FEASIBILITY STUDY

OYSTER RIVER FLOOD PROTECTION SERVICE

JANUARY 31, 2022

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Schedules

(*Cover photo courtesy of Campbell River Mirror © 2014*)

Executive Summary

This report is prepared in response to a resolution passed by the Strathcona Regional Board on January 29, 2020 which directed as follows:

> THAT a further report that examines the boundaries, cost implications and process for establishing a dike maintenance service in more detail be prepared for the Board's consideration.

Based on this direction, research was conducted into the establishment of a service to cover costs for maintaining the dike infrastructure that provides protection from flooding for a large number of homes, businesses, and other private and public assets in the Oyster River area of Electoral Area D. As a result of that research a number of recommendations are herewith presented for the consideration of the Regional Board including:

- THAT a service should be established to ensure that annual maintenance and repair of the flood protection infrastructure can be undertaken in accordance with applicable engineering standards as set out in the capital funding agreement with the Province of B.C.;
- THAT the 200-year floodplain of the Oyster River as modified by recent LIDAR data should be designated as the area benefiting from the flood protection infrastructure;
- THAT the costs of operating the service that cannot be recovered by other means should be secured through taxation of real property within the area receiving a benefit from the flood protection infrastructure;
- THAT property taxes for the service would most appropriately be levied against both land and improvement assessments within the benefiting area; and
- THAT, if a flood protection service is established, the Regional District should seek proportional funding from the Comox Valley Regional District (CVRD) if it is determined that properties located south of Oyster River may derive benefit from existing flood protection infrastructure.

In order to secure capital funding to cover recent renovation and upgrading of the Glenmore Road dike infrastructure, the Strathcona Regional District entered into a contract with the Province of BC to assume maintenance responsibilities for that infrastructure. In the event of a flood, the Regional District will likely be held liable for damages sustained by residents and property owners if it can be shown that the Regional District was negligent in its maintenance obligations. Having a service in place will ensure that regular and appropriate maintenance of the dike infrastructure will occur. In the event the Regional District fails to establish a service, all costs related to maintenance or non-maintenance of the dike infrastructure (including legal costs and damage awards) would need to be charged to the electoral area administration service.

For the reasons outlined above, it is recommended that the Regional District give serious consideration to the establishment of a flood protection service for the Oyster River area.

Introduction

The intent of this study is to examine the feasibility of establishing a service to cover the costs of maintaining flood protection infrastructure for the Oyster River area within Electoral Area D. Flooding is a significant natural hazard that can damage important infrastructure, cause serious economic loss for homeowners and their families, and create social disruption. The Oyster River has a long history of flooding which has led to various flood and erosion control measures being put in place over the last 50 years.

There has also been speculation that changes in climatic patterns and sea levels may impact the frequency and magnitude of flooding in BC. Some estimates predict that sea levels along the BC coastline will increase by approximately 1 metre by the year 2100 which could impact flood hazards for coastal areas. Therefore, it is important for local governments to understand the potential flood hazards faced by communities and consider how best to mitigate those risks in the short-term and long-term. It is also noted that the limited availability of insurance to cover losses from overland flooding events can be a significant challenge for owners of private property.

Under common law and in accordance with applicable legislation, local governments are generally held responsible for the operation and maintenance of flood control infrastructure including:

- periodic inspection
- performance monitoring
- repairs and replacement
- contingency emergency planning
- dike flood patrol
- emergency measures

Figure 1 – 2014 flooding of Oyster River (*Campbell River Mirror*, 2014)

While much of the cost associated with the development or upgrading of flood protection infrastructure may be covered by senior government grants, ongoing operating and maintenance costs must generally be borne by the local area for which the infrastructure was developed and from which it benefits.

With the above considerations in mind, this study will present information to assist property owners when considering the use of local property taxes to cover maintenance and repair costs associated with the flood protection infrastructure on the Oyster River.

Background

The Oyster River is located at the south end of Electoral Area D and forms a natural boundary between the Strathcona Regional District and the Comox Valley Regional District. A dike was constructed upstream of the river's estuary in 1992 in response to seasonal flooding events which, depending on the conditions each year, varied in magnitude and severity. The dike infrastructure extends approximately 570 metres along the south side of Glenmore Road (see Figures 2 & 4) to its downstream terminus approximately 500 metres west of Lorna Lane. The elevation of the dike crest ranges from 23 metres ASL* at the upstream end to 18 metres ASL at the downstream end. North of Glenmore Road, the top width of the dike is 4 metres, while south of Glenmore Road, the top width is reduced to 3 metres. The dike protects approximately 450 homes, businesses and other properties from the effects of Oyster River flooding. (*ASL = above sea level)

Figure 2 – A portion of the Glenmore Road dike on riverside slope

(*McElhanney Engineering Ltd*. 2019)

Upon completion of the dike structure in 1992, the Comox Strathcona Regional District (CSRD) assumed the responsibility for structural repair and maintenance. Since no service was established at that time the ability to fund annual maintenance requirements did not exist. In 2008 the CSRD was divided into the Comox Valley Regional District and the Strathcona Regional District at which time the responsibility for maintenance of the dike infrastructure was transferred to the Strathcona Regional District. The Strathcona Regional District subsequently applied for and received $520,000 from the Province of BC under the Structural Flood Mitigation Program to assess the dike's condition, and to renovate and upgrade the dike infrastructure. These funds were provided in recognition of the fact that no funding had accompanied the transfer of responsibility from the Comox-Strathcona Regional District to the newly incorporated Strathcona Regional District. The Provincial funding was used to rehabilitate the dike infrastructure which had deteriorated over time through neglect and lack of maintenance. These funds were provided on the condition that the Strathcona Regional District would commit to ongoing maintenance of the dike infrastructure to ensure its integrity in accordance with accepted engineering standards.

In addition to the dike, the flood protection infrastructure includes:

- gate valve – to prevent backflow into dike structure.
- floodbox – to transfer internal drainage flow to dike exterior.
- riprap – to protect soil from erosion due to concentrated runoff and to stabilize slopes that are subject to seepage.
- trash rack – to prevent outlet blockages.

Figure 3 – Riprap and flood box at outlet channel of dike

(*McElhanney Engineering Ltd*. 2019)

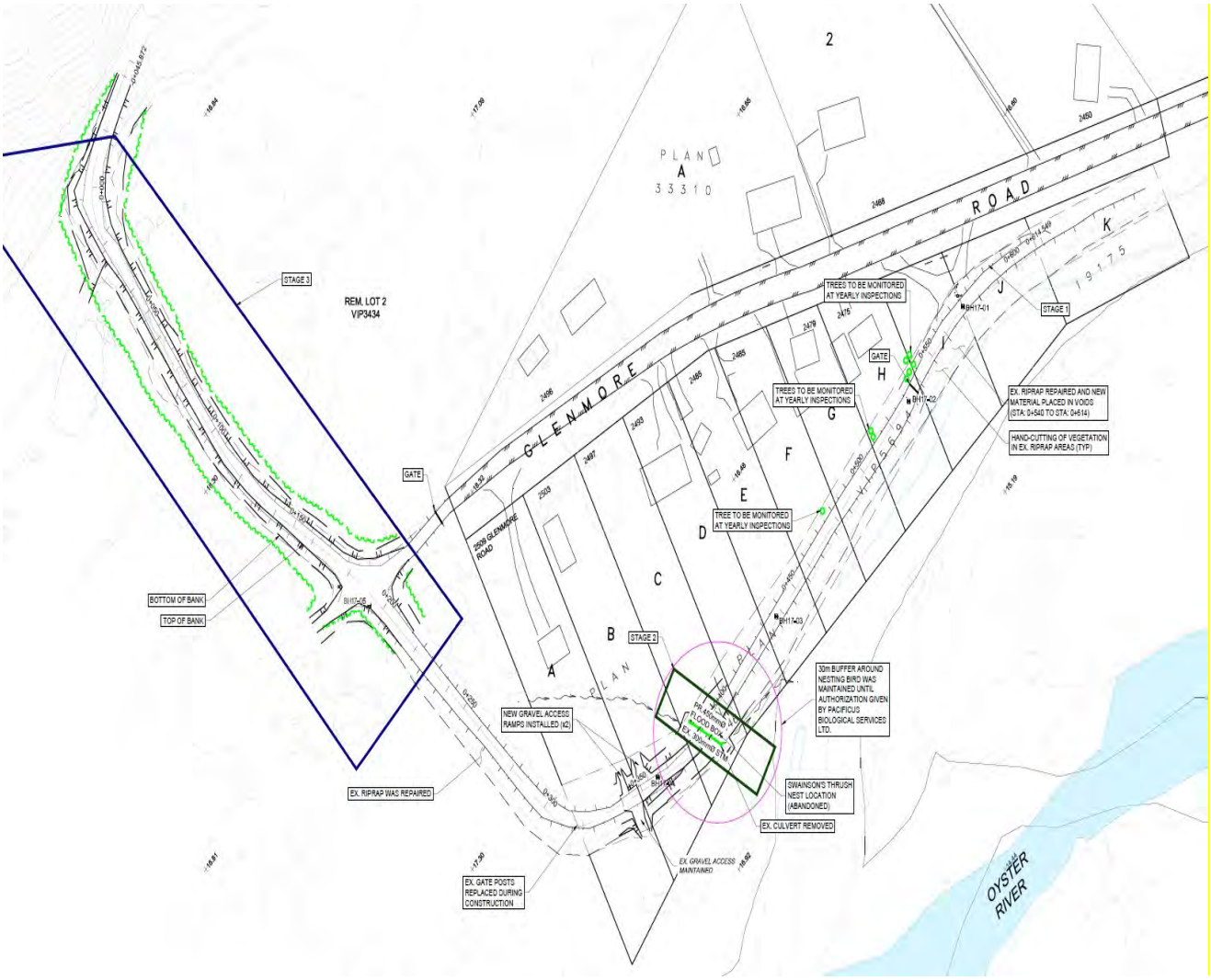


Figure 4 – Diagram of Oyster River Dike (*McElhanney Engineering Ltd. 2019*)

Capital and Operating Costs

As a result of the upgrades and improvements made recently to the Glenmore Road dike, there is little in the way of capital expenditure that is required to be done in the short term. However, to ensure that residents and businesses in the area receive full benefit from recent capital improvements, it is necessary to have a program that ensures regular maintenance and repairs are done to this important flood protection infrastructure.

A breakdown of the anticipated costs associated with the proposed flood protection service is shown in the following table. The maintenance tasks shown are based on the recommendations contained in the report from McElhanney Engineering Ltd. which supervised the dike rehabilitation project in 2019.

Table 1: Annual Maintenance Cost Estimates for Oyster River Flood Protection Infrastructure

Item	Annual Cost Estimate*	Five-Year Cost Estimate
Dike Inspection and Reporting	$1,600	$8,000
Vegetation Maintenance (mowing)	$2,400	$12,000
Floodbox Maintenance	$750	$3,750
Engineering Costs	varies	$1,500
Vegetation – Tree Removal	varies	$2,500
Service Implementation and Administration	$1,500	$7,500
Total	**$6,250**	**$41,750**

*It should be noted that some maintenance costs cannot be accurately predicted on an annual basis and are therefore projected using a five-year cycle.

Based on the preceding information it is estimated that annual maintenance costs will vary between $6,250 and $8,350 in a given year, and possibly higher in years when additional maintenance tasks must be performed. For the purpose of investigating the cost implications to homeowners, businesses and others in the service area the higher number will be used throughout this report.

Service Area Boundaries

With respect to the proposed Oyster River flood protection service, it was necessary to determine which properties receive a benefit from having the existing infrastructure in place. Accordingly, three distinct benefiting area scenarios were considered for this study:

Option A - properties along Glenmore Road only.
Option B - properties within the 200-year floodplain of the Oyster River and downstream of dike.
Option C - all properties within Electoral Area D.

After careful consideration of the pros and cons associated with each of these alternatives and, respecting the principle that those who stand to benefit from a Regional District service should contribute to its funding, it was concluded that the boundaries for the service should include all properties located downstream of the dike infrastructure and within the 200-year floodplain* of the Oyster River. Additional information on the different service areas that were considered and the issues relevant to each is shown in the table below.

Table 2: Comparison of Possible Service Area Alternatives for Oyster River Flood Protection

Benefiting Area Scenario	Comments
1. Properties along Glenmore Road only	The majority of properties receiving benefit from the flood protection infrastructure would not pay towards its upkeep or maintenance.
2. Properties within the 200-year floodplain* of Oyster River	-Aligns with the Dike Construction Guidelines of the Province of BC which state that dikes must be constructed to protect against a flood with an annual probability of occurrence of 0.5%, also known as a 1 in 200-year flood. -Floodplain boundaries may be altered over time due to geomorphologic changes. -Flooding may still occur outside of designated floodplain area.
3. All properties in Electoral Area D	Properties located outside of the floodplain area would receive little or no direct benefit from the flood protection service.

*1984 floodplain boundaries updated with recent LIDAR data to include properties south of Mayfly Creek with elevations lower than 15 metres ASL.

With respect to properties within the 200-year floodplain of Oyster River and located in Electoral Area C of the Comox Valley Regional District (CVRD), preliminary discussions indicate that the CVRD may be interested in providing some financial support for the flood protection service if it can be demonstrated that properties within its jurisdiction would receive a benefit from the service. Although the receipt of funding from the CVRD for maintaining flood protection infrastructure is a possibility, the process by which such funding would be secured could involve complex interjurisdictional issues and is subject fundamentally to establishment of a service by the Strathcona Regional District. Should a flood protection service be established as recommended in this study it is proposed that further discussions with the CVRD be held to evaluate potential scenarios for sharing of annual maintenance costs.

Potential Revenue Sources

Having determined the most appropriate boundary for the flood protection service and the annual budgetary requirements to properly maintain the flood protection infrastructure, it was necessary to consider possible sources of revenue that could be used to meet contractual obligations and ensure that the dike infrastructure does not fall into disrepair.

User Fees - As with all local government services, the incorporation of user fees is always attractive as it can help to minimize reliance on property taxes. However, in this case, the service being proposed is of broad public benefit and does not include any interactive components such that 'users' of the service could be distinguished from 'non-users' of the service. In the absence of such a distinction the incorporation of a user fee would not be considered a feasible alternative.

Grants - Revenue received by way of grants is another possible source of funding, however such funding is usually reserved for capital works rather than ongoing maintenance costs. Since the proposed budget for the service is based on annual maintenance and upkeep (rather than capital improvements) it is suggested that reliance on grant funding to cover these costs would likely lead to the flood protection infrastructure being maintained at a low standard and falling into disrepair.

Donations – Although the Regional District is able to accept voluntary donations to cover operating costs for any service (and to issue tax receipts for same), the Regional District is not aware of any such donations being received in the past for this flood protection infrastructure. Should such contributions be received in the future they could be used to offset reliance on other revenue sources.

Property Taxation - The use of property taxation in such circumstances is often the only reliable method for ensuring that sufficient financial resources are available when needed to attend to scheduled and unscheduled maintenance requirements. As with all Regional District services, the costs to operate the service must be covered by those who derive benefit from the service.

Based on the foregoing, it is suggested that accessing the local property tax base is the most viable method for ensuring that sufficient funding is available to meet the annual requirements associated with flood protection infrastructure maintenance and repair.

Property Taxation Options

If the annual costs of maintaining flood protection infrastructure are to be shared collectively within the community through a system of property taxation, it will be necessary to consider the various types of taxation that are available. When considering property taxation as a revenue source to cover ongoing costs of a service, it is appropriate to strive for a system that correlates the amount paid by individual properties to the benefit received by those properties. Following are the most common types of property taxes that are used, depending on the nature of the service and the relationship of the service to the properties benefiting from the service:

- taxation of land only based on the value of the land
- taxation of improvements only based on the value of the improvements
- taxation of land and improvements based on the value of the land and improvements
- taxation of each property at a uniform rate (parcel tax)
- taxation of each property based on road frontage or parcel area (frontage tax or area tax)

While no perfect taxation system exists, it is generally accepted that the best system would be one that has the strongest relationship between the benefit received by properties and the amount paid by those properties. In the present case, the benefit received is strongly correlated to the value of assets being protected from flood damage. This would tend to discourage the use of parcel taxes, frontage taxes or area taxes as preferred methods for sharing costs since these systems do not correlate strongly with the concepts of value or benefit.

The table below illustrates the relative costs projected for the flood protection service using a variety of property taxation methods. As may be seen, the sharing of costs based on land and improvement assessments not only yields a lower tax rate in comparison to other methods but also recognizes that flood waters can result in damage to land in addition to buildings and structures. While personal property is not included in the assessed value of real property, there is typically a strong correlation between these types of property and, for the reasons outlined above, it is suggested that the fairest and most appropriate method of sharing annual service costs would be to levy a tax on land and improvements with the amount of taxation for each property based on the assessed value of that property.

Table 3: Analysis of Residential Rates Using Various Property Taxation Formulas

Taxation Method	Occurrences	Assessment Values (2021)	Annual Residential Rate
Land only	429	$155,683,877	$0.05193 per 1,000 of taxable land assessments
Improvements only	388	$133,243,117	$0.05631 per 1,000 of taxable improvement assessments
Land and improvements	445	$288,926,994	$0.02701 per 1,000 of taxable land and improvement assessments
Uniform parcel tax	410	n/a	$20.37 per separate parcel of land
Frontage or area tax	Data not available		

Tax Rate Calculations

Using land and improvement assessments as the basis for allocating annual costs it is possible to estimate the tax rates that would likely result if the maximum annual requisition was levied within the proposed service boundary. The calculations in the table below are based on 2021 property valuations supplied by the Assessment Authority of BC and, while the property values within the proposed service area may change somewhat year to year, the calculations are believed to be accurate enough for purposes of this study.

Table 4: Calculation of Annual Tax Rates for Proposed Oyster River Flood Protection Service

Assessment Class	Occurrences	2021 Net Taxable Values	Conversion Factor	Converted Assessments	% Share	Requisition Share	Tax Rate* (per $1,000)
1. Residential	411	$274,769,037	0.100	$27,476,904	88.9	$7,420	0.02701
2.Utility	1	347,500	0.350	121,625	0.4	33	0.09452
3.Supportive Housing	-	-	0.100	-	-	-	-
4.Major Industry	-	-	0.340	-	-	-	-
5.Light Industry	4	1,247,800	0.340	424,252	1.4	116	0.09182
6.Business/Other	15	11,229,300	0.245	2,751,179	8.9	744	0.06616
7.Managed Forest Land	-	-	0.300	-	-	-	-
8.Rec./Non-Profit	3	1,105,000	0.100	110,500	0.4	30	0.02701
9.Farm	11	228,357	0.100	22,836	0.1	7	0.02701
Total	445	$288,926,994		$30,919,774	100.0	$8,350	

*Note: the various tax rates shown for different property classes is a result of the Province of BC rural property taxation system which uses converted (weighted) assessments when calculating tax rates.

Annual Service Costs

On the assumption that the annual costs of maintaining the flood protection infrastructure are to be supported by the properties that derive a benefit from that infrastructure, it is possible to estimate the annual costs to be borne by the owners of homes, businesses and other types of property within the proposed service area. The table below provides an estimate of those costs for each type of property found within the service area based on the value of that property. Property owners can easily determine the estimated annual costs for their specific property by using the rates shown in the table below or by multiplying the applicable tax rate shown in Table 4 against their assessed values as specified in their most recent property assessment notice.

Table 5: Annual Flood Protection Infrastructure Costs by Property Class and Valuation

Taxable Value	Class 1 (Residential)	Class 2 (Utilities)	Class 5 (Light Industry)	Class 6 (Business & Other)	Class 8 (Rec/Non-Profit)	Class 9 (Farm)
50,000	$1.35	$4.73	$4.59	$3.31	$1.35	$1.35
100,000	2.70	9.45	9.18	6.62	2.70	2.70
200,000	5.40	18.90	18.36	13.24	5.40	5.40
300,000	8.10	28.35	27.54	19.86	8.10	8.10
400,000	10.80	37.81	36.72	26.49	10.80	10.80
500,000	13.50	47.25	45.91	33.10	13.50	13.50
600,000	16.21	56.71	55.09	39.72	16.21	16.21
700,000	18.90	66.17	64.26	46.35	18.90	18.90
800,000	21.61	75.63	73.45	52.99	21.61	21.61
900,000	24.31	85.06	82.63	59.60	24.31	24.31
1,000,000	27.02	94.51	91.81	66.30	27.02	27.02

Each owner of property will have their individual perspective on whether the value of the service being provided by the flood protection infrastructure warrants the cost to their property of maintaining that infrastructure. For this reason, the decision to establish a flood protection service is subject to approval of the electors by assent voting or alternative approval process.

The options available for seeking the approval of the electors are described in more detail in the following sections of this report.

Approval Process

In the event it is decided to proceed with establishment of an Oyster River flood protection service, there are several steps that must be undertaken by the Regional Board including the presentation of the initiative to the electors for approval:

Step 1 - A service establishing bylaw must be introduced and given first 3 readings by the Regional Board. The bylaw must set out the nature of the service to be provided, the geographic area that would benefit from the service, the method of taxation to be employed for recovering annual costs, and the maximum amount that can be requisitioned each year from property owners for the service.

Step 2 - The Regional Board must decide whether it will seek approval of the electors for the establishing bylaw through an assent voting process or alternative approval process (AAP).

Step 3 - The service establishing bylaw must be submitted to the Inspector of Municipalities for approval.

Step 4 - If approved by the Inspector of Municipalities the service establishing bylaw must be submitted for approval of the electors. If assent voting is to be used, the approval threshold is a simple majority of the votes cast by qualified electors. If using an alternative approval process, the threshold for approval is less than 10% of the electors objecting in writing to passage of the bylaw. An assent voting process is relatively expensive (especially when used for a small geographic area) while an AAP is much more cost effective while still allowing elector opposition to an initiative to be accurately gauged.

Step 5 – If elector approval is received the Regional District may proceed to adopt the service establishing bylaw.

Given the relatively high cost associated with the assent voting option, it is recommended that serious consideration be given to using an AAP for obtaining elector assent. Should the bylaw fail to receive elector approval using that method, the ability to use an assent voting process would still be an option and, depending on the number of electors who objected via AAP, there may be a rationale for continuing with that process.

A proposed schedule with milestones for establishing the proposed Oyster River flood protection service is outlined below.

Implementation Schedule

The following table provides more detailed information on the various steps that would need to be undertaken to implement an Oyster River flood protection service assuming that the initiative is to be established using an alternative approval process (AAP). The dates shown are approximate only and are the earliest dates for which the corresponding action could be taken.

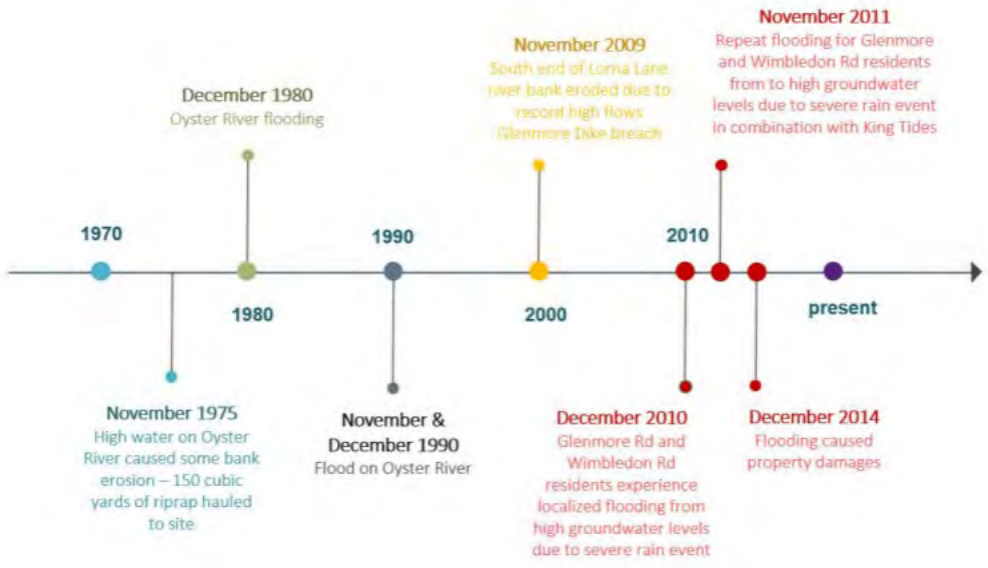
Table 6: Schedule of Milestones for Creation of Oyster River Flood Protection Service

Schedule	Action
February 9, 2022	Electoral Areas Services Committee reviews report and recommends process for establishing Oyster River flood protection service be initiated.
February 23, 2022	Regional Board considers feasibility study and authorizes preparation of establishment bylaw for Oyster River flood protection service.
March 16, 2022	Regional Board gives first 3 readings to Bylaw No. ___, being Oyster River Flood Protection Service Establishing Bylaw 2022, and authorizes approval of the electors to be obtained by alternative approval process (AAP).
March 21, 2022	Bylaw No. ___ submitted to Inspector of Municipalities for approval under s.342 of *Local Government Act*.
May 4, 2022	Inspector of Municipalities approval received for Bylaw No. ___.
May 11, 2022	Regional Board establishes elector response form, elector response deadline and determines total number of eligible electors for AAP.
May 18, 2022	First publication of AAP notice for Bylaw No. ___.
May 25, 2022	Second publication of AAP notice for Bylaw No. ___.
July 4, 2022	Deadline for filing AAP responses with Regional District.
July 13, 2022	If elector approval received, Regional Board adopts Bylaw No. ___.
October 31, 2022	Deadline to provide copy of Bylaw No. ___ to BC Assessment Authority for tax coding purposes.
March 22, 2023	Regional Board adopts 2023 operating budget for Oyster River flood protection service.
July 4, 2023	Deadline for payment of property taxes for flood protection infrastructure maintenance.

Schedule 'A'

History of Oyster River Flooding Events

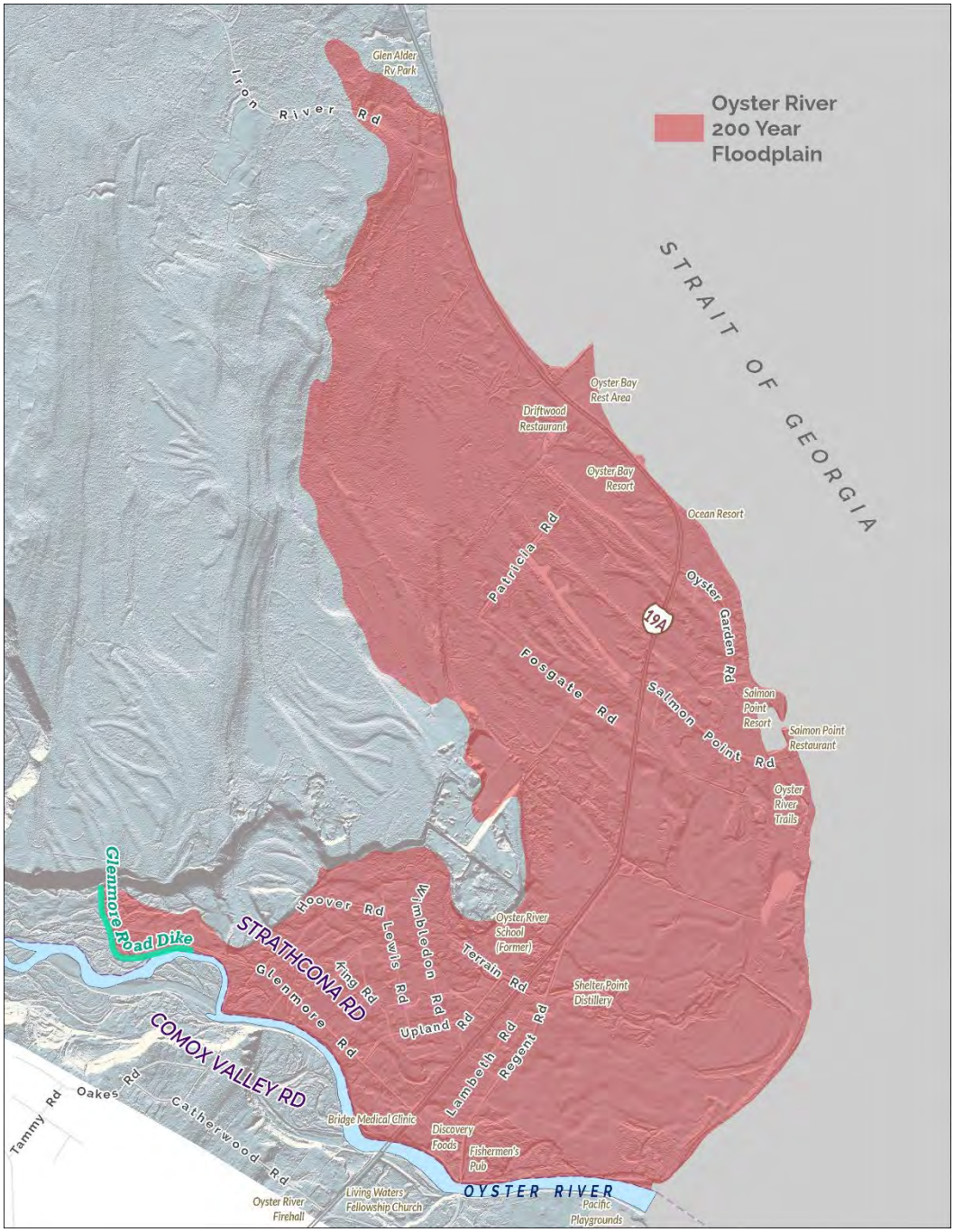
The information below provides a timeline of flooding events and mitigation measures for the Oyster River in recent times. While relatively little information is available prior to 1970 there is no doubt that the Oyster River has a long history of flooding that pre-dates settlement in the area.



Source: Oyster River/Saratoga Beach Flood Risk Assessment (*Comox Valley Regional District*, 2018)

Schedule 'B'

Oyster River 200-Year Floodplain

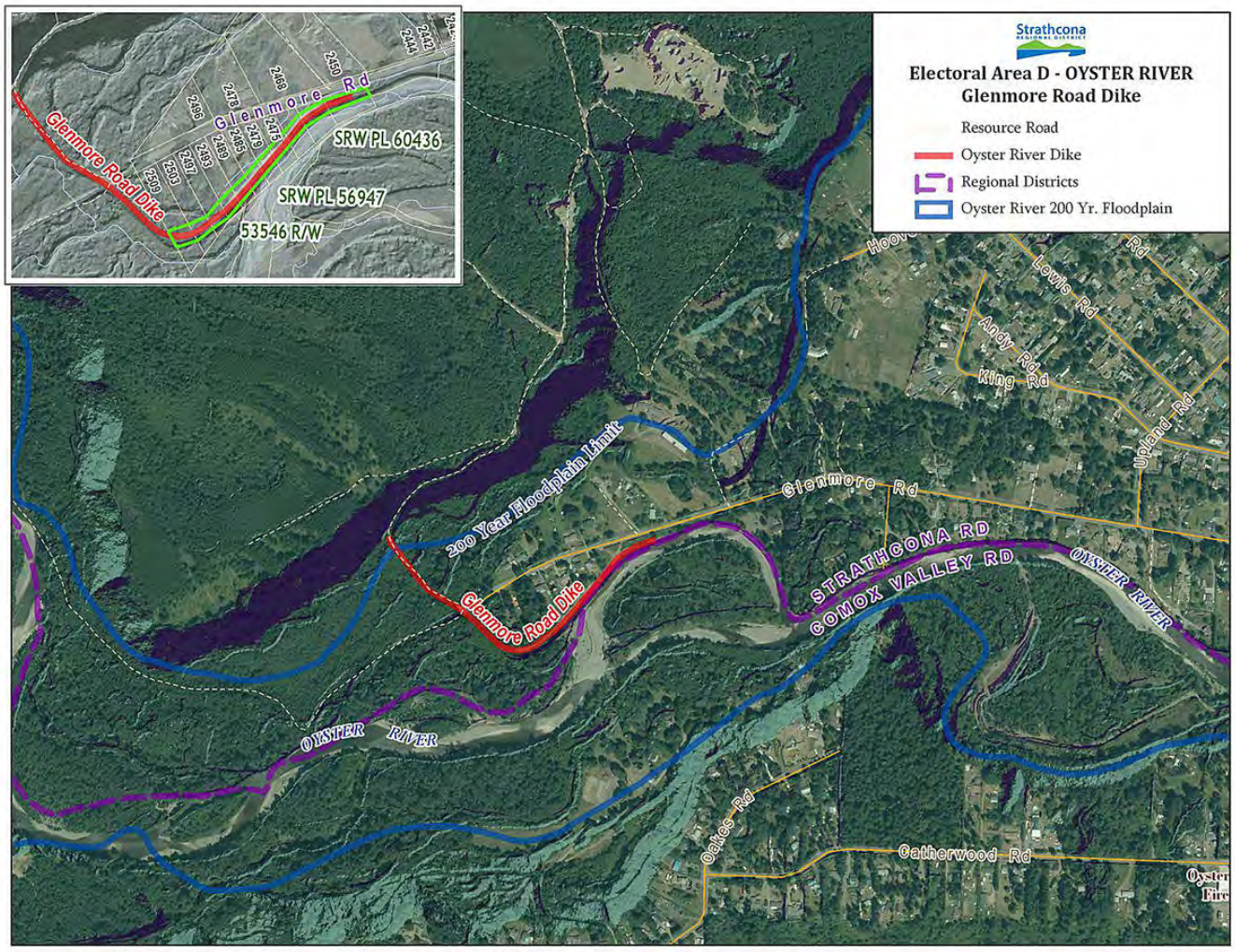


Proposed service area map showing that part of Electoral Area D lying within the 200-year floodplain of the Oyster River downstream of Glenmore Road dike based on updated LIDAR data.

Schedule 'C'

Dike Operation and Maintenance Manual

(for Dikes and Associated Flood Protection Works)



Public Safety Section
Water Management Branch

Province of British Columbia
Ministry of Environment (MoE), Water Stewardship Division

November 2019

Operation and Maintenance Manual

FOR

Glenmore Road Dike #24

Of The

Strathcona Regional District

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Table of Contents

1. Background Information

This chapter provides background information applicable to all flood protection systems. ***Site specific information is included in the following chapters.***

An O & M Manual is the most important reference for management of the flood protection system. It is the place to turn whenever there are questions or concerns about flood protection in a community, from how to maintain vegetation, to where to turn in a flood emergency. Regular inspection and maintenance of works is necessary to maintain the dependability of the system.

The O & M Manual is intended to be a comprehensive and up-to-date document into which new information will be added over time and as experience is gained. Future operators and residents can then benefit from and build on previous experience.

1.1 Administration

Administration information is important as it clarifies the ownership and management issues specific to the flood protection system.

Fundamental administration information is identified in Chapter 2, and includes the following:

- areas and facilities that could be affected by flooding,
- local government and association,
- diking organization and taxation arrangements,
- management arrangements for inspection and maintenance,
- regional contacts including PEP, governments and authorities
- local contacts such as local committee or ratepayers association members,
- landowners and stakeholders affected by flooding or involved in management of the system,
- provincial and federal legislation applicable to works on and around the flood protection system,
- relevant local legislation and bylaws.

1.2 Physical Works

The flood protection works are described in this section. Areas with restricted access need to be identified, as access to the dike system is very important during emergency events. There should be no obstacles that prevent access by authorized vehicles. **Access to dikes should be restricted to authorized vehicles only and access routes must be kept accessible at all times**.

Fundamental descriptive information is identified in Chapter 2, and includes:

- An overview including identification of the watercourse, location, year of construction and upgrades, and a list of structures and associated appurtenances
- A description of the structures and appurtenances associated with the works including location, lengths, sizes, etc.
- Access difficulties and considerations.

1.3 Flood Hazard

The flood hazard, for which the flood protection works have been constructed, is identified in this section. Certain conditions and times of the year can be established as ‘sensitive’ to flooding. **Unexpected conditions, including rain, temperatures, storms, and debris jams, can create flood conditions at any time of the year**.

Fundamental information on the predictable flood hazard is identified in Chapter 2, including the sensitive months and the types of activities to be performed during, before, or after each period. Issues that create sensitive months include the identifiable high and low water periods and the usual wet season. Other important information includes the 'fisheries construction window' – the time period each year, for the specific watercourse, during which permits for construction MAY be obtained (through MOE). The availability of hydrometric data is also identified.

Information regarding how to obtain data for this chapter can be obtained from MOE.

1.4 Inspection

Frequent periodic inspection is essential for identification of areas requiring maintenance before major problems develop. Both inspection and maintenance are required to maintain the dependability of the flood protection system.

Information in this section includes a description of the items to be covered in routine annual inspections and in special inspections. Annual inspections should be completed prior to the *flood hazard* 'sensitive month' of the high flow season (see above) and early enough to allow adequate time for any required work to be completed prior to possible flood events. Special inspections are conducted during high and low water events, after an occurrence of a flood or earthquake, and as needed to react to particular situations such as storms, stream channel sedimentation or degradation, ice or debris jamming events, etc.

In addition to annual inspections, the appurtenances of the flood protection system (such as pump station and floodbox) may require more frequent checks to verify that the system is operational. These surveillance visits provide an opportunity for frequent surveillance to check for any obvious problems with the system.

All inspections should be scheduled, conducted and documented according to the "*Flood Protection Works, Inspection Guide"* (3).

1.5 Maintenance

The flood protection works must be maintained to assure serviceability of the structures in time of flood. Failure to maintain works properly may render the flood protective system inoperative during periods when protection is needed. As well, neglect of maintenance will mean significant capital expenditures in the future to rehabilitate a deteriorated structure.

Maintenance should correct all problems and concerns identified in inspections, and should include the control of development and construction on, through or in, the vicinity of flood control works, to ensure that the standard of protection provided by the works is maintained.

Access to the dike crest, slopes and adjacent bank protection must be maintained to permit inspection and repair of the dike, bank protection, and adjacent flood protection works.

Vegetation control is an important aspect of maintenance as excessive growth can obscure problems and tree roots can threaten the stability of the dike itself. Vegetation on the dike slope should ideally consist of closely trimmed grass. Tree and brush growth should be removed for the following reasons:

- Vegetation attracts burrowing animals whose burrows are detrimental to dike stability.
- Tall vegetation obscures signs of seepage or damage to the dike which thus may go undetected and eventually cause dike failure.
- Tree roots, when they decompose, can encourage the development of pipes and consequent dike failure.
- Large trees pose an additional threat to dike stability, especially during flood events when the dike structure becomes saturated. High winds and overbank erosion during floods can cause trees to fall resulting in the displacement of dike fill material and possible failure of the dike as well as debris problems downstream. In coastal regions especially, these conditions may occur simultaneously.

Vegetation control should be in accordance with *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* (5).

Fundamental maintenance information is identified in Chapter 3, and includes a schedule, based on the *flood hazard* 'sensitive months' (see above), for surveillance checks, inspections, and routine maintenance activities. Maintenance may be required more frequently than identified in the schedule when safety, security, and operational issues warrant. A 'typical' troubleshooting guide is included as a reference and this table can be modified as necessary for specific facilities.

1.6 Emergency Work

If there is a threat to the safety of the dike, the Local Diking Authority may carry out any work that is essential to prevent the dike or bank protection from failing, when site conditions provide a safe working environment. Further information is available in the *Flood Planning & Response Guide* (7).

The local diking authority is responsible to ensure there is adequate personnel, equipment and materials available to respond to emergency conditions. As the river rises to critical levels, crews should be prepared to undertake emergency repairs as discussed below. Environmental agencies should be consulted for advice as to good environmental practise.

Emergency Warning

An emergency warning is necessary when the possibility of uncontrollable dike failure is identified. Such failure could occur due to an identified potential overtopping or a breach.

If a potential failure is identified, the local Emergency Response Plan should be implemented.

The Local Authority and community group(s) should confine their efforts to preventing flooding while ensuring the safety of the workers.

Emergency Repairs

If there is a threat of failure to the dike system, repair work that is essential to prevent the dike or bank protection from such failure should be undertaken immediately, as long as working conditions remain safe. An emergency warning (see above) should be issued if there is concern of an imminent dike failure. If high water levels are sustained for some time, and the dikes become thoroughly saturated, it may become necessary to restrict traffic on the dike crest road and in low-lying areas near the dike.

A summary of typical emergency conditions and repairs is included in Chapter 2, **Table 14**, and supplementary information on failure modes and repair is identified in Chapter 3**.**

1.7 Emergency Response Plan

An emergency response plan is important to provide for the safety of the public and is required by provincial legislation. Emergency plans are intended to prevent loss of life, and to minimize damage to and loss of property resulting from flooding. For detailed information, see the *Flood Planning and Response Guide* (7).

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2. Fundamental Information

Table 1. Administrative Information for the Flood Protection System

Item	Description
Areas that could be Affected by Flooding and Areas Protected by Facilities *(towns, communities, districts, public facilities, etc.)*	☑ Towns, communities, districts: Oyster River - Strathcona Regional District Area D ☑ Homes, residential complexes: homes on Glenmore Road ☑ Agricultural lands, farms, etc.: large rural properties ☐ Airport: N/A ☑ Highways, Roads, Railroads: Highway 19A, access road to gravel pit ☐ Schools: N/A ☐ Utilities: N/A ☑ Public Facilities: trail network ☑ Businesses: Michael Oviatt Trucking and Aggregate
Local Government *(municipality / regional district)*	**Strathcona Regional District** Address: 301-990 Cedar Street, Campbell River BC V9W 7Z8 Phone: (250) 830-6700 Fax: (250) 830-6710 Email: administration@srd.ca
Local Association *(residents' association, rate payers' association, etc.)*	N/A
Diking Taxes : Paid by local residents? ☐ **Yes** ☑ **No**	**If yes,** Diking taxes paid to: *(local government, district, association, Inspector of Dikes, etc.)* Diking taxes provided to: *(rate payers association, etc)* By: *(direct taxation / grant from district)*
Dike Right-of-Way or Easement	ROW: registered ☑ **Yes** ☐ **No** Easement: registered ☐ **Yes** ☑ **No**
Management of System	Diking Authority (under the Dike Maintenance Act): Strathcona Regional District
Dike Inspections	Group responsible to conduct dike *inspections (Local Diking Authority, Inspector of Dikes, etc.)* **Strathcona Regional District** Is there a special agreement in place for inspections? ☐ **Yes** ☑ **No**
Dike Maintenance	Group(s) responsible to undertake maintenance activities: **Strathcona Regional District** Is there a special agreement in place for inspections? ☐ **Yes** ☑ **No**

Table 2. Regional and Local Contact Names and Agencies

Organization	Office Address & Phone	Representatives & Phone Numbers	After-hours Phone Numbers
Provincial Emergency Program (PEP)	**1-800-663-3456**		
Strathcona Regional District *Shaun Koopman*	301-990 Cedar Street Campbell River, BC V9W 7Z8	P (250) 830-6702 F (250) 830-6710 E SKoopman@srd.ca	P (250) 830-6702
FLNRORD Deputy Inspector of Dikes *Brian Epps*	2080-A Labieux Road Nanaimo, BC V9T 6J9	P (250) 751-3141 F (250) 751-3103 E Brian.Epps@gov.bc.ca	P (250) 751-3141
RCMP *Campbell River*	275 S. Dogwood Street Campbell River, BC V9W 8C8	P (250) 286-6221 F (250) 286-5617	P 911

Table 3. Summary of Legislation Applicable to Flood Protection Works

Legislation	Type of Work Proposed	Contact Authority* *(for information & direction)*
Written approval from the Office of the Inspector of Dikes (MOE) is required, as per the Dike Maintenance Act, prior to the start of any construction work on or near flood protection works. Approvals from other government offices may also be required.		
Dike Maintenance Act	▪ Proposed work at or near existing flood protection works ▪ Proposed new flood protection works.	▪ MOE
Water Act	▪ Any work proposed in and about watercourses. ▪ Any instream work or crossings. ▪ Proposed gravel or sediment removal or excavation.	▪ MOE
Canada Fisheries Act	▪ Any proposed work or vegetation removal in or adjacent to waters frequented by fish or containing fish habitat (marine or fresh water).	▪ MOE ▪ DFO
Land Act	▪ Proposed gravel removal / borrowing	▪ BCAL (where the stream-bed is on Crown Land).
Forest Act	▪ Removal of merchantable trees and wood from Crown land including streambeds and banks.	▪ FLNRORD
Navigable Waters Protection Act	▪ All proposed work within, above or under the wetted perimeter of a navigable water (defined in the Act).	▪ MOT
BC Environmental Assessment Act	▪ Major projects. (Legislation under development.)	▪ MOE
Local Government Act	▪ Provides for formation of bylaws and Improvement Districts. ▪ Authorizes new Diking Authorities. ▪ Provides authority for local government to regulate diking works.	▪ Local Government. ▪ PEP
Emergency Program Act	▪ Requires a local government to establish and maintain and emergency management plan. ▪ Provides local government authority to declare a state of emergency.	▪ Local Government.
Other Legislation (*local bylaws, etc)*		

MOE: BC Ministry of Environment, Water Stewardship Division
MOF: BC Ministry of Forests.
DFO: Department of Fisheries and Oceans (Government of Canada)
BCAL: BC Assets & Land Corporation
MOT: Ministry of Transport (Government of Canada)
PEP: Provincial Emergency Program

For further information on legislation relevant to flood protection works, see *Guidelines for Management of Flood Protection Works in British Columbia* (1), and www.qp.gov.bc.ca/bcstats/.

Table 4. Summary of Relevant Available Guides

Information covered	Guide	Date of publication
▪ Summary of **legislation & regulation** relevant to flood protection works. ▪ Approvals & controls under the Dike Maintenance Act. ▪ Responsibilities for flood management. ▪ Overview of operation, maintenance, & emergency measures. ▪ Checklists.	Guidelines for Management of Flood Protection Works in British Columbia (1)	March 1999
▪ Responsibility of local government for flood hazard management and **development in flood prone areas**: ▪ Authority and regulation, ▪ Implementation of controls, ▪ Official Community Plans, ▪ Floodplain bylaws. ▪ Steps in preparation of a floodplain bylaw (including a sample bylaw).	Regulatory Tools for Flood Hazard Management A Guide for Local Government (2)	March 2000
▪ A complete guide to **inspection** of flood protection works including dikes and appurtenances. ▪ Inspection scheduling, preparation, record keeping, report forms, patrol logs, etc. ▪ Field guides to identifying problems. ▪ Explanation of typical issues affecting flood protection works.	Flood Protection Works Inspection Guide (3)	March 2000
▪ Guide to design and placement of riprap for bank and slope protection. ▪ Design considerations. ▪ Construction practices and placement. ▪ Emergency repair. ▪ Maintenance. ▪ Technical appendix.	Riprap Design and Construction Guide (4)	March 2000
▪ Minimum standards for vegetation management on flood control structures. ▪ Environmentally sensitive approach to vegetation control. ▪ Consideration of fish habitat and dike maintenance activities.	Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment (5)	March 1999
▪ Responsibilities under the Emergency Preparedness Act (EPA). ▪ Flood response activities. ▪ BC Flood Plan	Water Related Hazards Emergency Response Plan and Procedures (6)	February 1998
▪ Emergency planning and preparedness in B.C.	See web site: www.pep.bc.ca	

Table 5. Overview of the Flood Protection Works

Item	Description
Watercourse *(river, lake, inlet, ocean)*	Oyster River
General Location *(town, region, local name)*	Oyster River, BC
Specific Location *(right/left/both banks when looking downstream)*	Left Bank
Year of Original Construction	1992
Year(s) of Upgrades / Rebuilds	2009, 2014, 2019
Dike(s)	☑ **Yes** ☐ **No** Number: Dike #24
Bank / Slope Protection	☑ **Yes** ☐ **No** Number of locations: 4
Floodbox(es)	☑ **Yes** ☐ **No** Number of locations: 1
Pipe / Storm Sewer(s)	☐ **Yes** ☑ **No** Number of locations: N/A
Pump Station(s)	☐ **Yes** ☑ **No** Number: N/A
Trash Rack(s)	☑ **Yes** ☐ **No** Number of locations: 1
Water Level Gauge(s)	☐ **Yes** ☑ **No** Number: N/A
Other:	☐ **Yes** ☑ **No** Number: N/A
Access Route *(direction, road, etc.)*	Glenmore Road
Access restricted *(locked gate / private property ,etc.)* ☑ **Yes** ☐ **No**	**Access / keys available through:** Raven Forest Products Ltd. Michael Oviatt Trucking and Aggregate

Table 6. Physical Description of the Works

Item	Location	Description
Dike	*(left/right bank)* Left bank	*(length)* 614.6m earth dike (198m of which has a semi-impermeable barrier)
Bank / Slope Protection	*(left/right bank)* Left bank	*(type of protection (e.g. riprap))* Riprap in 4 locations
Flood Box	*(location)* Sta. 0+390	*(number, size, material at each location)* Sump Inlet Headwall: concrete Culvert: 450mm SDR35 PVC Gate Valve: 450mm Outlet Headwall: concrete Flap Gate: 450mm
Pipe / Storm Sewer	N/A	*(number, size, material at each location)* N/A
Pump Station	N/A	*(number and type of pumps, etc.)* N/A
Trash Rack	*(location, purpose)* Flood Box	*(size, type, etc.)* Concrete Sump Inlet Headwall
Water Level Gauge	*(location)* N/A	N/A

Table 7. Sensitive Months for Flood Concern and Hydrometric Considerations

Item	Sensitive Months	Importance and Activities
Usual High Water Period (Usual flood season)	November to February	▪ Annual inspection and necessary maintenance should be completed prior to usual flood season. ▪ High water inspections and watches may be needed.
Usual Wet Season (heavy rainfall)	November to February	▪ High water inspections and watches may be needed.
Usual Low Water Period	July to September	▪ Low-water inspections to be completed. ▪ Repairs to areas exposed during low water should be completed. ▪ Annual maintenance should be done in months prior to onset of usual flood season.
Fisheries Construction Window	July 1 to September 15	▪ Period when work in the specified watercourse is allowed. (Approval through MOE & FOC required.)

*** Note: Unexpected conditions, including rain, temperatures, storms, and ice and debris jams, etc., can create flood conditions *at any time of the year*.**

Table 8. Annual Inspection Activities

Component	Inspection Items[1]	Operational Duties
Safety	▪ Take safety seriously and take precautions.	▪ Review safety requirements and take precautions.
Reporting	▪ *Flood Protection Works Basic Inspection Checklist*[1]	▪ Fill in inspection checklist. Identify required maintenance work. ▪ File inspection report in O & M Manual and forward copy to Dikes Inspector.
Access	▪ Check for security; safety, vandalism; signage, operation. ▪ Check condition of crest road. ▪ Check for obstructions to access, conditions of fences, gates, etc., availability of keys.	▪ Initiate repair or correct access and safety issues as soon as possible.
Dike	▪ Check crest, slopes, and toe for o settlement, depressions, sinkholes o cracking, slides, sloughing, o erosion, o seepage, piping, boils, o loss of freeboard, low spots. ▪ Look for unauthorized activity (construction, excavation, etc). ▪ Check for areas where vegetation hampers inspection and/or may weaken the dike. ▪ Look for rodent activity – paths and burrows. (Beavers can cause serious sinkholes.) One or more inspections annually to be done **at low water** to include toe.) ▪ Check for unauthorized excavation or construction on or adjacent to dike. ▪ Check river flow pattern for changes, deposition, scour, debris jams, etc. ▪ Check condition of scour or erosion around bridges or other structures in the vicinity.	▪ Identify needed repairs. ▪ Report unauthorized activity. ▪ Complete Basic Inspection Checklist[1] and Flood Protection Inspection Report[1] during annual inspection. Insert copy of report into O & M Manual and provide copy to DIOD. ▪ <u>SITE-SPECIFIC NOTE</u>: Trees left in place on land side of dike slope at #2493 Glenmore Road (Lot D) and #2475 Glenmore Road (Lot H) to be inspected annually. If an issue with any of these trees is identified, that tree is to be removed.
Bank / Slope Protection	▪ Check bank protection along river for signs of erosion, damage to existing protection, including: ▪ Loss, disturbance, weathering, or abrasion of protective material, ▪ Sloughing or cracking on slope, ▪ Scour at the toe (Toe to be done at **low water**), ▪ Erosion or scour of upstream or downstream ends (outflanking), ▪ Animal burrows and activity, ▪ Vegetation growth through bank protection material.	▪ Identify needed repairs.

Component	Inspection Items[1]	Operational Duties
Floodbox	▪ Check condition of flap gates and gate valve and operation to open and close freely providing a watertight seal. ▪ Check inlet and outlet for debris, structural conditions, etc. ▪ Check for leaks: look and listen for trickling or flow in inlet channel. ▪ Check outlet **at low water** for leaks and operation of gates.	▪ Identify needed repairs. ▪ Monitor identified minor leaks.
Pipe or Storm Sewer	N/A	N/A
Pump Station	N/A	N/A
Trash Rack	▪ Check structural condition. ▪ Check for debris or sediment blockage hampering flow.	▪ Identify needed repairs.
Water Level Gauge	N/A	N/A
Low Water Inspections	▪ Check toe for rodent activity, seepage, settlement, condition of bank protection etc. ▪ Check all outlets for leaks, gate operation, debris, etc.	▪ Identify needed repairs.

[1] For more information, see *Flood Protection Works, Inspection Guide* (3).

Table 9. Special Inspections

Type of Inspection[1]	Inspection Items[1]	Operation Duties[1]
Low water inspections	▪ Conducted at least once annually (see Table 11).	▪ See Table 8 Annual Inspection Activities.
High water patrol inspections	▪ Conducted during floods and high water events. ▪ Monitor the performance of the flood control works. ▪ Monitor land side slope and toe for excessive seepage and possible piping problems.	▪ Organize dike patrols, if required in flood years. ▪ Initiate or take corrective action as required.
Post Flood	▪ Conducted after a flood event.	▪ Develop high water profile. ▪ Inspect and assess condition of works.
Post Earthquake	▪ Integrate with emergency plan.	▪ Conduct a rapid overall assessment of remaining level of protection. ▪ Identify immediate danger of secondary damage.
Other	▪ As needed at other times of the year to react to particular situations including: ▪ Storms, earthquakes. ▪ Stream channel sedimentation. ▪ Debris or ice jamming.	▪ Organize dike patrols, if required. ▪ Initiate or take corrective action as required. ▪ Other duties as needed

[1] For more information, see *Flood Protection Works, Inspection Guide* (3).

Table 10. Routine Surveillance Check List (Whenever you visit the site.)

Component	Inspection Items[1]	Operational Duties
Safety	▪ Take safety seriously and take precautions.	▪ Review safety requirements and take precautions.
Access	▪ Check for security; safety, vandalism; signage, operation.	▪ Initiate repair of access and safety issues as soon as possible.
Dike (crest, slopes, toe)	▪ Check for obvious problems & damage (erosion, rodent burrows, sinkholes, etc.)	▪ Initiate repair immediately or with annual maintenance work as needed.
Bank / Slope Protection	▪ Check for obvious problems & damage (erosion, loss of material, scour, etc.)	▪ Initiate repair immediately or with annual maintenance work as needed.
Floodbox	▪ Check for obvious leaks, debris blockage, gate closure problems.	▪ Initiate repair immediately or with annual maintenance work as needed. ▪ Monitor identified minor leaks.
Pipe / Storm Sewer	N/A	N/A
Pump Station	N/A	N/A
Trash Rack	▪ Check for obvious damage and blockage problems.	▪ Initiate repair immediately or with annual maintenance work as needed.
Water Level Gauges	N/A	N/A

[1] For details on inspections see *Flood Protection Works, Inspection Guide* (3).

Table 11. Inspection and Maintenance Schedule

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Routine Surveillance[1]	√√	√√	√√	√√	√√	√√	√	√	√	√	√√	√√
Annual Inspection[1,2]								√				
High Water Inspection[2]	During high water events.											
Low Water Inspection[2]	At least once annually.											
Routine Maintenance	At least once annually.											
Vegetation Control[3]								√				

[1] Once monthly during low water months (✓); twice monthly during high water and wet months (✓✓); more often during periods of heavy rain. Refer to local tide charts to determine low water.

[2] For more information see *Flood Protection Works, Inspection Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.

[3] Vegetation control should be at least once or twice annually, depending on growth. For more information see *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment.* BC Ministry of Environment, Lands & Parks and Department of Fisheries and Oceans Canada; March 1999.

Table 12. Routine Maintenance Activity Summary

Component	Maintenance Items	Schedule	Action
Gates, locks, access	▪ Operation of security, safety, and access systems. ▪ Clear access needed at all times.	▪ Annually or more often if needed. ▪ Safety issues immediately.	▪ Lubricate locks, hinges, etc. ▪ Correct sign and access issues.
Dike	▪ Integrity of slope and bank erosion protection. ▪ Settlement, sinkholes, loss of material in dike crest and cross section, and other dike damage. ▪ Beaver or other animal activity causing damage to dike. ▪ Inspect concrete for integrity, cracking, etc.	▪ Annually or more often if needed for operation. ▪ Safety issues immediately.	▪ Repair damage and settlement to maintain design elevation and section. ▪ Repair erosion protection. ▪ Carefully explore and expose all rodent holes and tunnels. Excavate and fill with suitable compacted material. ▪ Control animal population as necessary.
Floodbox	▪ Gate operation. ▪ Prevention of backflow through floodbox.	▪ Annually or more often if needed for operation. ▪ Safety issues immediately.	▪ Lubricate hinges and locks. ▪ Investigate cause and location of suspected leaks. ▪ Clear debris.
Pump Station	N/A	N/A	N/A
Vegetation Control	▪ Mowing / trimming grass and weeds on dike crest and slopes including toe.	▪ At least once or twice annually.	▪ Mow dike from crest to toe of slope. ▪ Remove trees as needed.
Water Level Gauges	N/A	N/A	N/A
Critical Dike Damage	▪ Major leak or settlement. ▪ Structural damage to any part of system. ▪ Stability of dike threatened	▪ Immediately.	▪ Repair immediately. ▪ Inform DIOD. ▪ Invoke Emergency Plan if necessary. ▪ Advise landowners as necessary.
Special Maintenance Items	▪ Creek bed erosion ▪ Sedimentation	▪ As necessary and determined by established procedures.	▪ Establish procedure for sediment/debris removal ▪ Establish design allowances.

Table 13. Troubleshooting Guide

Problem	Details	Action
Beaver holes	▪ Sinkholes or dike damage.	▪ Carefully explore and expose all tunnels leading to/from main hole. ▪ Excavate holes & tunnels and fill with suitable compacted material.
Motor doesn't start	N/A	N/A
No Power	N/A	N/A
Pump runs rough	N/A	N/A
Backflow through Floodbox	▪ Leaking suspected by eye or ear. ▪ Gate not properly sealed.	▪ Monitor minor backflow concern (some minor leaking occurs occasionally when small debris stuck in gate – may correct itself at next high water) ▪ Check hinge and gate valve operation at low water. Lubricate or arrange for repair as necessary. ▪ Look for obvious blockage at gates – logs, submerged objects or rocks blocking free swing of gate doors. Arrange for debris removal as necessary.

Table 14. Summary of Emergency Conditions and Repair

Emergency Condition	Definition	Problem	Repair
Active boil	Stream of seepage water carrying silt and sediment and rising as a spring in a depression – on landside of dike	Sudden failure due to undermined dike foundation.	Construction of an impervious ring around boil to stop transportation of solid material.
	Contact emergency organization if (1) active boils extensive, (2) inactive boils and water levels rising. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
Slope Seepage (excessive)	Percolation of water through or under the dike foundation – usually visible in landside toe ditch.	Sloughing of landside toe, threatening dike stability.	Add free draining fill berms where landside slope soggy.
	Obtain expert advice on slope stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
Riverside Erosion	Scour of riverside slope of dike, berm, or bank.	Removal of dike material under the water surface resulting in dike failure.	Additional bank protection (such as large riprap). End dumping acceptable in emergency situation only.
	Obtain expert advice on bank protection and stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE BREACH IS POSSIBLE.		
Wavewash	Erosion of the dike slope by wave action (high wind and wave conditions).	Removal of exposed materials causing breach.	Placement of protective material or filled sacks. Patrol identified areas and monitor closely.
	Obtain expert advice on likely locations of wavewash prior to high water.		
Local Overtopping	Flow of water over the dike crest.	Breach of dike due to wash out of crest material once overtopping occurs.	Sandbags for raising short sections of the dike. Other methods of adding material for longer dike sections.
	IMPLEMENT EMERGENCY RESPONSE PLAN IF OVERTOPPING OR BREACH IS POSSIBLE. No heavy equipment on dike when water level is high.		
Internal Drainage	Local runoff and drainage from areas inside dike which is trapped due to high water on the receiving watercourse.	Saturation of landside of dike. Possible flooding of areas internal to dike.	Temporary pumping or upstream diversion of inflow from higher elevations.
	Maintain a list of potential pump and generator suppliers.		

3. Supplementary Information

3.1 Administration

The O & M Manual can serve as the place to document all information regarding the flood control works, and a list of local contractors and experts can be very useful when work is required on the works. Additional information and suggested tables are included in the *"Flood Planning and Response Guide"* (7).

Additional administrative information is included:

Information	**Located:**
☑ Copies of Relevant Documents & Drawings	
☑ Vegetation Maintenance and Staging Plan *(2221-49230 C101)*	Appendix A
☑ Existing and Design Plan and Profile *(2221-49230 C102)*	Appendix A
☑ Existing and Design Sections *(2221-49230 C103)*	Appendix A
☑ Dike and Outlet Box Details *(2221-49230 C104)*	Appendix A
☑ Oyster River: Glenmore Dike Assessment Final Report	Appendix B
☑ Right of Way Information *(VIP 56947)*	Appendix C
☑ Government Acts *(Dike Maintenance Act)*	Appendix E
☑ Stakeholders ▪ Agencies and individuals concerned with flooding issues.	Table 15
☑ Property Owners	Table 16
☑ Local Contractors and Suppliers ▪ Local or experienced professionals *(such as engineering firms and construction firms).* ▪ Local contractors and equipment. ▪ Locally available rental equipment (such as pumps and generators). ▪ Local sources and available materials (such as gravel pits, sources for riprap and fill material).	Table 17
☑ Local Authority supplies available: ▪ Stores, services, equipment, ▪ Radios and cellular telephone numbers, ▪ Employees with first aid certification.	

Table 15. Stakeholders

Corporation	Contact Person	Phone	Involvement
Strathcona Regional District	Shaun Koopman	(250) 830-6702	Protective Services Coordinator
Michael Oviatt Trucking and Aggregate	Michael Oviatt	(250) 923-0311	Vehicle access to gravel pit

Table 16. Property Owners within the Flood Protection Area

Landowner Name	Property Identification (address, legal description)	Phone Number
Raven Forest Products Ltd.	Rem Lot 2, Block 29, Comox District, Plan 3434	(250) 287-2215
Steven Raymond Moren	Lot A, Block 29, Comox District, Plan 19175 (#2509 Glenmore Road)	(250) 923-2545
Cornelia Bray Kevin Bray	Lot B, Block 29, Comox District, Plan 19175 (#2503 Glenmore Road)	Not Listed
Mark David Tidmarsh	Lot C, Block 29, Comox District, Plan 19175 (#2497 Glenmore Road)	Not Listed
Kurt Andrew Dawson	Lot D, Block 29, Comox District, Plan 19175 (#2493 Glenmore Road)	(250) 923-1559
Donald Amarjit Gill Sandra Gill	Lot E, Block 29, Comox District, Plan 19175 (#2489 Glenmore Road)	Not Listed
Donald Amarjit Gill Sandra Gill	Lot F, Block 29, Comox District, Plan 19175 (#2485 Glenmore Road)	Not Listed
Grant Wayne Rogers Debra Lee Rogers	Lot G, Block 29, Comox District, Plan 19175 (#2479 Glenmore Road)	(250) 923-6451
Lucas Allen Lenaour	Lot H, Block 29, Comox District, Plan 19175 (#2475 Glenmore Road)	Not Listed
Strathcona Regional District	Lot I, Block 29, Comox District, Plan 19175	(250) 830-6700
Crown	Lot J, Block 29, Comox District, Plan 19175	(250) 286-9300
Strathcona Regional District	Lot K, Block 29, Comox District, Plan 19175	(250) 830-6700

Table 17. Local Contractors & Suppliers

Corporation	Contact Person	Phone	Expertise
McElhanney Ltd.	Mark DeGagné	(250) 287-7799	Engineering, Surveying, Geotechnical and Materials Testing, Environmental Services
Wacor Holdings Ltd.	Al Wakita	(250) 287-9644	Construction Contractor, Gravel Supplier
Upland Contracting Ltd.	Brad Maxwell	(250) 286-1148	Construction Contractor, Gravel Supplier
Five Star Aggregate and Excavating Ltd.	Nevin Zimmerman	(250) 923-7553	Construction Contractor, Gravel Supplier
Michael Oviatt Trucking and Aggregate	Michael Oviatt	(250) 923-0311	Construction Contractor, Gravel Supplier
United Rentals		(250) 287-4888	Equipment Rental
C & L Supply 1988 Ltd.	Rodney Semkiw	(250) 287-9231	Equipment Rental

BOLD indicates 24HR Emergency Phone Number

3.2 Physical Works

☑ **Additional Physical Works information is included:**

	Information	Located:
☑	Design criteria	Table 18
☑	Record drawings	Appendix A
☑	Oyster River: Glenmore Dike Upgrade Assessment Final Report	Appendix B
☑	Construction photos	Appendix D

Table 18. Design Criteria

Item	Object	Criteria
Designated Flood Event		☑ 1 in 200 year event ☐ 1894 flood of record ☐ 1 in 20 year event
Dike Design	▪ Crest elevation ▪ Freeboard	▪ 19.5m to 21.1m (Sta. 0+000 to Sta. 0+170) ▪ 0.6m

3.3 Flood Hazard

☑ **Additional flood hazard information is included:**

	Information	Located:
☑	Record of past flooding events.	Table 19
☑	Record of hydrometric records and gauges.	Table 20
☑	Records of historical flood events (newspaper articles, interviews, etc.).	Section 3.3
☑	Photographs of flood events and damage.	Section 3.3
☑	Floodplain mapping.	Map 1
☑	Annual peak flow and stage (water level).	Table 21
☑	Mean monthly and annual flow data.	Table 22
☑	Temperature and precipitation records.	Figure 1

Table 19. Past Flooding Events Record

Date (month, year):	**Flood Severity** *(return period, severity)*	**Flooded Area** (general description)
December 2014	Max. Daily Discharge: 272m3/s Max. Daily Water Level: 2.583m	Oyster River flood event. Glenmore Road Dike breach. Flooding caused property damage. Emergency repair completed. Permanent upgrades designed.
November 2011	Max. Daily Discharge: 180m3/s Max. Daily Water Level: 2.292m	Oyster River flood event. Localized flooding and high groundwater levels due to severe rain event and king tides. Flooding caused property damage.
December 2010	Max. Daily Discharge: 238m3/s	Oyster River flood event. Localized flooding and high groundwater levels due to severe rain event. Flooding caused property damage.
November 2009	Max. Daily Discharge: 253m3/s	Oyster River flood event. Glenmore Road Dike breach. Flooding caused property damage. Emergency repair completed.
November and December 1990	Max. Daily Discharge: 202m3/s	Oyster River flood event. Flooding caused property damage. Glenmore Road Dike constructed 1992.
December 1980	Max. Daily Discharge: 220m3/s	Oyster River flood event. Flooding caused property damage.
November 1975	Max. Daily Discharge: 260m3/s	Oyster River flood event. Flooding caused bank erosion. Bank armoured with riprap.

Source: *Oyster River / Saratoga Beach Flood Risk Assessment Final Report*. Ebbwater Consulting. 2018.

Environment Canada.

Table 20. Hydrometric Records and Streamflow Gauges

Information		Additional data
Geodetic Survey of Canada bench markers	Monument Location: Bridge over Oyster River on Highway 19A	All elevations are geodetic and derived using dual frequency GNSS observations and processed using the PPP service of Natural Resources Canada (McElhanney 2019)
River levels at gauge: 08HD011 **Location:** Oyster River below Woodhus Creek	Source: Environment Canada	☑ annual peak flow and stage (water level) ☑ mean monthly and annual data (See Tables 20.1 and 20.2)
River flood levels: 2.583m max. daily water level (2014), not measured (2009) **Location:** 08HD011	Reports prepared by:	☐ included in:

State of Emergency Declared in Courtenay, B.C.

Darcy Wintonyk, ctvbc.ca
Published Monday, November 16, 2009 9:19PM PST

A city on the eastern shores of Vancouver Island declared a state of emergency Monday in response to major flooding.

Courtenay Mayor Greg Phelps issued the warning because of high water levels in the Puntledge, Courtenay, Tsolum and Browns Rivers.

The Courtenay Engineering Department evacuated 54 people around Maple Pool Campsite and surrounding homes on Headquarters Road. More residences were on evacuation alert.

Numerous roads and bridges were closed just before noon, including Highway 19A and Old Island Highway.

On Monday evening, officials said that the roads had reopened and that water levels in the rivers had dropped significantly. No widespread flooding was anticipated.

Two evacuation receptions centres were set up, the first at a Salvation Army Church on Fitzgerald Avenue, and a second at Comox Presbyterian Church on Aspen Road.

Officials asked residents not to go to the churches unless they were evacuated from their homes.

Island hit hard

A major frontal weather system moving through B.C.'s south coast caused multiple power outages and floods.

Heavy rain, combined with snow melt, prompted flood warnings for multiple Vancouver Island rivers. As of late Monday afternoon, they included the Salmon River at Sayward, Oyster River (south of Campbell River), Tsolum River (Courtney), Englishman River (Parksville), Nanaimo River, Chemainus River, Cowichan River and Koksilah River (Mill Bay).

Some parts of the Island recorded a couple hundred millimeters of rain over the past day and a half.

The Nanaimo and Cowichan Rivers were near two-year return period levels and were rising.

Environment Canada said the coast will continue to be whipped with a strong frontal system, bringing an additional 30 to 90 millimeters of rain to the already soggy coastal region in the next 24 hours.

Oyster River Could Exceed 20-Year Flood Level

Mike Davies, Campbell River Mirror
Published Tuesday, December 9, 2014 5:00AM PST

Folks with property on the Oyster River should probably be filling their sandbags.

“River levels on Vancouver Island and the Central Coast have risen substantially overnight (Dec. 8),” according to the alert issued at 10:45 a.m. on Dec. 9.

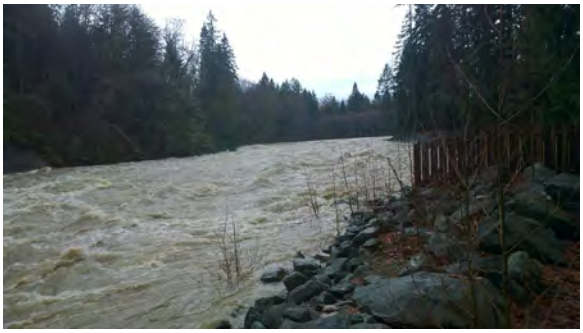
“Flows on the Tsolum River and Oyster River are now above the 10 year flood level and are expected to continue to rise today (Dec. 9), potentially exceeding the 20-year flood level.”

We will continue to monitor the situation and update this story at campbellrivermirror.com

Photographs of Flood Events and Damage

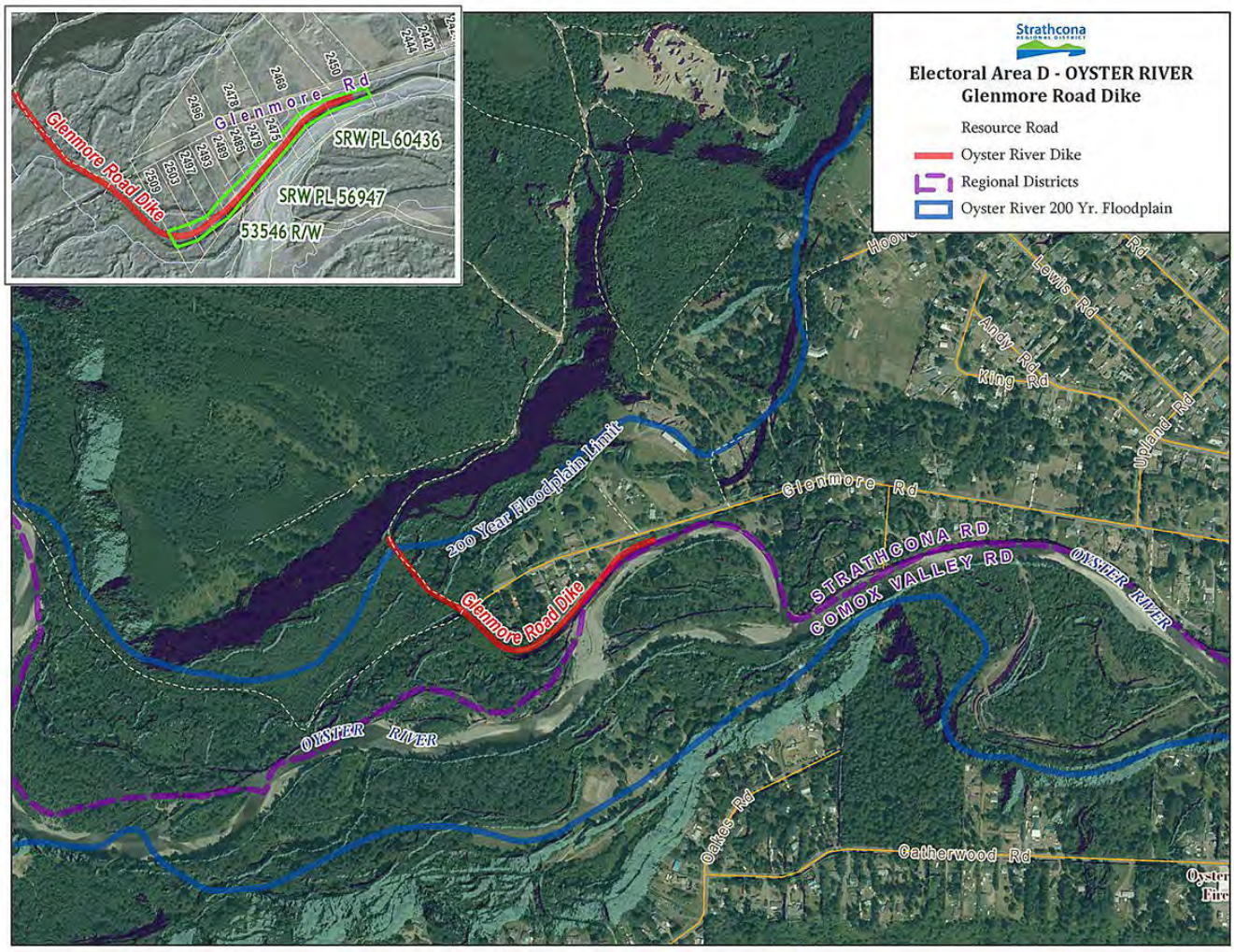
Source: Campbell River Mirror, 2014

Source: Campbell River Mirror, 2014



Source: McElhanney Ltd., 2014

Source: McElhanney Ltd., 2014



Map 1. Floodplain Mapping

Source: *Electoral Area D – OYSTER RIVER, Glenmore Road Dike*. Strathcona Regional District. Accessed 2019.

Table 21. Annual Peak Flow (m^3/s) and Stage (m) - 08HD011

Max. Daily Discharge (m^3/s)		Min. Daily Discharge (m^3/s)		Max. Daily Water Level (m)		Min. Daily Water Level (m)	
1992-10-24	109	1992-09-21	0.567	-	-	-	-
1993-12-04	83.2	1993-10-12	0.744	-	-	-	-
1994-03-02	161	1994-10-08	1.18	-	-	-	-
1995-11-18	153	1995-09-26	1.72	-	-	-	-
1996-01-11	112	1996-10-02	1.15	-	-	-	-
1997-10-09	121	1997-08-20	2.26	-	-	-	-
1998-01-24	105	1998-09-30	0.722	-	-	-	-
1999-11-09	132	1999-10-11	1.76	-	-	-	-
2000-05-21	54.5 E	2000-10-12	1.08	-	-	-	-
2001-11-15	145	2001-09-25	1.42	-	-	-	-
2002-01-07	147	2002-11-04	0.651	-	-	-	-
2003-10-18	210	2003-10-05	1.21	-	-	-	-
2004-11-15	170	2004-08-20	1.42	-	-	-	-
2005-12-22	145	2005-09-27	0.790	-	-	-	-
2006-11-15	110	2006-10-14	0.976	-	-	-	-
2007-11-12	174	2007-09-28	1.73	-	-	-	-
2008-05-18	84.2	2008-09-20	1.01	-	-	-	-
2009-11-16	**253**	**2009-09-04**	**0.659**	-	-	-	-
2010-01-11	**238**	**2010-09-10**	**2.11**	-	-	-	-
2011-11-27	**180**	**2011-09-20**	**2.48**	**2011-11-27**	**2.292**	**2011-09-20**	**0.933**
2012-01-04	175	2012-10-11	1.21	2012-01-04	2.280	2012-10-10	0.853
2013-09-30	69.8	2013-09-19	1.55	2013-09-30	1.748	2013-09-19	0.879
2014-12-09	**272 E**	**2014-09-16**	**0.562**	**2014-12-09**	**2.583**	**2014-09-16**	**0.834**
2015-02-06	153	2015-08-04	0.709 E	2015-02-06	2.218	2015-08-04	0.925
2016-01-28	238 E	2016-08-28	1.21	2016-11-03	2.495	2016-08-28	0.945
2017-11-23	129	2017-10-09	0.524 E	2017-11-23	2.080	2017-10-09	0.879

E - Estimated

Table 22. Mean Monthly and Annual Data (m^3/s) - 08HD011

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1992	34.6	25.8	10.0	14.5	11.4	8.61	4.34	1.46	0.962	11.7	14.2	6.68	12.0
1993	6.35	10.5	15.7	14.2	26.1	15.8	5.79	3.53	1.40	2.47	5.69	20.2	10.6
1994	17.3	8.30	23.8	21.0	14.5	10.7	4.74	2.79	2.56	4.97	10.0	24.2	12.1
1995	22.0	24.8	19.6	13.7	30.6	19.9	10.0	3.85	2.45	16.4	48.0	29.0	20.0
1996	25.2	19.3	13.0	25.0	12.3	11.4	5.93	2.05	1.91	10.6	14.0	8.56	12.4
1997	17.9	9.34	15.6	21.4	29.5	20.3	11.6	4.86	13.3	38.3	27.6	16.3	18.8
1998	31.6	23.8	16.7	9.91	30.8	22.4	8.75	2.20	0.979	6.58	23.7	17.8	16.3
1999	18.1	12.8	10.7	18.0	30.9	43.1	31.4	13.3	3.78	5.81	30.2	16.2	19.5
2000	4.82	8.25	6.41	14.3	14.8	21.2	9.17	3.45	1.82	9.37	7.74	10.2	9.29
2001	12.2	4.08	8.88	12.9	15.9	14.5	6.66	4.62	2.46	6.47	34.7	13.0	11.4
2002	25.0	6.10	4.79	15.4	17.7	17.5	6.03	2.32	1.33	0.806	27.8	21.5	12.2
2003	22.4	7.87	23.3	22.9	19.5	20.6	7.66	2.75	1.71	33.1	4.19	11.8	14.8
2004	22.5	10.0	13.9	19.2	21.4	12.0	4.78	1.95	4.44	8.82	33.3	21.7	14.5
2005	26.7	7.92	8.01	18.1	21.4	9.20	3.69	1.67	1.20	17.0	16.7	28.4	13.3
2006	22.5	8.73	10.2	17.0	31.2	26.8	8.99	2.07	1.57	2.88	29.2	19.5	15.1
2007	22.7	12.3	21.1	15.9	24.6	22.3	13.0	4.30	2.74	24.1	21.7	16.3	16.8
2008	8.02	4.20	7.68	7.95	34.2	18.6	7.80	2.65	1.53	7.38	22.0	6.06	10.7
2009	**6.61**	**3.31**	**6.73**	**10.8**	**19.8**	**9.80**	**3.57**	**1.16**	**1.64**	**9.29**	**46.5**	**11.1**	**10.9**
2010	**38.4**	**16.8**	**12.5**	**18.5**	**22.7**	**27.9**	**15.1**	**5.31**	**4.37**	**13.5**	**16.1**	**25.6**	**18.1**
2011	**14.9**	**17.0**	**11.0**	**9.47**	**28.6**	**37.0**	**22.2**	**8.23**	**10.3**	**13.6**	**18.1**	**8.62**	**16.6**
2012	19.9	12.1	9.10	19.1	23.5	25.9	15.3	3.94	1.62	7.93	19.9	11.1	14.1
2013	4.25	6.90	14.2	19.0	25.5	15.0	5.08	2.27	6.72	7.70	9.74	3.95	10.0
2014	**9.26**	**3.19**	**13.2**	**13.7**	**20.0**	**6.60**	**2.61**	**0.950**	**1.63**	**29.9**	**22.7**	**37.3**	**13.4**
2015	17.1	27.5	16.0	7.41	4.71	3.13	1.03	1.18	5.76	7.11	15.1	28.7	11.2
2016	22.1	21.3	26.3	23.6	15.2	10.8	4.97	1.95	1.95	45.5	55.3	5.50	19.5
2017	12.8	13.6	9.50	21.9	28.0	16.2	5.28	1.66	0.740	8.77	32.7	7.42	13.2

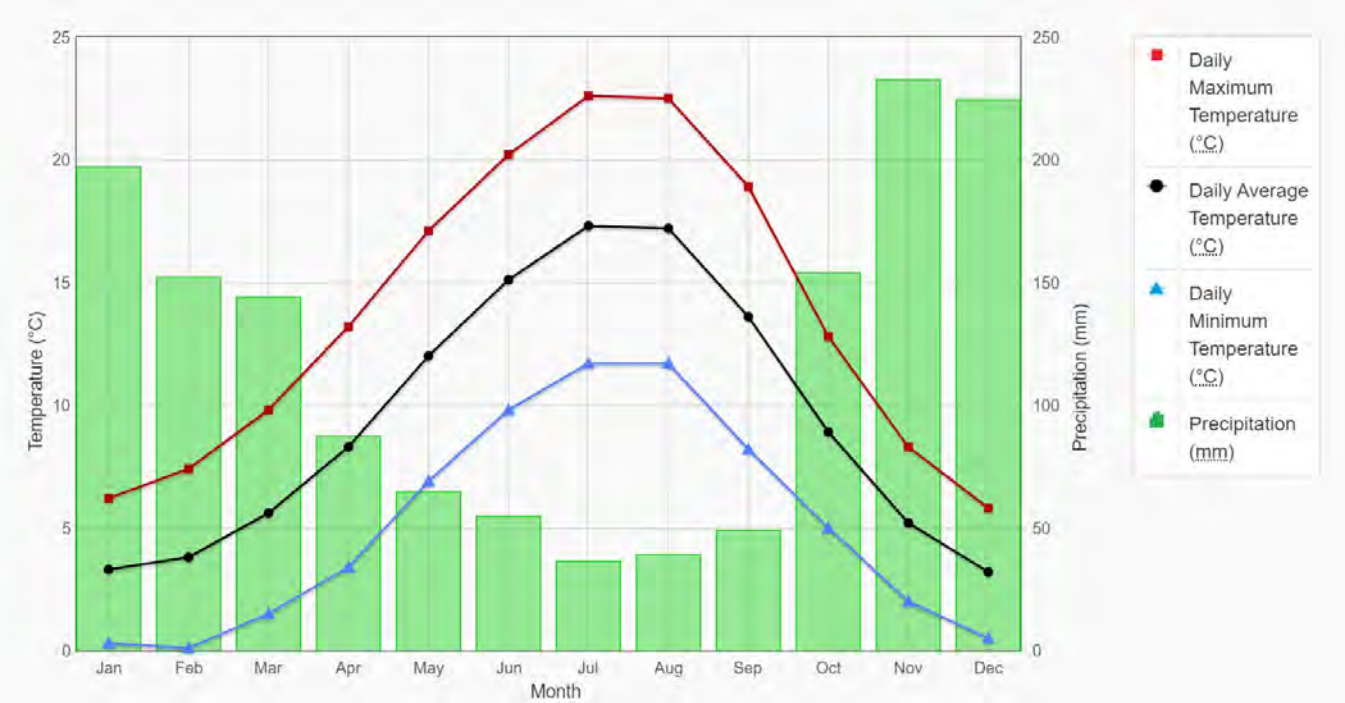


Figure 1. Temperature and Precipitation Records - 1981 to 2010 Canadian Climate Normals
OYSTER RIVER UBC

Source: Environment Canada

3.4 Inspection

☑ **Additional inspection information is included:**

	Information	Located:
☑	Inspection reports	Appendix D

3.5 Maintenance of Flood Protection Works

The information presented below is supplementary to the summary presented in Chapter 2 and provides additional detail to the maintenance activities identified in that table.

☑ **Additional information is included:**

	Information	**Located:**
☑	Summary of Supplementary Dike Maintenance Considerations	Table 21
☑	Summary of Supplementary Slope & Bank Protection Maintenance Considerations	Table 22
☑	Summary of Supplementary Floodbox Maintenance Considerations	Table 23

Dike Maintenance

Access, Fences, and Gates

Access should be restricted to authorized vehicles only, wherever possible. Access should always be free of obstacles since an emergency can occur at any time and access may be needed for fire fighting, rescue, etc. Gates and locks should be kept in good working order, with keys readily available. (The location of the key is included in Chapter 2, Table 5.)

Dike Crest, Cross-section, and Embankment

To provide the intended flood protection, the crest elevation and dike cross-section must be maintained. The crest elevation protects against the water levels predicted for the design flood event and the cross-section provides dike stability at those water levels. Dike crowns should be graded for good drainage, and vegetation controlled appropriately.

Every three to ten years the dike crest profile should be surveyed and compared to the design profile. Any low areas should be raised by the addition of crushed gravel surfacing, prior to grading of the whole dyke crest as required to maintain a smooth riding surface.

A significant part of maintenance of the dike itself is the early identification of problems. Identification and repair of problems is discussed further in *Guidelines for Management of Flood Protection Works in British Columbia* (1), and *Flood Protection Works, Inspection Guide (3)*.

Vegetation Control

Vegetation is the most effective means of protecting the dike from surface erosion due to rain, currents, and wave wash. The root systems of larger trees and shrubs can threaten the stability of the dike system by providing routes for piping. Piping removes fill material and can result in structural failure of the dike. Thus, from a flood protection perspective, vegetation on dike slopes should consist of closely trimmed grass.

Large trees pose an additional threat to dike stability, especially during flood events when the dike structure becomes saturated. High winds and overbank erosion can cause trees to fall resulting in the displacement of dike fill material and possible failure of the dike. In coastal regions especially, flood and storm conditions can occur simultaneously. (9)

Trimming of vegetation is important to:

- allow proper inspection of the surface and slopes for seepage and erosion,
- prevent piping, which can lead to dike failure, due to tree and brush root systems,
- discourage burrowing animals whose burrows are detrimental to dike stability,
- prevent large trees, and thus prevent potential piping routes along root systems, from establishing on the dike.

In recognition of environmental and recreational opportunities, and of the cost of mowing, longer grasses and small bushes are acceptable on dike slopes under controlled conditions. Vegetation should be well trimmed just prior to the high water season so that proper inspections can be made as water levels rise. Trees should not be permitted to attain a diameter greater than about two inches. Larger trees, and their root systems, should be removed and the excavation properly backfilled. This work is best carried out after the predicted flood season has passed.

The document *Environmental Guidelines for Vegetation Management* (5) presents effective techniques for vegetative maintenance which balance the environmental benefits of vegetation with the operation of the dike for flood protection.

Animal Burrows

Animal burrows can threaten the stability of the dike and embankment as well as cause significant settlement and erosion. If animal holes or burrows are discovered during inspection, the holes and tunnels should be completely excavated and backfilled with suitable compacted material.

Trapping of the animals may be advisable in such areas after consultation with local Fish and Wildlife authorities.

Internal Drainage

Internal drainage systems are installed to prevent excess flow through the dike fill which can convey material out of the dike resulting in a piping failure of the foundation and ultimately the embankment. Inspection of the dike system should identify potentially serious seepage problems.

Serious seepage problems, particularly where seepage waters are observed to be muddy indicating that material is being lost from the dike, the responsible individuals should be notified without delay so that corrective action can be taken immediately if necessary.

Table 23 summarizes the dike maintenance considerations.

Table 23. Summary of Supplementary Dike Maintenance Considerations

Component	Important Considerations	Maintenance Activity
Access, Fences, & Gates	■ Maintain clear access at all times. ■ Fences & gates reduce vandalism, provide safety, reduce liability. ■ Restrict access to authorized vehicles only.	■ Maintain roadways, fences, gates, etc. ■ Ensure locks are in good order and keys are readily available. ■ Keep access clear at all times.
Dike Crest, Cross Section, & Embankment	■ Crest elevation protects against water levels. ■ Cross section and embankment (slope) provide dike stability at high water.	■ Repair damage and settlement with appropriate fill materials and compaction[1]. ■ Grade crown for drainage. ■ Maintain crest road. ■ Control vegetation. ■ Repair seepage problems[1]. ■ For erosion protection see below. ■ Occasional survey to verify crest profile.
Vegetation Control[2]	■ Trimmed grass protects from surface erosion. ■ Large vegetation and roots interfere with inspection, threaten stability of dike by providing a piping route, and can displace dike materials and create debris during flood event.	■ Trimming, mowing and weed control. ■ Remove large trees and shrubs.
Animal Burrows	■ Burrows threaten stability of dike and embankment.	■ Excavate burrows and tunnels and fill with suitable compacted material[1]. ■ Discourage animals[1].
Internal Drainage	■ Prevents excess flow through dike fill. ■ Piping can result in dike or foundation failure due to lost material.	■ Repair drainage system[1]. ■ Install additional drainage systems.

[1] Obtain expert advice as needed. Contact MOE for assistance.

Slope & Bank Erosion Protection

Bank erosion protection is installed on steep slopes adjacent to the watercourse to prevent erosion from degrading the material comprising the dike embankment. The protection is comprised of angular pieces of blasted rock, or riprap, which protects the fine materials in the embankment from degradation due to swiftly moving waters of the main watercourse. The gradation and size of the rock is determined by the stream velocity and/or wave strength and the slope of the bank.

Bank protection requires varying degrees of maintenance depending upon the degree and frequency of exposure to stream flow or wave action. The protection should be maintained to design grade and thickness. Riprap surfaces should be kept clean of all trees and brush as the root system of a toppled tree can displace riprap to expose finer materials subjecting the embankment to severe erosion attack.

Damage to dike slopes should be repaired by the addition and compaction of appropriate earth fill materials to restore the slope to original conditions, and by the addition of suitable graded rock riprap. Approval must be obtained from MOE before commencing repair work within the wetted perimeter of the dike system. Where severe erosion has or is occurring at points of concentrated attack, redesign of protection may be needed before repairs are effected. Technical advice can be obtained from MOE.

Table 24 summarizes the erosion protection considerations. For more information see *Riprap Design and Construction Guide* (4).

Table 24. Summary of Supplementary Slope & Bank Protection Maintenance Considerations

Component	Important Considerations	Maintenance Activity
Riprap or Rock Slopes[2]	▪ Angular pieces of rock provide protection against erosion due to high water velocities and waves.	▪ Maintain design grade, elevation, and thickness by addition of suitable rock[1]. ▪ Repair slides, settlements, washes, and material loss. ▪ Prevent undercutting at ends of protection.
Vegetation Control[3]	▪ Vegetation and roots threaten the integrity of the erosion protection.	▪ Remove vegetation from protected areas.
Animal Burrows	▪ Burrows displace protective materials and threaten slope stability.	▪ Excavate burrows and tunnels completely and fill with suitable compacted material[1]. ▪ Discourage animals[1].
Debris & Drift	▪ Debris can cause rock materials to be dislodged.	▪ Remove debris, drift, refuse, etc. washed onto the slope.

[1] Obtain expert advice as needed. Contact MOE for assistance.

[2] For further information see *Riprap Design and Construction Guide* (4).

[3] For further information see *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* (5).

Floodbox

The purpose of the floodbox is to allow the gravity discharge of the internal drainage water from behind the dike into the main watercourse during time when the external water level is lower than the level behind the dike. The system consists of a single 450mm diameter culvert through the dike with a flap gate at the outlet to prevent backflow from the watercourse when water levels are high. Additionally, an emergency gate valve, which is normally to be left open and closed only when the flap gate fails, has been installed near the inlet. When the gate valve is closed, temporary pumping may be required to assure that internal water levels are maintained below the top of the flood box pipe. It is recommended that a temporary gas or diesel driven pump capable of pumping 500-750usgpm be obtained to pump water over the dike. More pumps may be required of rainfall runoff exceeds the recommended pump capacity. Trash racks are fitted at the inlet.

Maintenance of a floodbox consists of cleaning the inlet and the outlet of any accumulated debris and sediment to ensure the water can flow freely through the culvert, and cleaning and lubricating the closure gate to ensure that it swings freely and closes properly with a good seal. The dike slopes adjacent to the floodbox should be kept clear of trees and brush to allow unimpeded inspection of the inlet and outlet and to restrict the amount of debris accumulating in the channel.

The floodbox should be checked regularly in areas where beavers are present since these animals can plug culverts or construct dams very quickly. Unusually high water levels are a good indication of beaver activity. Culverts should be cleared immediately, before the situation becomes more difficult to rectify.

Table 25 summarizes the floodbox considerations.

Table 25. Summary of Supplementary Floodbox Maintenance Considerations

Component	Important Considerations	Maintenance Activity
Floodbox (Pipes and Culverts)	▪ Provides drainage for areas behind the dike from which surface runoff would otherwise be trapped.	▪ Keep pipes clear of trash and debris. ▪ Inspect frequently where beavers exist.
Inlet and Outlet Channels and Headwalls	▪ Channels direct flow into culvert(s). ▪ Headwalls provide structural and hydraulic control.	▪ Clear any debris or blockage. ▪ Identify, evaluate and repair structural problems[1].
Gates, Valves, Operating Mechanisms, Emergency Closures	▪ Control mechanisms allow the pipes to be closed in times of high water (on the watercourse) to prevent reverse flow or for repair purposes.	▪ Lubricate and test operate gates regularly. ▪ Maintain in good operating condition. ▪ Clear debris and blockage.
Trash Racks	▪ Trash racks keep large debris from entering the pipe where it could become lodged against a wall causing a blockage inside the pipe.	▪ Clear trash and debris. ▪ Maintain in good operating condition and repair damage, corrosion, etc.
Riprap	▪ Riprap provides erosion protection to the surfaces of the structures that are in the watercourse.	▪ See previous section on Slop & Bank Erosion Protection.

[1]Obtain expert advice as needed. Contact MOE for assistance of necessary.

3.6 Emergency Repair Work

☑ **Additional information is included:**

	Information	Located:
☑	Summary of dike emergency problems	Table 14
☑	Descriptive paragraphs and supplementary explanation of common problems and their repair	Section 3.6

Active Boiling

A *boil* is a definite stream of seepage water issuing from the earth, usually near the landside toe of the dike or appearing as a spring in a ditch or depression on the landside. An *active boil* is a boil that is actively upwelling sandy or silty water. Recognition of a boil is discussed in the document *"Flood Protection Works Inspection Guide"* (3).

Water that flows from a boil carries with it material from beneath the dike itself and may gradually undermine the dike and result in a failure by causing sudden subsidence of the dike foundation. Due to the difficulty in evaluating the seriousness of a boil, all boils should be marked, uniquely named, and watched closely for changes.

A boil that discharges **clear** water in a steady flow is an *inactive boil* and is usually not a serious threat to the safety of the dike. The only action necessary in this case is to make careful and frequent observation of the boil and to drain excess water off to prevent its impoundment near the dike. If the flow increases and carries a material load of sand or silt, corrective action, as for an active boil, should be taken immediately. (7). All flowing inactive boils should be flagged and uniquely numbered and closely monitored throughout the flood period in case they start to transport solids.

The dike emergency organization should be notified if (1) the area of active boils is extensive, or (2) the area of inactive boils is extensive and the river level is expected to rise.

Repair:

The simplest and most effective method of treating an active boil (one that is carrying sand and silt) is to construct an impervious ring around it of a sufficient height to stop the transportation of solid material. It should not be built to a height which stops the flow of clear water because of the probability of building up an excessive local pressure head, which could cause dike failure or additional boils nearby. Sandbag rings are the most generally accepted method of repair, but concrete well rings, short pieces of large diameter pipe, earth berms, sheet steel pilings, etc., can all be used.

The recommended method of building a sandbag ring is:

- **Scarify the base**
  for the ring (internal diameter of which should be at least 1.5 times the contemplated height) to provide a watertight bond between the natural ground and the sack ring (**a very important step**).

- **Lay sacks in a ring**
  around the boil and surrounding weak ground starting at the outer edge and working towards the centre. Joints should be staggered and loose earth used as a mortar.
- **When proper height**
  is reached (when clear water only is being discharged) a 'V'-shaped drain constructed of wood or sheet metal should be inserted near the top of the ring to carry off water in a controlled manner and in the desired direction.
- **An alternative method**
  of controlling an active boil is by placing a blanket of pea gravel or other free-draining gravel over it. The thickness of the gravel blanket must be increased until the seepage water runs clean. **Note**: When soil conditions are such that boils occur, it will probably be impossible of imprudent to bring loaded dump trucks into the area. First consideration should be given to methods that do not impose heavy loads on the ground adjacent to boils.

Excessive Slope Seepage

Seepage is the percolation of water through the dike or under the foundation. Although not dangerous in itself, it may threaten the stability of the dike by saturating the soil and causing sloughing of the landside slope. Seepage is usually first visible in the seep ditch at the landside toe of the dike. As the water rises against the dike, the seepage flow increases. As long as the wetted area is relatively small on the landside slope, and no movement of soil at the base is observed, no action other than keeping the water drainage away from the dike will be necessary. (7)

Repair

Where seepage on the dike's landslide slope leads to soggy unstable conditions, free draining fill berms may be added. Where time permits, expert advice regarding slope stability should be obtained before taking corrective action.

Riverside Erosion

Riverside erosion is *scour* of the riverside slope of the dike, berm, and/or adjacent banks by abnormally high water velocities. Scours are particularly dangerous due to the treacherous manner in which they develop and the difficulty of detection until almost irreparable damage has been done. The danger is that the scour will work into the dike slope. This type of scour resembles the caving bank of a river in that it erodes under water and has a vertical caving face. When the water is near the top of the dike, and by the time the vertical caving face appears above the water surface, a large portion of the dike is gone. (7)

Repair

Where river currents are eroding the face of the dike or nearby overbank, additional large rock riprap should be placed with an excavator or end-dumped if the site is accessible to heavy equipment and safe for operation. If time permits, expert advice should be obtained.

Under emergency conditions, maintenance of bank protection by end-dumping quarry-run rock into the bank is acceptable. Fines should naturally settle against the embankment face, and the coarser stones will work to the outside. However, under normal maintenance, placement by hydraulic excavator or clamshell is preferred. Specification of riprap placement is further discussed in the *Riprap Design and Construction Guide* (4).

If overtopping or creation of a breach is possible, an Emergency Warning should be issued (see above).

Wavewash

Wavewash is the erosion of the slope of a dike by wave action. The wave action may be caused by passing boats, on-shore winds, or storms. In any case, wave action may cause serious damage to a dike if the water surface is near the dike crown or is the dike has fine materials exposed.

Expert advice can often predict the locations where wavewash is likely to occur, and in that case filled sacks and other materials should be kept available for

an emergency. During periods of high wind and waves, patrols should closely monitor the identified areas. Under water washouts can occur under high wind and wave conditions, and wavewash can lead to formation of a breach in the dike due to progressive loss of dike material.

The necessity for wavewash protection cannot be foreseen in all cases, and observation must be continuous under high water conditions, as described in the "*Flood Protection Works Inspection Guide"* (3).

Repair

The type of wavewash protection to be constructed depends on local conditions. The result of excessive erosion due to wavewash is likely to be a breach, and if a breach is possible, an Emergency Warning should be issued (see above).

Local Overtopping

Local overtopping is the flowing of water over the dike crown. Overtopping may occur over a small local area, at a depression in the crown, but presents a significant danger. Once water flows over the dike crest, fill is usually washed away from the crest and landside slope creating a breach. Such a beach is virtually impossible to close until the water levels equalize on both sides of the dike. Equalization of the water levels occurs either due to subsiding water levels or due to uncontrolled flooding of the landside area.

Although dike crowns are constructed to the design elevation plus freeboard, local settling can occur over the years to reduce the crown elevation. As well, the design event can be exceeded. Either situation can result in overtopping during a flood. As the prediction of flood profiles is uncertain, and because dikes often have varying freeboard, patrols should **pay close attention to lower than average freeboard**.

Repair

Sandbags are usually considered for raising low sections of dike. However, progress is slow and an excessive amount of labour is required. Sandbags should normally only be considered for raising short sections of dike. As an alternative to sandbags, reinforced plastic sheeting can be used to contain loose granular of other fill. Heavy equipment and trucks can be used to raise a dike **provided this work is done well in advance of high river levels**. No heavy equipment should be allowed on the dike when the water level is near the top of the dike as the vibration might cause a failure.

If overtopping or creation of a breach is possible, an Emergency Warning should be issued (see above).

Internal Drainage

Internal drainage is the local runoff and drainage from the areas behind the dike on the landside that drain to the main watercourse through the floodbox of pump station.

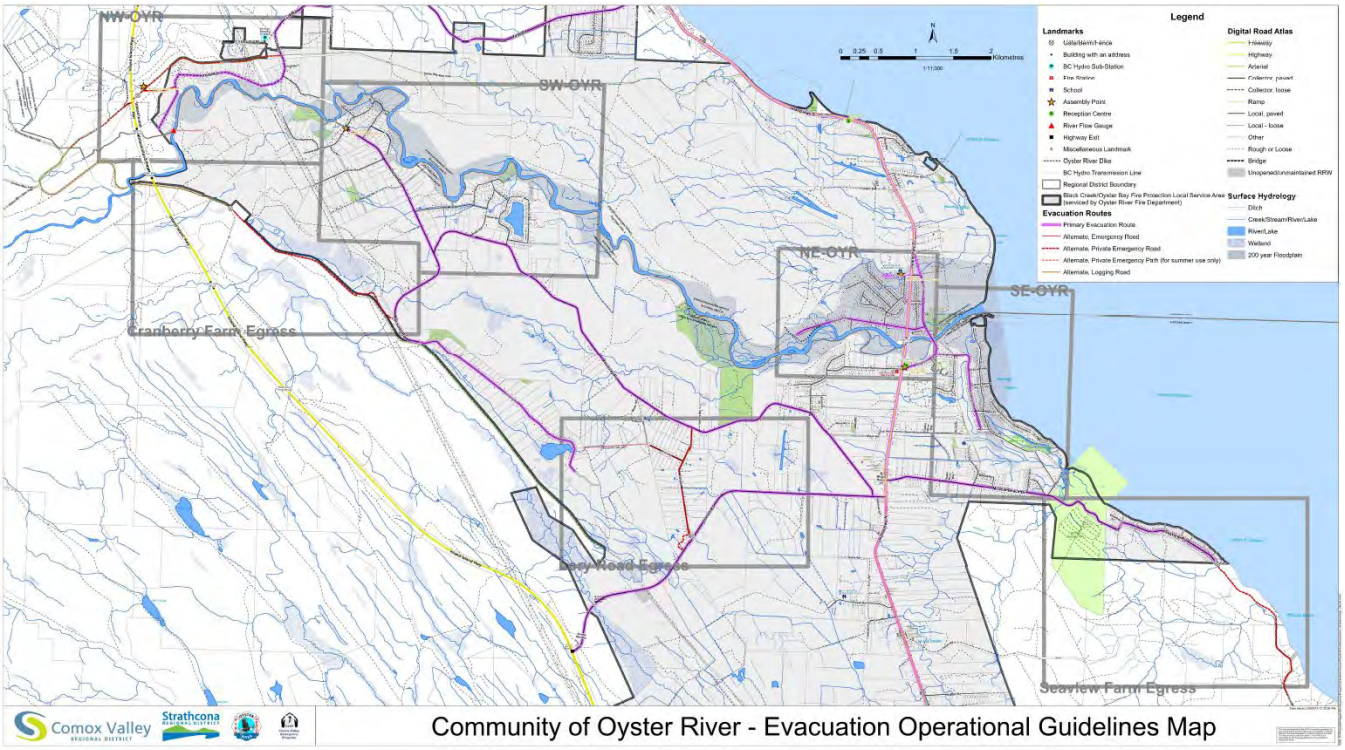
Local drainage will not escape in diked areas that lack adequate permanent pumping facilities. Temporary pumping of local drainage, or interception and diversion of inflow from higher elevations, may be necessary to alleviate this condition.

3.7 Emergency Response Plan

☑ **Additional Emergency Response Plan information is included:**

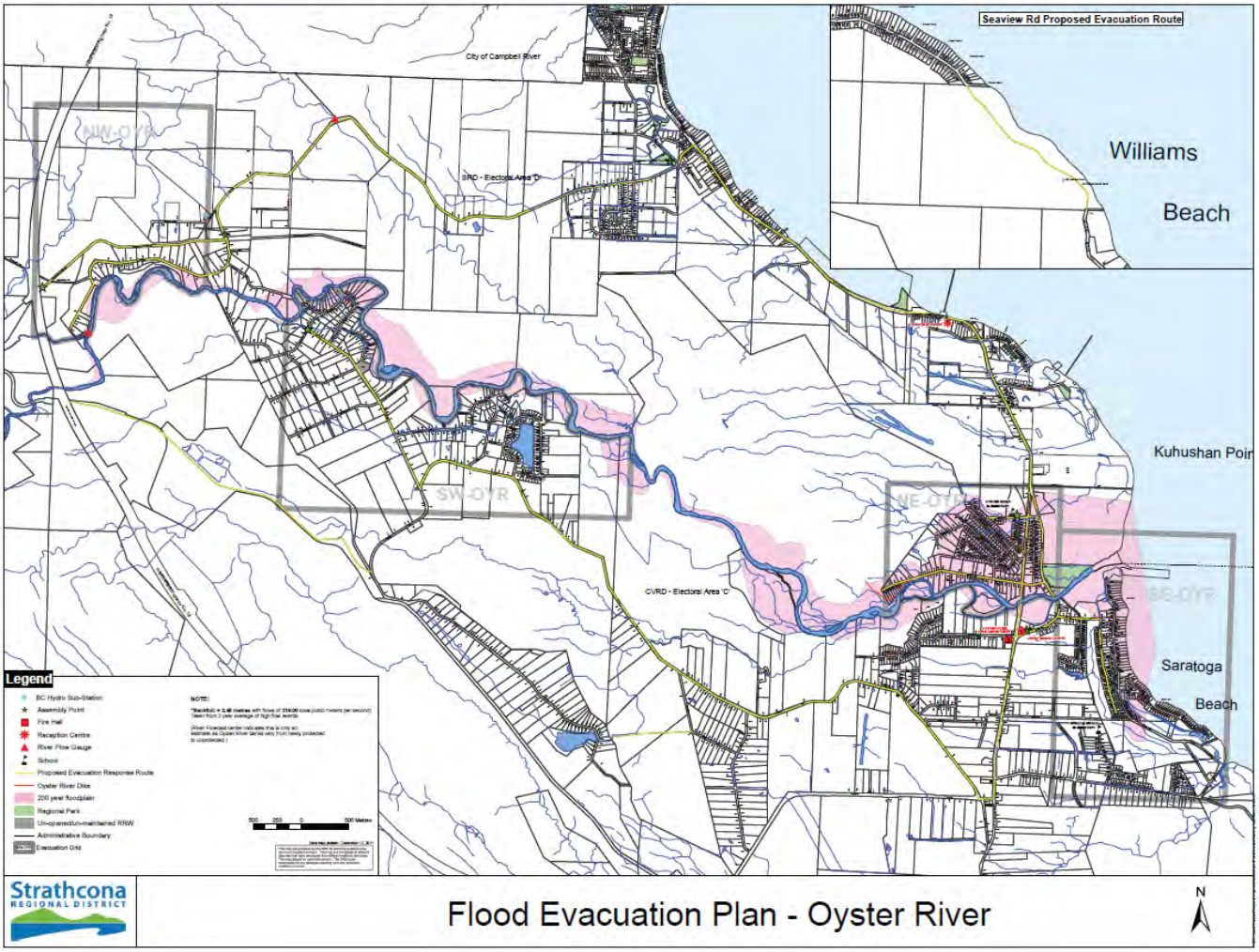
	Information	Located:
☑	Evacuation Operational Guidelines – Oyster River.	Map 2
☑	Flood Evacuation Plan – Oyster River.	Map 3
☑	Flood Response Management Area – Oyster River.	Map 4

The Strathcona Regional District has prepared the above referenced Community Emergency Plans and Maps for the area surrounding the Glenmore Road Dike.



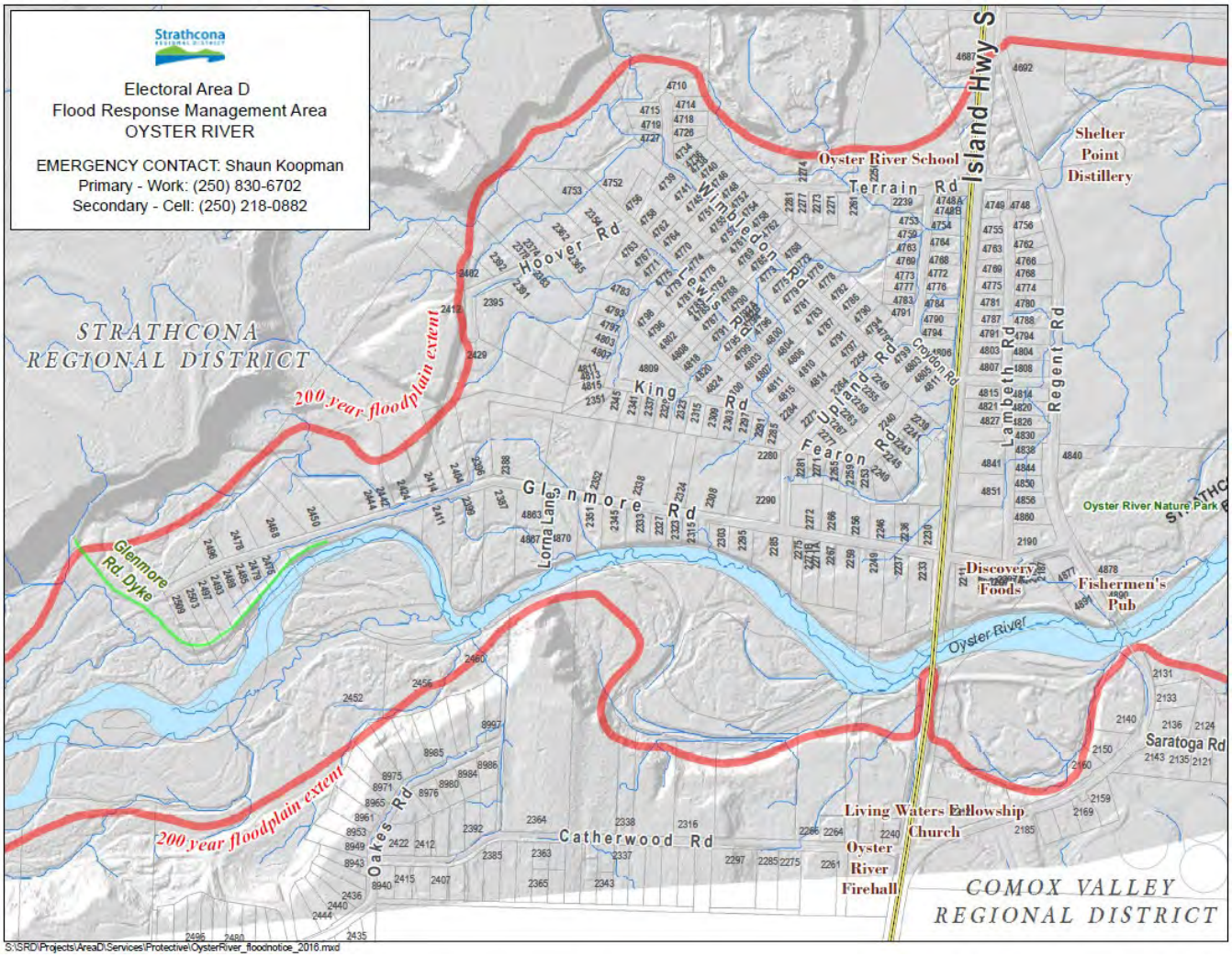
Map 2. Evacuation Operational Guidelines – Oyster River

Source: *Community of Oyster River – Evacuation Operational Guidelines Map*. Strathcona Regional District. 2013.



Map 3. Flood Evacuation Plan – Oyster River

Source: *Flood Evacuation Plan – Oyster River*. Strathcona Regional District. Accessed 2019.



Map 4: Flood Response Management Area – Oyster River

Source: *Electoral Area D Flood Response Management Area – Oyster River*. Strathcona Regional District. 2016.

4.0 References

1. *Guidelines for Management of Flood Protection Works in British Columbia*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 1999.
2. *Regulatory Tools for Flood Hazard Management A Guide for Local Government*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
3. *Flood Protection Works, Inspection Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
4. *Riprap Design and Construction Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
5. *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment*. Ministry of Environment, Lands & Parks, Department of Fisheries and Oceans Canada. March 1999.
6. *Water Related Hazards*. Emergency Response Plan and Procedures. Water Management Branch, Ministry of Environment, Lands & Parks; February 1998.
7. *Flood Planning & Response Guide for British Columbia*. Water Management Branch, Ministry of Environment, Lands & Parks; and Provincial Emergency Program, Ministry of Attorney General. March 1999.
8. *Flood Fight Manual, A Manual of High—Water Practices and Construction*. US Army Corps of Engineers, Portland District. October 1993.
9. *Operation and Maintenance Manual, Local Flood Protection Works*. US Army Corps of Engineers, Portland District. 1990.
10. *Oyster River / Saratoga Beach Flood Risk Assessment Final Report*. Ebbwater Consulting. 2018.
11. *Electoral Area D – OYSTER RIVER, Glenmore Road Dike*. Strathcona Regional District. Accessed 2019.
12. *Community of Oyster River – Evacuation Operational Guidelines Map*. Strathcona Regional District. 2013.
13. *Flood Evacuation Plan – Oyster River*. Strathcona Regional District. Accessed 2019.
14. *Electoral Area D Flood Response Management Area – Oyster River*. Strathcona Regional District. 2016.

APPENDICES

☑ **Additional information is appended:**

Information		**Located:**
☑	Glenmore Road Dike Upgrades Record Drawing Set.	Appendix A
☑	Oyster River: Glenmore Dike Upgrade Assessment Final Report.	Appendix B
☑	Statutory Right of Way Plan VIP 56947.	Appendix C
☑	Inspector's Daily Reports.	Appendix D
☑	Dike Maintenance Act.	Appendix E

APPENDICES

☑ **Additional information is appended:**

Information	**Located:**
☑ Glenmore Road Dike Upgrades Record Drawing Set.	Appendix A

CLIENT: WACOR HOLDINGS LTD.

DESCRIPTION: GLENMORE ROAD DIKE UPGRADES
OYSTER RIVER, BC

McElhanney Project No.: 2221-49230

PROJECT LOCATION
NTS

RECORD DRAWING
November 27, 2019

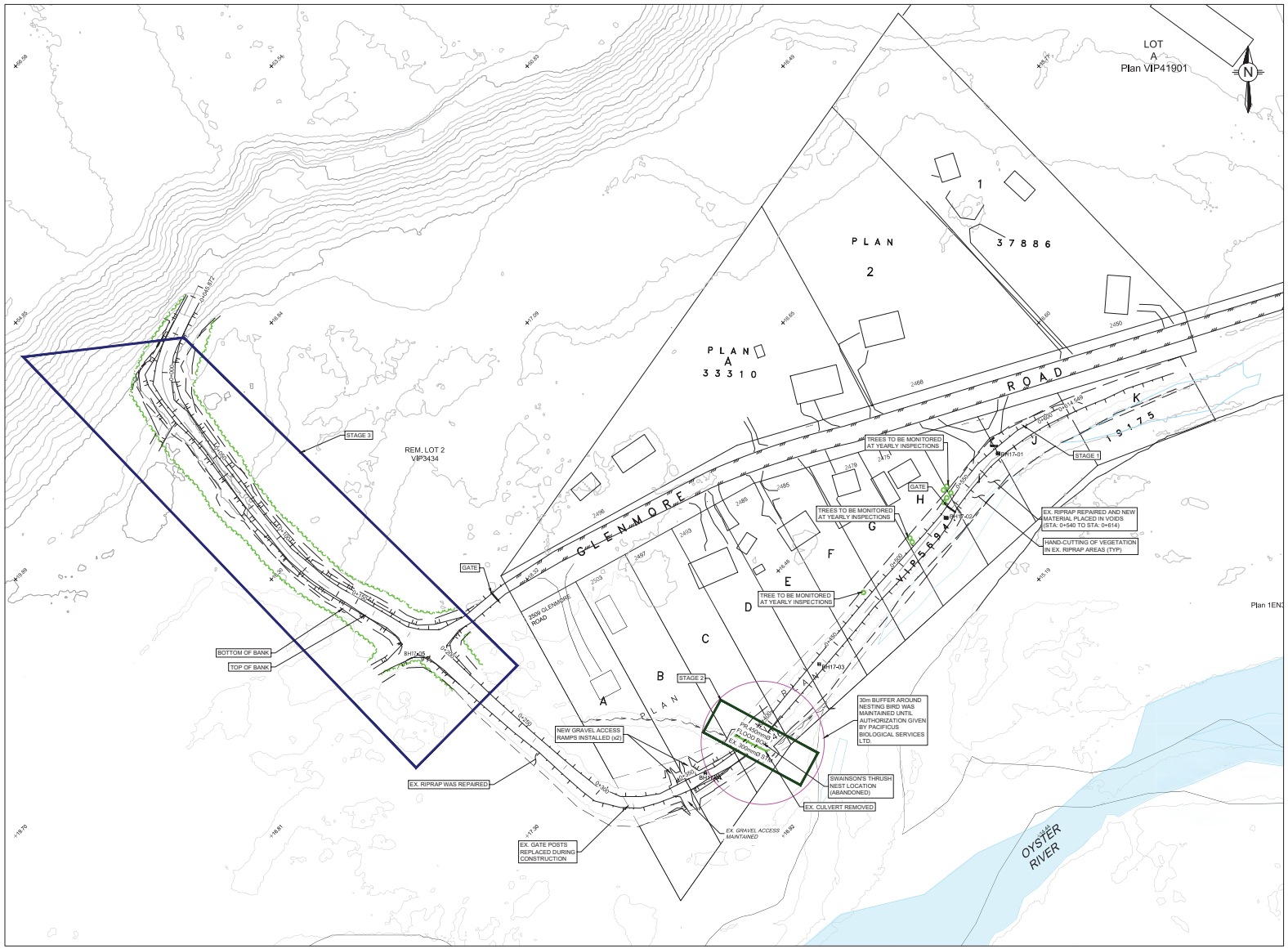
DRAWING INDEX

No.	LOCATION/DESCRIPTION	REVISION
C101	VEGETATION MAINTENANCE AND STAGING PLAN	
C102	EXISTING AND DESIGN PLAN AND PROFILE -0+025 - 0+285	
C103	EXISTING AND DESIGN SECTIONS	
C104	DIKE AND OUTLET BOX DETAILS	

PROJECT:
MCSL 2221-49230

McElhanney

1196 DOGWOOD STREET
CAMPBELL RIVER, BC. V9W 3A2
PH (250) 287-7799



VEGETATION MAINTENANCE AND STAGING PLAN

SCALE: 1:1000

NOTES:

"ORIGINAL DESIGN" - DESIGN DRAWINGS BY KPA ENGINEERING. PLAN AND PROFILE SHOWN IN THIS DRAWING SET ARE TAKEN FROM PDF VERSIONS OF THE AUGUST 1991 DRAWING SET.

"AS-BUILT" - EXISTING DIKE CONDITIONS AS OF LIDAR PICKUP JULY 2015

FLOOD EVENT IS 200-YEAR RETURN PERIOD FLOW (ESTIMATED) PLUS 15% FOR CLIMATE CHANGE = 576 m³/s.

STAGE 1 - VEGETATION REMOVAL

*MATURE GROWTH TO BE CLEARED DOWN TO 100mm

STAGE 2 - OUTLET BOX

STAGE 3 - DIKE REBUILD

ALL CLEARING OPERATIONS ARE IN ACCORDANCE WITH THE "ENVIRONMENTAL GUIDELINES FOR VEGETATION MANAGEMENT ON FLOOD PROTECTION WORKS TO PROTECT PUBLIC SAFETY AND THE ENVIRONMENT".

RECORD DRAWING

INFORMATION ON EXISTING UTILITIES MAY NOT BE COMPLETE OR ACCURATE. PRIOR TO CONSTRUCTION CONTRACTOR SHALL EXPOSE LOCATIONS OF ALL EXISTING UTILITIES AND ADVISE THE ENGINEER OF POTENTIAL CONFLICTS.

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED, TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AGENCIES. McELHANNEY CONSULTING SERVICES LTD., ITS EMPLOYEES, SUBCONSULTANTS AND AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING CONTRACTORS, SUPPLIERS, CONSULTANTS AND STAKEHOLDERS, OR THEIR EMPLOYEES OR AGENTS, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

BC 1 CALL 1-800-474-6886

NO.	REVISION	DRAWN	DATE	CHECKED	DATE
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1	ISSUED FOR APPROVAL	GW	2019/06/13	MD	2019/06/13
0	ISSUED FOR INFORMATION	JLC	2017/11/08	EH	2017/11/08

EXISTING	LEGEND	DESIGN
T	U/G TELUS	
C	U/G SHAW	
HD	U/G HYDRO	
E	OVERHEAD HYDRO	
G	NATURAL GAS	

EXISTING	LEGEND	DESIGN
S	SANITARY SEWER	
D	STORM DRAIN	
W	WATER MAIN	
	PAVEMENT	
	CURB & GUTTER	
	SIDEWALK	

EXISTING	LEGEND	DESIGN
SMH / DMH	SAN. SEWER MANHOLE / STORM DRAIN MANHOLE	SMH / DMH
SIDE INLET / TOP INLET	CATCH BASIN	SIDE INLET / TOP INLET
HYD	FIRE HYDRANT	HYD
WV	WATER VALVE	WV
UP	UTILITY POLE	UP
ANC	GUY LINE ANCHOR	ANC

DESIGNED:	JLC
DRAWN:	JLC
CHECKED:	MD
APPROVED:	MD
A1 SCALE:	1:1000
DATE:	19/11/27
DATE:	19/11/27
DATE:	19/11/27

McElhanney
1196 DOGWOOD STREET
CAMPBELL RIVER, B.C.
V9W 3A2
PH (250) 287-7799

PROFESSIONAL ENGINEER — 2019-11-27

WACOR HOLDINGS LTD.

VEGETATION MAINTENANCE AND STAGING PLAN

GLENMORE ROAD DIKE UPGRADES

OYSTER RIVER, BC

SHEET NO:	C101
McELHANNEY PROJECT #:	2221-49230
SHEET	1 OF 4
REV.	3

DESTROY PRINTS OF PREVIOUS REVISION

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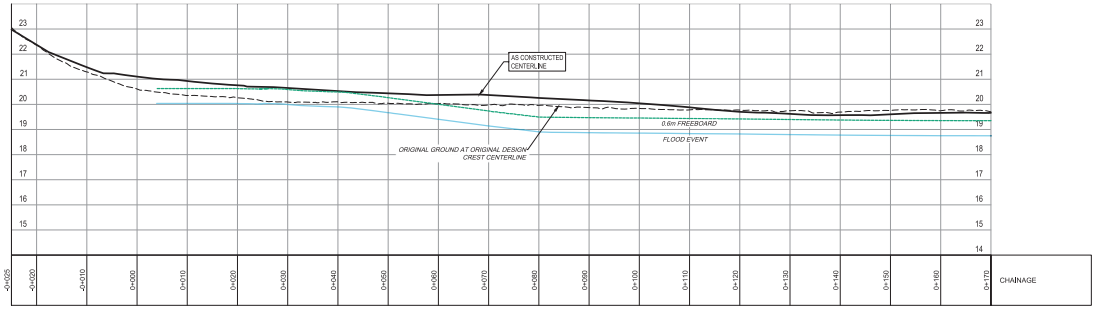
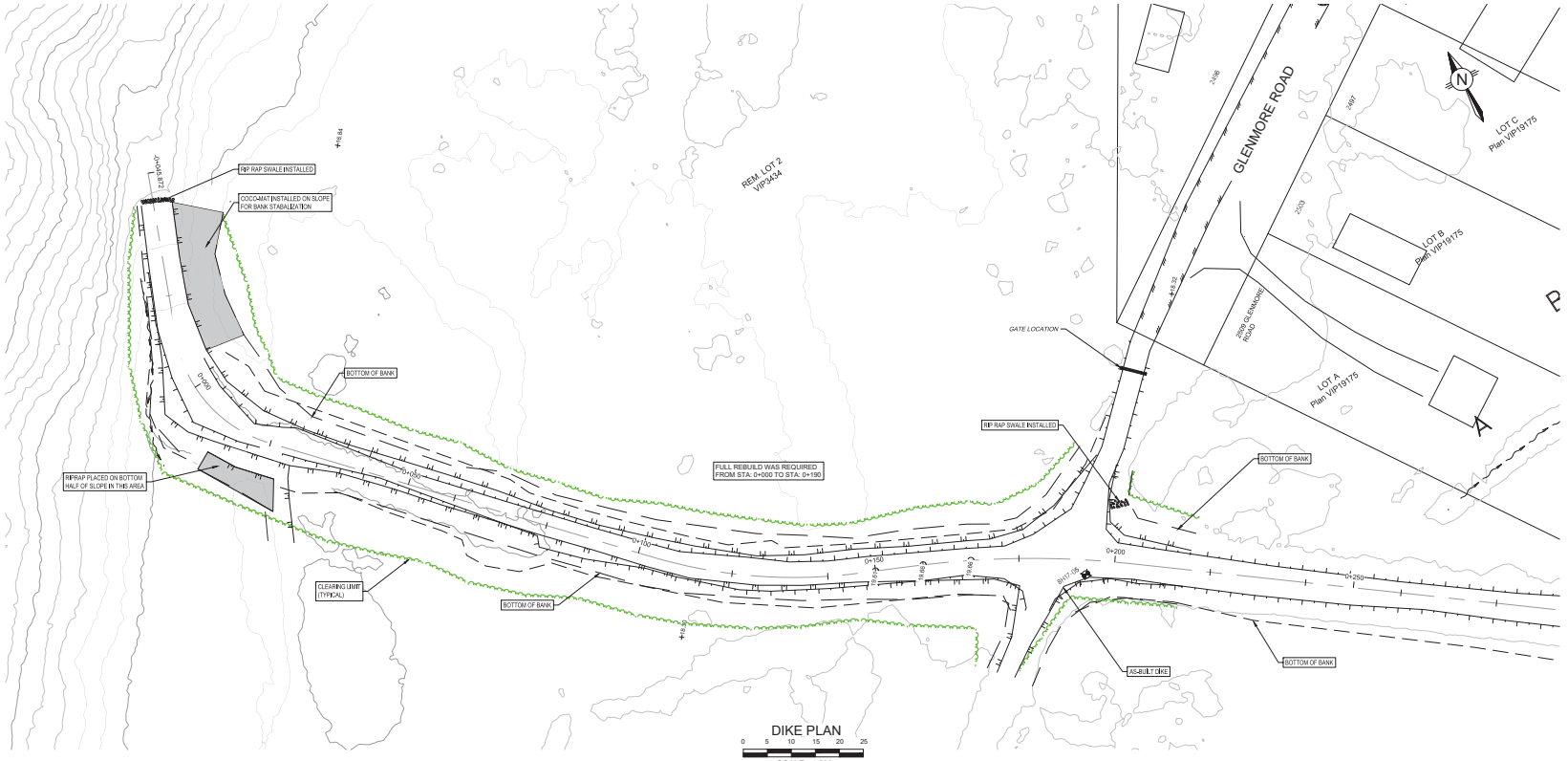


DIKE PROFILE
SCALE 1:500H; 1:50V

200 YEAR FLOOD EVENT
0.6m FREEBOARD
ORIGINAL GRADE
DESIGN GRADE



DIKE PLAN
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SCALE: 1:500

RECORD DRAWING

INFORMATION ON EXISTING UTILITIES MAY NOT BE COMPLETE OR ACCURATE. PRIOR TO CONSTRUCTION CONTRACTOR SHALL EXPOSE LOCATIONS OF ALL EXISTING UTILITIES AND ADVISE THE ENGINEER OF POTENTIAL CONFLICTS.

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BC 1 CALL 1-800-474-6886

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1	ISSUED FOR APPROVAL	GW	2019/06/13	MD	2019/06/13
0	ISSUED FOR INFORMATION	JLC	2017/11/08	BH	2017/11/08

EXISTING	LEGEND	DESIGN	EXISTING	LEGEND	DESIGN	EXISTING	LEGEND	DESIGN
T	U/G TELUS	T	S	SANITARY SEWER	S	SWALE		
C	U/G SHAW	C	D	STORM DRAIN	D	SMH DMH	SAN. SEWER / STORM DRAIN MANHOLE	SMH DMH
HD	U/G HYDRO	HD	W	WATER MAIN	W	SIDE INLET TOP INLET	CATCH BASIN	SIDE INLET TOP INLET
E	OVERHEAD HYDRO	E		PAVEMENT		HYD	FIRE HYDRANT	HYD
G	NATURAL GAS	G		CURB & GUTTER		WV	WATER VALVE	WV
				SIDEWALK		UP	UTILITY POLE	UP
						ANC	GUY LINE ANCHOR	ANC

DESIGNED: JLC | A1 SCALE: 1:500
DRAWN: JLC | DATE: 19/11/27
CHECKED: MD | DATE: 19/11/27
APPROVED: MD | DATE: 19/11/27

McElhanney
1196 DOGWOOD STREET
CAMPBELL RIVER, B.C.
V9W 5A2
PH (250) 287-7799

PROFESSIONAL ENGINEER — J.L.C. DEGAGNE — 29805 — PROVINCE OF BRITISH COLUMBIA — 2019-11-27

WACOR HOLDINGS LTD.

DIKE PLAN AND PROFILE
-0+025 - 0+285

GLENMORE ROAD DIKE UPGRADES
OYSTER RIVER, BC

SHEET NO: C102
McELHANNEY PROJECT #: 2221-49230
SHEET 2 OF 4
REV. 3

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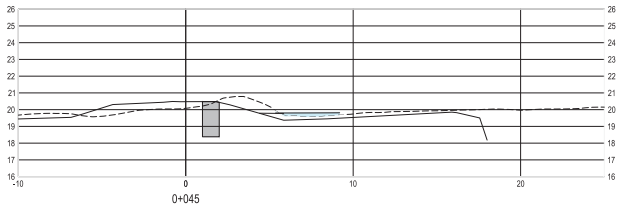

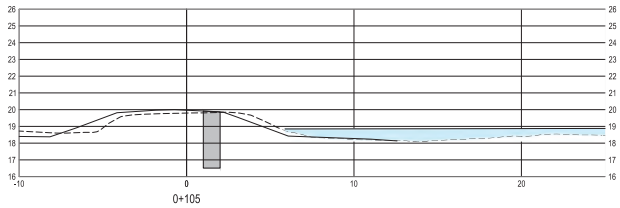

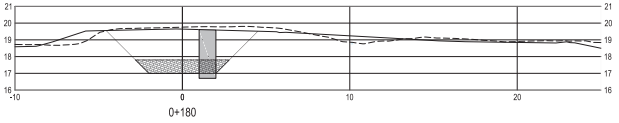

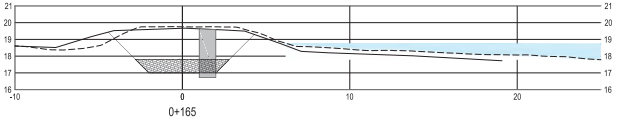

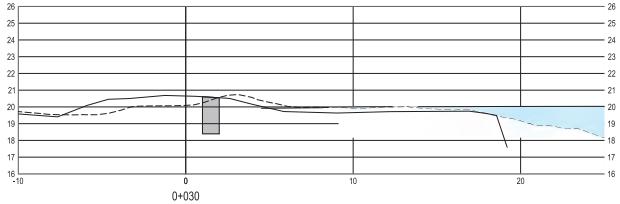

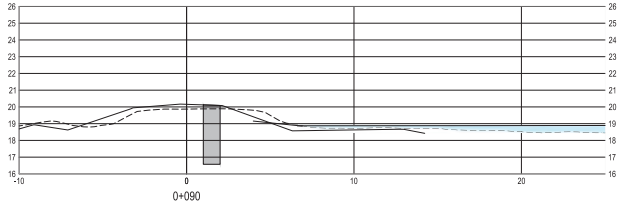

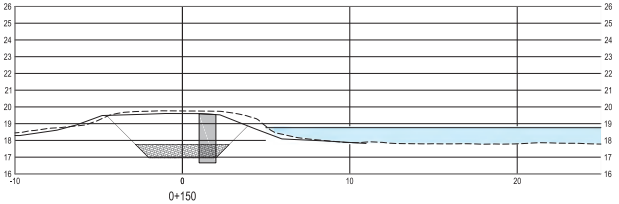

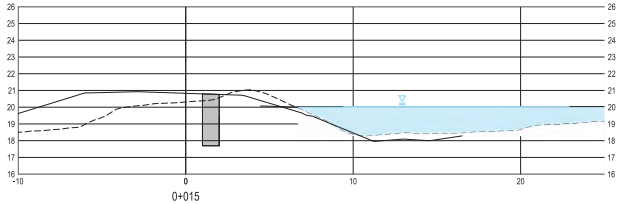

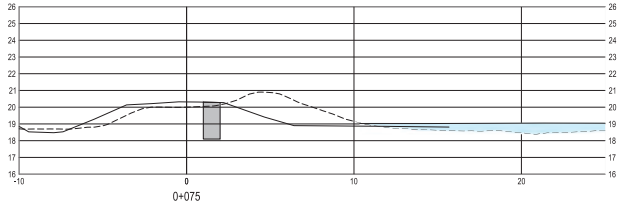

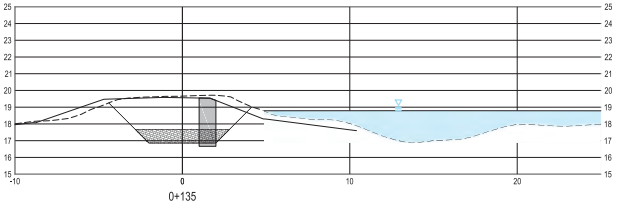

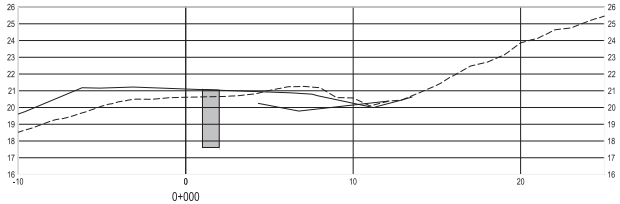

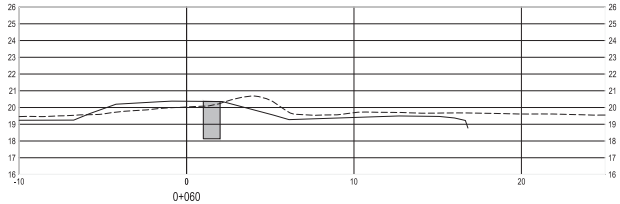

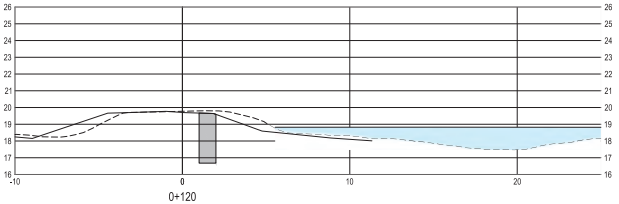

DIKE SECTIONS

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FLOOD EVENT

ORIGINAL GRADE

SURVEYED GRADE

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T	U/G TELUS	T	S	SANITARY SEWER	S	SMH DMH	SWALE	
C	U/G SHAW	D	D	STORM DRAIN			SAN. SEWER STORM DRAIN MANHOLE	SMH DMH
HD	U/G HYDRO	W	W	WATER MAIN	W	SIDE INLET TOP INLET	CATCH BASIN	SIDE INLET TOP INLET
E	OVERHEAD HYDRO			PAVEMENT		HYD	FIRE HYDRANT	HYD
G	NATURAL GAS	G		CURB & GUTTER		WV	WATER VALVE	WV
				SIDEWALK		UP	UTILITY POLE	UP
						ANC	GUY LINE ANCHOR	ANC

DESIGNED: JLC
DRAWN: JLC
CHECKED: MD
APPROVED: MD
A1 SCALE: 1:150
DATE: 19/11/27
DATE: 19/11/27
DATE: 19/11/27

McElhanney
1196 DOGWOOD STREET
CAMPBELL RIVER, B.C.
V9W 3A2
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PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
J. C. DEGAGNE
29825
2019-11-27

WACOR HOLDINGS LTD.

EXISTING AND DESIGN
DIKE SECTIONS

GLENMORE ROAD DIKE UPGRADES
OYSTER RIVER, BC

SHEET NO: C103
McELHANNEY PROJECT #: 2221-49230
SHEET 3 OF 4
REV. 3

DESTROY PRINTS OF PREVIOUS REVISION

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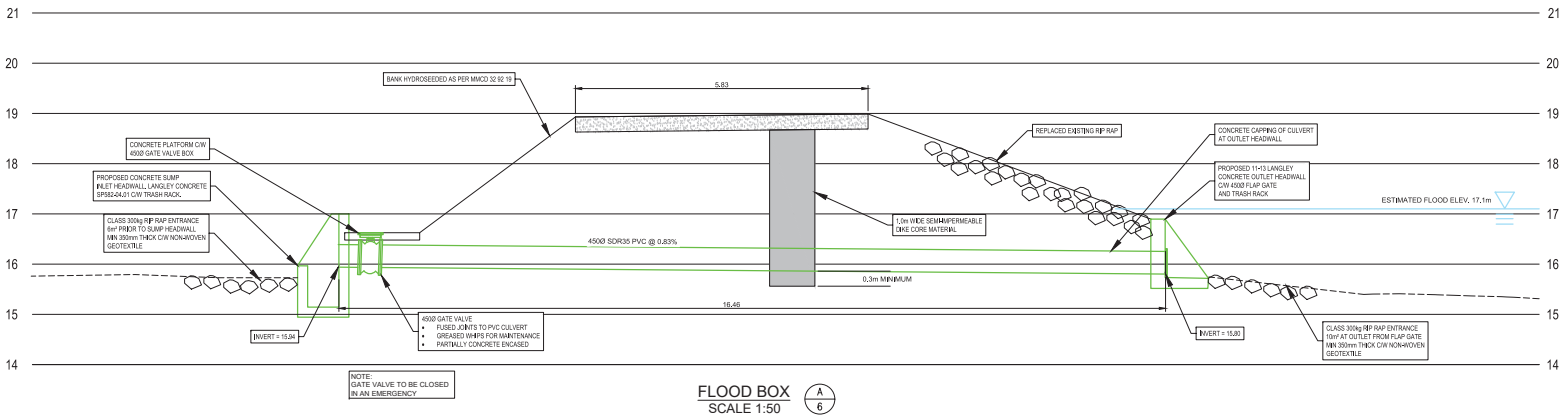
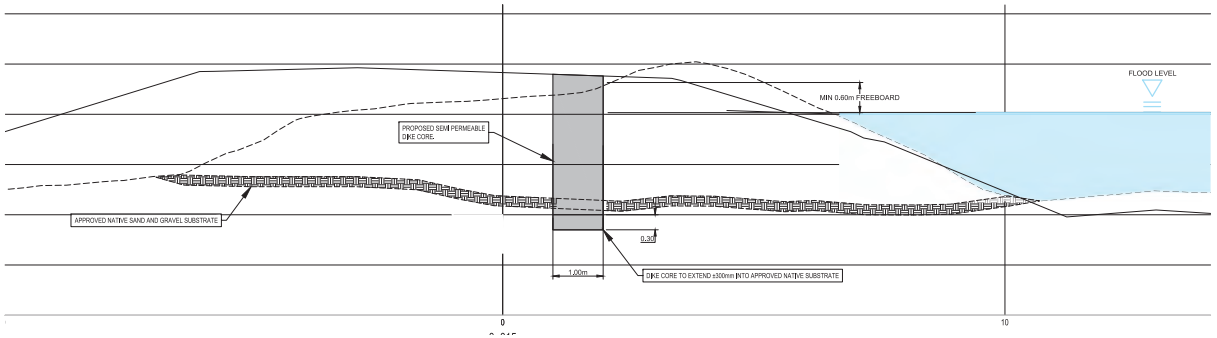
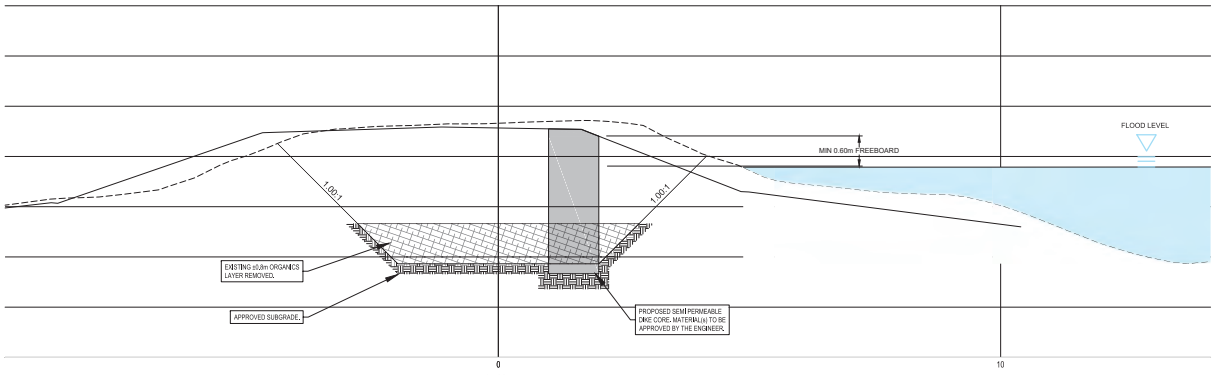


FLOOD BOX (A/6)
SCALE 1:50



TYPICAL DIKE KEYWAY SECTION
SCALE 1:50



TYPICAL DIKE REBUILD SECTION
SCALE 1:50

RECORD DRAWING

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SCALE: 1:50

FLOOD EVENT
ORIGINAL GRADE

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0	ISSUED FOR INFORMATION	JLC	2017/11/08	BH	2017/11/08

EXISTING	LEGEND	DESIGN	EXISTING	LEGEND	DESIGN	EXISTING	LEGEND	DESIGN
T	U/G TELUS	T	S	SANITARY SEWER	S	SMH / DMH	SAN. SEWER / STORM DRAIN MANHOLE	SMH / DMH
C	U/G SHAW	C	D	STORM DRAIN	D	SIDE INLET / TOP INLET	CATCH BASIN	SIDE INLET / TOP INLET
HD	U/G HYDRO	HD	W	WATER MAIN	W	HYD	FIRE HYDRANT	HYD
E	OVERHEAD HYDRO	E		PAVEMENT		WV	WATER VALVE	WV
G	NATURAL GAS	G		CURB & GUTTER		UP	UTILITY POLE	UP
				SIDEWALK		ANC	GUY LINE ANCHOR	ANC

DESIGNED:	JLC
DRAWN:	JLC
CHECKED:	MD
APPROVED:	MD
A1 SCALE:	1:50
DATE:	19/11/27
DATE:	19/11/27
DATE:	19/11/27

McElhanney
1196 DOGWOOD STREET
CAMPBELL RIVER, B.C.
V9W 3A2
PH (250) 287-7799

2016-11-07

WACOR HOLDINGS LTD.

DIKE AND FLOOD BOX DETAILS

GLENMORE ROAD DIKE UPGRADES
OYSTER RIVER, BC

SHEET NO: C104
MCELHANNEY PROJECT #: 2221-49230
SHEET 4 OF 4
REV. 3

DESTROY PRINTS OF PREVIOUS REVISION

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APPENDICES

☑ **Additional information is appended:**

Information	**Located:**
☑ Oyster River: Glenmore Dike Upgrade Assessment Final Report.	Appendix B

Prepared for:

Strathcona REGIONAL DISTRICT

Oyster River: Glenmore Dike Assessment Final Report

December 8, 2017 | Submitted by: Mark DeGagné, P.Eng. & Ben Singleton-Polster, P.Eng.

McElhanney

McElhanney Consulting Services Ltd.

1307 Shoppers Row
Campbell River BC V9W 2C9

Contact: Mark DeGagné, PEng, Project Manager

Phone 778-560-2001 | Fax 855 407 3895
Email: mdegagne@mcelhanney.com

2221-49111-00

OQM | Organizational Quality Management Program

Certified ISO 9001:2008

McElhanney

December 8, 2017

Strathcona Regional District
301 – 990 Cedar Street, Campbell River, BC V9W 7Z8

Oyster River: Glenmore Dike Upgrade Assessment: FINAL Report

We are pleased to provide the enclosed Report for the Oyster River: Glenmore Dike Assessment project.

For this project, we brought together our in-house experts and staff from around Vancouver Island to complete several assessments of the Glenmore Dike. These experts included:

- Mr. Ben Singleton-Polster, P.Eng. – Geotechnical Engineer
- Mr. Bill Purdy, P.Eng. – Geotechnical Review
- Mr. Eric Heel, P.Eng. – Hydrotechnical Engineer
- Mr. Mark DeGagné, P.Eng. – Hydrotechnical Review & Project Manager
- Campbell River Office Survey staff.

We trust that we have captured the requirements of your comments from the draft report in this final version. We have prioritized the recommended upgrades into three levels based on the immediacy of the need to improve the dike performance.

The acting Inspector of Dikes, Brian Epps, requested a copy of the report so that they can provide input and feedback if required.

We thank you for the opportunity to have worked with you on this important project, and look forward to continuing our relationship on future projects that you may feel we can be of assistance with.

Yours truly,

McELHANNEY CONSULTING SERVICES LTD.

Mark DeGagne, PEng
Project Manager
mdegagne@mcelhanney.com | 778-560-2001

1307 Shoppers Row
Campbell River BC
Canada V9W 2C9

Tel 250 287 7799
Fax 855 407 3895
mcelhanney.com

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[1] Appendix A & D documents have been provided as part of the electronic report submission and are not included in the hard-copy report submission.

Executive Summary

The Strathcona Regional District (SRD) is responsible for the Glenmore Road Dike. Constructed in 1992, the structure has received emergency repairs under flood conditions in 2009 and 2014. McElhanney completed a visual assessment of the dike and a drilling program to characterize the subsurface soils. The results of the drilling program were used to assess the potential for liquefaction, dike stability and potential remediation options. The results of the visual assessment, LiDAR data supplied by SRD and published water flow data were used to assess predicted flood levels and river flow characteristics.

The dike visual assessment showed the 450mm flood box requires replacing to function as intended. In addition, significant vegetation was growing on the dike obscuring visual observations of the side slopes and trees growing in the riprap could potentially topple leaving portions of the dike without riprap protection. The maintenance of the vegetation and flood box are considered top priority (**Priority 1**) items for the dike upgrades. The estimated cost for these upgrades is $138,000. In addition, the SRD should maintain an allowance of $7,000 a year for annual maintenance and inspections of the dike in accordance with the Annual Dike Inspection Checklist making reference to the Flood Protection Works Inspection Guide (2000) from the BC Provincial Dike Maintenance Act.

The hydrologic assessment of floods in the Oyster river determined the 200-year Return Period Flow at the Glenmore dike to be 493 m^3/s, which was then increased by 15% for the purposes of this analysis to account for potential future climate change effects. The resulting design flow of 567 m^3/s was simulated in a 2D hydraulic model that was developed for the area around the Glenmore dike.

The results of the hydraulic modelling showed that the existing dike crest including 0.6 m of freeboard is sufficient for the design flow event. However, this dike crest elevation included the temporary emergency berm repair area. As a **Priority 2** item the temporary emergency berm should be reconstructed into a permanent upgrade to the dike between Sta 0+000 and 0+090. Because organic soils exist below the dike cap, this upgrade requires reconstruction of the dike, which may include the requirement to improve compaction of the in-situ foundation soils below the organic layer. The estimated cost for this work is about $303,000, which includes a significant allowance for the potential for Rapid Impact Compaction (RIC) of the foundation soils.

The conditions encountered during the subsurface investigations (boreholes) along the dike comprise a layer of granular fill (up to 4.2 m in thickness) overlying native sands and gravels over till and/or bedrock. The liquefaction index was calculated based on Seed's Simplified Analysis. The results of the analysis showed liquefaction index for the soils ranged from L0 (No Liquefaction) for earthquake level one (EQL-1) to L2 (Liquefaction in zones) for earthquake level two (EQL-2) and three (EQL-3). Slope stability and seepage analysis also show significant risk of failure of the dike for the larger design earthquakes (EQL-2 and EQL-3). To mitigate the potential failure of more significant and severe earthquakes the SRD should consider upgrading the dike along the entire alignment, which requires rebuilding the dike and flattening the side slopes, as well as the likelihood of a broader foundation soils improvement program. The estimated cost includes a significant allowance ($1,000,000) for the foundation soils improvement program, which is an iterative procedure of in-situ compaction testing and dynamic compaction methods. The total estimated cost for **Priority 3** work to rebuild the dike for long-term seismic stability is $3,775,000.

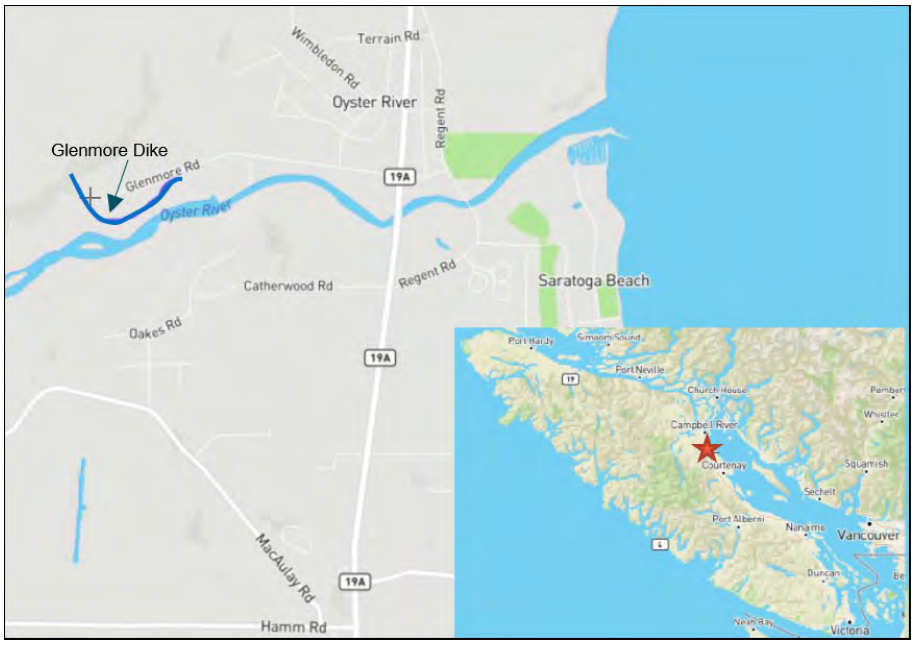
All estimates are considered Class 'D' at this conceptual level of study, and further assessments and design are required. Estimates include a 30% contingency and allowances for detailed engineering, administration and environmental permitting are included.

Lastly, it is recommended that the Earthquake Inspection Checklist as discussed in the guidelines be added to the SRD dike operations and maintenance manual.

1. Introduction & Background

The Glenmore Road Dike system was constructed in 1992. Upon completion, the Strathcona Regional District (SRD) accepted responsibility and the associated liability for the structure. The current Dike protects approximately 300 residents and several local businesses from flooding of the Oyster River. The Dike extends 570 m along the south side of Glenmore Road (see **Figure 1**), to its downstream termination approximately 500 m west of Lorna Lane. The elevation of the Dike crest ranges from 23 m at the upstream end to 18 m at the downstream end. North of Glenmore Road, the top width of the Dike is 4.0 m; south of Glenmore Road, the top width is reduced to 3.0 m.

Figure 1: Location Map



In December of 2014, the Oyster River experienced record flows which resulting in a minor breach of the existing dike and high-water levels near the upstream end of the dike. McElhanney worked with the SRD to review the emergency work to repair the dike in this area. A Technical Memorandum was provided shortly after the completion of the emergency repair works that provided an update to the hydrology of the Oyster River, and the field review of the emergency repair works.

Given that the Glenmore Road Dike has experienced some minor local failures in recent years (breeches/overtopping), and that climate change is expected to cause increased rainfall intensities / volumes (and therefore river flows) in the future; McElhanney recommended completing a hydraulic analysis of the Oyster River to confirm the flood protection level provided by the dike, including incorporating the effects of climate change on future flow rates. This task was completed by first conducting a hydrologic analysis (with climate change), and then developing a hydraulic model of the river reach at the dike location.

The results of the hydrotechnical work were used to inform the geotechnical assessment, which focussed on the stability of the existing dike, requirements for dike modifications, if any; and a seismic assessment based on the latest standards and guidelines for flood protection structures. The geotechnical analysis utilized the results of field inspections and a subsurface drilling program completed as part of this project.

This report summarizes the findings of these assessments completed in the fall of 2017, and provides recommended courses of action to improve the dike to safely withstand future estimated flood events and

earthquakes, which have been analyzed in conjunction with Engineers & Geoscientists of BC's guidelines for both the hydrotechnical and geotechnical aspects of this important flood protection structure. Although the hydrotechnical assessment was not required by the SRD as part of the original Request for Proposal (RFP), the work was incorporated into the original project budget due to efficiencies during the field investigations / drilling program phase.

This report provides summary and detailed documentation for a physical site inspection (Section 2.0) with noted deficiencies, followed by the hydrotechnical assessment in Section 3.0. These two sections are utilized in the overall geotechnical analyses. The results of which are summarized in Section 4.0. These results then lead to recommended upgrades and probable costs, which are provided in Section 5.0. The report is completed with a summary of conclusions and recommendations stemming from the assessments in Section 6.0.

1.1. Background Information

Several sources of information that have been utilized in the preparation of this report, including the most recent experience that McElhanney has had with assisting the SRD during recent events to bolster the dike, and repair such elements as the flood box at the bend between the north-south leg and the east-west leg.

To provide a central location for the composite of previous information, **Appendix A** features the following data, reports and maps[2]:

1. Survey and Mosaic Information from Flood Mapping Program (MoE,1982 and 1983)
2. Preliminary Floodplain Mapping – Oyster River (MoE, May 1984, Dwg 5532-1)
3. Floodplain Management Bylaw, 2005 (SRD, Latest Amendment, June 2017)
4. Recent Inspector of Dikes Reports (MoE, 1992 and 2010)
5. Oyster River Erosion and Flood Protection Chronological Summary, supplied by the SRD with entries from November 5, 1975 to December 9, 2014
6. Oyster River Dike Assessment and Recommendations for Permanent Upgrades (McElhanney, 2015)
7. KPA Engineering Drawings & Design Report for Glenmore Dike Construction (July 1991)
8. Lidar Digital Elevation Data from 2014, (SRD, 2014)[3]

Despite all efforts to locate and examine the report that would accompany the Preliminary Floodplain Mapping, no copies have been located, and as such the hydrological analysis and results for the modelling are not known at this time. This includes the estimated 1:20 and 1:200 Year Flood Discharge Estimates used in the floodplain mapping.

[2] Appendix A documents have been provided as part of the electronic report submission and are not included in the hard-copy report submission.
[3] LiDAR Digital Elevation Data was originally provided to McElhanney by SRD

2. Dike Condition Assessment

2.1. Geological Setting

Published surficial geology information indicates that the surficial soils are expected to consist of alluvium, glaciofluvial gravels and sand and till (Geology, Northern Vancouver Island Project, MAP 2013-NVI-1-1).

2.2. Water Well Drilling Records

Historical water well drilling records were accessed from the BC Water Resource Atlas. The following three water wells appear to be near the site:

- Well Tag Number: 94812 (2475 Glenmore Road)
- Well Tag Number: 110229 (2444 Glenmore Road)
- Well Tag Number: 106131 (2411 Glenmore Road)

Water well tag number 94812 appears to be located near the northern end of the dike. Water well 94812 soils comprise silt and boulders to about 2.4 m depth over silt and gravel to 4.6 m depth over silt and clay to 9.1 m depth and a water depth at 4.2 m at time of drilling. Water well with tag number 110229 is reported to have been drilled at 2444 Glenmore Road with soils comprising soft organics to 1.2 m depth over dense gravel to 5.5 m depth over hard silt, clay and gravel (till) to 5.8 m depth and a water table at the time of drilling at 3.5 m depth. Water well with tag number 106131 is shown to be drilled at 2411 Glenmore Road with soils comprising soft organics to 0.9 m depth over loose sand to 2.4 m depth over sand with a layer of clay to 37.6 m depth and a water depth of 13.7 m.

2.3. Dike Condition Assessment

A dike condition assessment, guided by provincial guidelines for flood protection works management (BC, MELP, 1999) was completed on September 19, 2017, including a field reconnaissance with McElhanney Engineering staff along with the acting Inspector of Dikes (IoD), Mr. Brian Epps. Appendix B contains the Dike Condition Assessment Report complete with photos.

In general, the Dike itself appears to be in stable condition with suitably sized rip rap protection on the east-west leg, which is frequently exposed to the main channel discharges of higher velocity. As noted previously, there has been a lack of vegetation maintenance throughout the entire dike length and this should be a priority item for the SRD to place in their budget, especially along the east-west leg where higher velocity flows can dislodge a tree and its root system and compromise the dike structure. Access to and unobstructed views of the dike are important to allow the SRD to complete inspections during periods of flooding.

The only other serious defect observed was the flood box at Sta 0+380, which was completely blocked on the dry side end, and significantly blocked on the river side. The observed end condition suggests that the corrugated metal pipe is failing, and the entire flood box structure should be upgraded with a proper centre access structure with a flap gate and a positive gate for isolation of the river to the protected areas behind the dike.

3. Hydrotechnical Assessment

A hydrotechnical assessment of the Oyster River near the Dike was completed to update both the hydrologic estimates of river discharge during flood events, and the hydraulic modelling of the river reach adjacent to the dike to determine the characteristics of flow through the reach including predicted flood levels. The scenarios presented below include an allowance for climate change, and the assessment was conducted in accordance with the current Engineers & Geoscientists of BC Professional Practice Guidelines for Legislated Flood Assessments in a Changing Climate in BC.

3.1. Hydrologic Assessment

The current floodplain mapping for this area was completed by the BC Ministry of Environment in 1984 (see map attached in **Appendix A**). The 1984 maps indicate flood levels for the 20- & 200-year return periods (including freeboard), but the supporting report containing the background information is not available. Due to the missing background documentation and the 30 years of new stream gauge data available since the publication of this report, this original 1984 mapping is out-dated and requires updating. There would have only been a few years of stream gauge data for the Oyster River available when the 1984 mapping was completed, compared to almost 40 years of stream gauge data available today.

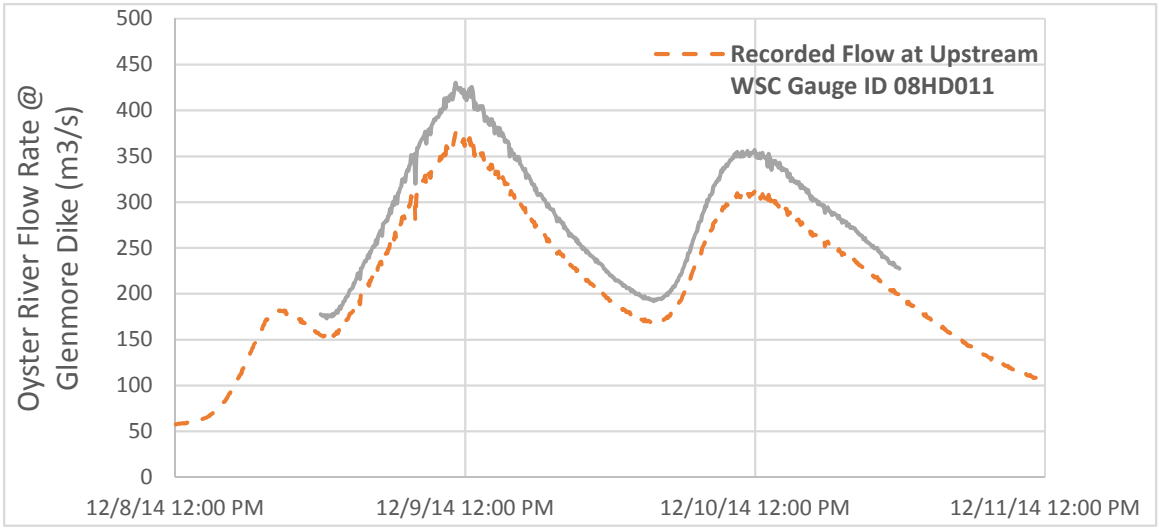
A Water Survey of Canada (WSC) Gauge exists approximately 10 kilometers upstream of the Glenmore Dike location, Gauge ID 08HD011 Oyster River Below Woodhus Creek. This station now has approximately 39 years of quality data, recorded from 1974 to present. This data includes the recent high-flow events of December 2014 and November 2016, and also represents the flows resulting from land-use changes in the river's catchment such as continued forestry operations.

Recent High-Flow Events

There have been two high flow events on the Oyster River within the past few years which were observed by SRD staff, McElhanney, and area residents. **Figure 2**, below, shows the flow rate in the Oyster River for the December 2014 event as recorded at the WSC Gauge, as well as the estimated flow rate at the Glenmore Dike which has been adjusted to account for the increased catchment area downstream of the WSC Gauge location. The peak flow rate at the gauge for this event was 376 m^3/s at 11:15 a.m. on December 9, 2014.

During this high-flow event, the SRD contacted Mr. Mark DeGagné, P.Eng. from McElhanney to conduct an emergency inspection and oversee emergency dike raising works along the upstream portion of the Glenmore Dike, due to high water levels that appeared close to overtopping the dike. At that time, the dike was raised approximately 0.5 m to 1.0 m throughout a 90 m section at the upstream end of the dike from Station (Sta.) 0+000 to approximately Sta. 0+090 on the attached McElhanney Drawings 2221-49111 attached in **Appendix C**.

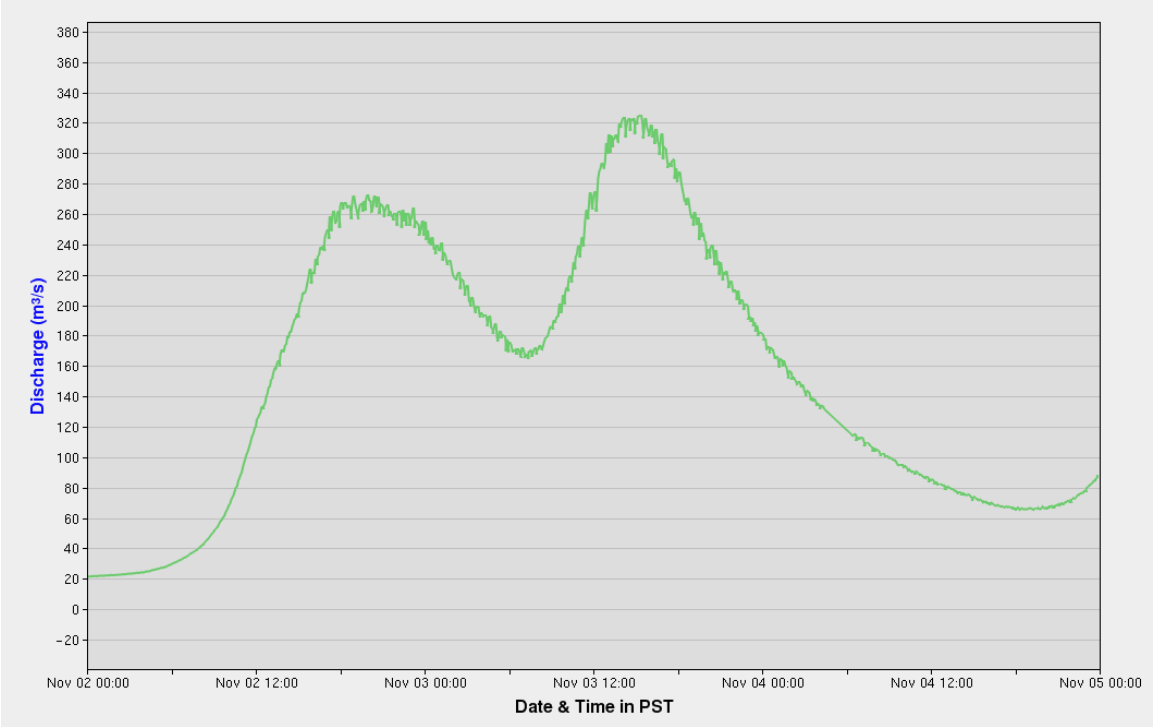
Figure 2: Oyster River Flow Rate During Dec 2014 High-Flow Event



The second recent high-flow event occurred on November 2nd and 3rd of 2016. The peak flow rate recorded at the WSC Gauge was approximately 320 m^3/s, as depicted in the hydrograph on **Figure 3**.

These two events were used to judge the accuracy of our model, and the commonality of the hydrographs between the two events was used to formulate a synthetic hydrograph for the 1:200-year design flow event.

Figure 3: Oyster River Flow Rate @ WSC Gauge During November 2016 High-Flow Event



Hydrologic Determination of Design Flows

For the purposes of this analysis, the annual peak flow with a 0.5% chance of occurring in any given year (1:200-year probability) was chosen as the design flow event in accordance with current Engineers & Geoscientists of BC, Professional Practice Guidelines for Legislated Flood Assessments in a Changing Climate in BC.

The basis for the determination of the design flow is a frequency analysis on the annual peak instantaneous flows from the upstream WSC Gauge (Gauge ID 08HD011 Oyster River at Woodhus Creek) using the 39 years of available data. Using the most up-to-date data in this analysis is critical, because some of the largest flow events on record have occurred in the last few years. The calculated 200-year return period flow at this gauge is 430 m3/s.

Next, this flow rate needs to be adjusted to incorporate the additional catchment area to the Oyster River between the gauge location and the Glenmore Dike location. The gauge has a total catchment area of 302 km^2, with an additional 57 km^2 between the gauge and the Glenmore dike. The majority of this additional catchment area is from the Little Oyster River. Several methods were investigated to determine the best method for calculating the flow contribution from the additional catchment area downstream of the gauge: statistical analysis of the Little Oyster River WSC Gauge data showed there was not enough

quality data to complete an accurate analysis; and regional analysis of nearby gauged rivers showed too much regional variability to prove useful.

Ultimately, an equation developed by the BC Ministry of Environment as part of the British Columbia Streamflow Inventory (March 1998) report was utilized, which allows for the adjustment of peak instantaneous flows to larger or smaller catchment areas.

$$\left(\frac{Q_1}{Q_2}\right) = \left(\frac{A_1}{A_2}\right)^{0.785} \quad where:$$

$$Q_1 = 200 - Year\ Return\ Period\ Flow\ @\ WSC\ Gauge = 430\ m3/s$$
$$Q_2 = 200 - Year\ Return\ Period\ Flow\ @\ Glenmore\ Dike$$
$$A_1 = \ Catchment\ Area\ to\ WSC\ Gauge = 302\ km2$$
$$A_2 = Catchment\ Area\ to\ Glenmore\ Dike = 359\ km2$$

Solving this equation for Q_2 provides a calculated 200-year Return Period Flow at the Glenmore Dike of **493 m³/s**.

Using the above noted statistical analysis for the 39 years of peak flow data on the Oyster River, the December 8 to 10, 2014 high-flow event – 376 m³/s (as measured at the WSC Gauge) – is estimated to be approximately a 35-year return period event.

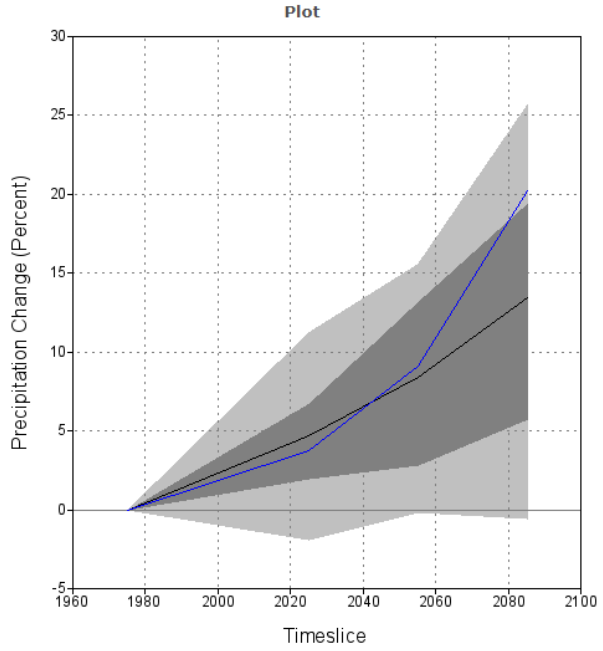
The above noted design flow cannot be compared to the 200-year return period flow that was utilized in the 1984 floodplain mapping because the background documentation is unavailable and therefore the flow utilized at that time is unknown. However, the 1991 design report which was provided for the construction of the Glenmore Dike is included here in **Appendix A**. This report completed two different analyses to determine their recommended 200-year return period design flow for the Glenmore Dike: a frequency analysis utilizing the 14 years of flow data available at the time from the upstream WSC Gauge; and a regional analysis utilizing data from the Courtenay, Puntledge & Tsolum rivers. At the time, these two methods derived estimated 200-year return period flows ranging from 407 m³/s (based on the 11 years of WSC gauge data, adjusted to the Glenmore Dike location) to 576 m³/s (based on extrapolation from the Tsolum River catchment).

These findings from the 1991 report correlate well with the updated findings contained herein. There have been several high-flow events in recent years, which help explain why the 1991 analysis based on the Oyster River gauge flow data available at the time found a lower 200-year flow than calculated herein. Similarly, a regional analysis was completed for this project (which was ultimately not relied upon for our analysis) which found that the other rivers in the area (Tsolum, Salmon) tend to skew the Oyster River flows artificially high when compared to the Oyster River gauge data. Therefore, it is logical that the 1991 report's findings of a design flow of 576 m³/s (extrapolated from the Tsolum River data) is higher than our updated finding of a 200-year design flow of 493 m³/s.

Climate Change Adjustment

The Pacific Climate Impacts Consortium (PCIC) publishes through their online Plan2Adapt tool that provides estimates of precipitation changes out to the 2080 timeframe. The PCIC calculations use many different climate models, each of which has a separate projected change in precipitation. Based on their published data, the precipitation for the Fall & Winter to 2080 is estimated to increase by approximately 12% based on the median of all climate models. However, the uncertainty and range of estimates is quite high, with the 25th to 75th percentile estimate ranging from a 6% to 18% increase in rainfall by 2080 (see **Figure 4**). For the purposes of this analysis, we have used an adjustment factor of a 15% increase in peak flows due to climate change effects.

Figure 4: Estimated Future Precipitation Change Due to Climate Change for the Strathcona Regional District (Data from PCIC's Plan2Adapt Online Tool)



Interpretation

This figure shows the range of projected **Fall - SON** precipitation* (rain plus snow) change (percent), for the **Strathcona** region over three time periods (2020s, 2050s, and 2080s), according to a PCIC-standard set of GCM projections (see 'Notes' tab for more information). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set.
- The blue line indicates the model used for display purposes (CGCM3 A2 run 4).
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

Note: some variables do not come directly from the climate models (see 'Notes' tab for more information).

Design Flow

The computed present day 1:200-year Flood Return Discharge of 493 m^3/s was increased by 15% for climate change, and therefore design flow rate utilized herein was determined to be **567 m^3/s** through the dike reach.

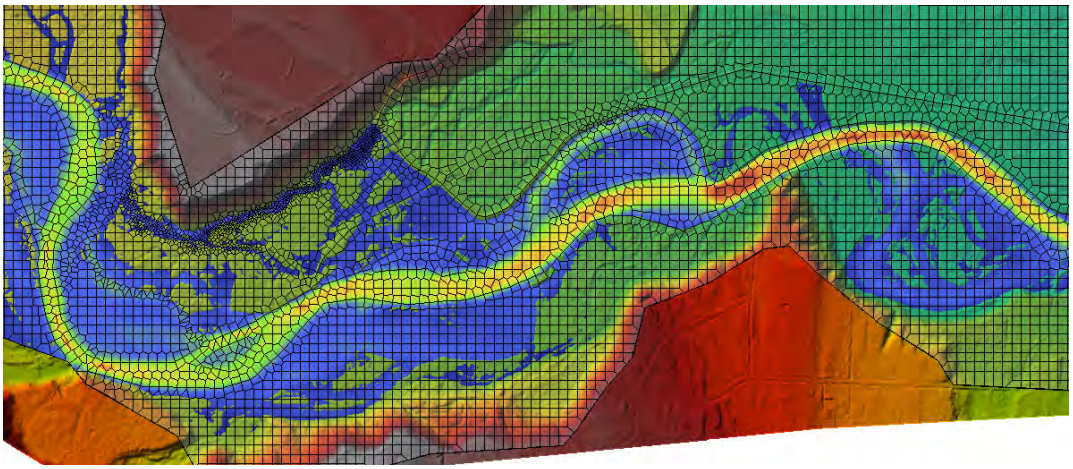
3.2. Hydraulic Assessment

The LiDAR data provided by the SRD allowed for the development of a detailed three-dimensional surface which was used in the development of the hydraulic river model using HEC-RAS river modelling software. This two-dimensional modelling software allows for dynamic simulation of flood events showing the propagation of the flood through the reach. The flood levels, flow direction, localized velocity distribution, and depths can all be estimated by this modelling software. **Figure 5**, below, shows the hill shaded digital elevation model in the study area, which the physical channel and overbank floodplain areas are based on.

Figure 5: Digital Terrain Model (DTM) Shown in Grey Hillshade & Oyster River Main Flow Channels (Light Blue)

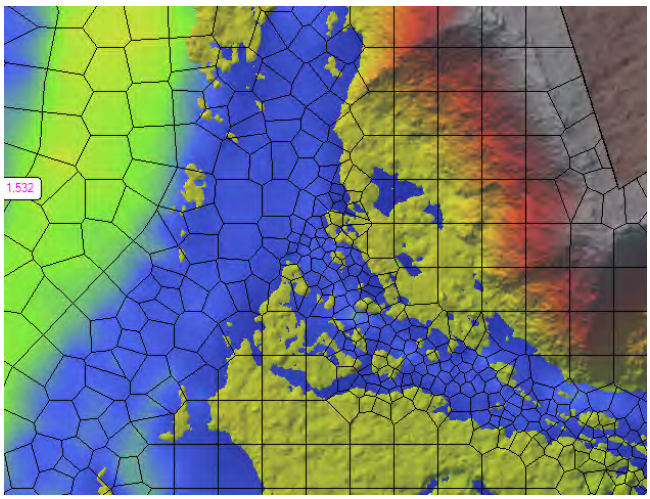
The US Army Corps of Engineers Hydraulic Engineering Centre (HEC) has developed the River Analysis System (RAS) software and recently updated it to complete 2D hydrodynamic simulations. This model was developed using a maximum 20 m “cell size”, covering the Oyster River floodplain in the vicinity of the Glenmore Dike, as shown on **Figure 6**.

Figure 6: Analysis Mesh Showing 20m Maximum Cell Size



This cell size is then refined in areas where additional detail is required (see **Figure 7**), such as small side channels or hydraulically complex locations. This HEC-RAS 2D model covered a 3.5 kilometer stretch of the through Glenmore Dike reach of the Oyster River, and was comprised of 7,330 computational cells.

Figure 7: Detail of Variable Cell Size

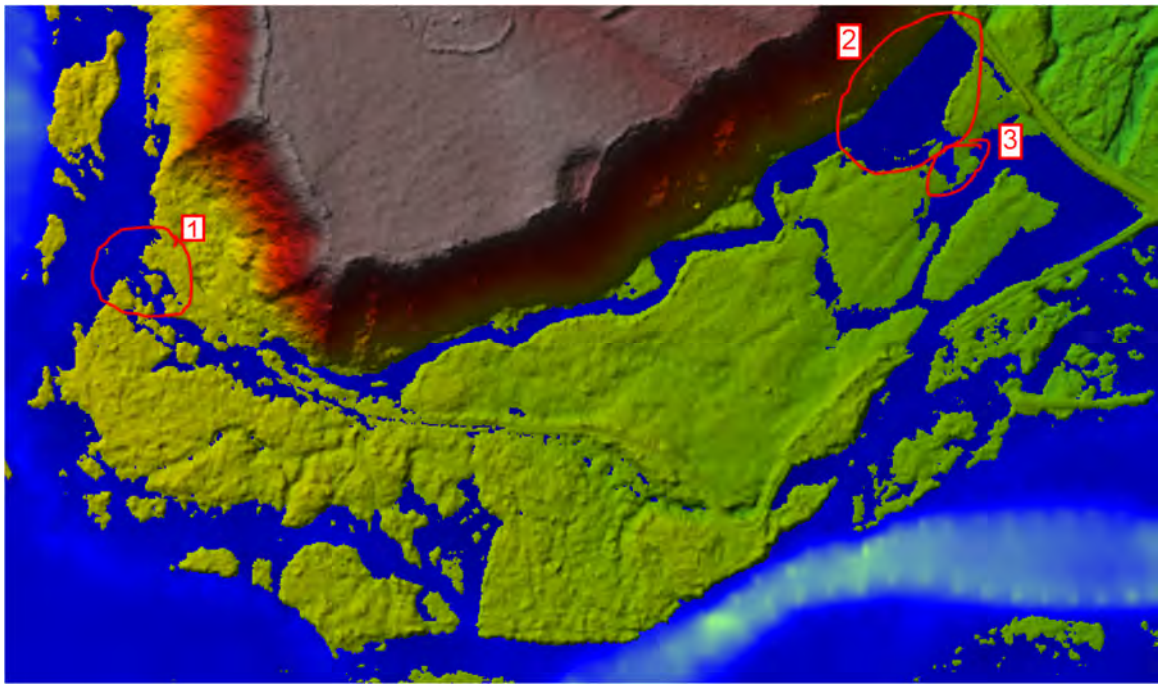


December 2014 High-Flow Event

During the December 2014 high flow event (December 8-10, 2014), it was reported by SRD that water levels were within 0.3 m of breaching the Glenmore Dike near the upstream end. These observations are confirmed by the model simulations which show the development of a small side channel along the base of the bluff upstream of the dike (see **Figure 8**, below). The following comments are provided as to the behaviour of the flood waters in this side channel, and are supported by the included digital animation of this flood event simulation (USB flash drive included as **Appendix D**):

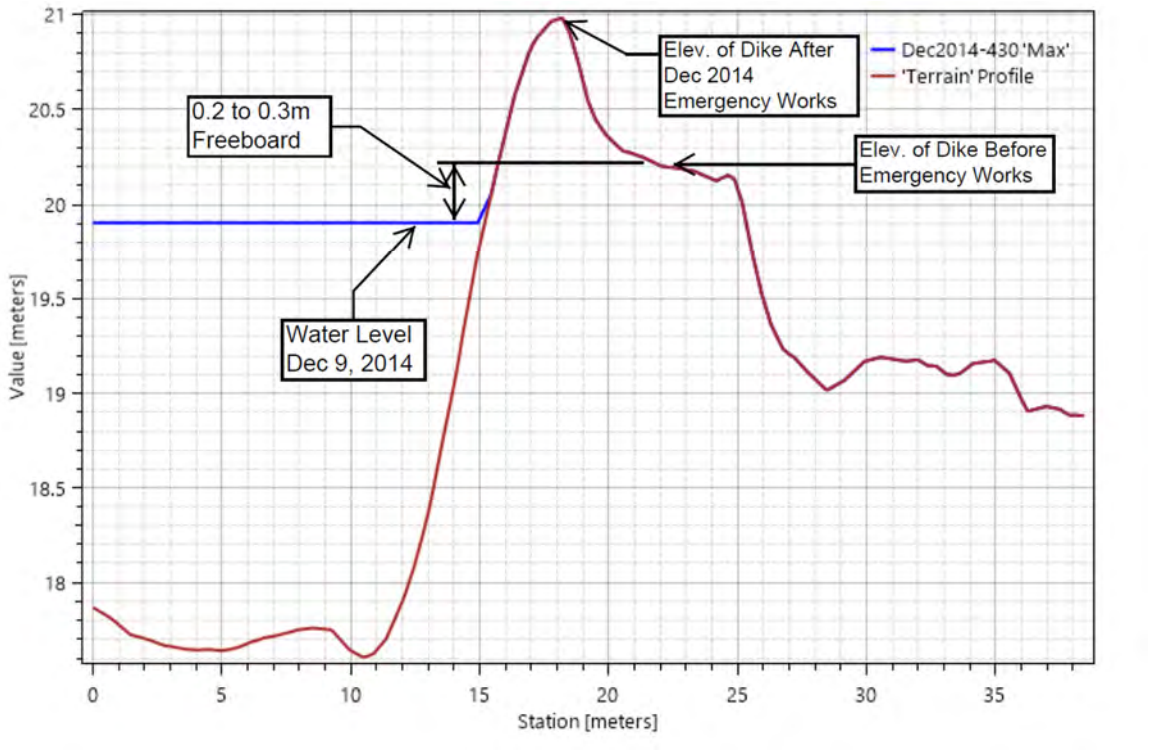
- Side channel is dry until the water surface elevation at the mouth is high enough to breach the main channel bank (1), allowing flows to enter the channel;
- Water is impounded against upstream end of Glenmore Dike (2);
- When relief / overflow elevation is reached, water levels at (2) stabilize and a flow path is opened back to main river channel (3).

Figure 8: Side Channel at Upstream End of Glenmore Dike - December 2014 High-Flow Event



The cross-section shown on **Figure 9** illustrates the modelled water level adjacent to the North end of the dike during the peak of this December 2014 event. There is a close correlation with the observed water levels near the upstream end of the dike. This cross-section is at dike Sta. 0+015 (see attached McElhanney Drawings 2221-49111 for station locations). The emergency works which raised the height of the dike are also clearly visible in this cross-section, because the section is based on LiDAR data collected after the emergency works occurred.

Figure 9: Dike Cross-Section During Peak of December 2014 High-Flow Event (Dike Sta. 0+020)

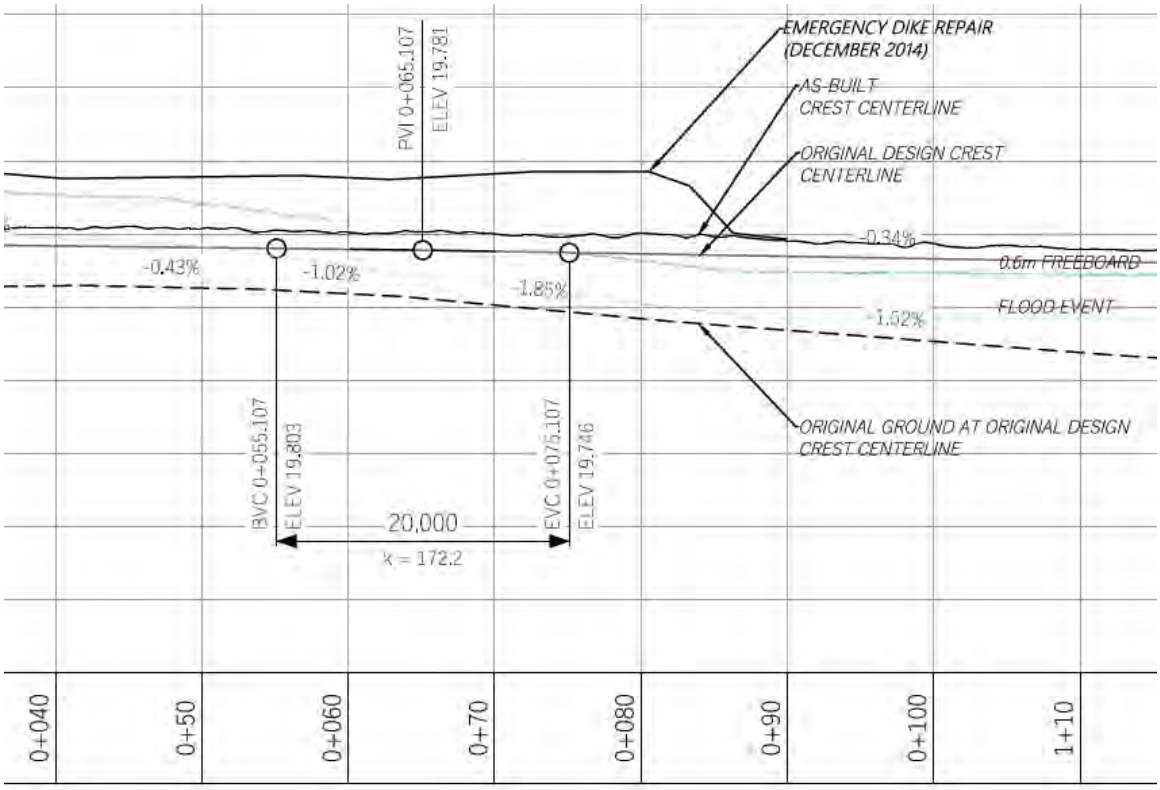


On the basis that the simulated 2014 event produces consistent results with observations, further modelling of the design flood event was completed using the same physical model characteristics.

Design Flow Event – 200-Year + Climate Change

The attached McElhanney Drawings 2221-49111 illustrate the predicted water surface elevations along the entire length of the Glenmore Dike during the above noted design flow event. These drawings show that along the entire length of the dike, the dike crest elevation is high enough such that no flooding occurs during this 200-year design flow event, and 0.6 m freeboard is maintained at all locations.

Figure 10: Dike Profile at Emergency Repair Section



As shown on the left-hand side of **Figure 10**, the emergency repair section is required to remain at the full height of the repair to ensure the required 0.6 m freeboard. Therefore, these works should be made permanent and be built to the full width of the dike, with properly engineered materials and compaction techniques (refer to **Section 5** for detailed upgrade recommendations & cost estimates).

The attached Peak Velocity Map (see **Appendix E**) illustrates the peak flow velocities seen during the design flow. Along the upstream half of the dike (Sta. 0+000 to 0+400) flow velocities are predicted to be low, around 1.0 m/s. From Sta. 0+400 to the downstream end of the dike (Sta. 0+615), up to 3.0 m/s are predicted. To adequately protect against erosion from these flows, the dike should be protected throughout this section by minimum Class 25 rip-rap (Ministry of Transportation & Infrastructure spec). Based on the visual inspections of the dike completed at the beginning of this project, this section is adequately protected by rip-rap larger than this minimum size. However, this should be continuously monitored and re-inspected once vegetation clearing has occurred. If any gaps or unprotected spots are observed, they should be protected with additional rip-rap as soon as possible to mitigate potential erosion.

4. Geotechnical Field Program

The geotechnical assessment consisted of a review of background information, surficial geology, water well drilling records, site reconnaissance, drilling investigation, liquefaction assessment and dike stability analysis. The site reconnaissance was completed on September 19, 2017 as described in the attached memo. The geotechnical drilling investigation was completed between September 18 to 20, 2017. The drilling information was used to assess and quantify the type and consistency of the in-situ soils for use in the liquefaction and dike stability assessment.

McElhanney completed a drilling investigation that generally followed the MFLNRO 2014 Seismic Design Guidelines for Dikes, 2nd Edition (guidelines). In discussion with the SRD the drilling program was reduced to fit within the available budget while providing reasonable coverage on the dike. The guidelines Section 12, recommend soil investigation to a depth 10 m to 30 m spaced at 300 m intervals along the dike with holes on the landside, waterside and centre of the dike. Due to access and private property issues the majority of the holes were drilled along the dike crest. On completion of drilling the holes were backfilled with bentonite and cuttings. McElhanney originally proposed to seal the test holes with grout. However, the drilling company and the driller are also the local water well drilling company and they recommended the holes be sealed with bentonite as in their experience bentonite provides a better seal.

McElhanney completed drilling of 5 boreholes to a depth of between 6.6 m and 15 m along the 600 m length of the dike. The holes were all terminated in dense till or bedrock. The holes were drilled at approximately every 100 m of dike length with closer hole spacing along the northeast river side and wider spaced holes along the southwest towards the valley side slope. Due to the potential for cobbles, boulders, riprap, and local availability, a sonic drill rig was used to advance the holes. Standard penetration tests (SPT) were completed at regular intervals to provide additional detail on soil density and for input into the seismic analysis. Laboratory testing on select drill samples was completed at McElhanney's Courtenay laboratory facility.

4.1. Geotechnical Investigation

The geotechnical drilling took place between September 18 to 20, 2017 and comprised drilling 5 boreholes to a depth of between 6.6 m and 15 m along the 600 m dike as shown on Dwg. Sheet 1 (**Appendix C**). The boreholes were drilled using a GeoProbe Sonic drill owned and operated by Drillwell Enterprises of Duncan, BC.

During the drilling, McElhanney logged and sampled the soils and noted any groundwater conditions encountered in the drill holes. The drill holes were often drilled using water to retrieve the soil sample. As such, observations of groundwater were limited. Detailed borehole logs are shown in **Appendix F**. The soils observed in the field were classified by the attached Modified Unified Classification Systems for Soils.

Select samples collected in the field were submitted to McElhanney's laboratory in Courtney for moisture content and fines content testing. The laboratory test results are summarized on the borehole log sheets in **Appendix F**. Fines content analysis results are shown in Table 1 below.

Table 1. Summary of Laboratory Fines Content Analysis

Borehole No.	Depth of Sample (m)	Fines Content (%)
BH17-01	3.4	5.7
BH17-02	1.8	10.5
BH17-02	4.7	4.9
BH17-02	3.4	55.9
BH17-03	4.7	5.6
BH17-03	6.4	1.4
BH17-04	1.8	10.6
BH17-04	3.4	5.2
BH17-05	4.9	5.4

4.2. Soil Conditions

In general, the subsurface conditions encountered in the boreholes along the dike comprise a layer of granular fill up to 4.2 m in thickness overlying native sands and gravels over till and/or bedrock. Table 2 and the following sections summarize the soil conditions encountered during the drilling program on the dike.

Table 2. Summary of Ground Conditions Encountered

Borehole No.	Depth of Test Hole (m)	Depth of Gravel Fill (m)	Depth of Silt and Sand (m)	Depth of Sand and Gravel (m)	Depth of Silty Sand, Silt, Clay(Till) (m)	Depth Siltstone / Mudstone Bedrock (m)
BH17-01	9.0	0.0 - 4.2		4.2 - 7.6	-	7.6 - 9.0
BH17-02	9.0	0.0 – 3.6	3.6 – 4.5	4.5 - 7.2	-	7.2 – 9.0
BH17-03	15.0	0.0 – 3.6	9.6 – 12.0	3.6 – 9.6	12.0 – 13.1	13.1 – 15.0
BH17-04	6.6	0.0 – 1.5		1.5 – 3.6	3.6 – 6.6	-
BH17-05	9.0	0.0 – 1.8	1.8 – 2.7 (topsoil)	2.7 – 6.6	6.6 – 9.0	-

Refer to the borehole log sheets in **Appendix F** for the detailed subsurface conditions observed in each borehole. The borehole log sheets provide a detailed description of the soil and should be used in preference to the generalized description provided below.

GRAVEL AND SAND FILL: The road on the dike crest and the dike appear to be comprised of a surficial layer of 75 mm minus road gravels with sandy gravel below. The gravel generally had trace to some fines with loose to dense zones. This sand and gravel fill was found in all five boreholes ranging in thickness from 1.5 m to 4.2 m.

GRAVEL AND SAND: The native soils below the dike fills comprise an interlayered varied sequence of gravel with trace sand, silty sand and sand and gravel. The soils generally had trace silt to silty with loose to dense zones. This sand and gravel was found in all five boreholes ranging in depth from 1.5 m to 9.6 m. This soil is generally consistent with typical of river deposits and the geology mapping.

SILT AND SAND: A soft, brown to light grey layer of silt and sand to trace sand was observed in BH17-02 and BH17-03. This silt and sand was generally non-plastic and loose to soft ranging in depth from 3.6 m to 12.0 m.

ORGANIC TOPSOIL: Within BH17-05 between 1.8 m and 2.7m depth organic soils likely from the old forest floor were observed.

SILT, SAND, CLAY TILL: Dense to very stiff silt, sand and clay was observed in BH17-03 to BH17-05. The drilling advance was stopped within this soil in BH17-04 and BH17-05 and in BH17-03 the till was underlain by siltstone and mudstone bedrock. This silt, sand and clay till underlying the fluvial soils and above the bedrock is generally consistent with the quaternary geologic history of the area.

SILTSTONE AND MUDSTONE BEDROCK: Within BH17-01 and BH17-02 hard siltstone and mudstone bedrock was observed in the bottom of the boreholes. This bedrock is generally consistent with the geology mapping in the area.

4.3. Groundwater Conditions

Groundwater monitoring instrumentation was not installed for this project; therefore, the exact groundwater levels and seasonal variations are unknown. Groundwater conditions were observed in BH17-01 only and showed the water at a depth of 5.1 m below ground surface. Groundwater levels within the well records indicated ground water depths between 2.4 m and 4.3 m below ground surface. The groundwater conditions are expected to vary seasonally based on river level, precipitation, snow melt, surface water runoff and subsurface groundwater flow.

4.4. Seismic Ground Motion Parameters

The guidelines are intended to be used as a guide to inspect, assess and design “high consequence” dikes in BC. Based on the proximity of the dike to low lying residential properties and the historical flooding risk, the Glenmore Dike should be considered a “high consequence” dike and thus the guideline recommendations were generally followed for this geotechnical assessment.

The guidelines Section 11 recommend performance criteria under different design earthquakes. Earthquake level 1 (EQL-1) is to be designed for the 40% in 50 years probability of exceedance. EQL-2 is to be designed for the 10% in 50 years probability of exceedance and EQL-3 is to be designed for the 2% in 50 years probability of exceedance. The performance criteria are summarized as follows:

- EQL-1 (Performance Category A): No significant damage to dike structure and post disaster flood protection is not compromised. Maximum allowable vertical and horizontal displacement is less than 0.03 m. Designed using Moment Magnitude (Mw) of 6.
- EQL-2 (Performance Category B): Some repairable damage to internal structures and post disaster flood protection is not compromised. Maximum allowable vertical displacement 0.15 m and horizontal displacement 0.3 m. Designed using Moment Magnitude (Mw) of 7.
- EQL-3 (Performance Category C): Significant damage to internal structures and post disaster flood protection is possibly compromised. Maximum allowable vertical displacement 0.5 m and horizontal displacement 0.9 m. Designed using Moment Magnitude (Mw) of 7.

Ground motion seismic parameters for input into the assessment and modelling were obtained from the Natural Resource Canada website for the 2015 National Building Code as shown on the attached.

The PGA at the crest was modified based on Equation 1 of the guidelines for the apex angle (Table 4 of guidelines) of the dike and for the Site Class D soils (Table 3 of guidelines) at the site, as shown in Table 3 below.

Table 3. Summary of Seismic PGA used in Analysis

Earthquake Level	Sa (0.2)	PGA Firm Ground	Site Class Amplification	Apex Angle Amplification	Design PGA at Crest
EQL-1	0.11	0.047	1.3	1.3	0.079
EQL-2	0.29	0.131	1.29	1.3	0.220
EQL-3	0.63	0.298	1.15	1.3	0.446

4.5. Liquefaction Triggering Assessment

The Liquefaction Index (Li) was calculated based on Seed's Simplified Analysis as described in the guidelines and 1998 NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. The Seed Simplified Analysis used SPT blow counts collected from the drilling program. These blow counts were corrected based on methods presented in the NCEER. In addition, due to the gravelly soils which underlie the site, some of the SPT blow counts were corrected based on the methodology presented by Singh and Huber (GeoEdmonton 2008). The results of the detailed liquefaction triggering assessment are shown in **Appendix G** for each of the boreholes and earthquake design levels. A summary of the Liquefaction Index is shown in Table 4 below.

Table 4. Summary of Liquefaction Index used in Analysis

Borehole No.	Station	EQL-1	EQL-2	EQL-3
BH17-01	0+570	L0	L0	L2
BH17-02	0+540	L0	L2	L2
BH17-03	0+430	L0	L0	L1
BH17-04	0+360	L0	L2	L2
BH17-05	0+195	L0	L0	L0

The results of the liquefaction triggering assessment showed Liquefaction Index for all the soils and stations to be L0 (no liquefaction) for EQL-1. The EQL-2 results for Sta. 0+540 and 0+360 showed L2 (liquefaction in zones) and L0 for all the other stations. For EQL-3 the results showed L2 for Sta. 0+570, 0+540 and 0+360 and L1 (complete liquefaction not expected) for station 0+430 and L0 for Sta. 0+195.

The groundwater surface is unknown and expected to vary seasonally. The soft liquefiable soils in some areas are close to the groundwater surface. Thus, for the Liquefaction Index a range of potential groundwater surface levels was assessed.

McElhanney recommends the SRD update their dike operation and maintenance manual to include a post seismic Earthquake Inspection Checklist as discussed in the guidelines.

4.6. Dike Stability Assessment

McElhanney completed limit equilibrium pseudo-static analysis using the software program Slope/W by GEO-SLOPE International Ltd. to analyse the slope stability during the three design earthquake levels generally following the method presented in the guidelines at five representative cross sections. The five cross sections were taken to be near the located of the boreholes and cross-section geometry was taken from the LIDAR data as shown on drawings in **Appendix C**. The results of the Slope/W analysis are attached in **Appendix H**.

Table 5. Summary of Seismic Dike Stability Analysis Results (FoS)

Borehole No.	Station	EQL-1	EQL-2	EQL-3
BH17-01	0+570	1.78	1.32	K_y=0.345 [1]
BH17-02	0+540	1.29	0.34 (Flow Slide)	N/A
BH17-03	0+430	1.66	1.19	K_y = 0.215 [1]
BH17-04	0+360	1.70	0.67 (Flow Slide)	N/A
BH17-05	0+195	1.49	0.62 (Flow Slide)	N/A

Note:
1. K_y refers to yield horizontal earthquake acceleration for use in Newmark displacement analysis.

The stability analysis shows that the dike section has an acceptable FoS under the design EQL-1. For EQL-2, Sta. 0+570 and 0+430 showed acceptable FoS under the design earthquake loading. Sta. 0+540, 0+360 and 0+195 all showed flow slides covering the majority of the dike cross section for EQL-2 and thus additional analysis for EQL-3 was not completed for these sections. Flow slides are significant translational displacement of the dike and possibly land behind the dike flowing towards the river. Under EQL-2 and EQL-3, the soil strength at these locations will require soil remediation and strengthening. For EQL-3, Sta. 0+570 and 0+430 showed that deformation would occur requiring further displacement analysis to be completed. Based on the analysis completed herein, it can be concluded that there is a significant risk of failure during the EQL-2 and EQL-3 earthquake events due to the liquefaction potential of the underlying foundation soils.

McElhanney completed limit equilibrium pseudo-static analysis to assess potential rapid drawdown cases. The results of the Slope/W analysis are attached as Appendix H. Transient seepage analysis was not completed to determine the rate of water inflow into the dike and outflow. However, the river level rise is of very short duration, so it is possible that the actual groundwater level is different than assumed. The results of the analysis generally show acceptable dike FoS for the rapid drawdown case. However, Sta. 0+570 and 0+540 show FoS near 1 for shallow slides on the dike slope. The dike in these areas is

relatively wide and high, and these surficial slides if they occur will likely not reduce the overall dike performance. McElhanney recommends an inspection of the dike slopes should be completed following a high-water flood event.

4.7. Displacement Assessment

McElhanney completed assessment of post seismic displacements using the Newmark method in the software program SLAMMER published by the U.S. Geological Survey. The yield horizontal earthquake acceleration (k_y) was determined as part of the Slope/W analysis. Earthquake records were selected from the database within SLAMMER. This database is derived from the Pacific Earthquake Engineering Research Center (PEER) at the University of California, Berkley. Earthquake records were selected from the Cape Mendocino, Coalinga, Coyote Lake, Imperial Valley, Landers, Loma Prieta, Mammoth Lakes, Morgan Hill, Palm Springs, Northridge, Parkfield, San Fernando, Santa Barbara, Superstition Hills, Westmorland, Whittier Narrows, Chi-Chi, Duzce, Friuli, Kobe, Kocaeli, Tabas, and Nisqually earthquakes. The results of the Newmark assessment are shown in Table 6.

Table 6. Displacement from Newmark Analysis

Borehole No.	Station	EQL-1 (m)	EQL-2 (m)	EQL-3 (m)
BH17-01	0+570	N/A	N/A	0.005
BH17-03	0+430	N/A	N/A	0.084

The results of the Newmark analysis showed that for Sta. 0+570 a displacement of 0.005 m would be expected and for Sta. 0+430 0.084 m would be expected. These displacements are within the acceptable level of displacement of 0.5 m for EQL-3. However, adjacent dike flow slides may cause displacements that are higher than expected. Thus, full dike reconstruction and/or soil ground improvements below portions of the dike are recommend to be completed to mitigate potential soil liquefaction. Soil ground improvements include rapid impact compaction, dynamic compaction, compaction piles or grout stabilization measures. Given the reasonable access to the site, rapid impact compaction (RIC) is likely the most suitable alternative for foundation soils improvement. The program would include excavating to an elevation just above the foundation soils; taking in-situ soil density tests in a grid pattern to determine the areas that require improvement; completing the RIC with specialized machinery; and then confirming the efficacy with follow up in-situ density tests.

4.8. Dike Seepage Assessment

McElhanney completed finite element seepage analysis using the software program Seep/W by GEO-SLOPE International Ltd. to analyse the dike seepage during the design flood event. Based on the design flow event height in relation to the dike crest only specific locations along the south and west portions of the dike have the landside of the dike at a lower elevation than the waterside. Thus, one representative section at Sta. 0+360 was assessed to determine the hydraulic gradient and water flow volumes through the dike. The values of hydraulic conductivity and volumetric water content equations were based on the results of the drilling program and correlations to similar soils. The results of the seepage assessment are included as **Appendix I**.

Piping on the landward side of the dike was assessed by determining the exit gradient at the landside toe of the dike. As shown, the exit gradients at the toe are between 0.05 and 0.1. Generally, exit gradients of 0.4 or less are considered stable to piping. However, exit gradients as low as 0.2 have in our experience

shown evidence of piping. The FoS against piping is thus expected to be at least 2 and possibly more and piping is not expected to occur.

The results of the seepage analysis showed that about 3.6 m^3 per hour per lineal metre of dike would be expected to flow though the dike for those sections where the ground level on the "dry" side of the dike is below the water surface on the river side of the dike. In some areas, this amount of seepage may be significant. During future detailed design of dike upgrades, consideration should be given to including an impermeable core or liner at these locations to reduce the rate of seepage and risk of piping.

5. Recommended Dike Upgrades & Cost Estimates

The following recommended dike upgrades have been prioritized to reflect the immediate and long-term performance needs for the dike system. They are based on our observations in the field, our discussions with the diking authority and the analyses presented in the previous sections. The costs provided are at a Class 'D' level at this stage of study, and carry a 30% contingency, which should later be refined during a more detailed design phase

Priority 1: Maintenance and Repairs

The site inspection completed in September confirmed earlier inspections completed by the Inspector of Dikes (IoD) and revealed two key issues that require pressing attention as they present an immediate risk to poor dike performance

- Vegetation Clearing (entire length of dike, both sides)
- Culvert Replacement (450 mm Diameter HDPE) & Flap-Gate Chamber (see drawings in **Appendix C**, Detail A, Sheet 6)

The vegetation clearing is of significant concern, especially on the east-west leg of the dike adjacent to the main flow channel. At this location, larger flow events can uproot trees and cause significant scour of the dike, which could lead to a significant breach or failure. It is recommended that an annual inspection and dike maintenance program be initiated, and would be best completed in late summer when flows are at their lowest and the dike is fully accessible. The annual inspection would focus on the condition of the rip rap, the flood box and the vegetation. An allowance of $7,000 should be set aside for annual maintenance based on a routine 3-4-hour inspection, followed by the coordination of, and execution of, any required maintenance. Vegetation maintenance is based on a 3-person crew for up to 3 days to slash and remove vegetation as required. No allowance for riprap repairs is provided, but should be assessed on a case by case basis.

The total estimated costs for priority one items is **$138,000**, including mobilization costs, engineering, contingency, and construction costs. A breakdown of the items is included in **Appendix J**.

Priority 2: Upgrades and Raise Dike at North End

In 2015 an emergency berm was constructed at the north end of the dike to raise it approximately 1.0m as flood waters lapped at the crest in this area. The hydrotechnical assessment shows that this part of the dike between Sta 0+00 and 0+090 requires raising and the geotechnical assessment has revealed that the dike is founded on organic soils, which should be replaced. Since this part of the dike has been compromised by recent flood events, the rebuilding and raising of this section of the dike should commence as soon as it can be afforded to mitigate the risk of future breach or failure. The scope of the rebuild and raising would include:

- Depending on the results of detailed design, depth of excavation and soils encountered ground improvements such as rapid impact compaction may be required to mitigate potential liquefaction;
- Excavate existing dike and remove underlying organic matter, soft liquefiable soils;
- Re-build dike as follows:
    - Crest width of minimum 4 m;
    - Landside dike slopes to be 2.5H:1V or flatter;

- Waterside dike slopes to be 3H:1V or flatter with appropriate riprap armouring;
- Where necessary, install impermeable core to reduce seepage;

The estimated cost for the above scope of work is approximately **$303,000**, which includes mobilization costs, additional detailed engineering and geotechnical assessment, construction and an allowance for foundation soils improvements. Additional, geotechnical investigations are warranted to assess the extent of the organic layer and determine the liquefaction potential of soils in the zone.

Priority 3: Dike Rebuild for Long-Term Seismic Stability

The geotechnical assessment has revealed that during significant (EQL-2) to severe earthquakes (EQL-3), the existing dike does not meet the required standard set by the MFLNRO 2014 Seismic Design Guidelines for Dikes, 2nd Edition. Should the Strathcona Regional District want to or be required to update the existing dike to meet this standard a full rebuild is recommended, which would include the following

- Excavate existing dike and remove underlying organic matter, soft liquefiable soils from station 0+090 to Sta 0+600;
- Depending on the results of detailed design, depth of excavation and soils encountered ground improvements such as rapid impact compaction may be required to mitigate potential liquefaction. An allowance for this probability has been accounted for in the cost estimate;

Re-build dike as follows:

- Crest width of minimum 4 m;
- Landside dike slopes to be 2.5H:1V or flatter;
- Waterside dike slopes to be 3H:1V or flatter with appropriate riprap armouring;
- Where necessary, install impermeable core to reduce seepage;
- Consider lowering dike crest downstream of Sta. 0+300 (existing dike crest currently site above the 200-year design water surface elevation plus 0.6m freeboard by over 1 metre in some locations).

The estimated cost for the priority 3 upgrades is $**3,775,000**, which includes detailed design and geotechnical assessment, as well as environmental permitting, which will be challenging given the proximity of the dike to the river.

6. Conclusion

A condition assessment of the Glenmore Dike was conducted by McElhanney in September 2017 and found several maintenance related issues, which are recommended to be rectified as Priority 1. These items include maintenance and repair to the dike including replacing the flood box and clearing vegetation.

A hydraulic assessment of the Oyster River within the Glenmore Dike was completed to determine the level of flood protection provided by the Glenmore Dike. The design flow used in the assessments was computed to be **567 m^3/s**, which is the estimated 200-year return period flow at the dike location, plus an estimated increase of 15% to account for potential future climate change effects. Under this design flow, the Glenmore Dike appears to safely protect against the design flow with minimum 0.6 m of freeboard. However, the sections which underwent emergency dike repairs / raising in December 2014 need to be re-built to be made permanent. These works are recommended as Priority 2.

Geotechnical subsurface investigations were completed to facilitate geotechnical analysis of the dike, which took into consideration a seismic liquefaction assessment, dike slope stability, and seepage. Based on these analyses, it was determined that significant portions of the dike are susceptible to failure during the design EQL-2 and EQL-3 seismic events. These design events represent the probability of a significant event (10% chance in 50 years), and a severe event (2% chance in 50 years) occurring. It is for this reason that long-term seismic upgrades are recommended, which require a complete dike re-build. These works are proposed for the priority 3 conceptual upgrades.

McElhanney recommends that the Earthquake Inspection Checklist discussed in the guidelines be added to the SRD dike operations and maintenance manual. Further, McElhanney recommends that the SRD complete the Annual Dike Inspection Checklist making reference to the Flood Protection Works Inspection Guide (2000) from the BC Provincial Dike Maintenance Act.

7. Limitations

McElhanney Consulting Services Ltd. (McElhanney) has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, has been prepared by McElhanney for the sole benefit of the Strathcona Regional District. It represents McElhanney's professional judgment based on the knowledge and information available at the time of completion. McElhanney is not responsible for any unauthorized use or modification of this document. All third parties relying on this document do so at their own risk.

The factual data, interpretations, suggestions, recommendations and opinions expressed in this document pertain to the specific project, site conditions, design objective, development and purpose described to McElhanney by the Strathcona Regional District, and are not applicable to any other project or site location. In order to properly understand the factual data, interpretations, suggestions, recommendations and opinions expressed in this document, reference must be made to the entire document.

This report is based on the results of a limited geotechnical drilling program with drilling at locations as noted. It is possible that different and/or poorer soil conditions than those described in this report may be encountered on the site.

8. Closure

We trust that the above information is sufficient for your present needs. Should you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

McElhanney Consulting Services Ltd.

Prepared by:	Reviewed by:
 Ben Singleton-Polster, P.Eng. Geotechnical Engineer bsingleton-polster@mcelhanney.com	 W.J. (Bill) Purdy, P.Eng. Senior Geotechnical Engineer wpurdy@mcelhanney.com
Eric Heel, P.Eng. Hydrotechnical Engineer eheel@mcelhanney.com	Mark DeGagné, P.Eng. Senior Hydrotechnical Engineer mdegagne@mcelhanney.com

APPENDICES

☑ **Additional information is appended:**

Information	**Located:**
☑ Statutory Right of Way Plan VIP 56947.	Appendix C

06-GXS-Rs

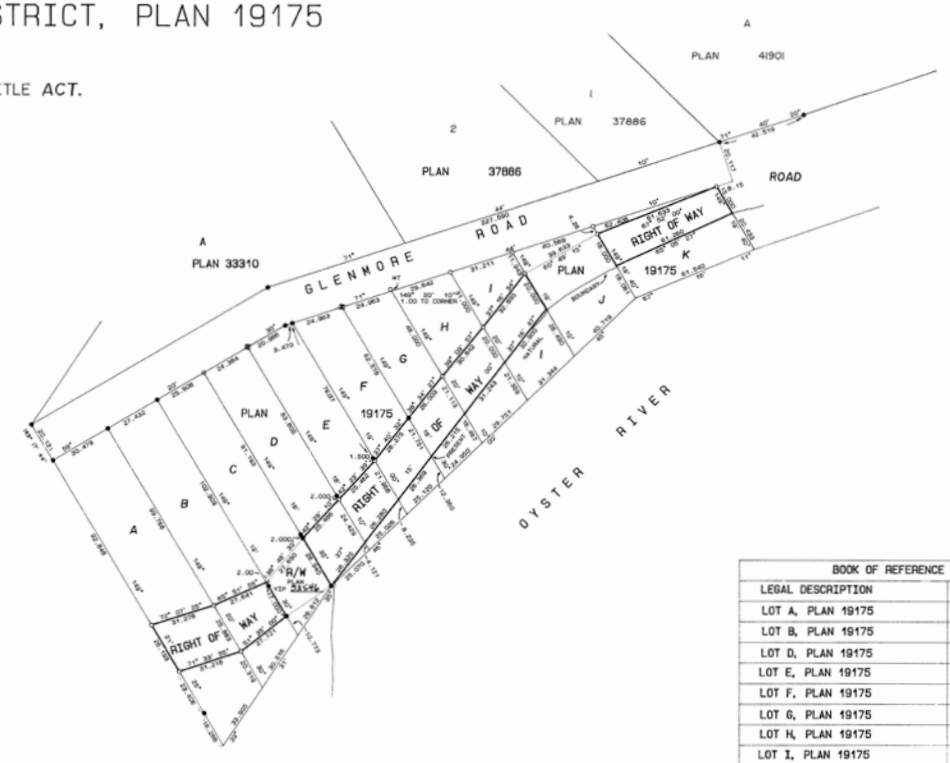
STATUTORY RIGHT OF WAY PLAN
THROUGH LOTS A, B, D, E, F, G, H, I, AND K
BLOCK 29, COMOX DISTRICT, PLAN 19175

PLAN VIP 56947

Deposited in the Land Title Office at Victoria, B.C.
This 25 day of July, 1983.
Ian M. McDonald
Deputy Registrar
EQ 9545

PURSUANT TO SECTION 113 OF THE LAND TITLE ACT.
B.C.G.S. 92F.085

SCALE 1: 1000
20 10 0 20 40 60
All distances are in metres.



COMOX STRATHCONA REGIONAL DISTRICT
AUTHORIZED SIGNATORY
AUTHORIZED SIGNATORY
WITNESS:
ADDRESS:
OCCUPATION:

LEGEND
BEARINGS ARE ASTRONOMIC AND DERIVED FROM PLAN 19175
ALL DISTANCES ARE IN METRES
● CCP DENOTES OLD STANDARD IRON POST FOUND
○ SP DENOTES STANDARD IRON POST SET
m² DENOTES SQUARE METRES
•1 DENOTES WITNESS
■ OP DENOTES OLD WOODEN POST FOUND

I, ROSS N. GLOVER, A BRITISH COLUMBIA LAND SURVEYOR, OF COMOX, IN BRITISH COLUMBIA, CERTIFY THAT I WAS PRESENT AT AND PERSONALLY SUPERINTENDED THE SURVEY REPRESENTED BY THIS PLAN AND THAT THE PLAN AND SURVEY ARE CORRECT. THE SURVEY WAS COMPLETED ON THE 28TH DAY OF JANUARY, 1982.

Ross N. Glover B.C.L.S.

BOOK OF REFERENCE	
LEGAL DESCRIPTION	R/W AREA
LOT A, PLAN 19175	794.4 m2
LOT B, PLAN 19175	616.4 m2
LOT D, PLAN 19175	626.6 m2
LOT E, PLAN 19175	565.1 m2
LOT F, PLAN 19175	534.1 m2
LOT G, PLAN 19175	521.0 m2
LOT H, PLAN 19175	595.1 m2
LOT I, PLAN 19175	609.8 m2
LOT K, PLAN 19175	1006 m2

THIS PLAN LIES WITHIN THE COMOX-STRATHCONA REGIONAL DISTRICT

ROSS N. GLOVER B.C.L.S.
IAN W. ZAMARKO B.C.L.S.
BRITISH COLUMBIA LAND SURVEYORS
221-B CHURCH STREET
COMOX B.C.
V9N 5N4

FILE: 456 DRAWING: A
COMPUTER FILE: 456A

APPENDICES

☑ **Additional information is appended:**

Information	**Located:**
☑ Inspector's Daily Reports.	Appendix D

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Alex Bates / Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-02	**Weather**	Overcast, 20.0˚C

WORK IN PROGRESS

Tree Falling: Sta. 0+000 to Sta. 0+170

LABOUR AND EQUIPMENT

Labour: 1 Operator, 1 Faller, 1 Traffic Control / First Aid, 1 Superintendent

Equipment in Use: 1 Komatsu PC 210 Excavator

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Active Swainson's thrush nesting site noted at Sta. 0+385

Debris on Dike: Trailer noted at Lot C/D

Trees on Dike: Trees noted within 3m Clearing Limit on some properties, may be of value to owners

Flood Box: Headwall and Flood Box examined for suitability

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: No Water in 'Overflow Channel'

Photo 2: Tree within 3m Clearing Limit

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-05	**Weather**	Overcast, 19.0˚C

WORK IN PROGRESS

Tree Falling: Sta. 0+170 to Sta. 0+225

Clearing and Grubbing: Sta. 0+000 to Sta. 0+170 and site office / laydown area

LABOUR AND EQUIPMENT

Labour: 1 Operator/Foreman, 1 Operator, 1 Traffic Control / First Aid, 1 Labourer

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Active Swainson's thrush nesting site noted at Sta. 0+385, 30m buffer flagged by Contractor

Debris on Dike: Trailer noted at Lot D/E, Wood debris from recent falling by owner noted at Lot A

SITE INSTRUCTION ISSUED

Nesting Survey: Pacificus Biological to be on site 2019-07-09

SITE PHOTOS

Photo 1: Swainson's Thrush Nesting Site

Photo 2: Falling, Clearing and Grubbing Progress looking toward Sta. 0+000

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-10	**Weather**	Rain, 16.5˚C

WORK IN PROGRESS

Clearing and Grubbing: Sta. 0+270 to Sta. ~0+360

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Foreman / Operator, 1 Operator, 1 Labourer, 1 Traffic Control / First Aid, 1 Traffic Control

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Active Swainson's thrush nesting site noted at Sta. 0+385

Debris on Dike: Trailer removed from Lot D/E

Flagged Trees on Dike: Flagged trees by Engineer (07/06) for retention noted at Lot F and Lot H

Gate at Lot A: Privately-owned gate knocked over during clearing and grubbing, Contractor has agreed to replace post

Flood Box Headwall: Modified to accommodate appropriately sized pipe using Quikcrete bag concrete

Ex. Riprap at Sta. 0+300: Stumps removed without disturbing riprap per Engineer (07/06)

Stockpiling of Till Material for Clay Plug: 250 tonnes stockpiled at Sta. 0+180, 250 tonnes stockpiled at Sta. 0+060

Staking of Edge of Dike: By Superintendent from Sta. 0+000 to Sta. 0+150

Road Widening: Road on top of dike widened from Sta. 0+000 to Sta. 0+020 inside bend to accommodate truck traffic to Oviatt's Pit during construction. This will be left in place upon completion of the project.

Imported Pitrun Material: 22 trucks of material imported from Oviatt Pit

Tracking Water Use: CRD has dropped off water meter and BFP for use when Contractor fills water truck

SITE INSTRUCTION ISSUED

Excess Material for Re-Use: Ex. material from dike shaping (Sta. 0+000 to Sta. 0+070) **can be re-used** to backfill area on leading edge of dike Sta. 010 to Sta. 0+020 per Project Manager

Thickness of Material above Clay Plug: Thickness of material above clay plug to be **300mm - 450mm** per Engineer

Nesting Survey: Pacificus Biological to be on site 2019-07-11

SITE PHOTOS

Photo 1: Flood Box Headwall Modification

Photo 2: Gate at Lot A Knocked Over

Photo 3: Stockpiled Till Material for Clay Plug

Photo 4: Road Widening, Sta. 0+000 to Sta. 0+020

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-12	**Weather**	Overcast, 20.5˚C

WORK IN PROGRESS

Installation of Clay Plug: Sta. 0+000 to Sta. ~0+040

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Foreman / Operator, 2 Operators, 1 Trucker, 1 Traffic Control / First Aid, 1 Traffic Control

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Swainson's thrush nesting site c/w eggs noted at Sta. 0+385

Installation of Clay Plug:

General Notes:

- excavation to be ~0.3m into native sand and gravel (refer to 2019-06-08 Test Pit Logs)
- backfill material to be 100mm Till
- bottom lift to be 0.6m, then 0.45m lifts to T.O. Clay Plug
- compaction of material with hoe pack to be 95% Modified Proctor Density
- top 1.2m of Clay Plug to be tested using nuclear densometer
- during backfilling and compaction, material in sloughing into trench to be removed (sloughing is resulting in a wedge-shaped plug ~1.0m at bottom and ~1.5m at top)
- 0.3m to 0.45m of ex. pitrun material to be placed over Clay Plug to final grade
- maintenance of 4.0m lane to accommodate traffic at all times during installation

Sta. 0+000:
- excavation 2.7m below final grade, 0.5m into native sand and gravel

Sta. 0+003:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-12

Sta. 0+005:
- excavation 3.4m below final grade, 0.4m into native sand and gravel

Sta. 0+007:
- compaction tested at 93% (MAX) Modified Proctor Density, see Field Density Report 2019-07-12

Sta. 0+012:
- excavation 3.8m below final grade, 0.5m into native sand and gravel

Sta. 0+016:
- excavation 4.0m below final grade, 0.5m into native sand and gravel

Sta. 0+020:
- compaction tested at 99% Modified Proctor Density, see Field Density Report 2019-07-12

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Overview of Work Area

Photo 2: Excavation at Sta. 0+005

Photo 3: Backfilling and Compaction at Sta. 0+005

Photo 4: Backfilling and Compaction at Sta. 0+005

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-16	**Weather**	Overcast, 20.5˚C

WORK IN PROGRESS

Installation of Clay Plug: Sta. 0+038 to Sta. 0+073

Importing 100mm Till Material for Clay Plug: 350 tonnes of material imported (total 850 tonnes on site)

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Foreman / Operator, 2 Operators, 2 Labourers, 1 Trucker, 1 Traffic Control / First Aid, 1 Traffic Control

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Swainson's thrush nesting site c/w eggs noted at Sta. 0+385

Grading and Compaction of Dike Inside Slope: Sta. 0+000 to Sta. 0+180, work done 2019-07-15

Vegetation Maintenance: Sta. 0+615 to Sta. 0+450, work done 2019-07-15 and 2019-07-16

Installation of Clay Plug:

Sta. 0+020 to Sta 0+030:
- excavation ~3.9m below final grade, ~0.3m into native sand and gravel per Contractor

Sta. 0+035 to Sta 0+065:
- excavation ~2.5m below final grade, ~0.3m into native sand and gravel per Contractor

Sta. 0+040:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-16

Sta. 0+050:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-16

Sta. 0+060:
- compaction tested at 96% Modified Proctor Density, see Field Density Report 2019-07-16

Sta. 0+067:
- excavation 4.2m below final grade, 0.3m into native sand and gravel

Sta. 0+070:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-16

SITE INSTRUCTION ISSUED

Riprap on E Section of Dike: Voids and instability noted, Contractor to address as part of Contract per Project Manager

SITE PHOTOS

Photo 1: Overview of Work Area from Sta. 0+000

Photo 2: Excavation at Sta. 0+060

Photo 3: Backfilling and Compaction at Sta. 0+060

Photo 4: Voids and Instability in Riprap, E Section

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-17	**Weather**	Overcast, 18.0˚C / Rain 20.0˚C

WORK IN PROGRESS

Installation of Clay Plug: Sta. 0+073 to Sta. 0+100

Installation of Temporary Bypass: Sta. 0+110 to Sta. 0+160

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Foreman / Operator, 2 Operators, 2 Labourers, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Nesting Activity: Swainson's thrush nesting site declared inactive by Pacificus, work can proceed in this area

Installation of Clay Plug:

Sta. 0+075:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-17

Sta. 0+080:
- compaction tested at 95% Modified Proctor Density, see Field Density Report 2019-07-17

Sta. 0+090:
- excavation 3.1m below final grade, 0.3m into native sand and gravel per Contractor

Sta. 0+094:
- excavation 3.3m below final grade, 0.3m into native sand and gravel per Contractor

Sta. 0+097:
- excavation 3.3m below final grade, 0.3m into native sand and gravel per Contractor

Sta. 0+100:
- excavation 3.1m below final grade, 0.3m into native sand and gravel per Contractor

Installation of Temporary Bypass:

Sta. 0+110 to Sta 0+160:
- construction of temporary bypass to accommodate traffic during full rebuild of Dike Sta. 0+120 to Sta. 0+150
- 4.0m lane to be maintained on Dike during construction of bypass
- suitable material from Dike to be reused for temporary bypass construction and full rebuild section
- unsuitable organic material to be stripped from Dike prism

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Overview of Work Area from Sta. 0+150

Photo 2: Backfilling and Compaction, Sta. 0+075

Photo 3: Flow of Traffic Maintained

Photo 4: Construction of Temporary Bypass

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-18	**Weather**	Partial Cloud, 18.0˚C

WORK IN PROGRESS

Full Dike Rebuild: Sta. 0+120 to Sta. 0+150

Vegetation Maintenance: Sta. 0+360 to Sta. 0+420

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Foreman / Operator, 2 Operators, 2 Labourers, 1 Trucker, 1 Faller, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Full Dike Rebuild:

Sta. 0+120 to Sta. 0+150:
- excavation of ~1.5m layer of suitable material, placed in temporary bypass and stockpiled at Sta. 0+080
- excavation of ~1.5m layer of sandy organic material with pockets of dark organic, stockpiled at Sta. 0+250
- approx. excavation dimensions 30.0m L x 6.0m W x 3.0m D = 540m^3
- compaction of subgrade with hoepack prior to backfilling
- backfilling with suitable Dike material and imported pitrun material
- backfilling in 0.45m - 0.6m lifts, compacted to 95% Modified Proctor Density with roller

Vegetation Maintenance:

Sta. 0+360 to Sta 0+420:
- Tree Falling
- Clearing and Grubbing

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Excavation in Rebuild Section, looking West

Photo 2: Excavation in Rebuild Section, looking East

Photo 3: Compaction of Subgrade in Rebuild Section

Photo 4: Vegetation Maintenance in Flood Box Area

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-19	**Weather**	Clear, 15.0˚C

WORK IN PROGRESS

Full Dike Rebuild: Sta. 0+120 to Sta. 0+150

Vegetation Maintenance: Sta. 0+250 to Sta. 0+360 and Sta. 0+020 to Sta. 0+040

Importing Material: Sta. 0+120 to Sta. 0+150

Trucking Sandy Organic Material Offsite: Sta. 0+250

LABOUR AND EQUIPMENT

Labour: 2 Superintendents, 1 Foreman / Operator, 3 Operators, 2 Labourers, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Full Dike Rebuild:

Sta. 0+120 to Sta. 0+150:
- backfilling in 0.3m lifts with suitable Dike material (up to lift 4) and imported sandy pitrun material (lift 4+)
- compaction with roller to ≥95 Modified Proctor Density

Sta. 0+130:
- lifts 3, 4 and 5 compaction tested at >95% Modified Proctor Density, see Field Density Report 2019-07-19

Sta. 0+140:
- lift 4 compaction tested at >95% Modified Proctor Density, see Field Density Report 2019-07-19

Vegetation Maintenance:

Sta. 0+250 to Sta 0+360 and Sta. 0+020 to Sta. 0+040:
- clearing and grubbing

Importing Material:

Sta. 0+120 to Sta 0+150:
- sandy pitrun material being imported from Oviatt pit for use in full rebuild section
- 11 loads imported (12 yards / load)

Trucking Sandy Organic Material Offsite:

Sta. 0+250:
- stockpiled sandy organic material being transported offsite
- 8 loads exported (17 tonnes / load)

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Backfilling and Compaction in Rebuild Section

Photo 2: Clearing and Grubbing, Sta. 0+285

Photo 3: Importing Sandy Pitrun Material

Photo 4: Trucking Sandy Organic Material Offsite

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-22	**Weather**	Clear, 20.0˚C

WORK IN PROGRESS

Full Dike Rebuild: Sta. 0+120 to Sta. 0+150

Vegetation Maintenance: Sta. 0+000 to Sta. 0+060

Importing Pitrun Material: Sta. 0+120 to Sta. 0+150

Importing 100mm Till Material: Sta 0+190

Trucking Sandy Organic Material Offsite: Sta. 0+250

Survey of Flood Box Area: Sta. 0+380 to Sta. 0+400

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 3 Operators, 1 Labourer, 2 Truckers, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Dump Truck and Pup, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'
Full Dike Rebuild:
- Sta. 0+120 to Sta. 0+150:
  - backfilling in 0.3m lifts with imported sandy pitrun material
  - compaction with roller to ≥95 Modified Proctor Density
- Sta. 0+130:
  - lifts 6, 7 and 9 compaction tested at >95% Modified Proctor Density, see Field Density Report 2019-07-22
- Sta. 0+140:
  - lifts 6, 7 and 9 compaction tested at >95% Modified Proctor Density, see Field Density Report 2019-07-22

Vegetation Maintenance:
- Sta. 0+000 to Sta 0+060:
  - clearing and grubbing
  - slope shaping

Importing Pitrun Material:
- Sta. 0+120 to Sta 0+150:
  - sandy pitrun material being imported from Oviatt pit for use in full rebuild section and slope shaping
  - 33 loads imported (12 yards / load)

Importing 100mm Till Material:
- Sta. 0+190:
  - 100mm Till material imported and stockpiled for use in Clay Plug
  - 1 truck and pup load (25 tonnes / load)

Trucking Sandy Organic Material Offsite:
- Sta. 0+250:
  - stockpiled sandy organic material being transported offsite
  - 6 loads exported (17 tonnes / load)

Survey of Flood Box Area:
- Sta. 0+380 to Sta. 0+400:
  - McElhanney Ltd. on site to lay out Flood Box Area for installation per Design

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Backfilling and Compaction in Rebuild Section

Photo 2: Clearing and Grubbing, Sta. 0+020

Photo 3: Importing Sandy Pitrun Material

Photo 4: Survey of Flood Box Area

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-23	**Weather**	Clear, 22.0˚C

WORK IN PROGRESS

Full Dike Rebuild: Sta. 0+120 to Sta. 0+150

Vegetation Maintenance: Sta. 0+290

Importing 100mm Till Material: Sta. 0+190

Importing Riprap: Sta. 0+240

Exporting Sandy Organic Material and Wood Debris: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 1 Labourer, 2 Truckers, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Dump Truck, 1 Dump Truck and Pup, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Full Dike Rebuild:
- Sta. 0+120 to Sta. 0+150:
  - backfilling in 0.3m lifts with suitable Dike material from temporary bypass
  - compaction with roller to ≥95 Modified Proctor Density
- Sta. 0+130:
  - lifts 11 and 13 compaction tested at >95% Modified Proctor Density, see Field Density Reports
- Sta. 0+140:
  - lifts 11 and 13 compaction tested at >95% Modified Proctor Density, see Field Density Reports

Vegetation Maintenance:
- Sta. 0+290:
  - clearing and grubbing

Importing 100mm Till Material:
- Sta. 0+190:
  - 100mm Till material imported and stockpiled for use in Clay Plug
  - 1 truck and pup load (25 tonnes / load), 2 tridem loads

Importing Riprap:
- Sta. 0+240:
  - Riprap material imported and stockpiled for use in Flood Box area
  - 5 loads

Exporting Sandy Organic Material and Wood Debris:
- Various Locations:
  - stockpiled sandy organic material and wood debris being transported offsite
  - 2 loads exported (17 tonnes / load)

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

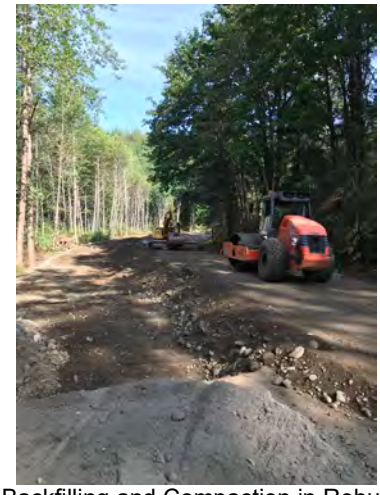


Photo 1: Backfilling and Compaction in Rebuild Section

Photo 2: Clearing and Grubbing, Sta. 0+290

Photo 3: Exporting Woody Debris

Photo 4: Stockpiled Riprap

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-24	**Weather**	Overcast, 22.0˚C

WORK IN PROGRESS

Installation of Flood Box: Sta. 0+380 to Sta. 0+400

Importing 100mm Till Material: Sta. 0+190

Importing Crush: Sta. 0+340

Exporting Organic Material and Wood Debris: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 2 Labourers, 1 Gradesman, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Dump Truck, 1 Diesel Plate Compactor, 1 Jumping Jack

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Installation of Flood Box:
Sta. 0+380 to Sta. 0+400:
- excavation, backfill and compaction of Flood Box area for installation of Flood Box per Design
- installation of Concrete Sump at inlet upon compacted crush material
- installation of 450mm Gate Valve
- compaction by means of Diesel Plate Compactor and Jumping Jack on lower lifts
- refer to Field Density Report dated 2019-07-24 for Nuclear Densometer test results

Importing 100mm Till Material:
Sta. 0+190:
- 100mm Till material imported and stockpiled for use in Clay Plug
- 3 tridem loads

Importing Crush:
Sta. 0+340:
- Crush material imported and stockpiled for use in Flood Box area
- 3 tridem loads

Exporting Organic Material and Wood Debris:
Various Locations:
- stockpiled organic material and wood debris being transported offsite
- 1 load

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Installation of Concrete Sump

Photo 2: Backfilling and Compaction

Photo 3: Preparation of Gate Valve

Photo 4: Installation of Gate Valve

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-25	**Weather**	Partial Cloud, 21.0˚C

WORK IN PROGRESS

Installation of Flood Box: Sta. 0+380 to Sta. 0+400

Importing 100mm Till Material: Sta. 0+190

Importing Crush: Sta. 0+340

Exporting Organic Material and Wood Debris: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Operator/Foreman, 2 Operators, 2 Labourers, 1 Gradesman, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Diesel Plate Compactor, 1 Jumping Jack

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Installation of Flood Box:

Sta. 0+380 to Sta. 0+400:

- installation of 450mm PVC Pipe at surveyed 0.75%, grade confirmed with level
- installation of Concrete Headwall at outlet upon compacted crush material
- backfilling and compaction to 95% Modified Proctor Density, 100mm Till Clay Plug from SG to FG-0.45m
- backfilling and compaction to 95% Modified Proctor Density, crush from SG to OBV +0.3m
- backfilling and compaction to 95% Modified Proctor Density, suitable Dike material from OBV +0.3m to FG
- compaction by means of Diesel Plate Compactor and Jumping Jack on lower lifts
- refer to Field Density Report dated 2019-07-25 for Nuclear Densometer test results

Importing 100mm Till Material:

Sta. 0+190:

- 100mm Till material imported and stockpiled for use in Clay Plug
- 7 tridem loads

Importing Crush:

Sta. 0+340:

- Crush material imported and stockpiled for use in Flood Box area
- 1 tridem load

Exporting Organic Material and Wood Debris:

Various Locations:

- stockpiled organic material and wood debris being transported offsite
- 5 tridem loads

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Clay Plug at Flood Box

Photo 2: Installation of 450mm PVC

Photo 3: Backfilling and Compaction

Photo 4: Confirmation of Pipe Grade

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-26	**Weather**	Partial Cloud, 22.0˚C

WORK IN PROGRESS

Installation of Flood Box: Sta. 0+380 to Sta. 0+400

Temporary Dike Widening: Sta. 0+100 to Sta. 0+150

Installation of Replacement Gate Post: Sta. 0+310

Exporting Organic Material and Wood Debris: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 1 Operator/Foreman, 2 Operators, 2 Labourers, 1 Gradesman, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck, 1 Diesel Plate Compactor, 1 Hamm 3410 Smooth Drum Roller

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Installation of Flood Box:
Sta. 0+380 to Sta. 0+400:
- concrete encasement of 450mm PVC Pipe at Sump, Gate Valve and Headwall
- backfilling and compaction to 95% Modified Proctor Density, 100mm Till Clay Plug to FG-0.45m
- backfilling and compaction to 95% Modified Proctor Density, suitable Dike material to FG
- compaction by means of Hoe Pack and Roller on upper lifts
- refer to Field Density Report dated 2019-07-26 for Nuclear Densometer test results

Temporary Dike Widening:
Sta. 0+100 to Sta. 0+150:
- section of Dike widened to accommodate minimum 4.0m lane for traffic during installation of Clay Plug

Installation of Replacement Gate Post:
Sta. 0+310:
- new gate post installed at property corner to replace old gate post damaged during clearing and grubbing

Exporting Organic Material and Wood Debris:
Various Locations:
- stockpiled organic material and wood debris being transported offsite
- 7 tridem loads

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Concrete at Sump and Valve

Photo 2: Concrete at Headwall

Photo 3: Backfilling and Compaction

Photo 4: Temporary Dike Widening

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-29	**Weather**	Clear, 21.0˚C

WORK IN PROGRESS

Installation of Clay Plug: Sta. 0+095 to Sta. 0+125

Importing 100mm Till Material: Sta. 0+190

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 3 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Installation of Clay Plug:

General Notes:

- excavation to approved subgrade consisting of native sand and gravel
- backfilling and compaction to 95% Modified Proctor Density, 100mm Till Clay Plug SG to FG-0.4m
- backfilling and compaction to 95% Modified Proctor Density, suitable Dike material to FG
- compaction by means of Hoe Pack
- refer to Field Density Report dated 2019-07-29 for Nuclear Densometer test results
- profile noted to be progressively wider toward top due to sloughing of clean material

Sta. 0+095:

- excavation ~3.5m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+100:

- excavation ~2.9m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+110:

- excavation ~3.0m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+120:

- excavation ~3.0m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Importing 100mm Till Material:

Sta. 0+190:

- 100mm Till material imported and stockpiled for use in Clay Plug
- 10 loads

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Excavation to Approved Subgrade

Photo 2: Backfilling and Compaction

Photo 3: Importing and Stockpiling Till Material

Photo 4: Field Density Testing

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-30	**Weather**	Overcast, 21.5˚C

WORK IN PROGRESS

Installation of Clay Plug: Sta. 0+125 to Sta. 0+150

Importing 100mm Till Material: Sta 0+190

Exporting Organic Material and Wood Debris: Various Locations

Grading Top of Dike and Slopes: Various Locations

Engineer Site Visit: Sta. 0+000 to Sta. 0+615 (See Site Instructions)

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 3 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 1 Komatsu PC210 Excavator, 1 Komatsu PC200 Excavator, 1 Kobelco SK200 Excavator c/w Hoepack, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'
Installation of Clay Plug:
General Notes:
- excavation to approved subgrade consisting of native sand and gravel
- backfilling and compaction to 95% Modified Proctor Density, 100mm Till Clay Plug SG to FG-0.4m
- backfilling and compaction to 95% Modified Proctor Density, suitable Dike material to FG
- compaction by means of Hoe Pack
- refer to Field Density Report dated 2019-07-30 for Nuclear Densometer test results
- profile noted to be progressively wider toward top due to sloughing of clean material

Sta. 0+130:
- excavation ~2.7m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+140:
- excavation ~3.7m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+145:
- excavation ~3.0m below final grade, 0.4m into native sand and gravel
- compaction tested at 95% Modified Proctor Density

Sta. 0+150:
- compaction tested at 95% Modified Proctor Density

Importing 100mm Till Material:
Sta. 0+190:
- 100mm Till material imported and stockpiled for use in Clay Plug
- 9 loads

Exporting Organic Material and Wood Debris:
Various Locations:
- stockpiled organic material and wood debris being transported offsite
- 1 load

Grading Top of Dike and Slopes:
Various Locations:
- preliminary road surface grading and slope shaping

SITE INSTRUCTION ISSUED

Engineer Site Visit:

Various Locations:
- hydroseed all disturbed areas on inside and outside banks, including ditch at Flood Box outlet

Flood Box Area:
- grout outlet headwall to smooth surface where flap gate to be mounted
- use mastic or gasket to seal when mounting flap gate

Flood Box Area:
- remove flagged tree on top of Dike

Sta. 0+400 to Sta. 0+615:
- repair voids in riprap as marked

***ALL SITE INSTRUCTIONS FROM ENGINEER PROVIDED TO SUPERINTENDENT 2019-07-30

SITE PHOTOS

Photo 1: Flagged Tree on Dike

Photo 2: Disturbed Banks to be Hydroseeded

Photo 3: Headwall to be Grouted Smooth

Photo 4: Marked Riprap Repair Area

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-07-31	**Weather**	Partial Cloud, 18.0˚C

WORK IN PROGRESS

Flood Box Outlet Channel: Sta. 0+380 to Sta. 0+420

Exporting Organic Material and Wood Debris: Various Locations

Grading Top of Dike and Slopes: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 3 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Komatsu PC200 Excavator, 1 Truck c/w Brush Box

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Flood Box Outlet Channel:
Sta. 0+380 to Sta. 0+420:
- maintenance of existing channel profile
- placement of riprap to armour Flood Box outlet per Drawing and Site Instructions (see below)

Exporting Organic Material and Wood Debris:
Various Locations:
- stockpiled organic material and wood debris being transported offsite

Grading Top of Dike and Slopes:
Various Locations:
- preliminary road surface grading and slope shaping

SITE INSTRUCTION ISSUED

Flood Box Outlet Channel:
Sta. 0+380 to Sta. 0+420:
- outlet channel to have a 'sweeping bend' to accommodate flow from Flood Box (i.e. not 90˚)
- ~10m^2 armouring at outlet to match outlet channel dimensions (i.e. not square)

Flood Box:
Sta. 0+390:
- large alder stump near inlet to be left in place to prevent undermining surrounding root structures unless otherwise instructed by Engineer
- ~6m^2 armouring at inlet to surround concrete sump on north, east and west sides
- grease nipples on gate valve to be accessible in road plate housing (i.e. 90˚ connectors, offset road plate slightly if necessary to accommodate access)

***ALL SITE INSTRUCTIONS FROM INSPECTOR PROVIDED TO OPERATOR 2019-07-31

SITE PHOTOS

Photo 1: Outlet Channel Maintenance

Photo 2: Outlet Channel at Headwall

Photo 3: Large Alder Stump to be left in Place

Photo 4: Gate Valve Grease Nipples

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-01	**Weather**	Overcast, 16.0˚C

WORK IN PROGRESS

Flood Box: Sta. 0+380 to Sta. 0+420

Exporting Organic Material and Wood Debris: Various Locations

Grading Top of Dike and Slopes: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 3 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Komatsu PC200 Excavator, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Flood Box:
Sta. 0+380 to Sta. 0+420:
- placement of ex. riprap to armour slope at Flood Box outlet
- base preparation, forming and pouring concrete slab planned for later today (not witnessed)

Exporting Organic Material and Wood Debris:
Various Locations:
- stockpiled organic material and wood debris being transported offsite

Grading Top of Dike and Slopes:
Various Locations:
- preliminary road surface grading and slope shaping
- access ramp to private property installed at ~Sta. 0+350 to compensate for damaging concrete stairs

SITE INSTRUCTION ISSUED

Flood Box:
Sta. 0+390:
- concrete pad at gate valve to be sufficiently sized to accommodate valve key operator (~2.25m^2)

***ALL SITE INSTRUCTIONS FROM INSPECTOR PROVIDED TO SUPERINTENDENT 2019-08-01

SITE PHOTOS

Photo 1: Riprap at Outlet Channel

Photo 2: Riprap at Outlet Channel

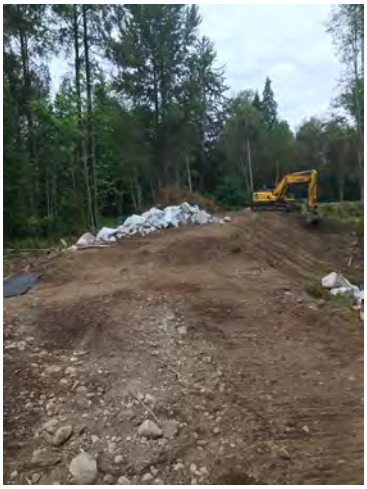


Photo 3: Access Ramp to Private Property

Photo 4: Equipment for Slab Preparation

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-12	**Weather**	Overcast, 16.0˚C

WORK IN PROGRESS

Flood Box: Sta. 0+380 to Sta. 0+420

Full Rebuild: Sta. 0+148 to Sta. 0+165

Riprap Repair: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Flood Box:
Sta. 0+380 to Sta. 0+420:
- grouting of inlet
- installation of grate at inlet
- removal of forms for concrete pad

NOTE: concrete pad poured 2019-08-02, grease whips installed on valve 2019-08-02, tree identified by Engineer removed 2019-08-02, riprap at outlet and inlet placed 2019-08-02

Full Rebuild:
Sta. 0+135 to Sta. 0+185:
- construction of temporary bypass using ex. Material

Sta. 0+148 to Sta. 0+165:
- compaction of subgrade material
- excavation of full rebuild section
- exporting of Sandy Organic Material
- backfilling and compaction of full rebuild section c/w clay plug to Lift 3
- refer to Field Density Report dated 2019-08-13 for Nuclear Densometer test results

Riprap Repair:
Various Locations:
- riprap repair in areas identified by Engineer started but not finished

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS	
 **Photo 1**: Concrete Pad at Flood Box Inlet	 **Photo 2**: Excavation of Full Rebuild Section
Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT

Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-13	**Weather**	Overcast, 16.5˚C

WORK IN PROGRESS

Flood Box: Sta. 0+380 to Sta. 0+420

Full Rebuild: Sta. 0+148 to Sta. 0+190

Inspection by Engineer: Various Locations

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 2 Truckers, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 2 Dump Trucks

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Flood Box:

Sta. 0+380 to Sta. 0+420:

- installation of flap gate at outlet

NOTE: one hole out of alignment - Hilti plug to be removed, hole to grouted with Xypex grout, new Hilti plug to be installed, flap gate to be sealed with Sikaflex

Full Rebuild:

Sta. 0+148 to Sta. 0+190:

- compaction of subgrade material
- excavation of full rebuild section
- exporting of Sandy Organic Material
- importing of Sandy Pitrun from Oviatt Pit (27 x 12 yard loads)
- importing of 100mm Till (11 truck and pup loads)
- backfilling and compaction of full rebuild section c/w clay plug
- refer to Field Density Report dated 2019-08-13 for Nuclear Densometer test results

SITE INSTRUCTION ISSUED

Inspection by Engineer:

Sta. 0+000 to Sta. 0+010 (Inside Bend):

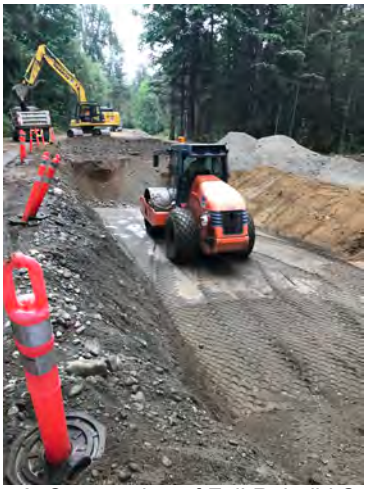
- place Sandy Organic Material from full rebuild section to make bank inside bend less steep
- install 2 rolls of coco mat
- hydroseed when weather permits

Sta. 0+008 to Sta. 0+023 (Outside Bend):

- install filter fabric 4m up bank
- armour with 0.3m minus riprap 4m up bank
- hydroseed when weather permits

Various Locations:

- T.O. road min. 4.0m, roads to be built up ~0.3m (top 0.15m to be crush), slopes to be 3:1

SITE PHOTOS	
 **Photo 1**: Compaction of Full Rebuild Section	 **Photo 2**: Installation of Flap Gate (see NOTE)
Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-14	**Weather**	Clear, 18.0˚C

WORK IN PROGRESS

Flood Box: Sta. 0+380 to Sta. 0+420

Full Rebuild: Sta. 0+148 to Sta. 0+190

Inside Bend per S.I. 2019-08-13: Sta. 0+000 to Sta. 0+010

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 1 Labourer, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Flood Box:
Sta. 0+380 to Sta. 0+420:
- installation of flap gate at outlet

NOTE: flap gate not re-mounted flush, see Site Instruction

Full Rebuild:
Sta. 0+148 to Sta. 0+190:
- importing of Sandy Pitrun from Oviatt Pit (28 x 12 yard loads)
- backfilling and compaction of full rebuild section c/w clay plug to Lift 11
- refer to Field Density Report dated 2019-08-14 for Nuclear Densometer test results

Inside Bend per S.I. 2019-08-13:
Sta. 0+000 to Sta. 0+010:
- placement of Sandy Organic Material from full rebuild section to make inside bank less steep

SITE INSTRUCTION ISSUED

Flood Box:
Sta. 0+380 to Sta. 0+420:
- seal outside edges of re-mounted flap gate at outlet with Sikaflex per Engineer

SITE PHOTOS	
 **Photo 1**: Re-Installed Flap Gate not Mounted Flush	 **Photo 2**: Placing Sandy Organic Material at Sta. 0+000
Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-15	**Weather**	Clear, 22.0˚C

WORK IN PROGRESS

Flood Box: Sta. 0+380 to Sta. 0+420

Full Rebuild: Sta. 0+148 to Sta. 0+190

Inside Bend per S.I. 2019-08-13: Sta. 0+000 to Sta. 0+010

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 2 Truckers, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 2 Dump Trucks

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

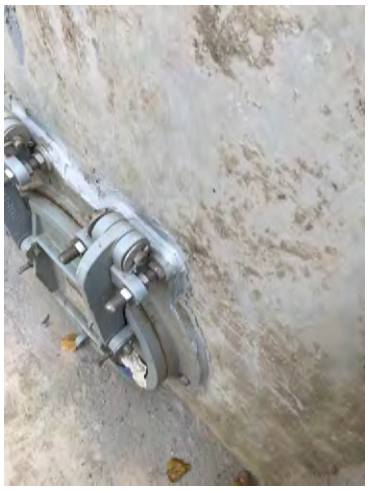
Flood Box:
Sta. 0+380 to Sta. 0+420:
- sealing outside edges of re-mounted flap gate at outlet with Sikaflex per Engineer

Full Rebuild:
Sta. 0+148 to Sta. 0+190:
- importing of Sandy Pitrun from Oviatt Pit (11 x 12 yard loads)
- importing of 100mm Till (8 loads)
- backfilling and compaction of full rebuild section c/w clay plug to Lift 16
- refer to Field Density Report dated 2019-08-15 for Nuclear Densometer test results

Inside Bend per S.I. 2019-08-13:
Sta. 0+000 to Sta. 0+010:
- placement of Sandy Organic Material from full rebuild section to make inside bank less steep

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS	
 **Photo 1**: Re-Installed Flap Gate sealed with Sikaflex	 **Photo 2**: Sandy Organic Material at Sta. 0+000
Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-16	**Weather**	Clear, 19.5˚C

WORK IN PROGRESS

Full Rebuild: Sta. 0+160 to Sta. 0+190

Outside Bend per S.I. 2019-08-13: Sta. 0+008 to Sta. 0+023

Stockpiling of Crush Material: Sta. 0+000

LABOUR AND EQUIPMENT

Labour: 2 Operators, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 1 Dump Truck and Tandem

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Full Rebuild:
Sta. 0+160 to Sta. 0+190:
- backfilling and compaction of full rebuild section c/w clay plug to F/G – 0.4m
- refer to Field Density Report dated 2019-08-16 for Nuclear Densometer test results

Outside Bend per S.I. 2019-08-13:
Sta. 0+008 to Sta. 0+023
- install filter fabric 4m up bank
- armour with 0.3m minus rip rap 4m up bank

Stockpiling of Crush Material:
Sta. 0+000
- preparation for surfacing of road
- Per S.I. 2019-08-13, T.O. road min. 4.0m, road to be built up ~0.3m (top 0.15m to be crush), slopes to be 3:1

SITE INSTRUCTION ISSUED

N/A

SITE PHOTOS

Photo 1: Filter Fabric at Sta. 0+008-0+023 per S.I.

Photo 2: Rip Rap at Sta. 0+008-0+023 per S.I.

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Chris Wall	**Contractor**	Wacor Holdings Ltd.
Date	2019-08-20	**Weather**	Partial Cloud, 20.5˚C

WORK IN PROGRESS

Placement and Compaction of Crush Material: Sta. 0+000 to Sta. 0+190

LABOUR AND EQUIPMENT

Labour: 1 Superintendent, 2 Operators, 1 Trucker, 1 Traffic Control / First Aid

Equipment in Use: 2 Komatsu PC210 Excavators, 1 Hamm 3410 Smooth Drum Roller, 1 Dump Truck

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Water Level: No water noted in 'Overflow Channel'

Placement and Compaction of Crush Material:

Sta. 0+000 to Sta. 0+190:

- Surfacing of road with 19mm crush material
- Per S.I. 2019-08-13, T.O. road min. 4.0m, road to be built up ~0.3m (top 0.15m to be crush), slopes to be 3:1

SITE INSTRUCTION ISSUED

Walkthrough Prior to Final Inspection:

Sta. 0+000 to Sta. 0+614:

- Vegetation maintenance and clearing limits reviewed Sta. 0+000 to Sta. 0+614
  WORK REQUIRED: removal of wood/debris at ~Sta. 0+210, handcutting of vegetation at ~Sta. 0+370, hydroseeding of disturbed areas Sta. 0+000 to Sta. 0+614, removal of stump at Lot J
- Full rebuild section/ T.O. dike / armouring reviewed Sta. 0+000 to 0+190
  WORK REQUIRED: placement and compaction of road surfacing material to be completed
- Flood box structure reviewed Sta. 0+0+390
  WORK REQUIRED: removal of old flap gate from site

SITE PHOTOS

Photo 1: Sta. 0+008 (LHS) facing Up Chainage

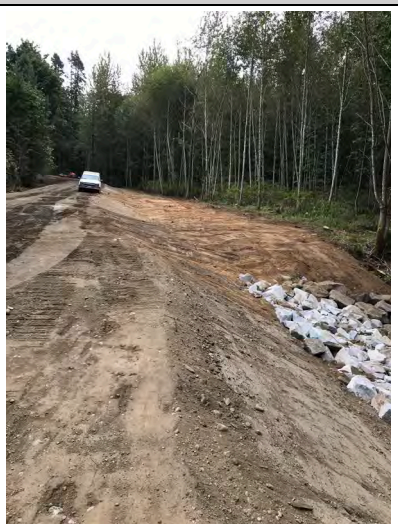


Photo 2: Sta. 0+008 (RHS) facing Up Chainage

Photo 3: Sta. 0+150 (LHS) facing Up Chainage

Photo 4: Sta. 0+150 (RHS) facing Up Chainage

Photo 5: Sta. 0+250 (LHS) facing Up Chainage

Photo 6: Sta. 0+250 (RHS) facing Up Chainage

Photo 7: Sta. 0+310 (LHS) facing Up Chainage

Photo 8: Sta. 0+310 (RHS) facing Up Chainage

Photo 9: Flood Box (Upstream)

Photo 10: Flood Box (Downstream)

Photo 11: Sta. 0+450 (RHS) facing Up Chainage

Photo 12: Sta. 0+570 (LHS) at Lot J

Prepared by:	Chris Wall
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Alex Bates	**Contractor**	Wacor Holdings Ltd.
Date	2019-09-19	**Weather**	Partial Cloud, 15˚C

WORK IN PROGRESS

N/A

LABOUR AND EQUIPMENT

N/A

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Alex Bates & Mark DeGagne of Mcelhanney, Shaun Koopman and Jesse Humphreys of the SRD as well as Lester Hill and Vic Sytnick of Wacor completed a final walkthrough to confirm all work was done as intended. A couple minor deficiencies were noted, once Wacor finishes the deficiencies McElhanney will notify the SRD.

SITE INSTRUCTION ISSUED

Final Inspection deficiencies noted:

- Erosion noted at ~Sta. 0+000, contractor to place Riprap to control any runoff water and stop further erosion
- Erosion noted at ~Sta. 0+200 on the Left side of the Glenmore entrance, contractor to place Riprap to control any runoff water and stop further erosion
- Flood box gate valve to be opened
- Removal of old flap gate from site

SITE PHOTOS

Photo 1: Sta. 0+000 (LHS) Erosion

Photo 2: Sta. 0+000 (LHS) Erosion

Photo 3: Sta. 0+200 (LHS) Erosion

Photo 4: Flood Box (Downstream)

Prepared by:	Alex Bates
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

QA INSPECTOR'S REPORT			
Project No.	2221-49230	**Project Name**	Glenmore Road Dike Upgrades
Inspector	Alex Bates	**Contractor**	Wacor Holdings Ltd.
Date	2019-11-5	**Weather**	Partial Cloud, 11˚C

WORK IN PROGRESS

N/A

LABOUR AND EQUIPMENT

N/A

OBSERVATIONS *(Items inspected, accidents, unsafe conditions, delays, standby, etc.)*

Alex Bates of Mcelhanney completed a walk through to confirm the deficiencies were all rectified. Riprap was placed at all places of erosion, Wacor placed riprap at a couple additional to control any runoff. The old flapgate was removed from site and the Gatevalve was opened.

SITE INSTRUCTION ISSUED

SITE PHOTOS

Photo 1: Sta. 0+200 (LHS) Riprap

Photo 2: Sta. 0+200 (LHS) Riprap

Photo 3: Sta. 0+000 (LHS) Riprap

Photo 4: Sta. 0+000 (LHS) Riprap

Prepared by:	Alex Bates
Signature:	

Note: A site inspection was performed on the above project and an examination of random samples of the work has been observed. The foregoing is an outline of the items observed and is not intended, nor are we responsible for, identifying defects and deficiencies in the work which are not reasonably apparent or visible at the time of inspection.

APPENDICES

☑ **Additional information is appended:**

Information	**Located:**
☑ Dike Maintenance Act.	Appendix E

This Act is current to October 30, 2019

See the Tables of Legislative Changes for this Act's legislative history, including any changes not in force.

DIKE MAINTENANCE ACT

[RSBC 1996] CHAPTER 95

Contents

Definitions

1 In this Act:

"dike" means 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;

"diking authority" means

(a) the commissioners of a district to which Part 2 of the *Drainage, Ditch and Dike Act* applies,

(b) a person owning or controlling a dike other than a private dike,

(b.1) if the final agreement of a treaty first nation so provides, the treaty first nation in relation to dikes on its treaty lands,

(c) a public authority designated by the minister as having any responsibility for maintenance of a dike other than a private dike, or

(d) a regional district, a municipality or an improvement district;

"improvement district" means an improvement district within the meaning of the *Local Government Act*;

"inspector" means the inspector of dikes referred to in section 2 and includes any acting, deputy or assistant inspectors of dikes;

"municipality" means a municipality as defined for the purposes of the *Community Charter*;

"order" includes any direction, decision or order of the inspector under this Act, including a decision to grant or refuse an approval under section 2 (4);

"private dike" means a dike built on private property that protects only that property.

Inspector of dikes

2 (1) The office of the inspector of dikes is continued under this section.

(2) The inspector may

(a) enter on any land and on a dike, with or without equipment, as necessary to carry out the purposes of this Act,

(b) require a diking authority or a person on whose land a dike, other than a private dike, is located to repair, replace, renew, alter, add to, improve or remove a dike, or a part of a dike, or anything used in connection with a dike,

(c) require a diking authority or a person on whose land a dike, other than a private dike, is located to construct or install a work or thing that in the opinion of the inspector is necessary to protect a dike or to increase its efficiency,

(d) authorize and empower any diking authority or person, on conditions the inspector may impose, to

(i) place, construct, renew, alter, repair, maintain, operate and use any buildings, structures, machinery, ways, rails, roads, pipes, poles, towers, cables, wires, conduits, conveyors or other works on, along, across, through, over or under any dike, other than a private dike, or any land on which a dike is located, other than a private dike, and

(ii) enter with or without equipment onto a dike, other than a private dike, or on land on which a dike is located, other than a private dike, for the purposes set out in subparagraph (i) or section 3,

(e) require a diking authority to provide routine or special reports on the construction or maintenance of dikes for which the diking authority is responsible,

(f) inspect or make an order for the inspection of any books or records in connection with the construction or maintenance of dikes in the possession or control of a diking authority,

(g) carry out or order an audit of a diking authority's program of construction and maintenance of dikes for which the diking authority is responsible, and

(h) subject to this Act and the regulations, do any other thing or require a diking authority to do any other thing relative to the construction and maintenance of dikes, including orders respecting flood hazard planning.

(3) The inspector and those employees considered necessary may be appointed under the *Public Service Act*.

(4) A person or a diking authority must not do any of the following unless it is done either with the prior written approval of the inspector or in accordance with the regulations made under section 8 (2):

(a) lower, or cause or allow to be lowered, the elevation of a dike or decrease, or cause or allow to be decreased, the width or cross section of a dike;

(b) install, or cause or allow to be installed, any culvert, pipe, flood box or any structure through a dike;

(c) construct, or cause or allow to be constructed, any works on or over a dike or dike right of way;

(d) alter, or cause or allow to be altered, the foreshore or stream channel adjacent to a dike;

(e) construct a new dike.

(5) In granting an approval under subsection (4), the inspector must consider the appropriateness of a standard established by regulation under section 8 (2) in relation to the dike that is the subject of the request, in light of

(a) the condition and location of the dike,

(b) the surrounding land and bodies of water and stream channels that are in close proximity to the dike, and

(c) the nature and condition of works related to the dike.

Orders made by inspector

2.1 (1) In this section, **"registered mail"** includes any method of mail delivery provided by Canada Post for which confirmation of delivery to a named person is available.

(2) An order made by the inspector must be

(a) in writing, signed by the inspector, and

(b) delivered or sent by registered mail to the last known address of the person or diking authority to whom it is directed.

(3) Anything sent by registered mail for the purposes of this Act is deemed to be received by the person to whom it is addressed on the 14th day after deposit

with Canada Post, unless the person received actual service before that day.

(4) The inspector may, at any time on notice to the person or diking authority to whom the order was directed, amend or revoke any order of the inspector.

Failure to carry out an order of the inspector

3 (1) If a person or diking authority fails to carry out an order of the inspector

(a) by the date specified in the order, or

(b) to the satisfaction of the inspector,

the inspector may take steps to fulfill the requirements of the order or authorize or employ another person to do so.

(2) If the inspector acts under subsection (1), any expense incurred by the inspector in fulfilling the requirements of the order or in authorizing or employing another person to do so, including any interest the inspector may have to pay, is a debt owing to the government by the person or diking authority to whom the order was directed.

(3) A debt owing under subsection (2) may be recovered in any court by the government from the person or diking authority to whom the order was directed.

(4) In an action referred to in subsection (3), the inspector's certificate as to the amount of the expense is evidence of the amount of the debt owing and of the necessity of doing the work authorized under this section.

Repealed

4 [Repealed 2003-72-3.]

Appeals

5 (1) Subject to subsection (1.1), an appeal lies to the minister from every order of the inspector.

(1.1) An appeal must not be taken

(a) from an order of the inspector requiring a person or a diking authority to comply with standards established by regulation under section 8 (2), unless the person or the diking authority to whom the order was directed is not responsible for the dike that is the subject of the order, or

(b) from a decision of the inspector refusing to grant an approval under section 2 (4).

(2) An appeal under this section must be taken within 15 days from the date on which the inspector makes the order appealed from.

(3) An appeal is taken within the meaning of this section when notice of intention to appeal has been delivered to the minister and a copy delivered to the inspector.

(4) The appellant must give such further notice of the appellant's intention to appeal as may be directed by the inspector.

(5) On an appeal under this section, the minister may confirm, quash, vary or add to the order appealed from and make any order as to costs that the minister considers just.

(6) The minister's decision under subsection (5) is final.

Offence

6 (1) A person or a diking authority commits an offence if that person or diking authority does any of the following:

(a) injures or interferes with a dike or its operation;

(b) hinders a diking authority, the inspector or a person acting on behalf of either of them from protecting property from flooding;

(c) contravenes section 2 (4) or an order of the inspector or the minister.

(2) A person or diking authority who commits an offence under this section is liable on conviction

(a) to a fine of not more than $200 000, and

(b) if the offence is a continuing one, to a fine of not more than $200 000 for each day the offence is continued

or to imprisonment not exceeding 12 months, or to both a fine and imprisonment.

(3) If a person or diking authority commits an offence under this Act, an employee, officer, director or agent of the person or diking authority who authorized, permitted or acquiesced in the offence commits the offence even though the person or diking authority is convicted.

(4) The time limit for laying an information respecting an offence under this Act is 2 years after the facts on which the information is based first comes to the knowledge of the inspector.

(5) A document purporting to have been issued by the inspector, certifying the day on which the inspector became aware of the facts on which an information is based, is admissible without proof of the signature or official character of the individual appearing to have signed the document and, in the absence of evidence to the contrary, is proof of the matter certified.

(6) A proceeding, conviction or penalty for an offence under this Act does not relieve a person or diking authority from any other liability.

Additional sentencing orders

6.1 (1) If a person or diking authority is convicted of an offence under this Act, in addition to any punishment imposed, the court may, having regard to the nature of the offence and the circumstances surrounding its commission, make

an order containing one or more of the following prohibitions, directions or requirements:

(a) prohibiting the person or diking authority from doing any act or engaging in any activity that may, in the opinion of the court, result in the continuation or repetition of the offence;

(b) directing the person or diking authority to take any action the court considers appropriate to remedy or avoid any harm that resulted or may result from the commission of the offence;

(c) directing the person or diking authority to pay the government an amount of money as compensation, in whole or in part, for the cost of any remedial or preventive action taken by or caused to be taken on behalf of the government as a result of the commission of the offence;

(d) directing the person or diking authority to perform community service;

(e) directing the person or diking authority to pay an amount of money the court considers appropriate to

(i) the trustee under Part 3 of the *Wildlife Act* for inclusion in the trust property, as that term is defined in section 118 of that Act, or

(ii) any other prescribed trust fund;

(f) directing the person or diking authority to post a bond or pay into court an amount of money the court considers appropriate for the purpose of ensuring compliance with any prohibition, direction or requirement under this section;

(g) directing the person or diking authority to submit to the minister, on application by the minister within 3 years of the date of the conviction, any information respecting the activities of the person or diking authority that the court considers appropriate in the circumstances;

(h) directing the person or diking authority to publish, in any manner the court considers appropriate, the facts relating to the commission of the offence;

(i) requiring the person or diking authority to comply with any other conditions that the court considers appropriate for securing the person's or diking authority's good conduct and for preventing the person or diking authority from repeating the offence or committing other offences under this Act.

(2) If a person or diking authority fails to comply with an order referred to in subsection (1) (h) directing the person or diking authority to publish the facts relating to the commission of an offence, the minister may publish those facts and recover the costs of publication from the person or diking authority.

(3) If

(a) an order under this section or section 6.2 directs a person or diking authority to pay an amount of money as compensation or for any other purpose, or

(b) the minister incurs publication costs under subsection (2) of this section,

the amount and any interest payable on that amount constitute a debt due to the government and may be recovered as such in any court of competent jurisdiction.

Variation of section 6.1 orders

6.2 (1) An application for variation of an order under section 6.1 may be made to the court that made the order by

(a) the Attorney General, or

(b) the person or diking authority against whom the order under section 6.1 was made.

(2) Before hearing an application under subsection (1), the court may order the applicant to give notice of the application in accordance with the directions of the court.

(3) On an application under subsection (1), if the court considers variation appropriate because of a change in the circumstances, the court may make an order doing one or more of the following:

(a) changing the original order or any conditions specified in it;

(b) relieving the person or diking authority referred to in subsection (1) (b) absolutely or partially from compliance with all or part of the original order;

(c) reducing the period for which the original order is to remain in effect;

(d) extending the period for which the original order is to remain in effect, subject to the limit that this extension must not be longer than one year.

(4) If an application under subsection (1) has been heard by a court, no other application may be made in respect of the order under section 6.1 except with leave of the court.

Repealed

7 [Repealed 2003-72-6.]

Power to make regulations

8 (1) The Lieutenant Governor in Council may make regulations referred to in section 41 of the *Interpretation Act*.

(2) Without limiting subsection (1), the Lieutenant Governor in Council may make regulations as follows:

(a) establishing standards of construction, operation and maintenance in respect to the matters described in section 2, including but not limited to adopting any standard devised by any other body;

(b) prescribing trust funds to which a payment under section 6.1 (1) (e) may be made, if those trust funds include as a purpose or objective

(i) the promotion of proper dike construction, maintenance or operation,

(ii) the protection or restoration of the environment from or as a result of flooding,

(iii) the protection of persons or property from flooding, or

(iv) a purpose similar to the trust purposes within the meaning of section 118 of the *Wildlife Act*.

(3) A regulation under subsection (2) (a) may make different provisions for

(a) different classes of dikes,

(b) different diking authorities, or

(c) different classes of persons or diking authorities.
