CITY OF PORT ALBERNI

PUBLIC WORKS FACILITY ASSESSMENT

4150 6th Avenue

Earthquake and Tsunami

Risk Mitigation

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Our Ref. #3721
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1.0 Introduction

1.1 Authorization

The City of Port Alberni has authorized McGill and Associates to undertake an assessment of the Public Works Facility (PWF) with regard to earthquake and tsunami risk and recommend mitigative measures for such risk that could prevent the City from maintaining and operating its essential infrastructure during an emergency situation. Alternatively, if the existing site is found to be at substantial risk to an earthquake or tsunami event, the Report will recommend the development of a new Public Works Facility in a different location.

The project proceeded in accordance with the McGill and Associates proposal dated September 7, 2018, City of Port Alberni, Public Works Facility, Earthquake and Tsunami Risk Mitigation.

1.2 Background

A tsunami in the Pacific Ocean resulted from an earthquake near Alaska in 1964. The tsunami inundated the low-lying coastal areas of the Alberni Inlet and the City of Port Alberni due to a 4-metre rise in the ocean level. The event caused considerable property damage, but no loss of life. From this first-hand experience, several initiatives and projects have been undertaken by the community to mitigate the risks from an earthquake or tsunami:

- The Cities of Alberni and Port Alberni amalgamated in 1967 and shortly thereafter constructed a dike system and instituted a floodplain bylaw to mitigate the effects of future tsunamis.
- A Tsunami Warning System was installed in 1989 and upgraded/expanded in 2012-2014. The audible emergency warning system comprises five loudspeakers strategically located in the vulnerable low-lying areas.
- Seismic upgrades were completed to the City Fire Station on 10th Ave in 2000.
- Several studies have been done by the City and other agencies on the impacts to the City from natural disasters. The studies are referenced in section 2.1 Literature Review.
- A new Regional Hospital (1990) and RCMP detachment (2005) have been built in recent years and met the current earthquake building design standards.
- An Emergency Operations Centre (EOC) has been set up in the Alberni-Clayoquot Regional District offices and is ready for activation at any time. A backup power generator has been installed at the site in 2018.
- An Emergency Operations Planning Committee has been formed from members of many organizations including the ACRD and City as well as other emergency responder agencies and meets regularly to discuss emergency planning issues.
- The Alberni Valley hosted a Provincial exercise in coastal emergency response in 2016. The scenario was a 9.0 Cascadia fault line earthquake followed by a 20 metre inundation tsunami in the Alberni Inlet. An official review of the exercise included a recommendation that the City evaluate the risk to the Public Works Facility from such an event.

Other events that have raised the community's awareness of earthquake/tsunamis to a high level include:

- Provincial Government seismic upgrades to schools and buildings
- News reports of devastating tsunamis; 2018 Indonesia, 2015/2016 Chile, 2011 Japan, 2004 Indian Ocean.

- Tsunami Warning Port Alberni, January 2018. This warning was triggered by a 7.9 magnitude earthquake off the coast of Kodiak, Alaska.

The Cascadia Subduction Zone (CSZ) is located off the west coast of Vancouver Island and stretches from the northern end of California to the northern end of Vancouver Island. Due to the composition of the fault, there is a significant risk of high-magnitude earthquakes from this fault, which in turn have the potential to generate a large tsunami.

The Public Works Facility at 4150 6th Ave. was built in 1966 and is located within the Tsunami Inundation Zone (TIZ). The 53 year old facility was constructed when seismic design requirements were not well developed. Building codes did not explicitly require buildings to have ductility built into them, limiting their ability to withstand a seismic event. There are a number of significant operational assets located at the Public Works Facility which will be vulnerable to earthquake and tsunami. They include heavy construction equipment, operations vehicles, parts and supply warehouses, utility and parks operations workshops, computerized system controls and operations communications centre, and emergency response equipment and supplies.

1.3 Scope of Work

In the evaluation of the risk to the Public Works Facility at its current location and identification of mitigation actions necessary, the Scope of Work is as follows:

Evaluation of Risk

- The project will begin with a thorough review of the risks associated with the anticipated 9.0-magnitude Cascadia Fault Line subduction earthquake and the ensuing tsunami with an expected inundation of 20-metres above tidewater (based on the Provincial Emergency Program and the international standard of 20m elevation). This evaluation will include a literature review of recent and reliable research on the Cascadia Subduction Zone, as well as an appraisal of the expected consequences from seismic and flood activity of this magnitude.
- The risk evaluation phase will further include an assessment of the expected sea level rise over the next 100 years and its impact and influence on the tsunami and flooding risks identified.

Detailed Assessment of City of Port Alberni Public Works Facility

This assessment will include a thorough description of the existing City of Port Alberni Public Works Facility, including its age, size, elevation, and constructed facilities, along with details related to on-site personnel and equipment, materials storage, and the intended use during emergency and non-emergency events.

Identification of Risk Mitigation Actions

- Based on the seismic risks and related tsunami and flood risks identified in the previous section, McGill will identify the measures necessary to mitigate these risks and maintain the City's Public Works Facility at its current location. This step will include a Class C cost estimate of the implementation of these risk mitigation actions.

Identification of Sites for Relocation

- McGill will identify necessary characteristics for alternative sites for the City's public works facility based on the risks identified previously. Requirements will also account for the physical and operational requirements of the facility. Based on these characteristics, viable alternate locations will be identified. A Class D cost estimate will be provided for the development of each of the sites identified.

Recommendations

- The technical evaluation will conclude with recommendations for mitigation strategies based on the risks identified above and the relative costs of the options available to the City.

The Scope of Work will also include meetings with the City's Planning and Engineering Department to gather, review, and discuss information that will be used for a strong presentation to government agencies for project grant funding of the City Public Works Facility earthquake and tsunami risk mitigation.

2.0 Evaluation of Risk

2.1 Literature Review

First, a review of the current City of Port Alberni bylaws will be noted:

City of Port Alberni Bylaw No. 4288 – August 1996 (see Appendix 1)

A bylaw to designate floodplains, set levels for construction and development on floodplains and to regulate land subject to flood hazards. This bylaw effectively prohibits building habitable space below an elevation of 3.65m G.S.C.

City of Port Alberni Official Community Plan (see Appendix 2)

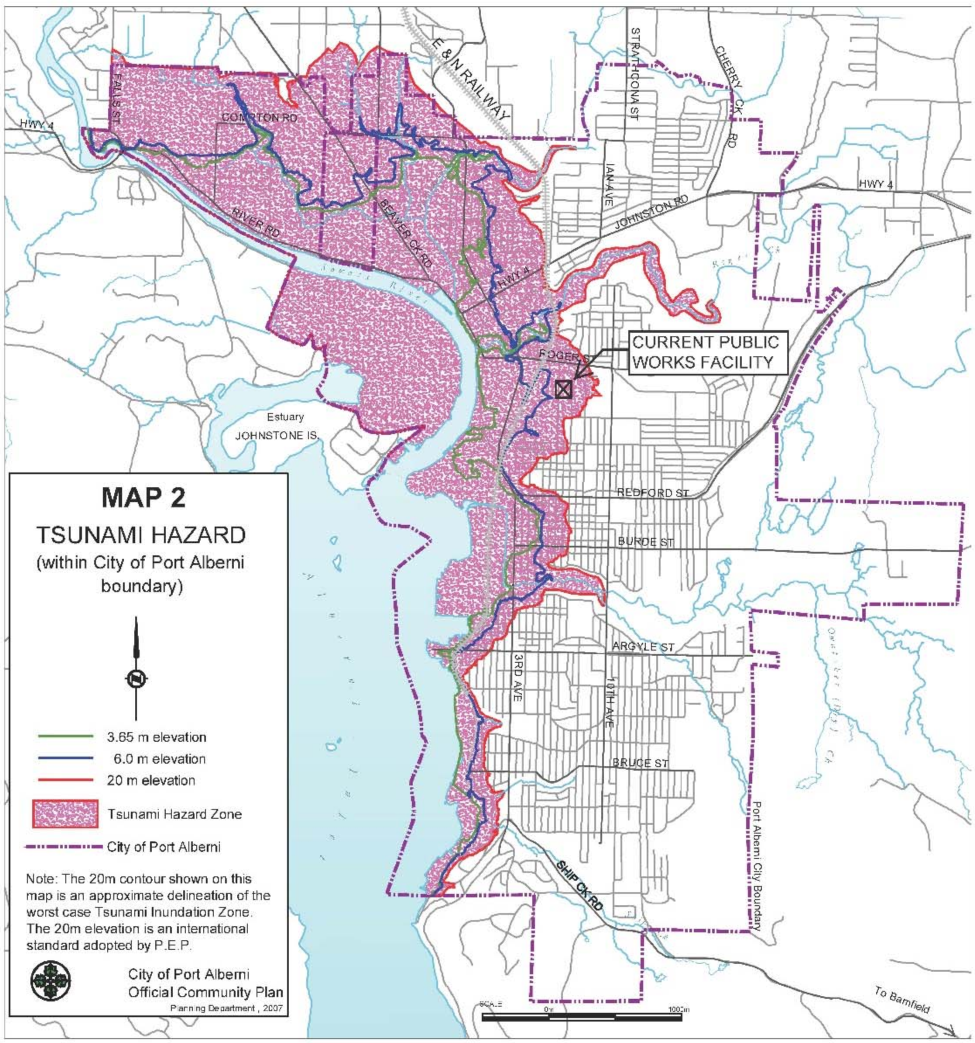
Section D, Plan Policies, 1.0 The Natural Environment, 1.4 Hazardous Areas, Council Policy - The City will maintain and update as necessary the Tsunami Floodplain Management Strategy which shall address such issues as:

- the emergency measures plan,
- a tsunami warning system,
- potential evacuation routes,
- flood control infrastructure,
- development and land use regulations for the 6m contour areas identified within the tsunami hazard area shown on Figure 1- Map 2 Tsunami Hazard (following page), and
- regulation of the storage and security of petroleum products, chemicals or hazardous goods in those areas identified within the tsunami hazard area.

Figure 1 – Map 2 Tsunami Hazard

City of Port Alberni | Official Community Plan

Map 2: Tsunami Inundation



The literature reviewed of recent and reliable research on the Cascadia Subduction Zone, regarding risks and the expected consequences from seismic and flood activity of this magnitude, is noted below and a summary of the articles are included in Appendix 3.:

1 Exercise Coastal Emergency Response – Alberni Clayoquot Regional District's Involvement in Exercise Coastal Response and a Five-Year Plan for the Emergency Program, February 2017.

2 Community clusters of tsunami vulnerability in the US Pacific Northwest – Nathan J. Wood, Jeanne Jones, Seth Spielman, and Mathew C. Schmidtlein. PNAS, April 28, 2015, volume 112, no. 17

3 California's Tsunami Risk, A Call for Action – California Tsunami Policy Working Group, 2014

4 The Earthquake Threat in Southwestern British Columbia: A Geologic Perspective – John J. Clague. Natural Hazards 26: 7-34 2002

5 A review of geological records of large tsunamis at Vancouver Island, British Columbia, and implications for hazard – John J. Clague, Peter T. Bobrowsky, Ian Hutchinson. Quaternary Science Reviews Vol 19, Issue 9, May 2000, 849-863

6 Tsunami Inundation Zone Study – UMA Engineering Ltd March 1992

7 Evaluation of Tsunami Levels Along the British Columbia Coast – Seaconsult Marine Research Ltd., Report March 1988

8 Port Alberni Tsunami Study Tsunami Analysis, Phase 1 – G.E. Simmons Assistant Deputy \Minister, Minister of Environment. Letter April, 1979

9 Tsunami Frequency at Tofino and Port Alberni. – Sydney O. Wigen, Institute of Ocean Sciences, March 1979

10 Climate Change, Change in Sea Level in B.C. (1910-2014) – Sea Level, Environmental Reporting B.C. http://www.env.gov.bc.ca/soe/indicators/climate-change/sea-level.html

11. Perspectives on Canada's West Coast Region; in Canada's Marine Coasts in a Changing Climate. Vadeboncoeur, N. University of British Columbia, p. 207-252 (2016)

12. Sea-Level Rise is Accelerating; The Real Question is How Fast?; Karin Bodtker, MRM, Coastal Ocean Research Institute, an Ocean Wise initiative, Ocean Watch B.C. Coast Edition p. 282-300.

2.2 Literature Evaluation Summary

Risk in this context is the likelihood of a place being harmed if exposed to a hazard of an earthquake and tsunami. Key findings of the literature reviewed on the Cascadia Subduction Zone earthquakes, about risks and the expected consequences from seismic and flood activity of this magnitude are noted below:

Hazards:

Tsunamis can originate hundreds or even thousands of kilometres away from coastal areas. The most serious tsunami would come from a mega thrust earthquake occurring in the Cascadia Subduction Zone, located off the West Coast of Vancouver Island. The entire West Coast of North America is recognized as a high risk area in the event of a mega thrust earthquake and the resulting tsunami.

Since the disastrous 2004 Indian Ocean tsunami, there have been a sequence of devastating tsunamis around the world and new research over the past decade has found that California's (Pacific Northwest) potential tsunami risk is far greater than previously thought, giving rise to a more urgent need to lessen the impact of these rare, but credible, threats.

The most vulnerable areas to future tsunamis of this type (large subduction earthquakes) are the outer coast and inlets of Vancouver Island, where damage to some coastal communities would be large.

Numerical modeling suggests that the waves from these tsunamis may reach up to 5m along the outer coast of Vancouver Island and up to 15m to 20m at the heads of some fjords.

One principal finding of a study is that the destructive tsunami of March 28, 1964 was not a unique event, but that it will probably be equalled or exceeded in a 100 year period. Tsunamis, therefore, need to be recognized as a significant factor in planning for land use in low lying areas, both at Port Alberni and other vulnerable portions of the British Columbia coast.

Recurrence:

The last great earthquake in the Cascadia subduction zone occurred in 1700. It is recorded by buried soil at more than 20 estuaries on the Pacific coast between central Vancouver Island and northern California (Atwater et al., 1995; Clague, 1997).

Geological studies have demonstrated that historically unprecedented, magnitude 8 to 9 earthquakes have struck the coastal Pacific Northwest on average once every 500 years over the last several thousand years; another earthquake of this size can be expected in the future.

Expected Sea Level Rise:

Key findings of the literature reviewed of the expected sea level rise on the West Coast of Vancouver suggest that sea level rise will not affect all areas of the British Columbia coast equally, largely due to differences in vertical land movement. Over a longer time period, changes in relative sea level across the West Coast region show significant variability. During the past 50 years, for example, sea level rose by 3.1 cm at Victoria and 2.0 cm at Vancouver but declined by 8.4 cm at Tofino (Bornhold and Thomson, 2013). Projected relative sea level rise for the year 2100 using the median value of the high emissions scenario (RCP8.5; after James et al., 2014-2015), for Ucluelet B.C. is 30 cm to 40 cm.

It should also be noted that new research by top climate scientists suggest that global sea level rise could accelerate much faster than previously predicted.

Summary:

Given the information provided by the literature review above, the risk of a CSZ earthquake and ensuing tsunami hazard, the level of risk assessed with the catastrophic consequences of death and financial loss and almost certain likelihood that an event will occur is high.

Geological evidence indicates that large tsunamis from the CSZ have an average recurrence of about 500 years and given that the last great earthquake at the Cascadia subduction zone occurred in 1700, we should not be surprised if a disaster of this nature occurs in the not so distant future.

An earthquake in the order of magnitude 8 or 9 would certainly cause the collapse of the Public Works Yard unreinforced masonry block buildings. Any loss of life would depend on the occupancy at the time of the event. The ensuing tsunami, where the numerical modeling suggests that the waves may reach up to 15m to 20m at the heads of some fjords, would inundate the site with water and debris.

With regard to sea level rise, the projected relative sea level rise for the year 2100 using the median value of the high emissions scenario (RCP8.5; after James et al., 2014-2015), for Ucluelet B.C. is 30 cm to 40 cm.

The Public Works Facility located in central Port Alberni, built at an elevation of 4.5 - 8.5m will be inoperable and unable to serve the City as an infrastructure operation centre or provide any Emergency Response or Recovery support in a natural disaster such as this until the operation was reconstructed.

3.0 Public Works Facility Assessment

3.1 Description

The main building of the Public Works Facility at 4150 6th Avenue was built in 1966 at an elevation of 8.5m. The operations yard elevation is between 4.5m and 8.5m. The facility was built 2 years after the tsunami struck in 1964 which inundated areas below 3.65m. The 53 year old Public Works building was constructed when seismic design requirements were not well developed and building codes did not explicitly require buildings to have ductility built into them. It was also constructed at a time when there weren't any engineering or planning studies that would indicate a tsunami hitting the west coast of Vancouver Island would affect any lands above 3.65m elevation. Subsequently, the B.C. Provincial Emergency Program (PEP). delineated the area below 20m as the Tsunami Inundation Zone, based on the international standard.

The City Public Works Facility is centrally located East / West between 6th Ave and the E&N Railroad tracks and North / South Wallace Street and Roger Street. Refer to Figure 5 - 6th Ave Public Works Facility orthophoto on the following page.

Land area is irregular shaped and is more or less 4.5 ha, Part of Lot 1, District Lot 1, Plan 5330 and is zoned M1 Light Industry uses.

Figure 5 – 6th Ave Public Works Facility Orthophoto

3.2 Facilities

There are two principal Public Works buildings and a number of equipment and material sheds. The main building is for Public Works operations (elev. 8.5 m) and is approximately 15,700 sq ft. and has eight main functions.

1. Administrative offices for Public Works Superintendents.
2. Warehouse for important weather susceptible parts and supplies.
3. Utility Shops for computer controls system, sewer, water, carpentry, and traffic operations.
4. Mechanical Shop for automotive and heavy duty equipment.
5. Lunch Room for approximately 40 staff.
6. Public Service Reception area.
7. Emergency Operations hub.
8. Communications central for computer controls system (SCADA), 2-way fleet radios, wireless digital connection to City Hall.

The secondary building is the Parks Operations office (elev. 4.5 m) and it is approximately 4,500 sq ft. and it has four main functions.

1. Administrative offices for Parks Superintendents.
2. Warehouse for important weather susceptible parts and supplies.
3. Utility Shops for irrigation, carpentry, automotive and equipment.
4. Lunch Room for approximately 10 staff.

There are also several out-buildings for equipment and supplies. There are four equipment sheds, and three parts and material supply sheds.

The largest area of the Public Works Facility is allocated for storage of operations (elev. 5.0 m) supplies such as:

- Fuel and gasoline storage and dispensing (8.0m elev.)
- Inventory of water and sewer pipe and fittings
- de-icing liquid storage tanks and equipment
- de-icing salt and sanders
- gravel, soil, and rock stockpiles
- inventory of street lights

The Public Works Facility is the main base of infrastructure operations for Public Works and Parks operations and is centrally located to service all areas of the City. These operations are critical to the health and safety of the residents. More specifically it is the provision of potable water, sanitary sewer, and traffic services each day that highlight the importance of the operation.

3.3 Staff

All of the Public Works services are provided by a skilled workforce of 46 staff in the following areas:

- Water and Wastewater Utility 11
- Street works and Solidwaste 18
- Mechanical Shop 5
- Parks Operations 6

- Administration 6
    - o Total 46

3.4 Vehicles and Equipment

The City's asset management inventory accounts for over 100 pieces of equipment at the Public Works Facility for a total value of $10,000,000. A listing of the various vehicles and pieces of equipment is included in Appendix 5. The inventory comprises of:

- 7 gravel trucks – single and tandem axle,
- 13 pcs heavy equipment – loaders, tractors, graders, garbage trucks, etc.
- 27 pcs light equipment – emergency generators, spreaders, mowers, compactors, forklifts, sweepers, etc.
- 32 staff vehicles – cars and pickup trucks for superintendents, chargehands, and trades
- 23 trailers – various small equipment, water tanks, generators, etc.
- 11 utility vehicles – purpose-specific utility trucks

All the equipment for the City's Engineering Department operations is serviced, managed and stored at the central Public Works Facility.

3.5 Emergency Response

The responsibility of the Engineering Department in an emergency is to respond, assess, and coordinate the disposition of departmental personnel, vehicles, and equipment to minimize hazards to life and property. The Public Works Facility is central to the municipality's emergency response and is also considered an intricate part of the regional Alberni Valley response to a large-scale incident, not only during the initial response efforts but during the recovery phase of the incident. The general responsibilities include:

1. Staffing of Public Works Emergency Operations Centre (EOC) and the City Hall EOC and have a representative at the Alberni Valley EOC.
2. Supply and equip the Public Works Emergency Operations Centre (EOC) with communications equipment.
3. Damage assessment and reporting.
4. Clear transportation corridors.
5. Traffic control and road closures to keep public out of hazard zones.
6. Restoration of damaged infrastructure eg. Water, sewer and road systems.
7. Coordinate through PEP EOC the support equipment for, and the individual emergency response plans of B.C. Hydro, Telus, and Fortis.
8. Supply vehicles and equipment where needed; both City and contracted.
9. Arrange for fuel supply and mechanical reports to vehicles, generators, and equipment.
10. Transportation of emergency personnel, materials and equipment.
11. Assist as requested in the location and rescue of trapped and injured people.
12. Other tasks assigned by the PEP Committee associated with an emergency or natural disaster.

Refer to Appendix 5 containing the following excerpts from the City of Port Alberni Engineering Department Emergency Response Plan, December 2003.

- Tsunami Roadblock Listing
- Waterworks Emergency Response Plan
- Wastewater Emergency Response Plan
- Bridges Emergency Response Plan

3.6 Past Public Works Facility Assessments

In 2001, a structural assessment on some vertical cracking was done by Herold Engineering Ltd. on some of the block pilasters on the south/west wall of the mechanical shop area. The architectural plans indicated a combination of 8-inch and 10-inch concrete block walls and did not indicate whether the walls were reinforced or grouted solid. It was suggested that the cracking in the pilasters is not due to any onerous loads on the pilaster and it appears the cracking would be like cracking in reinforced concrete elements exposed to the weather. (Ref. Letter June 4, 2001, Herold Engineering 01-182-003.)

In 1996, a hydrocarbon contamination site assessment was done by Seacor Environmental Inc. associated with the former underground fuel storage tanks located at the PWF. A site drilling program was undertaken to delineate the hydrocarbon impacted soils. The results of the hydrocarbon analyses indicated that the total extractable hydrocarbons exceeded the Commercial Land Use criterion in some areas. A Biocell Remediation Program was implemented, and the contaminated soils were remediated and Seacor Environmental recommended that the soils be disposed of for cover or fill material at the PWF. (Ref. Letters Oct 31, 1996, Nov 20,1996, April 1, 1997 Seacor Environmental).

In 1990, an appraisal of the industrial land and improvements on the PWF was done by J. Ruissen Appraisals Ltd. (Ref. Report July 10, 1990). The assessment did not specify the City's purpose of the appraisal at the time, but it may be associated with a proposal to locate a natural gas-powered generation station at the location of the PWF. A failed proposal for the sale of the land was prepared by Pacific Electric in 1992.

3.7 Current Public Works Facility Assessment

The PWF accommodates all the existing service functions it was designed to meet in 1966. The serious challenges to the facility in 2019 are issues associated with Functional and Locational Obsolescence.

3.7.1 Functional Obsolescence

Building Deficiencies

1. Earthquake Resiliency - The 53 years old Public Works Facility was constructed when seismic design requirements were not well developed, and the B.C. Building Code did not explicitly require buildings to have ductility built into them, thus limiting its ability to withstand a seismic event. A 1990 Seismic Survey of City-owned Buildings by Choukalos Woodburn Mackenzie Maranda Ltd. and highlights weaknesses in the ½ inch plywood roof and unreinforced masonry walls and makes some upgrade recommendations that will only partially meet the B.C. Building Code.
2. Heating Ventilating and Air Conditioning (HVAC) –The buildings are not equipped with air conditioning systems and it results in a very uncomfortable work environment for the inside workers during the summer months. As well, the natural gas hot water boiler heating system is at the end of its service life, along with the radiant floor heating lines in the concrete floor that frequently leak.
3. Tar and gravel membrane roof is 20 years old and is expected to be replaced in 10 years.

4. Asbestos and lead materials – It is typical of institutional buildings of this age to be built with materials contains asbestos and lead. Asbestos has been identified in the structure along with hazardous lead paint.
5. Masonry wall cracking – As noted in section 3.6 Past Assessments, a structural assessment on masonry wall cracking was done in 2001 that effectively acknowledged the cracking and did not identify any dangerous or onerous loads.
6. Emergency Operations functions – The Public Works Facility is identified as an Emergency Operations Centre in section 3.5 Emergency Response, and it will not be able to fulfill its public function in the event of a natural disaster as described.

Site Deficiencies

1. Covered equipment storage – The 3 existing equipment sheds are not large enough to properly protect the $10,000,000 of equipment that is stationed at the facility.
2. Site security – The perimeter fencing of the 4.5 ha site has been difficult to secure against the rise in vandalism and theft at the facility, even with security cameras.
3. Onsite management of street sweeping and catch basin debris – The existing waste management system for debris collected from the operation of the street sweeper and the vacuum truck is undersized and inadequate for current operations.
4. Wash rack – The existing truck washing and wastewater system is undersized and inadequate for current operations.

3.7.2 Locational Obsolescence

It was after the facility was built in 1966, that a series of studies and public awareness of the risk to tsunamis, led the municipality and the Provincial Emergency Program to designate the lands below 20m as a tsunami hazard zone.

In the current location (elevation 8.5m) the Public Works Facility cannot fulfill its function to the community in the event of a serious earthquake and or tsunami.

Currently, the facility is locationally obsolete.

3.7.3 Existing Structures Seismic Risk

The O&M Building and the Storage/Parks Building were built at the same time with similar designs. They are constructed primarily with partially reinforced masonry block walls and wood-framed roofing. The available architectural show that they were built circa 1966. The O&M building is approximately 15,700 ft^2 and consists of a single storey with two split levels to suit the grade of the site. The Parks building is a single storey 4,500 ft^2 building.

Roof Structure:

The flat roof structure of the O&M Building is made up of plywood sheathing on timber joists, supported on glue-laminated (glu-lam) beams or masonry block bearing walls. The roof line is constant, with the ceiling height varying from approximately 8’ in the offices, to 12’ in the shops and warehouse, to 16’ in the service bays. The roof over the service bays bears on 10” steel beams.

The Parks Building roof consists of plywood sheathing on truss-joist style trusses, supported on glu-lam beams on steel pipe columns.

Walls:

The exterior walls of the O&M Building are typically built with 8” concrete masonry unit blocks, with 10” concrete blocks used for the taller walls within the service bays. Bearing points supporting glu-lam beams are built as 16” pilasters reinforced and fully grouted. Interior walls consist of 8” concrete blocks. Typical walls are reinforced with a 16” deep horizontal bond beam at the top of the wall, to which the roof joists are anchored with ½” anchors at 48” o/c. Other than the horizontal bond beam and the vertical pilasters, the concrete block is unreinforced, and is very susceptible to cracking in seismic events.

The steel beams carrying the service bay roof are supported on steel 6” wide flange columns.

Main Floor and Foundation:

The typical floor for the O&M Building is a 5” thick concrete slab on grade, reinforced with #3 (3/8” diameter) rebar spaced at 15” o/c each way.

The foundation for the perimeter walls is a 16x16” grade beam footing, reinforced with 4-#5 (5/8”) bars. Pad footings are located beneath each pilaster and under each steel post in the service bays.

Horizontal Resisting Elements:

The O&M Building is located in the City of Port Alberni, which is one of Canada’s most severe seismic regions.

Horizontal forces result from wind and seismic events which act parallel to the surface of the earth. Wind blowing on the walls of the building can cause failure of both non-structural elements (parapet walls, etc.) and those parts of the buildings which are responsible for holding up the roof (ie: columns and the walls themselves). Walls must be designed to resist wind blowing directly on their face as well as to act as supports for perpendicular walls when the wind comes from the other direction. Earthquake loads result from sudden movements of the earth below the building itself, causing the building to shake as it tries to catch up to the ground's movement. The heavier and higher the building is, the greater the resulting seismic load is.

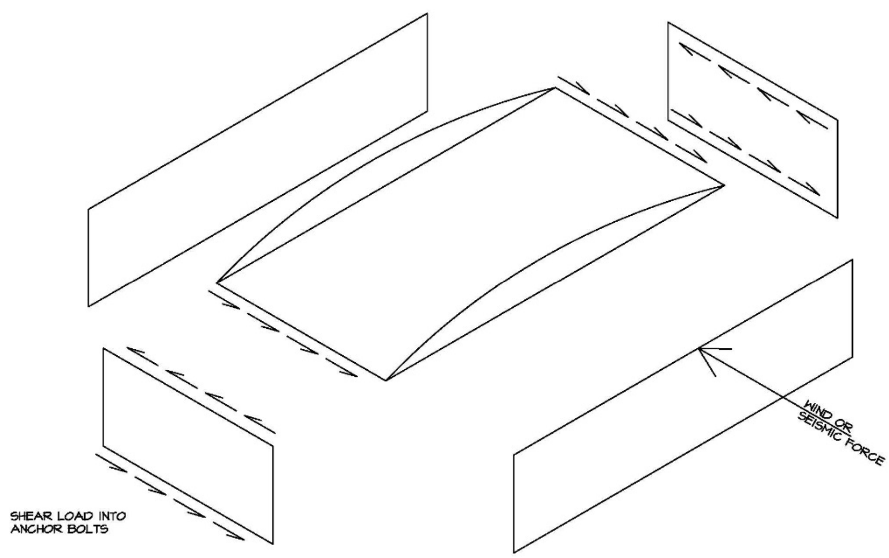


Figure 1: Diaphragm and Shearwall Load Path

Roof Diaphragm:

The roof diaphragm is acted upon when wind blows on the end walls or when seismic forces accelerate the roof mass itself. The diaphragm has to be strong enough to transmit these forces to the side walls. The O&M Building was built with plywood sheathing nailed to wood joists, as mentioned above. The diaphragm is unblocked and the nailing pattern of the sheathing is not noted. The roof joists are toenailed to a 2x6 plate anchored to the supporting concrete block walls.

Shear Walls:

Shear walls serve to transfer lateral loads from the roof level to the foundation. The concrete block walls, being largely unreinforced, are very brittle and lack the ductility needed to resist the cyclical nature of seismic forces. The lack of reinforcement means the walls will tend to crack, and once cracks have formed in the mortar joints, the concrete block units will tend to slip and move, resulting in the wall ceasing to act as a monolithic element. As well, the unreinforced concrete block walls are not anchored to the foundation.

With the facility at 53 years old, it has outlived its usefulness as a primary municipal services facility being both functionally and locationally obsolete.

The local government will not be able to meet public expectation to respond to their needs. The operational assets located at the facility, including heavy construction equipment, operation vehicles, parts and supplies warehouses, utility and parks operation workshops, communications centre, and emergency response equipment and supplies are at a high risk and severely increase the vulnerability of the community in the event of either an earthquake, tsunami or both.

4.0 Identification of Risk Mitigation Actions

Risk mitigation planning is the process of developing options and actions to enhance opportunities and reduce threats to project objectives. As the PWF is located within a region susceptible to extreme seismic events along with flooding due to tsunami inundation, measures necessary to mitigate these risks and maintain the City's Public Works Facility at its current location have been explored.

4.1 Mitigative Measures for Seismic Risk to Buildings

Both buildings were designed and constructed in the 1960's, and as a result, were not designed to withstand anticipated seismic loadings. It is understood that any significant seismic event will likely cause structural damage and, possibly, collapse of these buildings. This is exacerbated by the importance level assigned to a facility required to be a Post-Disaster Building, such as the Operations and Maintenance Facility.

Structural damage and/or collapse of the building would compromise the City's ability to respond after an earthquake, and as a result would lead to escalation of emergency situations such as failure of the water distribution or sewage collection systems, or of damage to the road network relied upon for emergency response.

The seismic deficiencies of the existing buildings are primarily related to the unreinforced concrete block walls and their lack of ductile resistance in the event of an earthquake. The concern is that the concrete block walls would essentially begin to crack and crumble, causing the roof to collapse on the building's occupants.

Following is a summary of the mitigative measures required for a seismic retrofit of the primary buildings on the PWF site.

Roof Diaphragm

- Install blocking between joist members under unsupported plywood panel edges.
- Expose the plywood diaphragm and nail the sheathing to the framing and blocking members.
- Install Blocking and framing anchors at perimeter of roof diaphragm to transfer shear forces to exterior walls.
- Block and restrain glulam beams at supports to prevent overturning during lateral movement.

Exterior Shear Walls

- Install reinforcement in existing concrete block walls, including horizontal bond beams at minimum 8' height (or remove portions of concrete block wall and replace with reinforced concrete walls).
- Dowel into foundation wall to anchor base of wall to foundation.

A seismic building retrofit would be a costly and challenging effort. The Class D cost estimate for construction is in the order of $800,000. This work would retrofit the PWF structures to a level that would allow the buildings to act as Post-Disaster facilities in the event of an earthquake. However, it will be much more challenging to overcome the issues related to tsunami inundation.

4.2 Mitigative Measures for Tsunami Risk to Buildings

Tsunami waves are typically the result of seismic events on the ocean floor or near coastal areas, when sudden movement of tectonic plates displaces the ocean water, propelling a fast moving wave outward from the epicentre. Tsunami waves can be amplified by entering a funneling channel such as the Alberni Inlet. As the tsunami approaches the shoreline and shallower waters, the wave slows down, but grows in both energy and height. Risks associated with tsunami events start with the impact of the enormous volume of water hitting coastal areas. Low lying structures can be extensively damaged by the force of the wave, causing total collapse and harm to the building's inhabitants.

Subsequent to the initial impact, flooding and water exposure would result, floating equipment and structures, saturating the buildings, spreading debris, causing electrical hazards and failure of water and sewer infrastructure.

Efforts to measure population vulnerability to tsunamis have primarily relied on indices that summarize population exposure, potential building damage, or institutional aspects of resilience. Vulnerability of specific sites to tsunami risk, however, can be assessed based on four primary factors:

- Elevation relative to the inundation zone.
- Aspect of the site slope relative to the anticipated wave direction of travel.
- Degree of average slope of the site
- Coastal proximity

Assessing the PWF for these parameters shows that the site is highly vulnerable to tsunami risk. That is, the elevation of the site is 4.5m to 8.5m and is well within the tsunami inundation zone of 20m. The facility's exposure faces toward the inlet and is relatively unprotected. The slope of the site itself is not steep enough to significantly dissipate the wave's energy, and the location is within one kilometre of the shoreline.

Options to mitigate tsunami risk reflect the fact that typical measures of eliminating the hazard or substituting it with a lesser risk are not possible. Tsunamis cannot realistically be stopped from happening, and it is not economically feasible to construct a barrier preventing the wave from inundating the land. Therefore, Tsunami Resilient Building Codes have been developed to encourage design and construction to allow for the risk-based assessment of anticipated tsunami forces and their impacts on proposed structures and project sites.

Utilizing the strategies described in these guidelines, mitigative measures to reduce tsunami impact include the following:

- Dry Flood-proofing the buildings by sealing them against water penetration and reinforcing them to resist lateral forces due to wave impact.
- Wet Flood-proofing to allow flow through of flood waters through the building, designing the site to be inundated.
- Raise the elevation of the PWF Site to the highest practical elevation relative to the existing building (approximately 8 metres elevation), by installing engineered fill and earth retaining structures.
- Relocating equipment and materials that are considered high priority for emergency response to the high ground closest to 6th Avenue, which would include building new equipment sheds.

- Relocate the communications systems, including two-way radio base station, SCADA, and main computer system, to a secure location outside of the inundation zone.
- Relocate the Public Works Facility. Construct to resist seismic forces and relocate to an area that is out of the tsunami inundation zone.

Unfortunately, no physical mitigative measure that can be taken at the present site will resist the full impact of the expected design event, which is anticipated to include flood levels in excess of 12 metres above the existing building elevation. For example, raising the overall site to match 6th Avenue, or wet flood-proofing the structures, would only be effective against smaller tsunami waves. Such retrofitting plans would not be sufficient to withstand total inundation in an extreme event.

Due to the high cost of retrofitting relatively old buildings to bring them up to Post Disaster levels of the current Building Code, and the inherent vulnerability of the existing low-lying site to tsunami risk, the best mitigation approach is to relocate the PWF site to a new location outside of the tsunami inundation zone.

5.0 Identification and Evaluation of a New Public Works Facility Site

Identification of sites for the development of a new Public Works Facility (PWF) takes into consideration the natural hazard risks identified and the physical and operational requirements of the facility. Nine criteria have been identified to help evaluate the most promising sites.

5.1 Public Works Facility Site Criteria

- Ground Elevation – The site must be greater than the 20m elevation Tsunami Inundation Zone that was an international standard adopted by the Provincial Emergency Program (PEP).
- Land Area – The present 6th Ave site is 4.5 ha. When the non-utilized areas are considered, a predominately level area of 3.0 to 3.5 ha would accommodate all foreseeable public works activities.
- Land Ownership – Suitable available sites in the City will be privately or publicly owned. Public lands may be held by the local, provincial, or federal government. The availability of the site will be determined through discussions with the land owner, which typically takes several months.
- Zoning / OCP – Land use planning is an important criterion. The zoning and Official Community Plan (OCP) would need to support a Light Industry type use. The public process of rezoning would be available to the City if a public works facility is not included in the proposed site’s current zoning.
- Municipal Services – The municipal services required will include: water, sewer, drainage, power, telecom (W,S,D,P,T). The availability and costs of providing them is an important criterion.
- Accessibility – Access to the arterial road network is essential for efficient operations and service supplier deliveries. Local roads are not designed or expected to be used for regular public works vehicle traffic.
- Area Fit – Area fit is a general planning term that assesses whether the site fits with existing uses, buildings, and geography, around it. The premise is that there is no perfect site and there are some sites better than others.
- Proximity – The proximity of the Public Works Facility to different areas in the City will affect the time and fuel used to service them. This applies to all emergency and non-emergency operations based out of the facility.

- Cost – The cost to develop a facility on each of the sites will vary mainly due to land, site preparation, and site servicing costs. The costs for the main building, vehicle and material bays, equipment sheds, engineering, and contingencies will be assumed to be the same for each of the sites.

5.2 Potential Public Works Facility Sites

The following nine locations have been identified as potential sites for the development of a new public works facility as shown on Figure 6 - Site Proximity Map, on the following page.

Northeast Area

1. Maebelle Road – Ministry of Transportation and Infrastructure, Central Vancouver Island Service Area Maintenance Contractor Operations. (approx. 3.2 ha). Outside City Limits ACRD zone P2 Parks and Public Use District.
2. Maebelle Road – School District 70 Operations. (approx. 2 ha). Outside City Limits ACRD zone P2 Parks and Public Use District. Note: local governance joint servicing agreements do exist in the South Island municipalities, however, Provincial Government and Municipal Government have conflicting authorities or mandates and agreements may be problematic.
3. Cherry Creek Road, North of Extra Foods. -City of Port Alberni. (approx. 5.0 ha). Zone A1, OCP Urban Agriculture ALR

Central North Area

4. Fall Fair Grounds, North end area, east of 10th Ave. – City of Port Alberni. (approx. 4.0 ha) Zone - P2 Institutional, OCP – Institutional
5. North Island College, East of NIC and north of Roger St. (approx. 4.0 ha). Zone - P2 Institutional, OCP – Parks and Open Space.

Central Area

6. Upper Burde Street – Privately owned. (approx. 3.5 ha) Zone – R1 Rural Residential, OCP – Future Residential
7. Burde Street Reservoir area - City of Port Alberni. (approx. 4.0 ha) Zone P2 Institutional, OCP – Future Residential

South Area

8. Anderson Avenue Public Works Storage, Anderson Ave and Ship Creek Road. - City of Port Alberni/Private. (approx. 1.8 ha) Zone FD Future Development, OCP Future Residential
9. Seizai Road – Privately owned. (approx. 2.5 ha) Zone ACRD zone P2.

Note: The large land requirement (3.0 – 3.5 ha) and specific building requirements made it impossible to identify any sites with buildings that could be renovated to suit.

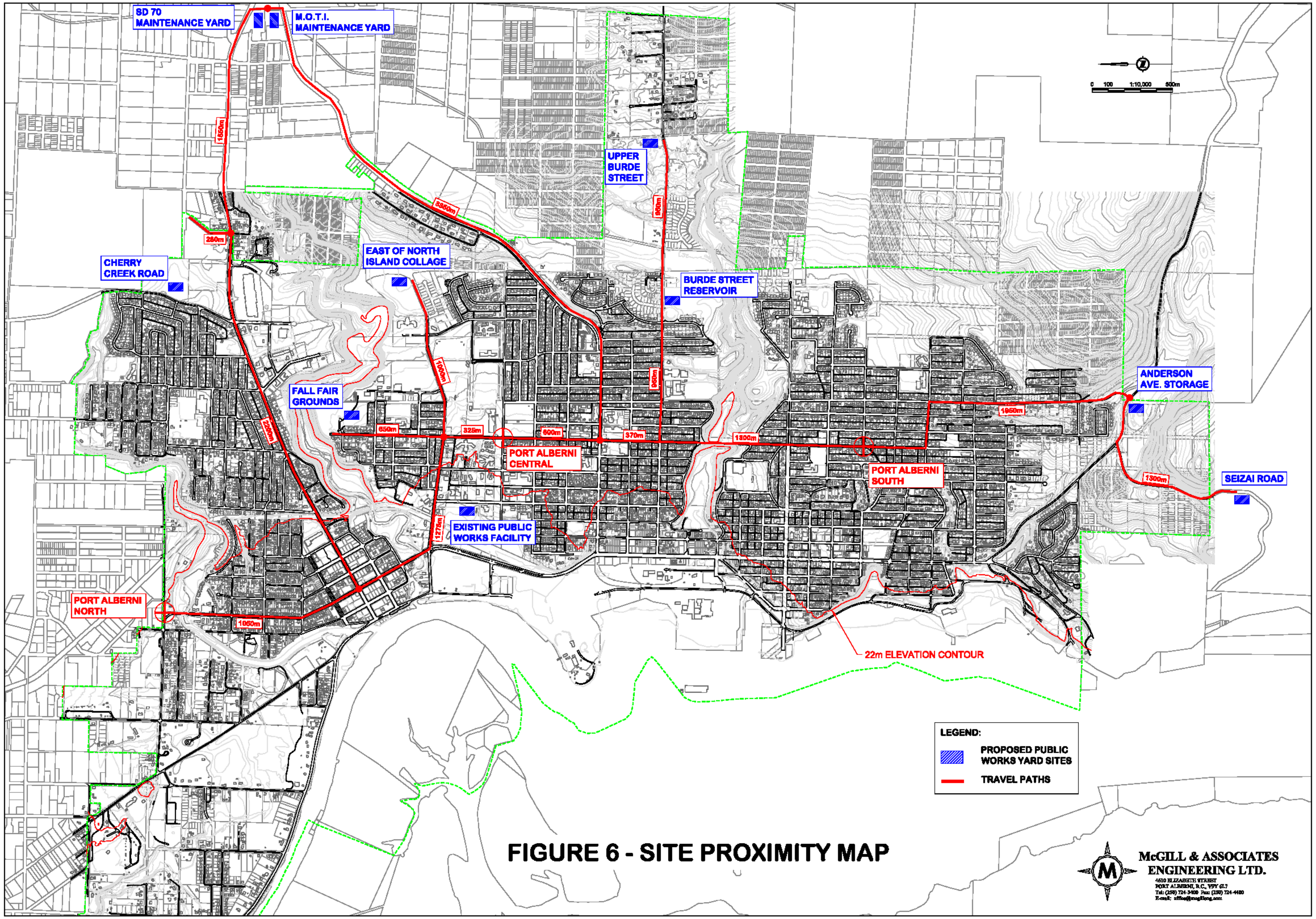


FIGURE 6 - SITE PROXIMITY MAP

5.3 Proximity Analysis

To model the proximity criterion, mentioned in section 5.1, a center point was selected for each of the **North** (Gertrude St @ Kitsuskus Creek), **Central** (10th Ave and Wallace St.) and **South** (10th Ave and Montrose St.) areas of the City. These points represent a location in the general areas where you can measure the distance (km) to each of the potential facility sites. The total distance (m) from the three points to each of the potential facilities will represent that site and be used to compare with the other sites. Refer to Figure 6 Site Proximity Map on the previous page.

This model broadly assumes that the public works facility provides its services equally across the City over time. This generally applies to services like garbage collection, water meter reading, snow removal, street sweeping, parks maintenance. Capital works such as underground utility replacements will be focused in the older parts of the City, but over time, the work will cover the entire City.

Table 5.3.1 Proximity Analysis, following, represents the simple model of the proximity criterion that differentiates each of the potential sites where assessments can be made between the sites.

1. The current 6th Ave site was modeled to be used as a reference point. It is well centered within the City when it was built in 1966, and this is shown with the lowest total distance score of 5570 m. It is closest to each of the three area points.

2. The last column in the table represents proximity relative to the current 6th Ave site.

3. Given that all evaluated sites are further away from the 3 main area center points in the City than the existing site, it is expected that the amount of time and fuel to service the City from any other site will increase.

4. Given that in 2017, 61,000 litres of gasoline and 163,000 litres of diesel fuel (total expense $282,000) was used at the current site, fuel costs can be expected to increase relative to the proximity of the proposed site.

5. Travel time for workers to job sites will also be expected to increase relative to the proximity of the proposed site.

6. The three sites with the lowest proximity total distance score are the Fall Fair Grounds, North Island College, and Burde Street Reservoir area. Relative to the current 6th Ave site, they are 29%, 48%, and 57% greater distance respectively.

Table 5.3.1

PROXIMITY ANALYSIS					
	Area Center Point (distance in metres)				
	North Point	**Central Point**	**South Point**	**Total Distance**	**Proximity Relative to Current 6th Ave Site**
POTENTIAL SITES					
Northeast					
1. Maebelle Road – MoT	4800	3950	5020	13770	147%
2. Maebelle Road – SD 70	4800	3950	5020	13770	147%
3. Cherry Cr Road	3530	4080	6350	13960	151%
Central North					
4. Fall Fair Grounds	2975	975	3245	7195	29%
5. North Island College	3325	1325	3595	8245	48%
Central					
6. Upper Burde Street	5520	2870	3200	11590	108%
7. Burde Street Reservoir area	4570	1920	2250	8740	57%
South					
8. Anderson Avenue Works	6870	4220	1950	13040	134%
9. Seizai Road	8170	5520	3250	16940	204%
CURRENT 6TH AVE SITE	**2000**	**650**	**2920**	**5570**	**0%**

See Appendix 6 for full size copy of this table.

Traffic Generation – The nature of the PWF operations and the number of employees (46) that work there result in a significant traffic volume. The traffic arises mostly from coming/leaving work, lunch and coffee breaks, material supplies, work reassignment, equipment breakdowns, and service suppliers. It is estimated that there are approximately 500 trips to and from the PWF each day.

5.4 Site Costs

The most current costing experience for public works facility has been mostly provided by Quesnel B.C. Quesnel (pop. 10,000) is in the final phase of design and tendering for a very similar facility in the spring of 2019. A quantity surveyor provided Quesnel with a 2020 Class B cost estimate and some of this information was used to prepare Class C cost estimates for this project.

Land costs – Land costs will depend on whether the site is privately or publicly owned. The proposed site is to be 3.0 to 3.5ha with an estimated land cost of $200,000/ha. The land costs will vary depending on the location, size, services and existing use. Public lands may be held by the local, provincial, or federal government. Long term leasing may also be an option.

Main Buildings costs - Given the current Public Works building has 15,700 ft^2 and Parks Operations building has 4,500 ft^2. The new facility is proposed to be 70% larger to accommodate meeting rooms and increased utility shop space, for a total of 34,000 ft^2. The most common construction method is concrete tilt-up walls, and is estimated to cost $225 / ft^2 for total estimated cost of $7.7 million.

(The main building includes administrative offices, a small warehouse, utility shops, mechanical shop, lunch room, reception area communications centre.)

Enclosed vehicle bays – Enclosed bays are heated and proposed for equipment that is most susceptible to adverse weather conditions. The proposed area is 8,000 ft^2 at $75.00 / ft^2 for a total estimated cost of $600,000.

Equipment and material bays – Coverall type buildings use a 25 year polymer skin and would be enclosing less weather susceptible equipment, wash bay and materials such as water pipe, fittings, wash rack, salt, and brine equipment. The proposed area is 15,000 ft^2 at $37.00 / ft^2 for a total estimated cost of $555,000.

Site development – The final site development work will include earthworks, grading, paving, drainage, security fencing, with a fuel island, and is estimated to cost $390,000.

Site servicing – The site services of water, sewer, power, telecom (W,S,D,P,T) will be estimated and provided by respective authorities. The values given below were estimated by McGill Engineering.

Engineering design – Professional design services that will include civil, structural, architectural, electrical and mechanical engineering are estimated to be 15 % of project costs.

Contingency – A contingency amount of 15% is budgeted for unforeseen design, costs, and construction items.

Table 5.4.1- Potential Site Costs summarizes the estimated cost for each items above for all of the potential PWF sites.

POTENTIAL SITE COSTS										
	COST ITEMS									
	Land	**Main Building**	**Enclosed Vehicle Bays**	**Equipment and Material**	**Site Developmen**	**Site Servicing**	**Sub Total**	**Engineering Design (15%)**	**Contingency (15%)**	**Total**
POTENTIAL SITES										
Northeast										
1. Maebelle Road – MoT	$640,000	$7,700,000	$600,000	$555,000	$390,000	$352,000	$10,237,000	$1,535,550	$1,535,550	$13,308,100
2. Maebelle Road – SD 70	$400,000	$7,700,000	$600,000	$555,000	$390,000	$352,000	$9,997,000	$1,499,550	$1,499,550	$12,996,100
3. Cherry Cr Road	$0	$7,700,000	$600,000	$555,000	$390,000	$630,000	$9,875,000	$1,481,250	$1,481,250	$12,837,500
Central North										
4. Fall Fair Grounds	$0	$7,700,000	$600,000	$555,000	$390,000	$150,000	$9,395,000	$1,409,250	$1,409,250	$12,213,500
5. North Island College	$800,000	$7,700,000	$600,000	$555,000	$390,000	$640,000	$10,685,000	$1,602,750	$1,602,750	$13,890,500
Central										
6. Upper Burde Street	$700,000	$7,700,000	$600,000	$555,000	$390,000	$920,000	$10,865,000	$1,629,750	$1,629,750	$14,124,500
7. Burde Street Reservoir	$0	$7,700,000	$600,000	$555,000	$390,000	$130,000	$9,375,000	$1,406,250	$1,406,250	$12,187,500
South										
8. Anderson Avenue	$360,000	$7,700,000	$600,000	$555,000	$390,000	$730,000	$10,335,000	$1,550,250	$1,550,250	$13,435,500
9. Seizai Road	$500,000	$7,700,000	$600,000	$555,000	$390,000	$710,000	$10,455,000	$1,568,250	$1,568,250	$13,591,500

See Appendix 6 for a full size copy of this table.

5.5 Site Information

Nine sites have been identified for the development of a new PWF and in the analysis, 9 important criteria have been identified above to help evaluate the most promising sites. Table 5.5.1 below summarizes the information for all the potential PWF sites.

POTENTIAL SITE INFORMATION

	CRITERIA								
	Ground Elevation	**Land Area**	**Land Ownership**	**Zoning / OCP**	**Site Services**	**Accessibility**	**Proximity Analysis**	**Area Fit**	**Cost**
POTENTIAL SITES	Greater than 20m	3.0 to 3.5 ha	Public / Private	M1 light industrial	Water, sewer, drainage, power, telecom (W,S,	Arteritial road network	Score	Do operations fit with existing uses and geography. (Hi, Med,	Land, buildings, services, and development costs
Northeast									
1. Maebelle Road – Ministry of Transportation and	94m	3.2 ha	Province	ACRD P2	W,P,T	Hwy 4 / Redford St.	13,770	Hi	$13,308,100
2. Maebelle Road – School District 70 Maintenance Yard	94m	2.0 ha	Province	ACRD P2	W,P,T	Hwy 4 / Redford St.	13,770	Hi	$12,996,100
3. Cherry Cr Road	63m	5.0 ha	City	A1 / Urban Argriculture ALR	W,P,T	Cherry Cr Rd. / Broughton Rd.	13,960	Hi	$12,837,500
Central North									
4. Fall Fair Grounds	45m	4.0 ha	City	P2 Institutional / Institutional	W,S,D,P,T	10th Avenue	7,195	Med	$12,213,500
5. North Island College	70m	4.0 ha	Province	P2 Institutional / Parks and Open Space	100m W,S,P,T	Roger St.	8,245	Med	$13,890,500
Central									
6. Upper Burde Street	106m	3.5 ha	Private	R1 Rural Residential / Future Residential	W,S,P,T	Burde St. (Collector)	11,590	Lo	$14,124,500
7. Burde Street Reservoir area	87m	4.0 ha	City	P2 Institutional / Future Residential	W,S,P,T	Burde St. (Collector)	8,740	Lo	$12,187,500
South									
8. Anderson Avenue Public Works Storage	118m	1.8 ha	City / Private	FD Future Development / Future	W,P,T	Anderson Ave. / Shipcreek Rd.	13,040	Hi	$13,435,500
9. Seizai Road	148m	2.5 ha	Private	ACRD P2	W,P,T	Seizai Rd. / Shipcreek Rd.	16,940	Hi	$13,591,500

5.6 Sites Evaluation

Given the information regarding each site shown above, a weighted evaluation matrix model was used to help evaluate the most promising potential sites. First, a subjective weighting factor was assigned to each criterion to define the relative level importance. In this case, McGill and Associates used their best judgement in assigning the factor of 8 to standard criteria and 15 to more important criteria, however, the City of Port Alberni is in the best position to determine the importance of each criterion with their understanding of the associated trade-offs and can request a re-evaluation. The weighting factors add up to 100.

Next in the evaluation, each criterion is scored on how well the specific location meets the criterion using satisfaction levels.

i. A score of 1.0 is given when the criterion is substantially satisfied.
ii. A score of 1.3 is given when the criterion is more fully satisfied.
iii. A score of 0.7 is given when the criterion is less fully satisfied.

Finally, weighted scores can be calculated for all the criteria for each potential location and added together for a total score and each of the locations can be ranked according to the model's scores and weighting factors. Table 5.6.1 below shows the potential site weighted evaluation matrix. The top four locations that have been identified for further considerations are:

1. Fall Fair Grounds site in the central area
2. Maebelle Road - Ministry of Transportation and Infrastructure in the north area
3. Maebelle Road – SD 70 Maintenance Department in the north area
4. Cherry Creek Road site in the north area

Table 5.6.1

POTENTIAL SITE WEIGHTED EVALUATION MATRIX										
	CRITERIA (Weighting Factor)									
	Ground Elevation	**Land Area**	**Land Ownership**	**Zoning / OCP**	**Site Services**	**Accessibility**	**Proximity Analysis**	**Area Fit**	**Cost**	**Total**
	8	**8**	**8**	**8**	**8**	**15**	**15**	**15**	**15**	**100**
POTENTIAL SITES										
Northeast										
1. Maebelle Road – MoT	1.0	1.0	1.0	1.0	1.0	1.3	0.7	1.3	1.0	**105**
2. Maebelle Road – SD 70	1.0	0.7	1.0	1.0	1.0	1.3	0.7	1.3	1.0	**102**
3. Cherry Cr Road	1.0	1.0	1.3	0.7	0.7	1.3	0.7	1.3	1.0	**102**
Central North										
4. Fall Fair Grounds	1.0	1.0	1.3	0.7	1.0	1.0	1.3	1.0	1.3	**109**
5. North Island College	1.0	1.0	1.0	0.7	0.7	0.7	1.3	1.0	0.7	91
Central										
6. Upper Burde Street	1.0	1.0	1.0	0.7	0.7	0.7	1.0	0.7	0.7	82
7. Burde Street Reservoir area	1.0	1.0	1.3	0.7	1.0	0.7	1.3	0.7	1.3	100
South										
8. Anderson Avenue PW	1.0	0.7	1.3	1.0	0.7	1.0	0.7	1.3	1.0	98
9. Seizai Road	1.0	0.7	1.0	1.0	0.7	1.0	0.7	1.3	0.7	91

See Appendix 6 for a full size copy of the table.

5.7 Preferred Sites Discussion

Nine sites were identified for the development of a new PWF. They were analysed against 9 important criteria and four sites have been identified as the most promising sites.

1. Fall Fair Grounds - Central Area: For this site, each of the evaluation criteria is either substantially or more fully satisfied except for the Zoning criteria.

The public process around relocating the PWF here would be formidable even if a rezoning of the land is not required. Depending on the configuration and access points a few residential homes will be impacted because they will be adjacent to the site or en-route to the site. Further analysis of the neighbourhood will be required to determine the extent of the impact and approaches to attenuate concerns. Sight and sound barriers and land acquisition could be used in the development process.

It has the most attractive rating from the proximity analysis 7195, which means it is relatively the closest site to all areas within the City. The site also has the least incremental distance to areas of the City relative to the existing 6th Ave site, at 29%. Operation and Maintenance cost increases for fuel and travel time associated with this site would be the least.

Having the site being owned by the City is a very attractive feature given that land acquisition processes can be challenging. The estimated cost for the development is lowest at $12.2 million but it is not significantly lower than other sites.

2. Maebelle Road, Ministry of Transportation and Infrastructure- North Area: For this site, located outside of the City limits, each of the evaluation criteria is either substantially or more fully satisfied except for the Proximity criteria.

It has a low rating from the proximity analysis 13,770, which means it is a relatively distant site to all areas within the City. The site also has a high incremental distance to areas of the City relative to the existing 6th Ave site, at 147%. Operation and Maintenance cost increases for fuel and travel time associated with this site would be significant.

The development of this area adjacent to the Redford Street Extension arterial road as a Ministry of Transportation public works facility provides good Area Fit and Accessibility ratings.

Although the site is owned by the Provincial Government for infrastructure purposes, it is anticipated that an agreement for purchase or a joint service agreement for the site will be protracted due to conflicting authorities or mandates.

3. Maebelle Road, SD 70 Maintenance Department – North Area: For this site, located outside of City limits, each of the evaluation criteria is either substantially or more fully satisfied except for the Proximity and Land Area criterion.

It has a low rating from the proximity analysis 13,770, which means it is a relatively distant site to all areas within the City. The site also has a high incremental distance to areas of the City relative to the existing 6th Ave site, at 147%. Operation and Maintenance cost increases for fuel and travel time associated with this site would be significant.

The land area of the site is small at approximately 2.0 ha and would require a significant re-evaluation of the area requirements or acquisition of part of the MOT site.

The development of this area adjacent to the Redford Street Extension arterial road as a School District maintenance facility provides good Area Fit and Accessibility ratings. Note, however, that the site is closer to residential housing than the MOT site

Although the site is owned by the Provincial Government for maintenance purposes, it is anticipated that an agreement for purchase or a joint service agreement for the site will be protracted due to conflicting authorities or mandates.

4. Cherry Cr Road – North Area: For this site, each of the evaluation criteria is either substantially or more fully satisfied except for the Proximity, site services, and zoning criterion.

It has a low rating from the proximity analysis 13,960, which means it is a relatively distant site to all areas within the City. The site also has a high incremental distance to areas of the City relative to the existing 6th Ave site, at 151%. Operation and Maintenance cost increases for fuel and travel time associated with this site would be significant.

Given that the site forested and is zoned A1 Urban Agriculture ALR, site servicing costs and rezoning will be issues to face.

The development of this area adjacent to Cherry Creek Road/Broughton Street and Johnston Road Shopping Mall, provides good Area Fit and Accessibility ratings.

Having the site being owned by the City is a very attractive feature given that land acquisition processes can be challenging.

6.0 Summary

6.1 Evaluation of Risk

- The risk of a CSZ earthquake and ensuing tsunami hazard, the level of risk assessed with the catastrophic consequences of death and financial loss is high during the lifespan of the PWF.
- Geological evidence indicates that large tsunamis from the CSZ have an average recurrence of about 500 years and given that the last great earthquake at the Cascadia subduction zone occurred in 1700, we should not be surprised if a disaster of this nature occurs in the not so distant future.
- An earthquake in the order of magnitude 8 or 9 would certainly cause the collapse of the existing PWF unreinforced masonry block buildings. Any loss of life would depend on the occupancy at the time of the event. The ensuing tsunami, where the numerical modeling suggests that the waves may reach up to 15m to 20m at the heads of some fjords, would inundate the site with water and debris.
- The Public Works Facility located in central Port Alberni, built at an elevation of 8.5m will be inoperable and unable to serve the City as an infrastructure operation centre or provide any Emergency Response or Recovery support in a natural disaster such as this until the operation was reconstructed.
- The Public Works Facility at 4150 6th Ave. was built in 1966 at an elevation of 4.5-8.5m. The facility was built 2 years after the tsunami struck in 1964 which inundated areas below 3.65m. The 52 years old Public Works building was constructed when seismic design requirements were not well developed and building codes did not explicitly require buildings to have ductility built into them. It was also constructed at a time when there weren't any engineering or planning studies that would indicate a tsunami hitting the west coast of Vancouver Island would affect any lands above 3.65m elevation.

6.2 Assessment of the Public Works Facility

- The Public Works Facility includes over 20,000 sq ft in the main buildings and 10 outer buildings for equipment and supplies on a 4.5 ha site. The PWF is the main base of infrastructure operations for Public Works and Parks operations and is centrally located to service all areas of the City. These operations are critical to the health and safety of the residents. More specifically it is the provision of potable water, sanitary sewer, and traffic services each day that highlight the importance of the operation.
- All the Public Works services are provided by a skilled workforce of 46 staff in various trades and positions.

- The City's asset management inventory accounts for over 100 pieces of equipment at the Public Works Facility for a total value of $10,000,000.
- The responsibility of the Engineering Department in an emergency is to respond, assess, and coordinate the disposition of departmental personnel, vehicles, and equipment to minimize hazards to life and property. The Public Works Facility is central to the municipality's emergency response and is also considered an intricate part of the regional Alberni Valley response to a large-scale incident, not only during the initial response efforts but during the recovery phase of the incident.
- With the facility at 53 years old, it has outlived its usefulness as a primary municipal services facility being both functionally and locationally obsolete.
- The local government will not be able to meet public expectation to respond to their needs. The operational assets located at the facility, including heavy construction equipment, operation vehicles, parts and supplies warehouses, utility and parks operation workshops, communications centre, and emergency response equipment and supplies are at a high risk and severely increase the vulnerability of the community in the event of the expected natural disaster.

6.3 Identification of Risk Mitigation Actions

- Seismic Risk Mitigation - The PWF buildings were not designed to withstand anticipated seismic loadings. The seismic deficiencies of the buildings are primarily related to the unreinforced concrete block walls and their lack of ductile resistance in the event of an earthquake.
- The mitigative measures required for a seismic retrofit of the primary buildings on the PWF site:
  - Install blocking between roof joist members under unsupported plywood panel edges.
  - Expose the plywood roof diaphragm and nail the sheathing to the framing and blocking members.
  - Install Blocking and framing anchors at perimeter of roof diaphragm to transfer shear forces to exterior walls.
  - Block and restrain glulam beams at supports to prevent overturning during lateral movement.
  - Install reinforcement in existing concrete block walls, including horizontal bond beams.
  - Dowel into foundation wall to anchor base of wall to the foundation.
- A seismic building retrofit would be a costly and challenging effort. The Class D cost estimate for the construction is in the order of $800,000. This work would retrofit the PWF structures to a level that would allow the buildings to act as Post-Disaster facilities in the event of an earthquake. However, it will be much more challenging to overcome the issues related to tsunami inundation.
- Tsunami Risk Mitigation - The PWF buildings are highly vulnerable to tsunami as they are well within the tsunami inundation zone of 20m,
- Options to mitigate tsunami risk reflect the fact that typical measures of eliminating the hazard or substituting it with a lesser risk are not possible.
- Due to the high cost of retrofitting relatively old buildings to bring them up to Post Disaster levels of the current Building Code, and the inherent vulnerability of the existing low-lying site to tsunami risk, the best mitigation approach is to relocate the PWF site to a new location outside of the tsunami inundation zone.

6.4 Identification and Evaluation of a New Public Works Facility Site

- Given the current Public Works building has 15,700 ft^2 and Parks Operations building has 4,500 ft^2. The new facility is proposed to be 70% larger to accommodate meeting rooms and increased utility shop space, for a total of 34,000 ft^2
- Nine sites have been identified for the development of a new PWF and in the analysis, 9 criteria have been identified above to help evaluate the most promising sites. Table 5.5.1 summarizes the information for all the potential PWF sites.
- Given that all new sites are further away from the 3 main area center points in the City than the existing site, it is expected that the amount of travel time and fuel to access job sites around the City will increase. The four preferred sites can expect up to 151 percent increase in time and fuel costs, with the preferred Fall Fair site having only a 29% increase due to proximity relative to the existing 6th Ave. site.
- A weighted evaluation matrix model was used to help evaluate the most promising potential sites. The top four locations that have been identified for further consideration are:
    1. Fall Fair Grounds – City of Port Alberni site in the central area
    2. Maebelle Road - Ministry of Transportation and Infrastructure in the north area
    3. Maebelle Road – SD 70 Maintenance Department in the north area
    4. Cherry Creek Road - City of Port Alberni site in the north area

- Refer to Section 5.7 Preferred Sites Discussion for details on each of the four sites.
- The **Fall Fair Grounds** site in the central area was the most preferred site. It either substantially satisfied or more fully satisfied all the evaluation criteria except for the Zoning criteria.
- The public process around relocating the PWF to the Fall Fair Grounds would be formidable, even if rezoning the land is not required. Depending on the configuration and access points a few residential homes will be impacted because they will be adjacent to the site or on route to the site. Further analysis of the neighbourhood will be required to determine the extent of the impact and approaches to attenuate the concerns. Sight and sound barriers and land acquisition could be used in the development process.
- The Fall Fair Grounds has the most attractive rating from the proximity analysis 7195, which means it is relatively the closest site to all areas within the City. The site also has the least incremental distance to areas of the City relative to the existing 6th Ave site, at 29%. Operation and Maintenance cost increases for fuel and travel time associated with this site would be the least of the sites considered.
- Having the site being owned by the City is a very attractive feature given that land acquisition processes can be challenging. The estimated cost for the development is lowest at $12.2 million but it is not significantly lower than other sites.

7.0 Recommendations

McGill and Associates's technical assessment of the City of Port Alberni's Public Works Facility recommends the following mitigative measures (strategies) for the essential services of the Public Works Facility to continue during the Response and Recovery phases of the City's Emergency Response:

- Review the new Public Works Facility proposal with City Council and include it with Council's Strategic Priorities.
- Obtain City Council approval to plan a public engagement process, to garner support for the broader concept of the need's analysis presented in this report. This process would start with a communications strategy.
- Develop a financing plan that reviews funding options such as borrowing, alternate approval, referendum, grants, and general revenue financing.
- Explore site availability with the prospective landowners early in the process.
- Undertake an internal building design consultation process with staff to optimize the function of a new facility with respect to services, equipment, and capacity. This would include a tour of other facilities around the Province.
- Pursue a land acquisition policy in advance of grant funding application, as it does not typically include land costs, and an application is stronger if the land component is secured.
- Include in the Official Community Plan update, a review of the City planning policies regarding tsunami inundation risk and consider natural hazard development permit areas.
- Update Engineering Department Emergency Response Plan and exercise tsunami hazard scenarios.
- Strengthen the relationship for natural hazard emergency response between the City of Port Alberni and the Alberni Clayoquot Regional District in order to present a comprehensive regional approach for favourable grant funding.
- Model any new sites identified in the public engagement process with the assessment and proximity models provided.

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Brad West, P. Eng.

APPENDIX 1

City of Port Alberni Bylaw No. 4288

CITY OF PORT ALBERNI

BYLAW NO. 4288

A BYLAW TO DESIGNATE FLOODPLAINS, SET LEVELS FOR CONSTRUCTION AND DEVELOPMENT ON FLOODPLAINS AND TO REGULATE LAND SUBJECT TO FLOOD HAZARDS.

WHEREAS:

A. The Council may pursuant to S. 969 of the Municipal Act, R.S.B.C. 1979, c. 290, designate floodplains within the City and set levels for development on such floodplains;

B. The Council may regulate the development of land situate in areas designated as floodplain;

C. Council considers it desirable to regulate development on a floodplain to reduce risk of injury to person and damage to property.

1. Title

This Bylaw may be cited as "Floodplain Bylaw".

2. Interpretation

In this Bylaw:

(A) "Building Inspector" means the Building Inspector for the City of Port Alberni".

(B) "Existing Building or Structure" means a building or structure existing as of the date of the adoption of this Bylaw;

(C) "Flood Construction Level" means the minimum elevation expressed in metres determined by reference to the G.S.C., below which no underside of any floor system, nor the top of any pad, supporting a Habitable Area shall be placed, constructed or located;

(D) "ft" means foot or feet;

(E) "G.S.C." means Geodetic Survey of Canada;

(F) "Habitable Area" means any room in a building or structure (including a manufactured building) designed, intended or used for dwelling, living, sleeping, eating or food preparation, or for the display or storage of goods and things susceptible to flood damage including display or storage as aforesaid for commercial, industrial or any other purposes;

(G) "m" means metre(s).

3. <u>Building Restrictions in the Floodplain Area</u>

3.1 This Bylaw shall apply to all lands bounded on the south by the Somass River, on the east by Kitsuksis Creek Floodway and Gertrude Street north thereof, on the north by Compton Road, Golden Street and Georgia Road and on the west by the City boundary.

3.2 a) No building other than a garage, carport or accessory building shall be erected, constructed or located at a flood construction level lower than elevation 3.65m (12.0 ft) G.S.C..

b) In addition to the foregoing:

(i) unless the building is situated on lands the natural elevation of which is 3.65m (12 ft) G.S.C. or greater, any basement, cellar or crawl space shall not exceed 1.2m (4 ft) in height to the underside of the floor joists;

(ii) such cellar, basement or crawl space shall not be used for the storage of goods or containment of a heating unit; and

(iii) on ground above elevation 2.75m (9.0 ft) G.S.C. any fill placed within the area covered by the building shall not extend more than 6.1m (20 ft) from the building periphery, nor so as to impair the drainage of any adjoining parcel or public allowance.

3.3 On any land described in this Bylaw no excavation for a basement, cellar or crawl space shall be permitted which provides for a finished floor level of the basement, cellar or crawl space below elevation 3.65m (12.0 ft) G.S.C..

3.4 If any existing building erected on the lands herein described which is now in contravention of Section 3.2 hereof is destroyed or damaged to the extent of 75% or more of its value above foundations as determined by the Building Inspector, it shall be lawful for the owner thereof to rebuild or replace the said building, provided that when constructed, the building shall conform to the provisions of Section 3.2.

READ A FIRST TIME THIS 27TH DAY OF MAY, 1996.

READ A SECOND TIME THIS 12TH DAY OF AUGUST 1996.

READ A THIRD TIME THIS 12TH DAY OF AUGUST 1996.

FINALLY ADOPTED THIS 26TH DAY OF AUGUST 1996.

MAYOR **CLERK**

tm\4288

APPENDIX 2

City of Port Alberni Official Community Plan

Section D 1.0 The Natural Environment

Section D: Plan Policies

1.0 The Natural Environment

1.1 Environmental Protection

The City of Port Alberni is set against a majestic mountain backdrop which is punctuated by Mount Arrowsmith to the east. Verdant forest surrounds the City and extends natural fingers along creek corridors to the waters of Alberni Inlet. On its western boundary, the City is contained by the waters of the Alberni Inlet, Somass Estuary, and Somass River, which is home to a productive aquatic and terrestrial ecosystem.

Recognizing the tremendous value of this asset, the City endeavours to balance economic growth and community development with the protection of its natural attributes. This is reflected within the community by residents who have indicated that the natural setting and features is one of Port Alberni's major strengths. As such, protection and acquisition of additional green space/ natural areas is a priority.

Council Policy

1. Ravines, watercourses and riparian areas will be preserved in their natural state, and wherever possible, will be linked to other park spaces or natural areas to create a comprehensive network of green space. Trail opportunities within these areas may also be considered when not detrimental to the environment.
2. Where possible, the City will consider conserving or protecting areas having significant wildlife values, and/ or significant wildlife corridors in an effort to maintain habitat and access.
3. The City supports efforts by community groups and public agencies to promote public awareness concerning conservation of water and energy.
4. The use of alternative forms of energy which reduce or eliminate environmental pollution and/ or improve conservation and efficiency of consumption is encouraged.
5. The City will promote an environmental ethic concerning the value of reducing, reusing and recycling resources, and will encourage lifestyles and development that contribute to the enhancement of environmental quality. As part of this the City will endeavour to facilitate development of a more comprehensive recycling program.
6. The City recognizes the value of habitat restoration in the overall health of local ecosystems and supports efforts to undertake restoration projects.
7. The City will work with government agencies, environmental groups, and citizen groups in an effort to reduce harmful emissions and improve air quality.

8. The City will encourage the use of innovative development standards particularly in regard to storm water management.

1.2 Watercourses

Council Policy

1. The City will attempt to protect Fisheries Sensitive Zones in conjunction with the Federal and Provincial agencies by protecting natural vegetation within riparian areas, requiring an appropriate development setback from the "top of bank".
2. The City may require development in or around watercourses (including watercourse crossings) to complete an environmental report as a part of any development approval process.
3. The City will work to manage the quality and quantity of stormwater runoff in order to help protect and/or enhance aquatic habitats.
4. Riparian setback areas will be preserved in a natural state except for public trails, benches, and interpretive signage where not detrimental to the habitat.
5. Redford Ponds and tributaries and similar environmentally sensitive areas comprise significant wildlife habitat and shall be subject to habitat protection policies as determined through detailed environmental analysis.

1.3 Marine Environment

Council Policy

1. Shoreline habitat and aquatic and terrestrial life is to be protected in the Somass Estuary by working toward to the guidelines contained in the Somass Estuary Plan.
2. Public access to the shoreline is to be provided wherever possible, and view corridors through to the Alberni Inlet are to be protected and preserved.

1.4 Hazardous Areas

Council Policy

1. The City will maintain and update as necessary the Tsunami Floodplain Management Strategy which shall address such issues as:
   - the Emergency Measures Plan;
   - a tsunami warning system;
   - potential evacuation routes;
   - flood control infrastructure;
   - development and land use regulations for the 6m contour areas identified within the tsunami hazard area on Map 2; and

- regulating the storage and security of petroleum products, chemicals or hazardous goods in those areas identified within the tsunami hazard area on Map 2.

2. To protect against the loss and to minimize property damage associated with flooding events the Council encourages agricultural, park and open space recreational uses of flood susceptible lands. Where floodable lands are required for development, the construction and siting of buildings and manufactured homes to be used for habitation, business or the storage of goods damageable by floodwaters shall be flood proofed to those standards specified by the City of Port Alberni Floodplain Bylaw.

APPENDIX 3

Hazard Literature Review Summary

APPENDIX 3

Literature Summary

The literature reviewed of recent and reliable research on the Cascadia Subduction Zone, and sea level rise, regarding risks and the expected consequences from seismic and flood activity of this magnitude, is noted below:

1 Exercise Coastal Emergency Response – Alberni Clayoquot Regional District's Involvement in Exercise Coastal Response and a Five-Year Plan for the Emergency Program, February 2017.

The Alberni Valley hosted Exercise Coastal Response in June 2016. Over the course of four days, 52 agencies and 600 individuals participated in the province's first full-scale earthquake and tsunami exercise. Though the exercise was initially designed to test the province's capacity to respond to a large disaster, it also allowed both the Alberni Clayoquot Regional District and the City of Port Alberni to build internal capacity to provide emergency response, specifically operations of an Emergency Operations Centre.

Between June 7th and 10th 2016, City and Regional District staff, alongside personnel from external agencies, ran an Emergency Operations Centre. The Emergency Operations Centre is activated during Level 2 and 3 emergency responses, and this exercise with an earthquake and tsunami merited a level 3 response.

Just as the exercise demonstrated the strengths of the local emergency program and participants, it also shone a light on opportunities for improvement in the Alberni Valley Emergency Program. Recommendation #6 in the exercise final report was, – "Conduct risk assessments of all key government infrastructure assets in the Alberni Valley starting with the City Works facility (6th Ave); develop mitigation plan if required".

2 Community clusters of tsunami vulnerability in the US Pacific Northwest – Nathan J. Wood, Jeanne Jones, Seth Spielman, and Mathew C. Schmidtlein. PNAS, April 28, 2015, volume 112, no. 17

Although tsunami scenarios are often regional, local vulnerability varies because of how communities choose to use tsunami-prone areas, the types of people in hazard zones, the local conditions that enable or hinder evacuations, and the ability and willingness to mitigate threats.

The sustainability and hazards literature includes multiple efforts to conceptualize vulnerability, yet they share a common perspective that is influenced by the exposure, sensitivity, and resilience of the system to a threat. Efforts to measure population vulnerability to tsunamis have primarily relied on indices that summarize population exposure, potential building damage, or institutional aspects of resilience.

Of all tsunami-prone areas in the United States, Cascadia Subduction Zone related tsunamis represent one of the greatest threats to human safety based on regional extent of the source, the limited amount of time available for evacuations (15-30 minutes for many communities), and the thousands of people that need to self-evacuate.

3 California's Tsunami Risk, A Call for Action – California Tsunami Policy Working Group, 2014

Since the disastrous 2004 Indian Ocean tsunami, there have been a sequence of devastating tsunamis around the world and new research over the past decade has found that California's potential tsunami risk is far greater than previously thought and giving rise to a more urgent need to lessen the impact of these rare, but credible, threats.

The frequency of damaging tsunami waves striking the California coast from major earthquakes from around the Pacific Rim is on the order of a hundred to a few hundred years.

Implement Tsunami Resilient Building Codes – Amend existing design and construction codes to include the risk-based assessment of anticipated tsunami forces and their impacts on proposed structures and project sites. Support continuation of the California Geological Survey's work with the ASCE Subcommittee on Tsunami Loads and Effects to develop prototype probabilistic inundation maps from local and distant tsunami sources to assist in the development of tsunami building code provisions.

4 The Earthquake Threat in Southwestern British Columbia: A Geologic Perspective – John J. Clague. Natural Hazards 26: 7-34 2002

Geological studies have demonstrated that historically unprecedented, magnitude 8 to 9 earthquakes have struck the coastal Pacific Northwest on average once every 500 years over the last several thousand years; another earthquake of this size can be expected in the future.

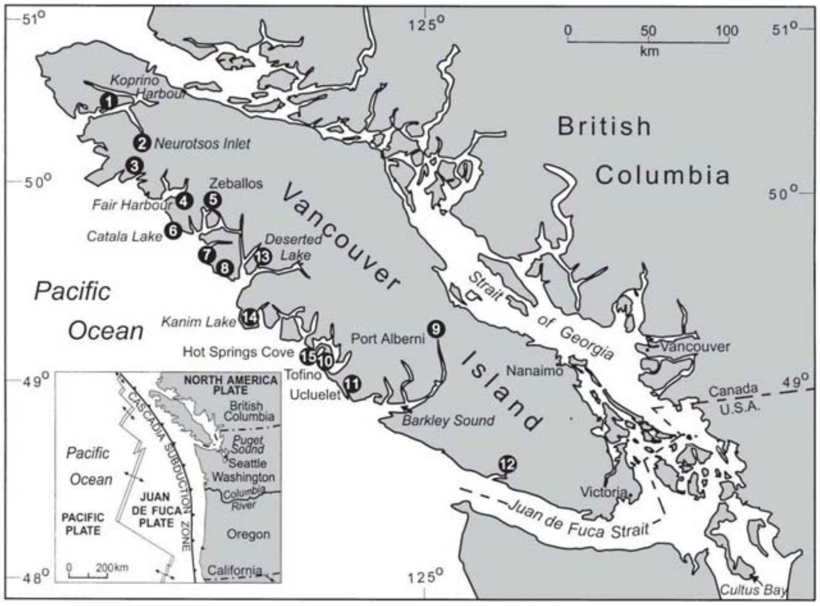
Ten moderate to large (moment magnitude, M, 6-7) earthquakes have occurred within 250 km of Vancouver and Victoria during the last 130 years (Rogers, 1998). This statistic alone indicates that the earthquake risk in the region is relatively high. The historic record, however, is short and may misrepresent the actual hazard: an earthquake larger than any in the last 130 years could strike the south coast, seriously damaging one or more cities in the region.

This record indicates that a magnitude 7 earthquake can be expected somewhere in southwestern British Columbia or northern Washington approximately once every 30-40 years, a magnitude 6 earthquake once about every 20 years, and a magnitude 5 earthquake once every 5 years. Earthquakes smaller than magnitude 5 are common, but most cause little or no damage.

Collectively, the data suggest that a great plate-boundary earthquake or a large, crustal or interpolate earthquake centered near any of the large cities in the Pacific Northwest will cause tens of billions of dollars damage (Munich Reinsurance Company, 1992). Considerable damage will also result from secondary phenomena, include liquefaction, landslides and tsunamis.

Intervals between successive great Cascadia earthquakes have ranged from perhaps as little as 100 years to more than 1000 years, making it difficult to estimate the time of the next event. Refer to Figure 2 Vancouver Island and its Tectonic Setting.

Figure 2 - Vancouver Island and it's Tectonic Setting



5 A review of geological records of large tsunamis at Vancouver Island, British Columbia, and implications for hazard – John J. Clague, Peter T. Bobrowsky, Ian Hutchinson. Quaternary Science Reviews Vol 19, Issue 9, May 2000, 849-863

Tsunamis are ocean waves generated by underwater disturbances of the seafloor or by surface impacts. They are triggered by earthquakes and, less commonly, by landslides, volcanic eruptions, and meteorite impacts. Earthquake triggered tsunamis are also called seismic sea waves and, erroneously, tidal waves.

British Columbia is also affected by tsunamis of more distant Pacific earthquakes. The largest tsunami to strike British Columbia this century was generated by the great (M 9.2) Alaska earthquake of March 27, 1964 (Wigen and White, 1964; Murty and Boilard, 1970). A series of waves radiated outward from the earthquake rupture area off south-central Alaska and, within a few hours, reached the outer coast of British Columbia, causing about $40 million damage mainly to the Vancouver Island communities of Port Alberni, Hot Springs Cove, and Zeballos.

The west coast of Vancouver Island is located at the north end of the Cascadia subduction zone, close to the source of great tsunami – producing earthquakes.

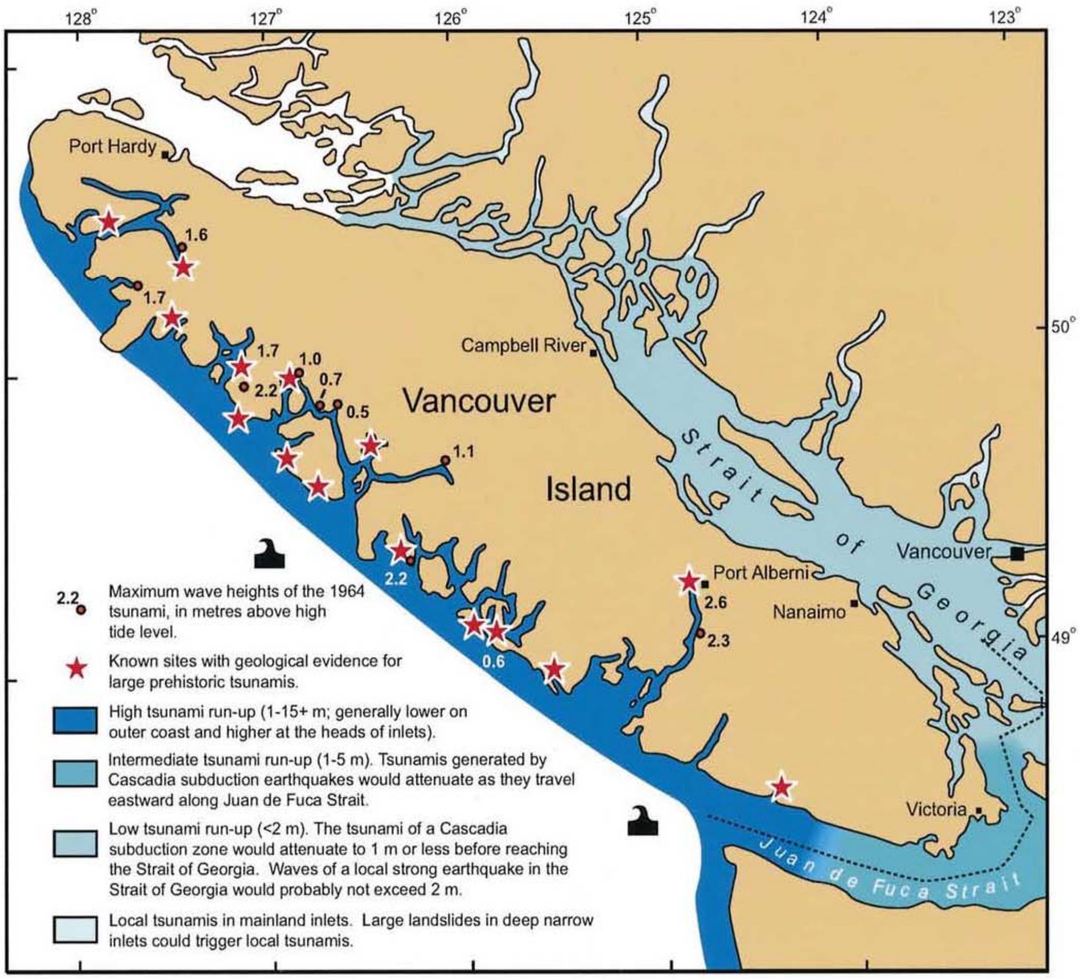
Western Vancouver Island has risen relative to the sea at a net rate of about 1m ka (exp -1) over the last several thousand years (Clague et al., 1982; Freile and Hutchinson, 1993).

The last great earthquake at the Cascadia subduction zone occurred in 1700. It is recorded by buried soil at more than 20 estuaries on the Pacific coast between central Vancouver Island and northern California (Atwater et al., 1995; Clague, 1997).

Recurrence - Previous estimates of average recurrence intervals for tsunami-generating earthquakes at the Cascadia subduction zone range from 200 to 600 yr, but these estimates have uncertainties that may total many hundreds of years (Atwater et al., 1995). The most recent and best estimate of average recurrence, about 500 yr, comes from a detailed study of buried soils at estuaries in southwestern Washington (Atwater and Hemphill-Haley, 1997).

Hazard - The most vulnerable areas to future tsunamis of this type (large subduction earthquakes) are the outer coast and inlets of Vancouver Island, where damage to some coastal communities would be large. Refer to Figure 3 – Large Recent Tsunamis, on following page and Figure 4 – Tectonic setting of Southwestern British Columbia, following.

Figure 3 – Large Recent Tsunamis



Large recent tsunamis

1700 A great earthquake on the Cascadia subduction zone triggered a tsunami that deposited coarse sediment in tidal marshes and low-lying lakes on western Vancouver Island. The distribution of the deposits indicates that the tsunami was much larger than the 1964 tsunami.

1960 A magnitude - 9.5 earthquake in Chile produced a tsunami that travelled the length of the Pacific Ocean. A 1.2 m wave was recorded at the Tofino tide gauge, and run-up was higher in many other areas. Log booms along the west coast of Vancouver Island and on the Queen Charlotte Islands were damaged.

1964 A magnitude - 9.2 earthquake in Alaska produced a tsunami that caused about $10 million damage on Vancouver Island. The amplitude of the highest wave at Port Alberni was over 6 m, damaging 260 buildings in the community. The maximum wave height at the Tofino gauge was 2.4 m.

Fig. 13. Generalized tsunami hazard map for south-coastal British Columbia based on the distribution of tsunami deposits and numerical modelling of wave heights. The map shows four generalized hazard zones, as well as sites with evidence for large prehistoric tsunamis and maximum wave heights of the 1964 Alaska tsunami. Details on three important recent tsunamis are given at the bottom.

Figure 4 - Tectonic Setting of Southwestern British Columbia

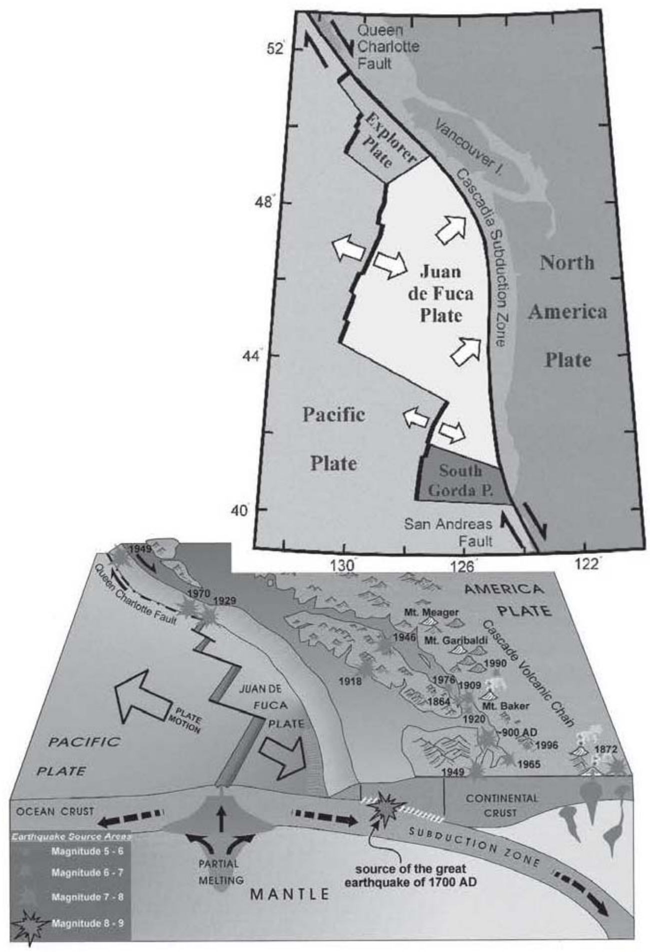


Figure 1. Tectonic setting of southwestern British Columbia and northwestern Washington. The oceanic Juan de Fuca plate is subducting beneath the continental crust of North America along the Cascadia subduction zone. Subduction and displacement of blocks of the North America plate on crustal faults are responsible for the large earthquakes that occur in the region.

Geological evidence indicates that large tsunamis from this source (Cascadia subduction zone) have an average recurrence of about 500 yr. Numerical modeling suggests that the waves from these tsunamis may reach up to 5m along the outer coast of Vancouver Island and up to 15m to 20m at the heads of some fjords. When such a tsunami next occurs, the first waves will strike less than 30 min after the earthquake, thus there will be little time to evacuate low lying areas.

6 Tsunami Inundation Zone Study – UMA Engineering Ltd March 1992

UMA Engineering Ltd. has been contracted to complete a Tsunami Inundation Zone Study for the City of Port Alberni. The purpose of the study is to develop land use polices and provisions concerning development of the lands within the established Tsunami Inundation Zone. The intent is to provide a rationale which enables policies to be developed which assist in reducing post-inundation recovery time in the affected area.

The total depth of inundation from a tsunami and the speed with which it occurs are greater than for a river flood. The 10.3 metre depth of inundation at Port Alberni would occur over a period of 25 minutes; or at a rate of rise in water level of over 1 metre in three minutes.

The shape of Alberni Inlet causes magnification of the wave height by a factor of about three between Barkley Sound and the head of the Inlet at Port Alberni. Movement of the tsunami up Alberni Inlet is also quite rapid.

The multiple wave aspect of the tsunami accentuates the inundation damage. The same is true of water borne objects from the lower part of the Zone (logs, boats, cars, etc.) which act as projectiles that impinge on structures.

Based on an earthquake similar to the March 27, 1964 earthquake in Alaska, it has been determined that a tsunami reaching Port Alberni could affect lands up to an elevation of 8.3 metres. The Zone in Port Alberni has been determined by combining high tide levels with a storm surge and this tsunami amplitude. The upper limit of the Zone is established at an elevation of 10.3 metres.

7 Evaluation of Tsunami Levels Along the British Columbia Coast – Seaconsult Marine Research Ltd., Report March 1988

Maximum tsunami water levels and currents along the British Columbia outer coast have been computed for waves originating from Alaska, Chile, the Aleutian Islands (Shumagin Gap) and Kamchatka. Three computer models have been developed to generate and propagate a tsunami from each of these source regions in the Pacific Ocean to the continental shelf off Canada's west coast, and into twenty separate inlet systems. The model predictions have been verified against water level measurements made at tide gauges after the March 28, 1964 Alaska earthquake.

The largest amplitudes can be seen to occur for the Shumagin Gap simulation, although several exceptions to this occur. Heights increase toward the head of Alberni Inlet as expected, reaching up to 8.3m.

8 Port Alberni Tsunami Study Tsunami Analysis, Phase 1 – G.E. Simmons Assistant Deputy \Minister, Minister of Environment. Letter April, 1979

There is no doubt that the 1964 tsunami did occur and there is a high probability that it will be equalled or exceeded in the future. Assuming the recurrence of the 1964 tsunami at H.H.W. Mean Tide, inundation would reach 6.0 metres G.S.C.

9 Tsunami Frequency at Tofino and Port Alberni. – Sydney O. Wigen, Institute of Ocean Sciences, March 1979

Principal finding of the study is that the destructive tsunami of March 28, 1964 was not a unique event, but that it will probably be equalled or exceeded in a 100 year period. Tsunamis therefore need to be recognized as a significant factor in planning for land use in low lying areas, both at Port Alberni and other vulnerable portions of the British Columbia coast. There is a need also to plan for educational programs and emergency preparedness measures in order that losses when a tsunami occurs will be minimal.

The literature reviewed of recent and reliable research on sea level rise in B.C.:

10 Climate Change, Change in Sea Level in B.C. (1910-2014) – Sea Level, Environmental Reporting B.C. *http://www.env.gov.bc.ca/soe/indicators/climate-change/sea-level.html*

Sea level changes when the overall volume of water in the ocean increases or decreases and when land moves vertically from geological processes (post glacial rebound). Thermal expansion - when the atmosphere warms, sea water warms and expands in volume – is a major influence on past changes in sea level and is expected to make the greatest contribution to a rising sea level over the next century. Sea level also changes when the overall volume of water in the ocean increases or decreases. As glaciers, ice caps and ice sheets lose mass from melting, water previously stored on land as ice and snow is added to the ocean.

Average sea level has risen along most of the B.C. coast over the past century. Average sea level rose at a rate of 13.3 cm per century at Prince Rupert, 6.6 cm per century at Victoria and 3.7 cm per century at Vancouver. In contrast, average sea level fell at Tofino at the rate of 12.4 cm per century.

11. Perspectives on Canada's West Coast Region; in Canada's Marine Coasts in a Changing Climate. Vadeboncoeur, N. University of British Columbia, p. 207-252 (2016)

Sea -level rise will not affect all areas of the British Columbia coast equally, largely due to differences in vertical land movement. Over a longer time period, changes in relative sea level across the West Coast region show significant variability. During the past 50 years, for example, sea level rose by 3.1 cm at Victoria and 2.0 cm at Vancouver but declined by 8.4 cm at Tofino (Bornhold and Thomson, 2013). Projected relative sea-level rise for the year 2100 using the median value of the high emissions scenario (RCP8.5; after James et al., 2014-2015), for Ucluelet B.C. is 30 cm to 40 cm.

12. Sea-Level Rise is Accelerating; The Real Question is How Fast?; Karin Bodtker, MRM, Coastal Ocean Research Institute, an Ocean Wise initiative, Ocean Watch B.C. Coast Edition p. 282-300.

New research by top climate scientists suggest that global sea level rise could accelerate much faster than previously predicted. Now cutting edge research from Hansen, former head of the NASA Goddard Institute for Space Studies, and others is telling us that we could see several meters of sea level rise over the next 50 to 150 years because feedback mechanisms caused by melting ice in Greenland and Antartica are amplifying and accelerating the melt.

APPENDIX 4

City of Port Alberni

Vehicle & Equipment List (2018)

Vehicle and Equipment List 2018

UNIT #	DESCRIPTION	YEAR	DEPARTMENT
130	Dodge Durango SSV	2015	City Hall - Bylaw Enforcement
131	Mitsubishi Outlander PHEV	2018	City Hall - Bylaw Enforcement
140	GMC 5500 utility truck	2007	Public Works Sewer Dept.
141	Dodge 5500 Service truck	2009	Public Works Sewer Dept.
150	Dodge 3500 Flat Deck	2008	Public Works Mechanic Shop
151	Dodge 2500 P/U	2008	Streets Superintendent Wilf Taekema
153	Chevrolet P/U	1994	Public Works - Fuel truck - (Ecav.)
154	Ford Ranger P/U 4X4	2008	Mechanic Supt - W Cheveldave
155	Dodge Ram 1500 4X4 P/U	2016	Public Works Streets Chargehand
156	Dodge Ram 3500	2019	Public Works - Paint Shop
157	Nissan NV200	2015	City Hall - Surveyor Tech.
158	Toyota RAV 4 Crossover	2014	City Hall - Surveyor Tech.
168	Ford F150 P/U	2003	Public Works Sewer Chargehand
169	Ford F350 - Service truck	2004	Public Works - Paint Shop
170	Ford Ranger P/U	2005	Utility Superintendent - B Mousley
171	Ford Ranger P/U	2008	Public Works
172	Ford F150 P/U 4WD	2019	Public Works
173	Ford F150 P/U 4WD	2019	Public Works
200	EZ. Loader boat Trailer	2007	Public Works - Lagoon Boat
240	GMC 5500 Service truck	2007	Public Works
241	Ford F550 Utility truck	2017	Public Works
259	GMC dump truck Single axle	1998	Public Works
260	GMC dump truck Single axle	1999	Public Works
262	Volvo dump truck Tandem axle	2002	Public Works
263	Ford Utility truck	2004	Public Works

UNIT #	DESCRIPTION	YEAR	DEPARTMENT
264	Volvo dump truck Tandem axle	2005	Public Works
265	Volvo dump truck Tandem axle	2007	Public Works
266	Freightliner truck Asphalt Patch	2011	Public Works
267	Volvo dump truck Tandem axle	2013	Public Works
300	Tiger Sabre Boom Mower	2004	Public Works
302	John Deere Backhoe	2007	Public Works
303	Case Backhoe	2009	Public Works
304	Cat Forklift GP40	1995	Public Works
332	Tampo wheel compactor	1962	Public Works
336	Rebco Trailer 6 X 10 Emerg.	2008	Public Works Emerg. Response Equi.
337	Rebco Trailer 5 X 8 20 KW	2008	Public Works Emerg. Generator
338	Express Trailer Flatdeck	2000	Public Works
340	John Deere Grader 772BH	1998	Public Works
342	Linkbelt Excavator 145X3DZ	2013	Public Works
350	John Deere Loader 624J	2005	Public Works
355	Volvo Grader 726B	2006	Public Works
359	Trailer with water tank	1983	Public Works U - Built Trailer
360	White / Hercules trailered	1984	Public Works Cowichan Genset
361	Snake River Genset 100 Kw	2013	Public Works Emerg. Generator
367	Langfab Pup Trailer	2006	Public Works Dump Box
369	Britco Trailer (lunchroom)	1990	Public Works Model 10X24
370	Trailer Fldck (Nicholls)	1990	Public Works (Yellow)
371	Sterling Box trailer(Paint Sprayer)	2014	Public Works (Paint Shop)
372	Stanley Hydraulic power unit	1991	Public Works HP -175
376	John Deere Loader	1992	Public Works
377	Ingersoll Rand air compressor	1992	P125DWD Air Compressor (Trailer)
378	Hi - Sander for 259	1992	Model - E2020-8
381	Stanley Compactor for backhoe	2015	Public Works
382	Swensen Sander for 264	1993	Model - EVRGH-100 (stainless)
383	Shoring Trailer	1994	Public Works - North West
385	Target Pavement cutter	1995	Public Works

UNIT #	DESCRIPTION	YEAR	DEPARTMENT
387	Langfab Pup Trailer	2016	Public Works Dump Box
388	JCTR flatdeck-lowbed triple axle	1996	Public Works - Trailer AT - 3
389	Wellscargo travel trlr for sewer	1997	Public Works Camera Equipment
393	Miller Welder (Portable)	1997	Public Works Shop (Big - 40)
395	Bomag Drum Roller	1995	Public Works
396	Express flatdeck	1998	Public Works
398	Swenson Sander for 265	2001	Public Works EV100 (stainless)
399	New Holland Tractor TV145	2004	Public Works
401	Freightliner Garbage Truck	2018	Public Works Residential
402	Freightliner Garbage Truck	2018	Public Works Residential
403	Freightliner Garbage Truck	2018	Public Works Residential
411	Tymco Sweeper 600	2016	Public Works
435	International Combo Hydro-vac	2012	Public Works - Flusher truck
518	Chevrolet Service truck	2003	Public Works Water works
520	Ford F350 service truck	2005	Public Works Water works
521	Chev, Silverado service truck	2012	Public Works Water Chargehand
522	Toyota Tacoma 4X4 P/U	2014	Public Works Water Tech
523	Nissan NV Van	2014	Public Works Water Works meters
524	Dodge Ram 5500	2019	Public Works Water works
602	Ford Ranger P/U	2000	Parks & Rec / Multiplex
604	U- Built Box trailer	2000	Parks & Rec
605	U- Built Box trailer	2000	Parks & Rec
608	Zamboni (Propane)	2003	Parks & Rec / Multiplex
609	Ventrac Tractor Mower	2004	Parks & Rec
610	Ford F250 P/U 4X4	2005	Parks & Rec
613	Ford F550 haul all	2006	Parks & Rec Garbage truck
614	GMC 5500 Hort. Utility truck	2005	Parks & Rec / Gardner
615	GMC 5500 Utility truck	2005	Parks & Rec
616	Chev cube van	2004	Parks & Rec - Carpenter
618	Portable Welder U-Built trler	1973	Parks & Rec
619	Ford E350 15 pass. Van	2006	Parks & Rec / Echo

UNIT #	DESCRIPTION	YEAR	DEPARTMENT
620	Rebco (Trailer)	2005	Parks & Rec
621	Multi - Quip. Cement mixer	2006	Parks & Rec
622	Ford F350 P/U 4X4	2007	Parks & Rec - Carpenter
623	Nissan Forklift	2000	Parks & Rec / Multiplex
624	John Deere Tractor	2007	Parks & Rec
625	Kubota F3680 Mower	2010	Parks & Rec
626	Tycrop Spreader	2007	Parks & Rec
627	Ford Ranger P/U	2008	Parks & Rec Dave Shanks mechanic
629	GMC 3500 4 X 4 P/U	2011	Parks & Rec
630	Toyota Tacoma P/U	2013	Parks Superintendent Jacob Colyn
631	Calkins Canoe trailer	1978	Parks & Rec
632	Toyota Tacoma P/U	2013	Building Superintendent Mark ZenKo
633	Toro Mower	2013	Parks & Rec
634	Yanmar Track Quad machine	2010	Parks & Rec
635	Express Custom Trailer	1990	Parks & Rec
636	Zamboni 552 (Electric)	2014	Parks & Rec / Multiplex
637	Ventrac Tractor Mower	2015	Parks & Rec
638	Pull Tank Water	1977	Paks & Rec
639	Boat Trailer canoe's ect.	1981	Parks & Rec
640	Vermeer Chipper BC 1000XL	2014	Parks & Rec
660	U - Built Equipment trailer	1989	Parks & Rec
671	Ty Crop Spreder (Retained)	1992	Parks & Rec
675	Ford E150 Variaty Club Van	1992	Parks & Rec / Echo
720	Ford F Star Van	2004	City Hall - IT Dept.
721	Dodge Caliber Car	2007	City Hall - Building Inspector
722	Chrysler Pacifica Plugin Hybrid	2017	City Hall- IT Dept.

APPENDIX 5

City of Port Alberni Engineering Department

Emergency Response Plan Excerpts

- Tsunami Roadblock Listing
- Waterworks Emergency Response Plan
- Wastewater Emergency Response Plan
- Bridges Emergency Response Plan

Dec 2003

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

ENGINEERING RESPONSIBILITIES

The responsibility of the Engineering Department in an emergency is to respond, assess, and coordinate the disposition of departmental personnel, vehicles, and equipment to minimize hazards to life and property.

GENERAL RESPONSIBILITIES

1. Staffing of Public Works EOC and the City Hall EOC, and have a representative at the Alberni Valley EOC.
2. Supply and equip the Public Works EOC with communications equipment.
3. Damage assessment and reporting.
4. Clear transportation corridors.
5. Traffic control and road closures to keep the public out of hazard zones.
6. Restoration of damaged infrastructure eg. water, and sewer and road systems.
7. Coordinate through the PEP EOC the support equipment for, and the individual emergency response plans of B.C. Hydro, B.C. Telephone and Centra Gas.
8. Supply vehicles and equipment where needed; both City and Contracted.
9. Arrange for fuel supply and mechanical reports to vehicles, generators, and equipment.
10. Transportation of emergency personnel, materials and equipment.
11. Assist as requested in location and rescue of trapped and injured people.
12. Other tasks assigned by the PEP Committee associated with an emergency or natural disaster.

March 2006

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

APPENDIX 7

TSUNAMI ROADBLOCK LISTING

In the event of a Tsunami Alert the Engineering Department shall deploy staff and equipment at the listed locations to stop traffic and advise motorists of the Tsunami hazard and direct them via routes not entering the Tsunami Zone whenever possible. Crews manning the checkpoints should strongly advise against entering the hazard zone however they should not restrain motorists from doing so if they insist.

Crews should be equipped with barricades, safety vests, traffic paddles, flashlights, and appropriate detour signs.

	LOCATION	CREW	DIRECTION
1.	River Road @ Falls Road	0	Reroute Alberni bound traffic up Falls Road via Malibar/Beaver Crk/Smith/ Cowley/Cherry Cr /Johnston/Maebelle. (May be relieved by Highways Dept. Staff)
2	Falls Road @ Compton Road	2	Turn back traffic bound for River Road. Reroute same as above.
3	Russell Road @ Russell Place	0	Turn back traffic bound for River Road. Reroute same as above.
4	Beaver Creek Road @ Compton Road	2	Reroute southbound north on Smith/ Cowley/Cherry Cr.
5	Beaver Creek/Compton/ Josephine	0	To direct the flow of traffic north on Beaver Creek.
6	Compton & Grandview	0	Turn back traffic bound for Compton.
7	Gertrude Street @ Compton Road at tracks	1	Reroute southbound & westbound on Compton. Direct South via Compton/Kitsuksis/Best/Cowley/Cherry Cr/Johnston/Maebelle

	LOCATION	CREW	DIRECTION
8	Kitsuksis & Short St.	1	Reroute southbound back along Kitsuksis/Best/Cowley/Cherry Creek/Johnston/Maebelle
9	Lathom Road @ Leslie Street	0	Close Lathom Road west of Leslie using unmanned barricades and detour signs.
10	Johnston Road at Leslie	2	Turnback westbound traffic. (May be relieved by Highways Dept Staff
11	Roger Street at 6th Avenue	0	Stop traffic going south on Roger.
12	8th Avenue & Roger	2	Stop westbound.
13	Redford Street @ 6th Avenue	2	Reroute westbound traffic east on Redford.
14	4th Avenue & Redford	0	On top of hill stopping southbound traffic.
15	6th Avenue @ Bute Street Burde St to N. Park Dr. & 5th	0	Close Bute St., Burde St., & North Park Drive eastbound from 7th Avenue with unmanned barricades and detour signs
16	5th Avenue @ Dunbar	0	Reroute northbound traffic east onto Dunbar Street and direct to 10th Avenue Fill.
17	4th Avenue & Strathern	0	Stop northbound traffic.
18	3rd Avenue @ Athol	2	Reroute northbound traffic east onto Athol St., and direct to 10th Avenue Fill. Close Athol St., westbound.
19	Kingsway & 3rd Avenue	0	To direct traffic south on 3rd and stop traffic heading south on Kingsway.
20	Argyle Street @ 1st	2	Reroute westbound traffic south onto 2nd then back east.

	LOCATION	CREW	DIRECTION
21	Kingsway Street @ Angus Street	0	Reroute northbound traffic east onto Angus to Argyle Street to 10th Avenue Fill.
22	2nd Ave @ Bruce Street., Stirling & South Streets.	0	Close Stirling St., Bruce St., & South Street eastbound from 2nd Avenue with unmanned barricades and detour signs

TOTAL STAFF 25

L:\Admin\Emergency Response Plan\Appendix 7 Tsunami Roadblock Listing.doc

May 2009

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

APPENDIX 8

WATERWORKS EMERGENCY RESPONSE PLAN

Distribution:
Brian Mousley
Steve Crowshaw
Ken Watson
Guy Cicon
Waterworks Office
Waterworks Vehicles
Emergency Operations Centre - 4th Ave
Ministry of Environment
Medical Health Officer
Dam Safety Officer

Nov 2006

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

APPENDIX 8

WATERWORKS EMERGENCY RESPONSE PLANS

INDEX

WATERWORKS EMERGENCY RESPONSE PLAN

PURPOSE OF PLAN:

The Plan is to prepare Waterworks Personnel and others to respond quickly and efficiently in the event of an emergency affecting the water system, so that water supply may be safe-guarded, maintained or returned to working condition as quickly as possible.

The plan is to be reviewed and updated regularly. Suggestions and changes to the plan should be forwarded to Norm Meunier, Utilities Superintendent (norm_meunier@city.port-alberni.bc.ca)

ACTIVATION OF PLAN:

All levels of government under their different Emergency Acts and Bylaws can activate the Plan when a "State of Emergency" is declared.

An Engineering Department Manager can also activate the Plan when the operation of the water supply is concerned.

Supervisors or Chargehands will call out staff as required for regular emergency situations. In the event of a major emergency or disaster, employees' first thought should be for their own safety and that of their family and home. Once personal and home safety has been established all personnel shall report to the Public Works Yard.

EMERGENCY ORGANIZATION

The Engineering Department Organization chart and Operations Callout list are attached. A list of Emergency Telephone numbers are also attached.

The Public Works Yard at 4150 - 6th Avenue will act as the Command Centre and assembly point for emergences. As an alternate or in the event of a major emergency, the Main Command Centre will be the Emergency Operations Centre at 3004 - 4th Avenue

COMMUNICATIONS

Two-way radio communications will hopefully be in service to transmit assessment reports and directions. A portable 2-way radio is in the Works Yard meeting trailer. HAM Radio (AV Communications Club) may be available as a secondary communication system.

Initial Communication would likely be with the Public Works Yard Command Centre. Depending on the scope of the emergency, communication may shift to a person in the Emergency Operations Centre (EOC) on 4th Avenue.

Direct all media and public questions to a Public Communications person in City Hall or the EOC.

DESCRIPTION OF WATER SYSTEM

The City of Port Alberni obtains water from two high quality surface coverage courses: China Creek and Bainbridge lake. There is also an intake on the Somass River for use during peak demands. Within the City there are five water storage reservoirs, 23 Pressure Regulating Valves 150 km of watermain, 715 Fire Hydrants, and 3 Dams. Water is disinfected via chlorination to meet Ministry of Health requirements.

Basemap drawings of the Water System are posted in the Waterworks Shop and are carried in Waterworks Vehicles. More detailed records of the system can be found in the Engineering Department at City Hall.

CITY OF PORT ALBERNI - ENGINEERING DEPARTMENT
INFRASTRUCTURE INVENTORY SUMMARY

* updated to end of 2008

WATERWORKS

Watershed - China Creek basin	6202	Ha	
- Bainbridge Lake Catchment	1310	Ha	
Intakes (Surface Supply)	3		
- China Creek - gravity	24,451	m3/day permit	
- Bainbridge Lake - pumped	9,763	m3/day permit	
- Somass River - pumped	13,564	m3/day permit	
Total Permitted Volume	47,778	m3/day permit	
Dams	3		
- China Creek - intake - concrete El. 184m (603.7')	5000	m3 storage	
- Lizard Lake -concrete/earthfill (440 acre ft) El. 732m (2	545,000	m3 storage	
- Bainbridge Lake - earthfill (1000 acre ft) El.150m (492')	1,230,000	m3 storage	
	1780000		
Pumpstations	5		
- Bainbridge - 2x50 HP @ 2508 gpm	100	Hp	
- Somass - 2x60 HP @ 750 gpm ea.	245	Hp	
- 1x125 HP @ 1390 gpm			
- Cowichan - 2x60 HP @ 2400 gpm	125	Hp	
- 1x5 HP @ 65 gpm			
- Johnston - 4x60 HP @ 800 gpm ea.	538	Hp	
- 1x7.5 HP @ 120 gpm			
- 2x145 HP diesel @ 2100 gpm			
- Arrowsmith - 2x5 HP @ 65 ea.	10	Hp	
Total Pumpstation Horsepower	1018	Hp	
Chlorination Stations	3		
- Bainbridge Pumpstation (gas injection)			
- Somass Pump/Intake (gas injection)			
- Johnston Pumpstation (gas injection)			
Chlorine Residual Test Points - Daily	9		
Bacterial Test Locations - Monthly	20		
Reservoirs	5		
- Upper Cowichan - floating cover El.158m	11,250	m3	1962/1963
- Lower Cowichan - floating cover El.146m	6,750	m3	1937
- Burde - floating cover El.86.8m	6,750	m3	1947
- Johnston - 2 cells, concrete El.66.8m	9,000	m3	
- Arrowsmith - 1 cells, steel tank El.173.6m	250	m3	
Total Reservoir Storage Volume	34,000	m3	

Supply mains steel- 400mm	1.32 km
Supply mains HDPE- 500mm	1.92 km
Supply mains PVC- 500mm	1.49 km
Supply mains steel- 600mm	4.83 km
Total Supply Mains	9.56
Distribution mains < 150mm	89.5 km
Distribution mains 200-300mm	48.5 km
Distribution mains > 300mm	22.1 km
Total Distribution Mains	160.1 km
Distribution mains - Asbestos Cement	77.5 km
Distribution mains - Cast Iron	32.8 km
Distribution mains - P.V.C.	31.9 km
Distribution mains - Ductile Iron	7.6 km
Distribution mains - Galvanized Iron	0.0 km
Distribution mains - Steel	0.8 km
Distribution mains - Wood Stave	0.0 km
Distribution mains - Type Unknown	9.5 km
Pressure Reducing Stations	19
Pressure Zones	12
Line Valves	1404
Air Valves	44
Hydrants (City)	718
Hydrants (Private)	35
Connections - Residential	6362
- Commercial	304
- Industrial	13
- City	62
Meters (Active)	6741
Meter Size Breakdown	
15 or 19 mm inside City	6345
15 or 19 mm outside City	50
25mm inside	100
25mm outside	2
40mm inside	77
40mm outside	2
50mm inside	114
50mm outside	5
75mm inside	22
75mm outside	1
100mm inside	6
100mm outside	1
150mm inside	10
150mm outside	3
over 150mm	3
	6741

Average Annual Volume Served	6,192,489	m3
Peak Day Usage	18,347	m3
Minimum Day Usage	3,305	m3
Average Day Usage	10,905	m3

March 2006

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

APPENDIX 9

WASTEWATER EMERGENCY RESPONSE PLANS

INDEX

CITY OF PORT ALBERNI - ENGINEERING DEPARTMENT
INFRASTRUCTURE INVENTORY SUMMARY

* updated to end of 2008

SEWER & DRAINAGE

Connections	6436
Storm Sewers	97.2 km
Sanitary & Combined Sewers	156.2 km
Sanitary & Combined Manholes	2229.0
Storm Manholes	1323.0
Catchbasins	2297
Grit Chambers	11
Sump Manholes	19
Pipe Type	
PVC Sanitary & Storm	53.6 km
AC Sanitary & Storm	51.7 km
Conc Sanitary & Storm	80.0 km
Vit Sanitary & Storm	26.2 km
Reline Sanitary & Storm	2.1 km
Other Sanitary & Storm	5.3 km
Unknown Sanitary & Storm	34.5 km
	253.4
Pipe Diameter	
150mm and less	18.6 km
200mm	101.0 km
250mm	36.9 km
300mm	33.5 km
350mm	3.8 km
375mm	10.4 km
400mm	3.3 km
450mm	9.0 km
500mm	2.2 km
525mm	2.1 km
600mm	10.4 km
>600mm	13.5 km
mixed & unknown	8.7 km
	253.4
Sewage Pumpstations	5
- Wallace - 2x40 Hp @ gpm,1x10 hp jockey	90 Hp
- Argyle - 2x140 Hp @ 250l/sec- only one at a time	280 Hp
- Josephine - 2x20 Hp submersibles	40 Hp
- Margaret - 2x20 Hp @ 1200 gpm	40 Hp
- 4th Ave - 2x10 Hp @ 400 gpm, submersibles	20 Hp
Storm Liftstation	1
- Margaret - 2x 75 Hp @ 20,000gpm	150 Hp
Forcemains	9.3 km
Storm Outfalls	95
Combined Overflows	4
Flood Gates	25

Major Culverts > 900mm	52	
Ditches	9	km
Sewage Treatment Facility (Lagoon)	1	
Aeration - 2 x 30HP (splash), 3 x 25 HP self-aspirating, 2 x 75 HP (splash), 2 x 30HP (directional) =	345	HP
Capacity (Volume)	80,000	m3
Average Flow	16,484	m3/day
Max Flow	42,774	m3/day
Min Flow	7,752	m3/day
Permit PE 297 - Flow (Continuous)	34,100	m3/day permit
- BOD5 (Monthly) 38mg/l avera	70	mg/l permit
- TSS (Monthly) 49 mg/l aver:	70	mg/l permit
- DO (Weekly) 2.2 mg/l average 2008		
Annual Volume Treated	6,016,538	m3

CITY OF PORT ALBERNI
ENGINEERING DEPARTMENT

EMERGENCY RESPONSE PLAN

APPENDIX 11

EMERGENCY RESPONSE PLANS

BRIDGES

GERTRUDE STREET AT ROGER CREEK

Construction

The Gertrude Street at Rogers Creek Bridge is a three span structure carrying four traffic lanes and two sidewalks over Rogers Creek. This superstructure consists of painted steel beams with a composite concrete deck. The substructure consists of creosote treated timber piles at the piers and abutments. Although the abutments are placed square to the roadway, the piers are skewed at 20 degrees to accommodate the creek alignment.

Gas on east side of bridge running north-south
Water main on west side running north south

GERTRUDE STREET AT KITSUKSIS CREEK

Construction

The Gertrude Street at Kitsuksis Creek Bridge, is a four span structure carrying two traffic lanes and sidewalks over Kitsuksis Creek. The superstructure and substructure consist of creosote treated timber components. The main span consists of glulam slab girders, with a 200mm transverse nail laminated deck, while the approach spans consists of sawn timber stringers with a 100mm transverse nail-laminated deck. The wearing surface is a reinforced asphalt overlay

Waterline running on east side running north-south
Gas.

FOURTH AVENUE BRIDGE AT DRY CREEK

Construction

The Fourth Avenue Bridge at Dry Creek is a single span structure carrying two traffic lanes and a sidewalk over Dry Creek. The superstructure consists of a longitudinally laminated treated timber deck with a composite cast-in-place concrete topping and an asphalt wearing surface. The substructure consists on cast-in-place concrete abutments on spread footings.

Water.
Telephone

VICTORIA QUAY AT ROGERS CREEK

Construction

The Victoria Quay at Rogers Creek Bridge is a four span structure carrying two traffic lanes and sidewalks over Rogers Creek. The superstructure consists of painted steel beams with a composite concrete deck. The substructure consists of creosote treated timber piles and caps.

Water

THIRD AVENUE BRIDGE AT DRY CREEK

Construction

The Third Avenue Bridge at Dry Creek is a two span cast-in-place concrete, open bottom type culvert type structure carrying five traffic lanes and two sidewalks over Dry Creek. The span reinforcement appears to consist of embedded railway rails supported by concrete abutments and a median wall

APPENDIX 6

Tables as included in body of report

PROXIMITY ANALYSIS

	Area Center Point (distance in metres)				
	North Point	**Central Point**	**South Point**	**Total Distance**	**Proximity Relative to Current 6th Ave Site**
POTENTIAL SITES					
<u>Northeast</u>					
1. Maebelle Road – MoT	4800	3950	5020	13770	147%
2. Maebelle Road – SD 70	4800	3950	5020	13770	147%
3. Cherry Cr Road	3530	4080	6350	13960	151%
<u>Central North</u>					
4. Fall Fair Grounds	2975	975	3245	7195	29%
5. North Island College	3325	1325	3595	8245	48%
<u>Central</u>					
6. Upper Burde Street	5520	2870	3200	11590	108%
7. Burde Street Reservoir area	4570	1920	2250	8740	57%
<u>South</u>					
8. Anderson Avenue Works	6870	4220	1950	13040	134%
9. Seizai Road	8170	5520	3250	16940	204%
CURRENT 6TH AVE SITE	**2000**	**650**	**2920**	**5570**	**0%**

S:\3721 CPA Public Works Yard\Reports\Assessment Report\tables\Proximity Analysis 5-3-1.xlsx

POTENTIAL SITE COSTS

	COST ITEMS									
	Land	Main Building	Enclosed Vehicle Bays	Equipment and Material	Site Development	Site Servicing	Sub Total	Engineering Design (15%)	Contingency (15%)	Total
POTENTIAL SITES										
Northeast										
1. Maebelle Road – MoT	$640,000	$7,700,000	$600,000	$555,000	$390,000	$352,000	$10,237,000	$1,535,550	$1,535,550	$13,308,100
2. Maebelle Road – SD 70	$400,000	$7,700,000	$600,000	$555,000	$390,000	$352,000	$9,997,000	$1,499,550	$1,499,550	$12,996,100
3. Cherry Cr Road	$0	$7,700,000	$600,000	$555,000	$390,000	$630,000	$9,875,000	$1,481,250	$1,481,250	$12,837,500
Central North										
4. Fall Fair Grounds	$0	$7,700,000	$600,000	$555,000	$390,000	$150,000	$9,395,000	$1,409,250	$1,409,250	$12,213,500
5. North Island College	$800,000	$7,700,000	$600,000	$555,000	$390,000	$640,000	$10,685,000	$1,602,750	$1,602,750	$13,890,500
Central										
6. Upper Burde Street	$700,000	$7,700,000	$600,000	$555,000	$390,000	$920,000	$10,865,000	$1,629,750	$1,629,750	$14,124,500
7. Burde Street Reservoir	$0	$7,700,000	$600,000	$555,000	$390,000	$130,000	$9,375,000	$1,406,250	$1,406,250	$12,187,500
South										
8. Anderson Avenue	$360,000	$7,700,000	$600,000	$555,000	$390,000	$730,000	$10,335,000	$1,550,250	$1,550,250	$13,435,500
9. Seizai Road	$500,000	$7,700,000	$600,000	$555,000	$390,000	$710,000	$10,455,000	$1,568,250	$1,568,250	$13,591,500

POTENTIAL SITE INFORMATION

	CRITERIA								
	Ground Elevation	**Land Area**	**Land Ownership**	**Zoning / OCP**	**Site Services**	**Accessibility**	**Proximity Analysis**	**Area Fit**	**Cost**
POTENTIAL SITES	Greater than 20m	3.0 to 3.5 ha	Public / Private	M1 light industrial	Water, sewer, drainage, power, telecom (W,S, D,P,T)	Arteritial road network	Score	Do operations fit with existing uses and geography. (Hi, Med, Lo)	Land, buildings, services, and development costs
Northeast									
1. Maebelle Road – Ministry of Transportation and Infrastructure	94m	3.2 ha	Province	ACRD P2	W,P,T	Hwy 4 / Redford St.	13,770	Hi	$13,308,100
2. Maebelle Road – School District 70 Maintenance Yard	94m	2.0 ha	Province	ACRD P2	W,P,T	Hwy 4 / Redford St.	13,770	Hi	$12,996,100
3. Cherry Cr Road	63m	5.0 ha	City	A1 / Urban Argriculture ALR	W,P,T	Cherry Cr Rd. / Broughton Rd. (Collector)	13,960	Hi	$12,837,500
Central North									
4. Fall Fair Grounds	45m	4.0 ha	City	P2 Institutional / Institutional	W,S,D,P,T	10th Avenue	7,195	Med	$12,213,500
5. North Island College	70m	4.0 ha	Province	P2 Institutional / Parks and Open Space	100m W,S,P,T	Roger St.	8,245	Med	$13,890,500
Central									
6. Upper Burde Street	106m	3.5 ha	Private	R1 Rural Residential / Future Residential	W,S,P,T	Burde St. (Collector)	11,590	Lo	$14,124,500
7. Burde Street Reservoir area	87m	4.0 ha	City	P2 Institutional / Future Residential	W,S,P,T	Burde St. (Collector)	8,740	Lo	$12,187,500
South									
8. Anderson Avenue Public Works Storage	118m	1.8 ha	City / Private	FD Future Development / Future Residential	W,P,T	Anderson Ave. / Shipcreek Rd.	13,040	Hi	$13,435,500
9. Seizai Road	148m	2.5 ha	Private	ACRD P2	W,P,T	Seizai Rd. / Shipcreek Rd.	16,940	Hi	$13,591,500

POTENTIAL SITE WEIGHTED EVALUATION MATRIX

	CRITERIA (Weighting Factor)									
	Ground Elevation	**Land Area**	**Land Ownership**	**Zoning / OCP**	**Site Services**	**Accessibility**	**Proximity Analysis**	**Area Fit**	**Cost**	**Total**
	8	**8**	**8**	**8**	**8**	**15**	**15**	**15**	**15**	**100**
POTENTIAL SITES										
Northeast										
1. Maebelle Road – MoT	1.0	1.0	1.0	1.0	1.0	1.3	0.7	1.3	1.0	**105**
2. Maebelle Road – SD 70	1.0	0.7	1.0	1.0	1.0	1.3	0.7	1.3	1.0	**102**
3. Cherry Cr Road	1.0	1.0	1.3	0.7	0.7	1.3	0.7	1.3	1.0	**102**
Central North										
4. Fall Fair Grounds	1.0	1.0	1.3	0.7	1.0	1.0	1.3	1.0	1.3	**109**
5. North Island College	1.0	1.0	1.0	0.7	0.7	0.7	1.3	1.0	0.7	91
Central										
6. Upper Burde Street	1.0	1.0	1.0	0.7	0.7	0.7	1.0	0.7	0.7	82
7. Burde Street Reservoir area	1.0	1.0	1.3	0.7	1.0	0.7	1.3	0.7	1.3	100
South										
8. Anderson Avenue PW	1.0	0.7	1.3	1.0	0.7	1.0	0.7	1.3	1.0	98
9. Seizai Road	1.0	0.7	1.0	1.0	0.7	1.0	0.7	1.3	0.7	91