Flood Mitigation Plan

Town of Osoyoos

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September 2022

Project No. 302-2001

TRUE

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List of Acronyms

TRUE	TRUE Consulting
ToO	Town of Osoyoos
NHC	Northwest Hydraulic Consultants
OBWB	Okanagan Basin Water Board
I&I	Inflow & Infiltration
MFE	Main Flood Elevation
FCL	Flood Construction Level

Units of Measure

ft	feet
Igpm	Imperial gallons per minute
km	kilometre
L/d	Litres per day
L/m	Litres per minute
L/s	Litres per second
lpcd	Litres per capita per day
m	metre
mg/L	milligrams per Litre
mm	millimetre
NTU	Nephelometric Turbidity Units
psi	pounds per square inch
USgpm	US gallons per minute

Referenced Reports

NHC (2020)	Okanagan Mainstem Floodplain Mapping Project, Final Report No. 3004430 prepared by Northwest Hydraulic Consultants Ltd., March 2020
RDOS (2018)	Regional District of Okanagan Similkameen Spring Freshet Operational Response Summary, prepared by Davies Wildfire Management, September 2018
DWV (2022)	Coastal Marine Management Plan, Final Draft Report, District of West Vancouver, January 2022
ToO (2021)	Official Community Plan Bylaw No. 1375, 2021, Town of Osoyoos, April, 2022
ToO (2022)	Town of Osoyoos Zoning Bylaw No. 1085, 1998, Town of Osoyoos, July, 2022
Province of BC (2018)	Flood Hazard Area Land Use Management Guidelines, Province of BC, 2004
BC Land Title & Survey (2019)	Official vertical Datums for Legal Surveys in British Columbia, Cristin Schlossberger, August 2019

Executive Summary

The Town of Osoyoos (Town) is a community located in the Southern-most portion of the Okanagan Valley in British Columbia. Osoyoos has an approximate population of 5,600 residents, which grows to about 20,000 during the summer. The town is centered around Osoyoos Lake, which saw significant flooding events in both 2017 & 2018.

In 2021, the Town obtained funding from the Community Emergency Preparedness Fund (CEPF) for the purposes of compiling a flood mitigation plan. The plan was developed by TRUE Consulting in consultation with the Town. This report documents the Town's Flood Mitigation Plan.

The project objectives were to:

- Build on NHC's previously completed floodplain mapping works to create a more detailed and area specific floodplain and wave hazard map.
- Utilize the more detailed floodplain map, LiDAR information, Bathymetric information, and topographic information to recognize public infrastructure at risk of flooding and erosion.
- Develop conceptual level designs with Class D cost estimates for the public infrastructure at risk of flooding and erosion.
- Complete stakeholder engagement to compile strategies and plans.
- Maintain continued comprehensive Town engagement and plan for future council and public meetings to implement the Flood Mitigation Plan and applicable strategies to mitigate the existing risks as defined within the plan.
- Recommend flood mitigation strategies, policies, and structural projects.
- Prioritize flood mitigation methods.
- Provide a final flood mitigation plan report.
- Adoption of this Flood Mitigation Plan by Council upon completion.

As outlined above, this report builds on the Okanagan Mainstem Floodplain Mapping Project executed by NHC for the OBWB and member municipalities, including the Town of Osoyoos.

The proposed flood mitigation plan is provided in Section 6 of this report.

Key recommendations of the Flood Mitigation Plan are as follows:

- Town of Osoyoos Council to adopt completed Flood Mitigation Plan
- Revise the existing OCP defining the updated active floodplain as determined in this Mitigation Report. Consider modifying any existing land use classifications at this time and include in OCP revision as necessary.
- Update the existing Town of Osoyoos Floodplain Bylaw
- Create a Flood Response Plan for the Town of Osoyoos
- Apply for grant funding and undertake the water and sanitary mitigation projects as outlined in Section 6.3, starting with high priority projects.

The Flood Mitigation Plan should be treated as a living document and should be updated regularly.

1.0 Introduction

1.1 Background

The Town of Osoyoos (Town) is a community located in the Southern-most portion of the Okanagan Valley in British Columbia. Osoyoos has an approximate population of 5,600 residents, which grows to about 20,000 during the summer. The Town of Osoyoos has one of the most ecologically unique landscapes in Canada. The beautiful natural surrounding including the desert, grasslands, and Lake Osoyoos, provide unique opportunities for recreation, leisure pursuits and environmental education. These resources are the heart of Osoyoos and are key to protecting the livability of the community.

The 2017 & 2018 flooding events experienced throughout the Town have exposed the limitations within the Town's existing flood management and mitigation strategies. Findings from the NHC's analysis determined that the current Flood Construction Level (FCL) for the Town will now be deficient and highlighted that significant portions of the Town are expected to flood on a more regular basis.

In February 2021, the Town of Osoyoos submitted an application to the Union of BC Municipalities (UBCM), requesting funding for a flood risk assessment, flood mapping, & flood mitigation planning. Funding for this work was provided by the UBCM through the Community Emergency Preparedness Fund (CEPF), which is a suite of funding streams intended to enhance resiliency of local governments, First Nations, and communities in responding to emergencies. Following the damaging flooding events in 2017 & 2018, the UBCM granted funding to the Town.

TRUE has set out to assist the Town in achieving their goal of building on previous works executed by NHC for the OBWB, the Okanagan regional districts, member municipalities, and the Okanagan Nation Alliance and member communities. NHC updated floodplain mapping for the Okanagan River and its lakes (including Osoyoos Lake). The Town's goals was to utilize the finding from NHC's report and perform further, more detailed and area specific analysis, to develop a lakeshore flood mitigation plan that will aid the Town in planning for future flood emergencies.

1.2 Project Objectives

Flood mitigation consists of the management and control of potential flood water movement through structural and non-structural methods. These methodologies are further discussed in Section 2.0. This flood mitigation plan will serve to highlight areas and infrastructure of concern throughout the Town and provide direction as to which steps should be taken to best mitigate the effects of flooding in order of priority. As outlined in the figure below, flood management is an evolving process. This flood mitigation plan works to build on previous data analysis, modeling, and mapping, in an effort to better assess risk to the Town and provide recommendations to mitigate these risks.

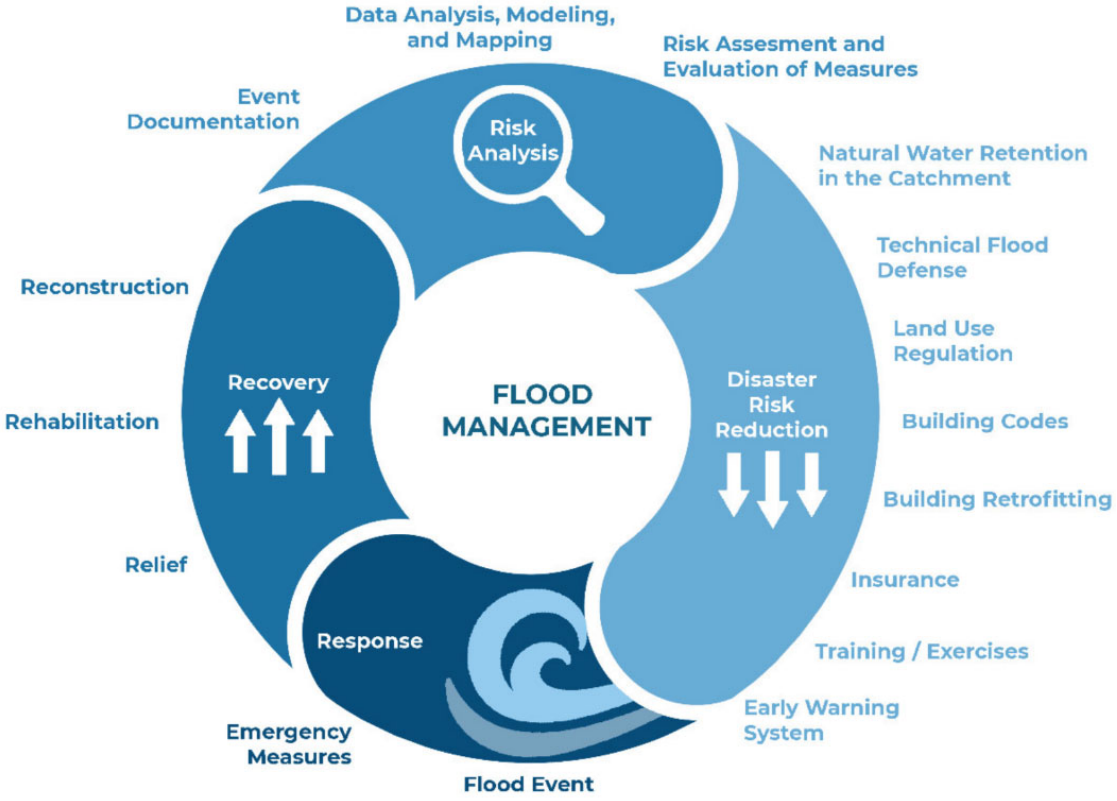


FIGURE 1-1: MANAGEMENT CYCLE IN FLOOD MANAGEMENT (MDPI, 2021)

This is considered a living document that will require updates over time to suit the ever-changing conditions of the watersheds, water courses, data investigation and collection, and/or projects that occur within the Town.

The objectives of this project are to identify areas and infrastructure throughout the Town that will be affected by the 200-year flood levels and complete an evaluation of the applicable long-term flood mitigation options. The evaluation process will provide an analysis of options to mitigate any flood impacts to the Town. Feasible mitigation options determined from this analysis will be summarized in project sheets for highest priority areas and infrastructure along with high level cost estimates (Class D), provided in Appendix C. The result of this process and flood mitigation plan will enable the Town of Osoyoos to:

- Have a thorough understanding of the current and future flood risks facing the community
- Have access to updated information to better respond to flooding events when they do occur
- Have a comprehensive, long-term Flood Mitigation Plan to mitigate community flood risk with consideration for climate change
- Be capable of budgeting and implementing the provided Flood Mitigation Plan including capital projects aimed at developing a more resilient community

1.3 Project Activities

Table 1-1 provides an overview of the project activities completed to compile this Flood Mitigation Plan report.

TABLE 1-1: PROJECT ACTIVITIES

Item No.	Project Task	Description
1.0	Background Review & Data Collection	▪ Compile and review background, technical, and policy information ▪ Review Town record drawings of existing infrastructure
2.0	Project Management	▪ Kick off Meeting ▪ Bi-Weekly Project meetings ▪ Project management and staff coordination ▪ Client coordination
3.0	Hydraulic Model Refinements	▪ Wave climate modeling ▪ Wave runup, overtopping, and inland hazard extents
4.0	Develop site specific lakeshore flood & wave hazard mapping	▪ Modelling and sensitivity analysis ▪ Collaboration with Town staff ▪ Prioritize areas of concern ▪ Create project sheets for recommended flood mitigation activities (structural and non-structural)

Item No.	Project Task	Description
5.0	Meeting No. 1 – Town of Osoyoos	▪ Meeting with Town staff for review and summary of Flood Mitigation Plan & Projects ▪ August 25th, 2022
6.0	Finalize Flood Mitigation Options	▪ Finalize flood mitigation document ▪ Council Meeting for adoption of flood mitigation plan document
7.0	Council Presentation	▪ To occur on TBD to present flood mitigation plan for subsequent council adoption

2.0 Flood Mitigation Strategies Overview

There are numerous strategies which, individually, will contribute to the reduction of flood risk and resulting damage; however, the most effective approach is often to combine multiple strategies. Over time, conditions and priorities will change and the resulting methods to approach flood mitigation at any given location will shift as necessary to best suit current conditions.

Flood mitigation strategies are classified as either structural or non-structural measures. The structural and non-structural classifications and their respective approaches are defined herein.

2.1 Non-Structural Flood Mitigation

Non-structural flood mitigation methods involve planning, floodplain mapping, land use management, and policy implementation based on the best available information. Flood mapping allows the Town to determine and characterize the active floodplain area in which designation of development permit area requirements can be applied using regulatory tools. The options for which a local government can act in this manner is informed by the 'Flood Hazard Area Land Use Management Guidelines', 2018 (Ministry of Water, Land and Air Protection, Province of British Columbia, May 2004) and in accordance with the Local Government Act (Gov BC, 2015). Upon completion of floodplain mapping, the following regulatory tools should be implemented.

2.1.1 Investigation

Compile all existing data regarding above and below ground infrastructure. Outline the existing information gaps in order to determine the data that requires improvement for the Town to make better-informed decisions. This process is crucial for implementing the best possible flood mitigation technique at any given location.

The Town of Osoyoos has an active Asset Management Plan in place that will facilitate the collection of existing data and aid in informing the data remaining to be collected. As investigation activities are conducted, both the flood mitigation plan and asset management plan should be updated to reflect the new data.

2.1.2 Land Use Management

2.1.2.1 Revise Official Community Plan (OCP)

Revise the OCP general land use policy statements and maps defining the Town's updated floodplain and include restrictions on the use of land subject to hazardous conditions whether it be flooding or erosion. The OCP would declare the floodplain area as a designated 'development permit area' for the purpose of:

- Protection of the natural environment, its ecosystems and biological diversity; and
- Protection of development from hazardous conditions.

The Official Community Plan must describe the special conditions or objectives that justify the designation in addition to specifying the guidelines respecting the manner by which the special conditions or objectives will be addressed (Division 7, Local Government Act).

2.1.2.2 Apply Local Government Bylaws and Development Permits

Adjust and/or develop a local government floodplain bylaw and corresponding development permits to apply to the designated development permit areas as defined in the OCP.

The floodplain bylaw should indicate which activities may require a development permit and which specific authorities may apply. Some of the concepts to be included within the bylaw and subsequent development permit requirements are floodplain setbacks, flood construction level, floodproofing, and modifications to existing structures and/or properties. These items to be included within the floodplain bylaw are further discussed herein.

Floodplain Setbacks

Setbacks are a horizontal measurement from development to the natural boundary. The natural boundary is generally the visible high watermark of any body of water and includes the best estimate of the edge of dormant or old side channels and marsh areas. A floodplain setback is established with the goal of keeping development away from potential erosion or flooding and prevent any potential flow restrictions within an existing watercourse.

As a minimum, buildings, manufactured homes or units, modular homes or structures should be setback 15 meters from the natural boundary of any lake larger than 15km in length. Where a lake is less than 15km in length and there is no history of severe flooding or concern for shoreline erosion, a minimum setback of 7.5 meters from any structure may be used. These minimum

distance guidelines can vary as more site-specific information is available through hydraulic modelling and floodplain mapping, and engineering assessments and reports.

Flood Construction Level (FCL)

FCLs are a construction elevation minimum intended to protect living spaces and areas used for the storage of goods damageable by floodwaters from flooding events. In development areas within the floodplain, both FCLs and setbacks should be considered congruently.

In areas used for habitation, business, or storage of goods damageable by flood waters, the elevation of the underside of the floor system should be no less than the determined Flood Construction Level. FCLs can be achieved using landfill (where the toe of imported material must be outside the setback requirement), structural means, such as raised concrete or wooden structures for a building to be placed on, or a combination thereof.

In areas where it is not reasonable or achievable to meet the FCL requirement, the area can be used for purposes that will not be hazardous or damaging in the event of flooding or erosion. Some examples of this may be open spaces and/or parks, parking lots, or storage of items that cannot be damaged by flooding etc.

Floodproofing

In scenarios where either the setback or FCL requirements cannot be achieved, floodproofing measures may be required in order to protect structures and areas below the FCL or within setback limitations. There are two methods of floodproofing – dry floodproofing and wet floodproofing.

Dry floodproofing is when a structure is watertight below the predetermined FCL. In addition to preventing water from entering the building, the foundation must additionally be designed to withstand potential uplift forces associated with flooding of the surrounding area.

Wet floodproofing is when a structure is designed and constructed with the ability to allow in water during a flood without damage.

Modification to Existing Structure and/or Properties

If a land use regulation bylaw is adopted at the time existing land, buildings, or other structures are lawfully used which the new bylaw applies and the existing use does not conform to the bylaw, the use can continue as a “non-conforming use” per Division 14 of the Local Government Act. In scenarios where non-conforming structures or land use requiring significant repair, reconstruction, or alteration, the new adopted bylaw will apply. The Local Government Act provides additional information regarding specific scenarios.

The above listed items to be included within a floodplain bylaw can further reference the requirement of a development permit to be approved by an approving officer (Town). Per Division 7 of the Local Government Act, the following provides a brief overview of the local government authority with respect to development permits. Additional information can be found in the Local Government Act.

Once areas have been designated as 'development permit areas', the following prohibitions apply:

- Land within the area must not be subdivided;
- Construction of, addition to or alternation of a building or other structure must not be started;
- Land within a designated development permit area must not be altered.

In scenarios where the above cases apply, a local government can issue a development permit that specifies requirements and conditions or set standards which may include the following:

- Specify areas of land to remain free of development;
- Require specified natural features or areas to be preserved, protected, restored or enhanced in accordance with the permit;
- Require natural watercourses be dedicated;
- Require works to be constructed to preserve, protect, restore or enhance natural water courses or other specified natural features of the environment;
- Required protection measures, including that vegetation or trees be planted or retained in order to
    - Preserve, protect, restore, or enhance fish habitat or riparian areas,
    - Control drainage, or
    - Control erosion or protect banks.
- Specify areas of land that may be subject to flooding, mud flows, torrents of debris, erosion, land slip, rock falls, subsidence, tsunami, avalanche or wildfire or other applicable hazards as areas that must remain free of development. Pertaining to this scenario:
    - Conditions and requirements may vary the use or density of the land, but only as they related to health, safety, or protection of property from damage.
    - Local government may require the applicant to provide a report to assist the local government in determining which conditions or requirements should be imposed. A report must be provided by the applicant at the applicant's expense and be certified by a professional engineer with experience relevant to the applicable matter.

Covenants

Where necessary, covenants can be applied to certain properties or areas under the Land Title Act that specify conditions that would enable the land to be used safely for its intended purpose. This would allow for additional flexibility in the Town's land use designation options for a given location.

2.1.2.3 Assemble Flood Response Plan

A flood response plan (FRP) can be prepared to monitor and respond to emergency conditions during high water levels throughout the Town of Osoyoos. The purpose of an FRP is to prevent any loss of life, minimize injury and trauma, and minimize damage to or loss of property resulting from flooding. Having a prepared FRP will minimize the time between a flooding event and the responsive action as it would be predetermined and outlined within this document.

2.2 Structural Flood Mitigation

Structural flood mitigation methods are physical changes or activities undertaken to protect from disasters and/or hazards by way of either controlling the physical process of flooding either temporarily or permanently, or as a last resort - physically retreating and/or removing development from areas of high flooding risk.

2.2.1 Protect Development

The goal of protecting development is to prevent flooding and/or erosion from impacting a developed area. Protection can be of temporary or permanent nature with consideration for specific flood hazard characteristics, available land space between the watercourse and development, and environmental impacts within the channel and riparian area.

It should be noted that although protecting development appears obvious for existing above-ground structures, this additionally includes underground utilities owned by the Town – namely the water and sanitary sewer systems.

2.2.1.1 Temporary Flood Mitigation Measures

One method to protect developed areas from flooding and/or erosion is to provide temporary measures such as sandbags or flood walls, and pumping. These methods can often be used congruently as necessary.

Sandbags are generally most cost effective when compared with other temporary flood walls – i.e. bladder systems, however; large quantities of both suitable sand and volunteers to fill bags is

generally required. In circumstances where the walls have water seepage, pumps can be utilized to move water from the land side to the watercourse as necessary.

Temporary measures are not an ideal solution and should only be utilized where there is no reasonable alternative. In higher risk flood areas, more permanent measures should be considered.

2.2.1.2 Permanent Flood & Erosion Mitigation Measures

There are several permanent structural flood mitigation measures that can be utilized during a lake-flood event, including but not limited to, waterproofing existing infrastructure, raising existing infrastructure, erosion proofing existing infrastructure, installing wave dampening measures, controlling flows, relocating infrastructure, and collecting an inventory of install-ready replacement equipment. The permanent mitigation measures above are further discussed herein. Often, the solutions discussed below are combined to mitigate flood risk.

A – Waterproofing

Waterproofing existing infrastructure or infrastructure components can be a fast and efficient way to permanently mitigate submergence risk. Waterproofing infrastructure such as manholes, lift stations, control vaults, electrical kiosks, and pumphouses is something that can be done without significant capital investment or alteration to existing infrastructure. Methods of waterproofing for larger structures, like pumphouses, control vaults, or control buildings can be done by means of wet or dry flood proofing as outlined in *section 2.1.2.2,* as many of the existing internal components can be submerged.

B – Raising

Raising existing infrastructure that is below the FCL may be deemed necessary if access to the infrastructure during a flood event is necessary, or waterproofing is not feasible. When raising infrastructure, it should be raised to the FCL outlined in the Town's bylaw. In most circumstances, raising electrical equipment associated with the Town's infrastructure is one of the most critical components of permanent flood mitigation.

C – Erosion Protection

Where the infrastructure is at risk of erosion from wave action, erosion protection by means of, riprap placement, structural landscaping, material placement, addition of geofabrics, or other methods of erosion protection should be implemented.

D – Wave Dampening

Wave dampening methods can be utilized to reduce wave amplitude prior to the wave reaching the structure. This helps control erosion and lower overall flood risk as energy is removed. Methods of wave dampening that can potentially be utilized by the Town include placement of large concrete blocks (in the order of 3 to 4 tonnes in size) in the direct path of wave action. By placing concrete blocks in the path of incoming waves causes the wave energy to be partially reflected lakeward, and thus protecting the infrastructure behind it. If the water levels are high enough, the concrete blocks can trip the wave, and take most of its energy out, thus reducing the potentially adverse effects.

E – Flow Control Measures

If the Town's sanitary systems become overwhelmed because of inflow and infiltration into the submerged sanitary system, failure of the downstream system can be mitigated by installing plug valves in the sections of gravity main that are expected to be submerged during the flood event.

F – Relocating

In cases where raising or water proofing is not feasible, the risk of erosion is high, or the existing infrastructure needs replacement, relocation of the infrastructure to an area of higher elevation may be required.

G – Install-Ready Backup Equipment

In cases where flooding is inevitable, having install-ready spare equipment is critical for getting infrastructure operational swiftly after flooding. Install-ready equipment may include spare pump motors, electrical control equipment, etc.

The advantages and disadvantages of the permanent mitigation measure activities outlined above are summarized in the table below.

TABLE 2-1: PERMANENT FLOOD MITIGATION MEASURES

Item	Measure	Advantages	Disadvantages
A	Waterproofing	▪ Protects vulnerable infrastructure from water damage ▪ Infrastructure can be waterproofed instead of relocated in many cases. ▪ Lower capital cost in many cases compared to raising/relocating	▪ Inaccessible when submerged ▪ Some waterproofing solutions may require additional maintenance and monitoring ▪ Some waterproofing solutions may make regular maintenance more difficult ▪ Cannot easily access during flood event

Item	Measure	Advantages	Disadvantages
B	Raising	▪ Infrastructure is above the FCL ▪ Accessible during flood event ▪ In most cases, less costly than relocation	▪ Can make regular accessibility more difficult ▪ High cost in certain cases ▪ Can negatively affect community aesthetics ▪ Infrastructure may still be inaccessible if access submerged
C	Erosion Protection	▪ Protects infrastructure from land erosion ▪ Reduces risk to the public	▪ Potential disturbance to Lake foreshore ▪ Does not provide flood protection ▪ May alter existing hydraulic characteristics
D	Wave Dampening	▪ Protects infrastructure from land erosion ▪ Reduces wave height at infrastructure ▪ Dissipates wave energy	▪ Does not provide protection from flooding ▪ Often needs to be used in combination with other flood mitigation strategies ▪ Requires land area to install ▪ May require specialized engineering analysis
F	Relocating	▪ Moves critical infrastructure out of flood hazard zone or above FCL. ▪ Allows Town to install new, updated equipment	▪ High capital cost ▪ Significant disturbance ▪ Potential land acquisition issues
G	Install-Ready Backup Equipment	▪ Fast installation following failure ▪ Mitigation solution when no other options are available.	▪ During flooding, equipment may fail ▪ Cannot install until flooding has stopped

2.2.2 Retreat Development

This should be used as a last resort but in some scenarios, this may be the best available option. In essence, this increases the setback from a watercourse by withdrawing existing development. For the Town, this would imply purchasing or otherwise acquiring floodplain land which would then be converted to an alternative land use designation through the methods as discussed in Section 2.1. In addition to protecting vulnerable development, this often lends itself to restoration of a watercourse to its natural state. This method of flood mitigation is a combination of both structural and non-structural methods as it requires a physical retreat from the floodplain, however; stringent regulatory tools will be necessary to successfully achieve this mitigation strategy.

3.0 Floodplain Mapping

Previous floodplain mapping completed by the Okanagan Basin Water Board, and summarized in NHC (2020), provides an example of recent mapping that is available within the Town's administrative boundary. Given that the 2020 mapping included the entire Okanagan mainstem, a high level of detail could not be applied to any individual shoreline reach (particularly related to wave induced hazards). Instead, the 2020 mapping applied simplifying assumptions and generalization which were necessary to complete the exercise. The NHC (2020) report clearly states that wave effects vary and are influenced by foreshore slope and surface treatment (grass vs rock foreshore). The previous mapping included a single representative transect (with an assumed slope and surface treatment) which was used to estimate wave related hazards for entire shoreline within the Town's boundary. The Town's shoreline is not uniform, but rather has a variety of foreshore types (rock revetments, sand beaches, gentle slopes, steep slopes). Using a single representative transect implies that wave effects could be underestimated for some reaches and overestimated for others.

The work carried out in this project builds upon the previous work. Tools used to quantify the wave related hazards are the same as in the NHC (2020) report. The emphasis in this work is on providing additional detail and considering site specific shoreline characteristics. A total of twenty four transects have been used within the Town's administrative boundary to quantify wave related effects and estimate a zone where wave action is anticipated to be heaviest. The transects in this work represent actual shoreline characteristics, rather than generalized (and simplified) shoreline features.

Shoreline around the perimeter of Osoyoos Lake is influenced by winds blowing over the large fetches of open water. Winds provide energy to the water's surface, which ultimately transforms into waves. The larger the fetch, the higher the waves. In lakes, winds generate waves.

3.1 Scope of Floodplain Mapping

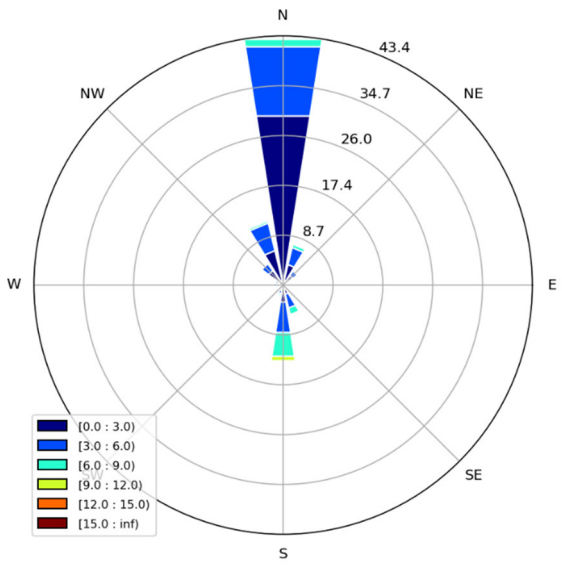
To estimate wave effects in this project the following tasks were completed:

1. Quantification of the representative wind climate,
2. Identification of a 200-yr design still water levels,
3. Collection of bathymetric soundings,
4. Numerical simulations of wind generated waves in the lake,
5. Propagation of waves from deep water to the shoreline,
6. Propagation of waves inland (for low crested shorelines),
7. Identification of a zone where wave induced effects are highest,
8. Estimation of wave runup based on existing and proposed shoreline treatments,

9. Estimating Flood Construction Levels, and
10. Preparation of a map for use by the Town staff and the public

3.2 Wind Climate

To establish wind climate for Osoyoos Lake, wind data collected at the Penticton Airport was used. Use of this station was identified by NHC (2020) as it best represents conditions relevant at Osoyoos. Hourly wind speed and directions were downloaded from the Canadian CWEEDS wind database, and processed accordingly. Historic wind observations were filtered to include winds from March to August, as those are winds that coincide with periods of high water level. Wind rose from the Penticton Airport is shown in Figure 3-1, with percent of occurrence shown in Table 3.



Direction [-]	Occurrence [%]
N	43.40
NNE	7.31
NE	3.08
ENE	0.93
E	0.9
ESE	0.5
SE	1.55
SSE	5.57
S	13.49
SSW	1.93
SW	1.06
WSW	0.83
W	1.69
WNW	1.50
NW	4.77
NNW	11.49

FIGURE 3-1: PENTICTON AIRPORT WIND ROSE BETWEEN MAR-AUG FOR YEARS 1953-2017

Time series data of wind speed and wind direction (for the Penticton airport record) were analyzed to estimate directional statistics. Annual maximum wind speeds were extracted for each direction on a 16-point compass. The annual maximum data (for each compass direction) were fit using the Gumbel statistical distribution (method of moments), which facilitated computation of wind speed magnitudes associated with various return periods.

TABLE 3-1: PENTICTON DIRECTION WIND CHARACTERISTICS BETWEEN MAR-AUG, YEARS 1953-2017

	Return Periods						
Dir [-]	2-yr [m/s]	5-yr [m/s]	10-yr [m/s]	25-yr [m/s]	50-yr [m/s]	100-yr [m/s]	200-yr [m/s]
N	11	13.2	14.6	16.4	17.8	19.1	20.5
NNE	9.2	10.5	11.3	12.4	13.2	14.0	14.8
NE	7.2	8.4	9.2	10.2	11.0	11.7	12.5
ENE	5.5	7.1	8.2	9.5	10.5	11.5	12.4
E	5.2	6.6	7.6	8.8	9.6	10.5	11.4
ESE	4.9	6.7	7.9	9.5	10.6	11.8	12.9
SE	7.0	9.2	10.7	12.6	14.0	15.3	16.7
SSE	10.0	12.2	13.6	15.5	16.9	18.2	19.6
S	13.6	15.3	16.5	17.9	19.0	20.1	21.2
SSW	10.2	12.1	13.3	14.9	16.0	17.2	18.3
SW	8.2	10.8	12.5	14.6	16.2	17.8	19.3
WSW	8.9	10.7	11.8	13.3	14.4	15.5	16.6
W	9.7	11.7	12.6	14.1	15.2	16.2	17.3
WNW	8.2	9.4	10.2	11.2	12.0	12.7	13.5
NW	8.5	9.8	10.6	11.7	12.5	13.3	14.1
NNW	9.6	11.5	12.7	14.3	15.4	16.6	17.7

Design wind climate derived from the wind data consisted of the following:

200-yr wind speed of 20.5 m/s from the North, and

200-yr wind speed of 21.2 m/s from the South

3.3 Design Water Level

The design water level used in this work is set as the 200-yr mid-century water level (NHC, 2020), which is reported as 280.2 m in the CGVD28 vertical datum. All elevations referenced in this Flood Mitigation Plan are referenced to the CGVD28 vertical datum. Further information regarding vertical datums is contained in Appendix D.

3.4 Bathymetry

TRUE Consulting survey crew used an echo sounder mounted on a small boat with an outboard motor to collect bathymetric soundings within the project limits. The soundings were collected from approximately 200 m offshore to the shoreline. A total of thirty nine transects were surveyed within the Town limits. Bathymetry was processed by our survey crew, and provided to engineering staff for wave propagation modeling.

3.5 Wind Generated Wave Modeling

To characterize the wave climate a SWAN (Simulating WAves Nearshore) numerical model was used (same model as in the previous NHC, 2020 mapping). SWAN is an open source spectral wave model developed at the Technical University of Delft, Netherlands. The SWAN model solves the spectral action balance equation which captures the effects of spatial wave propagation, refraction, shoaling, generation, dissipation and nonlinear wave-wave interactions. Processes of wave breaking, bottom friction and (simplified) diffraction effects have been included in the SWAN simulations carried out in this work.

The most important feature of SWAN relating to the current project is its ability to estimate the growth and propagation of wind generated waves. SWAN, like all spectral wave models, uses parameterization of the wind drag stress to impose forcing on the water body. Recently updated empirical formulations are included in the source code of the model.

The SWAN model was built using Osoyoos Lake bathymetric soundings (available from the Province and supplemented with the bathymetry collected in this work). A numerical model grid consisting of a 50 m grid was set up for the north and south portions of the lake (see Figure 3-2). Water level of 280.2 m CGVD28 was set in the model, and design winds applied over the surface of the water (20.5 m/s from the North, and 21.2 m/s from the South). The model was simulated, which produced wind generated waves at locations approximately 200 m offshore.

FIGURE 3-2: SWAN NUMERICAL WATER MODEL DOMAIN

FIGURE 3-3: SWASH NUMERICAL MODEL TRANSECT LOCATIONS

3.6 Wave Propagation Modeling

A transect based wave model was used to propagate the wind generated waves to the shoreline. SWAN's sister program SWASH (Simulating WAves til SHore) was used for wave propagation. SWASH is a phase resolving wave model that captures several nearshore processes (such as wave setup, wave transformation and breaking, wave uprush and overtopping). The SWASH model computes inland propagation of the wave bore (which occurs in conditions when extreme

high water level causes incoming waves to overtop the table land, thus allowing waves to propagate inland).

A total of twenty four transects were set up (using collected soundings for below water and Provincial LiDAR for above water topography), see Figure 3-3. A grid spacing of 1 m was used in the SWASH model to capture the necessary detail in the wave propagation simulations. Wind generated waves (from the SWAN model) were applied at the offshore limit of each transect.

The SWASH model was used to identify wave characteristics near the shoreline (wave height, period and direction) that was subsequently used in the computations of wave uprush. SWASH was also used to estimate wave propagation over inland areas and estimate wave induced effects in ponded areas (where wave effects are anticipated to be smaller).

3.7 Zone of High Wave Hazard

Shoreline reaches directly exposed to wave attack, in particular during times of high water levels, generate most severe wave effects. Such zones are more vulnerable to wave attack and are therefore delineated separately on floodplain mapping. In this project, this zone is defined using the United States Federal Emergency Management Agency's term called LiMWA (limit of moderate wave action). Line delineating LiMWA represents the approximate landward limit of the 0.45 m breaking wave.

Output of the SWASH model was analyzed to estimate the location where wave height reaches 0.45 m (the location of LiMWA). The extent of LiMWA was delineated on the mapping, and was generally found to be approximately 30 m +/- distance inland from the normal water level.

Developments lakeward of LiMWA are thus required to have a higher standard than other areas that are flooded (and where wave action is much less severe).

3.8 Wave Runup

Wave runup is estimated by computing a parameter that is referred to as R2% (two percent wave runup). R2% is defined as the height above design water level that two percent of the waves will reach, or exceed. In this work, the R2% quantity is referred to as wave runup, or wave induced effects.

The SWASH wave model was used to extract the wave characteristics (wave height, period and direction) at the shoreline, and thus used in the computation of wave runup. The runup was estimated using equations presented in EuroTop (2018), considered as standard industry practice.

Wave runup estimates were made assuming the following shoreline types:

- 2H:1V rock slope
- 3H:1V rock slope
- 3H:1V grass slope
- 4H:1V grass slope
- 5H:1V grass slope

The computation of R2% included the following parameters: i) wave height at the toe of slope, ii) wave angle (runup was adjusted for oblique waves), iii) shoreline slope (see above), shoreline treatment (rock and grass).

The following are estimates of R2% (measured in meters above still water level) for the shoreline types considered:

R2% (m)	Shoreline type and slope
1.6	rock, 2H:1V
1.3	rock, 3H:1V
1.7	grass, 3H:1V
1.3	grass, 4H:1V
1.0	grass, 5H:1V

For areas landward of LiMWA, no wave runup shall be applied. Wave related hazard for areas landward of LiMWA are included in the mandatory 0.6 m freeboard.

3.9 Flood Construction Levels

Flood Construction Level (FCL), in the context of large inland lakes, is defined as the following (see Figure 3-4):

A. For areas where wave effects are deemed to be significant (lakeshore flood zone located lakeward of LiMWA):

   FCL = 200-yr mid-century design water level (280.2 m) + wave runup (ranges from 1.0 to 1.6 m depending on shoreline treatment) + freeboard (0.6 m)

B. For inland (ponded) flood areas where wave effects are anticipated to be minor:

FCL = 200-yr mid-century design water level (280.2 m) + freeboard (0.6 m)

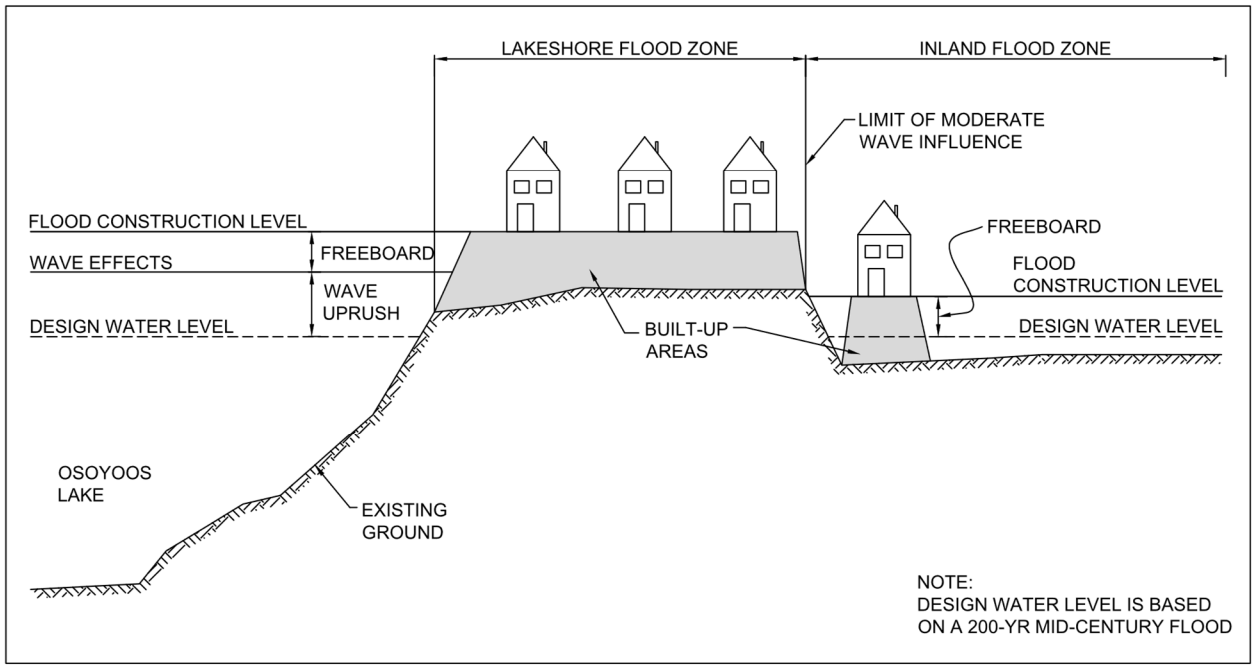


FIGURE 3-4: FLOOD CONSTRUCTION LEVEL DEFINITIONS

3.10 Floodplain Mapping

The lakeshore flood and wave related hazards have been mapped and complied using GIS software. The updated mapping is contained in Appendix A in simplified and detailed versions. These maps may be utilized by the Town for updating the OCP and generating a Floodplain Bylaw. The results of the mapping have also been placed on a user-friendly, web map interface, linked in Appendix B. The mapping includes:

- Flood inundation levels and their corresponding return period (no freeboard),
- Limit of Moderate Wave Influence
- Flood Construction Levels (incl. freeboard).

Upon finalization of this report, mapping will be provided on paper in addition to GIS formats, to support future spatial analysis that is anticipated for Flood Mitigation Planning.

4.0 Stakeholder Consultation

The stakeholder engagement plan requires input from the Town based on the technical information generated from TRUE's analysis. Following consultation with the Town we will begin work on the stakeholder engagement plan, in preparation for stakeholder and community engagement consultation.

Remaining stakeholder consultation shall take place after this report has been completed. The extent of the remaining stakeholder consultation process will depend on the preference and desire of the Town Staff and Council. Previous floodplain mitigation projects in the Province have been completed with a range of stakeholder consultation processes, ranging from limited (with only municipality offering comments) to extensive (with public, Municipality and/or Regional District, First Nation, FLNRORD and MOTI offering comments).

5.0 Priority Ranking

The priority rank of each structural and non-structural mitigation project identified during this analysis were assessed utilizing a decision matrix that weighed:

- Number of users impacted by failure,
- Consequence of failure,
- Flood vulnerability elevation & associated flood frequency,
- Erosion potential,
- And flood depth

The priority ranking of the projects serves as a general guide for which mitigation projects should be executed first. Numerical priority rank scores were simplified into classifications of "high", "medium", and "low" for simplicity. The projects and their associated priority ranking are further detailed in Table 6-1.

6.0 Flood Mitigation Plan

6.1 Implementation

This flood mitigation plan will act as a living document to be updated and revised as necessary based on Town projects and/or as existing data becomes more refined. This flood mitigation plan should be revisited and reissued every 5 years at a minimum. Additionally, revisions should be made as any relevant changes occur throughout the Town. It will take several years to implement the flood mitigation plan as there are many moving parts. The general timeframe will depend on funding availability and ability to complete design and construction of individual projects as recommended in addition to the creation and adoption of new bylaws.

Sections 6.2, and 6.3 provide the non-structural and structural flood mitigation plan for the Town of Osoyoos. These activities have been prioritized in Section 6.4.

6.2 Non-Structural Flood Mitigation Plan

6.2.1 Update & Modify Town OCP (Project L1.0)

The Town OCP should be updated to include the revised floodplain map (contained herein), and additional regulatory information associated with the updated findings from the most recent analysis.

6.2.2 Create Town Floodplain Bylaw (Project L2.0)

Develop a local government floodplain bylaw that applies to the OCP-defined floodplain area that will subsequently be adopted by council. The local government floodplain bylaw will be inclusive of the following elements at a minimum:

- Floodplain setbacks
- Wave action measures
- Flood construction level
- Floodproofing requirements
- Modification to existing structure and/or properties
- Covenants

The floodplain bylaw can replace Section 5 – Flood Proofing Provisions of the existing Town of Osoyoos zoning bylaw, with applicable updated information.

6.2.3 Assemble a Flood Response Plan (Project P1.0)

The Flood Response Plan (FRP) will provide the Town with a detailed outline of activities to follow in the event of a flood. The FRP will be assembled in a staged manner that outlines response activities based on Osoyoos Lake water levels. This FRP will be an important Town asset that will reduce the impact of damage of natural hazards to people, property, and infrastructure. Most flooding events allow an adequate warning period to implement an effective emergency flood response plan. This warning period is an important factor in developing the Town's flood response plan and should be discussed in detail within the plan.

6.2.4 Investigation (Projects I1.0 – I4.0)

In order to understand the existing infrastructure within the Town and the extent of risk at each potential location, data collection is paramount. It is recommended that the Town complete the following tasks to achieve better knowledge of their current systems:

- Complete video inspection (CCTV) of the existing sanitary system in the flood hazard area. This will provide data related to the current condition of the Town's sanitary infrastructure. A more accurate risk assessment can then be conducted that will dictate which areas require higher priority focus.
- Complete infiltration and inflow (I&I) analysis of the sanitary system in the flood hazard area. The I&I study will provide the Town with a better understanding of the groundwater and/or watercourse entering into the existing infrastructure. This may result in either relocating or replacing the existing mains and manholes to avoid the I&I, or waterproofing existing mains and manholes (assuming their condition is adequate based on the CCTV study) to better protect the overall system from infiltration and potential capacity exceedance.
- Complete a condition assessment of the Crowsnest Highway Bridge to facilitate potential infrastructure crossing upgrades and/or structural upgrades as deemed necessary.
- Complete a condition assessment of the lakeshore and low-lying retaining walls to facilitate potential upgrades or mitigation.

6.3 Structural Flood Mitigation Plan

Implementation of individual projects falls under the vein of Structural Flood Mitigation as discussed in Section 2.2 and will generally require the following elements.

- Pre-Construction Activities
  - Grant funding applications with the aid of this Flood Mitigation Report
  - Land acquisition as necessary
  - Studies and Assessments
  - Engineering, design, and tender process
- Construction Activities
  - Survey layout and control
  - Engineering inspections
  - Grant progress reporting
  - Environmental and archaeological monitoring and reporting as necessary
- Post-Construction Activities
  - Grant Reporting
  - Final survey
  - Record Drawings
  - Update Flood Mitigation Report
  - Update all other applicable Town reports i.e., Asset Management Plan etc.

A summary of the recommended projects to be completed throughout the Town of Osoyoos to address the existing flood risks is provided herein.

6.3.1 Water Supply Well Protection (Projects W1.0-W4.0 & WI1.0)

Many of the Town's water supply well are at risk of flooding and wave attack. As outlined in the table below, most of the well houses are set with a main floor elevation of approximately 280.0m.

TABLE 6-1: WATER INFRASTRUCTURE MITIGATION PROJECTS

Project Number	Project	Critical Infrastructure Elevation (m)	Corresponding Return Period for Critical Infrastructure (m)	Flood Vulnerability Elevation (m)
W1.0	Cottonwood Park Wells No.4&5	280	100	278.4
W2.0	Well No.8 - Kingfisher Drive	280.2	200	279.2
W3.0	Well No. 1 - Splash Park	280	100	280
W4.0	Well No. 3 Maple Drive	279.7	50	279.7
WI1.0	Pumphouse #9 Wellhouse & Intake	280	100	280

Based on the updated modeling and wave hazard analysis, the 200-year static Osoyoos Lake level is expected to rise 0.1m, to 280.2m. In the updated analysis, wave action has been considered, which highlights additional risk to the water infrastructure near the Osoyoos lake shoreline. Some typical structural mitigation measures proposed for the existing water infrastructure are as follows:

- Raising electrical control equipment and components within the building
- Installing erosion protection and wave reduction measures where necessary
- Installing waterproofing measures

Specific mitigation details for each project are outlined in the project sheets contained in Appendix C.

Generally, the most immediate flood threat to the water system is electrical malfunction, and as such, raising electrical equipment in the pumphouses is the most critical aspect regarding flood mitigation works.

6.3.2 Sanitary System Mitigation (Projects LS1.0-13.0 & SM1.0-9.0)

The Town's sanitary system generally consists of gravity collection systems that flow into lift stations. The lift stations pump from the North, East, South, and West extremities of the Town. In most cases, sanitary flows compound in the system as they travel to the center of town, and thus, lift stations increase in size (pumping capacity). All sanitary flows collect at the "Main Lift" station located near the center of town. The Main Lift station collects the sanitary water, process it, and pump it to the sewage lagoons, high above Town.

6.3.2.1 Lift Stations (LS1.0-13.0)

Many of the Town's lift stations and their associated infrastructure are at risk of being impacted by high flood waters and waves. As well, some of the low lying gravity manholes are at risk of submergence. If the manholes are not waterproofed, either temporarily or permanently, submergence will cause significant inflow and infiltration (I&I), which may overwhelm the sanitary lift stations causing surcharging of the sanitary system. Furthermore, many of the lift stations have electrical components that are at risk of high flood waters, if the electrical components become submerged there is significant risk of lift station failure. The lift stations at risk of flood water damage are outlined in the table below.

TABLE 6-2: SANITARY LIFT STATION MITIGATION PROJECTS

Project Number	Project	Critical Infrastructure Elevation (m)	Corresponding Return Period for Critical Infrastructure (m)	Flood Vulnerability Elevation (m)	Pump Capacity (L/s)
LS1.0	Starlite Lift Station	279.5	50	278.5	65
LS2.0	Lakeshore Dr & 44th Ave Lift Station	280	100	278.7	40
LS3.0	Oasis Lift Station	279.3	20	278.3	16
LS4.0	Main Lift	280.7	200	279.7	180
LS5.0	North Cottonwood Lift Station	279.3	20	279.3	22
LS6.0	Blue Blinker Lift Station	279.9	100	278.6	13
LS7.0	Bayview Lift Station	279.5	50	279.5	8

Project Number	Project	Critical Infrastructure Elevation (m)	Corresponding Return Period for Critical Infrastructure (m)	Flood Vulnerability Elevation (m)	Pump Capacity (L/s)
LS8.0	Harbor Key Lift Station	279.2	20	278.2	18
LS9.0	Inkaneep Point (87th St) Lift Station	279.9	100	279.9	16
LS10.0	95th Street Lift Station	279.9	100	279.9	14
LS11.0	Crab Apple Ct (Lacey Point) Lift Station	279.6	50	279.6	9
LS12.0	Haynes Point Lift Station	279.9	100	279.9	13
LS13.0	Roberts Point Lift Station	280.6	200	280.6	16

Typical flood and erosion structural mitigation options for the lift stations are:

- Raise the electrical kiosk or components in the electrical kiosk to an elevation outside of the flood hazard,
- Supply and install quick disconnection for electrical components in the control valve vaults
- Supply and install plug valves on the gravity mains into the lift stations
- Supply and install backflow preventers in the control valve vault floor drain
- Supply and install erosion protection and wave dampening measures at the lift station site
- Inspect the existing lift station lid seals and ensure they are waterproof.

Generally, the most immediate threat to the lift stations is submergence of the electrical system, as it can causes failure if the electrical components are not waterproof. In most cases, electrical equipment for the lift station is unique and requires long lead times to replace.

6.3.2.2 Manholes (SM1.0-9.0)

The location, quantity, and general submergence elevation for the manholes at risk of flooding are outlined in the table below:

TABLE 6-3: SANITARY MANHOLE MITIGATION PROJECTS

Project Number	Manhole Location	Approximate Rim Elevation Range(m)	Corresponding Return Period for Rim Elevation (m)	Quantity of Manholes to be Waterproofed
SM1.0	Osoyoos Lakeshore	278.1-279.6	2-50	0 (Already Complete)
SM2.0	Solana Key Court	279	10	5
SM3.0	Harbour Key Drive	279	10	13
SM4.0	Magnolia Place	279	10	4
SM5.0	Bayview Crescent	279.3	20	3
SM6.0	Maple Drive	279.3	20	1
SM7.0	Ponderosa Drive	279.3	20	3
SM8.0	Cottonwood Drive	279.6	50	3
SM9.0	Lakeshore Drive	279.6	50	12

Typical permanent flood and erosion structural mitigation options for the manholes are:

- Supply & install waterproof manhole lids
- Install additional grout as needed between the manhole rings.

It has been proposed that all manholes below the 1:50-year lake level, 279.7m, be updated to have waterproof lids. Manholes at a greater elevation will be temporarily waterproofed when flooding above 279.7m is expected.

6.3.3 Public Infrastructure Improvements (Project M1.0)

During the mitigation planning it was discovered that public infrastructure such as roads, pathways, parks, and washrooms could mainly be addressed through temporary or non-structural mitigation actions that will be detailed in a future Flood Response Plan (see project sheet NS-3). At the time of this report, the only piece of public infrastructure that requires permanent mitigation measures is the Osoyoos Marina. Permanent structural mitigation measures at the Osoyoos

Marina include installation of erosion protection at the wave breaks, on top of the retaining walls, and in front of the Lake Osoyoos Sailing Club, as well as raising pilings to ensure the docks do not become detached during high flood waters.

6.4 Project Prioritization

The recommended projects listed throughout this section have been prioritized in Table 6-1 and are ranked high, medium, and low. As projects are successfully undertaken and/or refined over time, this Flood Mitigation Plan should be revised to reflect these changes and the priority levels should be adjusted accordingly. Table 6-1 provides an independent list for each of the non-structural and structural flood mitigation priorities as they do not depend on each other, and grant funding is generally awarded for each category separately.

Each mitigation item has a project sheet and Class D cost estimate associated with it and is provided in Appendix C. These project sheets provide a brief project description and high-level cost estimate to enable the Town to plan and readily apply for funding based on these defined project scopes.

TABLE 6-4: FLOOD MITIGATION PRIORITIES AND STRATEGIES

Non-Structural Flood Mitigation Priorities				
Project No.	**Priority**	**Mitigation Approach**	**Description**	**Project Sheet Reference**
L1.0	High	Land Use Management	Update & Modify Town of Osoyoos OCP	NS-1
L2.0	High	Land Use Management	Update Floodplain Bylaw	NS-2
P1.0	High	Preparedness	Flood Response Plan	NS-3
I1.0	High	Investigation	Crowsnest Hwy Bridge	NS-4
I2.0	Medium	Investigation	Retaining Walls	NS-5
I3.0	Medium	Investigation	CCTV inspection	NS-6
I4.0	Medium	Investigation	I&I Study	NS-7
Structural Flood Mitigation Priorities				
Project No.	**Priority**	**Mitigation Approach**	**Description**	**Project Sheet Reference**
W1.0	High	Protect Development: Waterproofing, Raising, Erosion Protection	Cottonwood Park Wells No.4&5	S-1
W2.0	High	Protect Development: Raising, Erosion Protection	Well No.8 - Kingfisher Drive	S-2
W3.0	High	Protect Development: Raising, Waterproofing	Well No. 1 - Splash Park	S-3
W4.0	High	Protect Development: Raising, Waterproofing	Well No. 3 Maple Drive	S-4
LS1.0	High	Retreat Development: Relocation, Flow Control	Starlite Lift Station	S-5
LS2.0	High	Protect Development: Erosion Proofing, Wave Dampening, Waterproofing, Raising, Flow Control	Lakeshore Dr & 44th Ave Lift Station	S-6
LS3.0	High	Protect Development: Erosion Proofing, Wave Dampening, Waterproofing, Raising	Oasis Lift Station	S-7
LS4.0	High	Protect Development: Erosion Proofing, Waterproofing, Wave Dampening	Main Lift	S-8

Structural Flood Mitigation Priorities (Cont.)				
Project No.	**Priority**	**Mitigation Approach**	**Description**	**Project Sheet Reference**
SM1.0	High	Protect Development: Waterproofing	Osoyoos Lakeshore	S-9
WI1.0	Medium	Protect Development: Raising, Install-Ready Backup Equipment	Pumphouse #9 Wellhouse & Intake	S-10
LS5.0	Medium	Protect Development: Raising, Waterproofing	North Cottonwood Lift Station	S-11
LS6.0	Medium	Protect Development: Wave Dampening, Erosion Control, Raising, Waterproofing, Flow Control	Blue Blinker Lift Station	S-12
LS7.0	Medium	Protect Development: Wave Dampening, Erosion Proofing Raising, Waterproofing, Flow Control	Harbor Key Lift Station	S-13
SM2.0	Medium	Protect Development: Waterproofing	Solana Key Court	S-14
SM3.0	Medium	Protect Development: Waterproofing	Harbour Key Drive	S-14
SM4.0	Medium	Protect Development: Waterproofing	Magnolia Place	S-14
LS8.0	Medium	Protect Development: Raising, Waterproofing, Flow Control, Erosion Control & Wave Dampening	Bayview Lift Station	S-15
LS9.0	Medium	Protect Development: Raising, Waterproofing, Flow Control	Inkaneep Point (87th St) Lift Station	S-16
LS10.0	Medium	Protect Development: Raising, Waterproofing, Flow Control	95th Street Lift Station	S-17
LS11.0	Low	Protect Development: Raising, Waterproofing, Flow Control	Crab Apple Ct (Lacey Point) Lift Station	S-18
LS12.0	Low	Protect Development: Raising, Waterproofing	Haynes Point Lift Station	S-19
LS13.0	Low	Protect Development: Raising, Waterproofing, Flow Control	Roberts Point Lift Station	S-20

Structural Flood Mitigation Priorities (Cont.)				
Project No.	**Priority**	**Mitigation Approach**	**Description**	**Project Sheet Reference**
SM5.0	Low	Protect Development: Waterproofing	Bayview Crescent	S-21
SM6.0	Low	Protect Development: Waterproofing	Maple Drive	S-22
SM7.0	Low	Protect Development: Waterproofing	Ponderosa Drive	S-23
SM8.0	Low	Protect Development: Waterproofing	Cottonwood Drive	S-24
SM9.0	Low	Protect Development: Waterproofing	Lakeshore Drive	S-25
M1.0	Low	Protect Development: Erosion Proofing, Raising	Osoyoos Marina	S-26

7.0 Recommendations and Subsequent Steps

The recommendations and conclusions of this report are based on the best available information at the time this document was prepared. As further investigative works are completed and additional data becomes available, this report can be refined.

This flood mitigation plan assesses areas and infrastructure at risk of flooding near Osoyoos Lake with respect to people and existing infrastructure. This risk is based on a 200-year flood event with consideration for both free board (factor of safety), climate change, and wave action. As defined throughout the report, there are both Non-Structural and Structural solutions that can be utilized to mitigate flood event impacts throughout the Town.

As outlined in Section 6.4, there is a list of 33 priority projects and activities to complete upon adoption of this Flood Mitigation Plan. Although this seems like a large quantity of projects, most can be completed simultaneously. The list allows the Town to focus on a few items at a time and as activities or projects are undertaken, these priorities can be adjusted and refined. A summary of the highest priority projects that are recommended for the Town's subsequent steps is as follows.

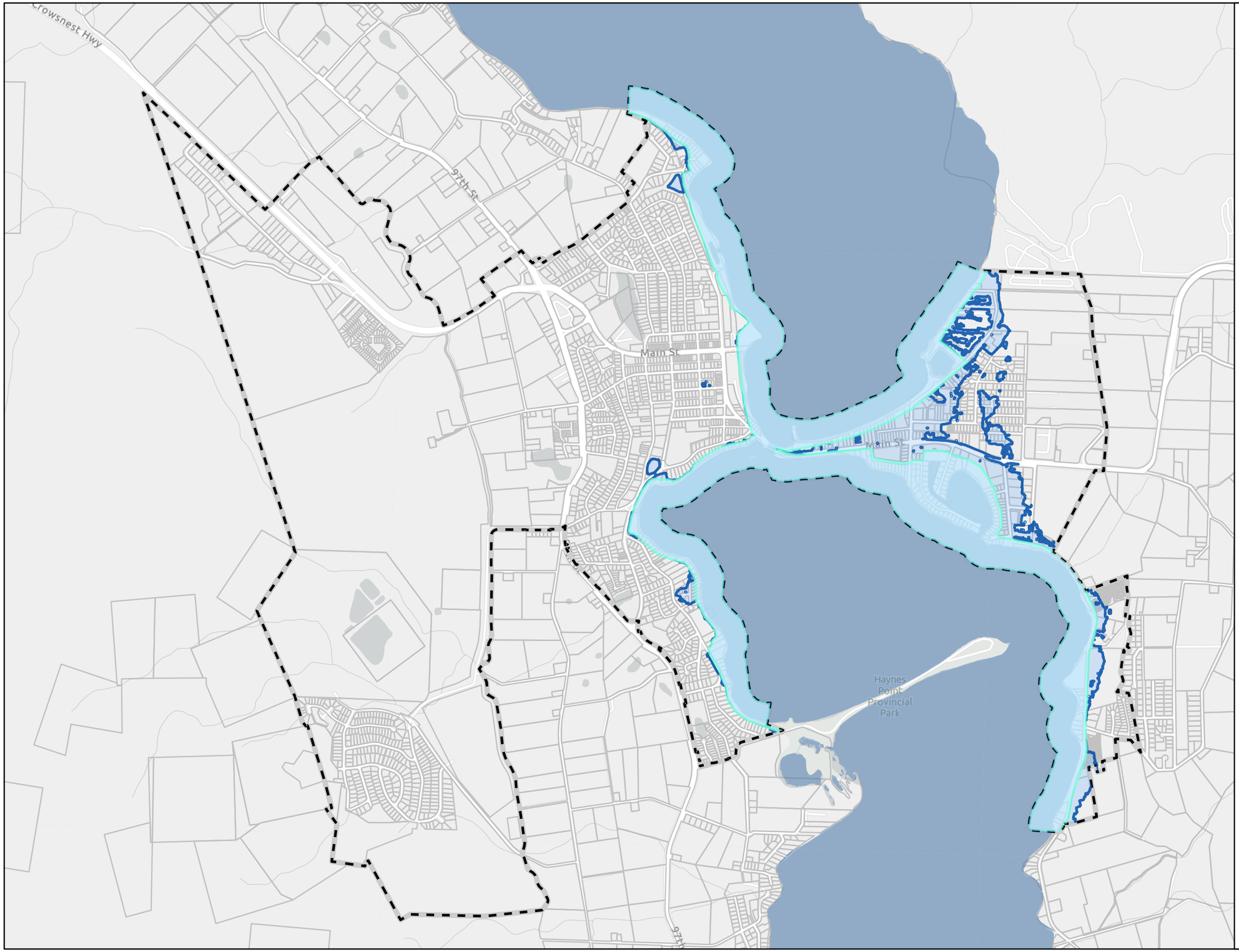
1. In consultation with the Town staff, TRUE Consulting to present the report findings at a Council meeting followed by a public meeting to discuss the Flood Mitigation Plan and its implementation process
2. Town of Osoyoos Council to adopt the completed Flood Mitigation Plan

3. Revise the existing OCP defining the active floodplain as determined in this Mitigation Report. Consider modifying any existing land use classifications at this time and include in OCP revision as necessary.
4. Update the existing Town of Osoyoos Floodplain Bylaw that addresses the elements as discussed in Section 6.2.2.
5. Create a Flood Response Plan for the Town of Osoyoos as discussed in 6.2.3.
6. Apply for grant funding and undertake the water and sanitary mitigation projects as outlined in Section 6.3, starting with high priority projects.

Upon completion of these items, this Flood Mitigation Plan should be updated to dictate the completed scope(s) in addition to revising the priority project lists. It is recommended that this report be reviewed and revised every 5 years at a minimum.

APPENDIX A

Floodplain Maps



Osoyoos
Canada's warmest welcome ®*

Floodplain Mapping
Osoyoos, B.C.
200 Year Floodplain Map

Flood Construction Level Lake Zone

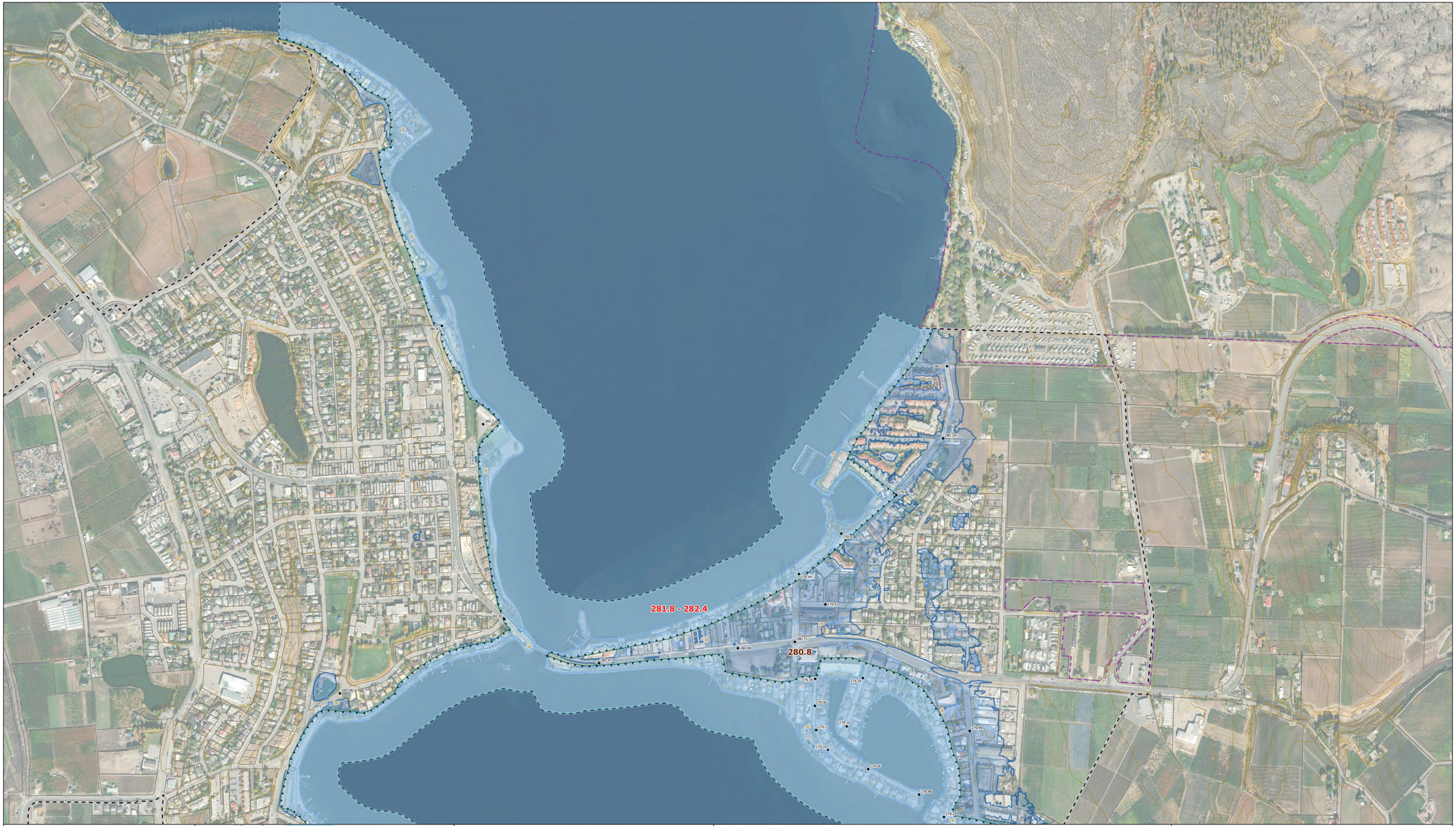
Flood Construction Level Shoreline Zone

Town Boundary

N

0 200 400 600 800 1,000
Metres

TRUE



Osoyoos
Canada's warmest welcome

Town of Osoyoos Floodplain Mapping
Osoyoos, B.C.
200 Year Floodplain Map

- Spot Elevation
  Labeled with elevation in metres CGVD28
- Minor Contour a: 1m Intervals
- Major Contour a: 5m Intervals
- Municipal Bouncary
- First Nation Reserve Boundary
- Limit of Moderate Wave Action (LiMWA)
- Inundation Extent - Design Without Freeboard
- 123.4 Inundation Extent With Freeboard (FCL)
  Labeled with elevation in metres CGVD28
- 123.4 Flood Construction Level (FCL) Shoreline Zone
  Labeled with elevation range in metres CGVD28

Footnote:
* FCL Shoreline Zone varies based on slope & treatment.

0 100 200 300 400 500 Metres

N

Reviewed by:	RA	Scale:	1:5,000
Revision #:	0	Issued for:	review
Datum: NAD 83 CSRS (Zone 11)		Drawn by:	RK/ET
Vertical Datum:	CGVD28	Date:	9/23/2022
Projection: Transverse Nercator		Project Ref No.	302-2001

TRUE

Figure A1

Sheet 1 of 2

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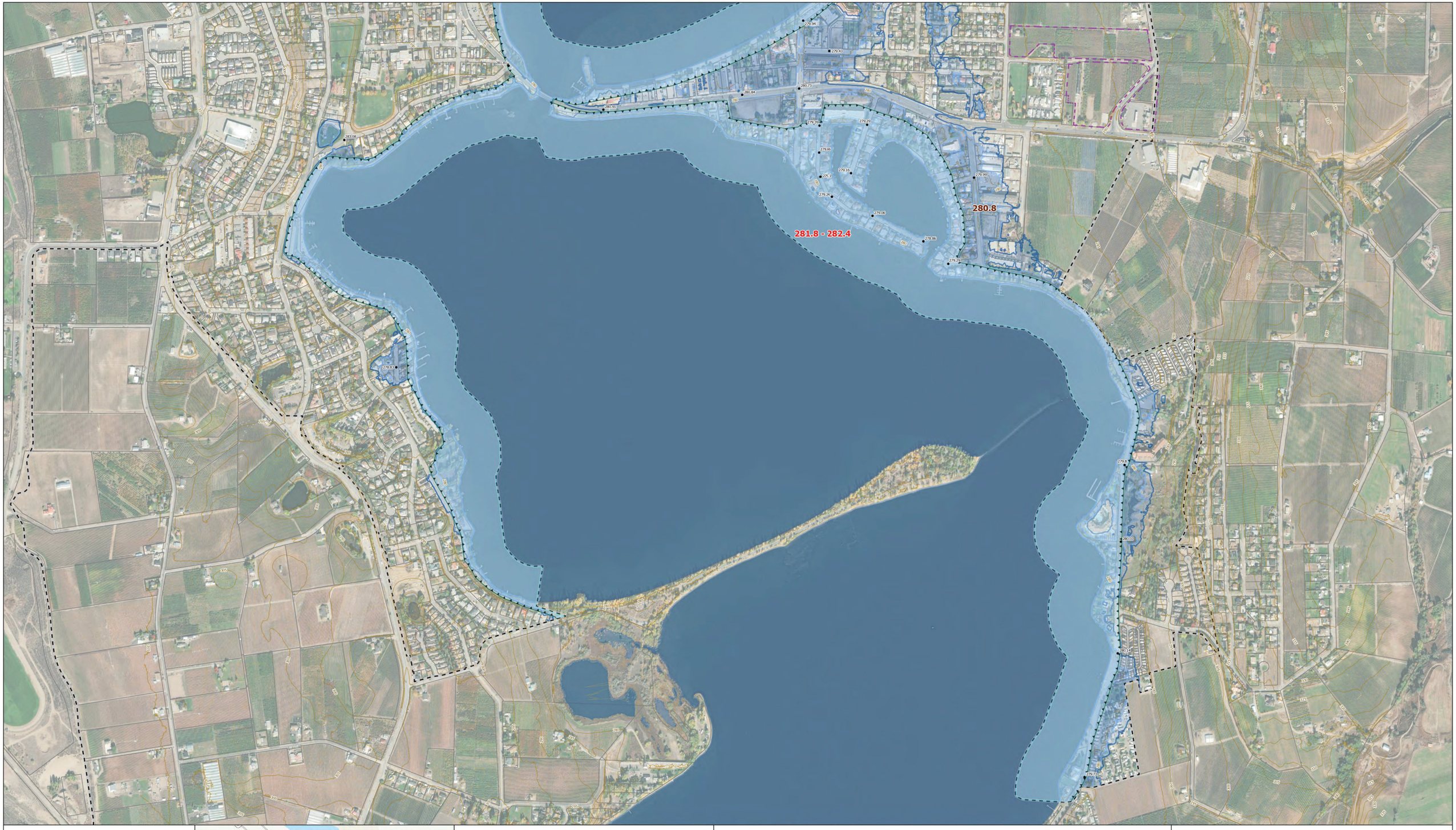

Osoyoos
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Town of Osoyoos Floodplain Mapping
Osoyoos, B.C.
200 Year Floodplain Map

- Spot Elevation
  Labeled with elevation in metres CGVD28
- Minor Contour at 1m Intervals
- Major Contour at 5m Intervals
- Municipal Bouncary
- First Nation Reserve Boundary
- Limit of Moderate Wave Action (LiMWA)
- Inundation Extent - Design Without Freeboard
- Inundation Extent With Freeboard (FCL)
  Labeled with elevation in metres CGVD28
- 123.4 Flood Construction Level (FCL) Shoreline Zone
  Labeled with elevation range in metres CGVD28

Footnote:
* FCL Shoreline Zone varies based on slope & treatment.

0 100 200 300 400 500 Metres

N

Reviewed by:	RA	Scale:	1:5,000
Revision #:	0	Issued for:	review
Datum:	NAD 83 CSRS (Zone 11)	Drawn by:	RK/ET
Vertical Datum:	CGVD28	Date:	9/23/2022
Projection:	Transverse Mercator	Project Ref No.	302-2001

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Figure A1

Sheet 2 of 2

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APPENDIX B

Interactive Web Map

Interactive Web Map Link: https://true-consulting.maps.arcgis.com/apps/mapviewer/index.html?webmap=2852f61099f541bf9c069f2db1dc7abf

APPENDIX C

Project Sheets and Class D Cost Estimate

NS-1: L1.0 - Modify & Update Town of Osoyoos Official Community Plan

Priority	High	**Type**	Non-Structural/Policy
Current Flood Vulnerability	varies	**Design Elevation**	varies

Description & Risk Profile

Based on the new floodplain and wave action analysis, the Town's existing Official Community Plan (OCP) "Hazard Areas – Flood Management" map and boundary should be updated.

Project Scope

Update the Town's OCP land use policy statements and maps defining the updated 200-year active floodplain and wave action area. The overall updates to the OCP should include:

- 200-year Floodplain map and wave action map within OCP
- Restrictions on the use of land subject to hazardous conditions whether it is flooding, erosion, or both
- Define the land within the floodplain map as a "designated development permit area" for the purpose of protecting the natural environment, it's ecosystems and biological diversity, and protection of development from hazardous conditions
- Description of special conditions and/or objectives that justify the development permit area justification and specifies how the special conditions and/or objectives will be addressed
- Adjustment to existing zoning bylaws to align with OCP changes as necessary
- Presentation to council for adoption of revised OCP

Capital Cost: $71,875

NS-1

Project L1.0 - Update & Modify Town of Osoyoos OCP

Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Project Initiation	LS	1	$4,200	$4,200
2.0	Background Information review	LS	1	$8,700	$8,700
3.0	Community & Stakeholder Engagement	LS	1	$18,600	$18,600
4.0	Floodplain Bylaw Preparation	LS	1	$14,500	$14,500
5.0	Floodplain Bylaw Finalization	LS	1	$11,500	$11,500
				Subtotal	**$57,500**
				Contingency (25%)	$14,375
				TOTAL	**$71,875**

NS-2: L2.0 - Floodplain Bylaw Creation

Priority	High	**Type**	Non-Structural/ Policy
Current Flood Vulnerability	280.7m	**Design Elevation**	varies

Description & Risk Profile

Once the Town's OCP is updated to include the new floodplain mapping & wave hazard areas, a floodplain bylaw should be created to ensure development permits are required within the designated development permit areas as defined in the OCP.

Project Scope

Develop a local government floodplain bylaw that applies to the OCP-defined floodplain area that will subsequently be adopted by council. The local government floodplain bylaw will be inclusive of the following elements at a minimum:

- Floodplain setbacks
- Wave action measures
- Flood construction level
- Floodproofing requirements
- Modification to existing structure and/or properties
- Covenants

Capital Cost: $71,625

NS-2.0

Project L2.0 - Floodplain Bylaw Creation

Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Project Initiation	LS	1	$4,200	$4,200
2.0	Background Information review	LS	1	$7,500	$7,500
3.0	Community & Stakeholder Engagement	LS	1	$16,600	$16,600
4.0	Floodplain Bylaw Preparation	LS	1	$15,000	$15,000
5.0	Floodplain Bylaw Finalization	LS	1	$14,000	$14,000

Subtotal	**$57,300**
Contingency (25%)	$14,325
TOTAL	**$71,625**

NS-3: P1.0 - Flood Response Plan

Priority	High	**Type**	Non-Structural/ Preparedness
Current Flood Vulnerability	varies	**Design Elevation**	varies

Description & Risk Profile

A flood response plan should be created for the Town to reference during a flood event. This plan can be used to monitor and respond to emergency conditions during high water levels throughout the Town of Osoyoos. The purpose of this Flood Response Plan will be to prevent any loss of life, minimize injury and trauma, and minimize damage to or loss of property resulting from flooding.

Project Scope

Assemble a flood response plan for the Town. This flood response plan should include an outline of activities to be taken at different stages (water levels at Zosel Dam) of a flooding event. This plan can be written in a staged manner by which depending on the flooding event, the associated reaction and/or location/s may vary.

The staged flood response plan would include, but not be limited to:

- Freshet planning activities (monitoring snow packs, river forecasts, etc.)
- Flood mapping of staged events (5-yr, 10-yr, 25-yr, 50-yr, 100-yr, and 200-yr)
- Trigger(s) to declare a Local State of Emergency
- Flood response team as subset of the EOC
- Temporary Flood Protection measures to be deployed (type, location, quantity)
- Triggers for declaring an Evacuation Alert
- Triggers for declaring an Evacuation Order
- Templates for statutory reporting requirements
- Communicating protocols
- Protocols for transitions from response to recovery

Most flooding events allow an adequate warning period to implement an effective emergency flood response plan. This warning period is an important factor in developing the Flood Response Plan and will be explored and discussed in detail within this plan.

Capital Cost: $134,200

NS-3.0

Project P1.0 - Flood Response Plan

Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Develop Flood Response Plan	LS	1	$107,000	$107,000
2.0	Public and council consultation	LS	1	$15,000	$15,000
				Subtotal	**$122,000**
				Contingency (10%)	$12,200
				TOTAL	**$134,200**

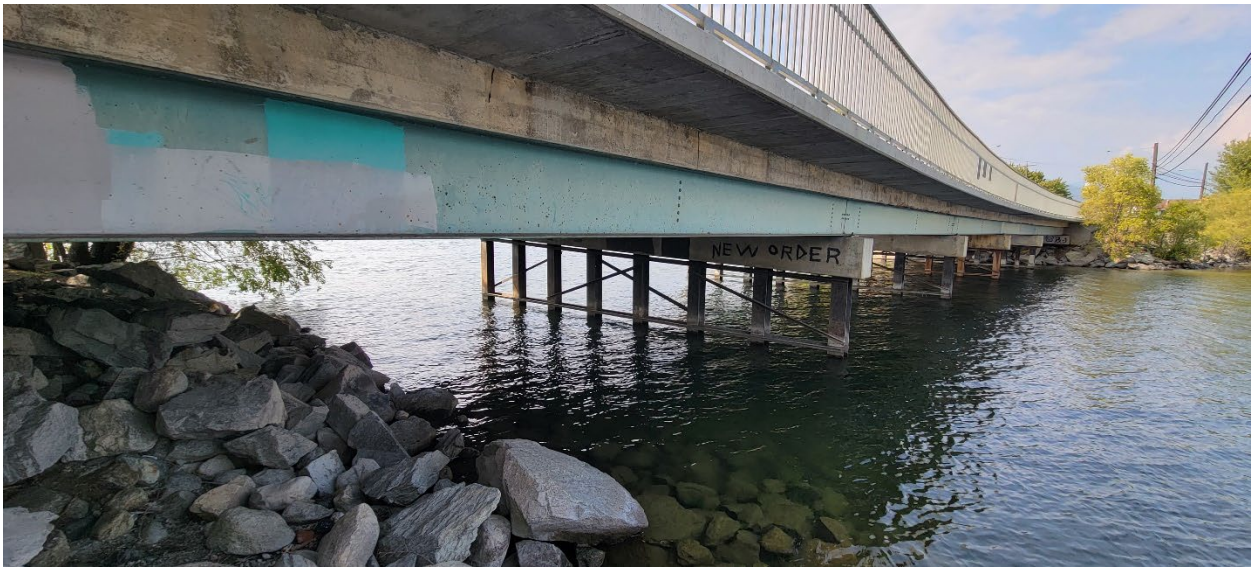
NS-4: I1.0 - Crowsnest Highway Bridge Updated Flood Level Investigation

Priority	High	**Type**	Non-Structural
Current Flood Vulnerability	280.3m	**Design Elevation**	TBD

Location Map

Streetview Map

Bridge Profile Photos (TRUE, 2022)



Description & Risk Profile

Crowsnest highway bridge, providing transportation and carrying a Town of Osoyoos watermain and sanitary forcemain.

Critical Infrastructure Elevations:

- Approximate Bridge Deck Elevation: 282.1m
- Approximate Bottom of girder elevation: 280.3m

Potential Risk to Infrastructure:

- High waters combined with wave action may cause direct impingement against the bridge girders. Bridge may not be designed for this.
- Erosion potential at bridge abutments.
- High water and wave action could cause damage to the Town's watermain and sanitary forcemain that run under the bridge.

Potential Risk to Public:

- Injury or death by bridge collapse
- Disconnection of Town
- Cross contamination between Osoyoos Lake and untreated sanitary water
- Evacuation of residences within the sanitary catchment area.
- Loss of water and fire fighting capacity

Scope of Work

- Execute a site-specific wave analysis to determine wave height at bridge
- Execute a site specific current analysis to determine water velocities in the bridge channel to determine if upgraded erosion protection is required
- Execute a structural review of the bridge to determine if mitigation is required
- Review utility (water, sanitary, electrical, etc) locations to determine if the infrastructure is at risk of flood impacts.
- Generate a site specific report of finding and mitigation solutions

Capital Cost: $TBD, following communications with the BC Ministry of Transportation & Infrastructure (MoTI)

NS-4.0

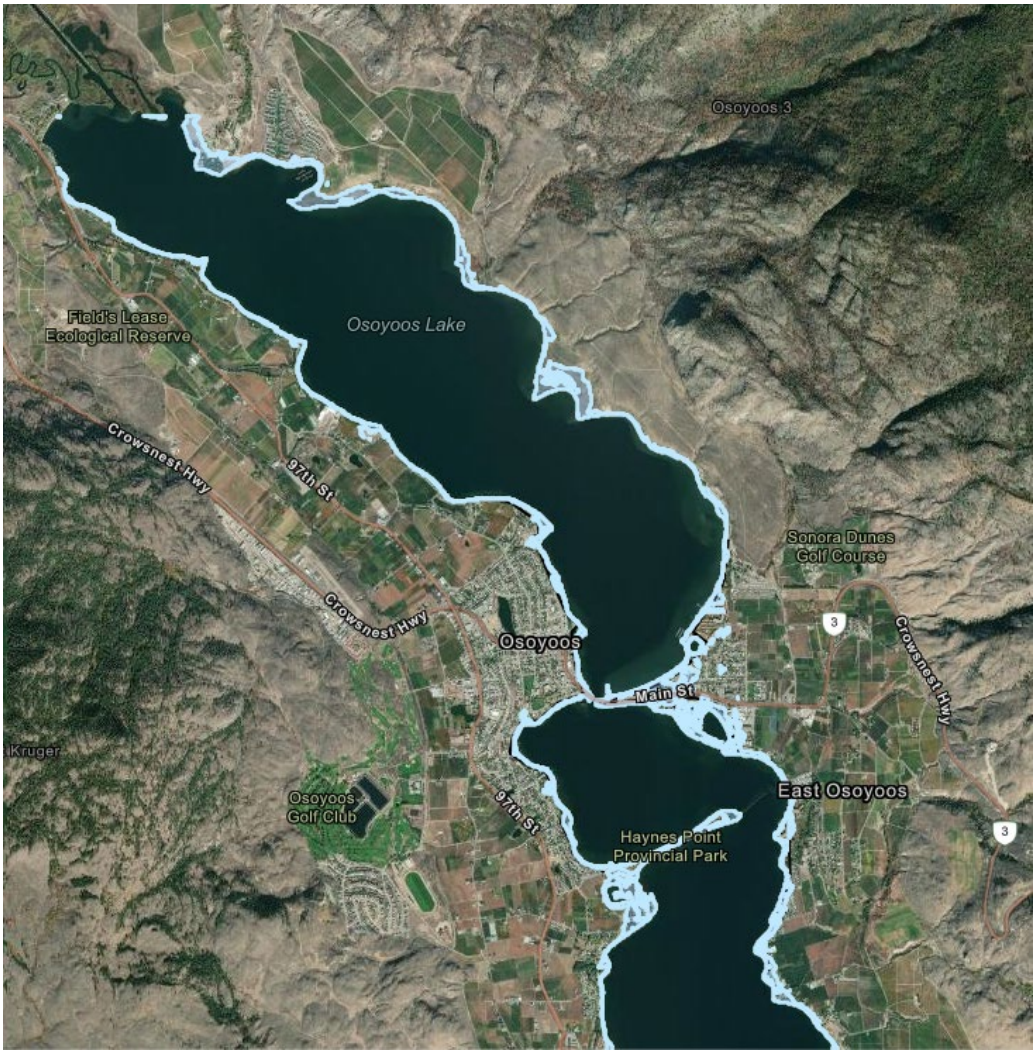
Project I1.0 - Crowsnest Hwy Bridge Investigation
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Topographic Survey of Bridge & Features	LS	1	$TBD	$TBD
2.0	Wave, current, utility, and structural review of bridge	LS	1	$TBD	$TBD
3.0	Mitigation report	LS	1	$TBD	$TBD
				Subtotal	**$TBD**
				Contingency (TBD%)	$TBD
				TOTAL	**$TBD**

NS-5: I2.0 Retaining Wall Protection Study

Priority	Medium	**Type**	Non-Structural
Current Flood Vulnerability	Varies	**Design Elevation**	Varies

Location Map



Description & Risk Profile

Private and public retaining walls line the Osoyoos Lake shoreline. Depending on the elevation of these retaining walls, they can be susceptible to damage from flooding and wave action. As shown in the image below.

Cottonwood Park Retaining Walls During 2018 Flood Event (Times Chronicle, 2018)

Project Scope

- Complete a review of the Town-owned retaining walls at risk of flooding, with Town staff.
- Background information collection & compilation
- Complete a report outlining site specific mitigation solutions and estimated costs. Some typical mitigation solutions could be:
    - Removal of the retaining wall
    - Redesign of the retaining wall
    - Toe armoring

Capital Cost: $34,000

NS-5

Project I2.0 - Retaining Wall Protection Study
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Conduct field review of Town-owned retaining walls	days	5	$2,000.00	$10,000
2.0	Background information collection	LS	1	$4,000.00	$4,000
3.0	Retaining wall mitigation report	LS	1	$10,000.00	$10,000
				Subtotal	**$24,000**
				Contingency (25%)	$6,000
				Engineering (15%)	$3,600
				TOTAL	**$33,600**

NS-6: I3.0 - Video Inspection (CCTV) of Sanitary Sewer

Priority	Medium	**Type**	Non-Structural
Current Flood Vulnerability	Varies	**Design Elevation**	Varies

Description & Risk Profile

The Town of Osoyoos would benefit from the implementation of a CCTV inspection program for their sanitary sewer. This program would provide an understanding of the risk associated with their existing infrastructure by completing a video inspection program to determine each pipe's condition, location, and elevation. In addition to providing better information to prioritize pipe segments that are at risk during a flooding event, this also provides information that would be valuable to the Town's Asset Management Plan.

Project Scope

Complete a CCTV inspection of piping at least within flood hazard area. General activities included in this scope are:

- Flushing & cleaning sanitary system
- Video inspection (CCTV)
- Bypass pumping as necessary
- Root cutting as necessary
- CCTV reporting document

Capital Cost: $251,000

NS-6.0

Project I3.0 - Video Inspection (CCTV) of Santiary Sewer System in Flood Hazard Area
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Flushing and Cleaning sewer system	l.m.	8700	$4.50	$39,150
2.0	Sanitary sewer CCTV inspection	l.m.	8700	$4.50	$39,150
3.0	Bypass pumping	hr	120	$200	$24,000
4.0	Root cutting	hr	120	$350	$42,000
5.0	Traffic Control	LS	1	$30,000	$30,000
6.0	CCTV reporting documentation	LS	1	$5,000	$5,000
				Subtotal	**$179,300**
				Contingency (25%)	$44,825
				Engineering (15%)	$26,895
				TOTAL	**$251,020**

NS-7: I4.0 - Inflow & Infiltration Study of Sanitary System in Flood Hazard Area

Priority	Medium	**Type**	Non-Structural
Current Flood Vulnerability	Varies	**Design Elevation**	Varies

Description & Risk Profile

An inflow & infiltration study (I&I) is required to be conducted throughout the portions of the Osoyoos sanitary system that is vulnerable to flooding. There is evidence to suggest infiltration and inflow is high during flooding events, based on Main Lift outflow volumes, as seen in the graphs on the following pages.

Risks to infrastructure caused by excessive I&I includes:

- Surcharging of sanitary system
- Premature failure of lift stations caused by continuous running of pumps
- Failure of electrical and mechanical equipment in lift stations
- Etc.

Risk to public caused by failure of this infrastructure includes:

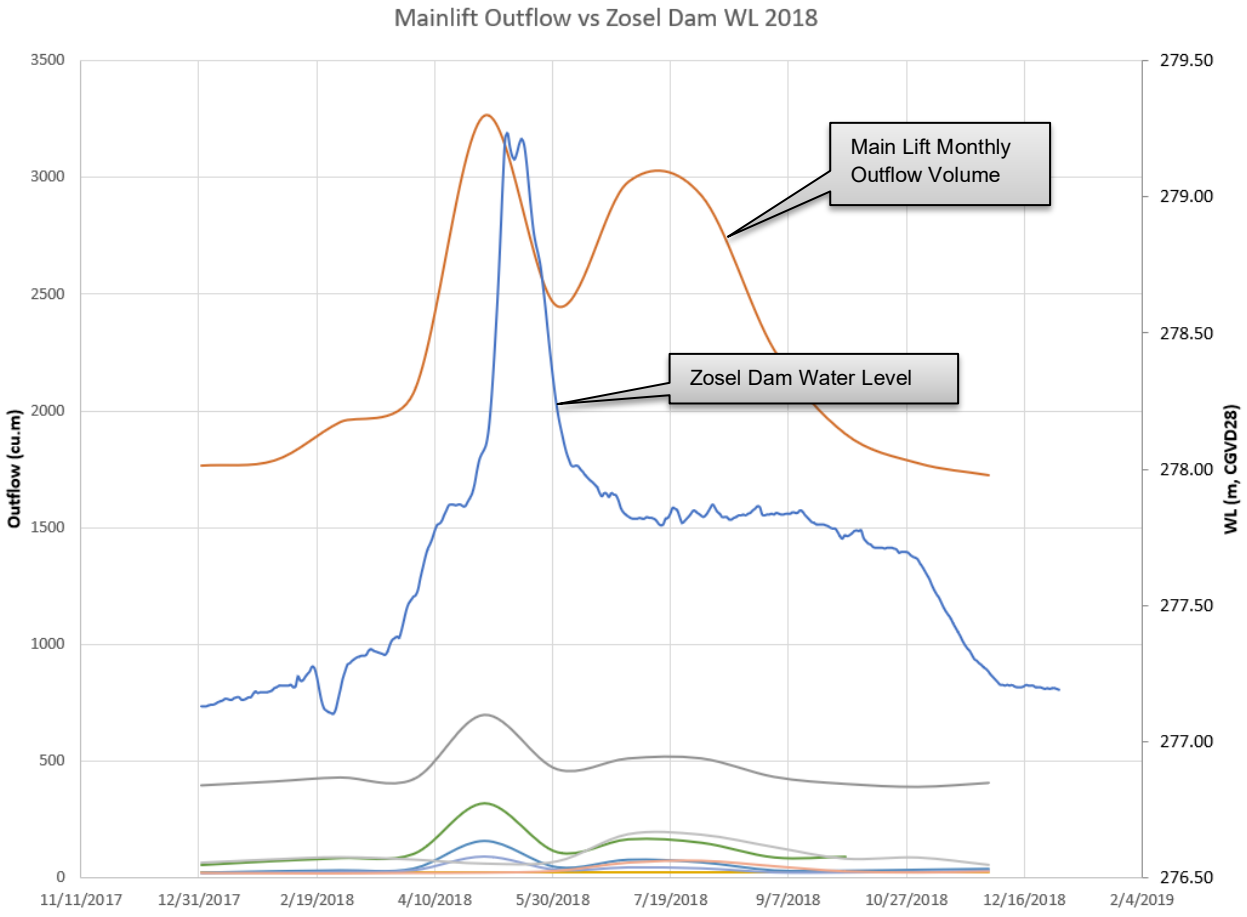
- Cross contamination between Osoyoos Lake and untreated sanitary water
- Surcharging of the downstream gravity system caused by lift station failure, or inability to keep up with increased flows caused by I&I.
- Evacuation of residences within the effected sanitary catchment areas.

Mitigation Solution

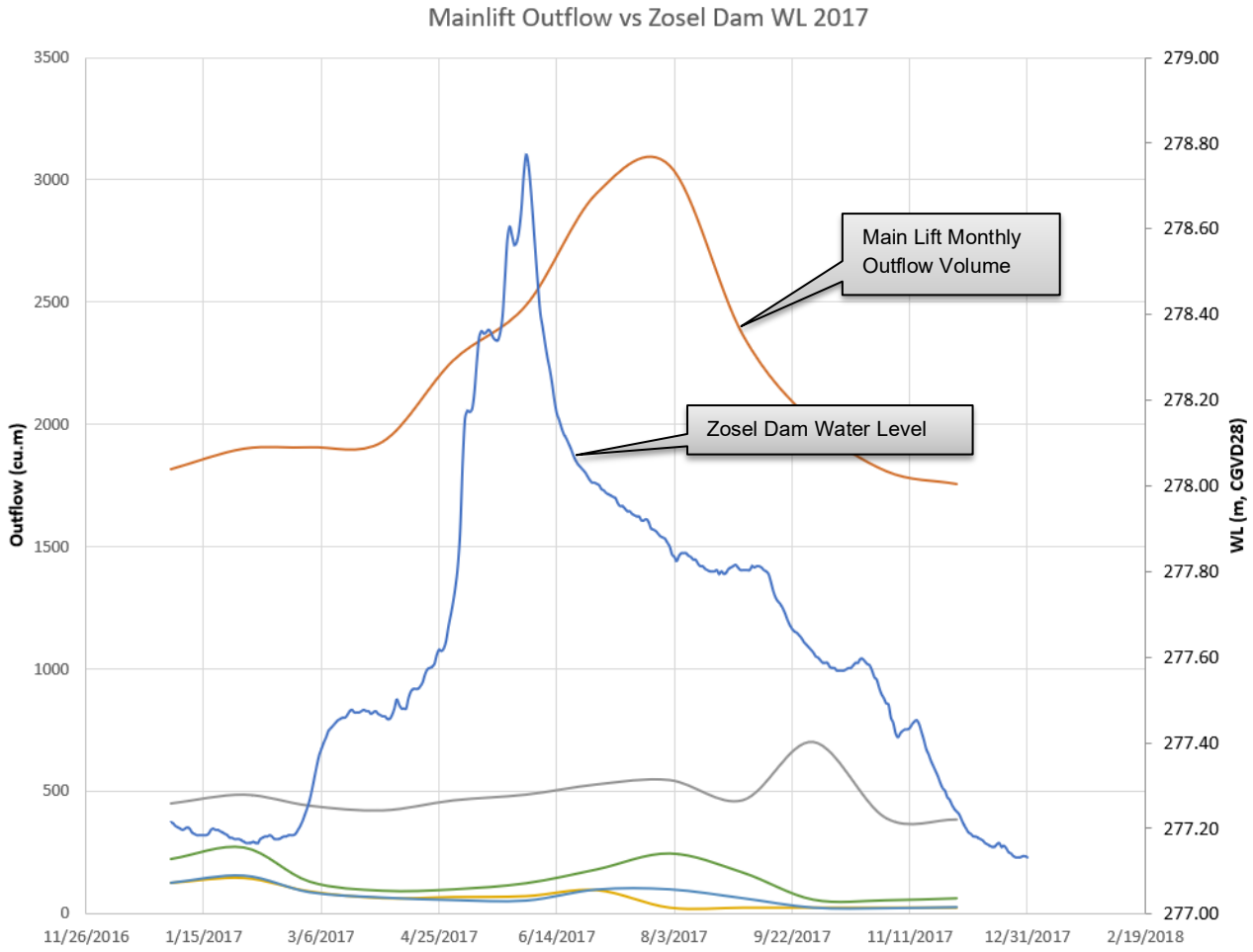
- Perform I&I study of sanitary system in flood prone areas.
- Create a map identifying areas of high I&I from study
- Waterproof necessary manholes, liftstations, sanitary mains

Capital Cost: $60,000

Lift Station Outflow vs Zosel Dam WL (Directly related to Osoyoos Lake WL)



Lift Station Outflow vs Zosel Dam WL (Directly related to Osoyoos Lake WL)



Project I4.0 - Inflow and Infiltration Study of Sanitary Sewer System In Flood Hazard Area
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Conduct I&I study	LS	1	$35,000.00	$35,000
2.0	Compile map identifying areas of interest	LS	1	$7,500.00	$7,500
				Subtotal	**$42,500**
				Contingency (25%)	$10,625
				Engineering (15%)	$6,375
				TOTAL	**$59,500**

S-1: W1.0 - Well No. 4 & 5 Flood & Erosion Proofing

Priority	High	**Type**	Structural
Current Flood Vulnerability	278.4 m	**Design Elevation**	282.4 m

Location Map

Primary Mitigation Map

Description & Risk Profile

- Two primary drinking water wells for town and residents
  - Providing a combined 120 L/s of potable water
- The wells heads and associated electrical are currently housed in masonry flow building
- Currently sits at an elevation of 280.0 m
- With waves it is anticipated that he well house could see flooding impacts starting at an elevation of 278.4 m
- Risk to this infrastructure includes:
  - Contamination of the wells by flood waters
  - Damage to the electrical supply
  - Damage to electrical controls
  - Damage to the building
  - Erosion potential around the building
- Risk to public caused by failure of this infrastructure includes:
  - A loss of water to residents throughout Town of Osoyoos
  - Loss of fire fighting capacity once reservoir is drained
  - Evacuation of the Town

Permanent Mitigation Solution

- Due quality and quantity of water, and limited alternative locations it is more prudent to protect in place while relocating key components
- Scope includes:
  - Elevate internal electrical components within building to elevation of 280.8m at a minimum.
  - Install enhanced shoreline protection and wave dampening methods on the west side
  - Install backflow prevention in floor drains

Capital Cost: $250,000

S-1

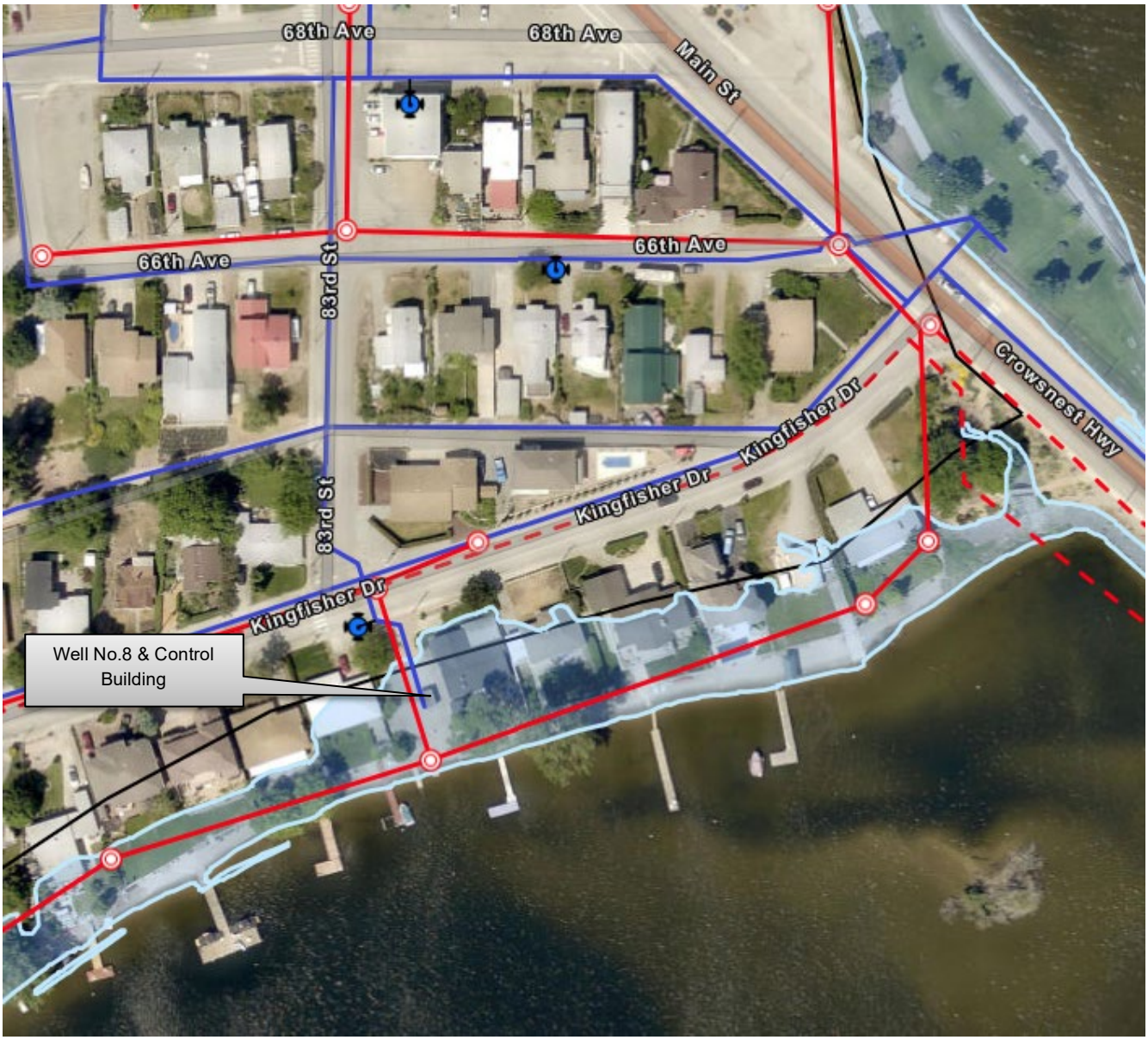
Project W1.0 - Cottonwood Park Wells No.4&5 - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Enhance shoreline and building protection for wave action	LS	1	$114,000	$114,000
2.0	Raise existing electrical controls to 280.8m minimum	LS	1	$50,000	$50,000
3.0	Supply & Install backflow preventor in floor drain	ea	1	$2,500	$2,500
				Subtotal	**$166,500**
				Contingency (30%)	$49,950
				Engineering (15%)	$24,975
				Environmental Monitoring (5%)	$8,325
				TOTAL	**$249,750**

S-2: W2.0 - Well No. 8 Flood & Erosion Proofing

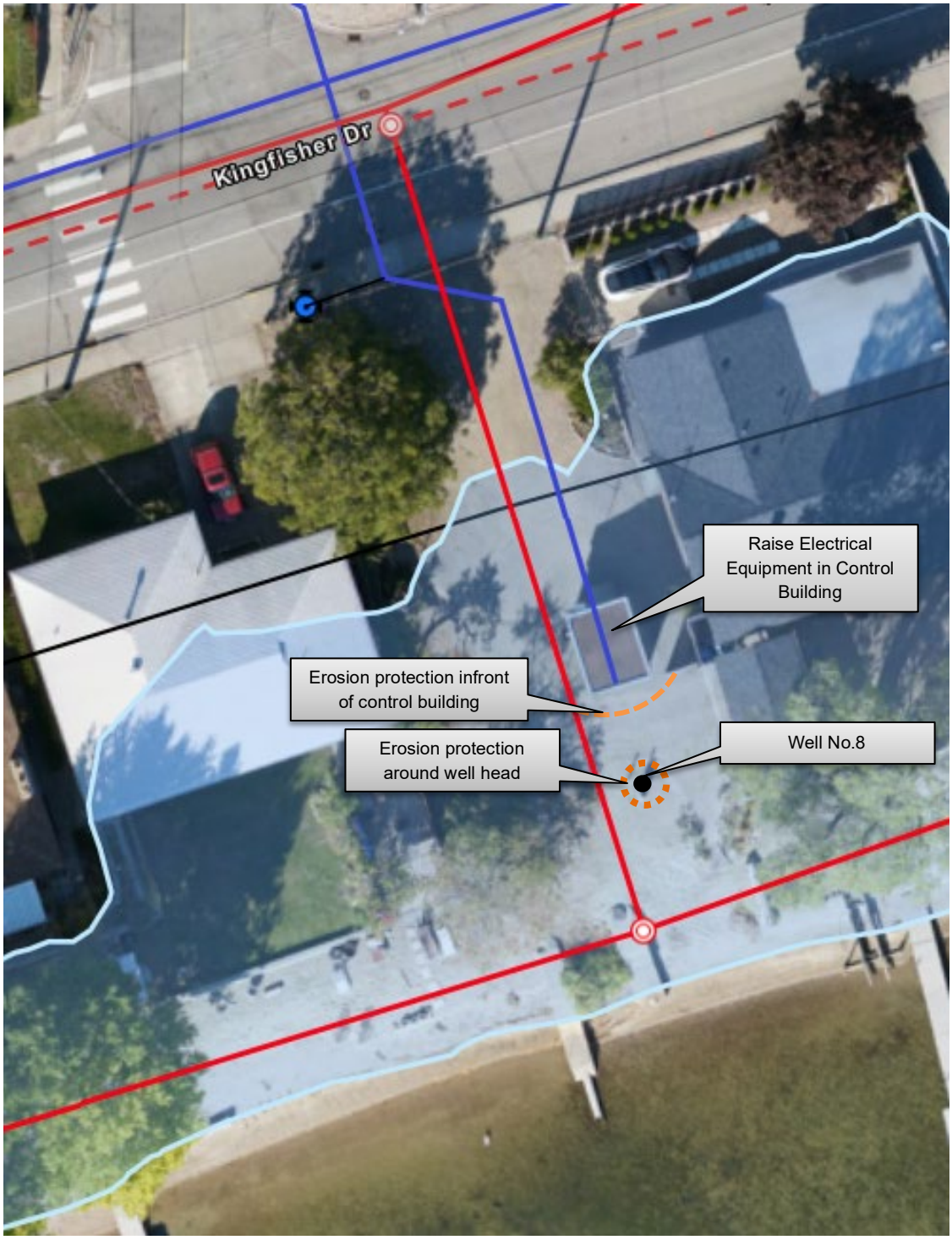
Priority	High	**Type**	Structural
Current Flood Vulnerability	279 m	**Design Elevation**	281.8 m

Location Map



Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- One primary drinking water well for town and residents
  - Distributes 41 L/s Potable Water to System
- The well head is exposed, while associated electrical and controls are housed in masonry building.
- Critical Component Elevations:
  - Well Head: 280.5m
  - Building MFE: 280.2m
  - MCC bottom: 280.5m
  - PLC bottom: 281.0m
  - UPS bottom: 280.6m
- With waves it is anticipated that the well & control building could see flooding impacts starting at an elevation of 279.2 m
- Risks to this infrastructure includes:
  - Contamination of the wells by flood waters
  - Damage to the electrical supply
  - Damage to electrical controls
  - Damage to the building
  - Erosion potential around the building & well head

- Risk to public caused by failure of this infrastructure includes:
  - A loss of water to residents & lowered capacity for fire fighting

Permanent Mitigation Solution

- Raise electrical equipment in building to an elevation of 280.8m
- Raise well head to 281.8m
- Install erosion protection and wave dampening measures around the wellhead and in front of the control building

Capital Cost: $173,000

S-2

Project W2.0 - Kingfisher Drive Well No.8 - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Raise electrical components in control building	LS	1	$50,000	$50,000
2.0	Raise well head to 281.8m	LS	1	$25,000	$25,000
3.0	Supply & install erosion protection around wellhead & at control building	LS	1	$40,000	$40,000

Subtotal	**$115,000**
Contingency (30%)	$34,500
Engineering (15%)	$17,250
Environmental Monitoring (5%)	$5,750
TOTAL	**$172,500**

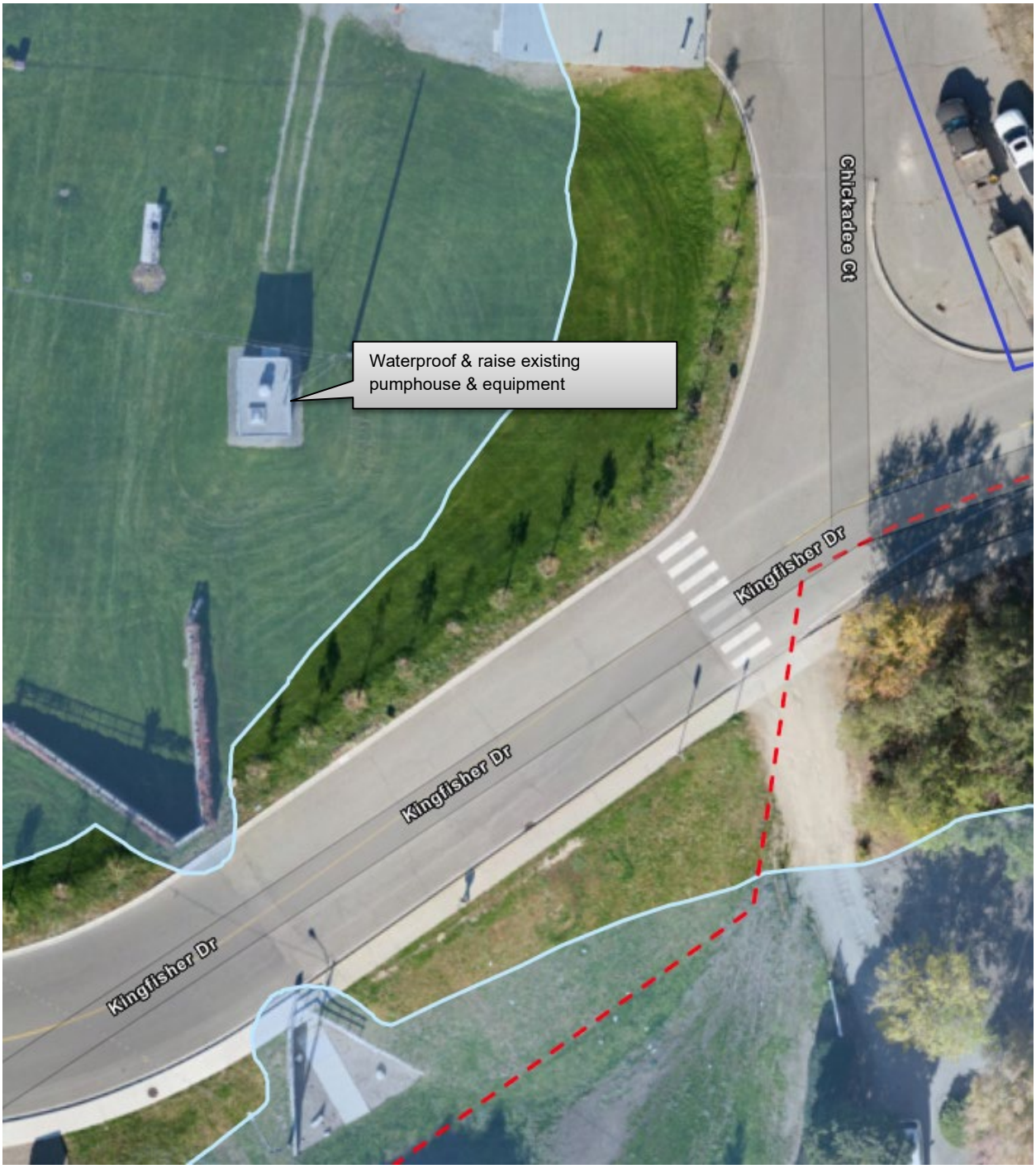
S-3: W3.0 - Well No. 1 Flood & Erosion Proofing

Priority	High	**Type**	Structural
Current Flood Vulnerability	279.1 m	**Design Elevation**	280.8 m

Location Map

Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- One primary drinking water well for Town and residents
    - Providing 19 L/s of potable water
- All equipment is contained within the pumphouse. Some critical infrastructure elevations are:
    - MFE: 279.7m.
    - Bottom of MCC: 280.2m
    - Bottom of PLC: 280.2m
    - Bottom of Motor: 280.5m
    -
- Risks to this infrastructure includes:
    - Contamination of the wells by flood waters
    - Damage to electrical controls
    - Damage to the building from long term saturated soils
    - Etc.
- Risk to public caused by failure of this infrastructure includes:
    - Loss of water to residents and reduced fire fighting capacity

Permanent Mitigation Solution

- Raise electrical equipment to minimum elevation of 280.8m
- Install backflow preventer in floor drain

Capital Cost Option 1: $80,250

S-3

Project W3.0 - Well No.1 Splash Park Flood Proofing
Class D Cost Estimate

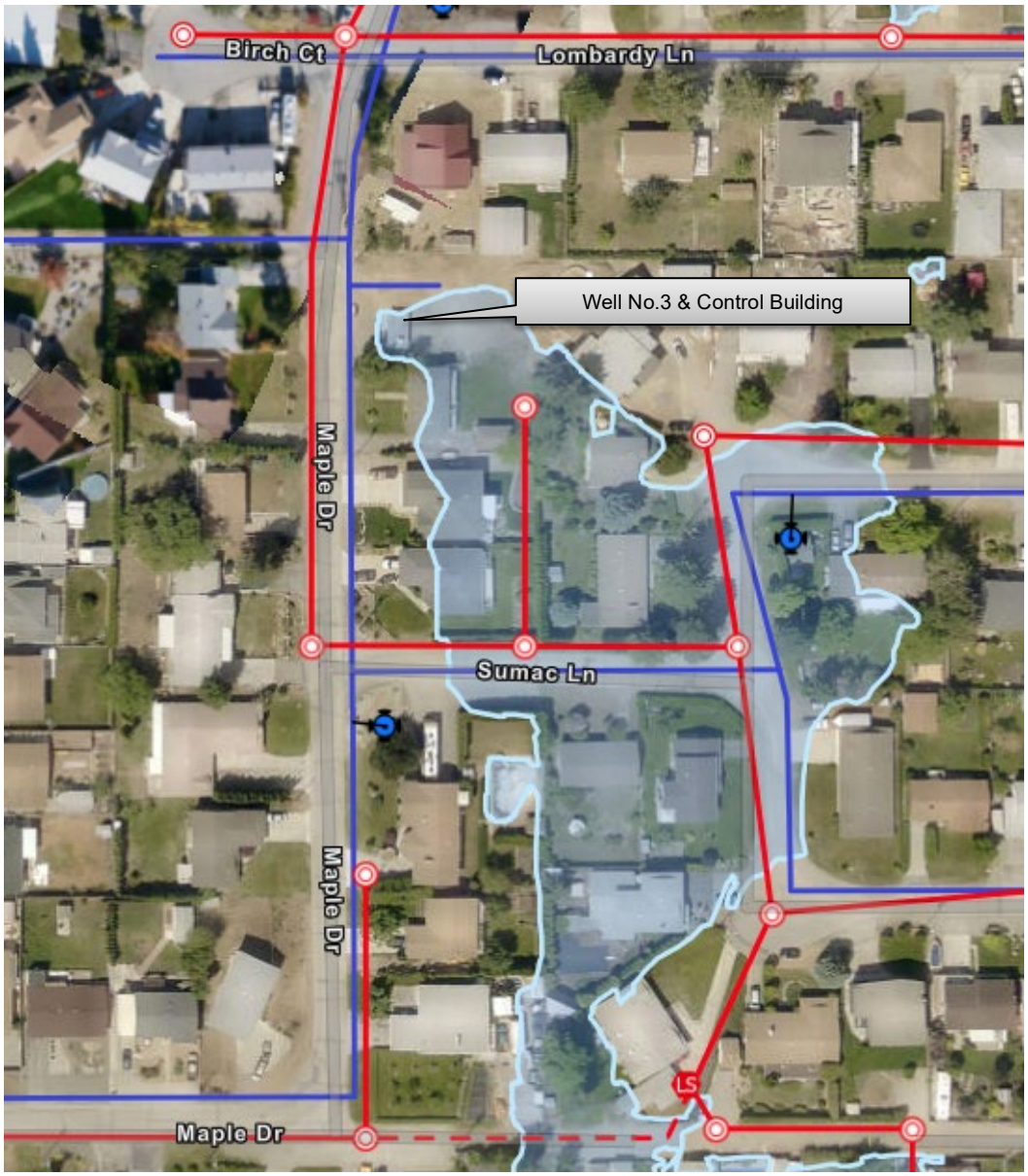
ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for electrical equipment raising	LS	1	$50,000	$50,000
2.0	Supply & install backflow preventers on floor drain lines	ea	1	$2,500	$2,500
3.0	Dewatering allowance	LS	1	$1,000	$1,000

Subtotal	**$53,500**
Contingency (30%)	$16,050
Engineering (15%)	$8,025
Environmental Monitoring (5%)	$2,675
TOTAL	**$80,250**

S-4: W4.0 - Well No. 3 Flood & Erosion Proofing

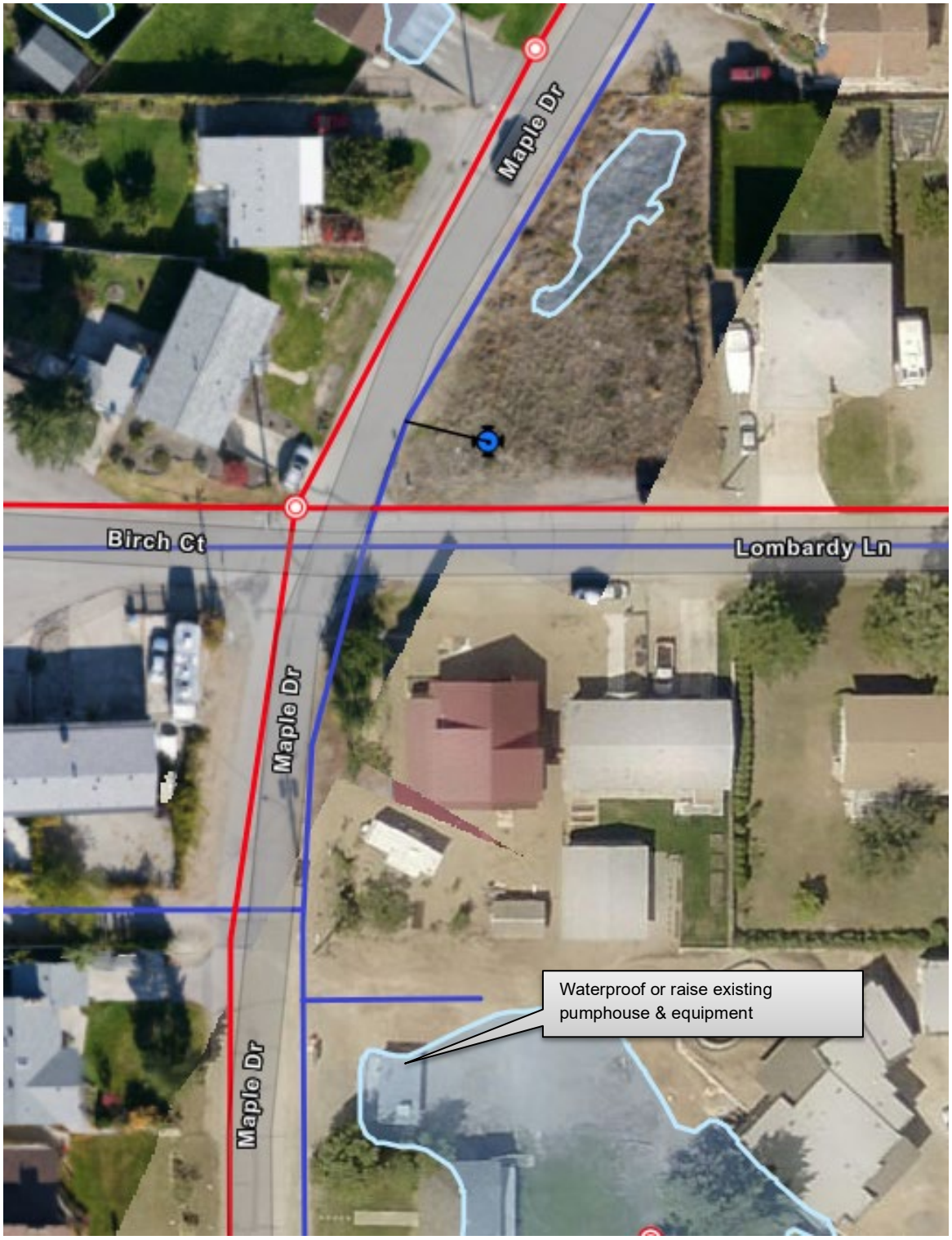
Priority	High	**Type**	Structural
Current Flood Vulnerability	279.4 m	**Design Elevation**	280.8 m

Location Map



Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- One primary drinking water well for Town and residents
    - Providing 29 L/s of potable water
- All equipment is contained within the pumphouse. MFE of pumphouse is currently sitting at approximately 280.0m. 200 year still water elevation is 280.2m, inland FCL is 280.8m
- Risks to this infrastructure includes:
    - Contamination of the wells by flood waters
    - Damage to electrical controls
    - Damage to the building from long term saturated soils
    - Etc.
- Risk to public caused by failure of this infrastructure includes:
    - A loss of water to residents and reduced fire fighting capacity.

Permanent Mitigation Solution

- Raise all electrical equipment to an elevation of 280.8m
- Install backflow preventer(s) in floor drain(s)
- Ensure all equipment below an elevation of 280.8m is waterproof.

Capital Cost: $54,000

S-4

Project W4.0 - Well No.3 Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for electrical equipment raising	LS	1	$30,000	$30,000
2.0	Supply & install backflow preventers on floor drain lines	ea	2	$2,500	$5,000
3.0	Dewatering allowance	LS	1	$1,000	$1,000

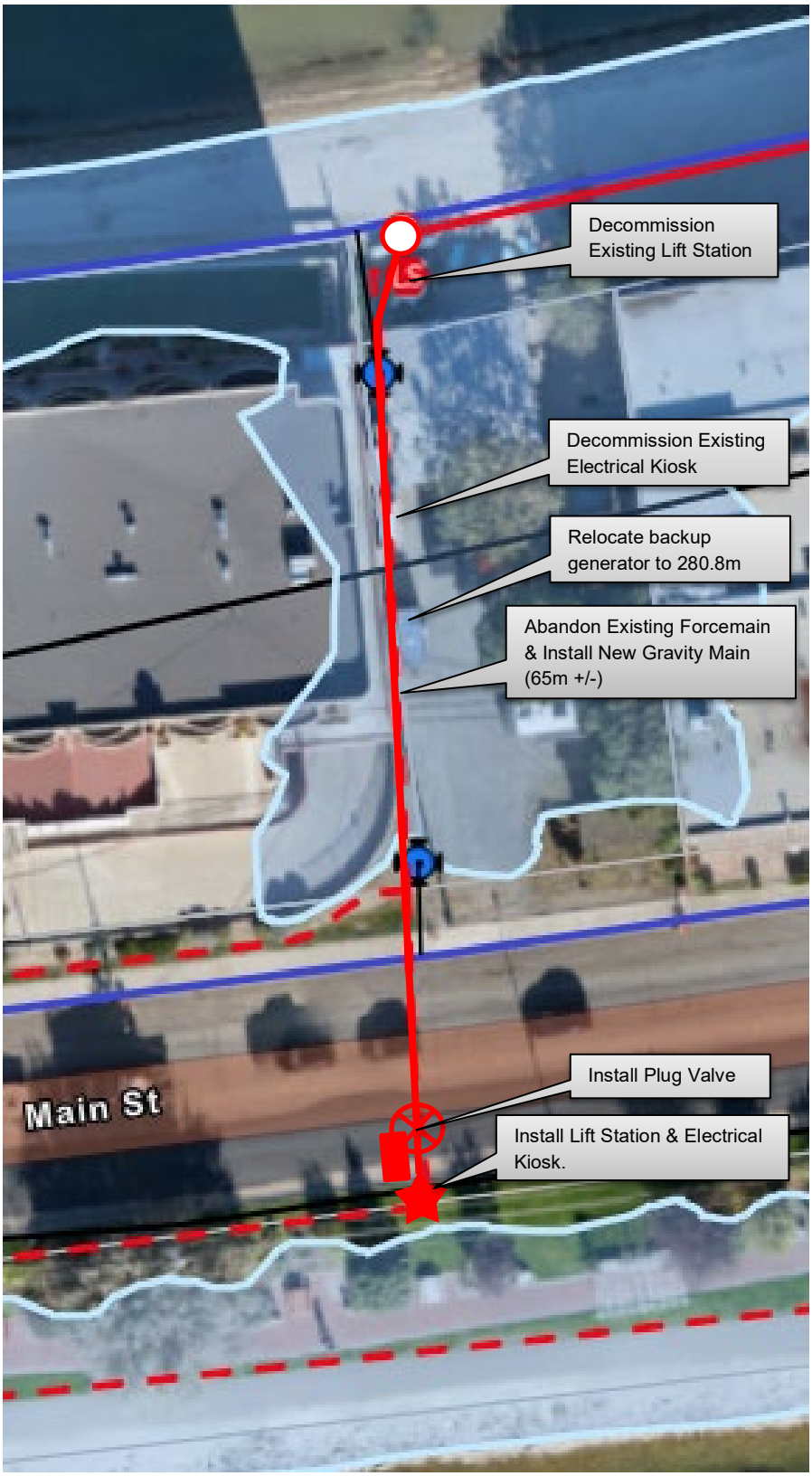
Subtotal	**$36,000**
Contingency (30%)	$10,800
Engineering (15%)	$5,400
Environmental Monitoring (5%)	$1,800
TOTAL	**$54,000**

S-5: LS1.0 - Starlite Lift Station Flood Proofing

Priority	High	**Type**	Structural
Current Flood Vulnerability	278.5 m	**Design Elevation**	280.8 m

Location Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main under Cottonwood beach to sanitary manhole SMH0289 near Main Lift.
    - Pumping Capacity: 65 l/s
    - Servicing the Towns North East Sector
- Critical infrastructure component elevations:
    - Liftstation Lid: Prior to 2017 Lid set at 278.8m. Following 2017, Lid raised to 280.0m.
    - Electrical Kiosk MFE: 279.5m
- With wave action the lift station could see flooding impacts at an elevation of 278.5m. Without waves, When Osoyoos Lake water levels reach 279.5m the electrical kiosk becomes submerged.
- The liftstation and electrical kiosk has been impacted by flood waters in both the 2017 and 2018 flood seasons.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical components within the lift station
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.

Permanent Mitigation Solution

- Because of the site constraints and proximity to Osoyoos lake, relocation of the lift station would be an optimal mitigation solution. This would include:
    - Decommissioning the existing lift station
    - Installing new gravity main (65m +/-)
    - Installing new lift station closer to Main Street
    - Install new electrical components if necessary

Capital Cost: $2,860,000

Project LS1.0 - Starlite Lift station Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Decomission, remove, & dispose of existing starlite lift station c/w all sanitary line disconnections, etc.	LS	1	$100,000	$100,000
2.0	Decomission, remove, & dispose of existing electrical equipment and kiosk	LS	1	$30,000	$30,000
3.0	Relocate backup generator to new lift station location	LS	1	$30,000	$30,000
4.0	Supply & install new lift station c/w all mechanical, internal components, and tie in to sanitary system.	LS	1	$570,000	$570,000
5.0	Supply & install electrical control kiosk & associated electrical equipment	LS	1	$350,000	$350,000
6.0	Directional drill gravity main	l.m.	65	$5,000	$325,000
7.0	Dewatering allowance	LS	1	$100,000	$100,000
8.0	Land acquisition allowance	LS	1	$400,000	$400,000

Subtotal	**$1,905,000**
Contingency (30%)	$571,500
Engineering (15%)	$285,750
Environmental Monitoring (5%)	$95,250
TOTAL	**$2,857,500**

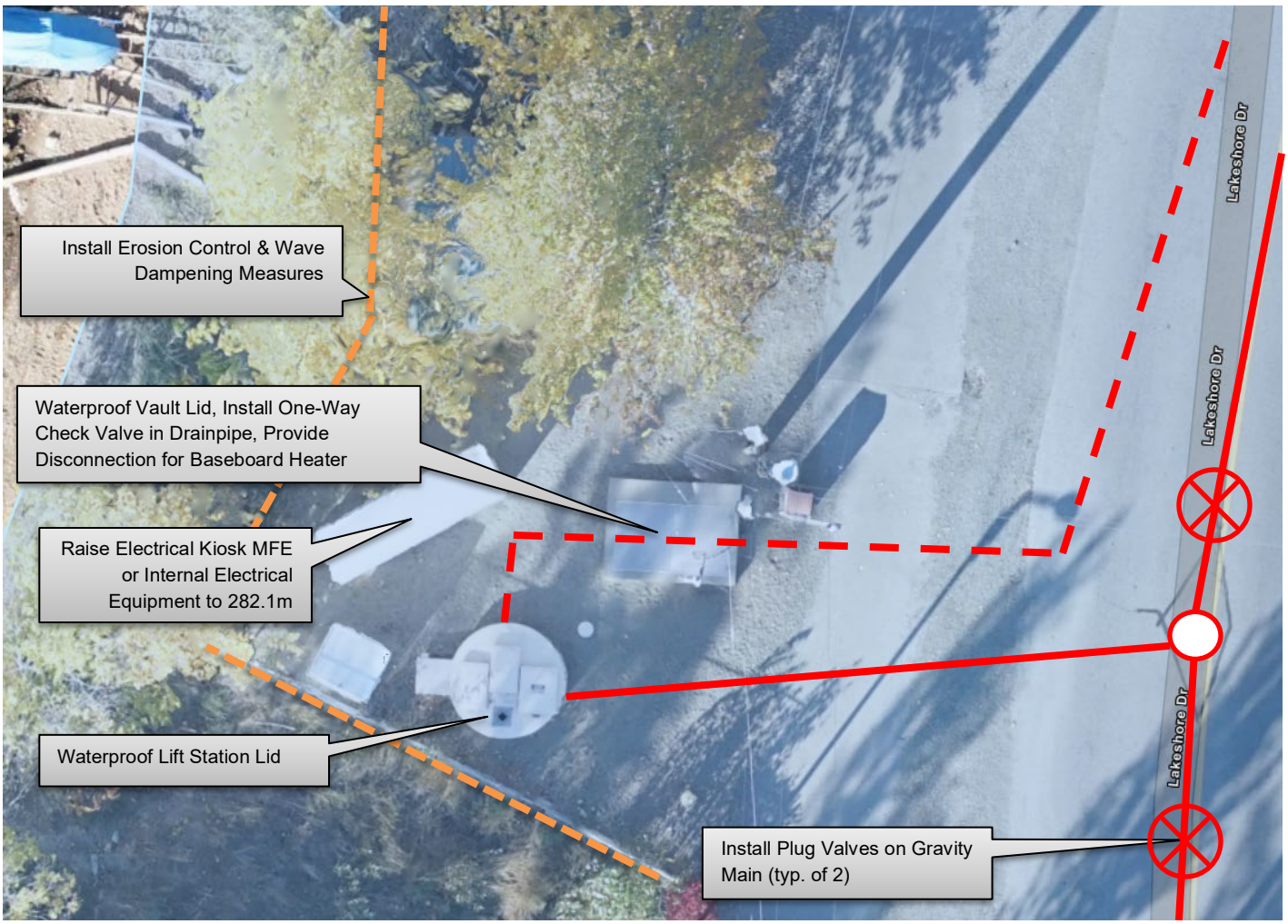
S-6: LS2.0 - Lakeshore Drive (45th St) & 44th Ave LS

Priority	High	**Type**	Structural
Current Flood Vulnerability	278.7 m	**Design Elevation**	282.1 m

Location Map

Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main on Lakeshore Drive (SMH0060 to SMH0042) to SMH0289 manhole near Main Lift.
    - Add flow and service population.
- Critical infrastructure component elevations:
    - Lift station Lid: 280.0m
    - Electrical Kiosk MFE: 280.0m
    - Vault Lid: 280.0m
- With wave action the lift station infrastructure could see flooding impacts at an elevation of 278.7m. Without waves, When Osoyoos Lake water levels reach 280.0m the sanitary Lift Station, electrical kiosk, and vault become submerged.

- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment
    - Etc.

Permanent Mitigation Solution

Relocation of the lift station & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Waterproof lift station lid
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 282.1m. Design elevations can be reduced to 280.8m if wave dampening measures are installed.
- Vault upgrades:
    - Install one-way check valve on vault drainpipe
    - Make lid waterproof
    - Provide disconnect for baseboard heater and other electrical components
- Install erosion control and wave dampening measures on the banks around the sanitary infrastructure.
- Install plug valves on the gravity mains flowing into lift station

Capital Cost: $289,000

S-6

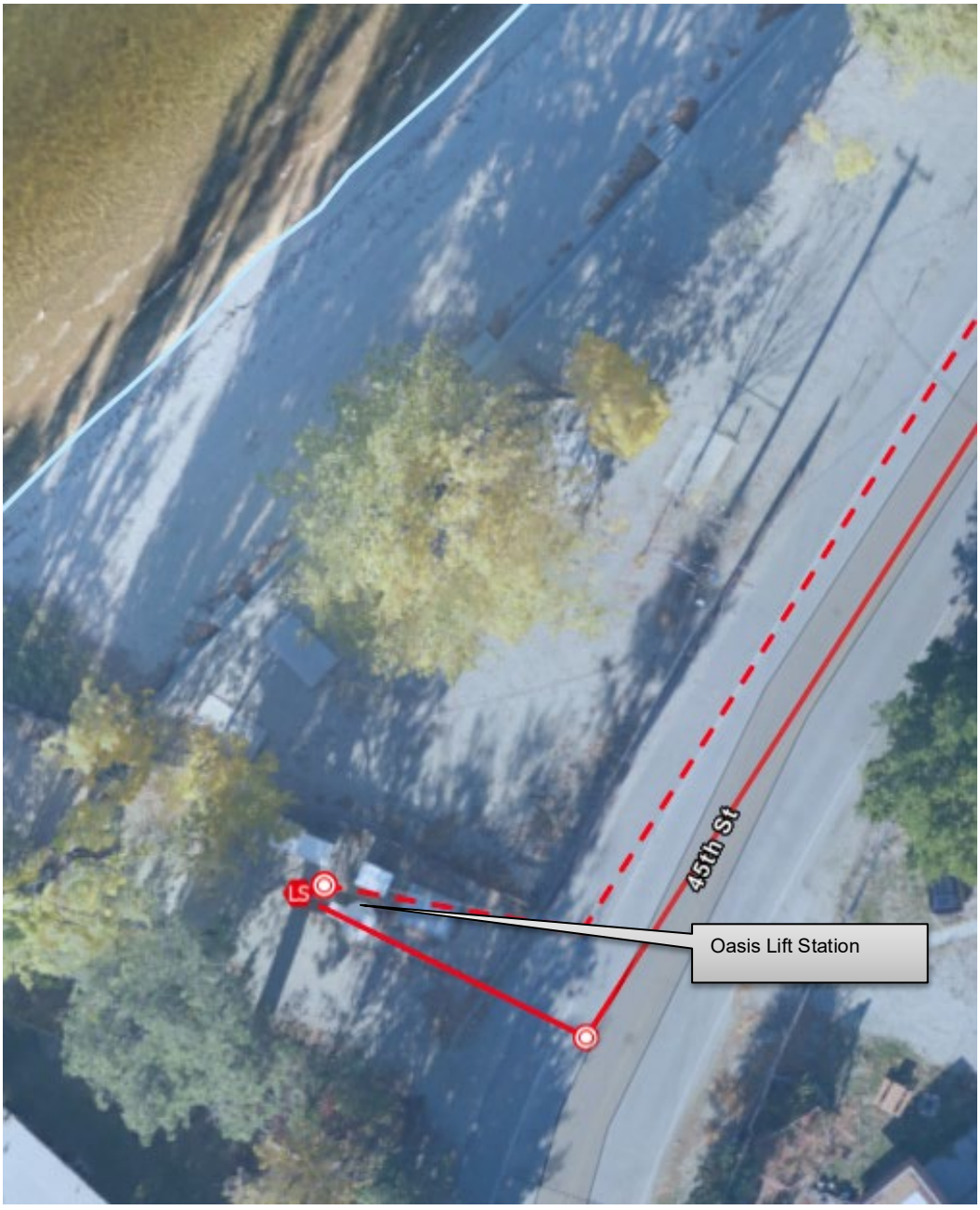
Project LS2.0 - Lakeshore Dr & 44th Ave Lift Station
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$10,000	$10,000
2.0	Allowance for electrical kiosk raising or electrical component raising	LS	1	$75,000	$75,000
3.0	Supply & install water proofing measure on vault lid	LS	1	$7,500	$7,500
4.0	Supply & install disconnection switch for vault baseboard heater	LS	1	$2,500	$2,500
5.0	Supply & install one-way checkvalve on vault drain pipe	LS	1	$2,500	$2,500
6.0	Supply & install erosion control measures	LS	1	$65,000	$65,000
7.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	LS	1	$30,000	$30,000
				Subtotal	**$192,500**
				Contingency (30%)	$57,750
				Engineering (15%)	$28,875
				Environmental Monitoring (5%)	$9,625
				TOTAL	**$288,750**

S-7: LS3.0 - Lakeshore Drive (45th St) Oasis LS Flood & Erosion Proofing

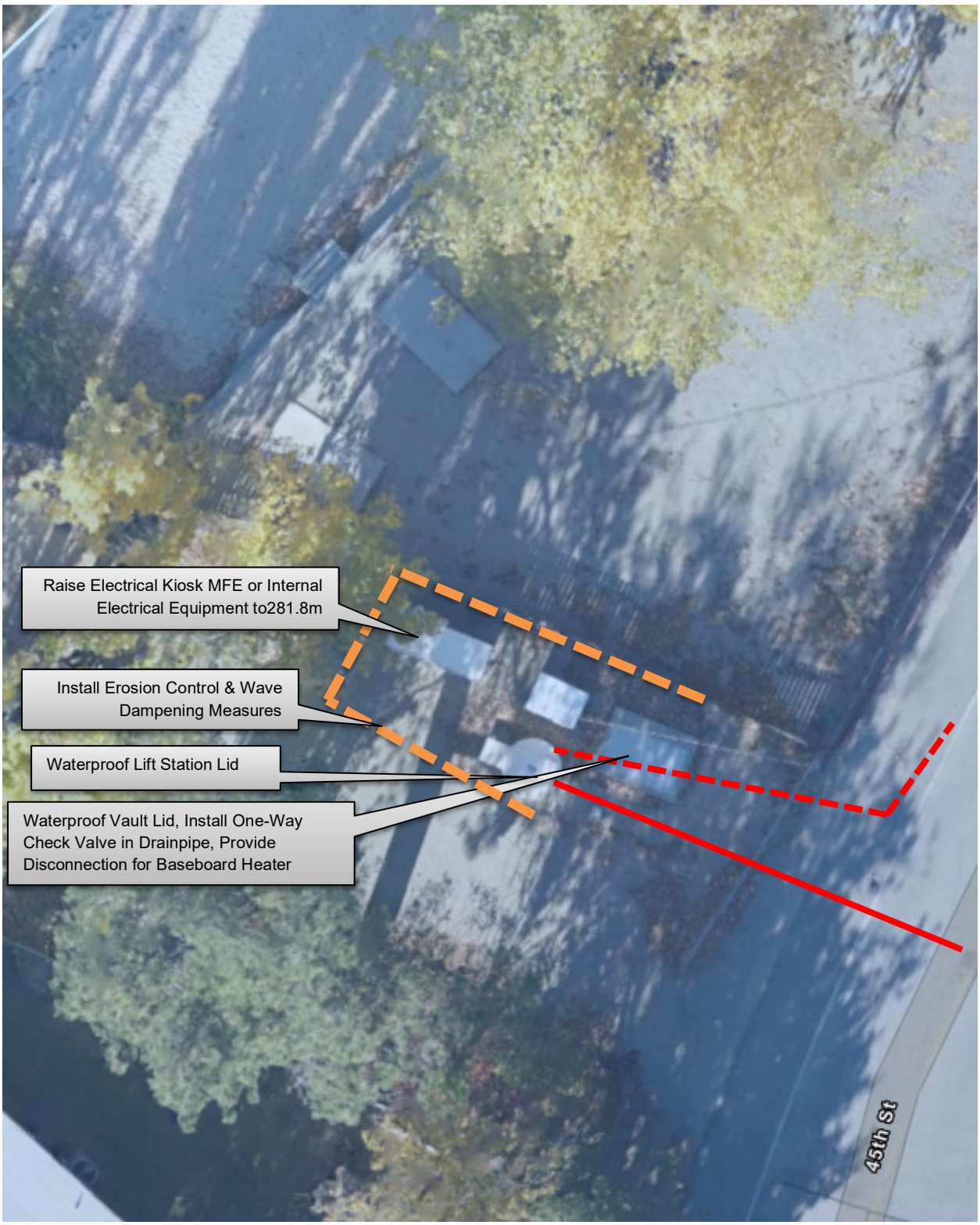
Priority	High	**Type**	Structural
Current Flood Vulnerability	278.3 m	**Design Elevation**	281.8 m

Location Map



Streetview Map

Permanent Mitigation Measures Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main on Lakeshore Drive (SMH0039 to SMH0027) to SMH0042 manhole on Lakeshore Drive, near its intersection with 30th Avenue.
    - Add flow and service population.
- Critical infrastructure component elevations:
    - Liftstation Lid: 279.3m
    - Electrical Kiosk MFE: 279.3m
    - Vault Lid: 279.3m
- With wave action the lift station could see flooding impacts at an elevation of 278.3m. Without waves, When Osoyoos Lake water levels reach 279.3m the sanitary Lift Station, electrical kiosk, and vault become submerged.
- The liftstation has been impacted by flood waters in 2018.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to backup generator
    - Damage to mechanical & electrical components within the lift station & vault
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Ensure liftstation lid is waterproof.
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 281.8m. Elevation can be reduced to 280.8m if wave dampening can be supplied.
- Vault upgrades:
    - Install one-way check valve on vault drain pipe
    - Make lid waterproof
    - Provide disconnect for baseboard heater and other electrical components
- Install erosion control and wave dampening measures around the sanitary infrastructure

Capital Cost: $184,000

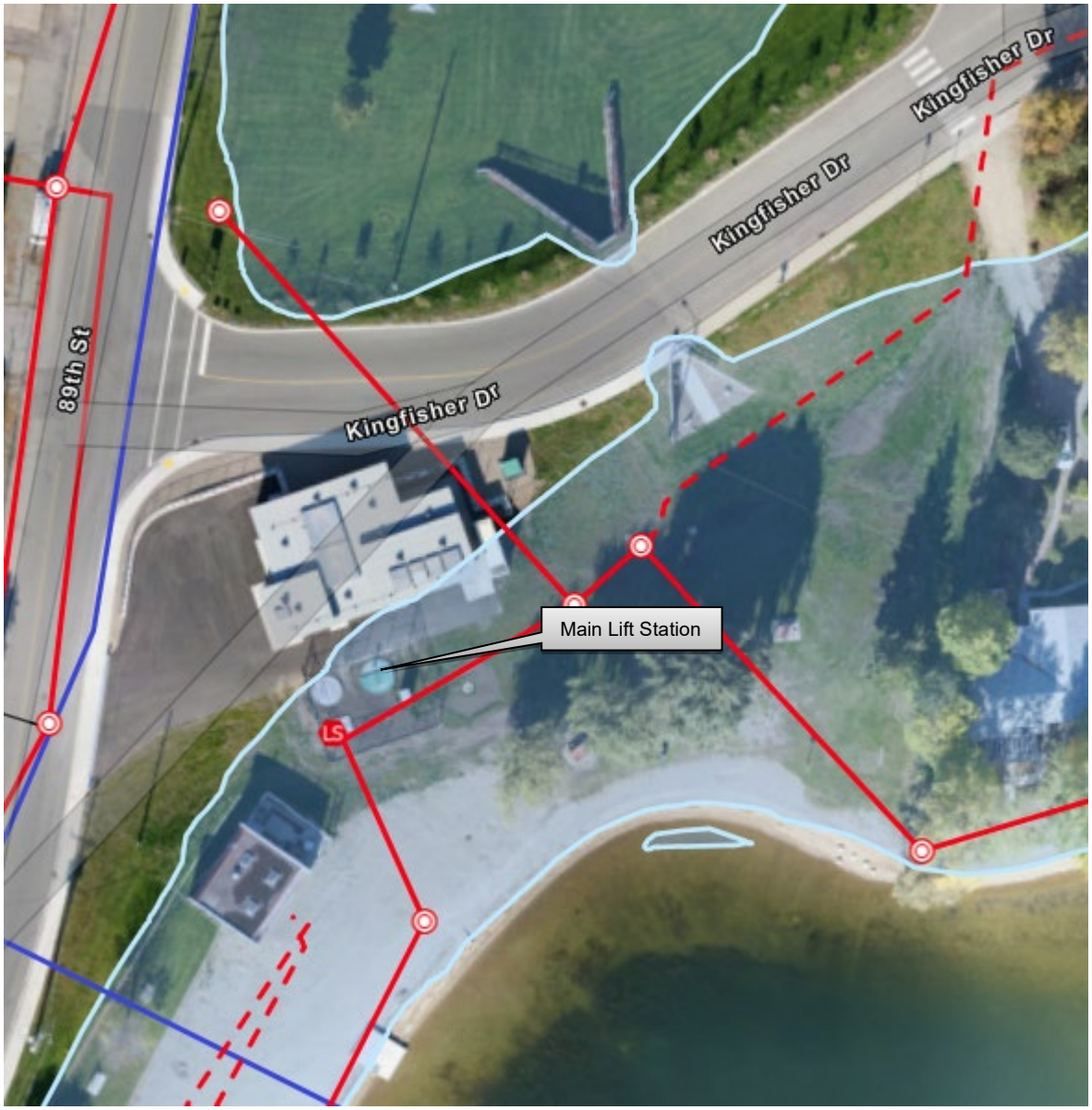
Project LS3.0 - Oasis Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$10,000	$10,000
2.0	Allowance for electrical kiosk raising or electrical component raising	LS	1	$75,000	$75,000
3.0	Supply & install water proofing measure on vault lid	LS	1	$7,500	$7,500
4.0	Supply & install disconnection switch for vault baseboard heater	LS	1	$2,500	$2,500
5.0	Supply & install one-way checkvalve on vault drain pipe	LS	1	$2,500	$2,500
6.0	Supply & install erosion control measures	LS	1	$25,000	$25,000
				Subtotal	**$122,500**
				Contingency (30%)	$36,750
				Engineering (15%)	$18,375
				Environmental Monitoring (5%)	$6,125
				TOTAL	**$183,750**

S-8: LS4.0 - Main Lift Station Flood Proofing

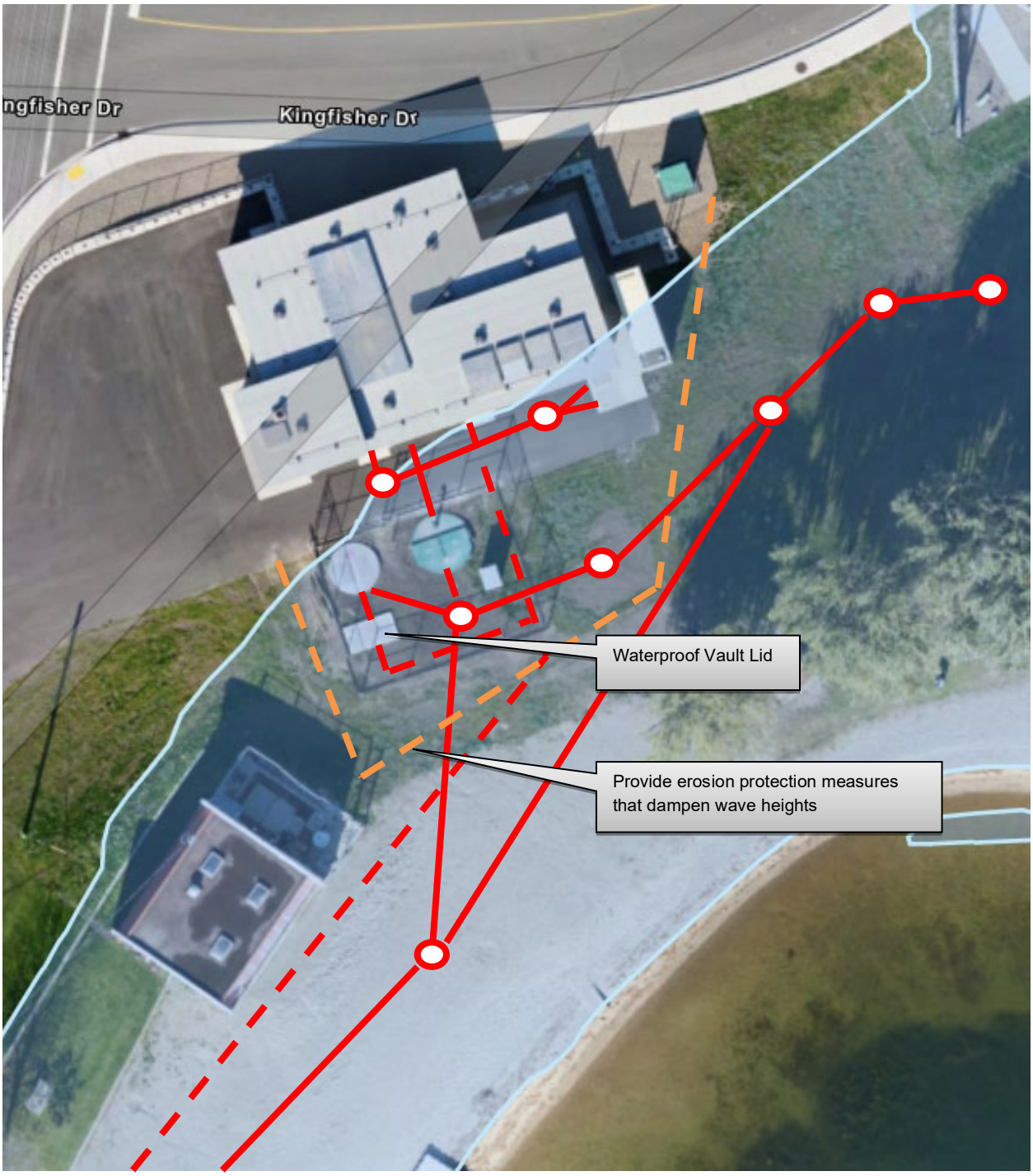
Priority	High	**Type**	Structural
Current Flood Vulnerability	279.7 m	**Design Elevation**	281.8 m

Location Map



Streetview Map

Permanent Mitigation Measures Map



Description & Risk Profile

- Main Lift is the most critical lift station in Osoyoos. All sanitary water flows to Main Lift before it is pumped to the treatment lagoons.
- Critical infrastructure component elevations:
    - Bypass Lift Station Lid: 280.5m
    - Low-Lift Station Lid: 280.5m
    - Wastewater Pump Station MFE: 280.7m
    - Wastewater Pump Station LFE: 278.9m
    - Control Valve Chamber Lid: 280.0m
    - Electrical Kiosk MFE: 280.0m, Internal Junction Box Minimum EL: 280.6m
    - Backup Generator MFE: 280.7m
    - Transformer MFE: 281.7m
- In its current configuration, with wave action, Main Lift could see flooding impacts at an elevation of 279.7m (1.0m below the wastewater pumpstation MFE). Without waves, when Osoyoos Lake water levels reach 280.0m the control valve chamber will become submerged, followed by the backup liftstations (280.5m) and wastewater pump station.(280.7m)
- Risks to this infrastructure include:
    - Damage to the building & infrastructure caused by erosion due to wave action
    - Damage to the building caused by long term saturation
    - Damage to the electrical components and controls
    - Damage to the mechanical components (pumps, motors, etc.) caused by excessive run times.
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure. For Main Lift, this would be the entire Osoyoos sanitary network.
    - Evacuation of residences within the sanitary catchment area. This would be the majority of the Town of Osoyoos.

Permanent Mitigation Solution

- The most important permanent mitigation measure to take for protecting the Main Lift infrastructure is erosion protection and wave dampening. This should be installed between Osoyoos Lake and the Main Lift Infrastructure. Vegetated riprap, structural landscaping, etc. could be installed to reduce erosion and dampen wave action.
- Some other permanent mitigation solutions are as follows:
    - Control valve chamber upgrades:
        - The internal components of this control valve chamber can operate while submerged. Lid waterproofing could be executed if deemed necessary.
    - Lift Station lids are already waterproof and are above the 200-year static water level 280.2m. No mitigation required.
    - Electrical junction boxes in the Kiosk are at a minimum elevation of 280.6m (above the 200 year static water level of 280.2m.). Confirm that junction boxes are waterproof/water resistant.

Capital Cost: $90,000

S-8

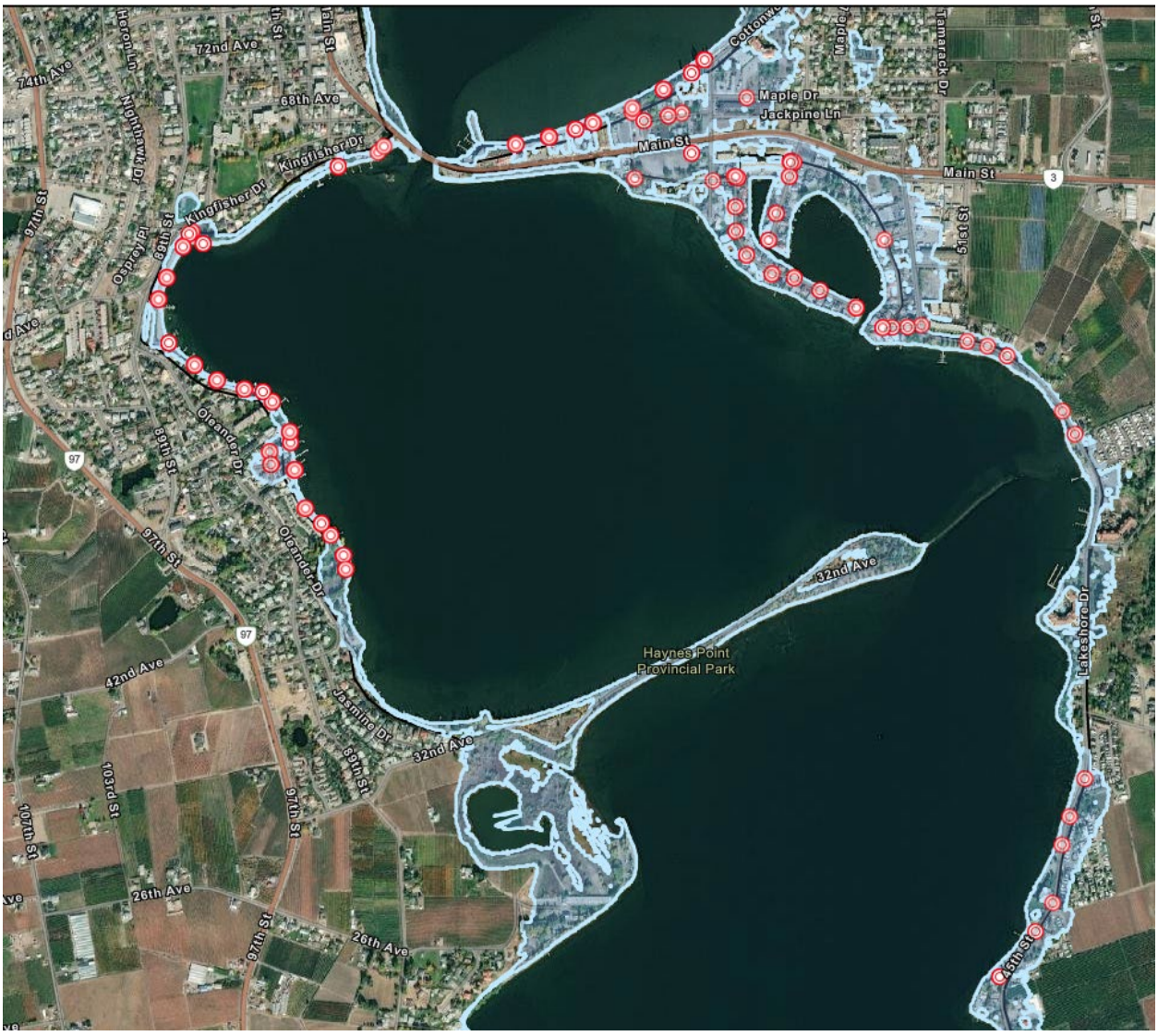
Project LS4.0 - Main Lift Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Supply & install erosion control and wave dampening measures to South of Main Lift Station	LS	1	$50,000	$50,000
2.0	Control vault lid waterproofing allowance	LS	1	$10,000	$10,000
				Subtotal	**$60,000**
				Contingency (30%)	$18,000
				Engineering (15%)	$9,000
				Environmental Monitoring (5%)	$3,000
				TOTAL	**$90,000**

S-9,14,21-25: SM1.0-9.0 Manhole Flood Proofing

Priority	High/Medium/Low	**Type**	Structural
Current Flood Vulnerability	Varies	**Design Elevation**	Varies

Location Map



Description & Risk Profile

As Osoyoos Lake water levels rise, the number of submerged manholes begin to grow, as seen in the table below:

The location, elevation, and quantity of the low-lying manholes are outlined in the table below:

Manhole Location	Approximate Rim Elevation Range(m)	Corresponding Return Period for Rim Elevation (m)	Quantity of Manholes to be Waterproofed
Osoyoos Lakeshore	278.1-279.6	2-50	0 (Assume already done)
Magnolia Place	279	10	4
Solana Key Court	279	10	5
Harbour Key Drive	279	10	13
Maple Drive	279.3	20	1
Ponderosa Drive	279.3	20	3
Bayview Crescent	279.3	20	3
Cottonwood Drive	279.6	50	3
Lakeshore Drive	279.6	50	12

Risk to Infrastructure:

- Surcharging of the sanitary system from I&I
- Failure of liftstation equipment caused by excessive run times because of increased flows

Risk to Public

- Cross contamination of Osoyoos Lake with surcharged sanitary water
- Failure of sanitary system leading to evacuation of effected sanitary catchment

Permanent Mitigation Solution

- All manholes below or equal to 279.6m to be permanently waterproofed.
- Manholes above 279.6m should be temporarily waterproofed when forecasted Lake water levels are expected to be above the level noted above.

Capital Cost: $356,400

S-9&14

Project SM1.0-4.0 - 1:2 (278.1m) - 1:10 (279.0m) Manhole Waterproofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Supply and Install permanent waterproof manhole lids at all manholes with rim elevations less than or equal to 279.0m	ea	22	$3,000	$66,000
2.0	allowance for manhole grouting and sealing	ea	22	$1,200	$26,400
3.0	Traffic Control	day	22	$1,200	$26,400
				Subtotal	**$118,800**
				Contingency (30%)	$35,640
				Engineering (15%)	$17,820
				Environmental Monitoring (5%)	$5,940
				TOTAL	**$178,200**

S-21-25

Project SM5.0-9.0 - 1:20 (279.3m) to 1:50 (279.6m) Manhole Waterproofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Supply and Install permanent waterproof manhole lids at all manholes with rim elevations less than or equal to 279.0m	ea	22	$3,000	$66,000
2.0	allowance for manhole grouting and sealing	ea	22	$1,200	$26,400
3.0	Traffic Control	day	22	$1,200	$26,400
				Subtotal	**$118,800**
				Contingency (30%)	$35,640
				Engineering (15%)	$17,820
				Environmental Monitoring (5%)	$5,940
				TOTAL	**$178,200**

S-10:WI1.0 - Irrigation Well No. 9 Pumphouse Floodproofing

Priority	Medium	**Type**	Structural
Current Flood Vulnerability	279.4 m	**Design Elevation**	280.8 m

Location Map

Streetview Map

Permanent Mitigation Map

Project WI1.0 - Pumphouse #9 & Intake - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for raising electrical equipment	LS	1	$25,000	$25,000
2.0	purchase install-ready pump motors	ea	2	$80,000	$160,000
				Subtotal	**$185,000**
				Contingency (30%)	$55,500
				Engineering (15%)	$27,750
				TOTAL	**$268,250**

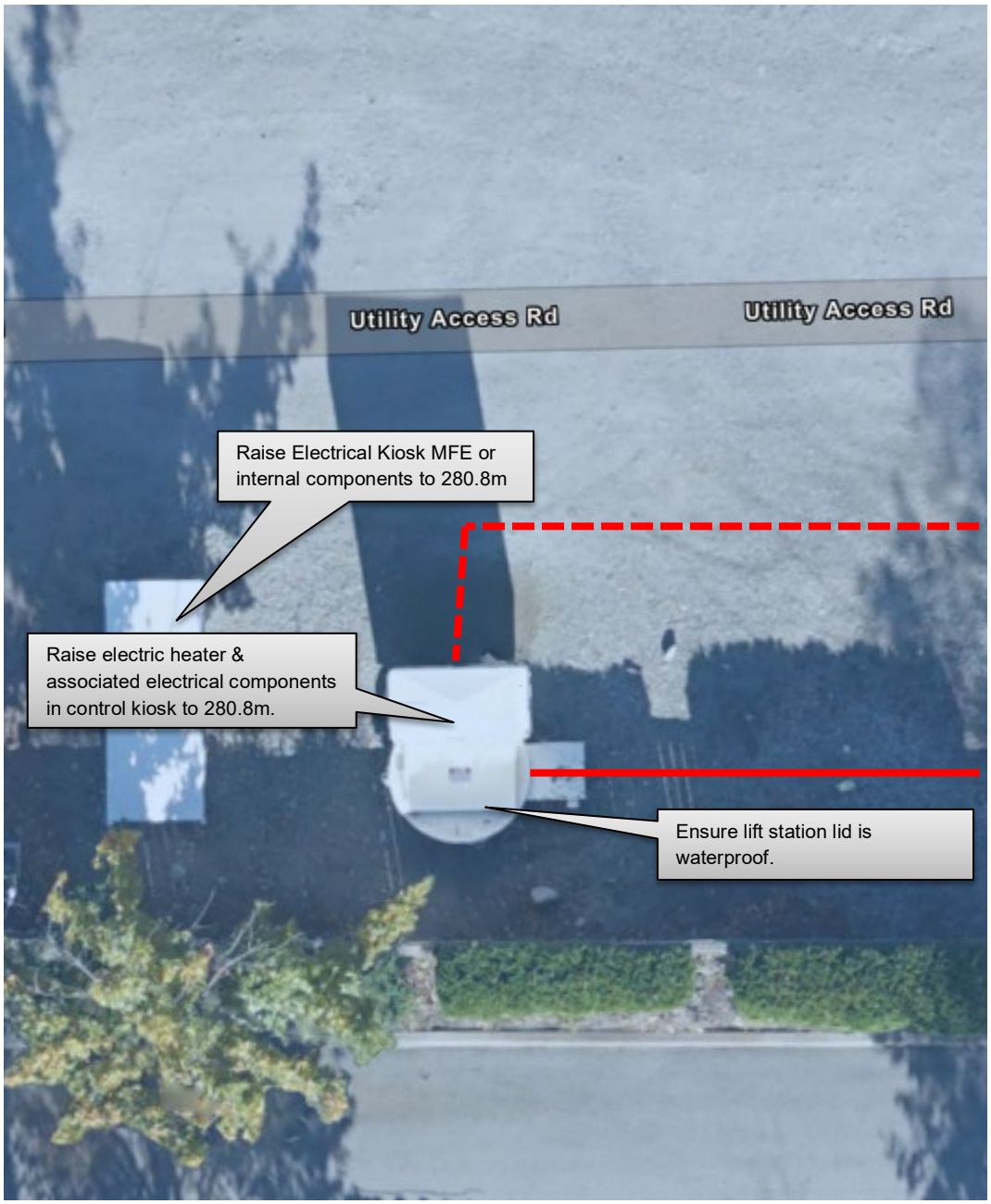
S-11: LS5.0 North Cottonwood Drive Lift Station Flood & Erosion Proofing

Priority	Medium	**Type**	Structural
Current Flood Vulnerability	278.7 m	**Design Elevation**	280.8m

Location Map

Streetview Map

Permanent Mitigation Measures Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main on Cottonwood Drive to sanitary manhole (SMH0622) on Cottonwood Drive.
    - Lift Station Flow: 22L/s
    - Area Effected: Approximately 30% of the North-East sector & the Nk'Mip Campgrounds
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.1m
    - Electrical Kiosk MFE: 279.3m
- With wave action the lift station could see flooding impacts at an elevation of 278.7m. Without waves, When Osoyoos Lake water levels reach 279.3m the electrical kiosk will be submerged, followed by the Lift Station.
- The liftstation has been impacted by flood waters in both the 2017 and 2018 flood seasons
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical components within the lift station
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.

Permanent Mitigation Solution

- Raise the electrical kiosk or electrical components within kiosk to an elevation of 280.8m.
- Ensure liftstation lid is still waterproof. If not, replace seal
- Raise electric heater and associated electrical equipment in control kiosk to 280.8m

Capital Cost: $127,500

Project LS5.0 - North Cottonwood Drive Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	raise electrical kiosk raising or electrical component raising	LS	1	$75,000	$75,000
3.0	Raise electric heater & internal electrical components in valve kiosk to 281.4m (min.)	LS	1	$5,000	$5,000
				Subtotal	**$85,000**
				Contingency (30%)	$25,500
				Engineering (15%)	$12,750
				Environmental Monitoring (5%)	$4,250
				TOTAL	**$127,500**

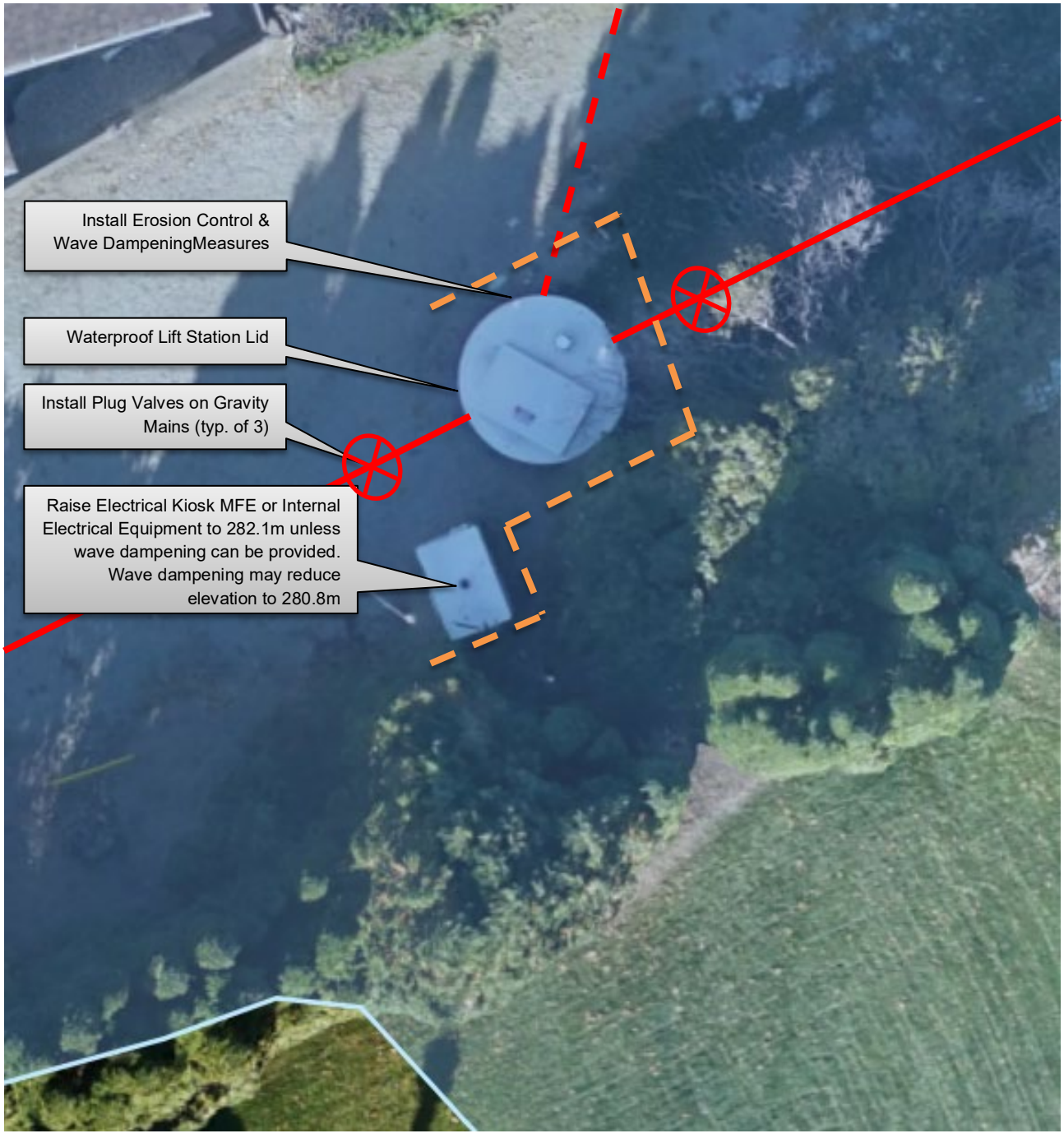
S-12: LS6.0 - Blue Blinker Lift Station Flood & Erosion Proofing

Priority	Medium	**Type**	Structural
Current Flood Vulnerability	278.6 m	**Design Elevation**	282.1m

Location Map

Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains and forcemains in the South-West Sector of Osoyoos to sanitary manhole SMH0518, along the Osoyoos Lake shoreline parallel to Magnolia Place.
    - Add flow and service population.
- Critical infrastructure component elevations:
    - Liftstation Lid: 279.9m
    - Electrical Kiosk MFE: 279.9m
- With wave action the liftstation could see flooding impacts at an elevation of 278.6m (1.3m wave height). Without waves, When Osoyoos Lake water levels reach 279.9m the sanitary Lift Station & electrical kiosk become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Ensure liftstation lid is waterproof
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 282.1m. If wave dampening is provided, elevation can be reduced to 280.8m.
- Install erosion and wave dampening control measures around the sanitary infrastructure.
- Install plug valves on the gravity mains flowing into lift station

Capital Cost: $236,000

Project LS6.0 - Blue Blinker Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
3.0	Supply & install erosion control measures	LS	1	$25,000	$25,000
4.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	3	$15,000	$45,000
5.0	Allowance for dewatering works	LS	1	$7,500	$7,500
				Subtotal	**$157,500**
				Contingency (30%)	$47,250
				Engineering (15%)	$23,625
				Environmental Monitoring (5%)	$7,875
				TOTAL	**$236,250**

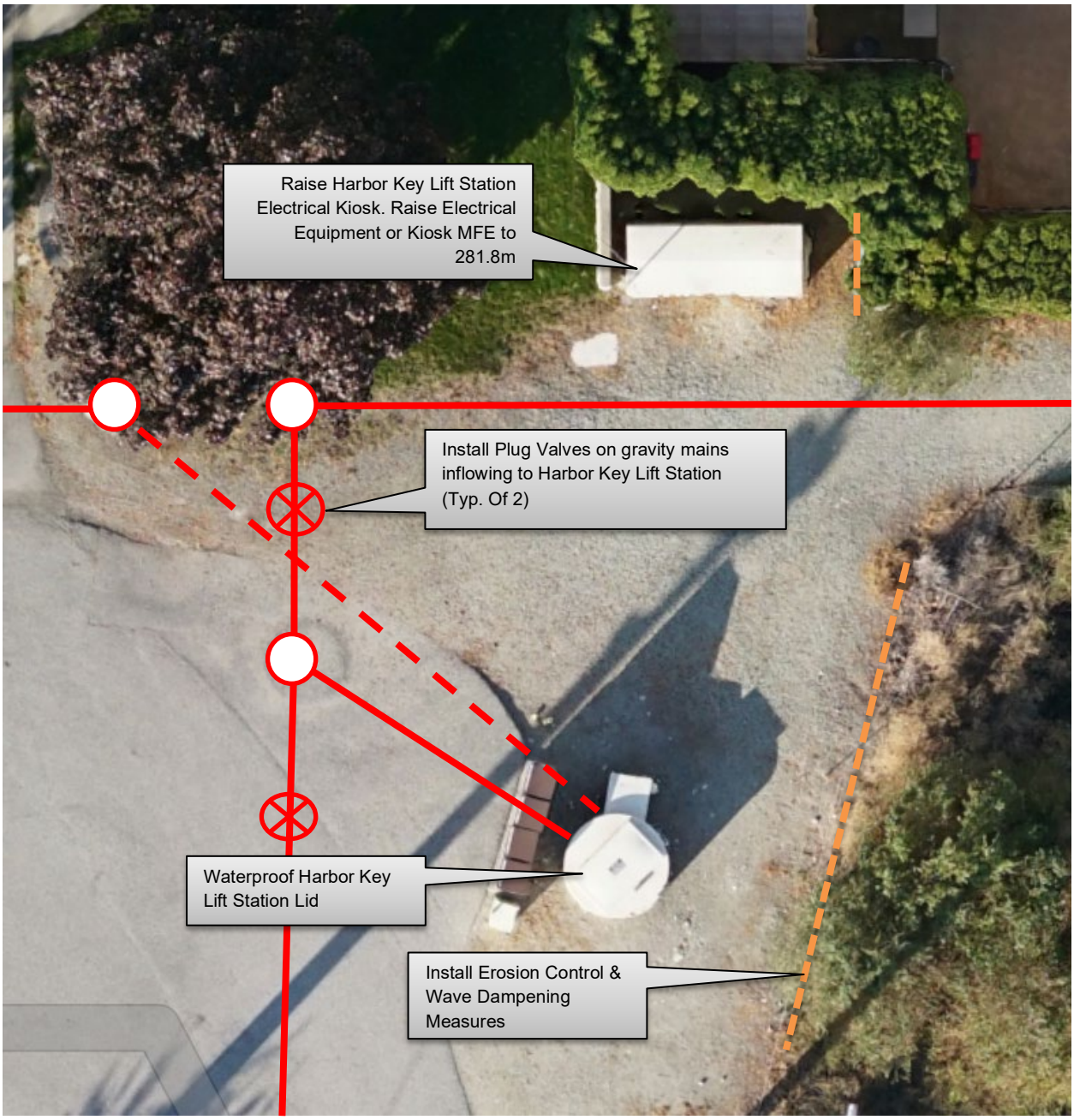
S-13: LS7.0 - Harbor Key Drive Lift Station Flood Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	278.2 m	**Design Elevation**	281.8 m

Location Map

Google Street View Map

Permanent Mitigation Measures Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains in the Harbor Key area (SMH0705 to SMH1013) to SMH0289 manhole near Main Lift.
    - Lift Station Pump Capacity: 8 L/s
    - Service Population: Approximately 10% of the Northeast Sector
- Critical infrastructure component elevations:
    - Liftstation Lid: 279.9m
    - Electrical Kiosk MFE: 279.2m
- With wave action the lift station electrical kiosk could see flooding impacts at an elevation of 278.2m. Without waves, When Osoyoos Lake water levels reach 279.2m the electrical kiosk become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment
    - Etc.

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Ensure Lift Station lid is waterproof.
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 281.8m.
- Install plug valve(s) on the gravity main flowing into liftstation to prevent excess inflow to lift station surcharging.
- Install erosion control and wave dampening measures

Capital Cost: $240,000

Project LS7.0 - Harbour Key Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

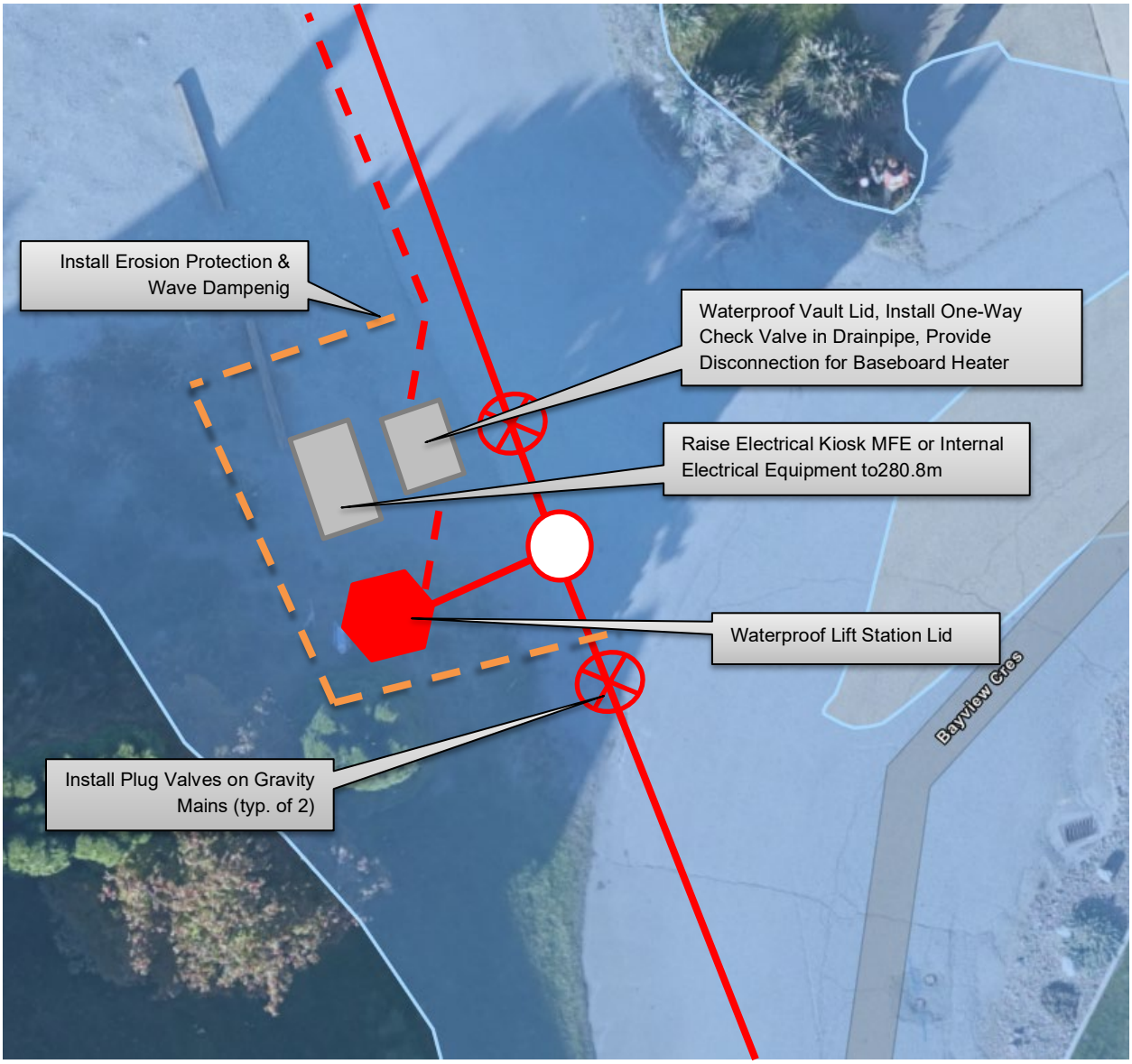
ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for lift station lid waterproofing	LS	1	$5,000	$5,000
1.0	Raise electrical kiosk or electrical component raising	LS	1	$90,000	$90,000
2.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	2	$15,000	$30,000
3.0	Allowance for dewatering works	LS	1	$5,000	$5,000
4.0	Install erosion control & wave dampening	LS	1	$30,000	$30,000
				Subtotal	**$160,000**
				Contingency (30%)	$48,000
				Engineering (15%)	$24,000
				Environmental Monitoring (5%)	$8,000
				TOTAL	**$240,000**

S-15: LS8.0 Bayview Lift Station Flood & Erosion Proofing

Priority	Medium	**Type**	Structural
Current Flood Vulnerability	278.9 m	**Design Elevation**	280.8 m

Location Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains in the Southeast quadrant of Osoyoos to SMH0959 in the back alley between the Adriatic Motel & Paradise Park RV Resort.
    - Pumping Capacity: 18 L/s
    - Service Population: Bayview Development Area
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.0m
    - Electrical Kiosk MFE: 279.5m
    - Control Valve Chamber Lid: 279.5m
- With wave action the lift station could see flooding impacts at an elevation of 278.9m. If the Osoyoos Lake static water level reaches 279.5m or water and wave levels combine to an elevation of 279.5m, the control valve chamber & electrical kiosk become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment
    - Etc.

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is not feasible for this location. As such, mitigation options include:

- Ensure lift station lid is waterproof
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 280.8m.
- Install erosion control measures around the sanitary infrastructure
- Install plug valve(s) on the gravity mains flowing into lift station
- Ensure control kiosk lid is waterproof

Capital Cost: $225,000

Project LS8.0 - Bayview Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
3.0	Supply & install erosion control measures	LS	1	$25,000	$25,000
4.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	2	$15,000	$30,000
5.0	supply electrical disconnect switch for control vault electrical components	LS	1	$5,000	$5,000
6.0	Allowance for control vault lid waterproofing	LS	1	$5,000	$5,000
7.0	Allowance for dewatering works	LS	1	$5,000	$5,000
				Subtotal	**$150,000**
				Contingency (30%)	$45,000
				Engineering (15%)	$22,500
				Environmental Monitoring (5%)	$7,500
				TOTAL	**$225,000**

S-16: LS9.0 - Inakeep Point Lift Station Flood Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	279.3 m	**Design Elevation**	280.8 m

Location Map

Streetview Map

Permanent Mitigation Measures

Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains and forcemains in the Northwest quadrant of Osoyoos to SMH0788 manhole on 89th St.
    - Lift Station Capacity: 16 L/s
    - Service Population: Approximately 40% of Northwest Sector (Area A)
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.3m
    - Electrical Kiosk MFE: 279.9m
    - Control Vault Lid: 279.9m
- With wave action the lift station electrical kiosk, control vault, and transformer could see flooding impacts at an elevation of 279.3m; Without waves, When Osoyoos Lake water levels reach 279.9 m the sanitary Lift Station control vault, electrical kiosk, and transformer becomes submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Ensure lift station lid is waterproof
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 280.8m.
- Raise the transformer MFE or electrical components within kiosk to an elevation of 280.8m.
- Ensure control valve vault lid is waterproof
- Supply quick disconnect for control vault electrical components
- Install one-way check valve on control vault floor drain
- Install plug valve(s) on the gravity main flowing into lift station.

Capital Cost: $232,500

Project LS9.0 - Inkaneep Pt Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	Raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
3.0	Raise electrical transformer	LS	1	$30,000	$30,000
4.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	2	$15,000	$30,000
5.0	Allowance for dewatering works	LS	1	$5,000	$5,000
6.0	Allowance for control vault lid waterproofing	LS	1	$5,000	$5,000
7.0	Supply & install one way checkvalve in vault drainpipe	LS	1	$2,500	$2,500
8.0	Supply & Install disconnection for control vault electrical equipment	LS	1	$2,500	$2,500
				Subtotal	**$155,000**
				Contingency (30%)	$46,500
				Engineering (15%)	$23,250
				Environmental Monitoring (5%)	$7,750
				TOTAL	**$232,500**

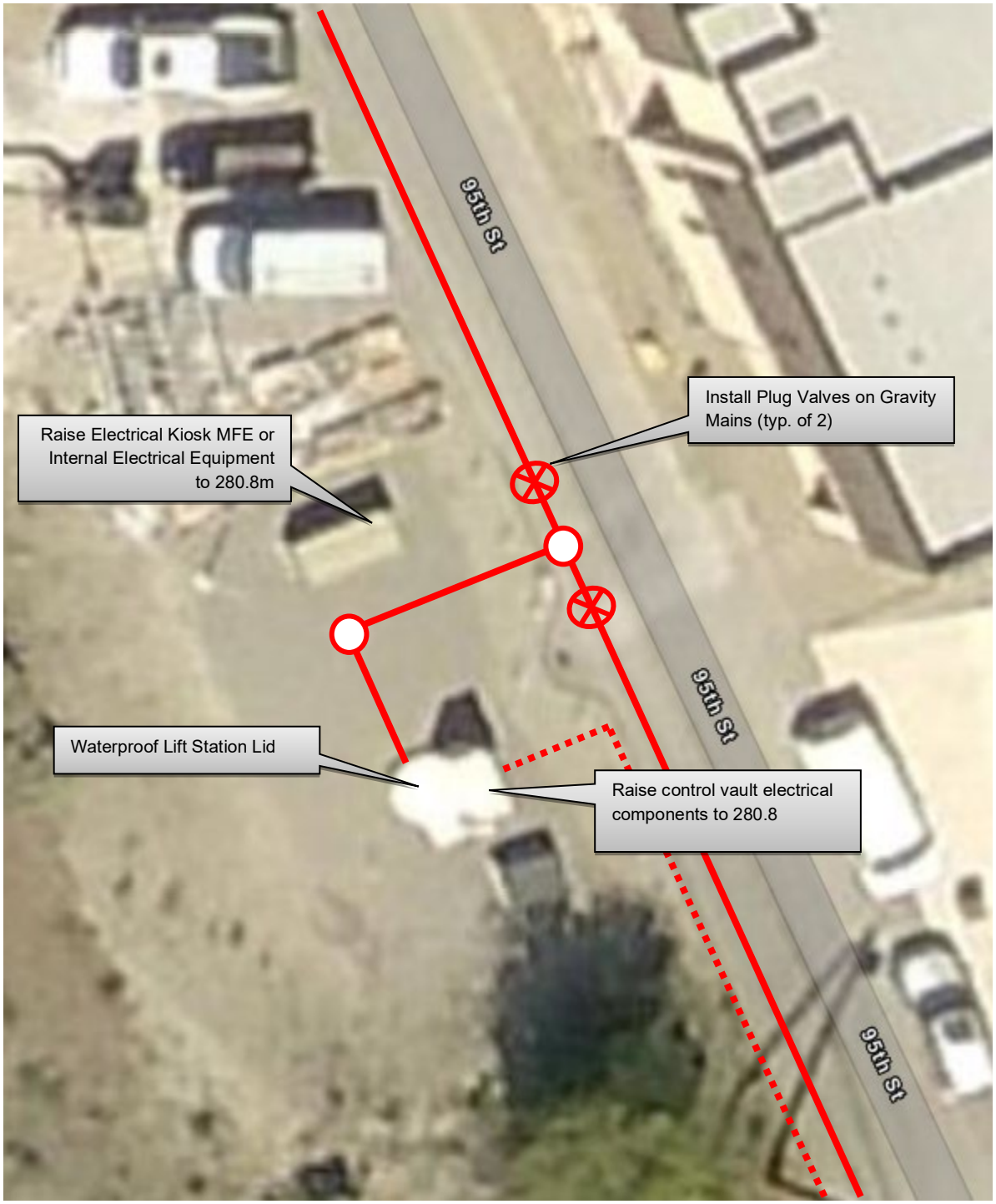
S-17: LS10.0 - 95th Street Lift Station Flood Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	279.3	**Design Elevation**	280.8

Location Map

Streetview Map

Permanent Mitigation Measure Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main on 95th Street to sanitary manhole SMH0722 at the East end of 87th Street.
    - Lift Station Pump Capacity: 14 L/s
    - Service Population: Approximately 30% of Northwest Sector (Area A)
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.2
    - Electrical Kiosk MFE: 279.9
- With wave action the lift station could see flooding impacts at an elevation of 279.3m. Without waves, When Osoyoos Lake water levels reach 279.9m the sanitary Lift Station and its associated electrical kiosk become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical components within the lift station
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.

Permanent Mitigation Solution

- Ensure Lift Station lid is waterproof.
- Raise the electrical kiosk or electrical components within kiosk to an elevation of 280.8m.
- Install plug valves on the gravity mains flowing into liftstation

Capital Cost: $180,000

Project LS10.0 - 95th Street Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	Raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
4.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	2	$15,000	$30,000
5.0	Allowance for dewatering works	LS	1	$5,000	$5,000
6.0	Raise electrical components in control vault	LS	1	$5,000	$5,000
				Subtotal	**$120,000**
				Contingency (30%)	$36,000
				Engineering (15%)	$18,000
				Environmental Monitoring (5%)	$6,000
				TOTAL	**$180,000**

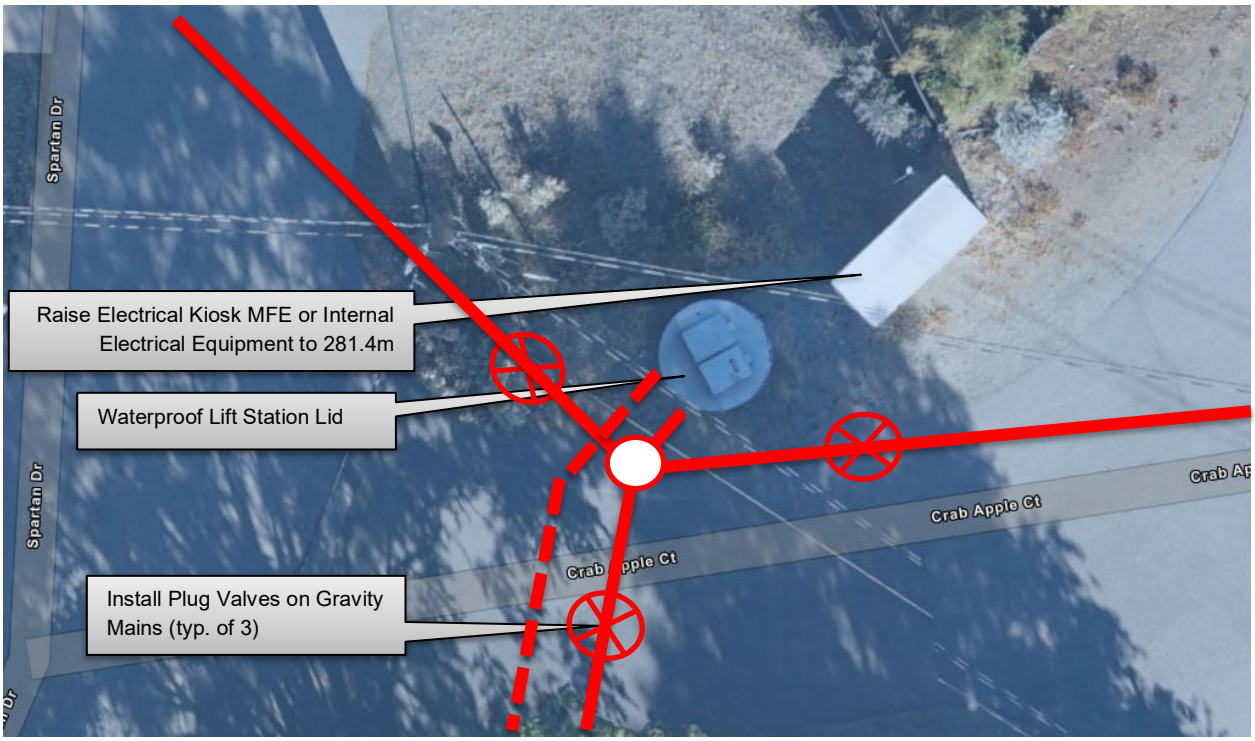
S-18: LS11.0 - Lacey Point (Crab Apple Ct) Lift Station Flood & Erosion Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	279.0 m	**Design Elevation**	280.8 m

Location Map

Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains on Spartan Drive, Braeburn Place, & 92nd Ave, (SMH0073, SMH0069, & SMH0069) to SMH0092 manhole on 87th St.
    - Lift Station Pump Capacity: 9 L/s
    - Lift Station Service Area: Approximately 15% of the Southwest Sector
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.3m
    - Electrical Kiosk MFE:279.6m
- With wave action the lift station could see flooding impacts at an elevation of 279.0m. Without waves, When Osoyoos Lake water levels reach 279.6m the electrical kiosk followed by the sanitary lift station become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

- Ensure lift station lid is waterproof.
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 280.8m.
- Install plug valves on the gravity main flowing into liftstation

Capital Cost: $195,000

Project LS11.0 - Crab Apple Ct (Lacey Point) Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Allowance for liftstation lid waterproofing	LS	1	$5,000	$5,000
2.0	Raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
4.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	3	$15,000	$45,000
5.0	Allowance for dewatering works	LS	1	$5,000	$5,000
				Subtotal	**$130,000**
				Contingency (30%)	$39,000
				Engineering (15%)	$19,500
				Environmental Monitoring (5%)	$6,500
				TOTAL	**$195,000**

S-19: LS-12 Haynes Point Lift Station Flood Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	279.3 m	**Design Elevation**	280.8 m

Location Map

Street View Map

Permanent Mitigation Measures Map

Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity main on 32nd Ave. (SMH0705 to SMH1013) to SMH0522 manhole along the Osoyoos Lake shoreline, parallel to Jasmine Drive.
    - Lift Station Pump Capacity: 13 L/s
    - Service Population: Haynes Point Provincial Park
- Critical infrastructure component elevations:
    - Liftstation Lid: 280.6m
    - Electrical Kiosk MFE: 280.1m
    - Vault Lid: 279.9m
- With wave action the lift station could see flooding impacts at an elevation of 279.3m. Without waves, When Osoyoos Lake water levels reach 279.9m the sanitary Lift Station vault will become submerged.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
    - Erosion potential around the infrastructure
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

Relocation of the liftstation & associated infrastructure is unsuitable for this location. As such, mitigation options include:

- Ensure lift station lid is waterproof.
- Raise the electrical kiosk MFE or electrical components within kiosk to an elevation of 280.8m.
- Vault upgrades:
    - Install one-way check valve on vault drainpipe
    - Make lid waterproof
    - Provide disconnect for baseboard heater and other electrical components

Capital Cost: $127,500

Project LS12.0 - Haynes Point Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	Raise electrical kiosk or electrical component raising	LS	1	$75,000	$75,000
2.0	Allowance for control vault lid waterproofing	LS	1	$5,000	$5,000
3.0	Supply & install one way checkvalve in vault drainpipe	LS	1	$2,500	$2,500
4.0	Supply & Install disconnection for control vault electrical equipment	LS	1	$2,500	$2,500
				Subtotal	**$85,000**
				Contingency (30%)	$25,500
				Engineering (15%)	$12,750
				Environmental Monitoring (5%)	$4,250
				TOTAL	**$127,500**

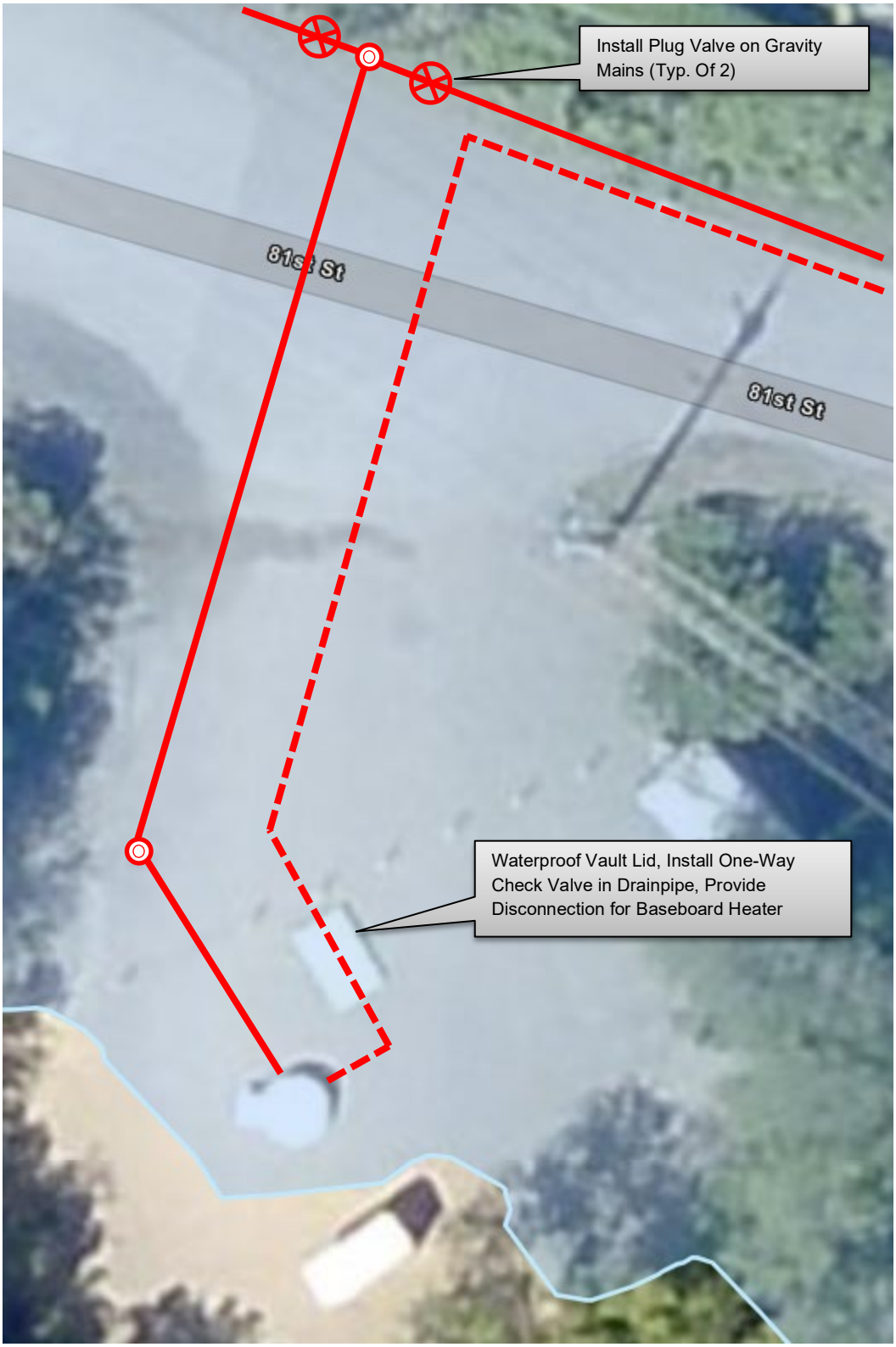
S-20: LS13.0 - Roberts Point Lift Station Flood Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	280.0 m	**Design Elevation**	280.8 m

Location Map

Streetview Map

Permanent Mitigation Map



Description & Risk Profile

- Sanitary lift station pumping sanitary waste from the gravity mains and forcemains in the Northwest quadrant of Osoyoos to SMH0777 manhole on 81st St.
    - Lift Station Pump Capacity: 16 L/s
    - Approximately 50% of the Northwest Sector (Area A)
- Critical infrastructure component elevations:
    - Liftstation Lid: 281.5m
    - Electrical Kiosk MFE: 280.9m
    - Control Vault: 280.6m
- With wave action the lift station could see flooding impacts at an elevation of 280.0m. If water and wave levels combine to an elevation of 280.6m, the control vault will be at risk of wave attack.
- Risks to this infrastructure include:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to mechanical & electrical components within the lift station & vault
- Risk to public caused by failure of this infrastructure includes:
    - Cross contamination between Osoyoos Lake and untreated sanitary water
    - Surcharging of the downstream gravity system caused by lift station failure
    - Evacuation of residences within the sanitary catchment area.
    - Risk of electrocution caused by submerged electrical equipment

Permanent Mitigation Solution

- Vault upgrades:
    - Install one-way check valve on vault drainpipe
    - Make lid water resistant
    - Provide disconnect for baseboard heater and other electrical components
- Install plug valves on the gravity main flowing into liftstation

Capital Cost: $60,000

Description & Risk Profile

- One primary irrigation well for the Town's agricultural sector
    - Supply's water to upwards of 500 Acres of farm land.
- The intake is located approximately 160m from the Osoyoos Lake natural boundary. Well heads, electrical, and mechanical components are located in masonry building.
- Approximate elevations of critical infrastructure are as follows:
    - Building entrance elevation: 280.0m
    - MFE: 278.2m
    - Pump motor elevation: 278.8m
    - Majority of internal electrical components: 280.0m
    - Electrical transformer & vault: 280.8m
- When water levels reach a static water level of 278.2m, there is potential for flooding of the pump station floor caused by backflow through the flood drains (Assuming there are floor drains). With waves it is anticipated that the well house could see flooding impacts starting at an elevation of 279.4 m. Without waves, flooding through access doors into the building could occur at 280.0m.
- Risks to this infrastructure includes:
    - Damage to the electrical supply
    - Damage to electrical controls
    - Damage to the building
- Risk to public caused by failure of this infrastructure includes:
    - A loss of water to farms

Permanent Mitigation Solution

Due to the quantity of water and limited alternative locations it is more prudent to protect in place while relocating key components.

- Permanent mitigation scope includes:
    - Raise critical electrical components within building to an elevation of 280.8m.
    - Purchase backup, replacement pump motors, for fast replacement following building flooding.

Capital Cost: $268,000

Project LS13.0 - Roberts Point Lift Station - Flood & Erosion Proofing
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
2.0	Supply & Install plug valves, c/w all asphalt removal and restoration, traffic control, etc.	ea	2	$15,000	$30,000
3.0	Allowance for dewatering works	LS	1	$5,000	$5,000
4.0	Raise electrical components in control vault	LS	1	$5,000	$5,000
				Subtotal	**$40,000**
				Contingency (30%)	$12,000
				Engineering (15%)	$6,000
				Environmental Monitoring (5%)	$2,000
				TOTAL	**$60,000**

S-26: M1.0 - Osoyoos Marina Flood & Erosion Proofing

Priority	Low	**Type**	Structural
Current Flood Vulnerability	Varies	**Design Elevation**	Varies

Location Map

Streetview Map

Permanent Mitigation Map

Description & Risk Profile

Osoyoos Marina, providing moorage, launching, and public rest areas.

- When Osoyoos Lake static water levels reach 279.0m the wave breaks, which include public picnic areas become submerged
- At 279.3m the launching ramp access becomes submerged.
- At 280.2m a portion of Spartan Drive and access to the launch becomes submerged

In this area, this area wave uprush can vary from 1.0m to 1.6m. Generally 1.0m wave uprush is expected at the wave breaks while 1.6m can be expected at the retaining walls.

Risk to the marina and associated infrastructure includes:

- Erosion of the wave breaks and infrastructure
- Damage to infrastructure from saturation
- Disconnection of docks from pilings depending on top of pile VS WSEL + wave action.

Permanent Mitigation Solutions

Permanent mitigation solutions include:

- Erosion protection at wave breaks
- Erosion protection at the top of marina retaining wall
- Raising the top of pilings to protect from dock disconnection
- Erosion protection at Sailing Club
- Closing boat launch when Osoyoos lake Levels reach 279.3m

Capital Cost: $150,000

S-26

Project M1.0 - Flood & Erosion Proofing Osoyoos Marina
Class D Cost Estimate

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	EST. QTY.	UNIT PRICE	TOTAL PRICE
1.0	raise dock pilings	ea	14	$2,500	$35,000
2.0	Armouring above retaining walls	LS	1	$50,000	$50,000
3.0	Armouring wave breaks	LS	1	$50,000	$50,000
				Subtotal	**$100,000**
				Contingency (30%)	$30,000
				Engineering (15%)	$15,000
				Environmental Monitoring (5%)	$5,000
				TOTAL	**$150,000**

APPENDIX D

Technical Memorandums

Memorandum

To:	TRUE Consulting	**From:**	Pat Prodanovic, Ph.D., P.Eng.
Attn:	Steve Underwood, P.Eng.		
Date:	August 3, 2022	**File No:**	302-2001

RE: Vertical Datum for Osoyoos Flood Mitigation Plan

This memo discusses the intricacies of using several different vertical datums for this project. Data available (and used) by the Town of Osoyoos is available at these vertical datums:

1. National Geodetic Vertical Datum 1929 (NGVD28) – a US based datum. This datum is used for reporting water levels at the Zosel Dam, which the Town uses during flood event.
2. Canadian Geodetic Vertical Datum 1928 (CGVD28) – a Canadian based datum used since 1935. This datum has been the standard vertical datum used in Canada for the past century.
3. Canadian Geodetic Vertical Datum 2013 (CGVD2013) – a Canadian based datum, updated using the latest space-based technologies (Global Positioning System, GPS). This vertical datum was brought to address several limitations of the older CGVD28 datum, and will become the standard vertical datum in Canada.

The Province notes that adoption of the CGVD2013 is in progress, and will take some time (10 to 20 years). Some of the publicly available data is already available in the CGVD2013 vertical datum (i.e., the Provincial high resolution LiDAR topographic data). Also, the recently completed Okanagan Mainstem Floodplain Mapping Project (2020) provided water surface elevations in both the CGVD28 and CGVD2013 vertical datums.

Recognizing that ultimate adoption of the CGVD2013 vertical datum will take some time, the office of the Land Title and Survey Authority of British Columbia has issued a directive on December 7, 2018 (and amended on August 28, 2019) that states “the approved vertical datum for legal surveys throughout the province is CGVD28 and the acceptable hybrid geoid model for all areas of BC (outside of the Metro Vancouver to Abbotsford area) is HTv2.0 (1997).”

Given the above directive, for the purposes of this project we are recommending that Town of Osoyoos continues using the CGVD28 vertical datum.

Having the ability to convert between the above vertical datums thus becomes necessary, as topographic and/or water surface elevation data is collected and referenced using different standards. For the Town of Osoyoos, these conversions are:

The conversion from NGVD29 to CGVD28 is reported by the 1982 International Joint Commission Order of Approval for Zosel Dam, which states that the CGVD28 datum is 0.26 ft lower than the NGVD29 datum. This means implies that to convert from NGVD29 to CGVD28, requires subtraction of 0.26 ft. For example, to convert an elevation of 912 ft NGVD29 to CGVD28 requires:

912 ft NGVD29 = 912 - 0.26 = 911.74 ft CGVD28 x 0.3048 (m/ft) = 277.90 m CGVD28

For the conversion from CGVD2013 to CGVD28, we have used a Natural Resources Canada (NRCAN) High Precision Vertical Benchmark located in Osoyoos (benchmark id 75C2000, located near the junction of Hwy 97 and Hwy 3). The elevations at the NRCAN High Precision Vertical Benchmark are the following:

CGVD2013 EL. 344.538 m

CGVD28 EL. 344.339 m

Therefore, to convert from CGVD2013 to CGVD28 requires subtraction of 0.199 m. For practical purposes, we recommend that the conversion factor be rounded to 0.2 m. Thus:

CGVD28 = CGVD2013 - 0.2 m

We trust the above is sufficient for the present purposes. Should you require clarification, please do not hesitate to contact the undersigned.

Regards,

Pat Prodanovic

Pat Prodanovic, Ph.D., P. Eng.

PP/slf