Integrated Flood Management Plan for the Lower Cowichan Valley, British Columbia

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ABSTRACT

Flooding is a river system's natural response to occasional large precipitation events. When people decide to use highly productive land on natural floodplains for socio-economic activities, protection from inundation becomes necessary. A traditional engineering-focused approach to flood control considers physical, technical, economic, and political limitations, but fails to adequately consider social, cultural, ecological and morphological constraints. This requires a better Integrated Flood Management (IFM) approach, that adopts a basin and multidisciplinary approach to flood management to maximise the net benefits from floodplains while reducing the vulnerability and risks due to flooding, promoting community involvement and preserving ecosystems. IFM combines traditional flood management tools with land use planning tools, and integrates environmental and cultural data with modern engineering tools.

The heritage designated Cowichan River and Koksilah River on Vancouver Island, British Columbia are recognized as providing highly productive fish habitat, while the lower floodplain contains of the town of Duncan, and significant agricultural land. The rivers have undergone anthropogenic alterations over the last century including bridge and dike construction, and channel realignment that have affected channel morphology. In recent years, the valley has experienced many impactful flood events.

In 2007, the Cowichan Valley Regional District, in partnership with Cowichan Tribes, the City of Duncan and the District of North Cowichan initiated the development of an IFM Plan for the Lower Cowichan with the goal of reducing the flood risk to all communities, while protecting aquatic and riparian habitat and addressing the cultural values of the rivers. The plan incorporates modern engineering tools and design, including two-dimensional hydraulic modelling, GIS, biological data and the traditional knowledge of the Cowichan First Nation. The plan promotes innovative methods of flood hazard management including flood zoning and development controls in order to minimise short and long-term economic, environmental and social costs and where possible, increase the environmental and social capital of the region.

INTRODUCTION

In 2007, the Cowichan Valley Regional District, on Vancouver Island, British Columbia, completed a water management plan for the Cowichan River Basin. This was a community based and funded plan that examined water issues in the region. One of the many outcomes of the project was the realisation that a more modern approach to flood management was needed in the lower reaches of the river, which has historically suffered from severe flooding. This prompted the Cowichan Valley Regional District along with its partners the Cowichan Tribes, the City of Duncan and the District of North Cowichan to hire a consultant to develop and complete an Integrated Flood Management Plan. In early 2008, Northwest Hydraulic Consultants and its partners began the process of developing the plan to meet two key goals:

- To reduce the flood risk to all communities on the floodplain, while protecting aquatic and riparian habitat and addressing the cultural values of the river.
- To promote innovative methods of flood hazard management to minimise short and long-term economic, environmental and social costs and where possible provide an increase in the environmental and social capital of the region.

BACKGROUND

Study Area

The headwaters of the Cowichan and Koksilah River system are located in the rugged mountains of southern Vancouver Island, with peaks ranging between 500 and 1100 metres in elevation and with a total drainage area of 1544 km^2. The lower slopes and floodplain of the river system contain significant areas of agricultural land as well as rural, urban and industrial development (Figure 1). Dikes have been built along the banks of both rivers to protect the developed urban core of the City of Duncan and the extensive agricultural and industrial zones downstream. Dikes have also been constructed on lands of the Cowichan Tribes at various times.

The Cowichan River is internationally designated as a Heritage River and recognized for its highly valuable and productive fish habitat. The river supports seven species of salmon and trout including important stocks of chinook, coho, chum, steelhead trout, brown trout, rainbow trout and cutthroat trout. The Cowichan River is utilized by Fisheries and Oceans Canada (DFO) as an index stream to enumerate chinook escapement. The mainstem Cowichan River supports a unique run of summer run chinook that is considered by DFO to be one of the highest value stocks on Vancouver Island based on conservation concerns and rebuilding efforts. The Cowichan River also supports a highly valued wild winter run of Steelhead trout whose status is also a conservation concern with active stock rebuilding efforts undertaken by the BC Ministry of Environment (MOE).

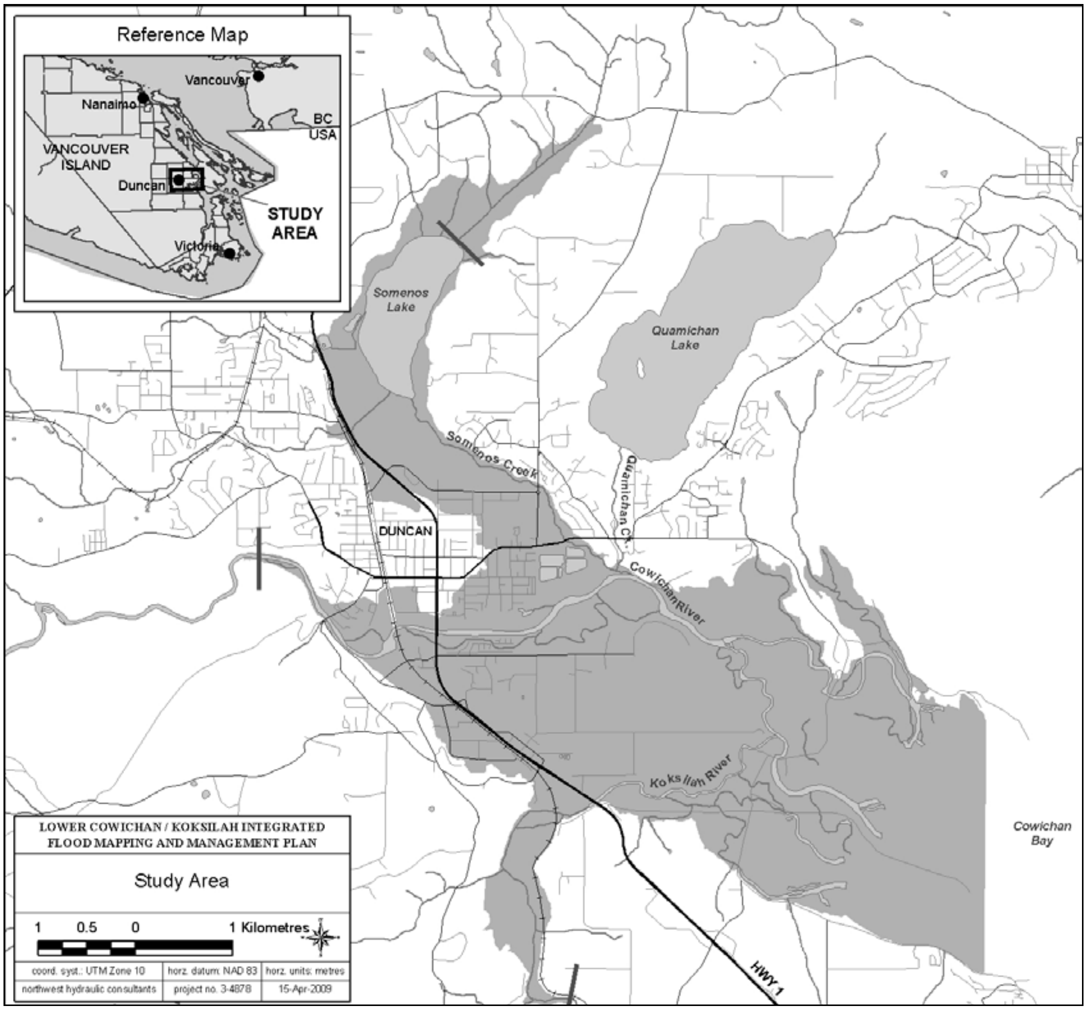

FIGURE 1: Extents of the Lower Cowichan Valley flood management planning area.

The valley has experienced many flood events resulting from high flows in the Cowichan River and its tributaries and from ponding in low-lying areas during heavy rain events. Large flow events in the Cowichan River were documented in 1979, 1986 and 2007. The most recent flood event of 2007 resulted in the closure of the Island Highway, a major Island route, as well as the evacuation of 17 families living on the floodplain.

Problem Identification

Nature of flood hazards and flood problems: There are at least five distinct types of flooding that may occur in the system, including:

- Flooding on mainstem rivers and related backwater flooding on tributaries.
- Flooding governed by high tides/storm surge in Cowichan Bay (Georgia Strait).
- Flooding triggered by erosion, sedimentation and debris jamming which may lead to dike failures, bank breaching or major channel shifting (avulsions).

- Interior flooding and drainage behind dikes related to ponding and flow obstruction.
- Stormwater drainage issues related to urban/commercial development and other upstream land-use changes.

Jurisdictions: The study area encompasses a wide geographic area that includes portions of the City of Duncan, Municipality of North Cowichan, Cowichan Valley Regional District and Cowichan Tribes. Federal/provincial agencies such as BC Ministry of Environment and Fisheries & Oceans Canada also have responsibilities and mandates for resource management. No overarching group or authority coordinates or provides a mechanism to facilitate overall management or maintenance of flood control infrastructure in the region. The concerns and priorities of each jurisdiction may also differ, and the need for certain type of flood planning may not be the same.

Environment: There is very high value fisheries habitat in the river system and it is critical to integrate flood management with fisheries enhancement efforts. Improving and stabilizing riverine habitat will lead to a more stable river system and can ultimately lead to a reduction of flood hazards in the future.

Adapting to Change: The area is undergoing rapid growth and therefore the plan needs to anticipate future societal and environmental changes.

Sustainability: The numerical model tools and planning maps will need to be maintained and periodically updated in response to changes in river sedimentation/erosion, future changes in flood control infrastructure, changes in habitat characteristics and developments on the floodplain. The hydraulic models and GIS-based flood hazard mapping will be the main tools for basing future decisions on flood hazard management in the region and have therefore been designed to be easily updated with new information.

Monitoring: Recommendations were given to develop a comprehensive monitoring plan to ensure that goals and objectives are being met in the long-term, and that recommended actions are being implemented. Results of the monitoring program will be used in an adaptive management context to guide future flood management actions.

TECHNICAL TOOL DEVELOPMENT AND RESULTS

Database

The plan characterizes the physical and biological environment of the area and identifies and maps environmentally sensitive zones as well as types of flood hazards and river processes. This data is stored in a comprehensive GIS database. The database includes information on topography (LiDAR), survey data, orthophotos, administrative boundaries, bridges and flood structures, channel networks, basic landuse, channel morphology, habitat mapping, and modelling inputs and results. The GIS database is a tremendous tool not only for the development of the plan but also for future decision making and for public engagement.

Modelling

A numerical hydraulic model allows the simulation of various flooding scenarios, making it a useful tool for assessing flood control alternatives and for mapping flood hazards. The model used for the Lower Cowichan Valley consists of a combination of one-dimensional and two-dimensional numerical modelling. The MIKE 11 modelling software, by the Danish Hydraulic Institute (DHI), is suitable for simulating discharges, water levels and other hydraulic parameters in the confined sections of the river or when flows remain below bankfull stage. The model simulates the branched network of channels that form the entire Cowichan/Koksilah River system and its tributaries. The model also simulates tidal effects in the lower reaches and unsteady flow variations during flood events. However, it is difficult to simulate complex overbank flooding, spills and bank breaching in any one-dimensional model. These floodplain processes are modelled with a two-dimensional model using DHI's MIKE 21 software. These two models are seamlessly connected using the overarching MIKE FLOOD software. The increased resolution and accuracy of the model represents a substantial improvement to previous hydraulic modelling efforts on the river.

The model was used to assess a wide range of flood conditions and flood scenarios. Five main types of simulations were performed:

- Present channel and dike conditions for a flood return period of 200 years (Figure 2).
- Improvements to existing dikes, where dikes were raised to confine flow within the dikes for flood return periods of 5, 50, 100, and 200 years. Floodplain spills were allowed to occur along all reaches not protected by dikes. This condition generally produced higher water levels than the results under the present condition simulations.
- Five different dike breach scenarios were modelled to assess the effect of a failure on flood spills and water levels. This involved removing a single dike and then re-running the simulation to assess the effect. The remaining intact dikes were raised in order to produce the highest water levels at the breach location.
- Climate change scenarios included effects of sea-level rise and changes to flood discharge due to variations in regional temperature and precipitation patterns.
- Three scenarios investigated the improvements and adverse effects of proposed dikes and setting back existing dikes.

From these modelling results, flood depth maps were generated to illustrate the location and extent of floodplain inundation. These results were used to prepare updated floodplain hazard maps.

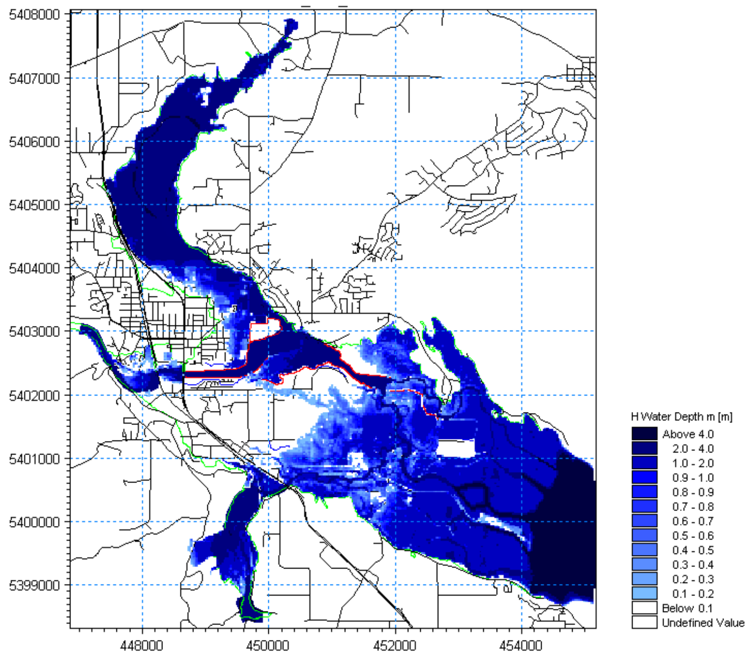

FIGURE 2: Modelling Results of Channelized Flows and Overbank Spilling - Maximum Water Depths for 200-year Flood (freeboard not included)

In addition, modelling results were used to assess the dikes in the study area, most of which have relatively little information available on their history of performance, maintenance records or technical design. The freeboard of the dikes was considered to be adequate if the dike crest was more than 1 m above the computed 200-year flood level. Based on this criterion, none of the existing dikes have adequate freeboard over their entire length. However, even if the existing dikes were raised to contain the 200-year flood flows, spilling on to the floodplain would still occur.

The vertical clearance of all existing bridges was assessed using the computed flood levels and surveyed levels of the bridges. Present day practice is to provide at least 1.5 m of vertical clearance on bridges that experience log jams. Only one bridge meets this requirement and three other bridges were found to surcharge during floods. This means the bridges will be more likely to trap debris and trigger blockage or log jam formation, which can cause higher flood levels and increased risk of channel erosion.

INTEGRATED FLOOD HAZARD MANAGEMENT PLAN

The Integrated Flood Management Plan consolidates and integrates all of the technical analysis and policy assessment. The document defines the short and long-term visions, goals and objectives for flood management and incorporates a broad spectrum of economic, social and environmental values.

Flood Hazard Mapping

Using the technical tools, key results of the hydrological and hydraulic modelling were summarized. The development of updated flood extents and depths (Figure 2), water surface elevation profiles, existing dike profiles (Figure 3) and flood hazard maps were presented. Flood hazard maps classified areas in zones of lower or higher hazard based on flood depth and water velocity.

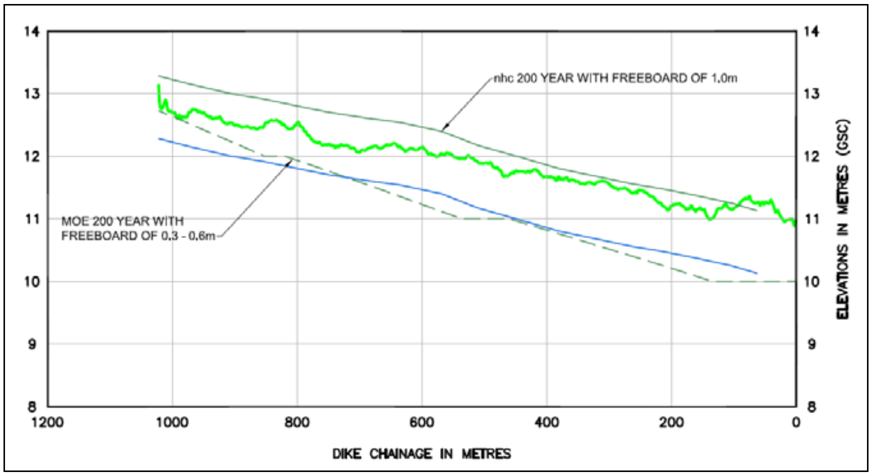

FIGURE 3: Dike and flood profiles (with and without freeboard) for 200-year flood with all existing dikes confining the flow.

Flood Control Infrastructure

The adequacy of the existing system of dikes and other flood control infrastructure was assessed on the basis of the computed flood profiles. No dikes currently meeting basic specifications. Recommendations on the need for upgrading or improving the dikes have been provided to the stakeholders. Other strategies for reducing erosion hazards by vegetation management, log jam stabilization, installation of new river training/river stabilization measures and gravel management was also outlined.

Stormwater Management

Using available information and working within existing guidelines and regulations recommendations on stormwater planning best management practices were provided, with a focus on on-site retention of water for new development areas.

Non-Structural Flood Management

Extensive emphasis in the plan was placed on non-structural measures for flood management. These included:

Development Controls: Various zones of flood hazard have been defined using the numerical models; this differs from traditional practice in British Columbia and Canada. Suggested development controls include hazard based zoning and special permit area development controls and no-adverse impact development within floodways.

Floodproofing: Best management practices for floodproofing of historical development areas and critical infrastructure is included in the plan.

Compensation: The plan includes an assessment of the use of agricultural and recreational areas for temporary flood water storage; including scoping concepts around developing a compensation mechanism for affected parties.

Acquisition and Relocation: Recommendations were be given to ensure that any damage flood event can be seen as an opportunity to correct past planning errors with the goal of reducing future flood damages. This may include the acquisition and relocation of vulnerable infrastructures that currently lie on the floodplain, in particular the relocation of the wastewater treatment plant, which currently abuts a dike.

Key project Identification

A prioritized list of infrastructure development, restoration and enhancement opportunities was described, based on known hydraulic and ecological factors. A ranking system was prepared, showing the sensitivity of habitat to flood management activities. This system will be used to identify areas of high sensitivity to disturbance and will be used to guide future planning decisions.

Project Success (Adaptive Management)

Recommendations were given to develop a comprehensive monitoring plan to ensure that goals and objectives are being met in the long-term, and that recommended actions are being implemented. Results of the monitoring program will be used in an adaptive management context to guide future flood management actions.

DISCUSSION

At this time it is hard to gauge the success of this approach to flood hazard management for the Cowichan Valley as the plan has not yet been adopted. Short-term success will be gauged by the level of buy-in to the plan from the original stakeholders and local residents as well as level of interest in the project from higher level governments. For the project to have successful outcomes it will require significant social and economic resources to ensure that the actions outlined in the plan are completed.

In the long-term the success of the project will ultimately be tested by a large flood event. If the actions of the integrated flood hazard management plan are followed through, we hope to see that not only is the valley less vulnerable to the large flood event, but that environmental and social values of the river have been increased since the adoption of the plan. We hope that the process followed for the development of the plan in the Cowichan Valley can be used as a model in other flood-prone regions of British Columbia.

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