previously, dam removal requires the input of many experts to study the implications of removing the structure, and the river s response to removal. Removal also involves in many cases, alterations to nearby infrastructures affected by the removal, and restoration activities for the river and its banks. This expert assessment, combined with the actual costs required for heavy equipment used during the deconstruction and the removal of accumulated sediments can in some cases, put the costs at a higher than expected level.

Experience shows that removing a dam is often less costly than repairing it

Costs associated with dam removal can vary greatly, depending on the size, type, condition and location of the dam, but experience shows that removing a dam is often less costly than repairing it.

If considered in the short term, direct costs associated with the removal can seem prohibitive. Economically, those high costs can make more sense when considering the savings on long term expenses such as the maintenance of the structure and the impoundment, ensuring safety for the public, paying insurance for liability issues, plus other expenses related to fish and wildlife protection. In addition, new opportunities such as recreational fishing, kayaking, and other river activities created by the removal, can actually pay off in the long run.

3.7 Funding Dam Removal

Determining who will bear the costs of removing the dam can be a complex issue to solve, especially if the owner has simply inherited the dam when buying the property. Even if they agree with the removal, owners of abandoned dams oftentimes don t have the financial resources necessary for paying for each phase of a removal project. As a result, project removal costs have been shared in many documented cases by

Determining who will bear the costs of removing the dam can be a complex issue to solve

the owner, the municipality, different levels of government and grants from private charitable foundations and corporations acting as partners.

From the start of the process, a partnership between the dam owner (or government agency if the dam is ownerless), upstream and downstream landowners, relevant government agencies, corporations and any other stakeholders should be established. By taking ownership of the process as a group, it will help in getting a better perspective on possible solutions while at the same time providing a diverse range of access to funds available for such endeavors.

Unfortunately, funds and other resources allocated to deal with the issue of aging dams are limited, since dam removal isn t yet seen to be a priority by most governments. Additional funding will certainly be required in the near future to deal with the growing number of potential problems that are likely to arise from abandoned dam structures. Many of these structures will have reached the end of their economic and structural life cycles, and are likely to be abandoned due to the high costs associated with their upgrading.

Project removal costs have been shared in many documented cases by the owner, the municipality, different levels of government and grants from private charitable foundations and corporations acting as partners

Nevertheless, time as come for individual dam owners, corporations and governments to take responsibilities for removing these abandoned dams while at the same time offering new opportunities to restore our rivers and pride in them. The first step in such an initiative is to undertake, as other Provinces of Canada and other States of the U.S.A. have done, an audit and an inventory of these abandoned dams, so as to evaluate their current state, the necessary costs of either removing or repairing them, and ultimately identifying those candidates that can be decommissioned.

3.8 Envisioning the Future — With or without the Dam

Motivation to proceed with a project to restore a river through dam removal can come from envisioning the future of the river without its barrier.

For certain people, just the idea of seeing fish travelling upstream and gaining access to more spawning and feeding habitats can be the only motivation to remove a dam. Others will be more sensitive to the return of natural conditions for wildlife, with the natural water levels bringing increased flows and habitat restoration for beavers, amphibians and birds.

River restoration can also mean the return of sports or even commercial fisheries

In certain cases, river restoration through dam removal can also mean the return of sports and even commercial fisheries, which can bring considerable economic benefits to a community. For many, removing a dam means that recreational opportunities are enhanced, like providing better access to a river for canoe and kayak runs and other recreational activities like wildlife viewing and rafting.

Others will place a high value on public safety issues related to the dam structure, whether this is caused by increased risks of flooding, threats to public safety should individuals venture on, near them or else swim or boat near the currents accentuated by the falling waters of the dam.

Another way of informing stakeholders of the value of removing the dam is to present possible scenarios of the river in the years to come if the abandoned dam remains in place. By presenting the likely impacts of the status quo on sediment accumulation, erosion, as well as fish and wildlife habitats, individuals can be in a better position to decide if they want the structure removed or not. Knowing the future repair and maintenance costs needed to fix a deteriorating structure can also have a significant impact on the decision of the owner and the community to keep the dam or not.

3.9 Evaluating the Alternatives to Removal

While removal is a viable option for dams that no longer make sense, complete removal of the dam is not always possible due to issues that are difficult to resolve. In this case, partial removal may be considered.

Decommissioning the dam without completely removing the structure means that the dam will be altered in some way, restoring the flow to some degree if not most of its required size, and permanently changing its original function. For example, part of the structure may be left in place and removed in a later phase when reservoir sediments have stabilized. By avoiding high expenses associated with the complete removal, such as added costs associated with sediment dredging, partial alterations of the dam structures can in some cases provide numerous benefits and still achieve the ecological objective of improved fish passage and greater in-stream flows.

Partial removal is sometimes the only option for restoring a river

3.10 Making the Decision to Proceed with the Next Phase

We are now ready to make a decision on whether to proceed or not with the next phase. Up to this point, much effort has been invested in gathering the basic information needed to decide if removal of the structure is a viable option for this stream and the various stakeholders. Many issues have been addressed following public consultations, preliminary costs and sources of funding have been explored, and different options have been reviewed. Table 5 presents a list of questions that will help in assessing the level of existing and potential support for the removal. This will help determine whether you or your organization should take on the project to the next phase which consists of a detailed assessment, involving substantial financial commitments and increased stakeholder inputs as the project evolves.

Table 5 — Should You Proceed with the Next Phase?

The following are helpful questions that will assist individuals and groups in taking the decision to proceed further in the assessment phase of the project of dam removal. This information is largely taken from the American Rivers Guide to Removing Dams That Don t Make Sense.

1. At this point in the project, what is the level of support for the removal of the dam?
2. What is the organizational and community support of dam removal supporters?
3. What is the level of community and political concerns around the dam and impoundment? And along the river?
4. What is the likelihood of increased understanding in the community about the benefits and values of a free-flowing river?
5. What is the need for local, provincial, or federal government support for decisions regarding dam removal?
6. What local, provincial, or federal government agencies would financially support the effort to restore the river through dam removal?
7. What is the likelihood of getting additional support?
8. What are the social, political, economic and legal tools available to create leverage for dam removal?
9. How willing is the dam owner to discuss dam repair or removal options?
10. Is the dam owner or another responsible party willing to assume liability or provide funding associated with the dam s removal?
11. Is there an entity that would be willing to conduct the dam s removal and assume liability for their actions?
12. Are there other local, regional, provincial or national groups willing to help you advocate for restoring the river through dam removal?

SECTION 4

Preparing Detailed Plans

4.1 Consulting with Experts & Assembling a Team

With each dam removal project having its own specific reality, there are no common solutions or procedures that can solve all of the technical issues that come up in the process of dam removal projects. Consulting with experts and assembling the right team from the start of the project is key to the success of the project.

Objective scientific guidelines are required to determine the specific procedures and consequences for removing a dam before the decision for removal is finalized. Engineers, hydrologists, geologists, fluvial geomorphologists, fisheries biologists, and economists team-up to develop a plan that will take into account the technical issues relevant to dam removal such as - structure evaluation and deconstruction techniques, stream hydrology characteristics and erosion impacts, sediment assessment, sediment removal and transport potential downstream, habitat assessment for fish, wildlife and other aquatic organisms. The economic implications of dam decommissioning and impacts on the surrounding community of the dam also need to be studied by an expert.

Consulting with experts and assembling the right team from the start is key to the success of the project

4.2 Assessing Accumulated Sediment

Sediments are particles suspended in a body of water that settle out and accumulate at the bottom of a stream. Sources of sedimentation include the erosion of forest soils exposed to logging, agricultural lands, overgrazed rangelands, degraded streambanks, strip mines, construction and engineering works.

Although sediment is a natural component of riverine ecosystems, it becomes a pollutant when it is present in excessive amounts. Sediments cause problems by covering aquatic organisms, reducing light penetration, filling in pools, and bringing insoluble toxic pollutants like heavy metals, poly-chlorinated biphenols (PCB s), industrial solvents, agricultural pesticides (including herbicides) and fertilizers into waterways. Sediments can also kill fish and other aquatic wildlife by clogging gills and causing suffocation.

Sediment becomes a pollutant wen it is present in excessive amounts

Depending on the conditions, sediment samples can either be gathered with waders or from a small boat with a hand held auger. In deep-water conditions or for deeper layers of sediment accumulations, boring equipment may be required. If conditions permit, temporarily draining the impoundment is another solution for gathering samples.

Determining the volume of accumulated sediment behind a dam structure, testing for contaminants and measuring the physical parameters such as grain size distribution, density, cohesion and organic and moisture content are crucial in deciding if, when and how the dam will be removed. To conduct such assessments, it is recommended that project sponsors **consult or hire a qualified geologist or fluvial geomorphologist**.

Sediment assessment is also critical in determining if dredging is necessary, and if contaminants pose a threat to the riverine ecosystem when they are released. The testing of physical parameters will also be needed to determine the potential for sediment transport downstream, the channel s stability, and the newly exposed bank s natural revegetation potential after removal of the dam.

Besides determining if pollutants are present, sediment assessments are also critical in determining if dredging will be necessary prior to removal

There is a long list of possible contaminants that can end up in waterways, which can greatly increase costs for lab analysis. Testing for chemical contaminants should be based on the actual possibility of a certain chemical being present at the site. Proper research should be

undertaken to determine past and present industrial activities along with agricultural land uses in the immediate area of the dam and upstream.

Contaminated sediments should be dealt with before proceeding with the removal phase

If contamination is found, it should be determined if it will be in the actual flow path of the channel that will be created, once the dam is removed, as buried toxic sediments may not pose a threat. If contaminated sediments stand in the way of the river s flow, they must be dealt with before the dam is removed to avoid polluting the riverine ecosystem. If dredging is not possible because of high costs or a lack of access by heavy equipment, other options may need to be considered until a method is found to remove or detoxify the accumulated sediments. Upstream and downstream sites should also be tested to determine if the contamination extends beyond the dam site.

4.3 Assessing Other Environmental Components

A variety of other research components are usually considered, in order to choose the appropriate solution for the greatest ecological benefit of the stream

Once the sediment assessment has been carried out, a variety of other research components are usually considered, in order to choose the appropriate solution for the greatest ecological benefit of the stream. These analysis are done with the objective of providing more knowledge of existing conditions, and to predict the way various environmental factors will react during and after the removal of the structure.

Depending on the scope of the project, the expert engineers, hydrologists, economists and biologists involved in the assessment will consider some, or all of these following research components.

Physical and Chemical Components

- River transect surveying
- Bathymetric & sediment depth mapping
- Hydraulic and hydrologic modeling
- Sediment transport modeling
- Sediment resuspension analysis due to wind

- Sediment loading analysis to the river below the dam
- Inundated floodplain analysis
- Surface water quality analysis
- Groundwater impacts of drawdown

Biological and Ecological Components

— Fish population assessment
— Invasive species assessment
— Migratory fish populations analysis
— Aquatic plant populations and management assessment
— Bird populations assessment
— Endangered, threatened, special concern species assessment
— Floodplain forest succession modeling
— Habitat assessment

The environmental assessment should also take into consideration the fact that complete removal is not always possible, and should allow for the possibility of partial restoration, either by removing part of the structure or by reducing the area of the impoundment. In the case where the dam and/or the impoundment cannot be altered, fish and wildlife resources should be actively managed with appropriate measures.

A detailed assessment of nearby infrastructures, especially the ones that were installed after the dam was built, should be undertaken

4.4 Assuring the Protection of Area Infrastructure

A proper assessment of nearby infrastructures, especially the ones that were installed after the dam was built, should be undertaken. This will determine if structures like bridges, storm drain pipes, culverts, utility pipes, wells and building foundations in the immediate area of the dam and downstream, are affected by the lowering of the water level, and possible erosion impacts. In some cases, they may need to be relocated or stabilized, which can add increased costs to the project. **A qualified hydrologist and engineer usually team up to carry out this assessment**.

4.5 Getting the Necessary Approvals

The approval process (government regulatory framework) is designed to ensure that a given project is handled safely, and that the removal of an abandoned dam does not have negative impacts on the environment, on nearby bridges and other infrastructures, and takes into consideration other concerns such as navigation. Depending on which regulations apply, the approval or regulatory process can significantly influence the project design and costs.

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Removing a small abandoned dam will in almost all cases require provincial and/or federal approval in the form of a watercourse alteration permit or an environmental assessment (from project screening to full environmental impact assessments depending on the complexity). Because abandoned dam removal is relatively new in many areas, the assessment process may be challenging at first to government officials. In all cases, individual dam removal initiatives will be considered distinct projects requiring its unique set of environmental assessments by the government agencies involved. Previous dam removal cases in nearby jurisdictions may therefore not be used as precedents for suggesting the regulatory process for a new dam removal project.

Before proceeding further with a dam removal project, it is best to consult with provincial and federal regulatory agencies

Before proceeding further with a dam removal project, it is therefore best to consult with the provincial and federal agencies responsible for regulating environmental assessments (New Brunswick Department of the Environment and Local Government and the Canadian Environmental Assessment Agency in the case of the Petitcodiac River watershed). A detailed set of questions need to be answered to obtain a watercourse alteration permit or register a project, such as defining the project proponent and project description, as well as describing the activities needing to be undertaken during the detailed assessment.

4.6 Getting Estimates and Securing Funding

Before committing financial resources to any component of the detailed assessment or the removal project, it is wise to adopt efficient tendering practices in order to obtain the most qualified expertise for the project at the most reasonable cost. As is common in similar projects, up to three estimates should be obtained for each contract component, as prices and services can vary greatly from one offer to another.

It is wise to adopt efficient tendering practices in order to obtain the most qualified expertise for the project at the most reasonable cost

Getting different estimates is also a way of obtaining more opinions on the removal procedures proposed in the project. In all cases, it is important to follow generally accepted regulatory guidelines for tendering project contracts, and most likely as well to follow government guidelines should public funds be used in the removal project. It is recommended therefore **that a qualified administrator or engineer be consulted** or hired to implement the administrative portion of this component.

Before beginning any component of the removal project, managers should also make sure that funding has been secured for the entire phase of the component being implemented (i.e. the preliminary assessment, the detailed assessment or the removal phase of the project). In some project cases that are more complex than others, funding for subsequent phases will only be obtained once a proper assessment of the previous phase has been completed.

4.7 Timing the Removal

Finally, choosing the right time of year to remove a dam is crucial to mitigating the impacts on the river being considered for a restoration project. It is a decision that can only be made after the natural habitat and dam related characteristics of a project s site have been carefully studied.

Generally, removal should not be undertaken during the periods of spawning or the migration of fish. Removal should also be avoided during heavy rain or flooding seasons, which could be detrimental to the demolition work and cause greater sediment erosion or run-off from the newly exposed banks. Here in the Inner Bay of Fundy region, for instance, removing the dam during the fall could mean that the newly exposed land will not grow any vegetation until the subsequent year. This tends to increase the erosion risks as well as contribute to poorer aesthetics of the restored site.

Removal should not be undertaken during periods of spawning or migration of fish

After studying all of the above implications, it might not always be possible to find an appropriate time in the year when the removal of a particular small dam will have absolutely no short term impacts on the river s aquatic species, sediment run-off, sediment transport and the revegetation of the river s banks. Depending on which of the issues poses lesser risks and impacts on the health of the river, one outcome can be chosen over another. With time, the long term benefits of a restored river will more than likely surpass the short-term impacts of removing the dam.

SECTION 5

Technical Procedures in the Removal

5.1 Draining the Impoundment During Removal

Although some dams can be removed while they are still retaining water, most conditions will require the draining of the impoundment in order to proceed with the deconstruction phase. If the dam is equipped with control gates that are in working condition, this can be a relatively simple operation. Another option is to create a breach in the structure and gradually increase its size, so that the impoundment can drain slowly to avoid erosion, and the stirring of bottom sediments so that they are not transported downstream.

Most conditions will require the draining of the impoundment in order to proceed with the deconstruction phase

If working during low flow periods, this step might not be necessary as the water levels in the impoundment might already be below most of the structure to allow access for deconstruction.

Temporary dams made with earth, sand bags or other materials can also be built to divert the flow of the river away from one side of the dam, while deconstructing on the other side of the structure**.** If necessary, a fish rescue plan should be implemented during the draining to mitigate the impacts on fish populations. A **qualified fish biologist should be consulted** or hired to prepare this plan.

5.2 Removing the Structure

Common demolition techniques include the use of heavy equipment like a hydraulic hammer or a claw attachment mounted on a backhoe for the removal of small dams. In order to use heavy equipment, access to the site must be considered. Machinery can operate from the stream bottom if conditions permit. In some cases, temporary roads, ramps and floats have to be arranged. These can increase the cost of the project dramatically and should be studied very carefully before proceeding. A structural or civil engineer should always supervise the demolition work.

A structural or civil engineer should always supervise the demolition work.

Explosives are sometimes used where the density of the structure s materials doesn t allow for mechanical means, but their use is limited because of safety issues and the lesser control of possible outcomes of that method.

Materials removed from the structure during the demolition should be hauled away and disposed of properly. However, materials such as concrete are sometimes used to stabilize banks, or to fill scour holes at the dam site, reducing the costs for disposal. Other materials such as metal can sometimes also be sold or reused.

5.3 Managing Accumulated Sediments

Although sediment removal has been a common practice for many years, the actual management of accumulated sediments required specifically for dam removal is a new challenge to many operators. Even with small dams, substantial volumes of sediments can accumulate behind the structure, and even though some amounts of sediment will inevitably be transported during dam removal, strategies must be put in place to alleviate the problem. In all cases, **a qualified geologist or**

geomorphologist needs to be consulted or hired to prepare sediment management plans.

Managing sediments during and after dam removal is usually done by using one, or a combination of the three following methods.

A qualified geologist or geomorphologist needs to be consulted or hired to prepare sediment management plans

The first method implies leaving nature shape its own course, therefore allowing the river to erode a new channel through the accumulated sediment. This approach favors the river s natural process to erode and transport sediment, naturally armoring its channel bed. In this scenario, only a portion of the sediments will be transported, as sediments in the newly exposed banks of the impoundment will eventually stabilize and remain in place.

Before selecting this option, the downstream river s capacity to handle the quantity of sediment release should be evaluated. While this approach is the less costly, it is not always appropriate, especially if contaminants are suspected to be present in the sediments, or if habitats are threatened. As stated previously in this guide, excessive sedimentation can be detrimental to the health of a river and its species.

Another method of managing sediments involves dredging parts or in some cases all of the impoundment with mechanical equipment. Although this option can be very costly and complex even for small dams, it is sometimes the only acceptable option, depending on the chemicals content and the physical characteristics of the sediment accumulated at the site.

Dredging procedures should be carefully planned and designed by a qualified engineer, hydrologist and/or a geologist

Dredging procedures should be carefully planned and designed by a qualified engineer, hydrologist and/or a geologist, taking into consideration the various characteristics of the river and the configurations of the channel. Appropriate stabilization techniques should also be implemented to avoid bank erosion and sediment transport downstream during and after the dam removal. Another factor to consider

is that along with dredging comes the challenge of finding an appropriate site for the disposal of the sediments. Depending on its physical and chemical composition, it should be reused or transported to a regular or hazardous waste landfill or another suitable soil treatment site.

The third method of dealing with sediments is done by gradually lowering the water level in the impoundment, leaving enough time between each level for the sediments to lose some of its water content, thereby revegetating and stabilizing the river s banks. This method can only be used by itself when there is a small amount of accumulated sediment in the impoundment, and when there is a more defined channel under the impounded water. To help stabilize the newly exposed sediments, techniques such as seeding for vegetation and the of laying stones or other natural materials is used in combination with the gradual lowering of the water level.

To further minimize the impacts of sediment transport, work should always be carried out during periods of the year when the flow of the river is at its lowest. There are also more control measures that can be applied, including the digging of holes in the riverbed downstream. These holes become sediment traps which will collect a portion of the suspended sediments, reducing the impacts on habitats located further downstream. Another option is the installation silt fencing at the water s edge until the sediments are stabilized by vegetation or removed.

To further minimize the impacts of sediment transport, work should always be carried out during periods of the year when the flow of the river is at its lowest

Small dams that have accumulated a high amount of sediments may require a more detailed analysis of the quantity of sediments that will be transported downstream following their removal. Although there are several methods and sediment transport models that have been developed and used successfully in dam removal projects, their levels of success in accurately predicting sediment transport downstream depends greatly on the experience, expertise and professional judgment of the practitioner involved.

As mentioned earlier, dam removal procedures vary from one project to another, as each river and the dam that blocks it is unique. The high costs associated with dredging large amounts of sediments and the challenge to find a disposal site often means that removing all of the sediments in an impoundment is not often chosen, especially in dam removal projects with larger areas of impoundments. As toxins are not evenly distributed in sediments, dredging can take place in the less contaminated areas of the impoundment, diverting the river s channel to flow through unpolluted sections of the impoundment.

A combination of approaches are often used for the management of sediments in small dam removal projects

To sum up, a combination of the above approaches are often used in small dam removal projects, and the final method chosen will be one that is adapted to the situation at hand, and the specific characteristics of the river and the dam that blocks it.

5.4 Reconstructing the River s Channel and Banks

Once the water has been drained with the removal of the structure, and if the conditions permit, the flow of water can be allowed to naturally form the channel through the former impoundment. This is a common low cost approach that is used in combination with some stabilization of the exposed banks, accomplished with using a combination of rock riprap, plants, stones and other natural materials. Bank stabilization is usually undertaken only after the channel has adjusted to the materials in the former impoundment, and stabilized into a somewhat steady pattern, as newly formed channels can shift and even jump out of banks that have been actively stabilized. To prepare a channel reconstruction plan, **a hydrologist and a fluvial geomorphologist need to be consulted**.

Bank stabilization is usually undertaken only after the channel has adjusted to the materials in the former impoundment, and stabilized into a somewhat steady pattern

Depending on the conditions relative to the former impoundment, and the geomorphologic characteristics of upstream and downstream channels, natural channel formation can also bring its share of complications and create adverse effects on the habitat being restored.

A more active channel reconstruction may therefore be needed, which involves dewatering, grading the channel to specified dimensions, stabilizing the bed and banks and reconnecting the segments. This procedure should take into consideration the objectives of the various stakeholders and criteria such as flood conveyance, channel stability, habitat enhancement for aquatic species and aesthetics.

Consultation with an experienced fluvial geomorphologist will be required to design a plan adapted to the existing conditions at the site.

For both natural channel formation and active channel reconstruction, consultation with an experienced fluvial geomorphologist will be required to design a plan adapted to the existing conditions at the site.

5.5 Revegetating the Exposed Land

Vegetation along stream and river banks have an important role to play. It filters water trickling down along the edge of a watercourse, provides habitat for wildlife, reduces erosion and provides shade, keeping water temperatures cool in the summer time, thus promoting high levels of dissolved oxygen which is crucial for fish and other aquatic species. To conduct a thorough revegetation plan, a qualified biologist or ecologist should be consulted.

Depending on conditions related to soil types and climate, natural revegetation of drained impoundments usually takes place without intervention and within weeks. Plants grow well in the nutrient-rich, highly organic sediment often found in impounded areas. Some plants will emerge from seeds already present in the sediments while others will come from seeds spread naturally to the site from nearby areas. When considering natural revegetation following a removal, an inventory of plants growing in areas nearby should be undertaken. The proliferation of certain exotic plant species should be avoided as non-native plants can quickly dominate the site, lowering overall diversity and creating adverse impacts, such as the capacity of the riverbanks to provide good habitat for wildlife.

To conduct a thorough revegetation plan, a qualified biologist or ecologist should be consulted

For a more managed approach to revegetation, newly exposed sediments can be planted with a fast-growing cover crop. This method will permit the stabilization of the banks while limiting erosion and will help in increasing recreational and aesthetic values in the short term. The dominance of exotic species will also be avoided. With time, cover crops can be replaced by other slower-growing species of shrubs and trees, the choice of which depends on the restoration goals and the input of others interested in the future use of the area.

5.6 Evaluation and Monitoring

Documenting dam removal is important in all phases of the project, so that it can serve in guiding other groups involved in future dam removals. Conducting research and monitoring the specific river and other affected ecosystems, during and after the dam structure has been removed, is especially helpful in understanding the many apparent changes and transformations that the now free-flowing river will undergo in the followings days, weeks and months. This phase of the project enables local residents to get involved in monitoring the health and quality of their local river, and the effects of the removal on that river. Research and monitoring can be undertaken or assisted by local conservation groups, university students and other interested groups and individuals.

Documenting dam removal projects is important in all phases of the project, as it can serve in guiding other groups involved in future dam removals

CONCLUSION

Following-up with the Community

After the dam has been removed, the restoration phase of the project can begin. Community participation in the planning for the former impoundment s future restoration should be encouraged at this stage. This is the time to implement the ideas that were raised while consulting with the community. It is very important that members feel a sense of ownership in what will become of their impoundment.

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Community members can be part of committees that review and evaluate the feasibility of implementing the ideas that were put forward for the future use of the area. Nature parks, hiking trails, interpretive centres, fishing access and boat launches to name a few, are projects that can benefit greatly from the input and effort of community members offering themselves as volunteers.

The public should be continually informed about the status of the river s health progress. People should be encouraged to go to the river. Community events can even be organized near the site of the former dam, once access is secured or once trails are ready for nature walks along the free-flowing river. Progress of the river and the impoundment s restoration should be recorded with photos and video footage.

Community members can be part of committees that review and evaluate the feasibility of implementing the ideas that were put forward for the future use of the area

Organizing river cleanups near the area of the former dam as well as upstream and downstream from the former impoundment is a good way to involve the community in restoring the river. Debris of all kinds are sometimes exposed when water is drawn down, and these should be removed as soon as this is feasible. Precautions should be taken before venturing out into the exposed lands if the built-up sediment is too soft to walk on.

The media should always be informed, as they are usually keen on covering events that foster community pride by showing individuals working for a common cause. The progress of the restoration and the events occurring around the development of the area such as parks, trails and interpretive centres should be publicized by all means possible.

In conclusion, the authors of this Information Guide would like to stress the fact that any experience gained on restoring rivers and removing abandoned dams that no longer serve their intended purpose is ultimately valuable to the larger society. This experience is not only valuable to the community where the removal project is taking place, but the knowledge gained through this process may someday also be shared with other communities or groups faced with an abandoned dam. They will benefit greatly from the experience acquired through the removal of the dam in your community.

Any experience gained on restoring rivers and removing abandoned dams that no longer serve their intended purpose is ultimately valuable to the larger society

APPENDIX 1

Small Abandoned Dams in the Petitcodiac Watershed

Humphreys Mill Abandoned Dam (c. 1923)

Humphreys Brook, Moncton

Dimensions of structure: 9.1 meters wide by 4.7 meters high

Area impounded: Approximately 2 acres

Area affected: 38 km2

Total length of stream: Approximately 20 kilometers

Built along with the first bridge in 1923, the Humphreys Mill dam was used for providing power to the Humphreys textile Mills. The present dam is not the first dam built on the site, since activities associated with the Humphreys textile and wood mill can be traced back as early as the 1820 s.

Nowadays the dam serves no useful purpose, and as it sits abandoned in Humphreys Brook, deteriorating with the years, it prevents fish from travelling upstream as well as posing a potential threat to public safety. Since it was abandoned some forty years ago, the impoundment has accumulated large amounts of silt. At this point (March 2002), it is unknown if contamination is present in the headpond sediment; prior testing and analysis are needed to determine this.

Negative impacts of the abandoned Humphreys Mill dam on the Humphreys Brook:

- Creates a complete obstruction to fish passage
- Prevents nutrients from flowing downstream
- Shows a high accumulation of sediments in the headpond
- Has a direct impact on the stream s biodiversity
- Poses a potential threat to public safety, and should this abandoned dam fail, poses a potential threat to the ecology of the Petitcodiac River system

A preliminary assessment on the feasibility of removing the abandoned Humphreys Mill dam is presented in Part II of this document entitled *Restoring Humphreys Brook — A Draft Decommissioning Plan*.

Navy Base Abandoned Dam (c. 1950)

Mill Creek, Riverview

Dimensions of structure: 36 metres long by 6 metres high

Area impounded: Approximately 12 acres

Area affected: Approximately 50 km2

Length of stream: Approximately 25 kilometers

Built around 1950, the dam on Mill Creek in Riverview was used for retaining water to be used in case of fire at the Naval Base on Ruddymeade Road, a facility which was closed down in 1970. In the following years, the Town of Riverview acquired title to the dam and the adjacent land from the Department of National Defense. Plans were to develop the area as a nature/recreation park. Today, siltation prevents the pond from being used for aquatic activities and the dam no longer serves its intended purpose, aside from being designated as an emergency water supply should a significant forest fire occur in the nearby vicinity. Cracks have also been detected in the dam, showing signs that the structure is weakening.

Negative impacts of the Navy Base abandoned dam on Mills Creek:

- Creates total obstruction to fish passage
- Prevents nutrients from flowing downstream
- Shows an accumulation of sediments in upper pond
- Has a direct impact on the stream s biodiversity
- Poses a potential threat to public safety, and should this abandoned dam fail, poses a potential threat to the ecology of the Petitcodiac River system

The Mill Creek Watershed Group, a local environmental committee located in Riverview, is actively involved in the restoration of Mill Creek and its members are advocating for the removal of this abandoned dam, as well as the creation of a nature/ecological park in the drained headpond s basin once the stream is restored.

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