NON-STRUCTURAL FLOOD MANAGEMENT SOLUTIONS FOR THE LOWER FRASER VALLEY, BRITISH COLUMBIA

by

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ABSTRACT

In rivers without dams, or insufficient storage capacity flood hazard reduction has traditionally been achieved using engineered structures. The objective is to move water away from vulnerable land as fast as possible, by straightening and smoothing water channels. This reduces the duration of a flood but increases the peak, the maximum volume of water flowing down a channel. A natural approach uses the landscape to store as much water as possible by returning flood plains to their natural state, so that water is gradually released back into streams and rivers. Thus flood peaks are reduced, and the duration lengthened, as compared to engineered rivers. This approach reduces risk, increases long-term economic gains and improves the environment

British Columbia's approach the flood damage reduction does not endorse natural flood control. This research project examines pathways to implement natural approaches to flood damage reduction in the province Policy makers face numerous obstacles when considering non-structural approaches including: high flood plain land values, private property rights, inter-jurisdictional issues, distributed responsibility, lack of information, awkward decision-analysis frameworks, social costs and the difficulty of policy making under uncertainty. Various non-structural adjustments to flood damage reduction are proposed for the Lower Fraser Valley including technical tools, policy objectives, policy instruments, policy paradigms, and best practices. The choice of adjustment will depend on local conditions.

Solutions to overcome obstacles and implement policy alternatives include the more effective use of existing Federal and Provincial legislation; numerous legislative barriers to non-structural approaches to flood control must be removed. Second, basin-wide planning institutions, are proposed as solutions to inter-jurisdictional, and the distribution of responsibility obstacles. Third, the gradual discontinuance of post-disaster payments by the Federal and Provincial governments, and the creation of a government aided flood insurance program, are suggested as a means of shifting responsibility and liability to flood plain dwellers. Finally, increased flood awareness among publics and policy makers is suggested to shift B.C.'s reactive structural approach to flood damage reduction to a more proactive natural approach.

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Finally, I would like to thank everyone at REM who opened my eyes to the world beyond engineering.

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ALR	Agricultural Land Reserve
B.C.	British Columbia
CRP	Conservation Reserve Program
DFA	Disaster Financial Assistance
DIANA	Department of Indian and Northern Affairs
EPA	Environment Protection Agency
FDR	Flood Damage Reduction
FEMA	Federal Emergency Management Agency
MELP	Ministry of Environment, Lands and Parks
NFIP	National Flood Insurance Program
OCP	Official Community Plan
ORP	Official Regional Plan
PEP	Provincial Emergency Program
SPA	Special Policy Area
UEA	Urban Exempt Areas
U.S.	United States

Chapter 1: Introduction

This chapter presents the major issues relating to this research project. It provides some background and a rationale for the research, contains project objectives and lists the research questions used to guide this investigation. It also relates the project methodology and explains the report organization.

1.1 Background and Project Rationale

Ever since the cessation of the nomadic lifestyle, humans have been involved in love-hate relationships with rivers. The same rivers that provide clean water, fertile soils and transportation routes, on occasion deluge flood plain dwellers. For nearly as long as human have settled the flood plain, engineers have been trying to hold back flood waters using various forms of dikes, levees and dams with varying degrees of success. A Chinese engineer, Yu, is credited with the design of the first flood control works on the Hwang Ho River in China during the third century B.C.. However, despite his and future engineers' efforts, more than seven million Chinese have been killed by the Hwang Ho's flood waters since 1887 (United States Public Broadcasting Service n.d.a.). Flood catastrophes afflict countries worldwide and Canada has had its share of damaging floods in recent times. In the spring of 1997, Manitoba's Red River surpassed its banks and threatened downtown Winnipeg, and in 1996 the Saguenay River flood waters in Québec left thousands homeless (CNN 1996).

The Fraser River

In British Columbia, the Lower Fraser Valley in particular, flooding is an equally important issue. The Fraser is a living, dynamic river, approximately 1200 kilometres long, which drains a catchment of close to 234 000 square kilometres, as seen in Figure 1-1. The Lower Fraser Valley comprises the lowland area near the mouth of the Fraser River, stretching from Hope in the east to the Strait of Georgia in the west. At Hope, the Fraser River is 5 m above sea level and has an average discharge of 2730 m^3/s. It is joined by several major rivers along the final 160

Figure 1-1: Fraser River Basin, British Columbia

km stretch, increasing the average discharge to 3700 m^3/s at the Fraser's mouth. The river is fed primarily by glaciers and snowmelt, and as a consequence, it experiences high flows in late spring and low flows in late winter. The variation in average flows ranges from 500 m^3/s to 14 000 m^3/s at the river's mouth. Historically, during peak flows, excess water would overtop the banks of the Fraser and flood approximately 1000 km^2 of wetlands and swamps adjacent to the river (Healey 1997).

The flooding of the Fraser River has affected residents of the region for thousands of years. The Stó:lô Nation, the original inhabitants of the Lower Fraser Basin, has a legend describing a particularly large Fraser River flood. The waters forced the Stó:lô to build rafts to save themselves. They eventually found dry land on what is today called Pointing Thumb Mountain, north of Yale. Remains of their camp high on the mountain are allegedly evident today. The following excerpt describes what the Stó:lô saw once the waters had receded:

> When they got back, there was nothing left of their homes. Even the house posts had fallen down in the mud. There was no sign of life… .
>
> . . . Everything was changed. Some of the creeks that had been there were no more, and there were new lakes and creeks in different places. The people were pretty weak before the salmon came again but that year there was lots of salmon and the people were saved. (Keller 1976)

Settlement in the Fraser Valley

When colonists arrived at the beginning of the 19th Century, they settled on the fertile flood plains of the Lower Fraser Valley. As the population grew, so did the demand for land. The newly arrived Europeans drained wetlands and small lakes, and razed forests for farmland, dramatically changing the landscape of the Fraser River Valley. By 1920, approximately 50% of the original forest cover had been removed and 30% of the natural wetlands had been drained in the Lower Fraser Valley (Healey 1997).

In order to protect the growing Lower Mainland population and valuable farmland from flood damage, control structures were built. The first known dike along the Fraser River was

constructed in 1864 on Lulu Island, what is today Richmond (McMullen 1999). Further dikes were built along the length of the Fraser River in an effort to protect valuable crops and settlements from spring floods.

The largest recorded flood on the Fraser River occurred in 1894, when discharges of 17 600 m^3/s were recorded at Hope. The damages were severe; dikes were breached and overtopped along the length of the Lower Fraser River. Those residing in the flood plain were forced to evacuate to Vancouver. As a result of the flood, the Canadian Pacific Railway line was closed for 41 days. The estimated damage to railway properties alone approached $1 million 1894 dollars. Additionally, much of the Fraser Valley could not support crops that season because fields were covered with silt and debris deposited by the flood (McMullen 1999 and Fraser Basin Management Board 1994). Clearly, this was a major social and economic disaster for the region.

Following the 1894 Fraser River flood, it was recognised that a better flood control system was necessary to keep the residents of the Fraser Valley safe. Although the need for action was recognised, no long-lasting policy strategy was established.

Over the next fifty years, the population of the region had grown by more than 1000 per cent to over half a million residents, such that when the next major flood occurred in 1948, thousands of businesses and homes were deluged. 20 000 hectares of the Fraser Valley were under water, 16 000 people were evacuated, and thousands of homes were destroyed. The economic cost of the 1948 flood was estimated at $17.5 million in 1948 dollars (Wynn and Oke 1992; The Fraser Basin Management Board 1994).

Following the 1948 Fraser River flood a series of joint Federal-Provincial boards were convened to study issues related to flooding in the region, culminating in the establishment of the Fraser River Board. Its mandate was to rebuild existing dikes, construct new dikes and determine which additional flood control measures would be suitable for the region. In 1968 the board initiated the Fraser River Flood Control Program who between their conception and 1994 spent $300 million (in 1994 dollars) of Federal and Provincial money on dikes, drainage structures and erosion protection along the Lower Fraser River. During the mandate of the program, controversial flood control measures such the damming of the Fraser north of Lillooet were

discussed and discarded due to the negative environmental impacts to the valuable salmon stocks.

From the 1940's to the 1970's, the flood management community, championed by University of Chicago professor, Gilbert White, was examining alternatives to structural flood control (White 1961). In the Lower Fraser Valley, structural measures alone were no longer adequate to protect communities. Various small efforts were made to regulate development on the flood plain. The Lower Mainland's 1966 Official Regional Plan delineated the 200-year flood plain, and established that it should not be used for urban development, except where historical settlements already existed. Nevertheless, these Urban Exempt Areas experienced rapid growth over the second half of the century (Fraser Basin Council n.d.).

Further measures to restrict growth on the flood plain included Section 82 of the 1979 *Land Title Act*, requiring that officers of the Ministry of Environment, Lands and Parks (MELP) consent to subdivision developments on the flood plain. MELP subsequently created a *Floodplain Development Control Program*. Although, it did not generally prohibit development of new subdivisions in flood plains, it did require that the developments be flood-proofed (McMullen 2000).

Over the same time period the *Canada Water Act* (1970) created an opportunity for joint Provincial-Federal water resources planning and structural project construction. Through the *National Flood Damage Reduction Program*, the *Act*, provided support for floodplain mapping projects, discouraging development in vulnerable areas. However, B.C. insisted on using this funding for structural works. B.C. did not participate in the *Act*'s floodplain mapping initiative until 1987. To date, 545 maps have been completed in the province, yet the Lower Fraser River flood plain has not been well covered (Booth and Quinn 1995). Under this initiative, both Provincial and Federal governments agreed not to invest money in public buildings within the designated flood plains. Furthermore, the governments agreed to provide no financial assistance to owners of flood damaged buildings that were built on the flood plain after designation and if the buildings were not flood proofed to Provincial standards (Day 1999; Peters 2000).

Despite the movement to implement land use planning and zoning as effective tools for flood damage control, flood control efforts along the Lower Fraser Basin are predominantly structural in nature. Presently, 600 km of dikes, 400 floodboxes and 100 pumps protect over 50 per cent of the Lower Mainland population (B.C. MELP n.d.a.).

There are currently 2 million residents in the lower mainland, and it is projected that there will be an additional million in the next 20 years (British Columbia Stats 2000). All these people require living space; space that is constrained by the mountainous nature of the region and puts tremendous development pressure on the valley floor, the Fraser River's flood plain.

The existence of Urban Exempt Areas has allowed for continued development in historical flood plain settlements, thus necessitating the building of more structural flood control works. This in turn attracts further developments to the flood plains that will require flood protection. Dr. Jeffrey Mant calls this cycle "serial engineering" (Friends of the River n.d.). Structural flood works are expensive and require continued maintenance to be effective. In addition, if the structural works fail, economic losses are great. There is currently approximately $13 billion worth of investment on the Lower Fraser Valley flood plains (Fraser Basin Management Board 1994). It is estimated that if a flood of 1894 proportions were to occur today, $1.8 billion of direct flood damage would result. However, this figure does not include many indirect damages such as health costs and lost business time. Additionally, it is widely thought that the figure if $1.8 billion significantly underestimates the true cost of damage that would be incurred. This situation indicates the spiralling costs associated with structural flood control works, as shown graphically in Figure 1-2.

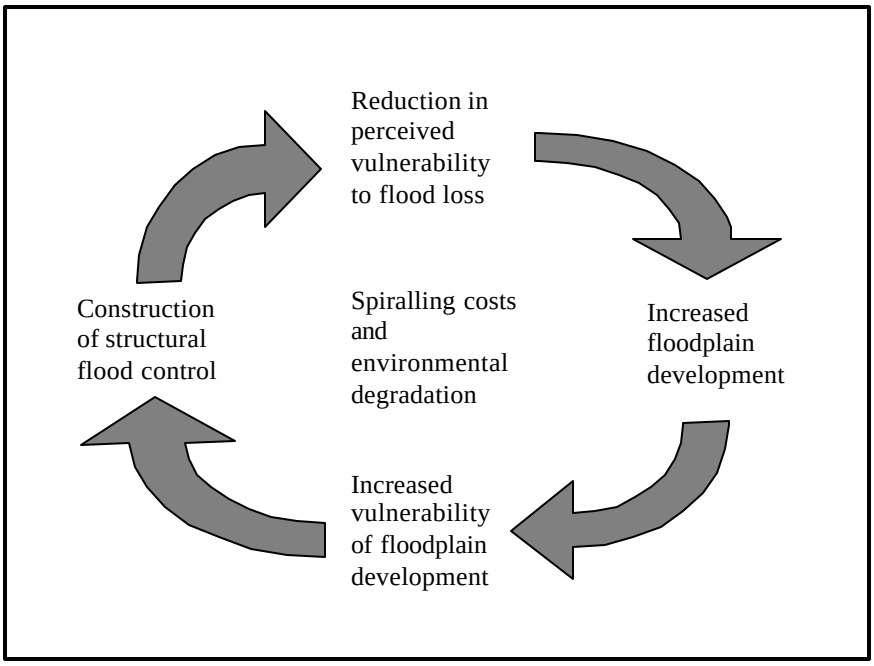

Figure 1-2: Spiralling costs associated with structural flood control

The development of the Lower Fraser Valley has significantly affected the natural hydrological regime. Development has increased the surface runoff after precipitation events as a result of replacing permeable ground cover with impermeable surfaces. Additionally, straightening and smoothing of water channels for flood control has the effect of reducing the duration of a flood, but increasing the peak, the maximum volume of water flowing down a channel. This increases the damage that occurs in a flood. Furthermore, structural flood control measures have detrimental environmental effects. For example, the construction of dikes, levees, and dams change in-stream and riparian habitat, creating wildlife concerns.

In the United States, structural flood control measures have not been successful at reducing flood damage. In fact, flood damage is on the rise despite the continued expenditure on structural flood control (Hunt 1999). In the Lower Fraser Valley, structural flood damage reduction measures have primarily been a reaction to flooding events. The structures, however, are creating problems, both economically and environmentally. Although they have been effective to date, it is argued that without some changes, a future "Fraser River flood could be a natural disaster of unprecedented proportion in Canada" (Fraser Basin Council n.d.). This statement illustrates the need for some lateral thinking regarding flood control in B.C., and possibly a move towards

natural flood control. There is a need to replace reactive structural approaches to flood damage reduction with proactive measures, such as natural approaches to flood damage reduction.

A Natural Approach to Flood Damage Reduction

The goal of a natural approach to flood damage reduction is getting the landscape to store as much water as possible by returning flood plains to their pre-development state, so that water is gradually released back into streams and rivers. Thus the flood peak is reduced, and the duration lengthened, when compared to the engineered approach. There are numerous advantages to this approach to flood control, including reduced flood and damage risk, long-term economic gain and environmental benefits (Hunt 1997).

Hydrologically, restoring wetlands to their natural state is an extremely effective tool for flood damage reduction. However, it requires the procurement of large areas of economically valuable riparian land to be successful. The acquisition of this land requires policy tools supported by the local political and social climate. In Canada, government policy has not actively promoted non-structural approaches to flood damage reduction (Day 1999).

Although, there are numerous reasons to adopt a non-structural approach to flood control in the Lower Fraser Valley, at this time it is unclear how this could be achieved. There is a need to research policy options and implications and to assess which policies would be the most appropriate to move B.C. from a reactive dependence on structures and emergency measures to a proactive approach to flood damage reduction.

1.2 Project Objectives

The aim of this research project is to examine the suitability of integrating a natural approach to flood damage reduction in the Lower Fraser Valley, B.C. into existing structural policies. A variety of policy options are examined to establish which policies would be most effective in promoting a natural approach to flood damage reduction in B.C.. Figure 1-3 summarizes the project, where the question mark indicates the various policy options and legislation that can be used to achieve a move from structural to natural approaches to flood damage reduction.

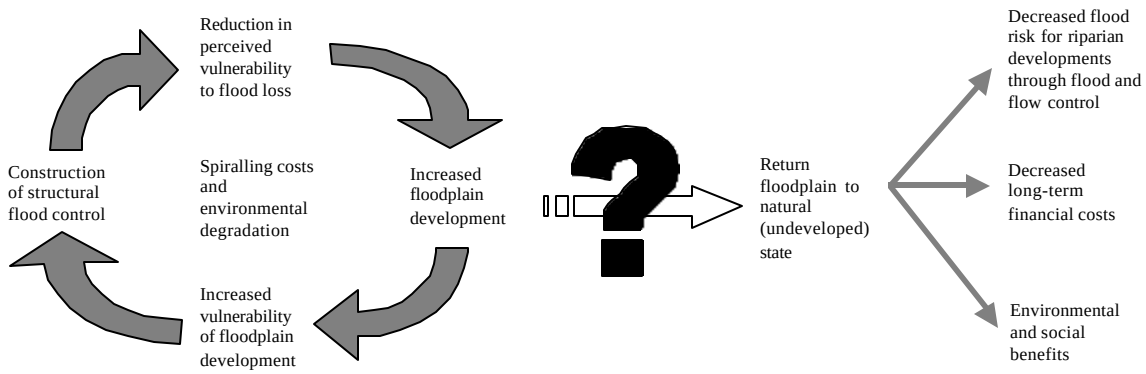

Figure 1-3: Structural and natural flood damage reduction options.

1.3 Research Questions

This paper examines the suitability and opportunity for a non-structural approach to flood damage reduction in the Lower Fraser Valley, B.C.. Four research questions have been developed to guide the research. Providing answers to the following research questions will permit central research question to be answered with confidence.

1. What is natural flood control?
2. What flood policy is currently in place in British Columbia?
3. What policy options are available to achieve natural flood control?
4. How can natural flood control be achieved in British Columbia?

1.4 Project Methods

The development of this research project involved the use of varying methods over two principal stages. The first stage involved a review of relevant literature pertaining to the topics addressed by the project. The project's methods in the second stage involved a complete analysis of Federal, Provincial and Municipal legislation as it pertains to non-structural adjustments to flooding.

1.5 Report Organisation

This document is divided into five chapters. Chapter 1 has presented the rationale for the project, the purpose of the study, research questions and a brief description of the research methods used in this project. Chapter 2 provides a comprehensive look at structural and non-structural flood control including an extensive literature review of these topics. Chapter 3 presents a thorough look at adjustments to flood control, once again citing published literature. Chapter 4 presents and analyses existing Federal, Provincial and Municipal legislation that pertains to flood management. Finally, Chapter 5 presents conclusions and recommendations regarding a non-structural approach to flood damage reduction in the Lower Fraser Valley.

Chapter 2: Flooding and Flood Damage Reduction: Natural Versus Structural Approaches

"To control flooding, we need to work with the forces of nature, instead of simply trying to eliminate them." (Haeuber and Michener 1998a)

This chapter examines structural and natural approaches to flood damage reduction through a hydrological discussion of natural and altered landscapes. It also discusses long and short-term social, economic and environmental benefits of a natural approach to flood control.

2.1 What is flooding?

Flooding is a natural process that occurs when the quantity of water in a watershed exceeds the capacity of streams, rivers, and lakes. In wide valleys such as in the Lower Fraser Valley, excess water flows out onto flood plains adjacent to these bodies of water. It is only since man has chosen to inhabit what the river bottom occasionally claims that conflict has arisen between the natural process of flooding and anthropogenic development. This section briefly examines the hydrology of flooding and explains methods used to mitigate damage.

2.1.1 Flood Plains

The flood plain is the lowland area adjacent to a river. It can be both dry and wet; the amount of time the flood plain is under water will depend on local circumstances. Flood plains form over long periods as a river channel meanders across a valley bottom depositing rocks and silt on the outside of river bends. This dynamic river movement creates flat landscapes of silt on both sides of the river channel, called flood plains. Extensive flood plains, as shown in Figure 2-1, are found in the Lower Fraser Valley.

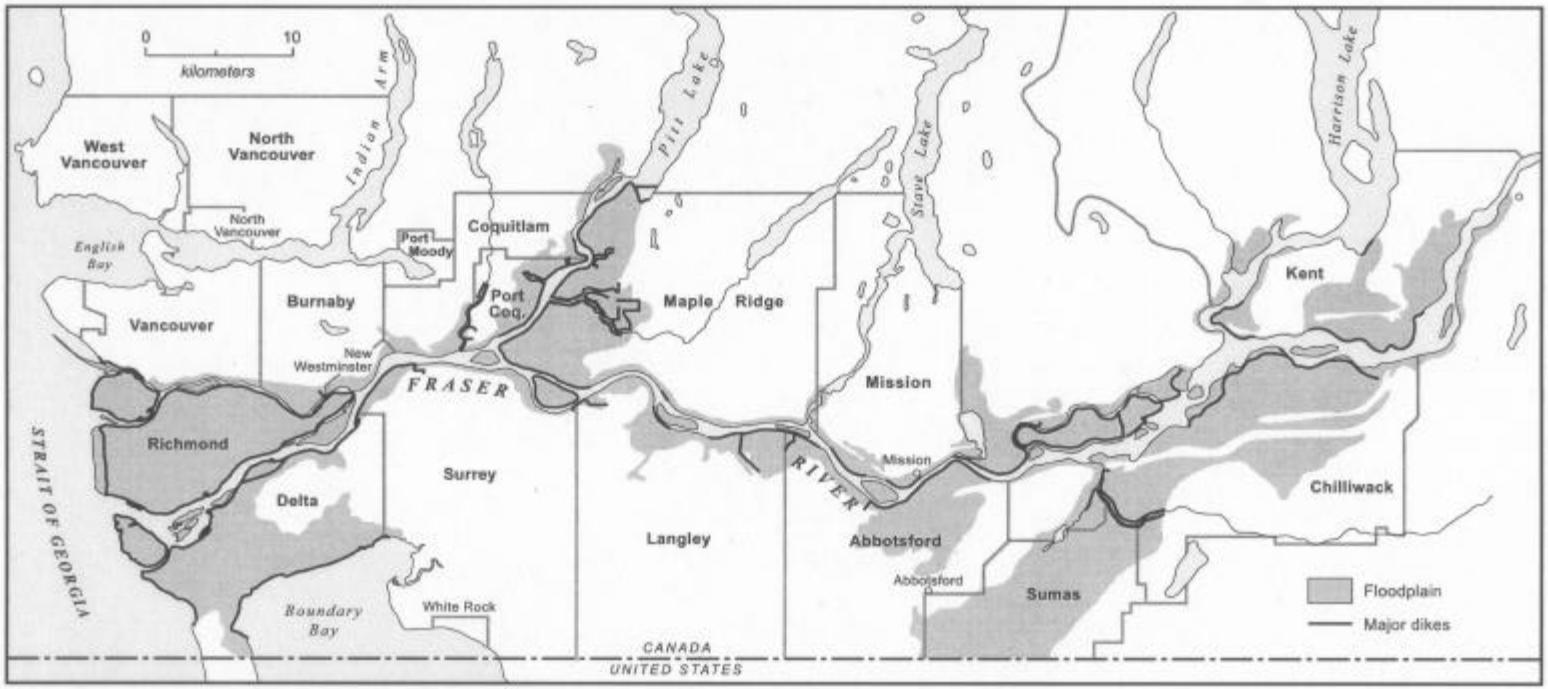

Figure 2-1: Lower Fraser Valley flood plains

Generally, the channel capacity is great enough to carry the flow of water, although during certain weather events excess water will spread out onto adjacent flood plains. In a natural system, this water remains on the flood plain for a short time where it plays a vital role in the natural cycle. Many of these roles are discussed later in this chapter. The flood water will recede when the capacity in the system is great enough to carry it away.

2.1.2 Floods

"A flood is any relatively high flow that overtops the natural or artificial banks in any reach of a stream" or river (Chow 1964). There are three major types of riparian flood occurrences in Canada: flash floods, spring freshets, ice jams and glacier-outburst floods (Andrews 1993). British Columbia is prone to spring freshet floods that occur when the snow pack melts, sending large volumes of water down mountain valleys into waterways, and often onto flood plains. Both the 1894 and 1948 Fraser River floods occurred during the spring when rain added to the snowmelt already in the river system caused flood plain inundation (Andrews 1993).

2.1.3 Flood Damage Reduction

People fear floods only because they have chosen to live on flood plains that would without control measures be inundated. There are two major approaches to reducing the damage caused by floods. Either, people and infrastructure can be removed from the water, or the water can be diverted away from the people.

Structural measures to move water include:

- dams, levees and dikes
- reservoirs and retarding basins
- channel modification
- catchment modification
- drainage schemes

- flood proofing of vulnerable properties (Penning-Roswell and Peerbolte 1994)

Structural flood control measures are mankind's way of attacking natural challenges. Large and impressive engineering structures are perceived to provide protection from natural flooding events.

As problems are realized with structural flood control measures, scientists and engineers are examining less aggressive, proactive options to flood control. Examples of non-structural measures to mitigate flood damage include:

- flood forecasting, flood warning and emergency planning
- land use planning controls
- acquisition and relocation
- flood insurance
- Public information and education (Penning-Roswell and Peerbolte 1994).

Land use planners and engineers have traditionally preferred to redirect water with large structures rather than removing people from vulnerable regions. There are numerous reasons why this approach is not suitable for current development and climatic conditions. The natural approach to flood damage reduction as described in this paper combines moving people with moving water. The advantages and disadvantages of this method are discussed later in the chapter.

2.2 Flood Damage Reduction – A Structural Approach

The B.C. approach to flood damage reduction has primarily been structural. 600 km of dikes, 400 flood boxes and 100 pump stations protect residents of the Lower Mainland (B.C. MELP n.d.a.; Peters 2000). Structural works can be successful at mitigating flood damage by holding back flood water from inhabited flood plains. However, long and short-term problems associated with the use of structural flood works are evident today.

Taylor Delaney observes that this "command and control approach to watershed management cannot necessarily be viewed as a success as evidenced by the floods of 1993 and 1995 in the Midwest" (1995).

Hoyt and Langbein (1955) state that "flood protection [structural flood control] is entirely feasible and is a rational method of meeting flood problems – provided one does not expect too much from it". Structural flood control has historically been used as a reactive method for controlling flood water on settled lands. For the most part, flood control structures are effective at minimizing the risk of flood damage to flood plain residents. However, there are three major direct and numerous indirect problems associated with structural flood works. Increases in flood damage risk, long-term cost and environmental degradation are discussed in more detail below.

2.2.1 Increased Flood Damage Risk

Since risk is the product of hazard and vulnerability, an increase in flood risk can be attributed to an increase to one or both of hazard and vulnerability. Increases to flood hazard and vulnerability will occur primarily as a result of man-made changes to the landscape. These changes and consequences are discussed below.

2.2.1.1 Increased Flood Damage Vulnerability

First, as Figure 1-2 suggests, there is an increased sense of security for those who live or work behind dikes and levees. As a result, flood plains have been extensively developed. The economic value of development on the flood plain is much greater than it would have been without the sense of security that comes with the construction of structural flood control measures (Hunt 1999). Thus, developers build subdivisions, malls and offices in areas that would otherwise be under water for at least part of the year. Increased development results in a greater vulnerability to flooding, which is directly proportional to risk.

2.2.1.2 Increased Flood Damage Hazard

The hazard associated with floods increases with the use of structural controls. This is due to hydrological changes to the river system and to problems surrounding the structures themselves.

Hydrological Hazards

The straightening and smoothing of river channels to convey as much water away from the potential flood areas as fast as possible drastically changes river hydrology. By straightening channels and removing bed roughness through the construction of concrete dikes, greater volumes of water will travel through a river system than would have occurred historically.

Channelized water is trapped within impermeable or semi-impermeable walls, so that very little water is dissipated to underlying aquifers, or evapo-transpirated by riparian vegetation. Also, the slug of excess flood water is not spread throughout meanders and side channels. This increases the volume of water flowing down a river during peak flow. Additionally, the straightening of river channels speeds the passage of water. Both these changes to the hydrology of a river system mean that during a flood event an engineered river will channel larger volumes of water in shorter time periods through the system than would have historically been present, creating a spikier hydrograph. Figure 2-2 shows two hydrographs depicting flows during a flood event in an unaltered and a constricted river.

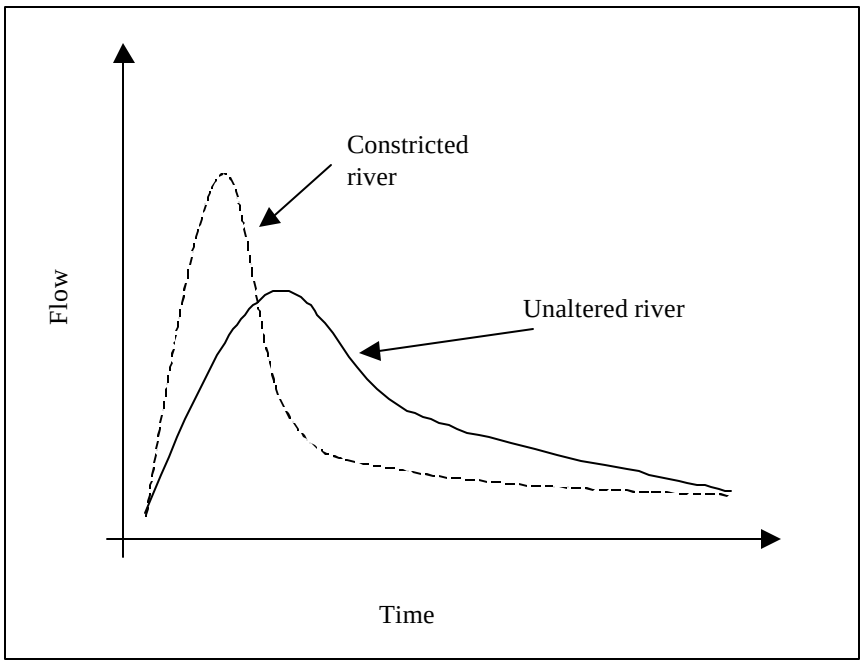

Figure 2-2: Hydrographs for unaltered and constricted river

For example, flood heights along the Lower Missouri River have been increased by as much as 12 feet because of the construction of levees (American Rivers 1997). The use of structures, in combination with the increased impermeability of the Illinois River watershed, have resulted in more erratic, larger and more frequent flooding of the adjacent flood plain (Sparks, Nelson, and Yin 1998).

The additional pressure on dams, dikes and levees from large volumes of water often lead to structural failures by seepage or overtopping (Hunt 1999). Flood control failures in B.C. occur with alarming regularity; there is a structural failure in B.C. on average, every two years (Woods 2000). This heightened likelihood of structural failure increases the hazard in the risk equation.

It is worth noting that all flood control structures are not necessarily created or maintained to an equal standard. For example, municipalities with a strong urban tax base typically have greater financial and staff resources for their dike operations and maintenance programs. Rural diking authorities may not have the same financial or

technical ability to maintain their structures over the long term. This may result in a flood protection system with variable structural integrity. During a large flood event, there may be structural failures among weaker structures while stronger structures may effectively withstand the peak flow (Litke 2001).

Structural Hazards

Despite construction of flood control projects, flood plain properties will be vulnerable to nature. Flood control structures are designed by balancing probable flood conditions and structure costs. Along the Lower Fraser River, structures are built to the design standard of the 1894 flood plus 0.6 m of freeboard; approximately the 1:200 year flood frequency (Peters 2000). Hence, structures are not built to withstand all flood events, as this would be economically unfeasible. Structures may be overtopped during flood events greater than the design of structural works, inundating vulnerable flood plain properties. Many structures, including levees and dikes then exacerbate the situation, as water is detained behind structures and is unable to escape back to the main channel.

In addition to problems adjacent to dikes and levees, the construction of flood control will adversely affect upstream residents. In order to protect downstream communities, dams and dikes hold flood water upstream. This excess of upstream water can result in the inundation of large areas. During the 1997 Red River Flood in Manitoba, structural flood control successfully kept Winnipeg's downtown core dry. However, this was at a cost to upstream communities who were inundated by flood waters backed up behind the structures. The suburban development of Grande Point, Manitoba was inundated because the Winnipeg Floodway gates were raised to protect the City of Winnipeg (Bumsted 1997). The increased vulnerability of upstream communities was the cost of flood control structures downstream. Clearly, the construction of structural flood control can create conflict between upstream and downstream communities.

Finally, ageing infrastructure contributes to increased flood hazard. In Canada, many major infrastructure projects were built in the 1960's when government spent up to 5% of

GDP on infrastructure (Shrubsole 2000). Along the Fraser River, for example, numerous flood control structures were built or rebuilt in the 1950's in response to the 1948 flood. These structures now require continual maintenance and may require replacement in the near future. While the structures continue to be in use the chance of a breach or failure is high, increasing the flood hazard.

Thus, through the use of structural flood control measures, both the hazard and the vulnerability of flood plain development increase. Given that hazard and vulnerability are multiplied to give risk, the increased risk to flood plain development is great.

2.2.2 Increase in Long-term Cost

The costs associated with structural flood control are on the rise. There are two major reasons for this. Increased post-disaster costs, and the high maintenance and capital costs of flood control structures, are most relevant.

First, the payments to flood damaged businesses and home owners by government and insurance bodies is greater in structurally controlled areas, for reasons cited in section 2.2.1. The increased risk of flood damage translates directly to increased costs when a flood strikes. In Canada, where there has traditionally been a dependence on structural flood control, payments for flood damages by government agencies and the insurance industry have been on the rise since 1975 (Shrubsole 2000). In the Lower Fraser Valley, property values on the Fraser River flood plain are increasing steadily. In 1994 there was $13 billion dollars worth of buildings and infrastructure and $250 to $300 million dollars worth of agricultural production in the Lower Fraser Valley. It is estimated that if a flood of 1894 proportions were to hit the region, costs of at least $1.8 billion dollars would be incurred. This is a significant increase in flood damage costs to estimates made in 1971 by Environment Canada; they estimated that if a flood of 1894 proportions were to hit costs would be approximately $284 million in 1971 dollars (Peters 2000). Between 1975 and 2000, $200 million in Disaster Financial Assistance was paid to British Columbians

for flood damages (Water B.C. 2000). These elevated damage cost estimates are a direct result of increased flood plain development.

Second, the capital and maintenance costs associated with structural works are great. In the Lower Fraser Basin, many flood protection works were built or re-built after the 1948 Fraser River flood. Many of these structures are now approaching the end of their design lives, and as such need much costly maintenance (Shrubsole 2000). Additionally, if the dependence on structural measures persists and as development levels increase in the region, more structures will have to be built to protect new developments, at great cost to tax payers. In the spring of 1999, the British Columbia government spent $6.95 million to fund 71 emergency flood control projects around B.C., all of them structural (B.C. MELP 1999a). This is in addition to $6 million of Federal dollars also spent on emergency structural flood control measures on B.C. First Nations lands for the same period (Canada. DIANA 1999). Clearly, expenditures on structural flood control are high in B.C..

2.2.3 Environmental Degradation

The presence of structural flood control along river corridors has a profound effect on the natural environment. First, there are an infinite number of relationships between terrestrial and aquatic organisms at the river's edge. These are jeopardized when the natural state of the river is altered to separate flood plain from river. Second, the natural disturbance that occurs during floods is eliminated when structures are built. Disturbances are an important part of the lifecycle of numerous macroinvertebrates, fish and plants. In addition, the hydrologic regime of a constrained river will be vastly different from a natural river. This will create environmental effects on natural populations. Finally, structural measures generally result in the desiccation of valuable wetland habitat. These issues are discussed in more detail below.

2.2.3.1 Flood Plain Separation

The construction of dikes and levees along rivers' edges effectively cuts off flood plains from the hydrologic system. For the most part, these floodplains are reclaimed as dry land and developed; much natural wetland and side channel habitat is lost (B.C. MELP 1996). The habitat within diked wetland that is not claimed for development will be altered as the connection between the wetland and the river is lost (Salvesen 1990). This separation affects numerous aquatic and terrestrial populations. Galat et al. (1998) note a significant decrease in fish harvests in the lower Missouri River as a direct result of flood plain separation. They also note that fish and turtles, which require both the river and floodplain during their lifecycle, are greatly disadvantaged when levees and dikes are constructed.

Of particular note on the Fraser River are the effects of dikes and flood boxes on salmon migration. Juvenile salmonids that over winter in small streams cannot migrate out to the mainstem of the river when flood box gates are closed. Additionally, structural flood barriers impede adult migration upstream to spawning streams (Thomson & Associates and Confluence Environmental Consulting 1999).

Additionally, when dikes and levees are in place a wetland is not renewed by rich alluvium during floods and the river is unable to drop its heavy silt load. Thus, the wetland habitat is depleted, genetic diversity of aquatic populations is limited and water quality degraded. Diking has had a noticeable detrimental effect on the productivity of the Fraser River estuary, the most important single area of aquatic bird habitat in B.C. (Farrow 1975).

2.2.3.2 Wetland Desiccation

Wetlands, once considered the scourge of developers, are now being recognized for their many values, including numerous ecological benefits. Wetlands are considered one of the Earth's most productive natural ecosystems (Salvesen 1990). The construction of dikes and levees will segregate rivers from their flood plain, thus draining any wetland areas

adjacent to the river. The loss of wetland flood plains affects all parts of the natural ecosystem.

Dikes deprive aquatic organisms of river shallows, which are essential for the survival of some macroinvertebrates and fish (Hickey and Salas 1995; Leach 1974). E. Maltby (1991) states that "two-thirds of the fish we eat depend on wetlands at some stage in their lifecycle". In addition, valuable rare plant and bird habitat is lost.

Additionally, contaminants such as fertilizers and pesticides that would have traditionally been absorbed by flood plain wetlands, *nature's kidneys*, are channelled directly downstream. This can affect water quality and consequently aquatic and terrestrial organisms (Sparks et al. 1998). For example, wetlands can capture and breakdown atrazine a common herbicide (Hunt 1997). A natural flood plain forest adjacent to the Minnesota River would reduce suspended sediment by 94% and phosphorus loading by 81 % during a flood event (American Rivers 1997).

Finally the loss of flood plains will limit groundwater recharge. When water does not rest on flood plains or wetlands, it has no chance to percolate down to aquifers. As such, groundwater is not recharged which can have long-term negative effects on ecosystems and in certain cases on drinking water supplies and agricultural irrigation.

The loss of valuable wetlands thus effects a multitude of organisms and degrades river water quality.

2.2.3.3 Upstream Inundation

The use of dams and reservoirs for flood control clearly has implications for upstream communities. Terrestrial ecosystems are drastically changed when they are temporarily or permanently covered in water as a result of a dam. Additionally, aquatic systems are changed when dams are in place as the moving (lotic) river will become still (lentic)

(Hickey and Salas 1995). This obviously creates changes in the aquatic habitat upstream of any dam.

2.2.3.4 Loss of Disturbance Regime

Some structural flood control measures, such as dams and reservoirs, restrict natural flood flows and the disturbance that this will cause downstream. Sparks et al. (1998) note that fluctuating river levels are particularly important to the river-floodplain ecosystem. Many organisms require periodic disturbances, such as floods, as cues for various life-cycle stages. Fish, for example, use periods of high flow as signals for spawning and migration (Leitman et al. 1991). Plants also benefit from periodic flooding. For example, along the Illinois River, the decurrent false aster (*Boltonia decurrens*) requires regular floods to remove competitors from the light (Sparks et al. 1998). High biotic diversity and productivity are found on flood plains and side channels when both aquatic and terrestrial communities experience predictable, moderate duration floods. This is termed the "flood-pulse concept" (Michener and Haeuber 1998). Clearly, the loss of the disturbance regime created by floods has numerous effects on natural ecosystems.

2.2.3.5 Altered Hydrologic Regime

In addition to changes on the flood plain, the river itself will be dramatically altered by the presence of structural flood control. The changes in the river can be explained by the altered hydrologic regime. During a flood event, the inundation of floodplains along an unaltered river has the effect of spreading out the water both spatially and temporally. A river that has been altered structurally for flood control with dikes and levees will not be able to spread out. Thus, a much larger quantity of water is forced downstream much faster than would be found in an unaltered river as seen in Figure 2-2.

The slug of fast moving water will scour river bottoms and move large rocks within the river. These changes affect river morphology which, in turn, brings about changes in habitat and therefore species composition.

The increased energy of a constricted river will allow water to pick up and carry large amounts of sediment. This sediment, which would otherwise be deposited on flood plains, is discharged to the ocean. This decreases the water quality of the downstream reaches of the river, and of the receiving ocean waters.

Additionally, the heightened flood peak can cause severe erosion along riverbanks. The powerful slug of water undercuts banks causing them to collapse. This has severe implications for riparian habitat and land values.

In conclusion, it is clear that the altered hydrologic regime that results when a river is constricted by structural flood control measures causes great damage to the river and adjacent lands.

2.2.3.6 Additional Problems

A further problem that can result from flood control measures is the killing of migratory fish in pumps. For example, axial-flow propeller-type pumps are in place along the Fraser River to pump water over dikes and levees into the mainstem of the river to avoid flooding on the inside of structures. Mortality rates of 25% to 70% in coho salmon smolts have been noted in fish passing through the pumps (Thomson & Associates and Confluence Environmental Consulting 1999). Given, that such high mortality rates have been noted, this clearly has implications for Fraser River salmon escapement.

Flood control structures have been built for hundreds of years to mitigate damage to human settlements. In some cases, structural measures have been successful at mitigating these damages. However, over time it has become clear that these same structures have the propensity to create even greater damages to property they were built to protect, and to the local environment. This fact was first noted by Charles Ellet Jr. in the 1840s, he concluded that levees along the Mississippi were creating flooding, not mitigating the damages (Environmental Review 1996). Unfortunately he was largely ignored.

However, current research as listed above notes numerous problems associated with flood structures including increased flood damage risks, increased long-term costs and environmental degradation. Clearly flood control structures are not solving the problems they were built to remedy. Alternative approaches are therefore gaining momentum, including flood plain and wetland restoration.

2.3 Flood Damage Reduction – A Natural Approach

The primary concept behind a natural storage approach to flood control is the restoration of hydrologic functions to river systems and wetland areas in particular. The reinstatement of biological and hydrologic processes will reduce flooding (De Laney 1995). Flood flows in basins with much wetland area can be 80% lower than in similar basins with little or no wetlands (Novitzki 1978). Additionally, any land returned to its natural state will have a reduced potential for flood damage as fewer buildings or fragile crops will be in the path of flood waters (Environmental Review 1996). Summarily, **a natural approach to flood damage reduction requires that people step back from the river to allow the adjacent lowland areas to get wet.**

Flow Control

Returning flood plains to their natural state controls flood flows in numerous ways. These behaviours can be broadly grouped into two areas: energy dissipation and water volume reduction.

Energy Dissipation

Wetlands disrupt the energy of flood waters by allowing water to spread out spatially and temporally, and by moving over the rough surfaces of vegetation. Flood plains allow water to spread out over a large surface area. In addition, flood plains provide connections to old streambeds that will reduce the level of water in the main stem (De Laney 1995). Temporal spreading of flood peaks will result from wetland storage, which

can desynchronize flood peaks that might otherwise have accumulated to create a large and damaging flood peak (Hunt 1997). The Ramsar Convention on Wetlands states that "an estimated 0.4 hectares of wetland can store over 6 000 cubic metres of flood water" (RAMSAR n.d.). Finally, energy will be dissipated as flood water passes over vegetation found on the flood plain (Hunt 1997). All the above have the effect of decreasing the flood peak, spreading a flood over time and space, and reducing the destructive power of flood waters.

Water Volume Reduction

In addition to benefits of increased energy dissipation, flood plains can decrease flood damages by reducing the volume of water continuing downstream. This occurs for several reasons. First, precipitation is intercepted by flood plain vegetation, thus decreasing any surface runoff that would have contributed to flood peak (McAllister 2000). Second, water that is temporarily stored on a flood plain will be partially evaporated and evapotranspirated to the atmosphere. Third, water may percolate to groundwater, restoring valuable aquifers (Maltby 1991). All the above have the effect of reducing the total and peak flow of water downstream, thereby decreasing to probability of flood damage.

Both energy dissipation and water volume reduction play important roles in the decreasing flood damage downstream. Hey and Phillipi (1995) state that "as little as 4% or 5% of any watershed would have to be restored" to successfully minimize flood damage. Maltby (1991) notes that in Wisconsin it has been shown that drainage basins with 15% coverage of wetlands and lakes have flood peaks reduced by 60-65 % over similar drainage basins with no wetlands or lakes. Clearly flood plains, and wetlands in particular are very effective forms of flood control.

There is limited literature on the amount and placement of wetland areas for flood control optimization. What literature exists is controversial. Mitsch and Gosselink (1993) claim that several small upstream storage areas (wetlands) effectively reduce flood damage

through desynchronization. Conversely, Ogawa and Male (1986) using a hydrologic model, show that upstream wetlands have limited benefits downstream. However, both sets of authors agree that flood plains and wetlands reduce flood peaks.

Given the lack of literature on this subject, specifically on watersheds that hydrologically approximate the Fraser River, it is difficult to recommend specific actions for this region. However, as an example, a flood peak at Hope of 16 000 m^3/s measured during the 1948 flood (Swanson 2000) would require hundreds of square kilometres of wetland in the Fraser Valley to mitigate flood losses. In this case, it would more appropriate to provide small wetland storage areas in the numerous and varied Fraser River tributaries. Additionally, small upriver storage areas would economically advantageous, as valuable Fraser River Valley land would not have to be purchased. Clearly, further research into ideal locations for wetland storage in the Fraser River watershed must be conducted.

In the Lower Fraser Valley, possible locations for wetland storage areas include the numerous Indian Reserves that border the Fraser River. Many of these Reserves are not currently protected by flood structures, and therefore could potentially be used to store flood water. However, if these lands were to be used to control flooding, neighbouring communities who would benefit from such a scheme must negotiate a compensation arrangement the First Nation owners of the land.

Flood Loss Reduction

In addition to benefits in flow control, the return of flood plains to their natural state can reduce flood losses. This results because fewer damageable properties are present in areas inundated during floods (Hunt 1999).

Wetland restoration will completely remove property from areas of possible inundation and have complete flow control benefits. However, a spectrum of land use options on the floodplain is available to reduce flood damage. For example, planting “flood-friendly crops” on the flood plain will reduce flood damages and have some flow control benefits.

Table 2-1 shows some possible land uses for flood plains and the relative value for flow control benefits.

Table 2-1: Flood plain use spectrum

			Alternative Flood Plain Uses			Status Quo
Flood Plain Use	Wetland Restoration	No Development	"Flood-Friendly" uses (eg. Recreation)	"Flood-friendly" Agriculture	Flood-Proof Buildings	No Restrictions
Flow Control Benefits	Complete benefits	Some benefits	Some benefits	Some benefits	Fewer benefits	No benefits
Property Damage	None	None	Little	Some	More	Maximum

Table 2-1 shows that a variety of flood plain uses can both benefit flow control and reduce flood losses. Clearly complete wetland restoration has the greatest benefits in terms of flow control and reduced property damage, however much is gained through the various alternative flood plain uses. Flood plains used for recreation, such as playing fields, will incur little damage when they are required to store water, yet will still have some flow control benefits. Numerous agricultural practices that work within the natural cycle of the river are used around the world. For example, some rice farms use water from floods in their fields as opposed to pumping water from distant sources (Environmental Review 1996). Additionally, there are crops that sustain minimal damage during flood events. A recent American Rivers (n.d.) study on alternative flood plain crops looked at alternative economic uses of the flood plain that could withstand periodic flooding. It concludes that hay production, grazing, speciality crops and hunting leases were economically attractive flood plain uses along the Minnesota River. It also notes that tree production, which preserves ecological integrity of the flood plain, is less economically attractive at this time.

The flood proofing of buildings on flood plains will clearly reduce flood losses. However, flow control will not be maximized. The level of flow control will depend on type of flood proofing used. For example, buildings raised on stilts will maximize the area over which water can spread, thereby attenuating flood flows.

Clearly, flood losses will be greatly reduced with a natural approach to flood control. Benefits may also be gained through various levels of flood plain development controls. A natural approach to flood control has numerous benefits including reduced flood damage risk, decreased long-term cost, environmental gains and additional benefits. Each of these is discussed more fully below.

2.3.1 Decreased Flood Damage Risk

Two arguments are used to explain the reduction in flood damage risk when employing a natural approach to flood control. First, the ejection of people and infrastructure from flood plains will remove them from the risk of inundation. Second, the hydrological changes associated with natural flood control, as explained above, will create a less damaging environment for those people and buildings remaining on the floodplain. A natural approach to flood control has the effect of reducing vulnerability, hazard and therefore risk.

2.3.1.1 Vulnerability Reduction

Clearly, returning wetlands to their natural state requires a removal of people and infrastructure from an area. Fewer buildings and people in the path of floods will decrease the overall vulnerability of a region to flood damage.

2.3.1.2 Hazard Reduction

In addition to reduction of vulnerability, a natural approach to flood damage control can reduce the hazard to those who remain on the floodplain. Changes in the hydrology of the riparian system will result in the reduced hazard. Wetlands and natural flood control features reduce the frequency and magnitude of floods (McAllister et al. 2000) as described in Section 2.3. An unconstricted river will therefore limit damage to property and people. Although, property may be inundated despite non-structural flood control

measures, the damage caused by a flood will be far less than damage resulting from the breach of structural flood control measures.

In addition, using a natural approach to flood damage control alleviates the upstream problems associated with structural flood control as discussed in Section 2.2.1. More communities are protected from severe flood damage as no one region is outside flood control structures. Thus the overall, long-term hazard of a region is reduced through the use of a natural approach to flood control.

Given that the risk of flood damage is the product of hazard and vulnerability, the decrease in one or both of these functions will reduce flood risk significantly. The natural approach to flood control can decrease both the hazard and vulnerability of property. Thus this approach is favourable when considering flood risk.

2.3.2 Decreased Long-term Cost

Little data are available regarding the hard costs of a natural approach to flood control. However, it can be surmised that over the long-term the benefits will far outweigh the costs as compared to a structural approach to flood control.

In the short-term, two major expenses can be associated with the use of natural approaches to flood control:

1. The acquisition or rights of use of appropriate land
2. The construction of rehabilitated wetlands

First, the acquisition of valuable flood plain land is the primary expense. In the Lower Fraser Valley much of this land is used for low-density residential developments and the remainder for agriculture. A booming population means that both these land uses, but low-density housing in particular, are in high demand. The cost of acquiring land to be used as wetland, not for housing or commercial structures, is thus very high. However,

in the Fraser Valley some of the alternative flood plain uses (see Table 2-1) that offer some flood control benefits provide viable options, in particular, the use of "flood-friendly" agriculture.

Unfortunately, the removal of development from flood plains necessitates the need to re-house flood plain residents elsewhere. The constrictive geography of the Fraser Valley requires that low-density non-flood plain development occur of the steep valley hillsides. This is both expensive and environmentally damaging. These costs must be carefully weighed against the advantages of a non-structural approach to flood damage reduction.

The cost of constructing wetlands will vary greatly with location. Agricultural lands will be easier to rehabilitate than paved industrial areas for example. The size and thoroughness of a project will further vary the cost of wetland construction. Hammer et al. (1993) (in De Laney 1995) state that agricultural lands can be changed to effective wetlands at a cost of less than US$ 3,000 per acre. The short-term cost of changing the landscape for purposes of flood control will depend on the level of restoration. Some flood plain use alternatives listed in Table 2-1 would have little or no restoration costs. There is very limited literature describing the short-term costs of a natural approach to flood control. A further costs to be considered, is the removal cost of existing flood control structures. These structures are found throughout the Fraser Valley, and in some cases will be difficult and therefore expensive to remove.

The financial benefits associated with a natural approach to flood control arise over the long-term. Unlike flood control structures, wetlands and floodplains require little or no maintenance. In addition, a natural approach has no design life, and should last as an effective measure for flood control in perpetuity. Thus, once the initial costs of acquisition and rehabilitation are borne, there should be no more major additional costs.

The City of Napa, California recently began a flood control project that promotes a natural approach to flood control including, the removal of flood-prone properties and the construction of a multi-purpose floodway. It estimates that savings of US$20 million will

be gained annually by using this new approach instead of traditional structural measures (U.S. Army Corps of Engineers and Napa County Flood Control and Water Conservation District n.d.). This figure does not include environmental and social benefits resulting from the project.

Although initial costs of a natural approach to flood control may seem prohibitive, over the long-term costs will be less than those incurred from structural flood control.

2.3.3 Environmental Benefits

In addition to providing flood control, flood plains greatly benefit the local environment. Environmental benefits include:

- enhanced wetland habitat
- enhanced riparian habitat
- enhanced aquatic habitat
- improved water quality
- increased groundwater recharge
- existence of a disturbance regime
- decreased instream erosion
- bank stabilization

Many of the above environmental gains can be attributed to the removal of damaging structural measures as described in section 2.2.3. The level of environmental improvements will depend on flood plain use. Table 2-2 shows the level of possible environmental enhancement for various flood plain uses.

Table 2-2: Environmental benefits for different flood plain uses

			Alternative Flood Plain Uses			Status Quo
Flood Plain Use	Wetland Restoration	No Development	"Flood-Friendly" uses (eg. Playing fields)	"Flood-friendly" Agriculture	Flood-Proof Buildings	No Restrictions
Flow Control Benefits	Complete benefits	Some benefits	Some benefits	Some benefits	Fewer benefits	No benefits
Property Damage	None	None	Little	Some	More	Maximum
Environ-mental Benefits	Complete benefits	Some benefits	Limited benefits	Limited benefits	Limited benefits	No benefits

Wetland restoration provides a full complement of environmental benefits. Although other alternatives may not restore historical habitat and biological diversity, they can enhance environmental quality. For example, "flood-friendly" agricultural practices can improve habitat potential. Along the Minnesota River, for example, alternative crops such as hay, pasture and tree production will create habitat and increase species composition (American Rivers 1997). Regardless of the type of natural flood control employed, environmental benefits will be gained, as fewer environmentally damaging structures are required.

2.3.4 Additional Benefits

In addition to environmental improvements, a natural approach to flood control can create both economic and social benefits. Agricultural and fisheries improvements result from the enhanced environmental conditions. Recreation and education opportunities are well documented in areas where a natural approach to flood control has been used. And finally, economic revitalization of riparian areas may also occur.

2.3.4.1 Agricultural Benefits

Agriculture in drainage basins that include a natural approach to flood control will benefit in two ways. First, erosion along watercourses is minimized. Thus, no valuable land is

lost to the river. Second, the use of natural storage will improve the reliability of water availability (Hunt 1997). Where wetlands are in place, base flow will be consistent throughout the year. And, flood plains provide opportunity for groundwater recharge; thus water pumped from aquifers for irrigation will also be more reliable. In Malaysia, water discharge from peat swamps is essential for the maintenance of rice paddies during the dry season (Maltby 1991). In the Turtle Lake area of North Dakota, annual benefit estimates of wetland preservation for agriculture are US$ 114.30 per acre of irrigated land (Piper and Platt 1998). In the Lower Fraser Valley agriculture has no specific need for water retention for irrigation. However, this form of irrigation could be used further upstream, in the drier parts of the Fraser Basin, such as the Thompson-Nicola and Cariboo-Chilcotin regions (Litke 2001).

2.3.4.2 Fisheries Improvement

Fisheries will benefit primarily as a result of improved environmental conditions when a natural approach to flood control is used. There are fewer barriers to fish passage, and more suitable habitat is available. For example, Indian Creek, Olympia, Washington has been restored to reduce flood damage. As a result, fish are able to reach upstream habitat that had been unavailable for years, since flood control structures were built on the stream (U.S., National Parks Service and Rivers, Trails and Conservation Assistance Program 1996). Salmon migration from valuable upstream habitat to the lower Fraser River is severely compromised by flood control works (Thomson & Associates and Confluence Environmental Consulting 1999). A natural approach to flood control could remove some of these barriers to salmon passage in the Lower Mainland.

2.3.4.3 Recreation

Green river corridors and wetlands provide excellent recreation opportunities. Hiking, fishing, boating and bird watching are all excellent examples of possible recreative activities in natural water storage areas. The City of Napa's recent Flood Protection Project includes pedestrian and bicycle paths along most Napa River banks. Additionally, provisions have been made for boat and fishing access along the riverbank

(U.S., Army Corps of Engineers and Napa County Flood Control and Water Conservation District n.d.). Woodlands, wetlands, trails and parks can be found along the edges of Mingo Creek in Tulsa, Oklahoma as a result of the city's "natural" approach to flood plain and storm water management (City of Tulsa 1994 and American Rivers 1997). These facilities provide excellent recreation for local citizens and tourists alike.

2.3.4.4 Environmental Education

A natural approach to flood control provides excellent educational opportunities. Environmental education can be realised through interpretive signs along natural river and wetland systems. For example, the Dungeness River Greenway Project in Washington State promotes environmental education. Using their natural flood control project they hope to educate the public about "the nature and the dynamics of the river system including landowners' rights, land use practices affecting the rivers' water quality and habitat value, and fisheries and wildlife issues" (National Parks Service and Rivers, Trails and Conservation Assistance Program 1996).

2.3.4.5 Economic Revitalization

Although direct economic gains from a natural approach for flood control are difficult to assess, many communities list economic revitalization as a benefit of natural flood control. For example, a flood control project at Grand Junction, along the shores of the Colorado River, improved industrial and business areas by providing a river focus in the downtown core (U.S., National Parks Service and Rivers, Trails and Conservation Assistance Program 1996). The restoration and relocation of Grafton, Illinois for flood control encouraged tourism development (U.S., National Parks Service and Rivers, Trails and Conservation Assistance Program 1996).

Table 2-3: Summary impacts and benefits of structural and non-structural approaches to flood damage reduction.

Impacts and Benefits	*Structural Approaches*	*Natural Approaches*
Flood Damage Risk (Hazard x Vulnerability)	• High vulnerability with increased development behind flood control structures • High hazard from: – Increased flood peaks – Possibility of structure failure	• Low vulnerability as little development on the flood plain • Reduced hazard through flow control (energy dissipation and water volume reduction)
Financial Costs / Benefits	• High post-disaster costs • High capital costs • High maintenance costs	• High acquisition and relocation costs • Low restoration costs • Low maintenance costs
Environmental Impacts / Benefits	• Flood plain separation • Wetland desiccation • Upstream inundation • Loss of disturbance regime • Altered hydrologic regime • Fish deaths on Fraser River	• Enhanced wetland habitat • Enhanced riparian habitat • Enhanced aquatic habitat • Improved water quality • Increased groundwater recharge • Existence of disturbance regime • Decreased instream erosion • Bank stabilization
Other Impacts / Benefits	• "Serial engineering" downward spiral	• Agricultural irrigation and erosion control • Fisheries improvement • Recreation opportunities • Environmental education opportunities • Economic revitalization

Flooding is a natural process, which occurs in every river system. Although, structural controls can be effective at mitigating damage, there are numerous problems associated with structures as described in this chapter and summarized in Table 2-3. These problems provide motivation to move away from reactive flood control measures to a more proactive approach. A natural approach can effectively control flood damage as well as providing social, economic and environmental benefits. Unfortunately, planners and engineers often underestimate the full benefits of a non-structural approach to flood damage reduction, as, the benefits of this approach are cumulative and long-term.

Chapter 3: Implementing Natural Approaches: Policy Options and Obstacles

"One of the most difficult challenges is policy formation in the face of uncertainty (Dovers and Handmer 1995)"

This chapter explores numerous policy obstacles and alternatives to achieving natural flood damage reduction in the Lower Fraser Valley.

Flood policy is a difficult subject, especially when ecological values are taken into consideration. Policies should accommodate the needs of both safeguarding human life and property, and the ecological need for habitat and a disturbance regime. For the most part, historical flood policy has focussed on safeguarding human life and property with flood control structures (Haeuber and Michener 1998b). Growing concerns about this approach, as outlined in Chapter 2, require that policy makers consider new approaches of flood management.

3.1 Policy Obstacles

The benefits of non-structural approaches to flood damage reduction are numerous, yet flood structures continue to be built throughout Canada. This is in part due to the numerous obstacles that exist for policy makers opting to pursue a non-structural approach to flood damage reduction. These include high flood plain land values, complex land ownership issues, multiple jurisdiction problems, a general lack of information, social costs and the difficulty involved with making policy decisions under uncertainty.

3.1.1 High Flood Plain Land Values Resulting from Historic Development

The concept of "serial engineering," first discussed in the context of increased risk to those behind structural flood controls, creates an impediment to a natural approach to flood damage reduction by greatly raising the value of property on flood plains. Flat

lands that are *protected* by structures attract development, which increases the value of flood plain lands for two reasons. First, flood plain property that is attractive for its many natural values, for example shallow slopes and access to water, becomes even more desirable when it is deemed safe from flood damage. Development pressures in the Lower Fraser Valley have made flood plain lands prohibitively expensive. Second, increased development raises the price of flood plain land as the cost of buildings and structures are generally added to the price of the land. The high price of flood plain property creates an obstacle for those wishing to purchase the land for various types of non-structural approaches to flood damage reduction.

3.1.2 Private Property Rights Versus Common Property Resources

A further obstacle to the use of flood plain lands for water retention is complex land ownership issues. In North America, in particular, private land ownership is considered an ultimate right; landowners have the entitlement to do what they will with the land they "own". In many cases this has meant draining land for agriculture or development and protecting land from further inundation with dikes and levees for the benefit of the private property owner. These changes to the land necessarily cause negative externalities downstream. For example, as Doris Wilson, owner of a flooded home explained to a U.S. Congressional Testimony in 1997, the drainage of a nearby wetland by a developer directly worsened the impact of a flood on her property, by removing the sponge which had previously soaked up flood waters (Schildgen 1999). Private ownership of land often results in land use choices that benefit the owner, but have negative consequences for the larger community.

The use of private land for the common good is not a part of the North American culture. Donald Hey noted (Environmental Review 1996):

> We must change our attitude about land ownership to say that when you buy a parcel of land, you buy not only the resources but the liabilities of that land. Therefore, if your land stores water, you have to keep it there, and if it provides

> wildlife habitat for a fugitive resource that is an endangered species, you have to keep it there or make sure it is provided someplace on your property of equal significance.

Clearly, water retention must be viewed as a common property resource, if the use of structural flood control is to be reduced.

3.1.3 Inter-Jurisdictional Complexity

The nature of floods requires complex decision making processes to create effective management. Rivers and therefore floods do not conform to jurisdictional boundaries. Effective flood management requires the co-operation of all stakeholders within a watershed. However, along any given river there can be numerous National, Provincial, Regional and Municipal jurisdictions, all of which will have differing goals with regards to flood management. Conflicts can arise between upstream and downstream communities when flooding occurs.

Beginning in the 1940s, the Ontario Provincial government created Conservation Authorities, whose role is to facilitate co-ordination between Municipal and Provincial governments on a watershed basis (Boyd, Smith and Veale 1999). This type of arrangement allows for more effective flood plain management, as dialogue within and between local and regional governments can occur. For example, Boyd, Smith and Veale (1999) note that the efforts of the Grand River Conservation Authority have reduced flood damages over the life span of the authority, in part due to the increased use of non-structural flood control measures.

The Fraser Basin Council has created a similar initiative along the Fraser River to facilitate an integrated approach to flood hazard management (Fraser Basin Council 1998). The process is being overseen by a Joint Program Committee, which is made up of 37 members from Federal, Provincial, Regional, Municipal and First Nations groups. Further to the Joint Program Committee, there are five subcommittees looking at

different aspects of flood hazard management, varying from traditional river engineering to land use planning to public education. Each of these subcommittees is made up of a cross section of participants. The Integrated Flood Hazard Management Process is using consensus-based decision making to plan and formulate policy recommendations that will eventually be tabled before appropriate governments (Litke 1999). Although the process is in its initial stages, several important steps have been realised in achieving the long-term goal of "full implementation of an integrated flood hazard management strategy to ensure minimal impact from the next great Fraser River flood" (Fraser Basin Council 2000).

Administrative complexity is a surmountable obstacle to a non-structural approach to flood damage reduction. Through the creation of appropriate communication channels, such as Ontario's Conservation Authorities and the Fraser Basin Council's Joint Program Committee, administrative issues can be overcome.

3.1.4 Responsibility

Ownership of the responsibility for flood control matters creates difficult problems when considering the long-term approach required for natural flood control. Problems arise primarily from a lack of co-ordination amongst different levels of government, from confusing and varied incentives programs, and the lack of a single body guiding flood management issues. Flood management can fall under numerous government departments: agriculture, water supply, transport, industry, and environment for example (WWF European Freshwater Program 2000). In order to create an effective flood management system, co-operation within individual governments, and among various levels of government, are required.

Mixed messages regarding flood control policy occur largely because "all levels of government are involved but no one is truly accountable" (Shrubsole 2000). Environment Canada and The Ontario Federation of Naturalists (1987) note that "coordination and communication within and among governments remains inadequate" with regards to wetland management. In addition, various incentives programs conflict.

In both the U.S. and Canada, some government incentives encourage flood plain development, whereas other government programs aim to protect flood plains, wetlands and other riparian areas (American Rivers 1997; Canada, Environment Canada 1987).

In Canada the effective abandonment of the *FDR Program* left a void in flood management policy. Shrubsole (2000) notes that once the Federal government stopped funding the *FDR Program*, no other level of government jumped in to fill the gap.

Further problems exist when the benefits of structural flood control are felt locally, and the costs are distributed more widely. This is evident particularly at the Municipal and Federal levels. Where, revenue benefits are gained at the Municipal level whereas the Provincial and Federal governments incur flood damage costs. For example, municipal tax revenue from areas that have been zoned to eliminate or reduce flood damage will be less than for areas that are densely developed. Additionally, should extensive flood damage occur, Provincial and Federal aid tends to be awarded despite flood plain designations. A very small percentage of the Lower Fraser Valley has been designated a flood plain under the *FDR Program*; disaster relief is therefore be paid out to flood plain dwellers. Thus, although the costs of flood plain development are borne by Federal and Provincial governments, financial benefits are gained at the Regional and Municipal level and by private developers.

3.1.5 Lack of Information (Publics, Policy Makers and Researchers)

A large obstacle to the initiation of non-structural flood control projects is the lack of information available to publics and policy makers. Although research in the field has improved over the last decade, the impact of this new information has not had a substantive effect on flood management (Haeuber and Michener 1998).

The major concern surrounding public knowledge is the ignorance of flood risk. For example, only 28% of Credit River flood plain homeowners responding to a 1991 survey in Glen Williams, Ontario perceived a risk of future flooding of their properties

(Kreutzwiser, Woodley and Shrubsole 1994). The flood memory half-life is notoriously short, even amongst those who live directly adjacent to rivers.

A further problem in shifting away from structural flood control, is the sense of comfort provided by solid engineering structures, even if this confidence is illusory. Dams and levees have been used as a traditional defence against rising rivers; such structures are easily understood. Whereas, a non-structural approach to flood control requires a greater understanding of numerous river processes. In the Prior Lake-Spring Lake Watershed District of Minnesota, local residents originally objected to an integrated flood plan incorporating non-structural measures. However, once the hydrologic processes were properly explained, residents overwhelmingly supported the proposed flood management plan (Nelson, Whiteford and Gontarek 2000). A well educated public will not only help political strategies that promote non-structural flood control, but may in fact be the impetus for a change movement from structural works. Publics have been the catalyst for policy change in some instances where, after repeated flood damage, awareness of flood management issues was raised.

A third problem relating to a lack of understanding among flood plain residents is the concept of post-disaster payments. Flood plain residents often falsely assume that senior level governments will automatically alleviate damage costs after flooding events. This is not the case, in B.C. there are clear guidelines for post-disaster payments as laid out in the Disaster Financial Assistance (DFA) arrangements. Many incurred damage costs are not eligible for financial assistance, and there is a $100 000 cap on payments to individuals or businesses, as such homeowners are financially liable for a portion of flood damage (Canada. Emergency Preparedness Canada 1998). Of particular note is property built on flood plains post-designation. These properties are not eligible for any post-disaster payments, placing the financial burden of flood damage solely on the property owner. Historical pay outs by senior level governments have led to the current situation where flood plain dwellers are unaware of their personal liability for flood damages.

A further challenge for politicians is the lack of substantive tangible products that result from non-traditional methods of flood control. “Dams are plaqueable”; they can be an excellent boost to any politician’s ego, whereas non-structural flood management tends to remove “plaqueable” buildings (Schildgen 1999).

Policy makers are faced with a difficult challenge in their efforts to initiate non-structural approaches to flood management. Primarily because public support for poorly understood non-structural flood control projects will be low. The success of any non-structural flood control project requires a high level of knowledge and understanding from both the publics and policy makers. Therefore, it is important to educate both these groups about riparian processes and the advantages associated with a holistic approach to flood management.

3.1.6 Current Decision Analysis Frameworks

At this time, flood management decisions are commonly made using a benefit-cost type analysis. All too often this type of analysis excludes negative and positive externalities associated with policy options. Straightforward, benefit-cost analyses will nearly always cause structural solutions to be advantageous, as the numerous environmental externalities are not considered in such calculations. Additionally, long-term costs are rarely considered, as time horizons tend to be limited to a couple of decades. Non-structural flood control options, which have high short-term costs and numerous positive externalities, are rarely favoured in this type of analysis (American Rivers 1997). New analysis options that include non-monetized externalities must be used if the full advantages of non-structural flood control options are to be realized.

3.1.7 Social Costs

Allowing flood waters to inundate flood plains in developed regions, necessarily means disrupting people. The social costs associated with removing homes and businesses out of the flood plain can be an overwhelming obstacle for policy makers concerned with

public opinion. However, it can be argued that social capacity will benefit in the long-term, as, the new community will be less vulnerable to flood events. And therefore will experience fewer social disruptions.

3.1.8 Difficulty of Policy Making Under Uncertainty

A final, yet very important, obstacle to flood management is the difficulty involved in creating policy under uncertainty (Dovers and Handmer 1995). The risks associated with floods are often difficult to quantify and are uncertain at the best of times. There is uncertainty in both the probable intensity and timing of flood events. Any changes to the level of risk that may arise from human interventions, as discussed in Chapter 2, add another level of uncertainty to the probability of flooding. Government expenditure is difficult to justify when benefits may never be realised, and will most probably not be realised during the current governmental term. This problem is exacerbated by the relatively short flood memory half-life. Even, in regions which are highly vulnerable to damaging floods, such as the Lower Fraser Valley, flooding is not at the forefront of public concern except during periods of flood threat. Increased levels of awareness amongst publics and policy makers through various adjustments to floods can improve this situation, thus giving policy makers a strong mandate to tackle flood management issues.

Table 3-1: Summary of obstacles to non-structural approaches to flood control

Obstacle	*Problem*
High flood plain land values resulting from historic development	• Raises land values, thereby increasing the cost of land acquisition for non-structural flood control projects
Private property rights versus common property resources	• Many flood plains are in private hands; owners do not value water retention as a common property resource
Inter-Jurisdictional Complexity	• Jurisdictional boundaries rarely coincide with watershed boundaries. • Conflicts between upstream and downstream communities can arise due toflood management issues
Responsibility	• Lack of inter-governmental and intra-governmental cooperation • Costs of flood plain habitation are borne by the wider community
Lack of Information	• Publics knowledge of flood risk and cost is low

	• Understanding of flood management issues is low for both publics and policy makers
Current Analysis Frameworks	• Benefit-costs calculations rarely favour non-structural approaches to flood control as time horizon is short, and non-monetized externalities are not included.
Social Costs	• Acquisition and relocation of families, businesses and communities can disrupt social networks in the short term.
Policy Making Under Uncertainty	• Justification of flood management spending is complicated by the uncertainty of flood events

Clearly, numerous challenges, as summarized in Table 3-1, face those who wish to promote innovative non-structural approaches to flood control. A need for pioneering flood management policies is therefore necessary to confront these obstacles.

3.2 Policy Alternatives

A natural approach to flood damage reduction, although effective is not necessarily politically palatable. Many of the obstacles described in Table 3-1 will dissuade policy makers worried about short-term public unrest. However, none of the obstacles are insurmountable as long as careful consideration is made of the social and economic impacts that may arise from a non-structural approach to flood damage reduction. Thus, in order to achieve some level of natural flood damage control a flood plain manager must carefully select appropriate policies for the local political climate. Numerous policy options are outlined in Figure 3-1.

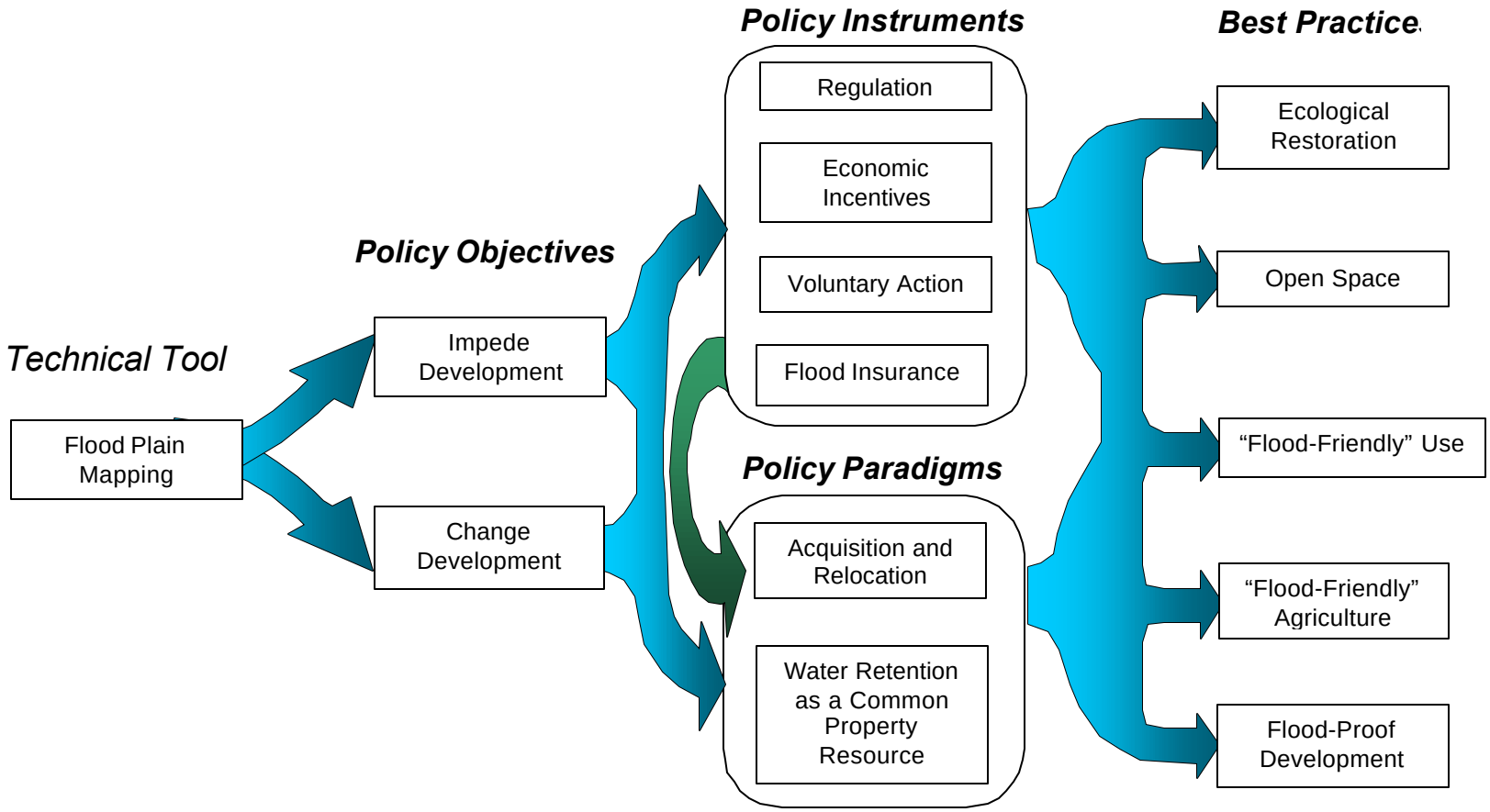

Figure 3-1: Non-traditional flood damage reduction policy alternatives

The numerous strategies to achieve a non-structural approach to flood damage reduction are described in Figure 3-1. This figure groups the various alternatives into five areas: technical tools, policy objectives, policy paradigms, policy instruments and best practices. In addition it shows possible paths for the accomplishment of best practices. Each of alternatives in Figure 3-1 is described in more detail below.

3.2.1 Technical Tool – Flood Plain Mapping

Flood plain mapping describes the process of delineating the area that can be expected to flood; usually the 200-year flood is used. This information can then be used to restrict or change development practices in the flood plain, thereby reducing flood damage costs. In order to impose restrictions on flood plain development it is helpful to first map and designate areas susceptible to flooding. To do so, two sets of policies must be in place; the first is to fund and carry out flood plain mapping programs, and the second is to designate and regulate flood plains. Canada's *FDR Program* provides for both these policy actions. However, the program is currently unfunded, and little mapping progress is being made in the Lower Fraser Valley (Booth and Quinn 1995).

In Ontario, where flood plain mapping through the *FDR Program* has been more prevalent than in B.C., public opposition to flood plain designation developed in some regions. Opposition resulted for two main reasons. First, in some instances it was perceived that property values within the designated area would decrease. However, at least two studies completed in Ontario, note none or little effect on property values within designated flood plains (Schaefer 1990; Shrubsole, Green and Scherer 1997). Second, flood plain controls were perceived to restrict development and economic growth (Schaefer 1990). This issue has been largely resolved through the formation of Special Policy Areas (SPA), in which flood plain regulations can be adjusted to suit the needs of the specific location. Controlled development and redevelopment are allowed provided flood-proofing and other specific restrictions are satisfied (Canada, Environment Canada 1996). Moreover, de Loë and Shrubsole (1999) note that in the Credit Valley

Conservation Region, Ontario, there has been a perceived high level of community support for the designation of flood plains as "natural" lands.

Despite public opposition to flood plain mapping and designation, it has proven an effective measure to reduce flood damage. Millerd et al. (1991) and Weiss (1987) (as cited in Brown, Moin and Nicolson 1997) note modest but quantifiable benefits from flood plain mapping.

3.2.2 Policy Objectives

Development direction once a flood plain has been mapped will depend on government policy objectives to either impede development or change development patterns on the flood plain. The policy objectives are broad goals that can be used to guide specific policy actions towards best practices for a non-structural approach to flood damage reduction. Clearly, the choice of policy objective will also depend on the current state of flood plain development.

3.2.2.1 Impede Development

Impeding development describes the halting of any growth on the flood plain. By keeping flood plains free from development, numerous flood control, and ecological benefits can be achieved. The barring of development on riparian flood plains requires that there be no development in the first place. Additionally, it requires minimal development pressures along a river corridor. There are few places in the world remaining where flood plains have been left entirely in their natural state.

In the Lower Fraser Valley the majority of flood plain land has been developed for agricultural, industrial or residential use. A few pockets of relatively untouched lands remain in municipal and regional parks, and low-grade development lands such as Burns Bog in Delta. Additionally, there are strong development pressures in the Fraser Valley. The population of the Lower Mainland is growing rapidly, and the Coast Mountains and

United States border constrict development to the narrow ribbons of comparatively flat land within the valley.

Once the decision has been made to impede any future development on the flood plain, further steps as outlined in Figure 3-1 should be undertaken to ensure maximum benefits for flood control. The choice of which policy, or policies, to pursue—acquisition and relocation, rights of use, regulation, voluntary action, or insurance action—will depend on current ownership of flood plain lands and on the level of understanding regarding a natural approach to flood control amongst publics and policy makers.

3.2.2.2 Change Development

In the Lower Fraser Basin, many flood plains have been extensively developed and population pressures exist to develop them further. Thus, in order to gain flood control benefits from the natural use of flood plains, a change in development and redevelopment practices must take place. This paradigm shift is particularly difficult to achieve when development inertia has set in. A change in development practices requires a good understanding of the problem by the publics and policy makers, and strong local government which is willing to consider an extended time horizon.

Large and damaging flood events can prove to be excellent catalysts for a change in development practices. Repeatedly flooded regions adjacent to the Mississippi and Red Rivers are now looking at alternatives to traditional land uses and structural flood control (U.S. National Parks Service 1996). The damages incurred during the 1990s were so great that attitudes of both the publics and policy makers have changed. Large flood events are small policy windows, which should be used to greatest advantage.

3.2.3 Policy Instruments

The policy alternatives outlined in this section describe proactive policy instruments, which can be used by all levels of government to encourage a non-structural approach to

flood damage reduction. These policy instruments can be used to achieve best practices and to promote a paradigm shift towards non-structural flood control amongst policy makers and private citizens.

3.2.3.1 Regulation

Government regulation of flood plain activities can be an effective tool to achieve many of the best practices options. However, government intervention into the rights of owners to do what they will with private land can be seen as invasive, or as a legal taking. Therefore, flood plain regulations should be carefully planned and implemented.

Regulation of flood plains can mean a variety of different things. But generally, it signifies that government in some way mandates the use of flood plain land. Government regulation can be used to force any of the best practices described in Figure 3-1: wetland restoration, the elimination of buildings, flood plain compatible uses, "flood-friendly" agricultural uses and the flood-proofing of current and new buildings. For the most part, government regulation comes in the form of municipal by-laws which regulate zoning and development type. For example, the City of Richmond uses by-laws and restrictive covenants to regulate the minimal habitable floor elevation of all new developments within the municipality (City of Richmond 1998). Regulation of flood plain development in B.C. also falls under the *FDR Program* of the *Canada Water Act.* However, as noted previously, this regulatory structure has not been entirely successful at reducing flood damage costs.

In addition to regulations, effective education programs and monitoring must be conducted. For example, a 1991 survey of flood plain residents in Glen Williams, Ontario notes that many homeowners regarded flood plain regulations as restrictive and unnecessary. Residents who received information about regulations directly from the Credit Valley Conservation Authority were most supportive of development regulations (Kreutzwiser, Woodley and Shrubsole 1994).

Adequate monitoring of regulations must occur, especially in areas where residents are less aware of flood risk. In these cases, homeowners are liable to renovate their houses without due consideration of flood damage risk or government regulations.

Regulation of flood plain uses can be an extremely effective tool to reduce flood plain losses as seen after the 1986 flooding of Southern Ontario and Michigan State. Ontario's regulation of flood plains under the *Planning Act* and *Conservation Authorities Act*, mandates land uses that are compatible with the flood plain. When damages were compared between Ontario watersheds and similar watersheds in northern Michigan, where development is not kept away from the flood plain, damage costs were three orders of magnitude greater (Brown, Moin and Nicolson 1997).

3.2.3.2 Economic Incentives

One of the most powerful incentives for change amongst private citizens is economic reform. Economic incentives can be used as a mechanism to encourage natural approaches to flood damage reduction. Senior level governments and local level government can implement economic incentives to create change. For example, the Federal government can provide incentive for homeowners to become more responsible for flood damage by discontinuing post-disaster payments. Thus, placing the onus of risk on the property owner and not on taxpayers at large. Subsidies and grants can also be used to promote natural approaches to flood damage reduction. For example, grants or subsidies can be given to homeowners to flood proof their property. This up front economic incentive will reduce the long-term costs of flood damage. Third, property tax assessments should include the cost of risk to flood plain properties. Not only does this decrease the value of flood plain homes, but increases flood awareness amongst flood plain dwellers. Citizen level change can be easily achieved by targetting pocket books; thus economic incentives are a powerful tool to achieve natural approaches to flood damage reduction.

3.2.3.3 Voluntary Action (Through Education)

Flood damage can be greatly reduced simply by the education of those at risk in how to minimise their losses. It has been shown that the greater the advice in advance of a flood, the lower the vulnerability of the possible victims (Handmer and Tunstall 1991 as cited in Green et al. 1994, 49) Two main areas of information will help the public in advance of a flood. First, sufficient warning is essential so that the public realizes that the flood risk is high. Second, adequate information is required about what measures can be taken by flood plain residents to minimise the damage.

The lack of flood knowledge is listed as an obstacle to a natural approach to flood damage reduction. Several examples of where increased levels of knowledge led to a more holistic approach to flood control were cited. However, education is rarely a part of flood control projects. In fact, a 1997 survey of flood plain officials in Canada suggested that "for the most part, municipalities do not take part in public education or the provision of information to the public regarding floodplain areas". This lack of knowledge must be addressed (de Loë, Rob and Dan Shrubsole 1999).

The education of flood plain property owners greatly increases the likelihood that they will make decisions regarding the use of their private property based on factual knowledge. In addition, educated citizens are more likely to lend support to large non-structural flood control projects if they fully understand the benefits and disadvantages of such action. In particular, the education of farmers and homeowners will likely mean an increase in "flood-friendly" agriculture and flood-proofed homes.

Public education programs are a simple cost-effective measure, which can have great impacts on flood control. Given that public perceptions greatly influence policy making. A public who fully understands the workings of the natural hydrologic system is more likely to support a natural approach to flood control.

3.2.3.4 Insurance Action

Flood insurance is probably best examined by considering U.S. FEMA's *National Flood Insurance Policy* (NFIP) program. The purpose of NFIP is to make flood insurance available to property owners in flood-prone areas. As a stipulation it requires that communities and local governments in flood-prone areas adopt and enforce flood plain regulations before their citizens may buy government endorsed flood insurance (FEMA 1999). It was originally designed to provide an alternative to disaster relief payments, which can be financially crippling. Flood insurance places the financial burden on those who enjoy flood plain living instead of burdening all Federal taxpayers. At its start, few communities opted into the program, creating a deficit each time flood victims were compensated. Recently, the government made a concerted effort to include more people in the program through advertising and mandatory purchase requirements. It managed to double the number of policyholders within four years. It has also entered into partnerships with private enterprise that insure flood-prone properties with a subsidy from the government; this increased the coverage of the program to include smaller communities.

Some critics of the program say it does not go far enough. The National Wildlife Federation in its publication *Higher Ground* points out that less than 30% of flood-prone properties are insured, and that many flood plain controls are not strictly enforced (National Wildlife Federation 1998). The document suggests that by decentralising the program, more policy goals would be achieved. Overall the NFIP in the United States has been successful at shifting the financial burden of flood damage to those who benefit most (Platt 1999).

In Canada, the Federal *Insurance Companies Act* allows for Insurance Companies to provide weather-related insurance including overland flooding (Canada 1991). However, insurance companies are unwilling to insure an event that is for the most part expected. In fact, the Insurance Bureau of Canada states "insurance is there to compensate you [the policy holder] for losses that are unexpected. If you live on a flood plain, it stands to reason that, at some point, you will be flooded. There's nothing unexpected about that"

(Insurance Bureau of Canada n.d.a). In lieu of providing flood insurance, the insurance industry has created a *Natural Disaster Reduction Plan*. The plan calls for "the creation of a natural-disaster protection fund; an increase of 15 per cent in current disaster (recovery) financial assistance arrangements; and the promotion of a culture of preparedness to improve the planning process" (IBC n.d.a). In this way it hopes to reduce flood damage across the country.

Flood insurance in lieu of disaster payments is an effective way of charging flood plain residents for the risks they incur rather than burdening the population at large. As an additional benefit, flood awareness is raised through mandatory purchase requirements; this can benefit many other non-structural approaches to flood control. Unfortunately, in Canada, residential insurance policies do not cover overland flooding damage. Some commercial policies may cover the cost of damages and closing (Shrubsole 2000). There is room within the industry to provide this type of insurance, with or without government assistance. However, the reluctance of insurance companies to enter into the flood insurance market as described by the Insurance Bureau of Canada suggests that some form of government intervention will be required in order to fully benefit from this adjustment to flood damage control.

3.2.4 Policy Paradigms

The policy alternatives in this section describe changes in approach and understanding to flood management amongst policy makers and citizens. These paradigm shifts will come about through the use of some or many of the policy instruments outlined above. The policy paradigms will in turn help enable the promotion of best practices, thus promoting a non-structural approach to flood damage reduction.

3.2.4.1 Acquisition and Relocation

In an effort to remove people from flood plains, one major new strategy for flood plain management is voluntary buyout and relocation of homes and businesses out of harm's way using government funds. This effectively returns flood plain lands to government

control. In this manner, appropriate measures can be taken to use the flood plain effectively to minimize flood damages downstream.

Acquisition and relocation most commonly works by way of government intervention. Governments, of any level, use public funds to buy up flood plain properties, either at full market value, or at reduced prices in cases where properties have been severely flood damaged. In some cases, property owners are further compensated to pay for their relocation costs. Acquisition and relocation have several benefits. First, it places small areas of the flood plain into public hands, where it can be used to greatest benefit in terms of flood damage reduction, reducing overall flood damage costs. Additionally, over the long-term the cost of flood damage assistance payments for repetitive loss properties are reduced as flood prone properties are removed. The acquisition of flood-prone properties can be a cost-effective use of public funds, as the initial output is much less than future expenditures on flood mitigation and disaster relief. For example, there is a single house in Houston, Texas that is insured under the US government's flood insurance plan that has been flooded repeatedly. The amount of money paid out in flood insurance is almost 800% the value of the house (at pre-disaster fair market value) (National Wildlife Federation 1998). In this case it would clearly be advantageous to buy the house and relocate the owner elsewhere

Acquisition and relocation may face public opposition. First, because the initial costs of buying flood-prone properties can be high, especially, when fair pre-disaster market values are paid. The costs of such ventures are borne by all taxpayers, not just those at risk to flooding. Unless there is good understanding of the long-term benefits to public coffers of acquisition and relocation, public support may be difficult to garner. Second, property owners may themselves oppose relocation schemes for social reasons. Relocating families and businesses away from traditional homes and homesteads is problematic. However, in situations where properties have been repeatedly flooded, a move can be considered socially beneficial.

In order for an acquisition and relocation program to be successful it requires strong public understanding and support. It must be clearly explained to the public that the initial public economic costs and private social costs will be greatly outweighed by the long-term public benefits of such a scheme.

In the United States, NFIP insured properties that have been damaged repeatedly can be bought by force under FEMA's regulatory Acts. In Canada, acquisition policies are less clear, and therefore few examples of flood plain property acquisition are readily found in the literature. However, there are examples of successful acquisition projects. The Grand River Conservation Authority, Ontario has on a couple of occasions acquired land and demolished buildings for flood control (Steinberg 2001). In Greater Toronto, 15% of the Don River Watershed's natural areas have been acquired and placed in public hands through the Metropolitan Toronto and Region Conservation Authority (The Don Water Regeneration Council and The Metropolitan Toronto and Region Conservation Authority 1997).

Acquisition and relocation are very effective steps towards a natural approach to flood control. However, they require further measures be taken to improve the flood control potential of the flood plain, once acquisition and relocation have taken place. Local level governments can most effectively carry out implementation of acquisition and relocation programs, as understanding of the local watershed issues is to be found at this level. However, funding and program structures can be dictated by higher level governments, as is the case with FEMA in the US.

3.2.4.2 Water Retention as a Common Property Resource

Land ownership issues were previously mentioned as an obstacle to a natural approach to flood damage control. Primarily because the North American approach to land ownership asserts absolute rights over what takes place on private land. However, if land ownership is viewed as a stewardship obligation, as is suggested by Donald Hey

(Environmental Review 1996), then the right of the river to flood the flood plain can be asserted.

The right of the river to use the flood plain requires not so much a specific government policy, but requires a shift from the current concept of land ownership. Flood water retention must be considered a common property resource in the same manner as some private properties are used as stopovers for migrating birds, or as lakes encircled by private land are used for public drinking water storage. This shift in thinking cannot be easily be mandated by government. It requires instead educated publics who are willing to change their attitudes towards land ownership and requires site and building design that minimises flood damage.

3.2.5 Best Practices

The policy decision on how to promote a natural approach to flood control has to be made in conjunction with a decision on what level of natural flood control would be most appropriate for the given development and risk conditions. Various best practices for non-structural flood control are discussed in this section.

3.2.5.1 Ecological Restoration

The restoration of flood plains to their natural wetland state provides excellent flood damage reduction possibilities in addition to numerous environmental and social benefits as discussed previously. Of course, wetland restoration has elevated initial costs. Precise costs will depend on initial conditions and on the size and location of the project. However, when total benefits of wetland restoration projects are assessed they become economically viable (American Rivers 1997). In order to promote wetland restoration as an effective tool for flood damage reduction, the additional social, economic and environmental benefits must also be included in cost calculations.

Given that flood damage reduction is not of common interest amongst the publics, the media and therefore policy makers, wetland restoration projects should be promoted as multi-objective projects with a handful of benefits. For example, in the Lower Fraser Valley, where the salmon fishery is of utmost importance to publics and policy makers alike, wetland restoration projects should be endorsed as salmon habitat improvements.

In the United States there are numerous examples of where policies of wetland acquisition and restoration have proven to be economically sound in addition to providing flood damage reduction benefits. For example, the U.S. Army Corps of Engineers chose in the late 1970's to acquire flood plain wetlands in the Charles River watershed north of Boston. The cost of this project, $10 million, was far less than the $100 million structures that would have been necessary to give the same protection to the residents of the watershed. When near-record flows occurred in 1979 and 1982, the wetlands absorbed the flood surge effectively (American Rivers 1997).

Wetland restoration clearly provides a multitude of benefits. However, the promotion of wetland restoration as a tool for flood damage reduction is difficult. Through careful consideration of local politics and public interests wetland restoration projects can be successful.

3.2.5.2 Open Space

A policy of keeping flood plains as open space is an effective tool for minimizing flood losses. The term open space can mean a variety of things from disused building lots, to golf courses to natural flood plains. In all cases flood control will benefit from the use of the flood plain for water detention. In addition, flood losses will be minimised both on the flood plain and downstream. A host of environmental benefits can also result from the creation of open space on flood plains.

Open spaces on flood plains can be achieved with public ownership through acquisition and relocation programs. In addition privately owned flood plain land uses can be adjusted through both regulation and voluntary actions.

A policy of keeping flood plains as open space can be politically challenging. To many, open space will be seen as a wasted development opportunity, especially given that the adjacent river may only "use" the flood plain once every couple of years. Education of publics and policy makers is once again key in creating open space. As for wetland restoration projects, open space projects can be promoted through the many other environmental and social benefits that result from preventing flood plain development.

Numerous examples of the use of open space for flood damage mitigation are found throughout North America (U.S.National Park Service and Rivers, Trails and Conservation Assistance Program 1996). For example, the City of Tulsa, Oklahoma notes that "open space use of the floodplain is the best policy" (City of Tulsa 1994). The City of Napa, California purchased open land adjacent to the Napa River for use as flood plain terraces (US Army Corps of Engineers and Napa County Flood Control and Water Conservation District n.d.).

Clearly, eliminating development from flood plains can benefit flood control. However, it can be challenging to prevent development from occurring, especially when great development pressures exist as in the Lower Fraser Valley where short-term financial profit is the major motivating force.

3.2.5.3 "Flood-Friendly" Use

Certain land uses can be effective at reducing flood flows and flood damages, while also being functional. For the most part recreational land uses offer the greatest benefits of a "flood-friendly" use. Parklands, sports fields, schoolyards and hunting grounds can, for example, be inundated for part of the year without damaging any major infrastructure. By allowing flood flows to submerge these "flood-friendly" lands on a temporary and

occasional basis, flow control benefits can be achieved downstream. Thus, in addition to flood damage reduction benefits on site, flood damage will be reduced downstream. Of course, in certain instances the flooding of recreational lands can be inconvenient and bothersome, especially, considering the timing of most freshet floods coincides with warm summer months, when local citizens enjoy recreational lands. On occasion, flooding of recreational lands can cause damage to park infrastructure. However, the damage incurred on "flood-friendly" lands will be much less than would have occurred on housing subdivisions.

Public ownership of lands adjacent to rivers provides the best opportunity to use land in a "flood-friendly" manner. Lands that are already in the public domain, or those that have been acquired through acquisition and relocation programs, can both be used. In both cases, recreational use of public lands is generally considered a positive use of land and money. Political benefits can be gained from this approach to flood damage reduction.

Incentives or regulations can convince private landowners to use their riparian corridors in a "flood-friendly" manner. Institutions such as schools who own large plots of land can make excellent stewards of flood plain lands. In cases of both private and public ownership, the education and knowledge level of landowners and policy makers with regards to flood issues must be high if such an approach is be attempted.

3.2.5.4 "Flood-Friendly" Agriculture

Agricultural lands can be used effectively to stem flood flows and reduce structural damages downstream. However, most farmers would not appreciate the decimation of crops for the benefit of downstream residents. There are, however, various initiatives and farming techniques than can benefit both the farmer and flood damage reduction.

Government initiatives to conserve agricultural lands for use during floods are effective non-structural flood control measures. In the United States, the *Conservation Reserve Program* (CRP) preserves millions of acres of farmland for flood control, water quality

improvements, and wildlife habitat. The program "provides incentives and assistance to farmers and ranchers for establishing valuable conservation practices that have a beneficial impact on resources both on and off the farm" (U.S. Department of Agriculture n.d.). In effect, this program compensates farmers for reducing production in critical areas such that flood damages are reduced. As a side benefit, certain sectors of the farm economy have been improved by reducing overproduction of certain crop types (Schildgen 1999). In Canada, no such Federal government programs exist, although non-governmental organisations such as Ducks Unlimited Canada play a role in influencing farmers to preserve areas of land for wildlife, which can benefit flood control (Ducks Unlimited Canada n.d.).

In lieu of removing valuable farmland from production, changes in farming techniques can vastly improve flood control. Farming and natural hydrologic features can be integrated through changes in cropping patterns and crop types. For example, water intensive crops, such as rice and cotton, can be planted during the wet season to take advantage of excess waters. Flood-tolerant tree crops and certain legumes, or biotechnology modified crops, can replace traditional crops. In the Florida Everglades, government programs have provided incentives for farmers to switch to rice crops, which has peak irrigation demands during the summer wet season and thus can benefit flood control (U.S. Department of Agriculture 1997). Of course, neither rice nor cotton are viable crops for the Fraser Valley due to climatic conditions. Little literature exists on flood-tolerant crops more suitable to the local temperate climate. However, a 1999 study by the U.S. EPA promotes the planting of "hybrid poplars" on agricultural flood plains in the Pacific Northwest for pulp and wood products. In addition to being flood-tolerant, these trees can reduce soil erosion and improve water quality (U.S. EPA 1999).

Grazing is an extremely effective use of agricultural flood plain land in terms of flood control benefits. Animals can be removed from risk areas during flood events, when the river can make full use of its flood plain, thus reducing flood damages. For the rest of the year, farm animals can make full use of excellent grazing fields.

In conclusion, there are numerous options available to farmers to reduce downstream flood damages. Generally, an approach to agriculture that considers and employs the natural environment as opposed to re-working the land to produce alien crops will benefit flood control. However, this approach requires government intervention to regulate farming techniques or to provide incentives for farmers to produce appropriate agricultural products. In this manner, farmers are duly compensated for benefits that will primarily be reaped downstream.

3.2.5.5 Flood-Proof Development

Flood-proofing of buildings is an effective measure to reduce flood damages. Flood-proofing describes the design or retrofitting of buildings to resist water and reduce flood damage. There are numerous flood proofing methods including:

- **Building on fill**: In this instance new developments can be raised above the probable flood level using fill. Thus when a flood occurs buildings should be above the water level. This method is commonly found in the Lower Mainland, where habitable areas are built on top of non-habitable basements and garages. Limiting flood damage to basement type property.
- **Building on piers, piles, columns or bearing walls**: Buildings can be raised above the flood level using piers, piles, columns or bearing walls. Flood water is then able to pass beneath the structure. Damage to the structure during a flood will be minimal
- **Closure and seal**: Lower-levels of buildings can be sealed against flood waters using various carefully designed systems. Retrofitting of vulnerable properties is possible using the closure and seal method. Unfortunately, if design flood levels are exceeded, this method can exacerbate the problem by retaining water inside the structure. Additionally, this method can create a condition of uplift on the foundations during a large flood event. This can result in shifting or complete failure of foundations.
- **Wet flood-proofing**: In this instance it is accepted that the interior of the structure will be inundated. The lower level of the structure is constructed with special

materials to reduce damage to the structure itself. Care must be taken to remove all objects of value from areas of inundation (Williams 1978).

Flood-proofing is an effective measure to reduce damages to buildings on the flood plain. However, few flow control benefits are gained. Flood-proofing is an excellent policy for flood plains that are already developed, as buildings can be retrofitted. Flood-proofing of buildings is often economically viable; costs vary from as little as 2 % to 50 % of property value depending on conditions (Williams 1978). When flood damage occurs, the cost of flood-proofing will prove to be minimal in comparison.

Along the fan of Deroche Creek in the Fraser Valley, flood-proofing of properties was the recommended action to reduce flood damages. Consultants suggested raising buildings to keep foundations open to allow flood flows to pass under the structures. They estimated that this would cost between $8K and $20K per house (Chantler, Jakob and Farstad 2001).

Flood-proofing of private property can be achieved through regulation at the municipal level. In addition, education of developers and property owners with regards to flood damage potential can provide impetus to flood-proof structures. Third, flood insurance policies may provide reduced premiums for homes that are flood-proofed.

3.3 Conclusions

This chapter lists numerous possible policy adjustments for flood control, as well as mentioning several obstacles faced by those wishing to pursue a natural approach to flood damage reduction. Clearly, not all policy options are suitable for all flood risk regions. Therefore, policies should be targetted to particular needs and requirements rather than universally applied. This creates the need to manage flood plain development at a local level. Regional level governments, especially those who delineate watershed boundaries, must also play a role in facilitating communication between local governments. Senior level governments have several roles to play in promoting a natural approach to flood

damage reduction. First, they can create appropriate regulations, which can be used effectively by local governments to suit local conditions. Federal and Provincial governments can also provide funding to local level governments to carry out non-structural flood control projects, which can be economically challenging in the short-term. Additionally, post-disaster payments to regions where flood plain development has occurred despite warnings should be abandoned. Finally, higher level governments can help educate publics and policy makers about hydrologic systems and alternatives to structural flood control.

A change in attitude towards flood control is not going to arrive quickly. However, the increasing costs of flood disasters and the growing awareness amongst publics and policy makers will enable a non-structural approach to flood control in Canada and the Lower Fraser Valley in the near future.

Chapter 4: Flood Plain Legislation and Policy

This chapter describes current policy and legislation in British Columbia related to flood plain management. It focuses on the policy alternatives described in Chapter 3.

Several levels of government have direct involvement with flood policy in the Lower Fraser Valley. Federal, Provincial and Municipal governments each have a wide variety of legislation to guide their actions. These are evaluated in this section. A substantial amount of relevant legislation exists to promote flood damage reduction; some designed specifically for and some in directly related to, flood management. Although there are positive aspects to the existing body of legislation, several significant barriers inhibit a non-structural approach to flood damage reduction.

The legislation described in this chapter is compared to the policy alternatives described in the Chapter 3, and summarized in Table 4-1.

Table 4-1: Summary of policy alternatives to achieve a non-structural approach to flood control

Alternative	*Description*
Technical Tools	
Flood Plain Mapping	• Delineation of the area that can be expected to flood. Usually, the 200-year flood is used.
Policy Objectives	
Impede Development	• Barring of further development on the flood plain
Change Development	• A change in development practices to allow for non-structural flood control options.
Policy Instruments	
Regulation	• Government control of land use on flood plain.
Economic Incentives	• Monetary incentives aimed at flood plain residents, in order to create change towards non-structural approaches to flood damage reduction.
Voluntary Action (Education)	• Increased public awareness of flood risk, and possible adjustments to floods.
Insurance Action	• Private insurance for flood plain dwellers, limiting liability to those at risk

Policy Paradigms	
Acquisition and Relocation	• The use of public funds to purchase vulnerable flood plain properties and to move residents to more suitable locations.
Water Retention as a Common Property Resource	• Change in public attitude towards to the use of private land for water retention during flood periods.
Best Practices	
Ecological Restoration	• Environmental and ecological enhancement of flood plains, such that water retention capabilities are improved.
Open Space	• The use of flood plains in a manner that minimizes buildings and maximizes open space.
"Flood-Friendly" Uses	• The functional use of flood plains for purposes that can undergo occasional inundation. (such as sports fields, parks, and golf courses).
"Flood-Friendly" Agriculture	• The agricultural use of flood plains using special crops and techniques that can undergo occasional inundation.
Flood-Proof Development	• Flood-proofing of buildings on the flood plain through various construction techniques.

4.1 Federal Flood Policy and Regulation

Canadian flood control policy since 1975 has fallen under the *Federal Flood Damage Reduction (FDR) Program* (Canada, Environment Canada 1996) which was created under the *Canada Water Act* following extensive flood damage throughout the country in the early seventies. In 1987, the mapping program in B.C. was accelerated through the additional signing of the *Canada-B.C. Agreement Respecting Floodplain Mapping* (British Columbia. MELP 1998a). The aim of the program is to "discourage future flood vulnerable development" (Canada, Environment Canada 1996), through flood plain mapping programs which are carried out by individual provinces with funding assistance and monitoring by the Federal government. Once mapped, a participating province must agree to designate a flood plain using the following policies:

1. There will be no building, approval or financing of flood prone development in hazardous areas.

2. There will be no flood disaster assistance for any development built after a site is designated.
3. Relevant authorities are encouraged to zone hazardous land to protect against flood risk.

Although the agreement is strongly worded, there is little legislation to back it up. Watt (1995) noted that the *FDR Program* was successful at identifying areas at risk to flood damage, and at redirecting development from these areas. However, in the Lower Fraser Valley the majority of *Canada Water Act* funding supported structural projects; comparatively little was spent on flood plain mapping (Booth and Quinn 1995). Hence, B.C. was unable to halt the rapid growth on the Fraser River flood plain from the 1970's to the present, because data were not available to delineate areas at risk of flooding (Day 1999). Although the program has been extended to 2003, the Federal and Provincial governments have allocated no funding to support this initiative (B.C. MELP n.d.a.). Despite Federal advocacy of non-structural flood control approaches, both the cost of structures along the Fraser River and the number of vulnerable people and properties increased dramatically over both the last quarter and half century (Fraser Basin Council n.d.; Sewell 1965).

A further Federal policy that affects flood management, is the *Federal-Provincial Disaster Financial Assistance* (DFA) arrangement. The DFA provides guidelines for the cost sharing of disaster payments between Federal and Provincial governments. Both governments contribute to the rebuilding of public and private properties after major floods, with the Federal government paying an increasingly larger share of the costs with escalating damage costs (Canada. Emergency Preparedness Canada 1988). This adjustment to disaster has been widely used in recent years: Federal subsidies were granted to Quebec after the Saguenay floods and to Manitoba after the Red River floods in 1997.

Private citizens, local level and Provincial governments rely upon post-disaster payments as an adjustment to flood risk. However, this adjustment compromises the nation's

budget: every time a natural disaster occurs and damages ensue because of poor planning, all Canadian taxpayers are charged for the recovery costs, regardless of the level of personal risk each citizen may carry. Additionally, post-disaster payments are on the rise (Shrubsole 2000), and are unlikely to be reduced in the near future if current planning practices continue thus further burdening Canadian taxpayers.

Increasing post-disaster payments can be curbed through the use of the second policy listed under the *FDR Program* that requires that no post-disaster funding be granted to homes and businesses within designated flood plains. The use of this policy provides economic incentives to flood plain dwellers to move out of the flood plain to avoid incurring flood damage costs.

4.1.1 Additional Federal Policies for Non-Structural Flood Control

In addition to the *FDR program*, which is designed specifically for flood management, there exist numerous other Federal regulations that can be used to promote the flood policy alternatives outlined in Chapter 3. These include *The Expropriation Act, The Emergency Preparedness Act, The Insurance Companies Act* and *The Agricultural and Rural Development Act (Canada 1985b, 1985a, 1991, 1985c)*.

The 1985 *Expropriation Act* gives powers to the Federal government to seize private land for a public work or other public purpose. This *Act* can therefore be used to acquire flood plain lands from private owners; the publicly owned land can then be used in a flood compatible manner as described in Chapter 3. Thus this act could be an effective tool for the acquisition and relocation of flood plain homes and businesses.

The recently created Federal Office of Critical Infrastructure Protection and Emergency Preparedness (2001) has the power under the 1985 *Emergency Preparedness Act* to "conduct public information programs relating to emergency preparedness and recommend preventative measures to alleviate the effects of emergencies or disasters" (Canada 1985a Section 5.d). This *Act,* therefore, allows the Federal government to

increase public awareness through educational programs. Such programs could be designed in an effort to provide the impetus for private landowners to voluntarily use their land in the best possible manner to mitigate flood damages. This *Act* is an effective tool for the promotion of voluntary action, as described in Chapter 3.

The 1991 Federal *Insurance Companies Act* creates opportunity for individual companies to sell insurance for weather-related risks, including flooding. Thus, this *Act* provides scope for the policy alternative of insurance action. However at this time the insurance industry is unwilling to assume the high-risk of such policies. A sharing agreement with government to assume part of the risk could create a market for overland flood damage insurance. This type of program has been somewhat successful in the United States (Platt 1999).

The 1985 *Agricultural and Rural Development Act* establishes an opportunity to promote the use of open space and "flood-friendly" agricultural practices. Section 3 of the *Act* states that Federal and Provincial governments can jointly agree to create projects for the "more efficient use and economic development of rural lands" (Canada 1985a Section 3.a) and for "the development and conservation of water supplies for agricultural and rural purposes"(Canada 1985a Section 3.b.i). It can be argued that flood protection is both an efficient and economic use of flood plains. In addition, wetland storage programs that use flood plains to store irrigation water throughout the growing season are excellent examples of water supply projects, which can be used for agricultural purposes.

The Federal legislation available for non-structural flood plain management as discussed in this section is summarized in Table 4-2.

Table 4-2: Federal legislation available for flood plain management in British Columbia

	Tech-nical Tool	Policy Objectives		Policy Instruments				Policy Paradigms		Best Practices				
Legislation	Flood Plain Mapping	Impede Development	Change Development	Regulation	Economic Incentives	Voluntary Action (Education)	Insurance Action	Acquisition and Relocation	Water Retention as a Common Property Resource	Ecological Restoration	Open Space	"Flood-Friendly" Use	"Flood-Friendly" Agriculture	Flood-Proof Development
Canada Water Act (FDRP)	✓	✓		✓	✓									
Various						✓[1]	✓[2]	✓[3]			✓[4]		✓[4]	

4.2 Provincial Flood Policy and Regulation

Apart from the joint Federal-Provincial *FDR program*, there are limited provisions in B.C. under the *Land Title Act,* the *Municipal Act* (now the *Local Government Act*), the *Drainage, Ditch and Dike Act,* the *Fisheries Act,* and the *Fish Protection Act* for flood management (British Columbia 1972, 1986 (2000), 1996b, 1996g, 1997). The *Land Title Act* and *Municipal Act* both have provisions to promote a non-structural approach to flood-damage control. Section 82 of the 1972 *Land Title Act* requires that MELP approve any subdivision development in a flood plain. However, the *Act* does not preclude development, though it may require that flood-proofing measures be in place. In 1986, the *Municipal Act* was passed. This *Act* provides Municipal government with the legal authority to adopt local flood plain by-laws (British Columbia 1986). The *Municipal Act* has since been replaced by the *Local Government Act* (June 2000), which has similar provisions to the *Municipal Act*. In addition, municipal governments can now require that new developments include runoff controls, by limiting the area of impermeable surfaces (British Columbia 2000). The building and maintenance of structural flood control is regulated through the *Dike Maintenance Act* (British Columbia 1996n). The

[1] *Emergency Preparedness Act* (R.S. 1985 C. 6 Section 5.d)
[2] *Insurance Companies Act* (R.S. 1991 C. 47 Section 12)
[3] *Expropriation Act* (R.S. 1985 C. E-21 Section 4.1)

Provincial *Fisheries Act* requires that fish passage be included in the design of all new riparian structural works including dikes, levees and dams (British Columbia 1996g). Additionally, the *Fish Protection Act* requires that no new dams be built on the Fraser River to ensure the continued economic viability of the salmon fishery (British Columbia 1997). The *Streamside Protection Regulation* associated with the *Fish Protection Act* will require riparian setbacks on new and redeveloped residential, industrial, and commercial areas in urban settings (British Columbia. MELP 1998b). Although designed to improve fish habitat, it will also benefit flood control through a combination of ecological restoration and open space best practices. The above legislation can be used to promote a variety of non-structural policy alternatives including: Impeding development, flood plain regulation, open space and "flood-friendly" use policies and flood-proofing of development.

4.2.1 Additional Provincial Policies for Non-Structural Flood Control

In addition to Provincial policies and regulations specifically designed to meet the needs of flood plain management are numerous pieces of legislation that can be effectively used to promote a non-structural approach to flood damage reduction. These include Section 219 of the *Land Title Act, The Property Law Act, The Agricultural Land Commission Act, The Environment and Land Use Act, The Environment Management Act, The Wildlife Act,* and *The Emergency Program Act* (British Columbia 1996j, 1996k, 1996a, 1996e, 1996d, 1996m, 1996c).

Besides the provision for land use designation in Section 82, the *Land Title Act* has provision for the promotion of other flood adjustments. For example, the *Act* allows for the placement and continuance of covenants to protect, preserve, conserve, maintain, enhance or restore land (Section 219.4.b). Similar provisions are found in Section 35 of the *Property Law Act*. Thus, it is possible for flood plain lands to be protected or restored to their natural state when land changes hands. This is especially effective when government sells flood plain land to developers; constraints on building for the purpose

[4] *Agricultural and Rural Development Act* (R.S. 1985 C. A3 Sections 3.a, 3.b.i)

of promoting a non-structural approach to flood control can be included in the land title as covenants. Thus, several of the best practices alternatives as outlined in Chapter 3, can be achieved including water retention as a common property resource, flood plain regulation, ecological restoration, open space and "flood-friendly" use policies.

One B.C. policy that has been effective at minimizing flood plain development was the establishment in 1973 of the Agricultural Land Reserve (ALR) through the *Agricultural Land Commission Act*. Although designed to stop the decline in agricultural lands, it has had the additional benefit of reducing flood plain development (Peters 2000). This *Act* is therefore an effective tool for impeding development.

A further piece of Provincial legislation that can be used to promote a non-structural approach to flood damage reduction is the *Environment and Land Use Act*. This *Act* establishes a committee whose aim is to promote environmental awareness, and to:

> . . . ensure that all the aspects of preservation and maintenance of the natural environment are fully considered in the administration of land use and resource development commensurate with a maximum beneficial land use, and minimise and prevent waste of those resources, and despoliation of the environment occasioned by that use.

Thus this *Act* provides an excellent avenue to both change development practices and to educate the publics as to how they can best use private lands for flood control purposes.

The Provincial *Environment Management Act* creates many legislative opportunities for use in promoting non-structural approaches to flood damage reduction. It provides an avenue for government to promote holistic environmental management. Section 2 states:

> The duties, powers and functions of the minister extend to matters relating to the management, protection and enhancement of the environment including, but not limited to, the following:
> (a) planning, research and investigation with respect to the environment;

(b) development of policies for the management, protection and use of the environment;
(c) planning, design, construction, operation and maintenance of works and undertakings for the management, protection or enhancement of the environment;
(d) provision of information to the public about the quality and use of the environment;
(e) preparation and publication of policies, strategies, objectives and standards for the protection and management of the environment;
(f) preparation and publication of environmental management plans for specific areas of British Columbia which may include, but need not be limited to, measures with respect to the following:
(i) flood control;
(ii) drainage;
(iii) soil conservation;
(iv) water resource management;
(v) fisheries and aquatic life management;
(vi) wildlife management;
(vii) waste management;
(viii) air management. (British Columbia. 1996d C.118 Section 2)

This entire section of the *Act* has relevance to the promotion of several of the policy options laid out in Chapter 3. This *Act* provides for a change in development practices along flood plains that considers the environmental and flood control values of the land. In addition, it provides for the promotion of environmental awareness, which can lead to voluntary actions on the part of private citizens to promote a non-structural approach to flood control. Third, the *Act* can be used to promote the ecological restoration of flood plains.

Under the *Wildlife Act* the government has broad authority to protect and enhance wildlife and habitat on Crown land. In addition, this *Act* provides funds for the enhancement of wildlife habitat and for the "acquisition and management of land for the conservation or enhancement of a population of species of fish or wildlife and its habitat". Clearly, these provisions can be used to pursue the acquisition of flood plains

and the ecological restoration of wetlands for wildlife, which will benefit flood control through the numerous advantages outlined in Chapter 3.

The Provincial Emergency Program (PEP) is given authority through the 1996 *Emergency Program Act*. PEP is able to promote a non-structural approach to flood damage mitigation through its various education and awareness programs. In this fashion, voluntary action to reduce flood damages by private property owners is more likely to ensue.

Table 4-3: Provincial legislation available for flood plain management in British Columbia

	Tech-nical Tool	Policy Objectives		Policy Instruments				Policy Paradigms		Best Practices				
Legislation	Flood Plain Mapping	Impede Development	Change Development	Regulation	Economic Incentives	Voluntary Action (Education)	Insurance Action	Acquisition and Relocation	Water Retention as a Common Property Resource	Ecological Restoration	Open Space	"Flood-Friendly" Use	"Flood-Friendly" Agriculture	Flood-Proof Development
Land Title Act		✓[5]		✓[6]					✓[6]	✓[6]	✓[6]	✓[6]		
Various		✓[7]	✓[8, 12]			✓[8,9, 12]		✓[10]	✓[11]	✓[12, 13]	✓[13]			
Local Govern-ment Act				✓[14]							✓[15]	✓[15]		✓[14]

[5] R.S.B.C. 1996 C.250 Section 82
[6] R.S.B.C. 1996 C. 250 Section 219.4.b
[7] *Agricultural Land Commission Act* (R.S.B.C. 1996 C.10 Section 3)
[8] *Environment and Land Use Act* (R.S.B.C. 1996 C.117 Sections 3.a, 3.b)
[9] *Emergency Program Act* (R.S.B.C.1996 C. 111 Section 4.2.a)
[10] *Wildlife Act* (R.S.B.C 1996 C.488 Sections 111.2.a, 111.2.b)
[11] *Property Law Act* (R.S. 1996 C.377 Section 35)
[12] *Environment Management Act* (R.S.B.C. 1996 C.118 Section 2.f.i)
[13] *Streamside Protection Regulation* under *Fish Protection Act* (R.S.B.C. 1997 C.21)
[14] 2000 C.323 Section 910
[15] 2000 C.323 Section 907.5.b

In summary, a multitude of Provincial legislation exists which can be used to promote a non-structural approach to flood damage reduction as shown in Table 4-3. However, there are at this time a minimum of laws and regulations to enforce these *Acts* at the Provincial level. The onus is on municipal governments to create by-laws to follow these *Acts,* and to monitor by-laws, once in effect.

4.2.2 Municipal Flood Policy and Regulation

Municipal and regional governments have a great ability to promote and establish by-laws and zoning regulations that endorse a non-structural approach to flood damage reduction. In the Lower Fraser Valley each municipality has the authority, but not the obligation, to create its own flood plain management by-laws; thus policy varies widely along the Lower Fraser River.

In 1966, the Official Regional Plan (ORP) for the Lower Mainland established flood plain boundaries in the Fraser Valley. No new urban developments were to be built in the flood plain. Areas that had been historically settled, "Urban Exempt Areas" (UEA) could continue to be developed. As a consequence the UEAs have experienced rapid growth and development since the 1970's (Peters 2000; Fraser Basin Management Program 1996).

In 1986, the *Municipal Act* called for municipalities to create Official Community Plans (OCPs) in lieu of larger ORP. The OCPs allows, but does not obligate, a community to "designate areas for protection of development from hazardous conditions" with the approval of B.C. MELP (British Columbia 1986).

In a 1998 B.C. MELP survey of B.C. municipalities, 15 of 16 Lower Fraser River communities mention flood provisions in their OCPs. However, only 4 of these communities had flood hazard management by-laws in place (B.C. MELP 1999b). A sample of three Fraser Valley Community's OCPs was examined in more detail. All three plans mention the need to designate and zone hazard areas. However, policies are

generally vague. For example, North East Coquitlam's 1993 OCP states that "lands subject to general liability to flood **should, where possible**, be used for parks, open space recreation or agricultural uses" (City of Chilliwack 1999; City of Richmond 1998; North East Coquitlam 1993). However, Peters (2000) noted that "in general, OCPs do not appear to have been effective in directing development away from the floodplain".

Although not many communities currently promote flood plain issues in their local legislation, they have the power to promote many of the policy alternatives outlined in Table 4-1. Through zoning by-laws, municipal government has the power to not only impede development in vulnerable areas but to change development practices through regulation. They can, therefore, create opportunities to have non-structural flood control through ecological restoration, open space and "flood-friendly" uses and through the regulation of flood-proof development. These policy alternatives are outlined in Table 4-4.

Table 4-4: Legislation available for local level flood plain management in British Columbia

	Tech-nical Tool	Policy Objectives		Policy Instruments				Policy Paradigms		Best Practices				
Legislation	Flood Plain Mapping	Impede Development	Change Development	Regulation	Economic Incentives	Voluntary Action (Education)	Insurance Action	Acquisition and Relocation	Water Retention as a Common Property Resource	Ecological Restoration	Open Space	"Flood-Friendly" Use	"Flood-Friendly" Agriculture	Flood-Proof Development
Various		✓	✓	✓		✓				✓	✓	✓		✓

Responsibility and Control Conflicts

The lack of concrete by-laws and policies among Lower Fraser Valley communities is no great surprise. Tax revenue from areas that have been zoned to eliminate or reduce flood damage will be less than for areas that are densely developed. Additionally, should extensive flood damage occur, Provincial and Federal aid tends to be awarded despite

flood plain designations. A very small percentage of the Lower Fraser Valley has been designated a flood plain under the *FDR Program* (Peters 2000); disaster relief will be therefore paid out to flood plain dwellers by the province, the Federal government, or both, in the event of a flood. Thus, although the costs of flood plain development are borne by Federal and Provincial government, financial benefits are gained at the municipal level and by private developers; lower level governments **benefit without responsibilities**, and higher level governments are **liable without any control** over the causes of the increasing potential for flood losses.

In summary, a multitude of legislation exists at all government levels for the purpose of flood plain management. But it is essentially ineffective in solving the problem of growing flood loss potential throughout British Columbia.

4.3 Provincial Legislative Barriers to Non-Structural Flood Control

Several pieces of Provincial legislation pose barriers to the promotion of non-structural flood control. *The Insurance Act*, and *The Expropriation Act* conflict with the policy alternatives described in Table 4-1 (British Columbia 1996i, 1996f). *The Riverbank Protection Act*, and the *Flood Relief Act* promote structural flood control as the only solution (British Columbia 1996l, 1996h). Moreover, there is an urgent necessity to create additional legislation to protect flood plains, and wetlands in particular, from further destruction.

Unlike the Federal *Insurance Companies Act,* the B.C. *Insurance Act* has no provisions for the coverage of flood events. Thus, adopting an insurance adjustment to cope with flood losses is not allowed for in B.C., reducing the policy options available for a non-structural approach to flood damage reduction. Similarly, the B.C. *Expropriation Act* is unlike its Federal counterpart in that there is no special provision for the expropriation of land for uses not specified within the *Act*. Again, this limits the choice of policy options available for flood plain management.

The *Riverbank Protection Act,* for example, allows singularly for the use of structural measures to prevent the encroachment of rivers on their banks. Bank erosion that this *Act* aims to avoid will only be augmented through the use of structural measures to reduce the energy of the river, as explained in Chapter 2. Fortunately, however, this *Act* has not been used recently (McMullen 2001).

The *Flood Relief Act* is designed to legislate emergency measures and disaster relief during and after a flood. It describes the cost-sharing agreement between the Federal and Provincial governments for repairing, strengthening and constructing of structural flood controls. No similar cost-sharing arrangements are made for the purpose of non-structural approaches to flood damage reduction. Howver, this *Act* has essentially been subsumed by the Federal *Emergency Program Act.*

In its 2000 submission to the Burns Bog Ecosystem Review, West Coast Environmental Law proposed a Wetland Reserve Act, which would function in the same manner as the *Forest Reserve Act* and the *Agricultural Land Reserve Act*, in order to preserve Provincially significant wetlands (West Coast Environmental Law 2000). Such an act could be an effective means of impeding further development in valuable wetland water storage areas, thus improving natural flood control possibilities. Should the B.C. government adopt this legislation, it will only benefit non-structural flood control if flooding issues are at the forefront of publics and government interest. However, the history in B.C. is that the province has never acted decisively to deal with flood issues in a balanced structural and non-structural manner.

4.4 Discussion

There are both legislative opportunities and barriers to non-structural flood control in B.C.. Using both traditional and atypical pieces of Federal and Provincial legislation, there is an opportunity to promote all of the policy alternatives proposed in Table 4-1. Unfortunately, several legislative barriers to non-structural flood control are also in existence, some of which conflict with the overarching goals of Federal and Provincial flood plain legislation. All relevant legislation is summarized in Table 4-5

Table 4-5: Flood plain legislation summary for British Columbia

		Technical Tool	Policy Objective		Policy Actions				Policy Paradigms		Best Practices					Status Quo
Government	Legislation	Flood Plain Mapping	Impede Development	Change Development	Regulation	Economic Incentives	Voluntary Action (Education)	Insurance Action	Acquisition and Relocation	Water Retention as a Common Property Resource	Ecological Restoration	Open Space	"Flood-Friendly" Use	"Flood-Friendly" Agriculture	Flood-Proof Development	
Federal	Various						✓[1]	✓[2]	✓[3]			✓[4]		✓[4]		
Provincial	*Canada Water Act (FDRP)*	✓	✓		✓	✓										
	Land Title Act		✓[5]		✓[6]					✓[6]	✓[6]	✓[6]	✓[6]			
	Various (Opportunities)		✓[7]	✓[8, 12]			✓[8,9, 12]		✓[10]	✓[11]	✓[10, 12,13]	✓[13]				
	Various (Barriers)							✗	✗							✗[16,]
Municipal	*Local Government Act*				✓[14]							✓[15]	✓[15]		✓[14]	
	Various		✓	✓	✓		✓				✓	✓	✓		✓	

[16] *Flood Relief Act* R.S.B.C 1996 C. 151 S.1c

Legislative Opportunities and Barriers

The summary of legislation clearly demonstrates that there are both opportunities and barriers to the promotion of non-structural flood control in B.C.. However, the existence of appropriate legislation does not necessarily mean that appropriate decisions are made with regards to flood control. Unless there is broad public and political support for non-traditional flood control approaches, none of the legislation described above will be used. The existence of appropriate and useful legislation does not necessarily mean that it will be employed. Many of the legislative opportunities described above are enabling and not regulatory, and as such require that the political will be motivated to use these pieces of legislation. B.C. has a poor historical record when it comes to following through on flood control policy. Substantial action, using current legislation, needs to take place in British Columbia immediately if the Federal and Provincial government are to avoid excessive damages when the next big Fraser River flood hits.

Additionally, a variety of inter-governmental legislative conflicts need to be resolved. There is a need to harmonize all related legislation— Federal and Provincial, regional, and municipal—to promote a single set of flood plain goals. Clearly, a substantive Federal flood policy is required to guide Provincial and local governments to make intelligent choices.

Disincentives for Local Government

In terms of flood plain management, the onus is on local government to create appropriate by-laws and regulations that follow senior level governments guidelines. Senior governments have created a vast array of legislation that is designed to encompass the full spectrum of flood plain issues that might arise across the Province or nation. However, this legislation may not be pertinent to the land use decisions of local governments. Local governments need freedom as well as financial and technical assistance from senior governments in order to make appropriate land use decisions. The *Local Government Act* gives authority to local government to make the decisions,

however, the *Act* does not obligate local government in any way to designate flood plains or to zone the land appropriately. Additionally, neither the Federal or Provincial governments give guidance with regards to appropriate zoning of flood plains. Thus, local governments have few incentives to make intelligent land use decisions that will reduce the long-term costs and damages associated with flooding.

In 1993, MELP proposed that floodplain management plans should be enabled under the *Municipal Act*, and that the Provincial government create accompanying *Guidelines for Floodplain Management Plans* (British Columbia MELP 1993). These guidelines would have helped local governments to make appropriate local decisions under provincial legislation. Unfortunately, floodplain management plans were not enabled in either the *Municipal Act* or its successor the *Local Government Act,* nor were floodplain management guidelines created. Once again, flood plains were once again left at the mercy of local government policies, which have neither the obligation nor the information to make rational choices.

The Ontario Ministry of Natural Resources has provided guidance to local level governments. In 1997, the Ontario government published a *Provincial Policy Statement* (PPS) to accompany the Provincial *Planning Act* (Ontario 1990). This document aims to empower municipalities to implement Provincial interests at the local level. Guidance for municipal planning decisions is given through the PPS and related documents, which describe the Ontario concept of flood plain management (Ontario Ministry of Natural Resources 2001). Thus, in Ontario, local governments retain authority to manage flood plain land uses. However unlike in B.C., the Ontario government provides assistance to local governments to help them make decisions that will improve flooding consequences for themselves and neighbouring communities.

Responsibility and Control Conflicts

In addition to legislative impediments to a favourable relationship between local and senior level governments there are financial and control barriers. The continuance of

disaster payments from senior level governments has led to a situation where all Canadian taxpayers assume the liability for flood losses, without the advantage of any strategies to limit financial exposure. Conversely, local level governments have control of land use decisions, which can be used to limit flood risk, yet, have no responsibility for damage that will occur because of their decisions. Thus, lower level government enjoy **benefits without responsibilities**, and senior governments are **liable without control.** Viewed with the advantage of hindsight, it is difficult to understand how the Federal and Provincial Canadian governments could have adopted such short-sighted policies toward flood control.

Chapter 5: Recommendations and Conclusion

5.1 We Are Going to get Wet

There is little doubt that a major flood will affect the Lower Fraser Valley in future. The problem lies in accurately predicting the timing and severity of such an event. It is clear that passivity by all levels of government, with regards to flood plain management has created a risk for millions of British Columbians; risks related to flood damage and potential loss of life. Given the current institutional arrangements for controlling flood plain occupancy in the province, the number of people at risk will continue to increase in the future as a result of population growth.

Over 50 % of the Lower Mainland population currently reside behind flood control structures (B.C. MELP n.d.a), each of who are susceptible to failure during a large flood event. The expected arrival of immigrants to the region will increase the number of homes and businesses at risk. Continued development in "urban exempt areas" has exacerbated the problem by directing development to flood plain areas, creating a cycle of "serial engineering". "Serial engineering" describes a process of building structural flood control for protection, which subsequently attracts further development that itself which requires increased levels of structural protection. Not only does this cycle degrade the natural environment, it also creates spiralling costs, as structures need to be maintained and rehabilitated on a continual basis. Structural maintenance and improvements cannot always keep pace with development and the ever-changing hydrological characteristics of the river, thus the risk to residents "protected" by structures is steadily increasing. This cycle must be broken if Fraser Valley residents are to be safe from flooding in the future.

All levels of government Federal, Provincial, Regional, and Municipal have contributed in some way to the current situation. Local level governments with the full co-operation of senior governments have permitted families and businesses to invade

flood plains throughout the country for the last 100 years with full knowledge of the risk this creates for property owners. For the most part, landowners are ignorant of the flood risk to their homes and lives. Both senior and local level governments are guilty of creating the current situation of Canada's densely populated flood plains. For this reason, a concerted effort on the part of all governments and private citizens is needed immediately if immense future flooding damage is to be avoided.

5.2 Structures, Structures Everywhere

Concerns regarding B.C.'s dependence on structural flood control measures were originally voiced during the 1950s and 1960s (Sewell 1965). Yet, structures continue to form the primary defense against floodwaters; over 600 km of dikes protect the Lower Mainland alone. Conversely, B.C. did not make full use of Federal *FDR Program* funding to map the entire Fraser River flood plain, which remains poorly covered (B.C. MELP n.d.b). This policy contributed to the continuing dependence on structures and reduced the possibility of initiating non-structural measures for flood control.

Structural flood control measures can be effective at mitigating damages to flood plain development. However, there is overwhelming evidence that structures will not protect residents in the long-term, will become increasingly expensive and will cause immeasurable environmental degradation. Structural flood control, although relatively successful to date, is not likely to prevent substantial damage from occurring in the Fraser Valley when the next flood of record strikes. In the meantime, structures continue to exert an unnecessarily heavy demand on government coffers, and cause extensive environmental degradation. British Columbia needs to take decisive action immediately to modify the current reactive structural approach into a more proactive non-structural strategy for flood control management.

5.3 A Natural Approach to Flood Damage Reduction

An alternative strategy to reducing flood losses exists based on the goal of restoring hydrologic functions in a river system, and reducing the number of people vulnerable to floods. Reinstatement of biological and hydrologic processes reduces the severity of flooding, and decreases the number of vulnerable properties, thus reducing the cost of future flood events. The positive externalities, or side effects, of this approach are numerous: overall environmental quality is improved; agricultural irrigation can be augmented; commercial and sport fisheries are enhanced; recreation and environmental education possibilities are increased; and local economies may be enhanced through community revitalisation. However, the extent of flow control and additional benefits in the Fraser Valley are unknown at this time. Further research into hydrological best management practices for the Fraser River Valley or similar watersheds is required in order to ensure complete benefits from the use of non-structural flood control approaches.

Examples of successful natural flood control projects are found across Ontario, Europe and the United States. Despite the proven advantages of such an approach, and the obvious disadvantages associated with the singular reliance on structures for flood control, British Columbia continues to rely on structural measures as the first defence against flooding.

5.4 Steps to a Solution

Canadian and British Columbian policies do not currently reflect the clear long-term advantages of a non-structural approach to flood damage reduction. British Columbians need to take steps to adjust flood management policy accordingly. This shift in approach requires two sets of actions. First, the obstacles to a non-structural approach to flood damage reduction must be overcome, and second, policy alternatives must be implemented.

5.5 Obstacles to a Non-structural Approach to Flood Damage Reduction

Flood policy is a very difficult area; the inherent uncertainty of natural disasters requires that decisions be made without fully understanding the consequences. In addition, a momentum favouring structural flood control has been created in British Columbia by the precedents established by all levels of government over the past century. This momentum has created as series of obstacles (Table 3-1) that must be overcome if a natural approach to flood damage reduction is to be gradually adopted in the Lower Fraser Valley. Additionally these perceived obstacles compound the numerous legislative barriers to changing the status quo towards a non-structural approach to flood damage reduction. Although there are numerous obstacles, each can be overcome with appropriate public flood policy.

5.6 Flood Adjustments Suitable for a Non-Structural Approach to Flood Damage Reduction

Historically, British Columbia has primarily relied on two forms of adjustments to flood damage. These adjustments include structural flood control, and post-disaster payments to affected areas, neither of which is likely to reduce flood losses in future. Structural flood control although mostly successful to date, is unlikely to be able to protect Fraser Valley residents as the region continues to grow, structures age and the hydrology of the Fraser River evolves. As a result of this continued dependence on structures for flood control, post-disaster payments to flood victims will continue to increase, overburdening Canadian taxpayers.

A series of adjustments that promote a non-structural approach to flood damage reduction, summarized in Table 4-1, are available to policy makers. Each adjustment plays a part in benefiting flood control. The appropriateness of each adjustment will depend on local conditions; thus flood management decisions must be made in part at a local level to ensure local buy-in. Local support is essential for effective flood management solutions. Flood adjustments create a large toolbox, from which local

policy makers can choose appropriate measures. Local participation helps to create momentum to follow through on a natural approach to flood damage reduction.

In order to overcome obstacles and implement policy alternatives, governments must pursue the following actions: enable appropriate legislation and remove legislative barriers, create basin-wide planning institutions, shift responsibility and liability to flood plain dwellers, and involve all relevant stakeholders in the planning process. Figure 5-1 summarizes the steps to engaging non-structural approaches to flood damage reduction, including the above actions.

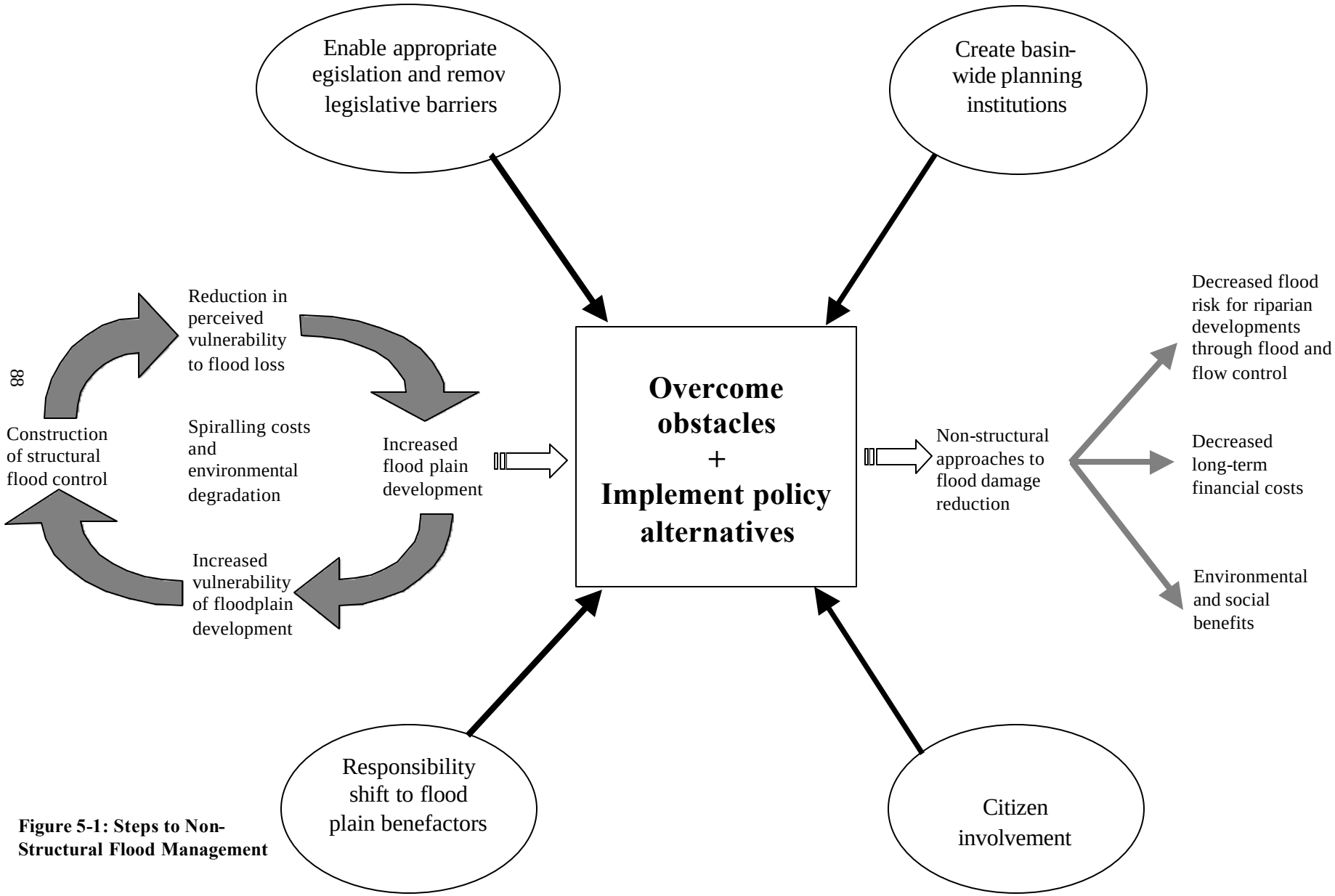

Figure 5-1: Steps to Non-Structural Flood Management

5.7 Legislation

Flood legislation in B.C., for the most part, includes many opportunities to promote non-structural flood control adjustments (see
Table 4-5). Especially when legislation is used imaginatively in order to realize flood control benefits. However, in some instances there is a need to remove legislative barriers, and improve legislative opportunities. Unfortunately, much of this legislation has not been used to promote a non-structural approach to flood damage reduction. Policy making defaults to the structural and reactive measures to combat potential flooding. This situation must be reversed for B.C. to avoid potentially heavy losses of life and property in future flood events.

5.8 The Need for Basin-Wide Planning Institutions

Senior level governments can aid in the co-ordination of flood management through the creation and funding of watershed institutions. Co-ordination and co-operation between and within governments is cited as an obstacle to non-structural flood control. Watershed institutions such as the Fraser Basin Council in B.C. and some Conservation Authorities in Ontario have shown that intelligent and effective flood plain management decisions can be made when communication channels are open (Fraser Basin Council 2000; Brown, Moin and Nicolson. 1997). Continued funding and support for these, and other innovative institutions is vital to the promotion of a non-structural approach to flood damage reduction. Co-ordination and co-operation amongst different issue groups will provide impetus to initiate publicly supported, multi-purpose projects, which can provide an array of flood control benefits.

5.9 Shifting Responsibility and Liability

In order to implement a non-structural approach to flood damage reduction, there is a need to have local control of flood plain management. However, this level of control also needs to come with responsibility. Given that local solutions to flood management are required, how can senior governments support local government given the current institutional arrangements? In fact, there are several opportunities for senior government involvement in the management of local flood plains.

First, there is a need to gradually shift financial responsibility and control to flood plain residents and their local governing bodies. At present, local government enjoys benefits without assuming responsibilities, whereas senior governments are liable without control. If local governments, and by extension residents, are responsible for post-disaster costs, the numerous non-structural adjustments to flood control will become more attractive. This shift can occur in two instances. First, if the Federal and Provincial government were to discontinue post-disaster payments. The *Canada Water Act* states that no funding will be given in cases where buildings on designated flood plains are damaged. However, funds continue to be handed out; in effect, flood plain property owners are currently subsidized by the entire nation, in the form of post-disaster payments. There is a need for senior level governments to act, or in this case, not act when floods cause damage in designated areas. Second, senior level governments need to provide incentives to insurance companies to insure at-risk properties. Overland flood insurance would require that flood plain owners assume financial responsibility for the risk of flood damage. Thus, non-flood plain owners would no longer be responsible for damages experienced by those living on flood plains. The NFIP in the U.S. is an excellent example of how such a Federally aided program could benefit more rational flood control policy in Canada. It is time that senior level governments stop disbursing disaster funds, and instead create an opportunity for flood plain residents to insure themselves. If this does not occur, flood plain residents will continue to exploit the current post-disaster payment system by over developing flood plains. Control and responsibility for flood plain flood management must be shifted to local government to achieve this goal.

5.10 Citizen Involvement

Grassroots buy-in to flood plain management programs is crucial for the success of non-structural approaches to flood damage reduction. At this time, many flood plain residents are oblivious to the risk to themselves and their property. Additionally, there is a false sense of security created by senior governments through the existence of DFA arrangements. Private citizens will be awarded post-disaster payments regardless of the level of risk they have assumed by living or doing business on the flood plain. A further deterrent to non-structural approaches to flood damage reduction is the appearance of structural reliability. Structures are easy to understand, whereas alternative adjustments to flood damage reduction require a greater understanding of complex riparian processes. Thus, at this time, private citizens are unlikely to support non-structural flood damage reduction measures because they continue to believe that government will protect their assets through structures and post-disaster payments.

Senior level governments can also be effective at educating both publics and policy makers about flood processes and the various adjustments available to combat flooding. National campaigns aimed at publics will improve local buy-in and increase voluntary actions that enhance flood control naturally. The Federal government can also act as a guide and mentor for other policy makers, helping them to make appropriate decisions regarding flood plain management. There is a need for the federal government to create a forum for discussion of best management practices for flood plain management through existing institutions and ministries. Such a forum would improve information exchange and the efficacy of watershed institutions.

Citizen support for non-structural flood damage reduction measures will only arise from changes to policy changes by all levels of government. First, through media campaigns governments can foster greater level of understanding amongst the publics and create the opportunity to explore alternatives to structural flood control. Second, and more persuasive, is the shift of the cost of flood protection to the private citizens who are individually at risk, and away from Canadian taxpayers as a whole. Currently, the DFA

arrangements charge all tax payers for flood damages, greatly subsidizing flood plain dwellers. Senior level governments need to desist from paying out for post-disaster costs. Instead, flood plain dwellers should pay for their own risk privately. However, given that senior level governments have created the current situation of densely populated flood plains, without properly informing property owners of the flood risk, they are in part liable to create and fund a solution. Thus it is only fair that senior level governments must help the insurance industry create a suitable program to fund disaster costs. Further research into creating an appropriate program is necessary at this time.

Table 5-1: Summary of recommendations

Summary of Recommendations
General
1. Break the cycle of "serial engineering" by ceasing to build structural flood control
2. Implement alternative policy adjustments
3. Target policy alternatives to local situations
4. Reform benefit-cost analysis framework to include non-monetary externalities
Legislation
1. Remove legislative barriers to non-structural flood control
2. Enable appropriate legislation as in Figure 4-5
Basin-Wide Institutions
1. Create watershed institutions to facilitate communication, education, co-ordination and co-operation among all levels of government and other stakeholders
Responsibility Shift
1. Rectify the current situation of local governments who enjoy benefits without responsibility and of senior level governments who experience liability without control
2. Discontinue post-disaster assistance payments
3. Encourage insurance industry, with the help of senior level governments, to create overland flood insurance programs to replace post-disaster assistance payments

Citizen Involvement
1. Create public awareness programs to encourage voluntary efforts to pursue a non-structural approach to flood damage reduction
2. Create economic incentives to encourage private citizens to increase flood awareness, and to flood-proof homes and businesses
Additional Research
1. Study the potential to initiate of wetland storage in the Fraser Basin, with specific interest in the best location for wetlands
2. Conduct detailed economic analysis of the costs and benefits of a non-structural flood control approach in the Lower Fraser Valley

The ideas presented in this research and conclusions are summarized in Figure 5-1 and Table 5-1. The obstacles in this figure are summarized in Table 3-1 and the policy alternatives are summarized in Table 4-1.

5.11 The Probability of Success

Progress in flood hazard management has been very slow in Canada. Research into non-structural flood management adjustments was first begun in the 1940s; little advancement has been made since with the exception of ecological concerns. Progress in the future will occur in one of two ways: either, through gradual, steady changes to policy resulting from enlightened governance, or through rapid change after a large flood event. For example, many changes to flood management in the Mississippi Valley resulted directly from the disastrous flood of 1993. Non-structural policy knowledge coincided with this large flood event and a public support for change opened a brief policy window. This window allowed for proactive non-structural flood management to be instituted in the Mississippi Valley. The Lower Fraser Valley could also be stimulated to change its approach to flood control through a similar large flood event.

5.12 Progress in the Lower Fraser Valley

Flood plain management is a difficult game. It requires that "the risk associated with the floodplain [is balanced] against the desire to make use of floodplain lands" (Boyd et al. 1999). Numerous obstacles to non-structural adjustments increase the difficulty of effective and efficient flood plain management. However, some progress has already been made in overcoming obstacles and to move towards non-structural flood control adjustments along Fraser River Valley. The creation of the Joint Program Committee for Integrated Flood Hazard Management by the Fraser Basin Council has created an opportunity to facilitate communication amongst flood plain stakeholders. This initiative offers the greatest potential for making progress in adopting non-structural flood control options in the Lower Fraser Valley.

A non-structural approach to flood damage reduction needs to take centre stage in flood management policy in British Columbia if the province is to avoid exponential flood damage costs. Tools are in place to promote a non-structural approach to flood damage reduction. However, B.C. has not taken advantage of these devices to date. B.C. lacks strong leadership and commitment to flood management issues. When decisions are made they tend to be temporary and reactive. Most often, these decisions are made in the face of potentially large flood events. Conversely, longer-term solutions to the flood problem in the Lower Fraser Valley are necessary to ensure the safety of its residents. Forward thinking policy makers must begin to make changes to the process of flood plain management in B.C. immediately to achieve this goal.

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