City of Richmond

Report to Committee

TO PW+T - Dec. 5/01

To:	Public Works and Transportation Committee	**Date:**	November 16, 2001
From:	David McLellan General Manager, Urban Development	**File:**	6045-01
Re:	**Federal Financial Support for Dredging of the Fraser River and Flood Protection Works**		

Staff Recommendation

That the following resolution be adopted and circulated to the Prime Minister, Minister of Finance, Minister of Fisheries and Oceans, Minister of Transport, Richmond Members of Parliament, Cities of New Westminster, Surrey, Delta, Coquitlam and Port Coquitlam, Districts of Maple Ridge and Pitt Meadows and the Township of Langley:

"WHEREAS in the 1900's the Federal Government developed and maintained commercial navigation channels in the Fraser River through the construction of training walls and regular dredging programs, and

WHEREAS until 1997 the Federal Government provided capital and operating funds for the said development and maintenance of the Fraser River navigation channels, and

WHEREAS significant waterborne commerce developed in response to the development and maintenance of Fraser River navigation channels, and

WHEREAS significant flood control benefits resulted from the development and maintenance of the said Fraser River navigation channels, and

WHEREAS users of the Fraser River navigation channels pay a Marine Services Fee to the Canadian Coast Guard but the Canadian Coast Guard does not include development and maintenance of the Fraser River navigation channels as services funded by the revenue generated by the Marine Services Fees, and

WHEREAS neither the Canadian Coast Guard nor the Federal Government now provide capital and operating funds for the development and ongoing maintenance of the Fraser River navigation channels, and

WHEREAS the Fraser River Port Authority has chosen to seek to keep the Fraser River navigation channels operational to the extent of the Authority's limited financial resources and is now the sole funding source for the development and maintenance of the Fraser River navigation channels, including but not restricted to the removal of the annual spring freshet infill in the Fraser River, and

WHEREAS the above mentioned significant waterborne commerce and the flood control benefits will be jeopardized if the maintenance of the Fraser River navigation channels is not continued and infill removed annually, thereby threatening the socio-economic activities occurring on adjacent lands within the boundaries of our City, and

WHEREAS many of the secondary channels, including the Steveston Harbour, are silting up very quickly and soon may become unusable for navigation, and

WHEREAS many of the local dykes in the lower reaches of the Fraser River were constructed under a joint Federal/Provincial/Municipal funding program, and

WHEREAS the Federal Government does not have any current active funding programs which assist local agencies in maintaining or upgrading these dykes, and

WHEREAS when a flood breaches the dykes, Federal Government emergency funds required will be far in excess of prudent expenditures in both dredging and dyke upgrading,

BE IT THEREFORE RESOLVED that the City of Richmond, in the strongest way possible, request the Federal Government, reinstate the funding for the continuing development and maintenance of the Fraser River navigation channels and dyking system and provide assurance that previous levels of development and maintenance of the Fraser River navigation channels and dykes will be maintained without jeopardy to waterborne commerce and flood control benefits."

David McLellan
General Manager, Urban Development

Att. 1

Staff Report

Origin

At a summer meeting of the Fraser River Port Authority and the Mayors of the municipalities where the Port is operational, a discussion occurred on the impact of the withdrawal of federal funding from dredging and dyke maintenance in the Fraser River Estuary. This report acts upon one of the suggestions of the Mayors, which was to petition the appropriate authorities for the restitution of appropriate funding. I understand that most of the other municipalities in attendance at this meeting have adopted similar resolutions.

Coincident with the events noted above, the Fraser Basin Council has facilitated a discussion on the issue of flood protection. One of the results of that work has been the attached discussion paper entitled "Comprehensive Management for Flood Protection Works", which has just recently been released. The purpose of this paper is to promote the establishment of a long term planning and sustained funding program for comprehensive management for flood protection works in the Fraser River Basin.

Analysis

It has become quite evident to many users of Steveston Channel that inadequate attention is being paid to the retention of reasonable navigation for this important commercial harbour. The situation is not unlike that found along other parts of the lower Fraser River and is due in large part to a drop in federal spending for channel maintenance. Until 1997, the federal government had allocated $5 million dollars per annum and typically $1.8 to $2 million was spent on an annual basis on dredging of the lower Fraser River. The Fraser River Port Authority is working towards an environmentally and financially sustainable model for its dredging program with a revenue reliance on the sale of Fraser River sand. At this time this model is expected to be depleted in approximately eight years.

Unlike the federal government in the United States, our federal agencies have invested very little in establishing a competitive gateway for shipping, despite the obvious, direct financial benefit to federal revenues.

Somewhat related to the issue of dredging, is the lack of a coordinated long term strategy for flood protection. The City of Richmond has been an active participant in the dialogue being facilitated by the Fraser Basin Council in addressing this issue. Although there is no immediate peril from the lack of a federal funding commitment to dredging and flood protection works the longer term impacts of insufficient funding may create an unacceptable risk. An ongoing investment by the Federal Government in flood protection works, as well as dredging, helps reduce the risk of traumatic loses to our local economy and the associated demands on Federal disaster recovery.

Financial Impact

No budgetary impact at this time, however, successful engagement of the federal government in long term financing of dredging and flood protection has the potential of reducing City capital funding requirements and increases the commercial viability of any City investment in waterfront activities.

Conclusion

The City should work with other lower mainland municipalities on a campaign to seek an ongoing federal government commitment to financial assistance for dredging and flood protection works in the lower Fraser Basin.

David McLellan
General Manager, Urban Development

DJM:djm

Comprehensive Management for Flood Protection Works

Prepared by:
Dike and Channel Maintenance and Habitat Subcommittee

Prepared for:
Joint Program Committee
For Integrated Flood Hazard Management
And the
Fraser Basin Council

October 2001

Executive Summary

It is the purpose of this discussion paper to promote the establishment of a long-term planning and sustained funding program for comprehensive management for flood protection works in British Columbia. The discussion paper presents a description of what comprehensive management is, a rationale why this approach is needed, and some possible funding models and mechanisms to facilitate program implementation. There are two key elements that are essential to a long-term comprehensive management program for flood protection works as discussed in this paper. They include:

- Long-term, coordinated planning; and,
- Adequate, sustained funding.

Section 1 of the report introduces the topic by highlighting the significance of flood hazards in British Columbia, particularly within the Fraser Basin, and a rationale as to why a comprehensive management approach is needed. Section 2 provides an overview of the types of management activities that are the potential components of a comprehensive management program. Section 3 presents two different funding scenarios, providing a comparison of "Current Funding Levels" versus "Enhanced Proactive Funding". Section 4 concludes the report with a summary of key messages regarding the vision, benefits, and scope of a comprehensive management program.

Flood hazards represent a significant and ongoing threat to community sustainability in the Fraser Basin and throughout British Columbia. Statistically, there is a one-in-three chance of experiencing a Fraser River flood of record in the next fifty years. The specific impacts of the next Fraser River flood of record are extremely difficult to predict. The following list highlights some of the significant vulnerabilities to flooding that could be significantly impacted if major failures occurred in the lower Fraser diking system during a flood of record:

- About 300 000 people living and working in the floodplain;
- About $1.8 billion in direct flood damages to private and public property; and,
- Significant economic impacts due to business disruption and the loss critical infrastructure.

Flood protection works provide an integral part of flood hazard management in BC, therefore regular maintenance and long-term management are necessary to continue to provide flood protection and reduce recovery costs. At present, aside from discretionary provincial assistance and the annual budgets of respective diking authorities, there are no coordinated, long-term planning processes, nor any permanent funding programs in place to assist local diking authorities in the management of flood protection works.

It is estimated that over the past decade in BC, expenditures for managing flood hazards have been on average, about $30 million per year. Of this, about half, $14.6 million per year has been spent compensating for damages after a flood event through Disaster Financial Assistance Arrangements, or constructing urgent mitigative works in response to an imminent flood threat. An ongoing, planned approach to managing flood protection works is financially and operationally preferable to the construction of urgent mitigative works. Similarly, mitigation of flood damages by taking preventative measures is financially and socially preferable to compensation after a flood has occurred. Therefore, it is recommended that all agencies responsible for flood protection, work together to establish a long-term fund for the ongoing comprehensive management of flood protection works.

There are numerous economic, social, and environmental benefits of comprehensive management for flood protection works. Some of these benefits include:

- Improved success in reducing flood damages and associated recovery costs;
- Improved ability for local authority work planning and budgeting;
- Improved opportunities for regional planning, collaboration, resource pooling, and general coordination of investment;
- Improved opportunity for rehabilitation / local management of dikes currently without a local authority responsible for management;
- Improved planning, design, and decision making, in comparison with the construction of urgent mitigative works in the face of an imminent flood threat;
- Improved financial efficiency (i.e. project tendering in an "urgent works" scenario is more expensive than tendering well in advance and phasing complex projects);
- Improved alignment of funding arrangements with users and beneficiaries, including all levels of government and the private sector;
- Improved access to funding for local diking authorities with financial need;
- Improved opportunity to accommodate and integrate environmental needs; and,
- Improved governance and avoidance of uncertainty associated with budget cycles.

There is a need for all managers of flood protection works to adopt a comprehensive management approach. This approach includes a broad spectrum of activities throughout the entire "life-cycle" of flood protection works. To initiate further dialogue regarding a comprehensive management program, an Enhanced Proactive Funding scenario has been developed within this discussion paper, including the following management activities:

- Routine / Annual Dike Operations, Maintenance, and Minor Repairs;
- Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works;
- Management of Dikes Without a Local Authority;
- Monitoring, Modeling, and Forecasting of River and Flood Processes;
- Flood Hazard Studies and River Management Plans;
- Rehabilitation and Replacement of Pump Stations; and,
- Construction of New Flood Protection Works.

Although order of magnitude funding levels have been developed for each management activity, the actual expenditures may vary from year to year, depending on local and provincial priorities, and depending on the total amount of funding secured for a comprehensive management program. Of the proposed annual investment of $23.5 million for the Enhanced Proactive Funding scenario, about $15.4 million is already being invested on an annual basis by various levels of government (see Appendix 3).

At this time it is unclear how different agencies with statutory authority for flood protection would participate in the development and implementation of a long-term comprehensive flood protection program. A collaborative approach is required because no single agency or level of government is able to address flood hazard management on its own. There is a need for all levels of government to work together. Although this report provides a basis to establish such a program, additional dialogue and analyses are required to develop the intergovernmental agreements necessary to fund and implement a comprehensive management program for flood protection works.

Qualifying Remarks

The enclosed document is provided as a framework and rationale for long-term planning and sustainable funding to support comprehensive management for flood protection works. While the primary geographic focus of the committee has been the Fraser River basin, information presented in this document represents the BC provincial scope. It was developed through grassroots dialogue with the input of numerous local, provincial, and federal agencies with responsibilities for managing flood protection works. Several relevant case examples are provided in Appendix 2 to illustrate important issues, recent management activities, and/or works proposed for the future. These case examples are not intended as a complete listing of all necessary works but rather as illustrations of the types of management activities required within a comprehensive management program.

This document seeks a balance of views and perspectives in an effort to build consensus regarding long-term planning and management of flood protection works. Although the principles and recommended approaches outlined within this document strive to reflect a general consensus among the individual members of the Joint Program Committee and Dike and Channel Maintenance and Habitat Subcommittee, they do not necessarily represent the policy nor position of the respective participating organizations. It is acknowledged that implementation of the recommended approach will require significant commitment, funding, and flexibility in its application to address many diverse local circumstances.

Limitations of the Discussion Paper

There are some explicit limitations within this discussion paper. This document does not provide a detailed and comprehensive inventory of all necessary flood protection projects. Rather, it makes an attempt to define a significant overview of the types of management activities required, as illustrated with case examples. This document does not prioritize, nor rank individual projects identified in this paper in order of importance. In many situations, the case examples illustrate significant flood hazards, including erosion hazards in relation to flood protection works; however, the document is impartial in the presentation of the issues and proposed solutions in a wide variety of circumstances. Finally, it should be noted that although this discussion paper provides a basis to establish a long-term planning and funding program; additional dialogue, analysis, and negotiation are required regarding the intergovernmental arrangements necessary for funding and implementation.

This document focuses on the management of flood protection works. Consequently there are many non-structural approaches to flood hazard management that are outside of the scope of this document. For example:

- Floodproofing techniques and land use planning tools;
- Emergency flood planning, preparedness, and response;
- Property acquisition and relocation of residents; and,
- Public or private flood insurance programs.

Although these non-structural approaches provide important functions in reducing flood damages, they are outside of the scope of this discussion paper. A comprehensive program to manage flood protection works should be closely linked and integrated with non-structural approaches to ensure effective flood protection by providing multiple defenses. This is fundamental to strengthening an integrated approach to flood hazard management.

Acknowledgments

The Dike and Channel Maintenance and Habitat Subcommittee developed this discussion paper for the Joint Program Committee for Integrated Flood Hazard Management, which was established in March 1998 by the Fraser Basin Council. The Joint Program Committee (JPC) currently includes 35 representatives of 5 federal departments, 5 provincial ministries, 4 regional districts, 17 municipalities, and 4 other organizations, each of which is involved in different aspects of flood hazard management.

The JPC provides a process for inter-agency dialogue, information exchange, clarification of roles and responsibilities, and networking to facilitate the implementation of priority management actions. The Fraser Basin Council provides the Chair of the JPC and the Secretariat (coordination, administration, writing, etc.) for the JPC and its subcommittees. Since the establishment of the JPC, five subcommittees have been convened, including:

- Dike and Channel Maintenance and Habitat;
- Flood Proofing and Land Use Planning;
- Emergency Preparedness, Response, and Recovery;
- Public Education; and,
- Finance.

The authors would like to acknowledge the Fraser Basin Council and the Ministry of Water, Land, and Air Protection for the use of various photographic materials throughout this document.

Joint Program Committee and Subcommittees Member Organizations - October 2001

1. Department of National Defense (Office of Critical Infrastructure Protection and Emergency Preparedness)
2. Environment Canada
3. Fisheries and Oceans Canada
4. Indian and Northern Affairs Canada
5. Public Works and Government Services Canada
6. Ministry of Water, Land, and Air Protection
7. Ministry of Sustainable Resource Management
8. Ministry of Public Safety and Solicitor General (Provincial Emergency Program)
9. Ministry of Transportation
10. Ministry of Community, Aboriginal, and Women's Services
11. Greater Vancouver Regional District
12. Fraser Valley Regional District
13. Thompson-Nicola Regional District
14. Squamish-Lillooet Regional District
15. Corporation of Delta
16. City of Burnaby
17. City of Port Coquitlam
18. City of Surrey
19. City of Vancouver
20. City of Coquitlam
21. City of New Westminster
22. City of Richmond
23. District of Pitt Meadows
24. District of Maple Ridge
25. Township of Langley
26. City of Abbotsford
27. District of Chilliwack
28. District of Mission
29. District of Hope
30. City of Kamloops
31. District of Kent
32. Union of BC Municipalities
33. Lower Mainland Municipal Association (Flood Control and River Management Committee)
34. Fraser River Port Authority
35. North Fraser Port Authority

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Comprehensive Management for Flood Protection Works

Prepared by:
Dike and Channel Maintenance and Habitat Subcommittee

Prepared for:
Joint Program Committee for
Integrated Flood Hazard Management

October 2001

1. A New Vision for Flood Hazard Mitigation

1.1 Introducing Flood Protection Works

Flood protection works are an integral part of flood hazard management in British Columbia. Throughout the province, these works have collectively averted millions of dollars of flood damages. Current approaches to management have been largely successful. However many flood protection works have not been significantly tested by a flood event equal to, or larger than, the flood of record. Flood threats will continue to exist as long as communities and infrastructure are located within British Columbia floodplains. Therefore there is a need to develop a long-term planning approach with adequate, sustained funding to support the ongoing management of flood protection works.

Significant responsibilities have been delegated to, and successfully carried out by, local diking authorities to manage flood protection works. However, there are numerous circumstances that challenge the technical or planning capabilities and/or the financial resources of individual local diking authorities. For example, major capital works such as dike rehabilitation or upgrades may warrant financial assistance from other levels of government or other partners. Regional river processes such as gravel aggradation and erosion may warrant regional scale planning, coordination of technical studies, and inter-jurisdictional management plans. At present, aside from discretionary provincial assistance and annual budgets of respective diking authorities, there are no coordinated long-term planning processes, nor permanent funding programs in place to assist local diking authorities in the management of flood protection works.

It is estimated that over the past decade in BC, expenditures for managing flood hazards have been on average, about $30 million per year (see Table 1 and Appendix 3). Of this, about half, $14.6 million per year has been spent compensating for damages after a flood through Disaster Financial Assistance Arrangements, or constructing urgent mitigative works in preparation for an imminent flood threat. An enhanced investment in proactive flood mitigation may reduce the need for urgent mitigative works and may defer or reduce future flood damages and recovery costs. Therefore the primary recommendation of this discussion paper is that a reliable, long-term, sustained funding program be established for the ongoing planning and comprehensive management of flood protection works.

1.2 Introducing Comprehensive Management

It is the purpose of this discussion paper to promote the establishment of a long-term planning and sustained funding program for comprehensive management for flood protection works in British Columbia.

Comprehensive management includes a broad spectrum of management activities, from initial design and construction of flood protection works, through the entire "life-cycle" of these structures. This includes everything from routine annual dike maintenance to upgrading a dike to a new design standard. There will be different needs in different areas at different times.

There are two elements that are essential to a comprehensive management program, including:

- Long-term, coordinated planning; and,
- Adequate, sustained funding.

This discussion paper is intended to provide a foundation to build greater dialogue and consensus regarding the establishment of a comprehensive management program to address some of the critical challenges facing managers of flood hazards now and in the future. The paper presents a program description of what comprehensive management is, a rationale as to why this approach is needed, and some possible funding models and mechanisms to facilitate program implementation.

Section 1 introduces the topic by highlighting the significance of flood hazards in British Columbia, particularly within the Fraser Basin, and a rationale as to why a comprehensive management approach is needed. Section 2 provides an overview of the types of management activities that are the potential components of a comprehensive management program. Section 3 presents two different funding scenarios, providing a comparison of "Current Funding Levels" versus "Enhanced Proactive Funding". Section 4 concludes the report with a summary of key messages regarding the vision, benefits, and scope of a comprehensive management program.

1.3 Benefits of Comprehensive Management

There are numerous economic, social, and environmental benefits of comprehensive management for flood protection works. These benefits are particularly relevant in relation to the current absence of financial certainty and coordinated, long-term planning. Some of the many anticipated benefits of a comprehensive management program include:

- Improved success in reducing flood damages and associated recovery costs;
- Improved ability for local authority work planning and budgeting;
- Improved opportunities for regional planning, collaboration, resource pooling, and general coordination of investment;
- Improved opportunity for rehabilitation / local management of dikes currently without a local authority responsible for management;
- Improved planning, design, and decision making, in comparison with the construction of urgent mitigative works in the face of an imminent flood threat;
- Improved financial efficiency (i.e. project tendering in an "urgent works" scenario is more expensive than tendering well in advance and phasing complex projects);
- Improved alignment of funding arrangements with users and beneficiaries, including all levels of government and the private sector;
- Improved access to funding for local diking authorities with financial need;
- Improved opportunity to accommodate and integrate environmental needs; and,
- Improved governance and avoidance of uncertainty associated with budget cycles.

The extent to which these benefits would be realized would depend upon the scope of the program, the levels of funding available for management activities, and the effectiveness of inter-jurisdictional coordination.

1.4 Significance of the Fraser River Flood Hazard

Many communities throughout the Fraser Basin and other river basins in British Columbia are vulnerable to flood hazards. The Fraser River Basin covers more than 25% of BC's land area and contains more than 2/3 of its population. Activities in the Fraser Basin contribute to 80% of the province's gross domestic product and 10% of Canada's gross national product. However the Fraser River, like all river systems, includes the threat of flooding. The Fraser River flood of record occurred in 1894 and the last major flood occurred in 1948. In 1948 flood protection barriers were breached in: Agassiz, Chilliwack, Kent, Harrison Hot Springs, Dewdney, Mission, Matsqui, Fort Langley, Pitt Meadows, and Coquitlam. 30 000 civilian volunteers and 3 000 Canadian Armed Forces personnel helped to fight the flood. Three weeks after the first dike was breached:

- 20 000 hectares had been flooded;
- 16 000 people had been evacuated;
- 2 300 homes were either destroyed or damaged;
- 1 500 people were left homeless;
- The total cost of relief and rehabilitation in the province amounted to an estimated $20 million in 1948 dollars (or $142 million in 1994 dollars). Of the 1948 total, $17.5 million was expended in the Lower Fraser Valley; and,
- It is believed that there were no directly related losses of life.

City of Chilliwack - 1894 Fraser River flood.

The specific impacts of the next Fraser River flood of record are extremely difficult to predict. The flood protection system is designed to withstand a repeat of the flood of record, however the dikes may be breached or overtopped if the design limit is exceeded. When this occurs next, many different levels of government, businesses, and residents will share in the impacts and costs. If major failures occurred in the lower Fraser diking system during the next flood of record, the estimated vulnerability includes the following:

- About 300 000 people live and work in the floodplain, requiring evacuation, shelter, and emergency services. Significant social impacts would be associated with a catastrophic flood event including:
  - ⇒ Risk of injury or loss of life;
  - ⇒ Hardship associated with evacuation and emergency services; and,
  - ⇒ Disruption of community infrastructure and service provision (e.g. schools, hospitals, roads, water supply, etc.);

- About $13 billion of development is located within the floodplain including homes, farms, businesses, schools, and hospitals, with potential for $1.8 billion in direct flood damages to private and public property (in 1994 dollars). It is believed that this is a conservative estimate of direct flood damages;

Oak Hills Subdivision in Kamloops - 1972 North Thompson River flood.

- Significant economic impacts would be experienced due to business disruption associated with direct flood damages and the loss of critical infrastructure such as transportation and utilities:
    - ⇒ Transportation - major provincial highways, rail lines, international and regional airports, and most federal port lands ($38 billion / year in cargo shipments);
    - ⇒ Agricultural production (between $250 and $300 million / year); and,
    - ⇒ Utilities - major hydro transmission lines, petroleum products and gas trunk lines, major sewage treatment plants, and regional landfill sites;

- Significant environmental impacts would be associated with a catastrophic flood including contamination or disruption of community water supplies and domestic groundwater wells.

Trans Canada Highway at Whatcom Road in Abbotsford - 1990 Nooksack River flood.

2. Flood Protection Works - What is Comprehensive Management

This discussion paper promotes the concept of adopting a comprehensive management approach. Comprehensive management includes a broad spectrum of activities from initial design and construction through the entire "life-cycle" of the structure. This section of the report provides an overview of what is meant by comprehensive management for flood protection works, including a description of each of the following management activities:

- Routine / Annual Dike Operations, Maintenance, and Minor Repairs;
- Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works;
- Management of Dikes Without a Local Authority;
- Monitoring, Modeling, and Forecasting of River and Flood Processes;
- Flood Hazard Studies and River Management Plans;
- Rehabilitation and Replacement of Pump Stations; and,
- Construction of New Flood Protection Works.

More detail is provided in Appendix 2, regarding specific roles and responsibilities for managing flood protection works, cost estimates for an enhanced proactive program, and case examples to illustrate specific management activities and associated project costs.

Definitions:

- Dike - "an embankment, wall, fill, piling, pump, gate, floodbox, pipe, sluice, culvert, canal, ditch, drain or any other thing that is constructed, assembled or installed to prevent the flooding of land." (*Dike Maintenance Act*).
- Design Flood Level – the flood level that is used in designing and constructing flood protection works such as dikes. Throughout much of BC this is the calculated 1 in 200-year flood plus allowance for hydraulic and hydrologic uncertainty. The design standard for the Fraser River is the 1894 flood of record plus 0.6 metres of freeboard.
- Diking Authority - includes provincial agencies, municipalities and diking districts that own and operate public flood protection works.

Roles and Responsibilities in Managing Flood Protection Works

The roles and responsibilities described in this section (and in Appendix 2) are in accordance with the *Guidelines for the Management of Flood Protection Works in BC* under the authority of the *Dike Maintenance Act*. Although the primary geographic focus of the committee that authored this report has been the Fraser Basin, information presented in this document represents the BC provincial scope. Currently there are 129 local diking authorities, municipalities, and agencies that own and operate approximately 1100 kilometers of public diking systems in BC. Approximately half of these flood protection works are located within the Fraser River Basin while the other half are in other river basins throughout BC.

Under common law and in accordance with pertinent legislation and/or agreements, responsibility for operation and maintenance (including inspection and emergency response) is vested with diking authorities. It is recognized that while local diking authorities have a responsibility in many management activities, some activities in some local areas may not be fully funded due to a limited ability to pay at the local level.

Provincial responsibilities and general supervision relative to the construction and maintenance of dikes lay with the office of the Inspector of Dikes. The provincial Dike Safety Program is delivered through the Deputy Inspector of Dikes in each region. Provincial responsibilities include:

- Approval of all works in and about dikes;
- Monitoring and auditing the owner's dike management program; and,
- An ability to issue orders to protect public safety (where necessary).

In addition, there are over 50 flood protection works in the province that do not have a local authority responsible for management (see section 2.3). The office of Inspector of Dikes regularly inspects these structures to provide information to the BC Flood Plan and to the local authority responsible for emergency planning.

The following are a few examples of the relevant legislation pertaining to flood hazard management:

- *Dike Maintenance Act;*
- *Emergency Program Act;*
- *Water Act; and,*
- *Fisheries Act.*

BC has recently published several important guides and reports to assist local diking authorities in carrying out various management activities, including:

- *Guidelines for the Management of Flood Protection Works in British Columbia;*
- *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment;*
- *Flood Protection Works Inspection Guide;*
- *Rip Rap Design and Construction Guide;*
- *Regulatory Tools for Flood Hazard Management – A Guide for Local Government; and,*
- *Flood Planning and Response Guide.*

In addition to ensuring public safety, there are also management objectives regarding environmental sustainability. For example, there are important roles for Fisheries and Oceans Canada and the BC Ministry of Water, Land, and Air Protection, with respect to flood protection works and the protection of environmental features and functions, including:

- Review the design, construction, and maintenance of flood protection works;
- Provide advice regarding environmental impacts; and,
- Ensure compliance with relevant environmental regulations.

It should be emphasized that all of the management activities outlined in this report (e.g. routine maintenance, major repairs, pump station rehabilitation, etc.) shall include consideration of environmental sustainability and related best practices for environmental protection. See Appendix 1 for an overview of issues, roles, and responsibilities regarding environmental sustainability in relation to flood protection works.

The remainder of section 2 of this report includes descriptions of seven different management activities that are the potential components of a comprehensive management program, as defined within the report.

2.1 Routine / Annual Dike Operations, Maintenance, and Minor Repairs

Routine / annual dike operations, maintenance, and minor repairs include:

- Periodic inspection and performance monitoring;
- Vegetation management and animal control;
- Surveying, repairing, and restoring dike slopes and dike crest profiles;
- Operation and general repairs;
- Securing right-of-ways;
- Floodbox, pump, and pump station maintenance;
- Contingency emergency planning;
- Dike flood patrol; and,
- Emergency measures.

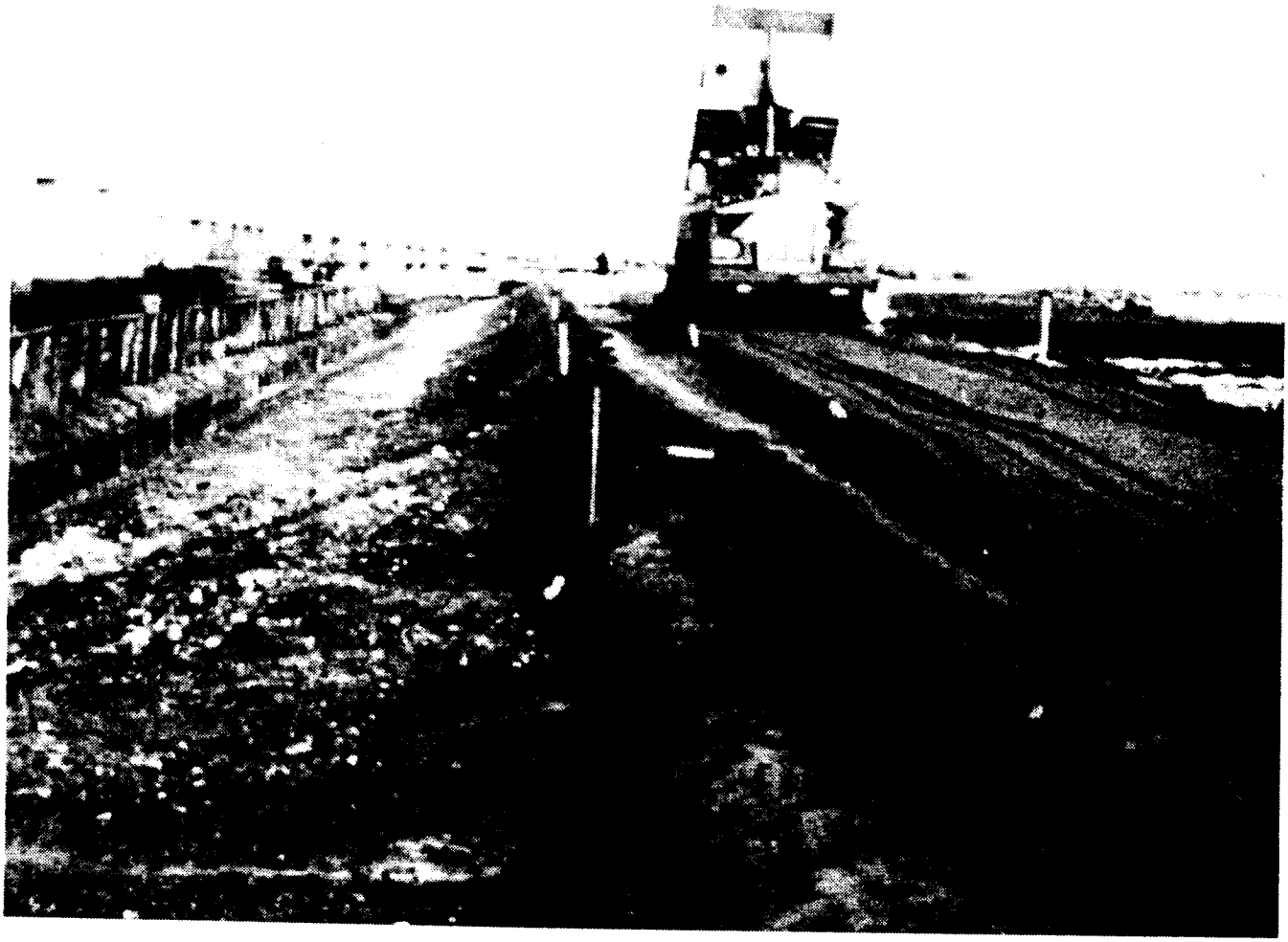
However, this category does not include periodic, non-routine major repairs to dikes or pump stations, nor any activities pertaining to internal drainage works.

Annual dike maintenance includes control of vegetation and burrowing animals to protect the integrity of dike fills, and to ensure effective access and inspection.

2.2 Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works

Major Repairs and Rehabilitation to Dikes and Riverbank Protection
These management activities include activities to repair, rebuild, replace, and rehabilitate primary dikes, and riverbank protection to maintain existing structures in order to meet current standards and/or original design capacities.

Major Improvements and Upgrades to Dikes and Riverbank Protection
These management activities include activities to raise, widen, or strengthen an existing dike, and/or strengthen riverbank protection works to achieve a new design standard.



City of Richmond - Major dike rehabilitation.

2.3 Management of Dikes without a Local Authority

There are over 50 flood protection works throughout BC, which do not currently have a local authority responsible for management. The provincial government is responsible for inspection of these structures. In the absence of annual maintenance activities, many of these structures have deteriorated over time. Many are in rural areas with limited financial resources and technical expertise available.

Maintenance of Dikes without a Local Authority
Maintenance activities include periodic inspection, vegetation management and animal control, slope repairs and restoration, performance monitoring, operation, securing right-of-ways, surveying and restoring dike crest profiles, floodbox maintenance, pump and pump station maintenance, general repairs, contingency emergency planning, dike flood patrol, and emergency measures. The BC Ministry Water, Land, and Air Protection undertakes inspection of flood protection works where there is no local authority responsible for management. Repairs are undertaken under the authority of the BC Flood Plan on an "as needed" basis, depending on the local circumstances and the flood potential.

Major Repairs and Rehabilitation of Dikes Without a Local Authority
These management activities include repairs and rehabilitation of dikes without a local authority to their original design standard, as constructed. There may be significant costs associated with major repairs and rehabilitation.

Upgrade of Dikes Without a Local Authority
These management activities include improvements and upgrades of dikes without a local authority to a higher design standard (e.g. upgrading a dike to the 1:200-year design flood from a lesser standard).

Due to varying local circumstances, it is likely that a combination of options will be required to address dikes without a local management authority. Therefore, local transition strategies are needed to facilitate the implementation of appropriate local solutions. The following list includes several management options:

- Status quo – inspection, emergency planning and response;
- Inform residents about potential flood risks;
- Undertake major repairs, rehabilitation, or upgrades to meet provincial standards;
- Develop partnerships to transfer flood protection structures to local diking authorities;
- Fund budgets for ongoing operations and maintenance;
- Floodproof structures and infrastructure behind these dikes (e.g. houses);
- Remove or decommission flood protection works where necessary to make safe;
- Change legislation to oblige local authorities to adopt flood protection structures; and,
- Place limitations on eligibility for Disaster Financial Assistance Arrangements.

2.4 Monitoring, Modeling, and Forecasting of River and Flood Processes

These management activities include monitoring river and flood level flows, monitoring snowpack levels, weather forecasting, and flood forecasting. The snow and water survey networks are important monitoring programs with respect to flood monitoring, modeling, and forecasting. Therefore it is critical that the federal / provincial hydrometric survey and snow survey networks are maintained over the long-term. Alternatively, it may be necessary to expand, enhance, and/or re-focus these programs over time. A rigorous monitoring program is necessary to track changes in hydrologic patterns that may be related to natural or human-induced climate change. During the freshet, weather forecasts become an increasingly important factor in forecasting river levels. Timely, accurate forecasting is particularly important to assist agencies in local and regional emergency preparedness and response. With respect to flood protection works, forecasting is critical to inform decision-makers regarding flood response and urgent mitigative works such as dike raising, sandbagging, or the construction of temporary berms.

2.5 Flood Hazard Studies and River Management Plans

These management activities include the gathering, analysis, and application of best available knowledge to assist in decision-making with respect to river management. Many local authorities and senior government agencies undertake technical studies to better understand specific flood and erosion hazards (e.g. calculate / update design flood profiles, monitor changes in river channels or riverbanks, identify areas with erosion hazards, quantify bedload movement, analyze accretion and erosion processes). Some times a river management plan or flood hazard management strategy may be developed following the completion of technical studies.

In some cases, long-term, regional river processes such as riverbank erosion, sediment deposition, or channel shifting and avulsion are beyond the management capabilities of individual local diking authorities. Therefore, these processes and related management activities may be considered beyond the realm of routine annual dike operations and maintenance. In these situations, there is often a need to pool financial resources and expertise on a regional scale in order to collect sound technical information, develop management recommendations, and implement appropriate solutions.

2.6 Rehabilitation and Replacement of Pump Stations

Pump stations are identified as a particular challenge for comprehensive management of flood protection works. As a result of dike construction along the lower Fraser River corridor, and development of low lands, there are requirements to manage "internal" drainage behind the dikes. Tributary streams and drainage ditches that once flowed freely into the Fraser must now be collected and released through flood boxes or pumped through the dike system using pumps during high water periods. There may be significant operational costs such as hydroelectricity to pump water. Pumping capability is particularly important to address seepage from the Fraser River during the freshet. A long period of high water (e.g. several weeks) may result in water seeping through diking systems or through the native

soil profile. Pump stations are also required to manage drainage associated with storm events. An additional challenge to managing internal drainage is that in some cases the outfalls of pump stations may be silting in. Therefore, there may be maintenance costs associated with the removal of sediment to maintain pumping ability. Stormwater management practices and master drainage planning are two approaches that may mitigate the demands on pump stations and other internal drainage infrastructure.

Major Repairs and Rehabilitation of Pump Stations
These management activities include activities to repair, rebuild, replace, or rehabilitate pump stations to maintain existing structures in order to meet current standards and/or original design capacities. There may be extremely high costs associated with rebuilding pump stations at the end of their "life-cycle" or with the replacement of certain components.

Major Improvements and Upgrades of Pump Stations
These management activities include activities to raise or strengthen an existing pump station to achieve a new design standard or increased pumping capacity. There could be significant costs associated with upgrading pump stations to handle a higher drainage capacity. For example, with increasing urbanization, there is typically an increase in the quantity and/or peak flow of runoff that must be pumped through the dike system. Therefore increased pumping capacity may be required to prevent internal flooding during storm events. Different kinds of improvements may be required in relation to environmental sustainability. For example, the installation of Archimedes screw pumps may significantly increase fish migration and survival.

2.7 Construction of New Flood Protection Works

These management activities include construction of new flood protection works such as dikes. For the most part, communities throughout British Columbia have already developed substantial flood protection systems. As such, emphasis should be placed on managing these existing works. In some cases however, construction of new flood protection works may be necessary to increase the level of flood protection provided to specific communities, or to complete an existing dike system in a situation where there may be gaps. Therefore there may be a few "one-off" projects that may be undertaken to address specific gaps in the diking system that could undermine existing flood protection works. Although there are some proposals being considered at different levels, the extent to which new works will be constructed is uncertain. The construction of new flood protection works is unique. This expenditure would not continue in perpetuity, therefore this activity should be considered a periodic expenditure, rather than an annual expenditure.

3. Funding Comprehensive Management for Flood Protection Works

Perhaps the most significant challenge to establishing a comprehensive management program is to secure enhanced funding levels from multiple jurisdictions for proactive management activities. This discussion paper is intended to provide a foundation for dialogue and consensus building regarding the establishment of a sustainable funding program and a long-term planning process. To further the process of dialogue regarding a comprehensive management program, two different funding scenarios are compared, including:

- Scenario 1 - Current Funding Levels; and,
- Scenario 2 - Enhanced Proactive Funding.

Appendix 3 includes additional financial details regarding these two different funding scenarios, as well as associated cost estimates, guiding principles for funding, alternative funding models, and specific delivery mechanisms.

3.1 Scenario 1: Current Funding Levels

Scenario 1 describes the status quo in terms of current funding levels for managing flood protection works. At present, aside from discretionary provincial assistance and annual budgets of respective diking authorities, there are no coordinated long-term planning processes, nor permanent funding programs in place to assist local diking authorities in the management of flood protection works. Although there are no coordinated, long-term funding programs in place at present, current funding levels include significant expenditures for a broad range of flood hazard management activities.

Table 1 below provides an overview of estimated expenditures for Scenario 1 - Current Funding Levels. Where known, cost estimates are provided for a period covering the past decade (1990 - 1999). Additional detail regarding Scenario 1 is provided in Appendix 3. For the purposes of this discussion paper a distinction is made between the following types of management activities:

- Regular budgets for proactive management activities - Estimated annual expenditures were $15.4 million / year for these activities between 1990 - 1999;
- Periodic funding for reactive management activities - Estimated annual expenditures were $14.6 million / year for these activities between 1990 - 1999; and,
- Other management activities - Estimated annual expenditures are unknown for managing pump stations and new flood protection works between 1990 - 1999, therefore further research and analysis is required.

Table 1. Estimated Expenditures for Scenario 1 - Current Funding Levels

Note: See Appendix 3, Table 3 for explanatory notes and qualifying remarks pertaining to Table 1.

Type of Management Activities	Estimated Current Expenditures	Who Pays for What?		
		Local Government	Provincial Government	Federal Government
1. Proactive Management Activities	**Annual Costs ($)**	**Annual Costs ($)**	**Annual Costs ($)**	**Annual Costs ($)**
1.1. Routine / Annual Dike Operations, Maintenance, and Minor Repairs	$5,500,000	$5,500,000	Unknown	Unknown
1.2. Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works	$4,000,000	$1,000,000	$3,000,000	Unknown
1.3. Management of Dikes Without a Local Diking Authority	$200,000	Unknown	$200,000	Unknown
1.4. Monitoring, Modeling, and Forecasting of River and Flood Processes	$5,700,000	Unknown	$2,850,000	$2,850,000
1.5. Flood Hazard Studies and River Management Plans	Unknown	Unknown	Unknown	Unknown
Sub-Total for Proactive Management Activities ($)	**$15,400,000**	**$6,500,000**	**$6,050,000**	**$2,850,000**
Sub-Total for Proactive Management Activities (% of Total $)	**100%**	**42%**	**39%**	**19%**
2. Reactive and Responsive Management Activities				
2.1. Disaster Financial Assistance and Urgent Mitigative Flood Works (1999)	$14,730,000	Unknown	$10,630,000	$4,100,000
Sub-Total for Reactive and Responsive Management Activities ($)	**$14,730,000**	**Unknown**	**$10,630,000**	**$4,100,000**
Sub-Total for Reactive and Responsive Management Activities (% of Total $)	**100%**	**0%**	**79%**	**28%**
3. Other Management Activities				
3.1. Rehabilitation and Replacement of Pump Stations	Unknown	Unknown	Unknown	Unknown
3.2. Construction of New Flood Protection Works	Unknown	Unknown	Unknown	Unknown
Total Annual Reactive and Proactive Expenditures ($)	**$30,130,000**	**$6,500,000**	**$16,680,000**	**$6,950,000**
Total Annual Reactive and Proactive Expenditures (% of Total $)	**100%**	**22%**	**55%**	**23%**

3.2 Scenario 2: Enhanced Proactive Funding

Scenario 2 emphasizes the importance of enhanced funding for targeted proactive management activities. This scenario is described as "Enhanced Proactive Funding". The Enhanced Proactive Funding scenario includes an annual investment of $23.5 million to address specific proactive management activities including:

- Routine / Annual Dike Operations, Maintenance, and Minor Repairs;
- Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works;
- Management of Dikes Without a Local Authority;
- Monitoring, Modeling, and Forecasting of River and Flood Processes; and,
- Flood Hazard Studies and River Management Plans.

Specific funding levels are suggested for each management activity, however, the actual expenditures may vary from year to year, depending on local and provincial priorities. Of this $23.5 million, about $15.4 million is already being invested by various levels of government on an annual basis to support proactive management activities (see Table 1).

The management of pump stations and the construction of new flood protection works are somewhat unique in their treatment within this paper. The Enhanced Proactive Funding scenario includes an annual investment of $5 million for the rehabilitation and replacement of pump stations. Current expenditures are likely significant, however these costs are unknown at this time. Therefore further analysis is required. The construction of new flood protection works is unique. This expenditure would not continue in perpetuity, therefore this activity should be considered a periodic expenditure, rather than an annual expenditure. An initial funding envelope of $5 million / year is suggested over a five-year period.

It is impossible to predetermine the future needs for urgent flood mitigation works or the future costs of disaster assistance in association with the Enhanced Proactive Funding scenario. In theory, these costs should be deferred and/or reduced over a period of time, however, the actual long-term cost-savings are unknown.

Four funding models are described below, that may help to achieve the Enhanced Proactive Funding scenario. Additional detail is provided in Appendix 3, including the potential scope of funding partners, the emergent cost-sharing formulae, and the primary challenges. Further analysis is required regarding the merits and limitations associated with each funding model. The four models considered within this discussion paper include:

1. Enhance Annual Government Budgets for Proactive Management - Enhance existing annual budgets for targeted proactive management activities. Three levels of government would contribute according to an agreed upon cost-sharing formula (e.g. 1/3, 1/3, 1/3).

2. Public and Private Sector Collaboration - Engage a broader group of funding partners that benefit from flood hazard mitigation. Enhance existing annual budgets for proactive management with contributions from both the public and private sectors.

3. Integrate Reactive and Proactive Funding Arrangements - Establish a stronger integration between reactive sources of funding (e.g. Disaster Financial Assistance Arrangements) and proactive management activities (e.g. dike rehabilitation).

4. Multiple Accounts Analysis - Undertake an analysis of funding roles and responsibilities, based upon the association of potential funding partners (e.g. governments; Crown Corporations; private sector) with funding criteria (e.g. costs, benefits, ability to pay).

The following funding levels for specific management activities were developed as part of the Enhanced Proactive Funding scenario of this discussion paper. These are order of magnitude estimates of what a proactive multi-year funding program could include.

Routine / Annual Dike Operations, Maintenance, and Minor Repairs
Local diking authorities shall continue to undertake routine annual inspection, operations, and maintenance of flood protection works, with technical support and guidance from the BC Ministry of Water, Land, and Air Protection. The Enhanced Proactive Funding scenario includes an estimated annual investment of $5.5 million. This amount represents the current annual investment.

Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works
A long-term planning and sustainable financing program is required to support major repairs, rehabilitation, and upgrades to flood and erosion protection works that may be beyond the financial ability of some local diking authorities. This could be based upon an expansion of the Flood Protection Assistance Fund or similar arrangement, and should include some form of cost sharing among all parties, including the federal government. The Enhanced Proactive Funding scenario includes an estimated annual investment of $10 million. Of this, $4 million is the current annual investment.

Management of Dikes Without a Local Authority
Dialogue is required between the provincial and local governments to develop appropriate transition strategies to address dikes without a local authority. There may be a role for financial assistance from senior governments in order to repair and rehabilitate some of these structures so they are more readily transferred to local authorities if that is the agreed upon solution. Due to a strong variation in local circumstances, a combination of structural and non-structural management options should be considered in developing locally appropriate solutions. The Enhanced Proactive Funding scenario includes an estimated annual investment of $1 million. Of this, $200,000 is the current annual investment.

Monitoring, Modeling, and Forecasting of River and Flood Processes
It is important to maintain current monitoring and forecasting capabilities, including the hydrometric survey and snow survey networks, the BC River Forecast Centre, Environment Canada's weather forecasting services, and real-time access to this information on the world wide web. It may also be necessary to expand, enhance, and/or refocus current monitoring and forecasting programs to improve local or regional flood forecasting and to improve an understanding regarding climate change impacts. The Enhanced Proactive Funding scenario includes an estimated annual investment of $6 million. Of this, $5.7 million is the current annual investment.

Flood Hazard Studies and River Management Plans
To address regional river processes such as riverbank erosion, sediment deposition, or channel shifting and avulsion, there is a need to collect sound technical information, monitor change, and undertake planning on a regional scale. Similarly, regional cost sharing is recommended (including financial assistance from senior governments) to support technical research, management planning, and implementation. Therefore flood hazard studies and river management planning should be supported by a long-term sustained funding program. The Enhanced Proactive Funding scenario includes an estimated annual investment of $1 million. Current annual expenditures are unknown at this time.

Rehabilitation and Replacement of Pump Stations
There is a need for long-term planning and sustainable funding to assist local diking authorities in the management of pump stations. The Enhanced Proactive Funding scenario includes an estimated annual investment of about $5 million. Current annual expenditures for pump stations are unknown at this time, therefore further analysis is required.

Construction of New Flood Protection Works
Due to the high capital costs associated with the design and construction of new flood protection works, there may be a need for cost-sharing and financial assistance where new flood protection works are warranted. Generally the principle of user-pay, or beneficiary-pay, should apply to the construction of new flood protection works. Beneficiaries could include private landowners, local, provincial, and federal governments, utility companies, the private sector, and others. The Enhanced Proactive Funding scenario includes an estimated investment of about $5 million per year over a period of 5 years.

At present there are no coordinated, long-term programs available to assist in the comprehensive management of flood protection works. Although this discussion paper provides a basis to establish such a program, additional analysis is required regarding specific intergovernmental arrangements for program funding and implementation. Federal, provincial, and local governments should initiate dialogue and negotiations regarding the scope and scale of the required program, potential funding sources and delivery mechanisms, and alternative funding arrangements for implementation. There is a feedback relationship between program design and funding policy. For example, the type, scale, and scope of program that is designed will influence the amount of funding required and potential contributors. Alternatively, the amount of funding available will influence the type, scale, and scope of the program that may be practical to implement.

4. Conclusions and Recommendations

4.1 Significance of the Fraser River Flood Hazard

Flood hazards represent a significant and ongoing threat to community sustainability in the Fraser Basin and throughout BC. Statistically, there is a one-in-three chance of experiencing a Fraser River flood of record in the next fifty years. The influence of climate change on flood frequency is unknown at this time. If major failures occurred in the lower Fraser diking system during the next flood of record, the following impacts could be experienced:

- About 300 000 people requiring evacuation, shelter, and emergency services;
- About $1.8 billion in direct flood damages to private and public property (1994 dollars);
- Unknown additional economic impacts would be experienced due to business disruption associated with direct flood damages and the loss of critical infrastructure such as transportation and utilities; and,
- Environmental impacts including contamination or disruption of water supplies.

4.2 A New Vision for Flood Hazard Mitigation

This discussion paper is intended to provide a foundation to build greater dialogue and consensus regarding the establishment of a comprehensive management program to address some of the critical challenges facing managers of flood hazards now and in the future. Comprehensive management includes a broad spectrum of activities from initial design and construction of flood protection works, through the entire "life-cycle" of these structures. Two essential elements of comprehensive management include:

- Coordinated, long-term planning; and,
- Adequate sustained funding.

Section 1 introduced the topic by highlighting the significance of flood hazards in British Columbia, and a rationale as to why a comprehensive management approach is needed. Section 2 provided an overview of the types of management activities that are the potential components of a comprehensive management program. Section 3 presented two different funding scenarios, providing a comparison of "Current Funding Levels" versus "Enhanced Proactive Funding". Section 4 now concludes the report with a summary of key messages regarding the vision, benefits, and scope of a comprehensive management program.

Flood protection works provide an integral part of flood hazard management in BC, therefore regular maintenance and long-term management are necessary to continue to provide flood protection, mitigate flood damages, and reduce recovery costs. It is estimated that over the past decade in BC, expenditures for managing flood hazards have been on average, about $30 million per year. Of this, about half, $14.6 million per year has been spent compensating for damages after a flood event through Disaster Financial Assistance Arrangements, or constructing urgent mitigative works in preparation for an imminent flood threat. An ongoing, planned approach to managing flood protection works is financially and operationally preferable to the construction of urgent mitigative works. Similarly, mitigation of flood damages by taking preventative measures is financially and socially preferable to recovery and compensation after a flood has occurred. An enhanced investment in

proactive flood mitigation could possibly reduce or defer future flood damages and associated costs. Therefore, the primary recommendation of this discussion paper is that all agencies responsible for flood protection, work together to establish a reliable, long-term, sustained funding program for the ongoing planning and comprehensive management of flood protection works.

The photograph below is provided to illustrate the physical and inter-jurisdictional complexity of flood hazard management. A comprehensive management approach is recommended to help all levels of government manage this complexity and resolve many of the related challenges.

Fraser River in the lower Fraser Valley.

4.3 Benefits of Comprehensive Management

There are numerous economic, social, and environmental benefits of comprehensive management for flood protection works. Some of these benefits include:

- Improved success in reducing flood damages and associated recovery costs;
- Improved ability for local authority work planning and budgeting;
- Improved opportunities for regional planning, collaboration, resource pooling, and general coordination of investment;
- Improved opportunity for rehabilitation / local management of dikes currently without a local authority responsible for management;
- Improved planning, design, and decision making, in comparison with the construction of urgent mitigative works in the face of an imminent flood threat;
- Improved financial efficiency (i.e. project tendering in an "urgent works" scenario is more expensive than tendering well in advance and phasing complex projects);
- Improved alignment of funding arrangements with users and beneficiaries, including all levels of government and the private sector;
- Improved access to funding for local diking authorities with financial need;
- Improved opportunity to accommodate and integrate environmental needs; and,
- Improved governance and avoidance of uncertainty associated with budget cycles.

4.4 Enhanced Proactive Funding for Comprehensive Management

Flood protection works provide an integral part of flood hazard management, therefore there is a need for all managers of flood protection works to adopt a proactive, comprehensive management approach. Comprehensive management includes a broad spectrum of activities from initial design and construction of flood protection works through the entire "life-cycle" of these structures.

To initiate further dialogue regarding the establishment of a long-term sustained funding program for comprehensive management, an Enhanced Proactive Funding scenario has been developed within this discussion paper. The Enhanced Proactive Funding scenario includes an annual investment of $23.5 million to address the following proactive management activities. These are the potential key components of a comprehensive management program, and include:

- Routine / Annual Dike Operations, Maintenance, and Minor Repairs ($5.5 million/year);
- Major Repairs, Rehabilitation, and Upgrades ($10 million/year);
- Management of Dikes Without a Local Authority ($1 million/year);
- Monitoring, Modeling, and Forecasting of River and Flood Processes ($6 million/year);
- Flood Hazard Studies and River Management Plans ($1 million/year).

Although order of magnitude funding levels have been developed for each management activity within this program scenario, the actual expenditures may vary from year to year, depending on local and provincial priorities, and depending on the total amount of funding secured for a comprehensive management program. Of the proposed annual investment of $23.5 million for the Enhanced Proactive Funding scenario, about $15.4 million is already being invested on an annual basis by various levels of government (see Appendix 3). Therefore, the Enhanced Proactive Funding scenario represents an overall increase in investment of $8.1 million/year, or a 53% increase.

The management of pump stations and the construction of new flood protection works are somewhat unique in their treatment within this paper. The Enhanced Proactive Funding scenario could also include:

- An annual investment of $5 million for the rehabilitation and replacement of pump stations; and,
- An investment of $5 million/year over a five-year period for the construction of new flood protection works.

This is in addition to the $23.5 million for proactive management activities identified above. Current expenditures for new works and pump station rehabilitation are unknown at present therefore further analysis is required regarding these important management activities.

4.5 Program Implementation and Project Planning

A permanent cost-sharing program with enhanced funding is needed to implement the proactive, comprehensive management approach being promoted by this paper. Specific project proposals would be submitted to a central coordinating body to assess overall flood protection needs on a multi-year planning cycle (e.g. five-year cycle). Project priorities would be assessed using specified evaluation criteria developed by the participating agencies. Potential criteria could include flood risk / degree of urgency, level of flood protection provided, benefit - cost analyses, and perhaps a criterion pertaining to equitable distribution of program funds.

Following project review and prioritization, a five-year plan would be developed along with annual work plans. The five-year plan would be reviewed and renewed annually as projects are completed and new proposals are submitted. In order to implement long-term planning and comprehensive management it would be beneficial that senior government financial assistance programs and funding mechanisms be harmonized with a five-year budget planning cycle similar to that required in local government planning processes.

At this time it is unclear how different agencies with statutory authority for flood protection would participate in the development and implementation of a long-term comprehensive flood protection program. A collaborative approach is required because no single agency or level of government is able to address flood hazard mitigation on its own. There is a need for all levels of government to work together. Although this report provides a basis to establish such a program, additional dialogue and analyses are required to develop the intergovernmental agreements necessary to fund and implement a comprehensive management program for flood protection works.

Finally, there are many non-structural approaches to reducing flood damages, such as floodplain bylaws, floodproofing designs, and emergency preparedness. Although these activities are outside of the scope of this discussion paper, a comprehensive program to manage flood protection works should be closely linked and integrated with non-structural approaches to ensure effective flood protection. This is fundamental to strengthening an integrated approach to flood hazard management.

Comprehensive Management for Flood Protection Works - Appendices

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Appendix 1. Environmental Sustainability

1.1 Flood Protection Works and Environmental Sustainability

Issues of environmental sustainability pose new challenges for the management of flood protection works. There are many differing perspectives regarding environmental sustainability. Careful thought and planning are required to simultaneously achieve flood protection and environmental protection objectives. There is an increasing awareness and understanding that flood protection works may have significant detrimental effects on ecosystem values and functions. Historically streams and rivers have undergone significant impacts through the development of flood protection works, such as:

- Destruction and alienation of habitat (e.g. dikes and flood boxes fragment watercourses and simplify fish and wildlife habitat); and,
- Interruption of migration routes and fish mortality due to pump stations.

Riparian vegetation provides vitally important habitat for fish, birds, and other wildlife species, including migratory species. However, public safety considerations for dike maintenance may involve substantial removal of vegetation and subsequent loss of habitat. Similarly, there is a need to control burrowing animals to ensure the integrity of diking systems. Vegetation control can greatly enhance the effectiveness of monitoring and controlling burrowing animals, however this simplifies both aquatic and terrestrial habitat. Bank protection such as riprap may also reduce the ecological structure, value, and diversity of riverbank habitat. The document *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* is intended to address the basic dike safety needs and identify some opportunities to retain habitat through vegetation management.

Dikes are also associated with pump stations and flood boxes to manage the internal drainage of watercourses behind the dikes. However, dikes, flood boxes, and pump stations may prevent fish from migrating into important spawning and rearing habitats located within the tributary systems behind the dikes. Pump stations in particular may kill fish through grinding. Fisheries and Oceans Canada has undertaken a study on pumps in relation to fish migration and mortality. As pumps are rebuilt, there may be an opportunity, or perhaps a requirement, to implement fish-friendly technologies such as Archimedes screw pumps. It is noted that if fish-friendly pumps can be fitted to existing pump station housing, this could significantly reduce the costs associated with this capital improvement. As flood boxes are replaced over time, there may be opportunities to adopt designs that better enable fish passage.

Through creative problem solving, innovative design, and best management practices for construction and maintenance, environmental objectives (e.g. food supplies, cover, etc.) may be achieved while ensuring a high standard of flood protection and public safety. Ideally, productive, functional streamside habitat may be maintained without compromising dike safety. However, environmentally sound management practices, for habitat mitigation or compensation, may come with increased costs, or may require additional research or technical support. This can be particularly challenging for local governments with finite capital budgets. Therefore, there is a need to develop and promote environmentally sound designs and practices that are both technically and economically viable.

The achievement of environmental objectives through design, construction, and operations may trigger new funding opportunities through habitat stewardship programs or green infrastructure programs to help offset any incremental costs associated with environmental sustainability. With time, affordable designs and technologies will emerge to mitigate environmental impacts while ensuring public safety.

1.2 Roles and Responsibilities for Environmental Sustainability

There are important roles for Fisheries and Oceans Canada and the BC Ministry of Water, Land, and Air Protection, with respect to flood protection works and the protection of environmental features and functions, including:

- Review the design, construction, and maintenance of flood works;
- Provide advice regarding environmental impacts; and,
- Ensure compliance with relevant environmental regulations.

These agencies recently published the *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* is intended to address the basic dike safety needs and identify some opportunities to retain habitat through vegetation management. In some cases there may be an advisory role for other agencies such as the Canadian Wildlife Service of Environment Canada.

It should be emphasized that all of the management activities outlined in this report (e.g. routine maintenance, major repairs, pump station rehabilitation, etc.) shall include consideration of environmental sustainability and related best practices for environmental protection. The federal policy regarding fish habitat is to work towards a net gain in total habitat. There is a role for environment agencies to provide advice and technical support to enhance progressive thinking and to encourage the proactive protection of fish and wildlife habitat. There is a role for all levels of government to work together to continue to resolve real and perceived conflicts between flood protection and habitat protection.

A variety of approaches and techniques may help in resolving potential conflicts between public safety and environmental protection. Some suggestions include:

- Improved communication, awareness, support, and coordination between local, provincial, and federal field staff and policy makers;
- Work plans and on-site visits by multiple agencies and interests for dialogue, understanding, and problem solving (e.g. Diking Authority, Inspector or Deputy Inspector of Dikes, Habitat Engineers, Conservation Officers, landowners);
- Public education about the importance of public safety and environmental protection;
- Develop alternative strategies and identify opportunities for creative, win-win solutions;
- Integrate environmental protection into the design, alignment, and construction of new flood protection works or during rehabilitation of existing works;
- Topping and/or thinning of existing mature trees may reduce the risk of blow down, thereby increasing the stability of root systems; and,
- Planting new trees and shrubs within containers to protect the integrity of dike fills by containing root systems.

Different solutions may apply in different circumstances, therefore collaboration and creative problem solving will be necessary to resolve environmental protection issues in relation to specific flood protection projects.

Appendix 2. Flood Protection Works - Roles, Responsibilities, Cost Estimates, and Case Examples

Appendix 2 provides an overview of roles and responsibilities, cost estimates, and case examples regarding the following components of a comprehensive management program:

- Routine / Annual Dike Operations, Maintenance, and Minor Repairs;
- Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works;
- Management of Dikes Without a Local Authority;
- Monitoring, Modeling, and Forecasting of River and Flood Processes;
- Flood Hazard Studies and River Management Plans;
- Rehabilitation and Replacement of Pump Stations; and,
- Construction of New Flood Protection Works.

An attempt has been made to develop order of magnitude cost estimates for the various management activities. Cost estimates are provided for both current funding levels and an enhanced proactive funding program. The cost estimates were identified through consultation with several local, provincial, and federal agencies. Specific case examples are also included in Appendix 2 to illustrate typical flood and erosion protection requirements, as well as representative cost estimates. The case examples are not intended to represent an all-inclusive listing of flood protection needs, nor do they necessarily represent regional or provincial priorities. The cost estimates have been prepared using a cross section of different data sources that use different accounting methods and procedures, and have varying degrees of accuracy. Therefore, the accuracy of the cost estimates is considered order of magnitude.

2.1 Routine / Annual Dike Operations, Maintenance, and Minor Repairs

Roles and Responsibilities

The roles and responsibilities described below are in accordance with the *Guidelines for the Management of Flood Protection Works in BC* under the authority of the *Dike Maintenance Act*. The Diking Authority is responsible for local management including all of the management activities outlined above. Local Diking Authorities fund and undertake maintenance programs with varying financial and technical capabilities. The Ministry of Water, Land, and Air Protection, Water Management (Office of the Inspector of Dikes) oversees the administration of the dike safety program, and the establishment of standards, policy, procedures, and regulations. There are provincial roles in providing approvals, auditing, monitoring, and regional advice.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
$5.5 million / year	$5.5 million / year

These cost estimates include work on dikes and associated contractor costs, however they do not include overhead, municipal staff time, vehicles, nor supervision. Nor do they include

the costs of internal drainage and pumping (maintaining drainage ditches, storm sewers, or other works that are not on or within a dike). A survey of local diking authorities was undertaken in recent years. The survey results were used in developing an approximate average cost of about $5 / linear meter for annual maintenance activities. This average maintenance cost was multiplied by the 1100 km of dikes in BC to develop a cost estimate of $5.5 million per year on a province-wide scale. It should be noted that the actual costs for individual diking authorities are highly variable depending on local conditions and numbers of floodboxes and pumps.

Case Examples

Local Authority (kilometers of dike)	Estimated Annual Cost	Estimated Annual Cost / Kilometer of Dike
City of Abbotsford (15.7 km)	$ 401,700 / year	$25,586 / km [1]
City of Chilliwack (44 km) [2]	$ 398,000 / year	$9,045 / km
Corporation of Delta (61 km)	$ 75,000 / year	$1,230 / km
District of Kent (18.5 km)	$ 101,000 / year	$5,460 / km
City of Port Coquitlam (18.4 km) [3]	$ 129,000 / year	$7,011 / km

1. Estimated maintenance costs for the City of Abbotsford include significant costs for pump operation and maintenance. About $65,000 is spent on maintaining the actual dike structures while the remaining costs relate to pumps.
2. About 8 km of the dike within the City of Chilliwack are roadways acting as dikes, and thus are maintained from the road budget rather than the dike budget. The costs noted above reflect the dike budget.
3. A portion of the dike listed for the City of Port Coquitlam lies within the City of Coquitlam. The City of Port Coquitlam maintains this under an inter-municipal agreement.

2.2 Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works

Roles and Responsibilities

Local diking authorities are responsible for ensuring that funds are available for contingency, repairs, and rehabilitation. In many cases, major repairs and improvements are undertaken within the local dike maintenance programs. It is recognized that, while local diking authorities have a responsibility in many of the identified activities, some activities in some local areas may not be fully funded due to a limited ability to pay at the local level.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
$4 million / year	$10 million / year

In recent years, the provincial government has provided financial assistance to local diking authorities under the BC Flood Protection Assistance Fund (FPAF). This program has been funded over the past four fiscal years to support major repairs and rehabilitation of existing

flood protection works. This is a $4 million cost-shared program including a 75% contribution from BC and a 25% contribution from local partners. Although this is not a long-term program with secured funding, it is a critical program that supports the management of flood protection works. Historically, the Fraser River Flood Control Program (1968-1995) provided provincial and federal support for rehabilitation and improvements in the Fraser River diking system.

There may also be an investment in urgent flood mitigation works by different levels of government if there is an imminent flood threat. For example in the spring of 1999, local, provincial, and federal governments invested approximately $16 million toward major repairs, rehabilitation, and upgrades to flood and erosion protection works in preparation for the spring freshet. A very high snowpack and an associated flood threat triggered a significant level of activity. Twelve municipalities in the lower Fraser Basin were informally surveyed regarding the local investment in urgent flood mitigation works. Approximately $1.5 million was spent by local governments in preparation for the 1999 freshet (average of $125,000 per municipality). Although the survey was unable to capture province-wide information on municipal expenditures, these figures do indicate a significant local contribution towards major repairs, rehabilitation, and upgrades.

The cost estimates for the Enhanced Proactive Funding scenario, are based on a Ministry of Water, Land, and Air Protection inventory and staff experience, including a recent survey of local diking authorities, the first two years of applications to the BC Flood Protection Assistance Fund, and submissions for assistance for urgent mitigative works in preparation of the 1999 freshet. These estimates do not include securing right-of-ways. It has been suggested that project budgets may require an additional 10% if it is necessary to secure additional right-of-ways.

Case Examples

Project	Estimated Project Cost
Corporation of Delta - Dike Toe Repairs - Rip Rap Upgrades	 $1,000,000 ($200,000 / year * 5 yrs) $1,500,000 ($300,000 / year * 5 yrs)
City of Chilliwack - Preparation for 1999 freshet - Major Riverbank Repairs in Minto Channel - Major Dike Rehabilitation to address Flood Profile / Dike Crest Deficiencies	 $ 481,000 $ 125,000 $7,000,000
City of Abbotsford - Discretionary Projects - Matsqui Dike Upgrade (for dike raising, widening, engineering) - Matsqui Dike / Beharel Road Erosion Protection	 $ 152,000 / year $ 450, 000 $7,000,000 (total estimated; or $3,000,000 for the most urgent erosion processes)
District of Kent - Major Dike Rehabilitation to address Flood Profile / Dike Crest Deficiencies	$3,400,000

2.3 Management of Dikes without a Local Authority

Roles and Responsibilities

There are over 50 flood protection works throughout BC, which do not currently have a local authority responsible for management. The BC Ministry Water, Land, and Air Protection undertakes inspection of flood protection works where there is no local authority responsible for management. Repairs are undertaken under the authority of the BC Flood Plan on an "as needed" basis, depending on the local circumstances and the flood potential for that area.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
$200 000 / year (in 2001)	$1 million / year

These estimates are based on a Ministry of Water, Land, and Air Protection inventory and staff experience. Approximately $200 000 is being expended in 2001/02 by BC for dikes without a local authority. The Enhanced Proactive Funding scenario does not include costs associated with securing right-of-ways, nor rehabilitation of all 50 dikes without a local authority in BC. The total cost to rehabilitate or upgrade all of these works could total up to $40 million. However, it should be recognized that there will likely be a wide range of costs for different circumstances and for different management options. Not all of these structures would include a favourable cost-benefit ratio to justify upgrading.

Case Examples

Project	Estimated Project Cost
Malakwa	$ 2,000 - $ 25,000
Mission Creek	$60,000 - $500,000
Birch Island	$ 5,000 - $ 80,000

2.4 Monitoring, Modeling, and Forecasting of River and Flood Processes

Roles and Responsibilities

The snow and water survey networks are funded primarily from provincial and federal contributions with some contributions from BC Hydro, Forest Renewal BC, local government, and the private sector. In addition to these monitoring programs, the Provincial Government provides forecasting services such as river runoff reports through the BC River Forecast Centre. The Federal Government provides a lead role in monitoring through the Water Survey of Canada and through the collection and analysis of meteorological data for weather forecasting. The *Canada – BC Hydrometric Agreement* outlines how senior levels of government work together and jointly fund the monitoring of river and flood levels. In recent years, near real-time data on river and lake levels has been available by BC and Canada on the internet at the following website: http://scitech.pyr.ec.gc.ca/water/Map.asp.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
$5.7 million / year	$6 million / year

The cost estimates above were developed using budget information from the provincial government. See case examples below.

Case Examples

Program	Estimated Annual Cost
Snow Survey Network	$ 800,000 / year
Federal / Provincial Hydrometric Survey	$4,666,000 / year
BC River Forecast Centre	$ 200,000 / year
World-Wide Web Access to River Levels	$ 60,000 / year

2.5 Flood Hazard Studies and River Management Plans

Roles and Responsibilities

Several provincial, federal, local, and First Nations authorities, and other stakeholders have a variety of roles and responsibilities that relate to river management studies, plans, and strategies. In fact there are many overlapping jurisdictions with respect to the management of rivers, flood protection works, and related issues. There are examples of river management plans being developed to address specific flood or river issues, however there are no ongoing programs to undertake or oversee river management planning, nor is there a lead agency with the mandate for developing and implementing river management plans. In some cases lead agencies emerge out of necessity to address critical issues. For example, individual federal, provincial, and local agencies may undertake flood and erosion studies on an ad hoc basis. The BC Flood Protection Assistance Fund may support technical studies regarding provincially significant flood and erosion hazards. For the most part, the emphasis of this fund is the management of flood protection works; therefore there are limited financial resources available to support flood hazard studies.

It is recognized that in many cases, long-term, regional river processes such as riverbank erosion, sediment deposition, or channel shifting and avulsion are beyond the management capabilities of individual local diking authorities. Therefore, these processes and related management activities may, in many cases, be considered beyond the realm of routine annual dike operations and maintenance. In these situations, there is a need to collect sound technical information, develop management recommendations, and share financial resources on a regional scale to implement appropriate solutions.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
Unknown	$1 million / year

It is very difficult to anticipate the types of river studies or management plans that may be required throughout BC. Typically such studies are undertaken after the occurrence of damaging events which provide evidence of changing conditions. Consequently it is very difficult to estimate the associated costs. The need for, and cost of, technical studies and management plans will depend upon the availability and accuracy of existing information, the geographic scale of the study area(s), and the severity of the perceived flood and erosion hazards. Costs can be expected to vary in relation to the geographic scale of the planning area, the scope of issues to be addressed in the plan / strategy, the timeline of the planning process, and the number of agencies and stakeholders involved.

Case Examples

Project	Estimated Project Cost
Corporation of Delta - River and shoreline monitoring	$ 75,000 over five years
City of Chilliwack - Fraser River Flood Erosion, and Habitat Studies	$ 750,000 - $1,000,000 ($250,000 / year * 3 or 4 years)
Delta - Fraser River channel dynamics study	$ 250,000 ($50,000 / year * 5 years)
Fraser River Management Plan: Hope to Mission[1]	$ 140,000 ($70 000 / year * 2 years)

1. A two-year planning process has been initiated in the lower Fraser to incorporate new technical information and stakeholder input into a Fraser River management plan from Hope to Mission. The project budget includes a project coordinator and expenses such as meetings, travel, printing of planning materials, etc.

2.6 Rehabilitation and Replacement of Pump Stations

Roles and Responsibilities

Local diking authorities are responsible for ensuring that funds are available for contingency, repairs, and rehabilitation. Local governments are responsible for stormwater management. It is recognized that, while local diking authorities and/or local governments have a responsibility in many of the identified activities, some activities in some local areas may not be fully funded due to a limited ability to pay at the local level. Various provincial programs have provided discretionary assistance in the past. There is no current program of assistance for pump station repairs, rehabilitation, or upgrading. Historical programs of provincial and federal support include the Fraser River Flood Control Program (1968-1995), and the ARDSA Program (ended in 1990).

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
Unknown	$5 million / year

Annual cost estimates for the management of pump stations were not available for this report. In addition, the costs associated with different management activities are quite variable due to differing sizes, ages and condition of pump stations. It is unclear what scope of management activities is required for the various pump stations over what timeline without a comprehensive survey of existing facilities. For example, how many pump stations require rehabilitation of existing structures versus replacement? If pump station upgrades are required, is this due to a need for higher pumping capacity as a result of urban development or is this due to flood hazards associated with the Fraser River? Eventually all Lower Fraser pump stations will require some form of rehabilitation, replacement, or rebuilding. Most of the existing pumps were built between 1968 – 1995 or earlier.

Case Examples

Project	Estimated Project Cost
Corporation of Delta - Floodbox Upgrades - Pump station Upgrades	 $750,000 ($150,000 / year * 5 years) $2,500,000 ($500,000 / year * 5 years)
City of Chilliwack - Pump Station Repairs	 $340,000 ($85,000 / year * 4 years)
City of Port Coquitlam - Pump Station Repair and Upgrade	 $1,500,000 (1 year)
City of Abbotsford - Pump Station Operation, Maintenance, and Repairs	$2,500,000 ($500,000 / year * 5 years)
Port Coquitlam - Pump Station Operation, Maintenance, and Repairs	$ 99,000 / year
District of Kent - Major Pump Station and Floodbox Repairs and Upgrades	$7,500,000

2.7 Construction of New Flood Protection Works

Roles and Responsibilities

Generally the principle of user-pay, or beneficiary-pay, should apply to the construction of new flood protection works. However, the Provincial Government may provide discretionary assistance where appropriate. For example, the BC Flood Protection Assistance Fund may provide assistance for the construction of new flood protection works. However this funding program emphasizes major repairs and the management of existing flood protection works. The ability of current funding levels to meet the diversity of local needs is limited. Many local diking authorities have identified the need for increased funding assistance to support the construction of new flood protection works.

Cost Estimates and Explanatory Notes

Current Funding Levels	Enhanced Proactive Funding Scenario
Unknown	$5 million / year * 5 years

It is extremely difficult to develop cost estimates regarding the construction of new flood protection works on a basin-wide or province-wide basis. This is to due to the following circumstances:

- The emphasis of this document is placed on the proper management of existing flood protection works. It is important to secure funding for the management of existing works prior to increasing the total amount of flood protection works in British Columbia.
- There are numerous social, economic, and environmental factors that must be considered in determining the need for, and design of, new flood protection works. The actual sizes, locations, and designs of individual projects are therefore highly variable, and the related costs are similarly variable. This poses challenges in the development of cost estimates.
- The construction of new flood protection works is not an ongoing, annual management activity to be undertaken over the long-term. Therefore, this does not represent an ongoing annual expenditure. It is anticipated that where warranted, the construction of new works would be addressed over a specified period. For example, funding arrangements could provide for an investment of $5 million / year over a period.

The cost estimates above are based on known areas of concern, such as the City of Kamloops, where significant populations do not currently have protection but are at risk of flooding.

Case Examples

Project	Estimated Project Cost
North Kamloops Dike	$17,000,000
City of Richmond Mid-Island Dike	$10,000,000
City of Chilliwack - Riverbank Protection of Ferry Island / Island 32 - Riverbank Protection of Island 22	 $ 500,000 $ 1,500,000
City of Coquitlam Dike	$ 5,300,000 (excluding property acquisition)

Appendix 3.
Funding Comprehensive Management for Flood Protection Works

3.1 Scenario 1: Current Funding Levels

Scenario 1 describes the status quo in terms of current funding levels for managing flood protection works. At present, aside from discretionary provincial assistance and annual budgets of respective diking authorities, there are no coordinated long-term planning processes, nor permanent funding programs in place to assist local diking authorities in the management of flood protection works. Although there are no coordinated, long-term funding programs in place at present, current funding levels include significant expenditures for a broad range of flood hazard management activities. Tables 2 and 3 below provide an overview of estimated expenditures for Scenario 1 - Current Funding Levels. Where known, cost estimates are provided for a period covering the past decade (1990 - 1999). A distinction is made between the following types of management activities:

1. Regular budgets for proactive management activities - Estimated annual expenditures were $15.4 million / year for these activities between 1990 - 1999;
- Routine / Annual Dike Operations, Maintenance, and Minor Repairs;
- Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works;
- Management of Dikes Without a Local Authority;
- Monitoring, Modeling, and Forecasting of River and Flood Processes; and,
- Flood Hazard Studies and River Management Plans;

2. Periodic funding for reactive management activities - Estimated annual expenditures were $14.6 million / year for these activities between 1990 - 1999; and,
- Disaster Financial Assistance Arrangements for post-disaster recovery; and,
- Urgent Flood Mitigation Works to prepare for an imminent flood threat.

3. Other management activities - Estimated annual expenditures are unknown for managing pump stations and new flood protection works between 1990 - 1999:
- Rehabilitation and Replacement of Pump Stations; and,
- Construction of New Flood Protection Works.

3.1.1 Regular Budgets for Proactive Management Activities

Local Government

- Local diking authorities establish annual budgets for management activities such as routine dike maintenance, inspection, and repairs.
- Many diking authorities build contingency funds over time to address larger capital expenses such as major repairs or dike rehabilitation.
- In addition to dike maintenance, local authorities also incur significant costs associated with the maintenance of internal drainage works such as ditches, culverts, and storm sewers. These drainage maintenance costs are significant, however they are not directly related to flood protection works therefore they are not included in the financial analysis of this report.

Provincial Government

- The BC Flood Protection Assistance Fund is a provincial program that is available to provide financial assistance to local diking authorities for flood protection works. Although funding within this program has been approved each of the last four years, this is reviewed on an annual basis. Therefore, there is no long-term certainty regarding the status of this cost-shared program.
- The provincial government contributes to the snow and hydrometric survey networks.
- The provincial government funds the BC River Forecast Centre.

Federal Government

- In July 2001, the department of Indian and Northern Affairs Canada announced funding approval in the amount of $3.5 million for the fiscal year 2001 - 2002, to address high priority flood and erosion projects on First Nations lands in BC. It is unclear at this time whether or not this initiative will be limited to a one-time investment, or if it will translate into an ongoing annual expenditure for flood protection works.
- The federal government contributes to the snow and hydrometric survey networks.
- The federal government provides weather forecasting services.

3.1.2 Periodic Funding for Reactive Management Activities

All levels of government have the ability to allocate periodic, or discretionary, funding to prepare for, or respond to, an imminent flood threat. Similarly, Disaster Financial Assistance Arrangements (DFAA) are available for recovery, rehabilitation, and clean up after a flood event. Cost estimates of periodic funding contributions from government between 1990 and 1999 are described in Table 2.

Urgent Mitigative Works (1999)

The 1999 Fraser River freshet provides an interesting case study of discretionary funding for what is commonly referred to as "urgent flood mitigation works". These works generally involve major repairs, rehabilitation, or upgrades to dikes, pump stations, floodgates, or riverbank erosion protection in preparation for a possible flood event. In the spring of 1999 local, provincial, and federal levels of government all contributed funding towards urgent mitigative works in response to the very high snowpack in the southern half of BC and the associated flood threat. For the province of BC, urgent mitigative works are expenditures that are eligible for DFAA. For the federal government, urgent works are not DFAA eligible.

About $16 million was invested in urgent mitigative works, by all levels of government in preparation for the 1999 freshet (See Table 2). This may suggest that annual funding levels are not adequate to meet ongoing flood protection needs. Apparently there is a need for a periodic "catch-up" that is triggered by a specific flood threat in a given year. In the context of an imminent flood threat, it makes sense to strengthen and reinforce flood protection works to protect BC communities. However, it could be argued that the urgent work that was undertaken could have, and perhaps should have, been undertaken well in advance of the 1999 freshet. In the context of an imminent flood threat, there is strong competition for resources such as equipment, materials, and technical expertise. If these works were

planned and implemented over the long-term, on an ongoing basis, there would be opportunities for better design and construction, lower costs, and less public panic.

Disaster Financial Assistance Arrangements (1990 - 1999)

Provincial and federal governments provide financial assistance for flood recovery under the *Canada-BC Disaster Financial Assistance Arrangements*. Post-disaster expenses that are eligible for DFAA include repair of major damages to flood control structures (and other infrastructure and private property) caused by a specific flood event. The DFAA agreement is noted within this report because flood protection works such as dikes and riverbank erosion protection may be damaged during a flood event. Therefore DFAA may be applied to the restoration of flood protection works to their pre-disaster state.

Over the last ten years, the provincial government has spent about $100 million in DFAA and the federal government has spent about $31 million in DFAA in BC. It is very difficult to predict future disaster costs because these are highly variable, and there is significant uncertainty about the location, frequency, and magnitude of future flood events. In general, DFAA payments are increasing. The costs of weather-related disasters in Canada – ice storms, floods and droughts – have skyrocketed over the past 15 years, rising by 20 to 30 times. The federal government paid out $1.2 billion in disaster assistance in 1998 - more than the previous 15 years combined. This trend will be greatly exacerbated with the occurrence of the next Fraser River flood of record. An additional investment in flood hazard mitigation could possibly reduce future flood damages and associated recovery costs.

Table 2. Overview of Disaster Financial Assistance Arrangements (DFAA) and Urgent Mitigative Works (UMW) Expenditures (1990-1999)

Level of Government	DFAA / UMW Expenditures (1990 - 1999) ($)
1. Provincial (DFAA)	$100,300,000
2. Provincial (UMW)	$6,000,000
3. Federal (DFAA)	$31,000,000
4. Federal (UMW for First Nations lands in BC)	$10,000,000
5. Local (UMW)	Unknown
Total Expenditures	$147,300,000
Average Annual Expenditures	$14,730,000

Explanatory Notes and Qualifying Remarks for Table 2:

1. This figure ($100.3 million) includes total Disaster Financial Assistance Arrangements payments by the provincial government for flood-related disasters between 1990 - 1999.

2. This figure ($6 million) includes urgent flood mitigation works that were funded by BC in preparation for the 1999 freshet.

3. The federal government has reimbursed the provincial government in the amount of $31 million between 1990 - 1999 through Disaster Financial Assistance Arrangements.

4. The federal government spent about $10 million in constructing urgent mitigative flood works for First Nations' lands in BC in preparation for the 1999 freshet.

5. Local government expenditures on urgent mitigative works are unknown, however an informal survey of Lower Mainland municipalities in 1999 indicated that twelve local governments collectively spent $1.5 million on urgent works, or about $125,000 each in preparation for the 1999 Fraser River freshet.

Table 3. Estimated Current Expenditures for Flood Hazard Management

Type of Management Activities	Estimated Current Expenditures	Who Pays for What?		
		Local Government	Provincial Government	Federal Government
1. Proactive Management Activities	**Annual Costs ($)**	**Annual Costs ($)**	**Annual Costs ($)**	**Annual Costs ($)**
1.1. Routine / Annual Dike Operations, Maintenance, and Minor Repairs	$5,500,000	$5,500,000	Unknown	Unknown
1.2. Major Repairs, Rehabilitation, and Upgrades to Flood Protection Works	$4,000,000	$1,000,000	$3,000,000	Unknown
1.3. Management of Dikes Without a Local Diking Authority	$200,000	Unknown	$200,000	Unknown
1.4. Monitoring, Modeling, and Forecasting of River and Flood Processes	$5,700,000	Unknown	$2,850,000	$2,850,000
1.5. Flood Hazard Studies and River Management Plans	Unknown	Unknown	Unknown	Unknown
Sub-Total for Proactive Management Activities ($)	**$15,400,000**	**$6,500,000**	**$6,050,000**	**$2,850,000**
Sub-Total for Proactive Management Activities (% of Total $)	**100%**	**42%**	**39%**	**19%**
2. Reactive and Responsive Management Activities				
2.1. Disaster Financial Assistance and Urgent Mitigative Flood Works (1999)	$14,730,000	Unknown	$10,630,000	$4,100,000
Sub-Total for Reactive and Responsive Management Activities ($)	**$14,730,000**	**Unknown**	**$10,630,000**	**$4,100,000**
Sub-Total for Reactive and Responsive Management Activities (% of Total $)	**100%**	**0%**	**79%**	**28%**
3. Other Management Activities				
3.1. Rehabilitation and Replacement of Pump Stations	Unknown	Unknown	Unknown	Unknown
3.2. Construction of New Flood Protection Works	Unknown	Unknown	Unknown	Unknown
Total Annual Reactive and Proactive Expenditures ($)	**$30,130,000**	**$6,500,000**	**$16,680,000**	**$6,950,000**
Total Annual Reactive and Proactive Expenditures (% of Total $)	**100%**	**22%**	**55%**	**23%**

Explanatory Notes and Qualifying Remarks for Table 3:

1.1 The *Dike Maintenance Act* and the *Guidelines for the Management of Flood Protection Works in BC* outline the roles and responsibilities of diking authorities for routine maintenance, including:

- Periodic inspection and performance monitoring;
- Vegetation management and animal control;
- Surveying, repairing, and restoring dike slopes and dike crest profiles;
- Operation and general repairs;
- Securing right-of-ways;
- Floodbox, pump, and pump station maintenance;
- Contingency emergency planning;
- Dike flood patrol; and,
- Emergency measures.

These cost estimates include work on dikes and associated contractor costs, however they do not include overhead, municipal staff time, vehicles, nor supervision. Nor do they include the costs of periodic, non-routine major repairs to dikes or activities associated with internal drainage and pumping (maintaining drainage ditches, storm sewers, or other works that are not on or within a dike). A survey of local diking authorities was undertaken in recent years. The survey results were used in developing an approximate average cost of about $5 / linear meter for annual maintenance activities. This average maintenance cost was multiplied by the 1100 km of dikes in BC to develop a cost estimate of $5.5 million per year on a province-wide scale. It should be noted that the actual costs for individual diking authorities are highly variable.

1.2 The BC Flood Protection Assistance Fund assists local diking authorities in managing flood protection works. This program focuses on major repairs and rehabilitation of existing works, however some technical studies and other miscellaneous management activities may be eligible. This is a $4 million cost shared program (75% contribution from the province and 25% contribution from local diking authorities). Funding has been approved for this program on an annual basis over the past four fiscal years.

1.3 The BC Ministry of Water, Land, and Air Protection undertakes inspection of flood protection works without a local diking authority responsible for management. Repairs are undertaken under the authority of the BC Flood Plan on an "as needed" basis, depending on the local circumstances and flood potential. The estimated current expenditure of $200,000 represents the expenditure for the 2001 / 2002 fiscal year.

1.4 The snow and water survey networks are funded primarily from provincial and federal contributions with some contributions from BC Hydro, local government, and the private sector. For the purposes of this document, it has been estimated that there is a 50% split between provincial and federal contributions toward monitoring programs. Although there may be some local expenditures for monitoring, the contribution from local governments is unknown at this time, and is believed to be a relatively minor component of total expenditures. The cost estimates were developed using budget information from the provincial government:

- The annual budget for the federal / provincial hydrometric survey network is about $4.7 million;
- The annual budget for the snow survey network is about $800 000; and,
- The annual budget for the BC River Forecast Centre is about $200,000.
- Therefore the total for monitoring and forecasting is $5.7 million.

1.5 Current expenditures for flood hazard studies and river management plans are unknown at this time. They are believed to be minor expenditures at present, and are grouped with line item 1.2 due to funding through the BC Flood Protection Assistance Fund. For the purpose of calculations undertaken in Table 3, a value of "$0" is applied to any spreadsheet cells where cost estimates are "Unknown".

2.1 Current expenditures on DFAA and Urgent Mitigative Works are estimated to have been approximately $146 million over the past decade (See Table 2). This is an average of about $14.6 million / year. There are no local contributions involved in DFAA, however there may on occasion be local expenditures for urgent mitigative works throughout the Fraser Basin and throughout BC. Local expenditures on UMW between 1990 – 1999 are unknown at this time. However an informal survey of twelve lower Fraser Basin municipalities in 1999 recorded a collective expenditure of about $1.5 million in preparation for the 1999 freshet.

3.1 There <u>are</u> ongoing expenditures for the management of pump stations; however, current expenditures are unknown at this time. For the purpose of calculations undertaken in Table 3, a value of "$0" is applied to any spreadsheet cells where cost estimates are "Unknown".

The cost estimates provided above have been prepared using a cross section of different data sources (See Appendix 3.6) that use different accounting methods and procedures, and have varying degrees of accuracy. Therefore, the accuracy of the cost estimates is considered order of magnitude.

Table 4. Enhanced Proactive Funding versus Current Investments in Flood Protection Works

Type of Management Activities	Alternate Funding Scenarios	
	Enhanced Proactive Funding	Current Funding Levels
	Annual Costs ($)	Annual Costs ($)
1. Proactive Management Activities		
1.1. Routine Maintenance and Minor Repairs	$5,500,000	$5,500,000 *(100% Local)*
1.2. Major Repairs, Rehabilitation, and Upgrades	$10,000,000	$4,000,000 *(25% Local)* *(75% Provincial)*
1.3. Dikes Without a Local Diking Authority	$1,000,000	$200,000 *(100% Provincial)*
1.4. Monitoring and Modeling of River and Flood Processes	$6,000,000	$5,700,000 *(50% Provincial)* *(50% Federal)*
1.5. Flood Hazard Studies and River Management Plans	$1,000,000	Unknown
Sub-Total for Proactive Management Activities	**$23,500,000**	**$15,400,000**
2. Reactive / Responsive Management Activities		
2.1. Disaster Financial Assistance & Urgent Mitigative Works	Unknown	$14,600,000 *(76% Provincial)* *(24% Federal)*
Sub-Total for Reactive / Responsive Management Activities	**Unknown**	**$14,600,000**
Total Annual Expenditures	**Unknown**	**$30,000,000** ($23.5 million + reactive expenses + other mgt. activities)
3. Other Management Activities		
3.1. Pump Station Repairs, Rehabilitation, and Replacement	$5,000,000	Unknown
3.2. Construction of New Flood Protection Works	$5,000,000 (per year * 5 years = $25 million)	Unknown

Explanatory Notes and Qualifying Remarks for Table 4:

The fundamental concept presented in Table 4 is that an increased investment in proactive management activities, may over time, defer and/or reduce the costs of reactive management activities, such as disaster assistance and urgent mitigative works. Therefore, improved, comprehensive management may be achieved over time with little or no increase in total financial costs.

Enhanced Proactive Funding

- Increased investment of $8.1 million per year for proactive management activities.
- Investment of $5 million per year for rehabilitation and replacement of pump stations. Current funding levels are unknown at this time.
- Periodic investment of $5 million per year for a period of 5 years for the construction of new flood protection works.
- Potential reduction in the need for disaster assistance and/or urgent mitigative works.

2.1 There is an imprecise and unpredictable correlation between proactive investment in flood mitigation and actual future disaster costs. Therefore Table 4 is not intended to imply that there will be a perfect correlation between an increased expenditure in proactive management and a similar decreased cost in reactive management (e.g. DFAA and urgent mitigative works). For example, one dollar invested in proactive management could equal a dollar in flood damage reduction; however, it could also result in a greater or lesser saving. It is impossible to estimate the actual financial outcome of an increased investment in proactive management.

3. Construction of new flood protection works may be warranted in some cases. However, new works are not an ongoing annual cost therefore this item is differentiated in Table 4 and is considered to be a periodic cost. For the Enhanced Proactive Funding scenario in Table 4, it is suggested that $5 million / year be invested for new flood works over a 5 year period.

The cost estimates provided in Table 4, have been prepared using a cross section of different data sources that use different accounting methods and procedures, and have varying degrees of accuracy. Therefore, the accuracy of the cost estimates is considered order of magnitude.

3.2 Guiding Principles for Funding Flood Hazard Mitigation

At present there are no coordinated, long-term programs available to assist in the comprehensive management of flood protection works. Although this discussion paper provides a basis to establish such a program, additional analysis is required regarding specific intergovernmental arrangements for program funding and implementation. Federal, provincial, and local governments should initiate dialogue and negotiations regarding the scope and scale of the required program, potential funding sources and delivery mechanisms, and alternative funding arrangements for implementation. There is a feedback relationship between program design and funding policy. For example, the type, scale, and scope of program that is designed will influence the amount of funding required and potential contributors. Alternatively, the amount of funding available will influence the type, scale, and scope of the program that may be practical to implement.

The following principles are suggested to facilitate dialogue and guide negotiations about possible future funding models to facilitate implementation. These principles were derived through ongoing dialogue among the Joint Program Committee, the Finance Subcommittee, and the Dike and Channel Maintenance and Habitat Subcommittee.

- **Shared Responsibility** - Governments have a responsibility to protect public safety and minimize flood losses; however residents and businesses in the floodplains also have a responsibility for their own safety and security;

- **Beneficiary Pay** - Funding models should strive for an equitable allocation of costs based on the benefits received and the ability of the community, and its constituent parts, to pay. Beneficiaries are diverse including governments, residents, property owners, businesses, insurance providers, visitors, and all social and economic interests that are dependent on the continuous provision of goods, services, and utilities such as transportation, energy, water supply, and sewerage systems;

- **Partnerships and Cost-Sharing** - Effective partnerships and cost-sharing arrangements are vital to funding a comprehensive management program; and,

- **Flexibility and Innovation** - There may be different funding rationales, different funding contributors, and different delivery mechanisms for different management activities. It is important to inform the development of funding models with current and historic funding levels and sources. However, innovative approaches and delivery mechanisms may be required.

3.3 Potential Funding Models for a Comprehensive Management Program

Four potential funding models are described in this appendix. Each of these could be used to establish a long-term funding program for the comprehensive management of flood protection works. A brief description is provided for each funding model. This includes the general approach, the scope of funding partners involved, a discussion of the emergent cost-sharing formulae, and an identification of key challenges associated with each model.

3.3.1 Enhance Annual Government Budgets for Proactive Management

This funding model involves the enhancement of existing annual budgets for targeted proactive management activities. Three levels of government would contribute according to an agreed upon cost-sharing formula (e.g. 1/3, 1/3, 1/3). In the hypothetical circumstance of a 1/3 cost-sharing formula, local, provincial, and federal governments could each contribute 1/3 of the total annual program costs. Alternatively, the government funding partners could each contribute 1/3 of the suggested additional investment. Other cost-sharing formulae could be examined within this general funding model. In most cases, the specific contributions of each government would be associated with current mandates, roles, and responsibilities. For example, the provincial government could contribute towards the management of dikes without a local diking authority. In some cases, historic roles and responsibilities could also be used to guide the allocation of government contributions. For example, the federal government could contribute towards major dike repairs, rehabilitation, and upgrades as with the historical Fraser River Flood Control Program (1968-1995). *The primary challenge that is anticipated with this funding model is the difficulty of finding new funds within existing government revenues with many competing priorities.*

3.3.2 Integrate Reactive and Proactive Funding Arrangements

This funding model involves establishing a stronger integration between reactive and proactive funding arrangements. Federal and provincial governments are primarily responsible for periodic investments in reactive management activities such as Urgent Mitigative Works and Disaster Financial Assistance Arrangements. Therefore, these governments have the greatest financial liability associated with a flood event. By formally dedicating a portion of reactive management funds (e.g. UMW, DFAA) toward proactive management activities, it is believed that these governments could reduce their financial liability over time. For example, the provincial and federal governments could each contribute 50% of the suggested additional annual investment, with the potential for reduced disaster payments in the future. At present, however, federal DFAA may only be approved after a flood disaster. Local government involvement could also be considered within the context of this funding model. *The primary challenge that is anticipated with this funding model is the requirement for policy analysis and policy change, either within the DFA Arrangements, or through a new policy initiative.*

3.3.3 Public and Private Sector Collaboration

This funding model involves the engagement of a much broader group of people and organizations that benefit from flood hazard management. In particular, there are numerous government departments, Crown Corporations, utility operators, and private businesses that would benefit from comprehensive management of flood protection works. Existing annual

budgets for proactive management would be enhanced through combined contributions from governments and the private sector. Two alternative approaches to cost sharing are suggested for consideration within this funding model. Perhaps Crown Corporations and the private sector could contribute 1/4 of the suggested additional annual investment (e.g. $8.1 million per year) while local, provincial, and federal governments could contribute the remaining 3/4. Alternatively, Crown Corporations could contribute towards a provincial share of 1/3 while local businesses could contribute towards a local share of 1/3.

In the event of a catastrophic Fraser River flood, there is potential for billions of dollars in direct flood damages and unknown additional indirect economic costs associated with the disruption of infrastructure, community services, and business activities. Although DFA Arrangements provide for provincial and federal financial assistance, a catastrophic Fraser River flood will result in a wide distribution of damages and costs throughout affected communities. Private commercial and industrial insurers have a significant exposure of financial liability. There will also be many costs borne by individual residents, families, and small businesses because the limits to DFAA eligibility will almost certainly be exceeded. Similarly, some commercial or industrial operators may incur costs if they have not purchased flood insurance, or if their coverage is exceeded. Therefore the argument may be made that all parties with financial liability associated with flooding, be compelled to invest in flood damage prevention by contributing towards a proactive and comprehensive management program. *The primary challenge that is anticipated with this funding model is engaging new funding partners that have historically had minimal financial involvement in flood hazard management.*

3.3.4 Multiple Accounts Analysis

This funding model would involve a detailed analysis of funding roles and responsibilities that would be based on specified funding partners and criteria. This model would require an assessment of how various funding partners (e.g. local, provincial, and federal governments; Crown Corporations; private sector; and other parties) are associated with various funding criteria. The following are suggested as possible funding criteria to support this model:

- Distribution of costs associated with a flood event;
- Distribution of benefits associated with flood prevention or flood damage reduction;
- Current mandates, roles, and responsibilities for flood protection;
- Historical mandates, roles, and responsibilities for flood protection;
- Current mandates, roles, and responsibilities for public safety;
- Current mandates, roles, and responsibilities for provision of critical infrastructure;
- Ability to pay; and,
- Other criteria?

Within this funding model, the relative contributions of each funding partner would be calculated according to the strength of their association with each criterion. *There are two primary challenges that are anticipated with this funding model. Different funding partners may assign different weights and different values to the various criteria. There are significant information requirements in order to objectively assign values to this model.*

3.4 Potential Delivery Mechanisms for Financing

The following are several possible delivery mechanisms to establish long-term funding for comprehensive management. Each of these delivery mechanisms could be utilized to support any of the funding models described above, however, most are associated with a specific funding partner.

Grants (Senior Governments)
- Greater abilities for revenue generation among senior governments;
- Recognizes broad social and economic benefits associated with flood protection;
- Senior government funding has been substantially reduced in recent years;
- Competition for funds within government budgets due to multiple priorities;

General Property Taxes (Local Governments)
- Costs are shared equitably across many direct and indirect local beneficiaries;
- Revenue generation is predictable and relatively easy to administer;
- Competition for limited funds within local government budgets;
- Difficult to raise large amounts of capital, particularly in small communities;
- Unclear association of property taxes paid with flood protection services received;

Property or Parcel/Frontage Taxes for a Specified Area (Local Governments)
- Common / historical mechanism for dike construction, operations, and maintenance;
- Floodplain beneficiaries pay, encouraging development outside of floodplains;
- Low ability to pay in small rural diking areas due to a limited population / tax base;
- Requires the definition of boundaries regarding the floodplain / flood prone areas;
- Cumbersome / difficult to administer;

Development Cost Charges (Local Governments)
- Private sector beneficiaries contribute (disincentive for floodplain development);
- Increased development costs, potentially discouraging development;

User Fees and Charges (Local Governments)
- Common for drainage maintenance utility;
- Beneficiaries pay;
- Difficult to quantify and allocate fees in proportion to direct and indirect benefits;

Disaster Financial Assistance Arrangements (Senior Governments)
- Compensation for flood damages available to homeowners, renters, small businesses, farmers, non-profit organizations, local and provincial government;
- Maximum amount payable per claim is $100 000 for home, business, etc.;
- Does not apply to proactive flood mitigation;

Flood Insurance (Private Sector)
- Available for commercial and industrial operations but not available for residential development; and,
- Incentive for insurance industry to be involved in flood damage reduction.

3.5 Sources of Financial Data

The cost estimates within this document were developed from a number of sources, including:

- Survey of local diking authorities by the Ministry of Water, Land, and Air Protection;
- Staff review within the Ministry of Water, Land, and Air Protection and within the Provincial Emergency Program;
- Project proposals from local diking authorities between 1997 – 1999 including applications and completed projects in 1998 and 1999 under the BC Flood Protection Assistance Fund as well as applications and completed projects in 1999 under the Urgent Mitigative Flood Works initiative;
- Case examples and associated cost estimates were provided by local diking authorities to supplement and cross-reference the province-wide estimates; and,
- Historical flood protection programs and associated expenditures (e.g. Disaster Financial Assistance Arrangements, Fraser River Flood Control Program).

Appendix 4. Issues Related to Sustainable Flood Hazard Management

4.1 An Integrated Approach to Flood Hazard Management

Integrated flood hazard management recognizes that structural approaches to flood hazard management (e.g. dikes) are not adequate in themselves to fully protect the public from flood threats. Dikes have a design limit, therefore there is a residual risk of dike failure, particularly if the design flood event is exceeded. Consequently, there is a need to provide secondary flood defenses using land use planning tools such as Official Community Plans, floodplain bylaws, Regional Growth Strategies, and floodproofing techniques to protect development from flood hazards using elevation gains or lateral setbacks. These approaches will help to reduce the extent and magnitude of development that is exposed to flood hazards. Similarly, emergency planning and response activities are also very important in supporting an integrated approach to flood hazard management.

Although these management activities are beyond the scope of this document, the value and benefits of adopting an integrated approach are important to raise within the context of comprehensive management for flood protection works. For example, there are challenges to flood hazard management associated with increased urban development and growth in the floodplain. It is recognized that when the diking system was upgraded under the Fraser River Flood Control Program (1968-1995), there was a resulting sense of security that facilitated increased urban development in the floodplain. With increased urbanization, population growth, and associated infrastructure development in the floodplain, there is a corresponding increase in the exposure and vulnerability to flood hazards. Therefore it is important that a comprehensive management program does not exacerbate this cycle of increased protection - increased development - increased vulnerability.

One way of fostering greater integration between different approaches to flood hazard management is to link financial assistance for the management of flood protection works as a financial incentive for floodproofing and land use planning. For example, financial assistance for diking could be made more accessible for local governments who have implemented a floodplain bylaw or who have demonstrated a commitment to emergency preparedness. Various incentives, policy mechanisms, and strategies should be explored to further encourage a greater degree of integration and mutual reinforcement between different flood hazard management approaches. Integrated flood hazard management includes:

- Integration among flood protection works, floodplain management, and emergency management;
- Integration among social, economic, and environmental considerations; and,
- Integration among all levels of government (federal, provincial, local, and First Nations).

4.2 Financial Incentives and Disincentives

There are two distinct views with respect to federal / provincial / local cost sharing programs to provide financial assistance for the management of flood protection works. One view maintains that cost-sharing with senior levels of government is appropriate due to the flood protection benefits provided to provincial and federal interests including infrastructure, economic activity, and trade. Further, it can be argued that cost sharing is necessary to

support some management activities in some areas due to a limited ability to pay at the local level. This is particularly true for rural remote communities with a limited tax base. It would also be financially advantageous for senior levels of government to reduce future disaster recovery costs (possibly billions of dollars in disaster financial assistance), through a relatively modest investment in proactive flood hazard mitigation.

A different view, however, identifies the potential for a cost-sharing program to provide a disincentive for proper annual maintenance by local diking authorities. For example, there is potential for routine maintenance to become a lower local government priority if there is a belief that cost-sharing programs will be available for major repairs at a later date. There is an additional concern that senior government cost-sharing could provide an incentive for an increased reliance on expensive capital works projects beyond what would occur in the absence of a cost-sharing program. This may result in an over-investment in flood protection works and possibly a reduction in non-structural approaches such as floodproofing, floodplain bylaws, or emergency planning.

4.3 The Importance of Right-of-Ways

Under the *Dike Maintenance Act*, it is the responsibility of local diking authorities to secure right-of-ways for dike inspection and maintenance. In many cases right-of-ways were secured at the time of original dike construction. In some cases however, right-of-ways have not yet been secured. This poses a challenge for routine dike inspection and maintenance if there are landowners that are reluctant to allow access to the portion of the dike system that is on their land. Due to increasing land values, there may be reluctance by some landowners to allow any encumbrances on their property such as a right-of-way.

There is a need to secure right-of-ways for all dike systems to ensure proper inspection, maintenance, and emergency response. This may be achieved through landowner contact, education, outreach, and potentially compensation. If landowners understand the importance of access for dike inspection and maintenance for the protection of their own safety and property, there may be a greater willingness to establish right-of-ways. In other cases, particularly if additional land is required for dike upgrading, there may be a need to consider landowner compensation to secure a right-of-way. This could, therefore, have cost implications. For example, if it were necessary to widen an existing dike in order to repair, stabilize, or upgrade the dike, the costs of that work may necessarily include the costs of securing an additional right-of-way.

4.4 Dike Design and Alignment - Setback Dikes

Setback dikes may support a more sustainable approach to flood hazard management. A setback dike is a dike that is constructed some distance inland from a riverbank and from the erosion hazards of a river. Setback dikes offer all of the flood mitigation benefits of riverside dikes, albeit of a reduced protected area. There are numerous additional benefits that are associated with setback dikes, as well as some challenges. The high cost of land, and competing uses for a limited land base are the primary challenges (i.e. any land on the riverside of a setback dike is unprotected and therefore becomes less developable). However, the feasibility of setback dikes should be considered to the greatest extent possible because of the following social, economic, and environmental benefits:

- Setback dikes allow for a wider floodway, and increased channel capacity;
- Setback dikes are removed from sustained river forces and require less erosion protection, reducing the costs associated with dike maintenance, restoration, and flood fighting; and,
- Setback dikes allow for improved environmental sustainability by protecting the quantity and quality of available habitat (e.g. retention of riverbank vegetation, sloughs, and back channels).

The strategic environmental and technical benefits of setback dikes could be better addressed if land and right-of-way costs were considered part of shareable capital costs.

From one perspective, setback dikes may be perceived to be impractical and costly. However, the benefits outlined above suggest that setback dikes could be seen as a best practice that is less costly and more beneficial in the long-term. In this regard, the initial cost of land acquisition for setbacks could be considered part of the legitimate cost of good dike design and alignment. Further, the initial capital costs of setback dikes could, over time, be offset by savings in maintenance costs, and possibly by generating revenue by providing public access to greenways or other recreational amenities.

4.5 Flood Hazard Mitigation and First Nations' Lands

It is beyond the scope of this discussion paper to provide an analysis of flood hazard management on First Nations' lands. However, a strong case must be made for improved coordination between First Nations and neighbouring communities. Of particular importance is the inter-relationship between flood hazards and flood protection works on all lands. The activities or inactions of one community could result in either an increased risk or increased protection from flooding for another community. For example, the design, construction, maintenance, and rehabilitation of flood protection works should be jointly planned, implemented, and cost-shared where appropriate. Communities could also strive to meet common standards regarding the flood construction level. Significant dialogue is required at local and regional levels to advance improved coordination between First Nations and neighbouring communities in implementing flood hazard management.

Many First Nations' communities have not been able to construct flood and erosion protection works to the same extent as neighbouring communities. Historical programs such as the Fraser River Flood Control Program have typically applied narrow benefit-cost analyses as a fundamental criterion to justify capital investment. Although the flood hazards are common, flood hazard management is addressed through different planning processes, different funding sources, and a different legislative framework.

In BC there are 197 First Nation Indian Bands living on, and using 1680 Indian Reserves covering about 0.3% of the land base of BC. There are 74 Reserves that are either fully or partly protected from flood hazards, including 63 km of dikes, and 26.5 km of bank protection. There have been many flood studies in the past, however many of these are out of date, and most were limited to structural approaches to flood protection (e.g. diking and bank protection). The absence of free-title land ownership within First Nations' communities (and the limited extent of development) has resulted in consistently unfavourable benefit-cost analyses for First Nations with respect to justifying investment in mitigative works. A

particular challenge for First Nations' communities is a tightly defined land base. It is a very complex process to add new lands to existing Reserves.

A broad-based study was undertaken between 1998 and 2000 to assess the extent of flood and erosion risks, potential options and cost estimates for mitigation on First Nations' lands. All 197 Indian Bands were surveyed regarding their interest in participating in the study, and their perceived risk of flood and erosion hazards. The total cost of the study was about $1.5 million. By 2000, 147 Indian Bands had participated in the study, including 345 Reserves. The studies were grouped into four regions:

- West Coast & Vancouver Island (47 Bands);
- Lower Fraser Valley (20 Bands);
- Southern Interior (46 Bands); and,
- Northern Interior (34 Bands).

A total of 394 potential projects have been identified within the studies, including 235 flood mitigation projects and 159 erosion mitigation projects. Different flood mitigation options were explored to reduce flood risk including flood protection works, raising structures or infrastructure, purchase of land and relocation/addition to reserve. Other factors were considered to assess the mitigation options, including environmental impacts, likelihood of rejection by the First Nation, and off-reserve impacts. For the current fiscal year (2001 - 2002), funding in the amount of $3.5 million has been allocated within the Pacific region to deal with the highest priority flood and erosion projects on First Nations' lands. These priorities were determined by the studies described above.

4.6 Risk, Uncertainty, and Regional River Processes

Flood hazard management applies a risk-based approach to management. Managers use historical data to predict the magnitude and frequency of future flood events. It is not practical to totally avoid flood risks; therefore an approach of managing risks within acceptable limits is required. There is however, significant uncertainty regarding flood hazards, river systems, and our understanding of these dynamic processes. For example, the various design floods throughout British Columbia are estimated based on limited available historic information.

In some cases, this information may not be sufficient to accurately predict future flood levels. Uncertainty associated with possible climate change scenarios compounds this problem. Sediment transport and deposition, channel capacity, and the shifting of river channels are all natural processes to be contended with in the management of flood and erosion hazards. Managers need to be aware of local situations such as channel aggradation, riverbank erosion, or changing flood profiles. There is a need to monitor these regional river processes and track changes over time. Regular information updates will improve the understanding of local and regional flood and erosion hazards as they change over time, and will therefore inform appropriate management options. These regional river processes are typically beyond the financial and technical capabilities of local diking authorities. Therefore regional coordination and collaboration are recommended.

4.7 Global Climate Change

There is additional uncertainty regarding flood and erosion hazards due to the prospect of climate change. Although there may be disagreement regarding the scope, magnitude, and causes of climate change impacts, there is relative consensus among the world's scientists that climate change is occurring and will continue to occur. Three climate processes may increase or decrease the future risk of flooding in any given year:

1. There may be more extreme weather events as a result of climate change, which could result in increased localized flooding. For example, there may be more significant and more frequent extreme storm events such as experienced by White Rock in 1999.
2. There may be general shifts in long-term climatic trends such as average, maximum, and minimum precipitation and / or temperatures. For example, there may be higher snowpack or rainfall levels, possibly resulting in increases in river flows. It is unclear at this time whether there will be more or less precipitation, within which parts of BC. Seasonal and geographic variations in precipitation are a particularly important factor.
3. There may be a rise in sea level, thereby increasing the threat of flooding from the sea, particularly in conjunction with high winter tides and storm surges.

Ultimately the flood threat in any given year will depend on the combination of several factors, all having significant uncertainty. For example a large snowpack, followed by a cool spring and a rapid warming could increase the flood threat. On the contrary, a small snowpack, followed by a warm spring and a cool summer would lessen the flood threat.