Chilliwack Bell Slough Improvements Feasibility Study [Final]

Feasibility Study

Prepared for:
City of Chilliwack

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Project No. 111700747

August 16th, 2023

Revision Record

Revision	Description	Author			Quality Check		Independent Review
0	Final – Submission for Client Review	LP	AM	TM	NG	NC	FK, LD
1	Final – Submission for Client	AM			NC		LP

Sign-off Sheet

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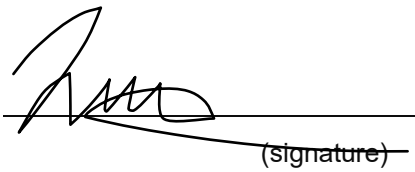
[Civil] Prepared by 

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Abbreviations

ALR	Agricultural Land Reserve
BC	British Columbia
BC WQG	British Columbia Approved Water Quality Guideline
BOD	Biological Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CN	Curve Number
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWH	Coast Western Hemlock
DEM	Digital Elevation Model
DO	Dissolved Oxygen
EC	Environment Canada
EGBC	Professional Engineers and Geoscientists of British Columba
FAO	Food and Agriculture Organization
GIS	Geographic Information System
HDPE	High-density Polyethylene
HGL	Hydraulic Grade Line
IAPP	Invasive Alien Plant Program
IDF	Intensity-Duration-Frequency
LiDAR	Light Detection and Ranging
MOE	Ministry of Environment
MOECCS	Ministry of Environment and Climate Change Strategy
MOFLNRO	Ministry of Forests, Lands and Natural Resource Operations
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
PCIC	Pacific Climate Impacts Consortium
PCSWMM	Personal Computer Storm Water Management Model
SARA	Species at Risk
SC	Special Concern
SCS	Soil Conservation Service
YSI	Yellow Springs Instruments

1.0 INTRODUCTION

1.1 Background and Objective

The Chilliwack Bell Slough is situated on the north-western region of the City of Chilliwack. The slough serves as a drainage channel where flows and surface runoff are concentrated in a primary flow conveyance route. The Bell Slough is part of a network of watercourses that was originally connected to the Fraser River prior to construction of the Fraser River dike system over 100 years ago. For decades, the Bell Slough has been landlocked with blocked water connectivity due to physical limitations at the upstream Nelson Slough interface and the downstream Fraser River interface. **Figure 1.1** illustrates the geographic location of the slough in addition to the interconnecting sloughs in the adjacent areas. The subject area is generally bounded by agricultural lands, rural residential developments, and industrial developments.

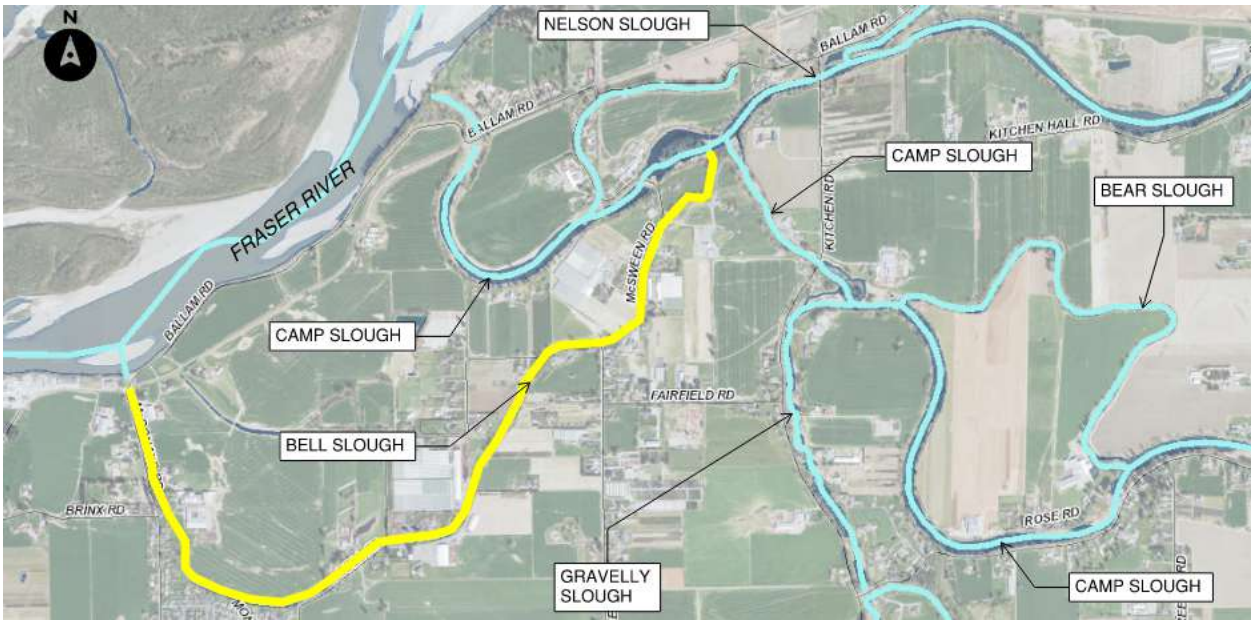

Figure 1.1: Bell Slough Physical Limitations

As a result of the limited connectivity of the Bell Slough and lack of water entering and flowing through the slough, there have been several negative impacts to the water quality and ecological performance of the slough. In addition, nutrient loading and stormwater runoff from adjacent properties may also have contributed to the declining environmental and habitat health of the slough. Stantec Consulting Ltd. (Stantec) has been retained by the City of Chilliwack (City) to complete this *Chilliwack Bell Slough Feasibility Study*, which will identify and evaluate potential hydraulic infrastructure, environmental and habitat rehabilitation, and operational measures that could be implemented to improve the hydraulic and ecological performance of the Bell Slough System. Subsequently, hydraulic modeling, environmental samplings and detailed analysis have been conducted to support this study, which is further explained in the following sections of this report.

1.2 Methodologies

1.2.1 Background Resources

A desktop review of historic reports on the Bell Slough, surrounding waterways, and lands was completed to determine background data on the slough. For the hydraulic assessment, hydrometric resources, aerial maps, and geomatic data were used.

The following studies, databases, software, standards, and resources were referenced in the preparation of this report:

- Environment and Climate Change Canada (ECCC, 2022) published information on real-time hydrometric data
- Government of British Columbia (Govt BC, 2020) ArcGIS light detection and ranging (LiDAR) data
- Computerized intensity-duration-frequency (IDF_CC) tool (University of Western Ontario, 2022) to generate local IDF curve information based on historical data and future climate conditions
- *District of Chilliwack Bell Slough Drainage Study* (Delcan, 1988) completed in 1988
- City of Chilliwack (City of Chilliwack, 2022) web map and open data catalogue (LiDAR, utilities, water features, orthophotos, etc.) and Bell Slough and Fraser River water level data
- *SWMM5 User's Guide* (13th Edition)

For the environmental assessment, a search of available data sources and mapping was conducted to identify known occurrences of invasive plant species, ecological communities, plant and/or wildlife species at risk, and aquatic resources. The environmental desktop review focused on a radius at least 1 km (records of wildlife, fisheries, watercourses) or 5 km (species at risk and identified critical habitat) surrounding the Bell Slough. The following studies, databases, standards and GIS resources were referenced in the preparation of this report:

- Habitat Wizard – reviewed for mapped known or historical occurrences of fish presence and species at risk within watercourses that cross the Project footprint
- The BC Conservation Data Centre (CDC) Ecosystems Explorer and *Species at Risk Act* (SARA) Public Registry – provincial and federal conservation species at risk status reviewed for mapped known or historical occurrences of wildlife and vegetation species within 5 km of the slough
- The Invasive Alien Plant Program (IAPP) database and map display – reviewed invasive plant species within 1 km of the slough
- City of Chilliwack web map and open data catalogue – reviewed for environmental, municipal, and legal land information

City of Chilliwack Watercourse Classification Map – provided the fish habitat classifications, which are:

- Class A – red-coded: Indicates fish presence or the potential for fish presence if current barriers or obstructions are removed or made passable to fish
- Class B – yellow-coded: No fish presence but provides water, food, and nutrients to a downstream fish-bearing waterbody
- Class C – green-coded: No fish documented and does not contain significant food or nutrient value. Watercourse is narrow and continuous with areas of existing or potential vegetation.
- Class D – green dash-coded: No fish documented and does not contain significant food or nutrient value. Watercourse is very narrow, with continuous or discontinuous areas of existing or potential vegetation that can be compromised by permanent infrastructure.
- Class E – blue-coded: Watercourse has not been assessed for the presence of fish or nutritional value.

1.2.2 Field Visits, Open Houses, Surveying and Surface Water Sampling

The following in-person field visits and public meetings were conducted to support the background information for this study:

- Site visit conducted by Stantec employees Tara McBryan and Jenny Minford on September 14, 2022
    - The focus of this visit was to document current ecological conditions within the slough and identify areas of concern/ opportunities for improvements. This included assessing riparian and aquatic vegetation, confirming wildlife features and liaising with City Staff and homeowners to understand current restoration efforts. During this visit in-situ water quality reading were taken at 11 locations across the slough using a YSI multimeter to help determine the quality of fish habitat.
- Site visit conducted by Stantec employees, Neal Cody, and Lily Pham on September 22, 2022
    - The focus of this visit was to identify hydraulic features across the slough. This included documenting barriers (e.g. Absence of culverts at crossing of the slough), and infrastructure at the upstream and downstream extents of the slough.
- A photolog of photographs from the above site visits has been developed and is illustrated in **Appendix A**
- Public-open house meeting conducted with Stantec employees, Neal Cody, Lily Pham, and Tara McBryan, City staff, and Chilliwack residents conducted on September 22, 2022
    - The purpose of this open house was to discuss the object of the *Chilliwack Bell Slough Feasibility Study* project and gather information from the public and residents living adjacent to Bell Slough. During this open house, public feedback was obtained in a *Chilliwack Bell Slough Study Questionnaire* (refer to **Appendix B**).
    - The presentation for the Bell Slough Study Open House and the relevant Historic Newspaper Archives can be found in **Appendix B**.
- Topographical survey of the Bell Slough completed on September 27, 2022
    - This survey provided quantitative data on elevation, channel characteristics and water depths of the Bell Slough, as well as data on existing infrastructure and their invert elevations. This information was used to develop a hydraulic model of the Bell Slough.
- Water quality sampling of the Bell Slough conducted on November 3, 2022
    - In-situ water quality and surface water grab samples were taken at 5 locations across the wetted section of the slough by City Staff. The samples were submitted to ALS laboratory for a panel of physical chemistry, anions and nutrients, plant pigments, microbiology, and total and dissolved metals analysis. Results were provided to Stantec for data analysis and interpretation.

2.0 CURRENT SITE DESCRIPTION

2.1 Existing Physical Conditions

The Bell Slough is an important natural resource, which was originally a braided side channel of the Fraser River but has been landlocked with limited connectivity upstream and downstream for several decades. On the upstream end, the Bell Slough is connected to the Nelson/Camp Slough but has limited and blocked connectivity due to McSween Road and several private driveways without culverts.

On the downstream end, the connectivity is controlled by a floodbox culvert which was installed through the Fraser River dike system during the 1990s. This floodbox is closed during larger Fraser River freshets. A search of historical newspaper articles from the Chilliwack Progress shows flooding reports from residents in the areas connected to the Slough prior to installation of the floodbox (see **Appendix B**). Since installation of the floodbox, the City has, when needed, pumped water with portable submersible pumps from the Slough back into the Fraser River to control water levels and prevent potential properties and basements from flooding.

The existing topography of the slough generally falls south and then further west towards the Fraser River. Runoffs from the adjacent agricultural lands, rural residential and industrial developments, as well as the upstream flows from Nelson/Camp Slough systems are currently conveyed through the Bell Slough. **Figure 2.1** illustrates the geographic location and current limitations of the Bell Slough.

The Fraser River dike system along the south bank of the Fraser protects the lands from high water levels overtopping. The dike top elevation in the vicinity of the Bell Slough floodbox is approximately 13.5m. According to the Bell Slough Study 1989, the lowest basement elevation around the Bell Slough is at 10760 McDonald Road which is 9.42m (fixed to CGVD28 datum, 9.30+0.12 = 9.42m).

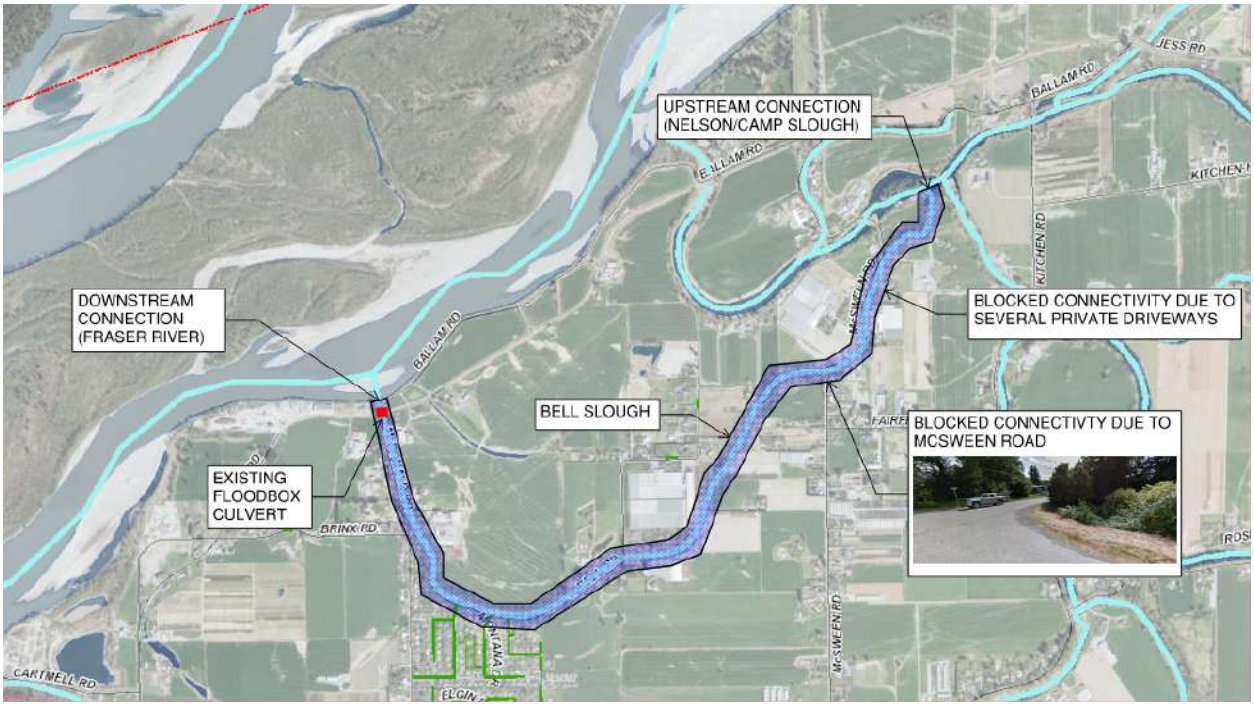

Figure 2.1: Bell Slough Physical Limitations

2.2 Environmental Current Conditions

The Bell Slough is located in the coast western hemlock (CWH) biogeoclimatic zone and has a very dry maritime subzone (xm). Within the Lower Mainland, this subzone occurs at lower elevations from sea level up to approximately 700m, extending from the south side of the Fraser River to the Chilliwack or Vedder Rivers. This upper limit is lower within the wetter parts of its range, specifically in the Fraser Valley. The CWHxm subzone is characterized by warm, dry summers and moist, mild winters, with long growing seasons and relatively little snowfall. Characteristic vegetation within this subzone include a prominence of western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*), shrub species including salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*), red huckleberry (*Vaccinium parvifolium*), moss species including step moss (*Hylocomium splendens*), Oregon beaked moss (*Kindbergia oregana*) and lanky moss (*Rhytidiadelphus loreus*), and a sparse herb layer including sword fern (*Polystichum munitum*), twinflower (*Linnaea borealis*) and bracken fern (*Pteridium aquilinum*)[1].

Based on this biogeoclimatic zone, there is potential for 10 rare plant species to occur within and adjacent to the riparian habitat of the Bell Slough (see **Table 2.1)**. Of these species, Vancouver Island beggarticks (*Bidens amplissima*) and Roell's brotherlla moss (*Brotherella roellii*) have moderate potential to occur based on habitat suitability and distribution[2]. The land surrounding the Bell Slough is a mix of residential (Montana Drive Neighborhood) and agricultural land reserve (ALR). In addition to native plant species there are agricultural crops and ornamental vegetation species within the riparian area of the slough. There have been 11 invasive plant species reported along the wetted portions of the slough in the Invasive Alien Plant Program (**Table 2.2**). Efforts have been made by community stewardship groups to both remove invasive species and replant native species within and around the slough[3].

Table 2.1: Plant Species of Conservation Concern with Potential to Occur Within and Adjacent to Bell Slough[4]

Scientific Name	Common Name	BC Provincial Status[1]	COSEWIC Status[2]	SARA Status[2,3]	Habitat Suitability[4]
Bidens amplissima	Vancouver Island beggarticks	Blue	SC	1-SC	Moderate
Cephalanthera austiniae	Phantom orchid	Red	E	1-T	Low*
Claytonia washingtoniana	Washington springbeauty	Red	-	-	Low*
Lindernia dubia var. *dubia*	Yellowseed false pimpernel	Blue	-	-	Low**
Lupinus rivularis	Streambank lupine	Red	E	1-E	Low to Moderate**
Miterllastra caulescens	Leafy miterwort	Blue	-	-	Low**
Pyrola aphylla	Leafless wintergreen	Blue	-	-	Low**
Sidalcea hendersonii	Henderson's checker-mallow	Blue	-	-	Low to Moderate **
Brotherella roellii	Roell's brotherella	Red	E	1-E	Moderate
Fissidens pauperculus	Poor pocket moss	Red	E	1-E	Low **

[1]BC Provincial Status: Red = Extirpated, Endangered or Threatened; Blue = Special Concern
[2]Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and *Species at Risk Act* (SARA): Threatened (T) = species likely to become endangered if limiting factors are not reversed; Special Concern (SC) = species may become threatened or endangered because of a combination of biological characteristics and identified threats; Endangered (E) = species facing imminent extirpation or extinction.
[3]Species designated on Schedule 1 of SARA
[4] Habitat Suitability and occurrences were assessed using Electronic Atlas of the Flora of British Columbia [5]
*Found predominantly in forests
** Habitat suitable; however, documented occurrences rare within area

[1] A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region (gov.bc.ca)
[2] E-Flora BC: Electronic Atlas of the Plants of British Columbia (ubc.ca)
[3] Cleaning up Bell Slough | Watershed Watch Salmon Society (watershedwatch.ca)
[4] BC species and ecosystem explorer (gov.bc.ca)
[5] E-Flora BC: Electronic Atlas of the Plants of British Columbia (ubc.ca)

Table 2.2: Invasive Plant Species Reported within Bell Slough[6]

Scientific Name	Common Name	Reported Location within the Slough
Arctium spp.	Burdock species	Near Fraser extent of slough
Daucus carota	Queen Anne's lace	Fraser extent of slough
Fallopia japonica	Japanese knotweed	One stand near Fraser extent of slough and 1 stand on Bell Road adjacent to slough
Fallopia x bohemica	Bohemian knotweed	Upstream extent of Bell Slough
Heracleum mantegazzianum	Giant hogweed	Near the intersection of Brinx Rd and MacDonald Road
Iris pseudacorus	Yellow iris	16 locations within wetted portion of slough
Matricaria perforata	Scentless chamomile	One location Fraser extent of slough
Myriophyllum spicatum	Eurasian watermilfoil	At Camp Slough and historic connection
Rubus armeniacus	Himalayan blackberry	At Camp Slough and historic connection
Senecio jacobaea	Tansy ragwort	Several locations along Fraser River and along roadways near the slough
Tanacetum vulgare	Common tansy	1 location Fraser extent of slough

Wetland and slough habitat is valuable to both terrestrial and amphibious animals. The Bell Slough is a potential habitat for a variety of provincially and federally listed wild-life species (Table 2.3). This includes two amphibian species, 29 bird species, one reptile species and nine mammalian species. The Bell Slough does not fall within critical habitat for any species of special concern; however, both the Sardis Pond and Nicomen Slough western painted turtle (*Chrysemys picta pop.1*) populations are approximately 3.5 km away from the slough, and there is critical habitat for barn owls (*Tyto alba*) within 3 km of the slough (**Figure 2.2**).

[6] Invasive Alien Plant Program (gov.bc.ca)

Table 2.3: Wildlife Species of Special Concern with Potential to Occur In or Around Bell Slough[7]

Scientific Name	Common Name	BC Provincial Status1	COSEWIC Status2	SARA Status2,3
Amphibians				
Rana aurora	Northern red-legged frog	Blue	SC	1-SC
Rana pretiosa	Oregon spotted frog	Red	E	1-E
Birds				
Accipiter gentilis laingi	Northern goshawk, *laingi* species	Red	T	1-T
Aechmophorus occidentalis	Western grebe	Red	SC	1-SC
Aeronautes saxatalis	White-throated swift	Blue	-	-
Ammodramus savannarum	Grasshopper sparrow	Red	-	-
Ammospiza nelsoni	Nelson's sparrow	Red	NAR	-
Ardea herodias fannini	Great blue heron, *fannini* subspecies	Red	NAR	-
Asio flammeus	Short-eared owl	Blue	T	1-SC
Bartramia longicauda	Upland sandpiper	Red	T	-
Botaurus lentiginosus	American bittern	Blue	-	-
Brachyramphus marmoratus	Marbled murrelet	Blue	T	1-T
Branta bernicla	Brant	Blue	-	-
Buteo lagopus	Rough-legged hawk	Blue	-	-
Butorides virescens	Green heron	Blue	-	-
Cardellina canadensis	Canada warbler	Blue	-	-
Chondestes grammacus	Lark sparrow	Blue	-	-
Chordeiles minor	Common nighthawk	Yellow	SC	1-T
Coccyzus americanus	Yellow-billed cuckoo	Red	-	-
Cygnus columbianus	Tundra swan	Blue	-	-
Cypseloides niger	Black swift	Blue	E	1-E
Eremophila alpestris strigata	Horned lark, *strigata* subspecies	Red	E	1-E
Euphagus carolinus	Rusty blackbird	Blue	SC	1-SC
Falco peregrinus anatum	Peregrine falcon, *anatum* subspecies	Red	-	1-SC
Falco rusticolus	Gyrfalcon	Blue	NAR	-
Megascops kennicottii kennicottii	Western screech-owl, *kennicottii* subspecies	Blue	-	-
Melanerpes lewis	Lewis's woodpecker	Blue	T	1-T
Nannopterum auritum	Double-crested cormorant	Blue	-	-
Nycticorax nycticorax	Black-crowned night-heron	Red	-	-
Pluvialis dominica	American golden-plover	Blue	-	-
Tyto alba	Barn owl	Red	R	-

[7] BC species and ecosystem explorer (gov.bc.ca)

Scientific Name	Common Name	BC Provincial Status1	COSEWIC Status2	SARA Status2,3
Mammals				
Corynorhinus townsendii	Townsend's big-eared bat	Blue	-	-
Lasiurus cinereus	Hoary bat	Blue	-	-
Myotis lucifugus	Little brown myotis	Yellow	E	1-E
Myotis thysanodes	Fringed myotis	Blue	DD	3
Myotis yumanensis	Yuma myotis	Blue	-	-
Scapanus townsendii	Townsend's mole	Red	E	1-E
Sorex bendirii	Pacific Water shrew	Red	E	1-E
Sorex rohweri	Olympic shrew	Red	-	-
Sorex trowbridgii	Trowbridge's shrew	Blue	-	-
Reptiles				
Chrysemys picta pop.1	Western painted turtle- pacific coast population			

NOTES

1. BC Provincial Status: Red = Extirpated, Endangered or Threatened; Blue = Special Concern; Yellow = Not at Risk
2. Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and *Species at Risk Act* (SARA): Threatened (T) = species likely to become endangered if limiting factors are not reversed; Special Concern (SC) = species may become threatened or endangered because of a combination of biological characteristics and identified threats; Endangered (E) = species facing imminent extirpation or extinction.
3. Species designated on Schedule 1 of SARA

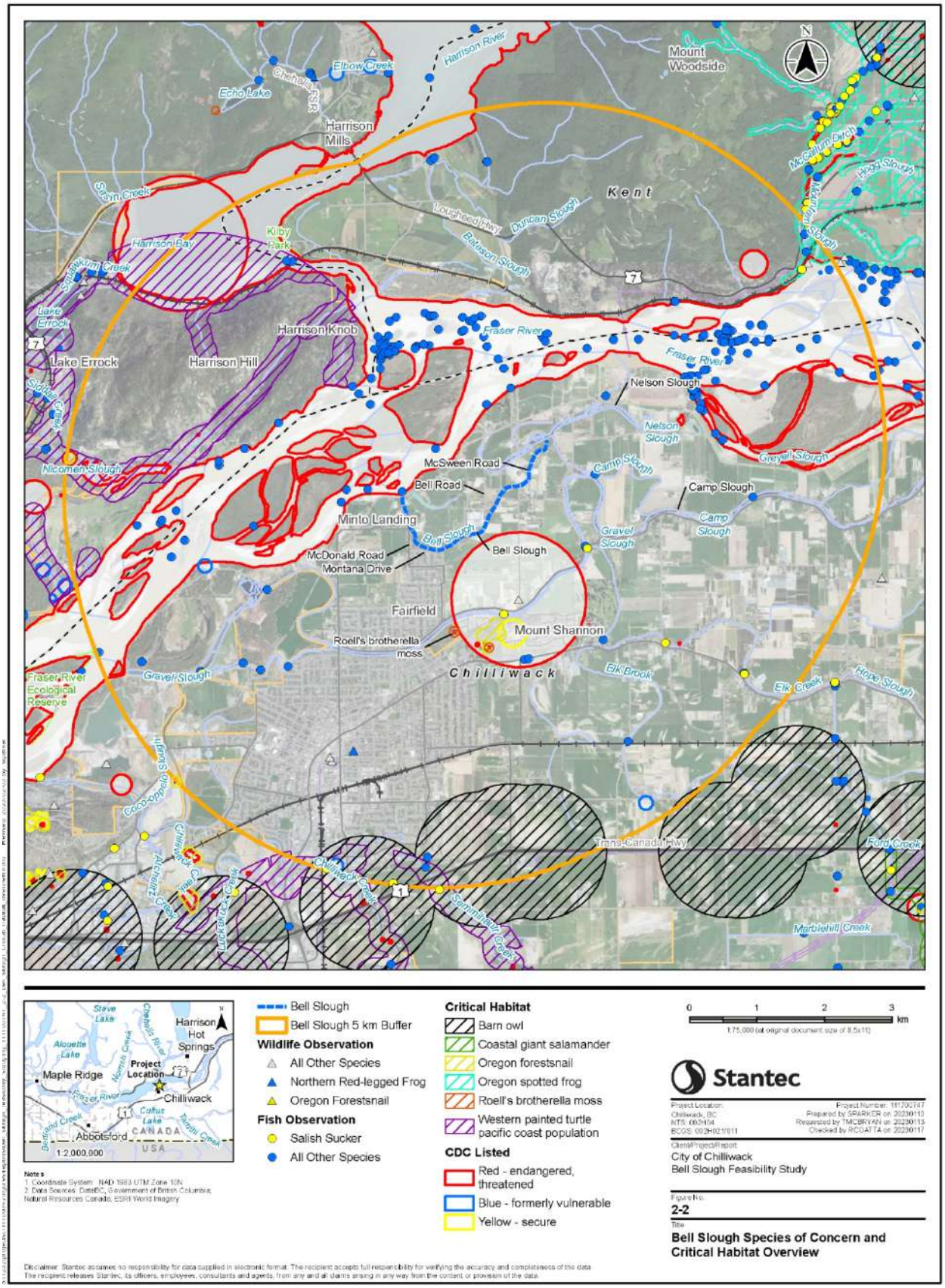

Figure 2.2: Species of Special Concern Critical Habitat Surrounding Bell Slough

The Bell Slough is classified as a Class A fish-bearing watercourse under the City's category system[8]. Historically, the Bell Slough (watershed code 100-078100) has had documented presence of 11 species of fish (**Table 2.4**). This has included salmonids, coarse fish species, and exotic species; however, the most recent catch records are from 1995. It is presumed that migratory species (salmon) would enter the slough from the Fraser River during the limited number of days in a year when water levels in the river are higher than those in the slough and the floodbox culvert is open (floodbox operations described further on in **Section 3.1.4.1**), as the remainder of the year the slough is isolated from other water bodies. These high-water events happen during spring freshet, and it is therefore unlikely that adult fall spawners (Pacific salmon) would be able to make use of this habitat. However, juveniles may use it as off channel habitat. The Bell Slough residents have mentioned historic observations of salmon, and several residents would like to see the slough provide habitat to these species again in the future. More recently, presumably due to low oxygen levels, a fish kill event occurred within the slough. City staff had communicated during the field visit that the mortalities were composed of exotic species.

Table 2.4: Fish Record for the Bell Slough[9]

Common Name	Scientific Name	Provincial Status[1]	Latest Observed
Black crappie	*Pomoxis nigromaculatus*	Exotic	1995
Bullhead (General)	*Ameriurus* spp.	Exotic	1995
Carp	*Cyprinus* sp.	Exotic	1995
Chum salmon	*Oncorhynchus keta*	No status	1985
Coho salmon	*Oncorhynchus kisutch*	No Status	1995
Cutthroat trout	*Oncorhynchus clarkii*	Blue	1995
Sucker (general)	*Catostomus* spp.	Yellow	1995
Northern pikeminnow	*Ptychocheilus oregonensis*	Yellow	1979
Peamouth chub	*Mylocheilus caurinus*	Yellow	1979
Redside shiner	*Richardsonius balteatus*	Yellow	1979
Threespine stickleback	*Gasterosteus aculeatus*	Yellow	1979
NOTE: [1]BC Provincial Status: Blue = Special Concern; Yellow = Not at Risk			

2.3 September 2022 Field Visits

2.3.1 Methodologies

As mentioned previously in **Section 3**, Stantec conducted two site visits of the Bell Slough in September 2022. The September 14 visit assessed riparian and aquatic habitat features and water quality while the September 22nd visit focussed on hydraulic features. **Figure 2.3** illustrates the water quality sampling locations where in situ measurements using a YSI multi-meter took place during the first visit. The following parameters were measured: dissolved oxygen (DO (mg/L)), DO (%), temperature (°C), Specific Conductivity (µS/cm), and pH as indicators of aquatic health. The results of the water quality measurements were compared against the *BC Water Quality Guidelines for Aquatic Life* (BC-WQG) [10].

[8] Watercourse Map Final (chilliwack.com)
[9] Habitat Wizard- Bell Slough Stream Report (gov.bc.ca)
[10] Approved Water Quality Guidelines - Province of British Columbia (gov.bc.ca)

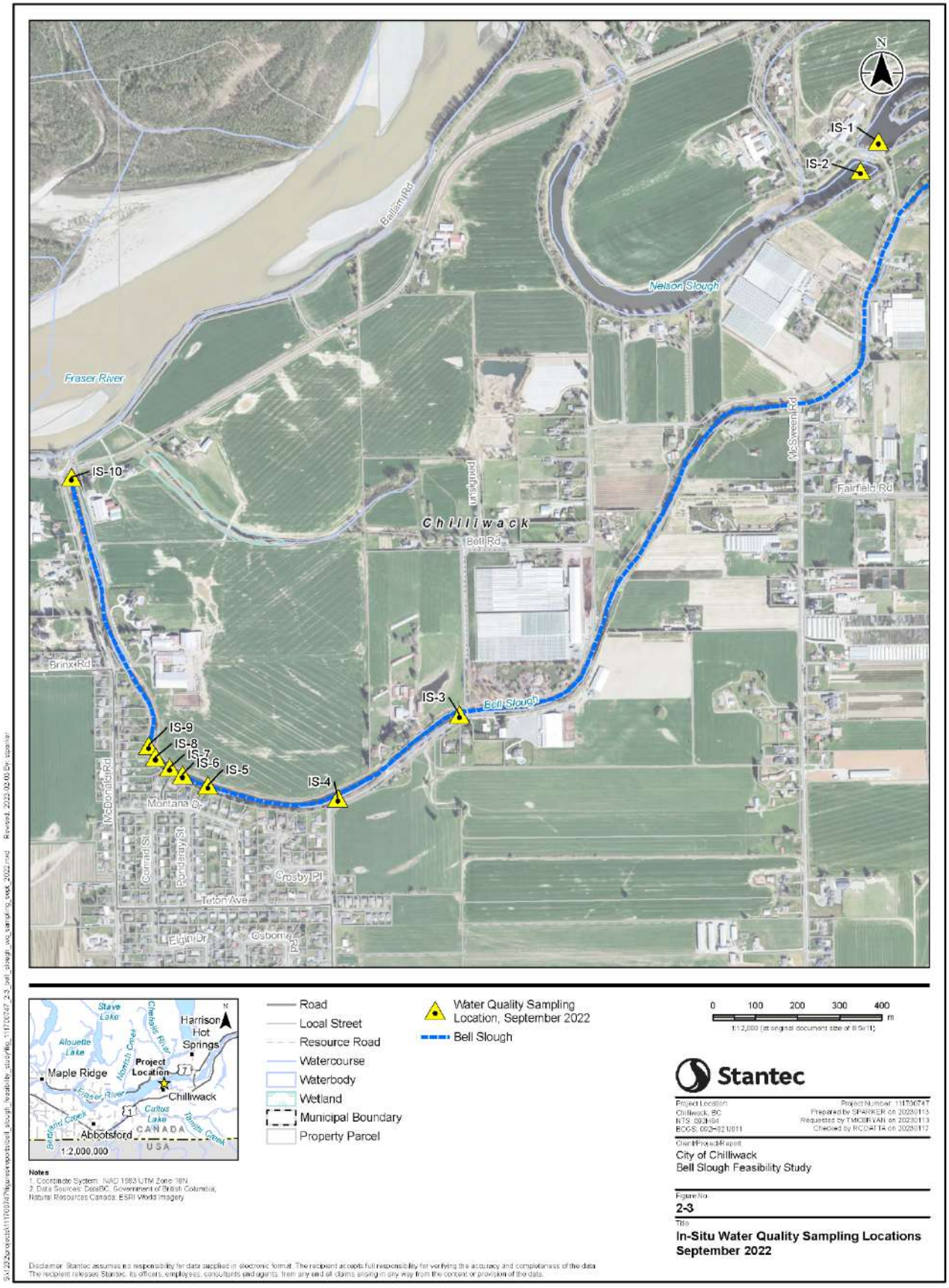

Figure 2.3: In-Situ Water Sampling Locations from September 14, 2022

2.3.2 Field Observations: Upstream – Camp Slough Interface

The farthest upstream portion of the Bell Slough was observed to be dry and largely overgrown with dense vegetation (**Appendix A:** Photos 1, 2). During the field visits, a caved-in 600 mm wooden culvert and flap gate (preventing flows from entering from the Camp-Nelson Slough) was observed at the tie in between the Bell Slough and the Camp-Nelson Slough (**Appendix A**: Photo 3).

During the environmental assessment, the Camp-Nelson Slough was accessed from McSween Road. Riparian vegetation consisted of conifers (western red cedar (*Thuja plicata*) and large deciduous trees which transitioned into a cattail dominated fringe around the slough (**Appendix A**: Photos 4,5). Water lily patches were present in the shallow portions of the slough; however, the majority of the surface was open. The substrate was a combination of gravels and fines. The Camp-Nelson Slough passes under McSween Road via a culvert. The downstream side of the culvert is riparian dominated by reed canary grass (*Phalaris arundinacea*) with some tall trees to provide shade (**Appendix A**: Photo 6). A deceased juvenile carp (exotic species) was found at the outfall of the culvert (**Appendix A**: Photo 7).

Water quality measurements were taken within the Camp-Nelson Slough on the west downstream side of the culvert and at the east upstream side of the McSween Road culvert. The results are presented in **Table 2.5**.

Table 2.5: In-Situ Water Quality at Camp Slough and the Bell Slough Interface

Station Number	Location	Temp (°C)	DO (mg/L)	DO %	Specific Conductivity (µs/cm)	pH
IS-1	Downstream of McSween Road	20*	5.99*	61.70	0.35	7.32
IS-2	Upstream of McSween Road	20.11*	11.28	124.10	0.36	8.08
Temp = temperature, DO = dissolved oxygen, * indicates levels that do not meet the BC Ambient Water Quality Guidelines for aquatic life[11].						

Temperature was higher than the BC-WQG in both sampling locations. The *in-situ* measurement was taken in a shallow portion of the slough with no shade; therefore, it is possible that colder pockets may exist within the shaded deeper portions of the slough. On the downstream side of the culvert, dissolved oxygen levels were below BC-WQG.

2.3.3 Midstream Bell Slough

Further downstream, McSween Road runs parallel to the slough. In this section, the slough is ephemeral, with most water coming from drainage and groundwater seepage from neighboring properties. During the September 2022 field visits, the channel had both dry stretches and shallow wetted pools (**Appendix A**, Photos 8, 9, 10). Additionally, at that time, works were underway to restore an infilled portion of the slough with large woody debris, contouring and wetted benches (**Appendix A**: Photo 10). The driveways along this section did not have any culverts to convey flow, and therefore, were barriers for water passage and fish passage (**Appendix A**: Photos 10, 11, 12). As with much of the slough, it was noticed that the riparian habitat quality varied with land ownership. There are patches of invasive species (e.g., Himalayan blackberry (*Rubus armeniacus*); however, there are also several large deciduous trees which provide crown closure over stretches of the slough. Cattails and reed canary grass grow in and around the isolated pools of water.

Despite the ephemeral nature of this section of slough, there is still valuable habitat for wildlife and a high degree of crown closure (which creates shade). A garter snake (*Thamnophis sp.*) was observed in a patch of tall grass in a shaded patch during the environmental site visit. Although not observed during the visit,

[11] B.C. Ambient Water Quality Guidelines (shinyapps.io)

City staff communicated that Pacific chorus frogs (*Pseudacris regilla*) inhabit the isolated pools in this stretch of the slough. Due to the life history of this species, with egg to metamorphosis taking 2 months, it is possible for them to take advantage of the ephemeral nature of the channel[12].

The slough continues downstream approximately another kilometer between agricultural fields and greenhouse operations before intercepting with Bell Road, as seen on **Figure 2.3**. Due to accessibility and time constraints this portion of the slough was not visited on foot. Footage and aerial images were captured at this location during a helicopter flyover completed on September 7, 2022 (**Appendix A**: Photo 13). No pools or continuous expanses of water were observed from the air, but a high degree of canopy forming trees in the riparian area was visible. On foot, observations were made on the upstream side of Bell Road where the ground was wetted and had isolated pools but lacked connectivity (**Appendix A**: Photo 14). The culvert which runs underneath Bell Road was not visible due to dense vegetation; however, the City's online webmap[13] and GIS information and survey, conducted on September 27, 2022, confirmed the existence of a 750mm concrete culvert.

Downstream of the Bell Road crossing of the slough is the upper extent of the permanently wetted portion of the slough (**Appendix A**: Photo 15). Bell Road runs adjacent to the slough for approximately 400m before the Montana Drive residences backing onto the slough begin. Two driveways cross the Bell Slough from Bell Road, both of which have culverts (**Appendix A**: Photo 16). City staff communicated that during the November 2021 flood events, the roadway and a few properties in this extent experienced damage from erosion. During the September 2022 visit, works to repair the road and bank of the slough had recently concluded (**Appendix A**: Photo 17). The bank running along Bell Road had been contoured to include benches which will be replanted with native riparian species. Across the slough from the road and neighborhood there are a few dairy farms with crop fields. The slough runs between the Montana Drive and McDonald Road Neighborhood and farmland for approximately 675 m before flowing through a partially collapsed culvert in the driveway to a dairy farm. The slough then runs parallel to McDonald Road for an additional 450 m before reaching the interface with the Fraser River.

During the field visit the section of slough behind the neighborhood was accessed using a canoe launched from a homeowner's property. From the shoreline, several birds were observed along the banks of this reach, including the provincially blue-listed green heron (*Butorides virescens*). This homeowner shared photographic evidence of a SARA-listed western painted turtle in their yard. The quality of riparian habitat largely varies with properties lines. Some homeowners and farmers have made efforts to remove invasive plant species, plant with native wetland species, and retain large trees for crown closure; whereas there are also areas dominated by Himalayan blackberry (**Appendix A:** Photos 16, 18, 19). One section of the riparian habitat has been impacted by livestock (goats), grazing in and about the slough (**Appendix A:** Photo 20).

While launching the canoe, a strong sulphur smell emanated from the slough as the sediment was kicked up. A dense mat of aquatic plant matter floating across the surface of the slough made paddling challenging. The mat biomass was made up primarily of smart weed (*Persicaria amphibia*) and duck weed (*Lemna* sp.*);* however, there were several other unidentified aquatic plant species present in less abundance. Free floating stands of grasses were present throughout the slough. The plant biomass on the surface of the slough was thickest behind the residences on McDonald Road. Due to accessibility and time constraints only a portion of the slough was paddled during the site visit. Water quality was measured in situ at 7 locations throughout this stretch of slough (**Figure 2.3, Table 2.6)**.

[12] E-Fauna BC Atlas Page (src: AtlasAccordian July 29, 2021) (ubc.ca)
[13] City of Chilliwack Webmap (chilliwack.com)

Table 2.6: In-Situ Water Quality for the Bell Slough Midstream

Station Number	Location	Temp (°C)	DO (mg/L)	DO %	Specific Conductivity (µs/cm)	pH
IS-3	Beside Bell Road crossing of the Bell Slough	17.30	3.30*	34.70	0.09	6.35*
IS-4	Bell Road	18.04 *	8.92	95.80	0.14	6.94
IS-5	Montana Drive	16.22	0.60*	5.50	0.15	6.63
IS-6	Montana Drive	16.03	0.35*	3.40	0.17	6.56
IS-7	Montana Drive	15.96	0.46*	4.60	0.17	6.57
IS-8	McDonald Road	15.76	0.15*	1.40	0.17	6.47*
IS-9	McDonald Road	16.32	0.28*	2.70	0.17	6.59

NOTES
Temp = temperature, DO = dissolved oxygen,
* indicates levels that do not meet the BC Ambient Water Quality Guidelines for aquatic life[14].

Across this portion of the slough, no station met the BC-WQG for all parameters measured. The shallow water next to the Bell Road crossing of the slough was low in oxygen and more acidic than the BC-WQG. At the most downstream extent where Bell Road (IS-4) runs adjacent to the slough, dissolved oxygen levels were well above the instantaneous minimum; however, temperature exceeded the long-term limit. The samples taken behind the Montana Drive and McDonald Road Neighborhood had dissolved oxygen levels well below the BC-WQG. Low oxygen, low pH, and high plant biomass is indicative of eutrophication.

2.3.4 Downstream-Fraser River Interface

During the September 14, 2022 field visit, the furthest downstream extent of the slough was accessed from a pull out at Ballam Road. The water in this area of the Bell Slough is covered in duck weed (*Lemna* sp.). The riparian habitat is dominated by reed canary grass with patches of Himalayan blackberry and Queen Anne's lace (*Daucus carota*). Efforts have been made by community volunteers along the right downstream bank side of the slough to remove invasive species and replant with native species. Due to heat stress, some of these saplings are alive but exhibiting slow growth. A Japanese knotweed (*Fallopia japonica*) stand had been treated within this restored area. Within the slough, invasive amphibian species (both bull frogs (*Lithobates catesbeianus*) and green frogs (*Lithobates clamitans*)) were present (a green frog, is seen within **Appendix A**: Photo 26). A water quality sample was taken in this section of slough (**Figure 2.3**, **Table 2.7**). Dissolved oxygen levels were lower than the BC-WQG. Although pH was higher than the lower BC-WQG limit of 6.5 and aquatic vegetation was less dense than the midstream this section also appears to show signs of eutrophication.

[14] B.C. Ambient Water Quality Guidelines (shinyapps.io)

Table 2.7: In situ water quality for the Bell Slough Downstream Extent

Station Number	Location	Temp (°C)	DO (mg/L)	DO %	Specific Conductivity (µs/cm)	pH
IS-10	Bell Slough Fraser River extent	16.86	1.95*	21.20	0.21	6.82
NOTES Temp = temperature, DO = dissolved oxygen, * indicates levels that do not meet the BC Ambient Water Quality Guidelines for aquatic life.						

During this visit, water in the Fraser River was lower than the slough. Several sockeye salmon anglers were fishing the gravel bars of the river. There was anthropogenic debris and a fire pit at the interface between the slough and river (**Appendix A**; Photos 28, 29).

2.4 Follow-Up Water Quality Grab Sampling

2.4.1 Overview and Objectives

Based on the low oxygen levels and dense aquatic vegetation observed during the September field visits, a subsequent water quality screening surface water sampling program was carried out on November 3, 2022. An in-situ water quality measurement and grab samples were taken at five stations by City staff as shown in **Figure 2.4**. The water samples were submitted to ALS Laboratories and the results were provided to Stantec for analysis and interpretation. Samples were taken using the BC field sample manual for water and wastewater[15] as guidance, with a field blank, replicate, and trip blank being submitted to the lab for quality control and assurance. Water samples were analyzed for physical characteristics, nutrients and anions, microbiological (faecal coliforms) parameters, dissolved metals, total metals, and plant pigments.

Results were visually screened for trends across the slough stations and compared against BC-WQG for aquatic life[16] and Canadian Council of Ministers of the Environment (CCME)[17] surface water guidelines for aquatic life. In cases where guidelines were not available results were compared to the characterization used in the BC Guidelines for Interpreting Water Quality Data (version 1)[18]. All analysis and graphics were completed using R (version 4.2.1).

[15] BC Field Sampling Manual Part E (gov.bc.ca)
[16] B.C. Ambient Water Quality Guidelines (shinyapps.io)
[17] Canadian Council of Minister of the Environment Resources (ccme.ca)
[18] BC Guidelines for Interpreting Water Quality Data (gov.bc.ca)

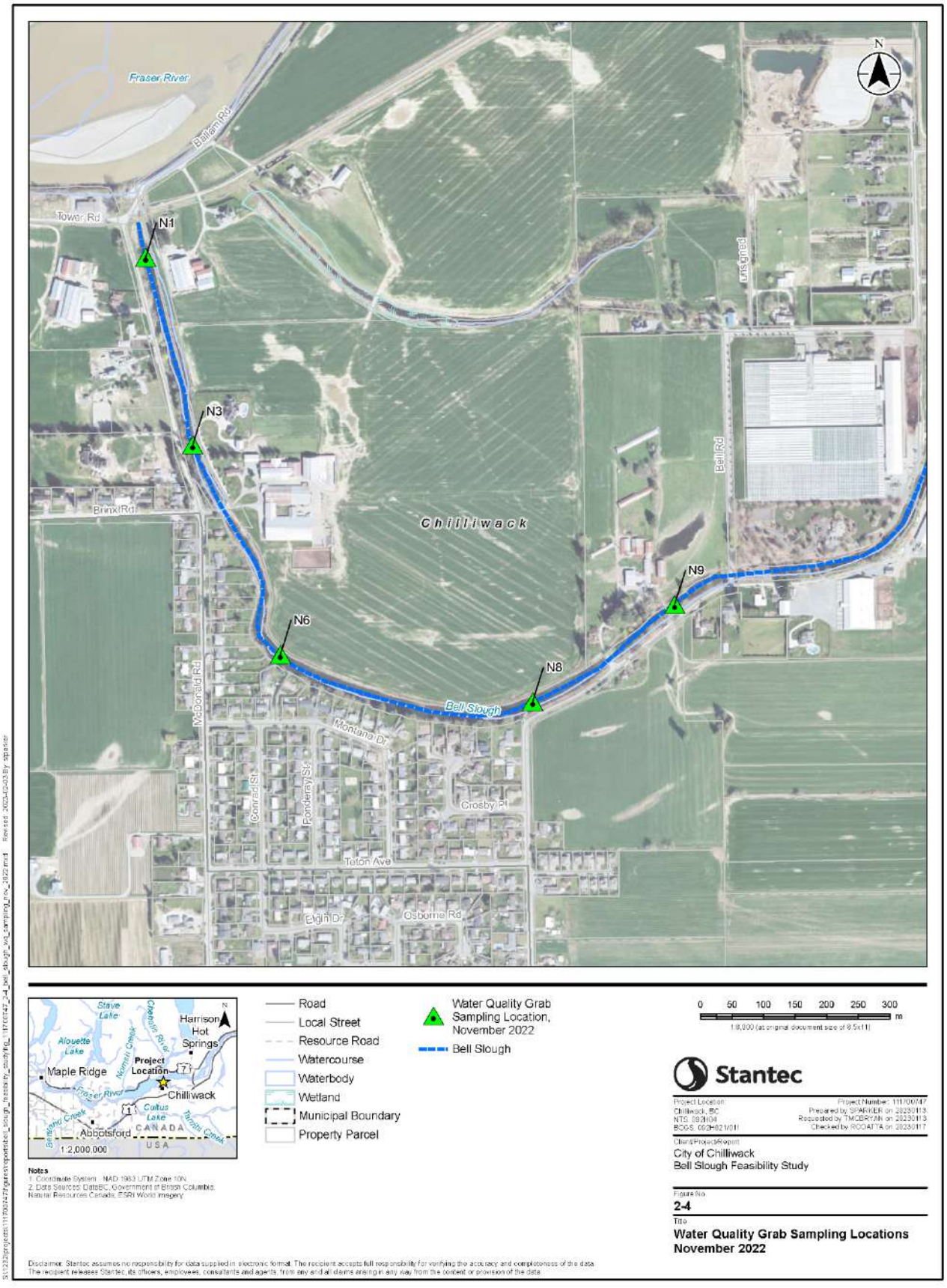

Figure 2.4: Water Quality Grab Sampling Locations from November 3, 2022

2.4.1 Water Quality Results and Discussion

2.4.1.1 *In-Situ Field Measurements*

Results from in situ water quality parameters measurements in November were overall not supportive of aquatic life, which is consistent with the findings of the September visit. Dissolved oxygen was below the BC-WQG (8mg/L) across all stations, with the lowest values at N3 and N9 (2.61 and 2.88mg/L respectively). The pH was also lower than guidelines across the slough (pH <6.5). Temperature levels were, as expected, cooler across the slough than during the September visit, with a spike in temperate at the downstream extent of the slough. Total suspended solids, conductivity and turbidity were elevated at the N3 station compared with the rest of the stations. Oxidative reduction potential (ORP) was consistent across stations with all values above 200mV, suggesting suitable water characteristics to facilitate chemical reactions. In an environmental context, ORP is a measurement of the ability of a freshwater system to break down waste products[19]. Plots of the field parameters measure in November are available in **Figure 2.5**. Aquatic habitat where dissolved oxygen levels are below 2mg/L are known as hypoxic zones[20]. Anthropogenic nutrient pollution is one of the most common causes of aquatic hypoxia[21]. Imbalances in nutrients cause blooms in aquatic plant biomass. Initially, increases in plant density result in high levels of dissolved oxygen produced from photosynthesis; however, as the bloom progresses and plants die off the biological oxygen demand (BOD) increases as microbes break down the decaying plant matter. This causes oxygen depletion and if the amount of oxygen dissolving at the surface is exceeded by BOD, the aquatic environment will become hypoxic or anoxic. This overall process is called eutrophication.

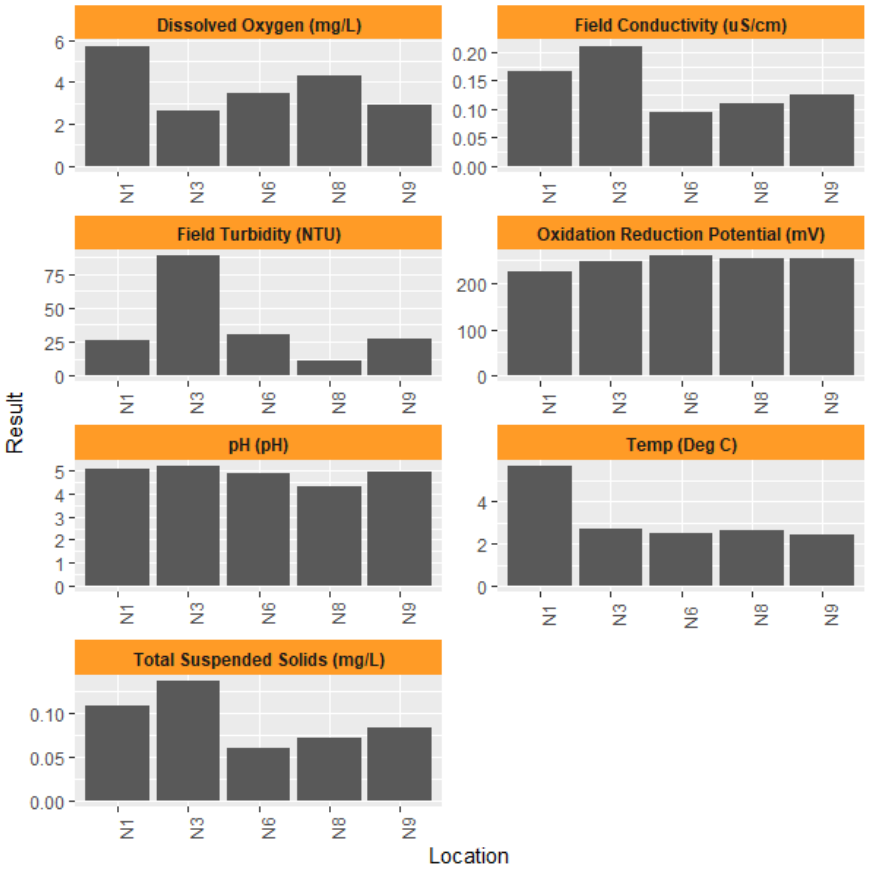

Figure 2.5: In-Situ Field Measurements from November 3, 2022

[19] Oxidation-Reduction Potential (ORP) (gov.nt.ca)
[20] Hypoxia Program - NCCOS Coastal Science Website (noaa.gov)
[21] Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems (nature.com)

2.4.1.2 *Plant Pigments*

The results from the laboratory analysis showed that plant pigments (as measured as chlorophyll a) were elevated at N6, and slightly higher at N3 than other locations within the slough (**Figure 2.6**). Plant pigment concentration is a proxy for plant biomass. Therefore, the analysis quantitatively supported the qualitative observations of plant biomass seen during the September field visit. There is no WQG or CCME guideline aquatic life for chlorophyll a concentration. However, values below 3 ug/L are considered oligotrophic (low productivity) and above 15 ug/L are considered eutrophic[22]. Stations 1, 3, 6 and 8 were all well above this level.

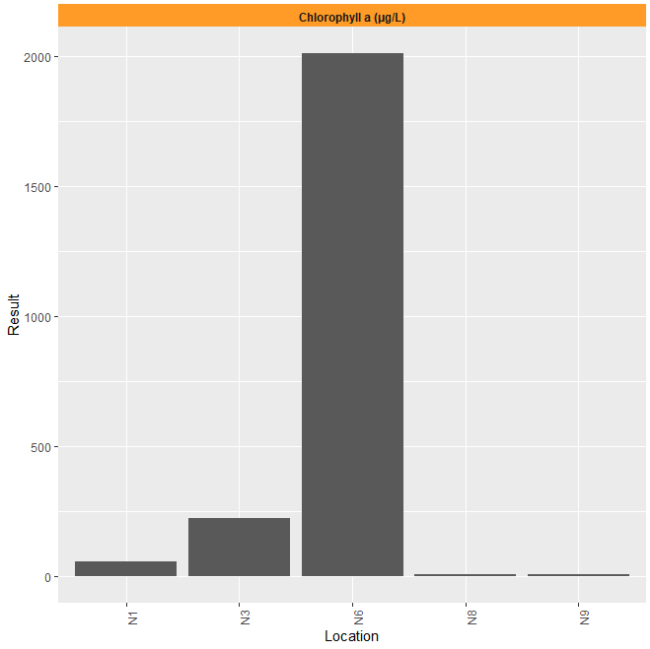

Figure 2.6: Chlorophyl A Concentrations (ug/L) from November 3, 2022

2.4.1.3 *Nutrients and Anions*

An array of nutrients and anions were measured to screen for potential point sources and identify the nutrient type causing eutrophication within the slough (**Figure 2.7**). Organic nitrogen, as Total Kjeldahl nitrogen, and ammonia, showed spikes at N3 and N6, whereas inorganic nitrogen species (nitrate and nitrite) were less concentrated and more localized to the N6 and N8 locations. Phosphorus and Orthophosphate levels peaked at both N3 and N6. Chloride is highest at the upstream end; however, Fluoride is highest at the downstream end of the slough. Bromide levels were below the laboratory detection limits of 0.05 mg/L and therefore was not plotted. Sulphate levels were elevated at the upstream and downstream ends of the slough. Based on these trends it appears that organic nitrogen and phosphate inputs are causing eutrophication in the center of the slough. While trends showed relative differences in nutrients, none of the nutrients exceeded the CCME or BC-WQG for aquatic life. For ease of viewing trends, the guidelines were not included in **Figure 2.7**. Despite not exceeding the toxic benchmarks for any nutrients, nutrient pollution can be deadly when it leads to hypoxic conditions. For example, there is not a BC-WQG benchmark for phosphorus; however, at values greater than 0.025 mg/L is considered eutrophic in lakes[23]. Every station across the slough was at least 6-fold greater than this value, with N3 being 78 times greater.

[22] BC Guidelines for Interpreting Water Quality Data (gov.bc.ca)
[23] [23] BC Guidelines for Interpreting Water Quality Data (gov.bc.ca)

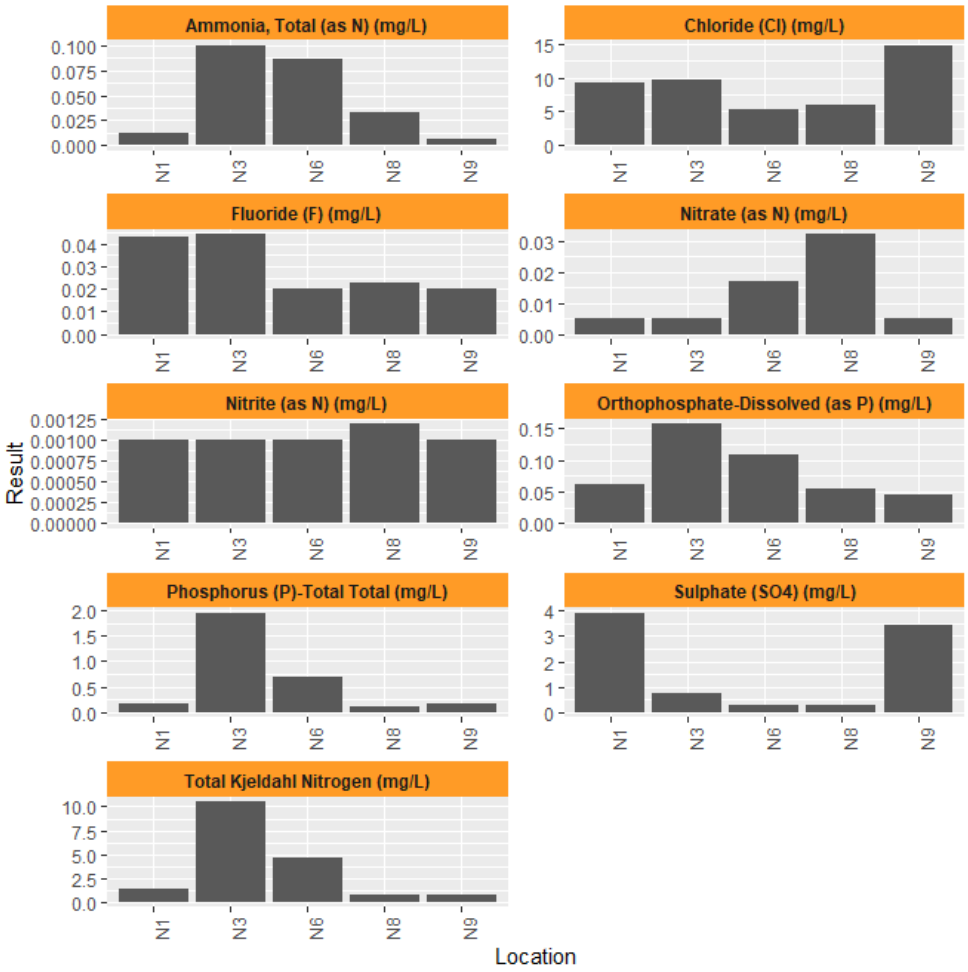

Figure 2.7: Nutrient and Anion Concentrations (mg/L) from November 3, 2022.

Note: There were no exceedances of BC-WQG or CCME guidelines; for ease of viewing trends guidelines were not plotted.

2.4.1.4 Faecal Coliforms

Faecal coliforms and coliforms (as *E.coli*), were assessed to determine if nutrient inputs were as a result of manure and/or septic contamination. The results for microbiology analysis suggests that there may be a point source of sewage or manure effluent which is introducing nutrients to the slough in proximity to stations 3 and 6 (**Figure 2.8**). There is no guideline for *E. coli* counts for aquatic life; however, there are drinking water and recreational guidelines. While water withdrawal for drinking water from the slough is not a probable goal for restoration, homeowners have mentioned that they would like the Bell Slough to be added to the Chilliwack Blue Way program. BC recreational guidelines for water quality are set for when a primary contact with the water is made frequently, via the trunk of the body and mouth contact to the water[24]. There was mention from one landowner that people have historically swam within the Bell Slough. The BC recreational guideline is 200 MPN/100mL E.coli; station N6 exceeded this value. Identification and subsequent inhibition of the bacterial inputs would be required in order for the slough to be safe for swimming.

[24] B.C. Ambient Water Quality Guidelines (shinyapps.io)

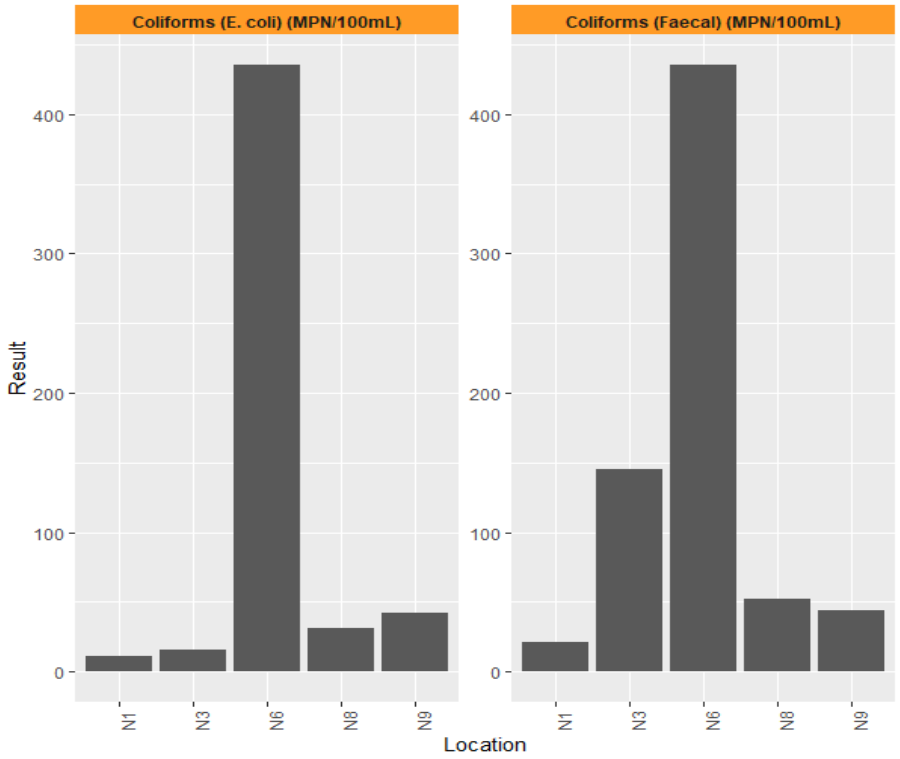

Figure 2.8: Coliforms (E.coli) and Faecal Coliforms Concentration (MPN/100mL) from November 3, 2022

2.4.1.5 Dissolved and Total Metals

Metals can be naturally occurring within soil and rock; however, they can also become elevated from pollution. Dissolved and total concentration of 38 different metals were screened across water quality stations. Each metal was compared between stations and against available CCME and BC-WQGs for dissolved and total concentrations. Laboratory reports with raw values are available in **Appendix C**. Several of the metals had concentrations below laboratory detection limits at some or all of the stations measured. This discussion focuses on metals in exceedance of guidelines as shown in **Figure 2.9**.

Both total and dissolved aluminum had exceedances across the slough for CCME long-term and BC WQG guidelines respectively. Aluminum toxicity is dependent on both pH and dissolved organic carbon levels which is why the BC- WQG guidelines for dissolved aluminum vary across stations. Aquatic plants are more tolerant of aquatic aluminum than aquatic animal species. Aluminum concentrations were highest at N6. Aluminum can be naturally occurring at high levels (5% of water bodies have dissolved aluminum greater than 0.1 mg/L) within BC; however, it can also be a waste product from wastewater treatment, dyes, and agricultural practices[25][26]. Given the variability of levels across the slough, it is more likely that these levels are from pollution, although the source is not clear.

Both total and dissolved iron had exceedances across the Bell Slough for long-term BC-WQG and CCME guidelines. Iron levels were highest at N3. Dissolved iron is generally low in freshwater environments; however, storm water run off and soil erosion can result in deposition in streams[27]. Hypoxic aquatic environments can also cause iron to unbind from the sediment. Iron is also common in fertilizers, animal

[25] BC Aluminum Water Quality Guidelines (gov.bc.ca)
[26] CCME Aluminum Technical Report (ec.gc.ca)
[27] Literature Review for Aquatic Toxicity of Iron (gov.bc.ca)

feed, and waste water. High iron levels within the Bell Slough are likely caused by all of these factors in combination. City staff have communicated that high iron levels are common across the City of Chilliwack.

Total zinc exceeded the short-term BC-WQG and the long term CCME guideline at all stations but N8. There is no guideline for dissolved zinc. Station N9 showed the highest levels of both dissolved and total zinc. Aquatic zinc concentrations in non-contaminated waters usually sit below the laboratory detection limit. It is estimated that 96% of zinc discharged into the global environmental is the result of human activities[28]. Road surface runoff, domestic waste, and agricultural land erosion are the most likely pathways that this metal entered the Bell Slough.

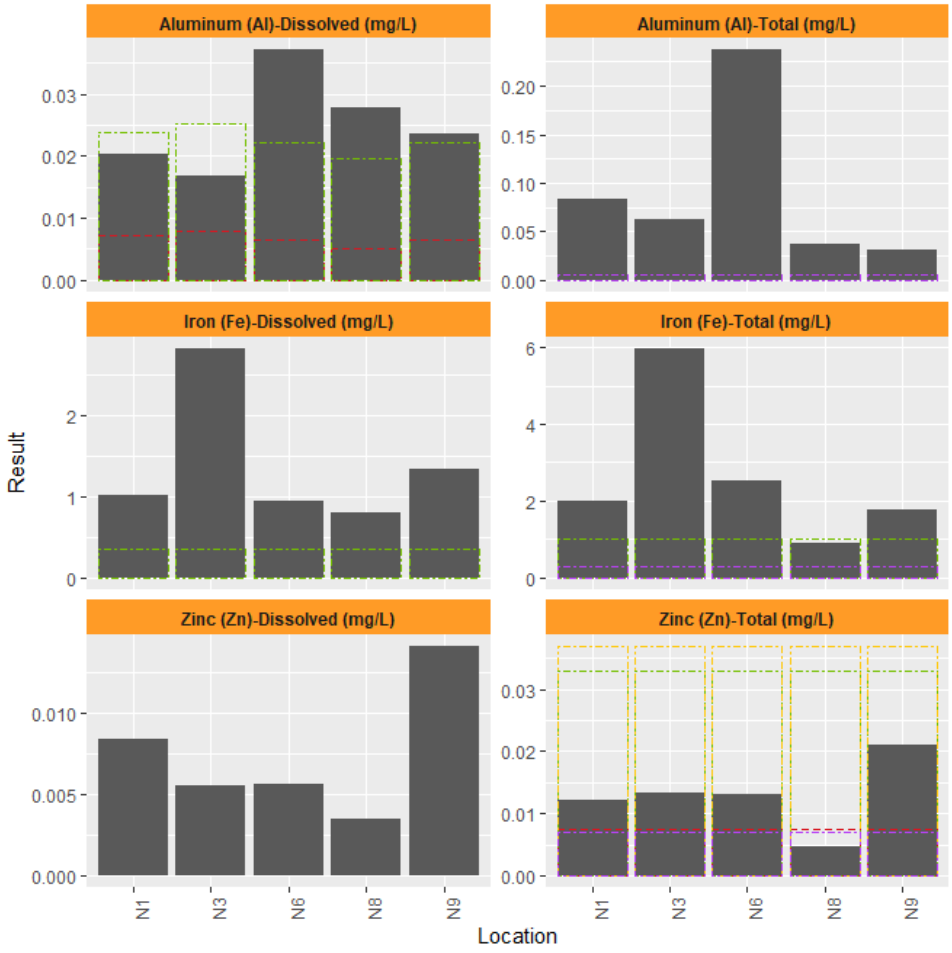

Figure 2.9: Metals with CCME or BC-WQG Exceedances November 3, 2022

Note:
Red outlines signify BC-WQG short term
Green outlines signify BC-WQG long term
Yellow outlines signify CCME short term
Purple outlines signify CCME long term

[28] BC Zinc Technical Report (gov.bc.ca)

3.0 HYDRAULIC ANALYSIS

3.1 Existing Conditions Model

3.1.1 Topography

A digital elevation model (DEM) produced from the point clouds collected with LiDAR through aerial photogrammetry, taken from the province of British Columbia's open LiDAR data portal, was used as the basis for the project topography. DEMs represent the bare earth surface with vegetation and structures removed. The data collected is from the year 2016 and has a spacing accuracy of 1m.

Additionally, to facilitate the development of the model, a topographical survey of the channel was conducted by Stantec to capture the topography beneath the water. Within the survey, the slough's top of bank, toe of bank and bottom elevations as well as culvert inverts were measured. The numerical model of the channel for use in the hydraulic analysis is built using cross-section geometry. A function of the personal computer storm water management model (PCSWMM) software, which was utilized for this investigation, is interpolating cross-sections between two bounding cross-sections to facilitate the channel width. The feature was further used within the model to create transects/cross-sections throughout the model wherever relevant survey data wasn't available to improve the model accuracy and performance.

3.1.2 Bell Slough Profile

For the purpose of this feasibility study, the Bell Slough channel was considered from the inlet of the existing floodbox culvert discharging to the Fraser River to the confluence point of Nelson Slough, Camp Slough and Bell Slough, accounting to an approximate length of 3.7km. As seen in **Figure 3.1**, which illustrates the profile of the Bell Slough, the channel slope appears to be inconsistent leading to entrapment of water and reduction in flow velocity throughout.

A total of 5 existing culverts are present within the Bell Slough and the culvert information was obtained through the City's database[13], whereas the invert elevation information was obtained through the survey done by Stantec in September 2022. Existing culvert locations is illustrated in **Figure 3.2**.

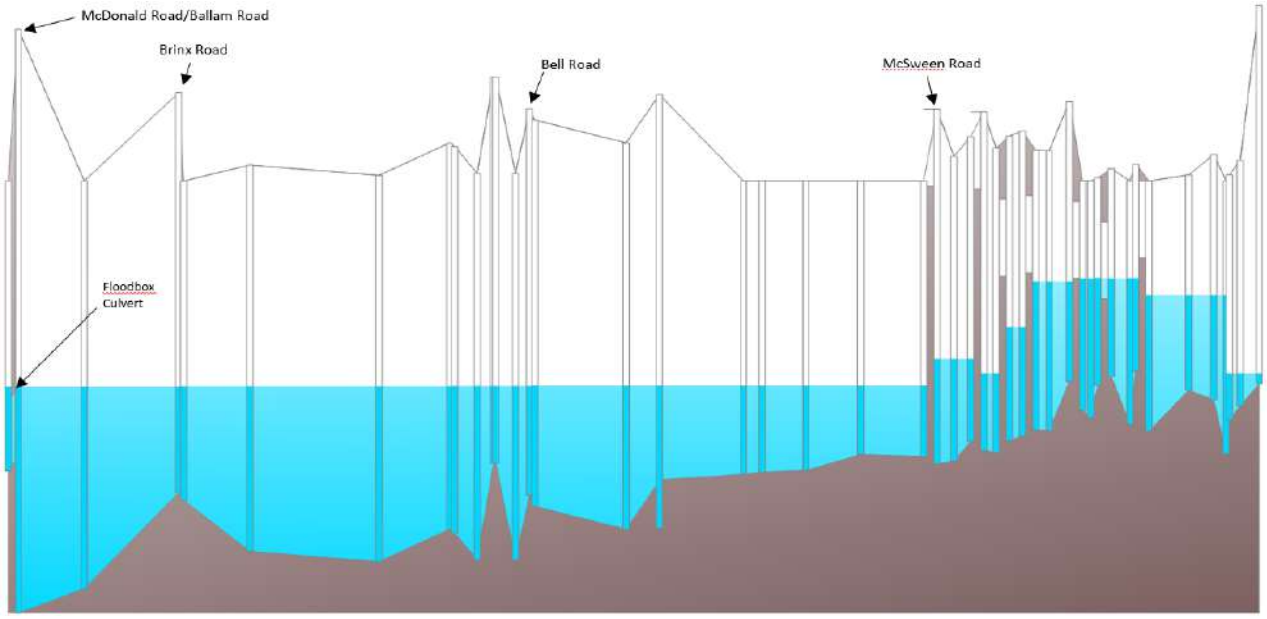

Figure 3.1: Profile of the Bell Slough

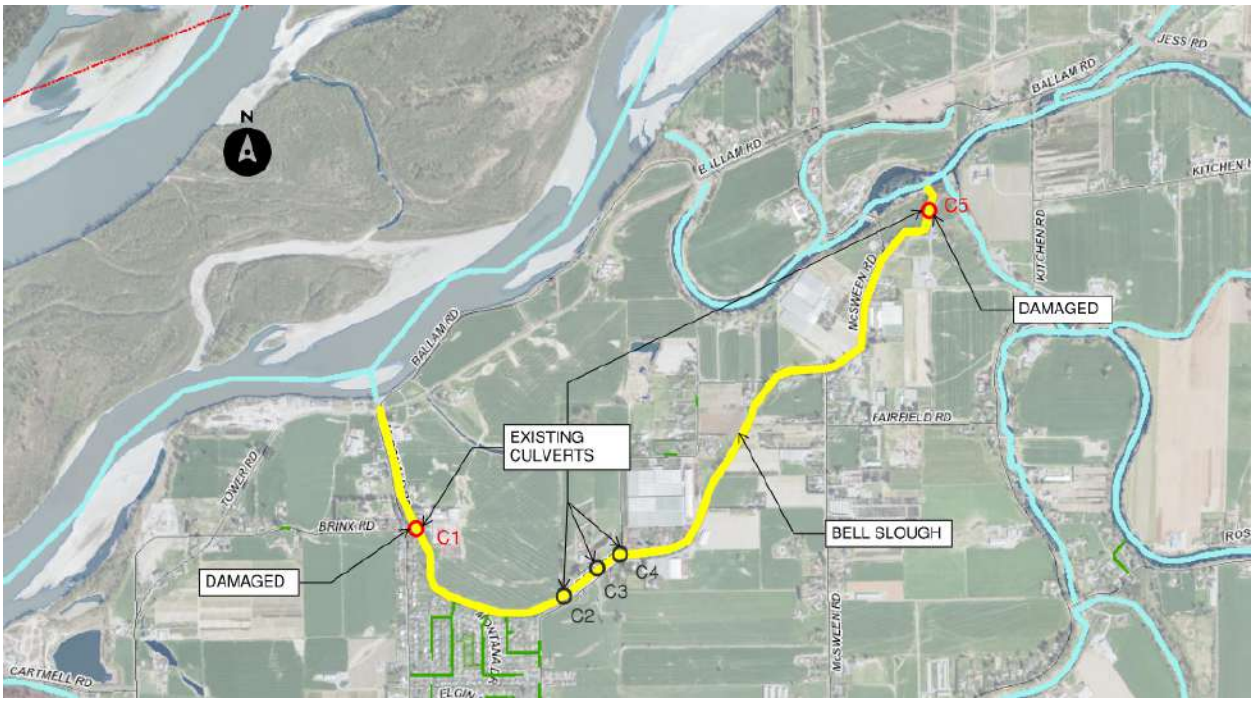

Figure 3.2: Existing Culvert Locations

3.1.3 Hydrologic Conditions

The Bell Slough has a watershed area of approximately 1500 hectares and consists of mainly agricultural lands with some residential and commercial developments as well. As per City's Zoning Map[13], the majority of area surrounding the Bell Slough has been categorized as an agricultural zone.

The historical rainfall data throughout the region of Chilliwack indicates that most of the precipitation occurs between the months of October to March, with some light rainfall occurring during the remaining months. The Bell Slough watershed receives most of its precipitation in the form of rainfall with exceptions of a few months when there is snowfall.

3.1.4 Historical Findings

3.1.4.1 Historical Pumping and Floodbox Culvert Operations

In 1989, a Bell Slough Study was conducted due to unequal water levels in the downstream portion of the slough due to surface and subsurface runoff from rainfall, cooling water discharge from greenhouses, and seepage flow from the Fraser River during freshets[29]. In efforts to control the water levels in the Bell Slough, a floodbox culvert was constructed in the 1990s across the dike at the west end of the Bell Slough, tying the slough to the Fraser River. However, the drawback of this culvert installation was that when the Fraser River water levels were too high, in conjunction with the discharge of cooling water from the greenhouses, there could be consequences of flooding to the adjacent farmlands or flooding of low basements. Pumping of the Bell Slough was therefore required to prevent such flooding during Fraser River freshets.

[29] Delcan 1989 The Bell Slough Study (No Website)

Currently, it is understood that the existing floodbox culvert is closed during larger Fraser River freshets. Historically, water has been manually pumped with a portable 6'' 6TS Thompson utility trash/sewage pump to draw down the water in the Bell Slough in efforts to control the water levels and prevent flooding. This pump is turned on when water levels reach 8.70m (CGVD28) at the inlet of the floodbox culvert. These operations are described in **Figure 3.3**. This operational procedure has been implemented and in practice ever since the floodbox culvert was installed.

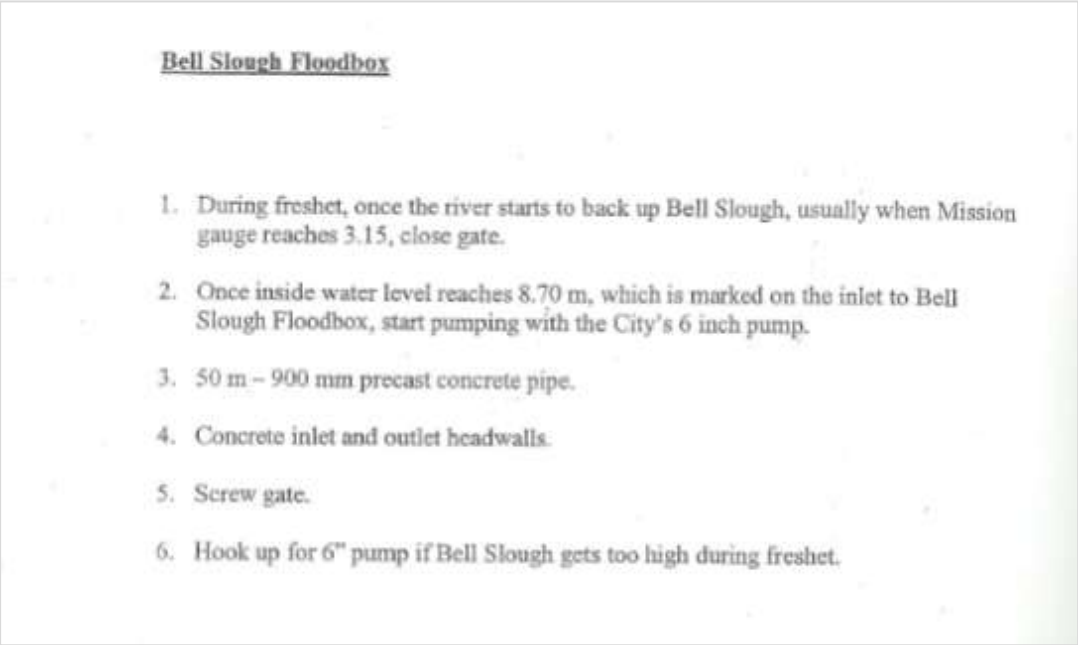

Figure 3.3: Floodbox Culvert Pumping Operations[29]

Regarding the pump stop operations and closure of the floodbox culvert, it is understood that there are currently no formal procedures in place to control these processes. The City communicated that historically the pumps were stopped and the floodbox culvert was opened once the operator observed that the slough water levels had dropped to a visually suitable low level. There is no documentation of what these water levels could have been.

3.1.4.2 Historical Water Levels

The water level of the Fraser River just downstream from the Bell Slough was determined based on interpreting the historically monitored data of Water Survey Canada (WSC) stations available from Environment Canada[30]. The water level data was taken from upstream and downstream locations (upstream station – Agassiz and downstream station – Mission). **Figure 3.4** illustrates the approximate locations of the weather stations (cloud shape) and WSC stations (triangle shaped) which were used to gather data for the analysis. The City of Chilliwack provided the monitored data from 2014-2022 for the Bell Slough and Fraser River (analysis point just downstream of the Floodbox Culvert) which were used in the analytical and modelling analysis for calibrating the PCSWMM model.

[30] Real-Time Hydrometric Data (wateroffice.ec.gc.ca)

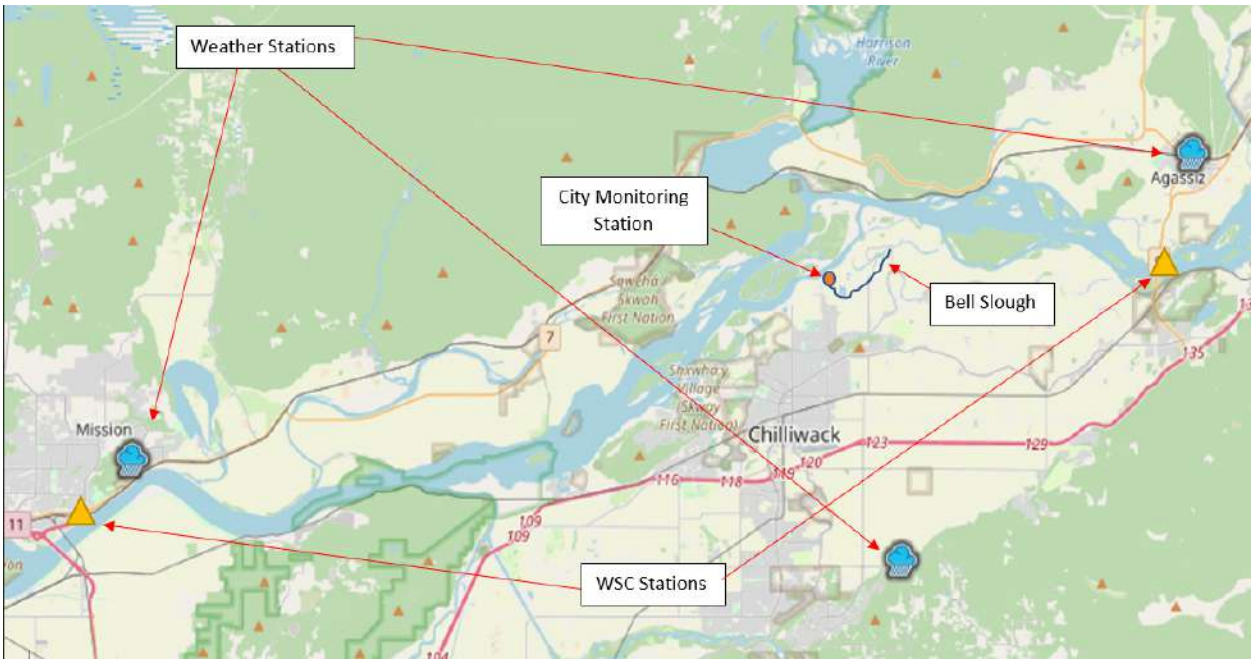

Figure 3.4: Environment Canada Station Locations (Agassiz and Mission)[30]

The data received from the City as well as from Environment Canada was based on CGVD28 datum and was converted to CGVD2013 datum to align with the other data available. Thus, any elevations mentioned within the report are based on CGVD2013 datum unless otherwise specified, and in order to convert back to CGVD28 datum, the elevation level needs to be reduced by 0.12m. As previously discussed, a submersible pump is turned on when water levels reach 8.70m (CGVD28) at the inlet of the floodbox culvert to draw water down in the Bell Slough. Assuming this level was based on CGVD 1928 datum and converting this to CGVD2013 datum, this translates the pump start water level to 8.82m.

Based on the data referenced from 1968-2022, and as inferred from **Figure 3.5**, the water levels for the Fraser River have been below the invert elevation (8.43m) of the outgoing floodbox culvert located at the downstream end of the Bell Slough 90% of the time. Refer to **Figure 3.6** for the percentages.

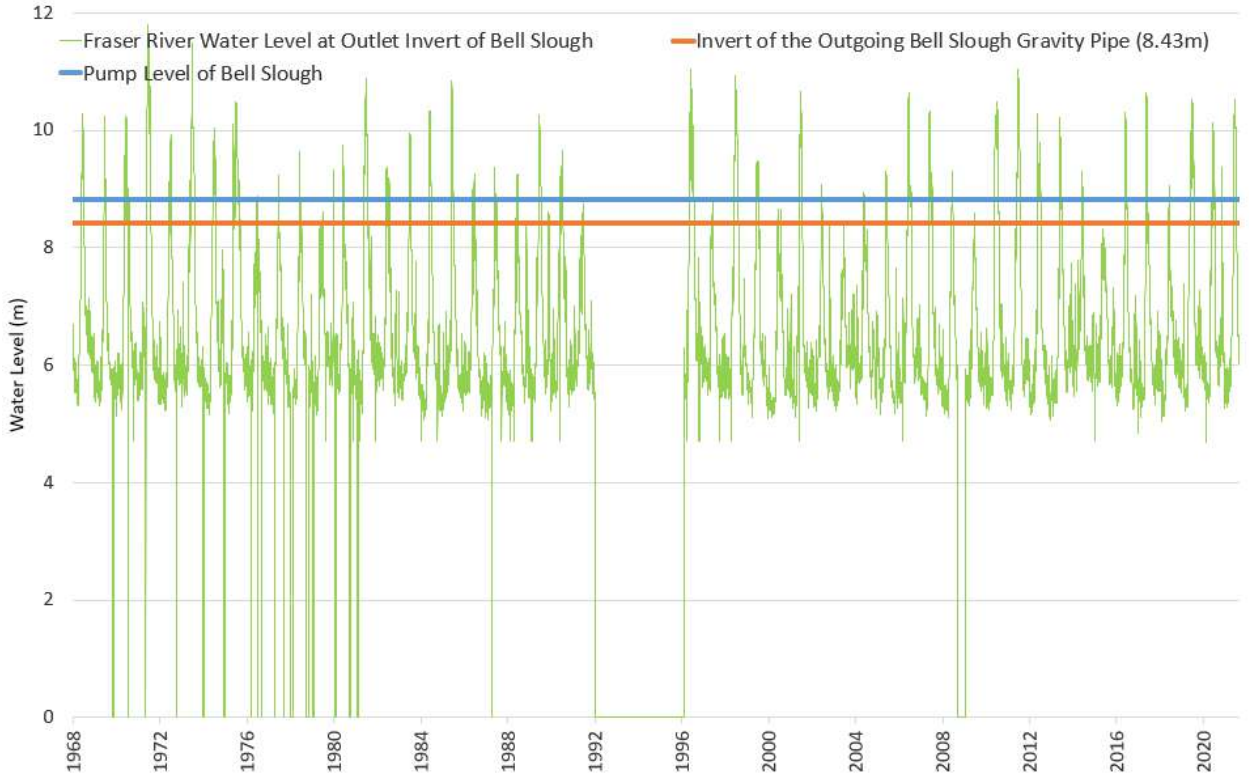

Figure 3.5: Fraser River Water Level Comparison with the Bell Slough

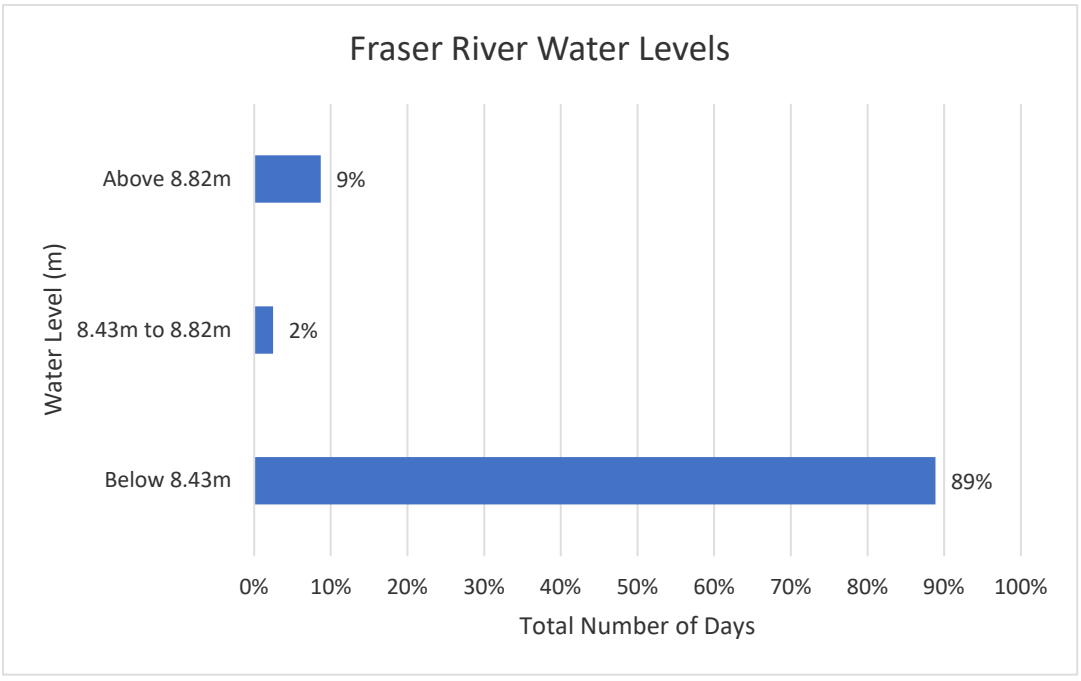

Figure 3.6: Fraser River Water Level Comparison from 1968 to 2022 with the Bell Slough Bottom Level and Pumping Start Level

3.1.5 Rainfall Inputs

The IDF parameters/intensities were obtained from the IDF-Climate Change (IDF_CC) generation tool developed by the University of Western Ontario[31] and are summarized in **Table 3.1**. The IDF_CC tool is a simple and generic decision support system to generate local IDF curve information that accounts for the possible impacts of climate change. The tool generates IDF curve information based on historical data, as well as future climate conditions. The dataset of the tool is available through the gauged locations module which uses version 3.20 of the Environment Canada IDF dataset (March,2021) as well as ungauged locations module that extracts IDF curve estimates directly from the gridded dataset produced by the IDF_CC tool.

The Bell Slough is within the watershed that has mainly rural drainage areas, therefore, US Soil Conservation Service (SCS) design storm was used to generate surface runoff. The SCS methodology estimates the design peak flows in smaller watersheds and determines the mass curve for percent of accumulated rainfall depth over a duration of 24-hour. Type II curve is applicable for most of the areas in Canada, however, in British Columbia, type I and IA are used. Therefore, the hydraulic modelling analysis is based on 1 in 10-year and 1 in 100-year SCS Type IA distribution curves.

The City of Chilliwack provided Stantec with a technical memo dated March 16th, 2018 (**Appendix D**) which included the updated IDF Curves for the City of Chilliwack. The City IDF curves are derived by combining the rainfall data from all stations in the region to create a regional set of IDF curves. However, the IDF data obtained from the IDF tool is based on the ungauged location analysis by specifically selecting the City of Chilliwack within the tool which would use the stations mentioned in **Figure 3.4** to triangulate the IDF's of each individual station and come up with the IDF for the specific location. Moreover, the generated Climate Change curves within the technical memo were actually derived from the IDF tool as well but were only projected till year 2056, whereas the IDF curves used by Stantec for the analysis use the latest climate model, CMIP6 scenario RCP 8.5 representing the upper boundary of the range of scenarios described in the climate change literature and the IDF data is projected till year 2100 to calculate more accurate IDF intensities.

A comparison of the intensity rates obtained through the IDF tool and the technical memo provided by the City of Chilliwack is provided in **Table 3.1**. Based on this comparison, the intensity rates generated using the IDF tool provides more statistically reliable values and is a more conservative approach for the hydraulic analysis.

Table 3.1: Intensity Rate Comparison

T (years)	2	5	10	20	25	50	100
CITY OF CHILLIWACK - INTENSITY RATES (mm/h)							
24 h	2.45	3.09	3.52	N/A	4.05	4.45	4.85
IDF TOOL GENERATED - INTENSITY RATES (mm/h)							
24 h	3.37	4.3	4.92	5.53	5.7	6.29	6.88
Climate	3.85	4.87	5.62	6.49	6.71	7.48	8.20

As indicated in **Table 3.1** and **Figure 3.7,** the IDF Tool generated rainfall intensities exceed the intensities of the City IDF curves. The 24-hour average intensity rate for the 100-year design storm event for the City IDF is 4.85 mm/h and the IDF tool generated intensity rate is 6.88 mm/h. Hence, for this study to be conservative, the SCS 24-hr 100 year and 100-Year Climate Change scenarios were implemented within

[31] Computerized IDF CC Tool for the Development of Intensity Duration Frequency Curves Under Climate Change (idf-cc-uwo.ca/)

the PCSWMM models using the IDF Tool generated intensities. The new generated IDF curves can be found in **Appendix D**.

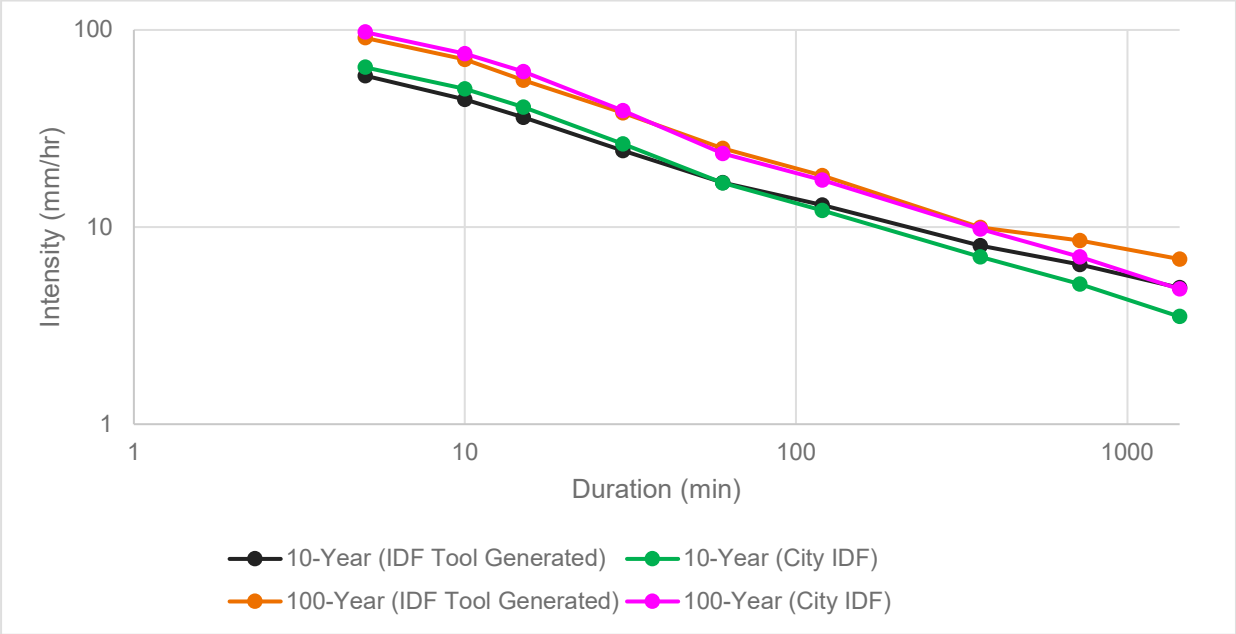

Figure 3.7: Comparison of City IDF curves and IDF Tool generated curves

3.1.6 Modelling Methodology

PCSWMM modelling software was used to generate the existing condition flows for the analysis of the Bell Slough. PCSWMM is a geographic information system (GIS) enabled modelling package that provides an opportunity to run hydrology, hydraulics, groundwater, and surface water quality modelling in the same platform. It runs EPA-SWMM engine in the background and the integrated GIS tool helps delineate catchments and create cross-sections of ditches/channels using a DEM attached to the model.

The following assumptions were applied to the existing condition model:

- Appropriate hydrologic parameters as per *User's Guide to SWMM5 (13th Edition)*, including Manning's 'n', initial abstraction and depression storage values, selected for local use
- The SCS Method was used to calculate CN values for each subcatchment based on existing land use and available soil information
- Land use across the slough was determined from aerial photographs using google imagery
- Subcatchment and drainage system were delineated using DEM data
- Chilliwack soil type was determined using the geology map by the Geological Survey of Canada[32]
- IDF Parameters were determined using the IDF generation tool by the University of Western Ontario[31]
- Infiltration rate for the soil was determined using the data from Food and Agriculture Organization of the United Nations (FAO)[33]

[32] Geology of Chilliwack (sccp.ca)
[33] Annex 2 Infiltration Rate and Infiltration Test (fao.org)

A DEM was created using LiDAR data. The GIS tool in PCSWMM was utilized to delineate the overall areas into sub-catchments and to create cross-sections of the existing ditches using this DEM. The pre-development stage model is shown in **Figure 3.8**.

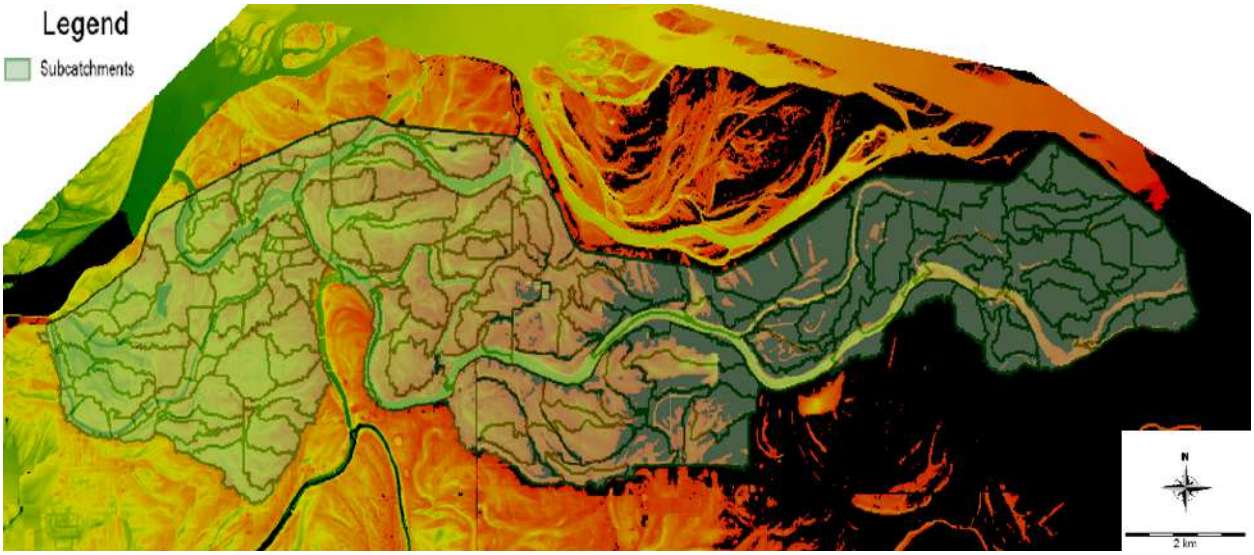

Figure 3.8: Delineated PCSWMM Model

For hydrologic computations, the 'Dynamic Model' was used that applies rainfall to a catchment and then applies infiltration and evaporation losses to estimate the site runoff. The model generates runoff hydrographs in each subcatchment using the dynamic equation. The runoff computation process considers catchment geometry, slope, surface roughness and other factors. Ditches and culverts were sized using the PCSWMM based hydraulic module, which solves the Saint-Venant equations to route a hydrograph through a conduit. Dynamic wave routing can account for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flows.

Infiltration was modelled using natural resources conservation service (NRCS)'s curve number method. Curve number is a parameterization of soil infiltration properties that considers the effect of both land use and soil type, as NRCS developed curve numbers for 49 different land uses, each divided into four different soil types. The selected curve numbers for different land uses and the derived runoff coefficients for a 1 in 100-year 24-hour event are provided in **Table 3.2**.

Table 3.2: Infiltration Parameters

Land Use	Curve Number[1]	Runoff Coefficient[2]
Cultivated Land *(with conservation treatment)*	71	0.51
Open spaces, lawns, parks etc. *(Fair condition: grass cover on 50 - 75% of the area)*	69	0.48

[1] Curve Numbers are based on Hydrologic Soil Group B which is associated with soil with moderately low run-off potential when thoroughly wet
[2] Runoff Coefficients were computed for a 1 in 100-year Climate Change Scenario

Storage areas have been assigned within the subcatchment areas to account for fields and other depressions. Therefore, based on the stage-storage relationship from the LiDAR, each storage area was defined for flood water storage volume at various water depths.

3.1.7 Model Calibration

The PCSWMM model was calibrated using the 2014-2022 historical water levels data within the Bell Slough provided by the City and comparing the data with the simulated water levels. According to the water level data, over the last few years there has been an increase in backflow frequencies from the Fraser River. 2016 was determined to be the year with no backflow whereas 2020 was the year with the highest number of backflows from Fraser River to the Bell Slough. Thus, the water level data for these two years were used to calibrate model. **Figure 3.9** illustrates the number of days with a backflow on a yearly basis from Fraser River to the Bell Slough.

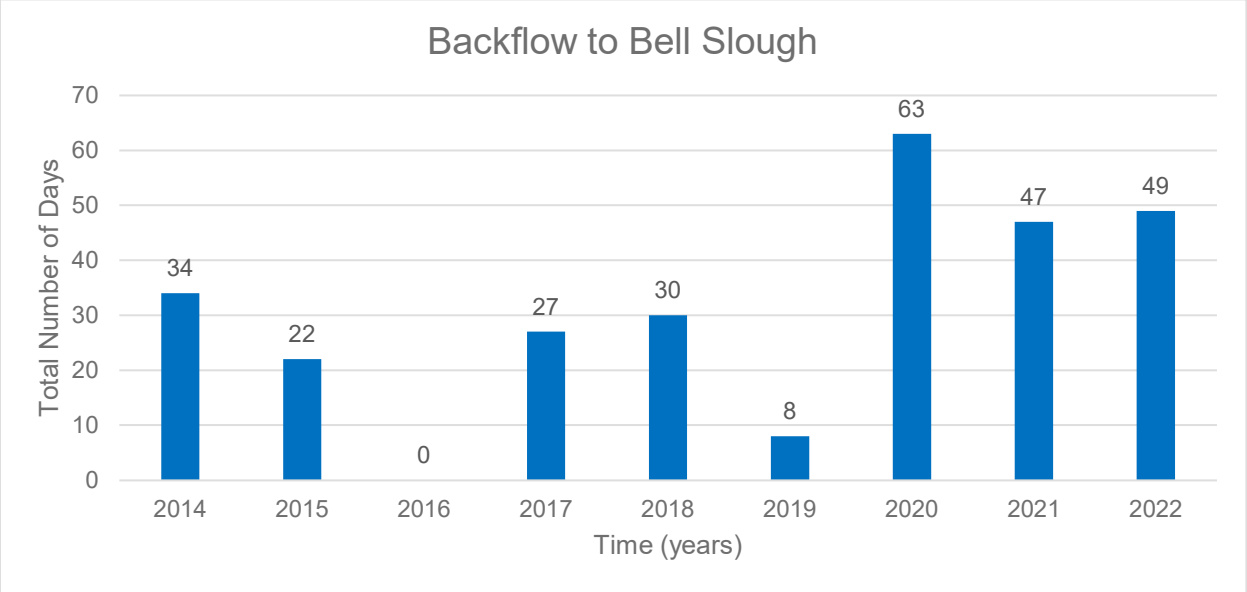

Figure 3.9: Backflow to the Bell Slough

3.1.7.1 Model Calibration for Year 2016

During calibration of the water levels within the Bell Slough, the PCSWMM model was run with the simulated flows and the 2016 water level data was added as an observed timeseries as seen in **Figure 3.10**. The comparison of simulated versus observed data indicate a close match in pattern. The highest water level event observed during 2016 was in November and the model shows similar peak in that time frame. This is a good measure for checking the model's usefulness in predicting the depth levels in response to the simulated inflows.

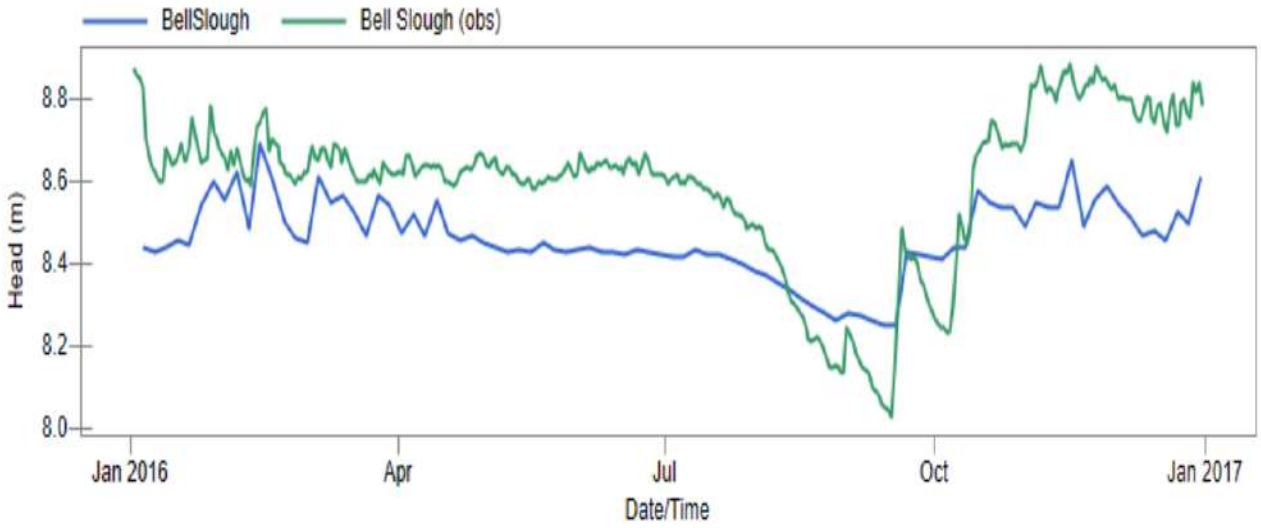

Figure 3.10: Model vs. Observed Data Comparison for the 2016 Water Levels at the Bell Slough Floodbox Culvert

However, as seen in **Figure 3.10**, the simulated depths in the Bell Slough are generally lower than observed. This can be due to many reasons, however it is suspected that groundwater influences are primarily at play, unfortunately surface water-groundwater interactions are not within the scope of this project. The floodgate opening and closing is primarily based on the water levels in the Fraser River as well as the Bell Slough, however, the gate remains open until freshet and the gate is closed once the Fraser River at Mission gauge reads 3.15m, which equates to a Fraser River at Bell Slough gauge reading of approximately 8.27m (fixed to CGVD28 datum).

The pumping of the water from Bell Slough into the Fraser River is based on the water levels occurring within the slough and the pumping starts and stops at certain levels. Under the existing operational procedures, pumping occurs when the gate is closed and the Bell Slough levels reach 8.82m (see section ***Historical Water Levels***3.1.4.2 for datum clarification). The model peaks seem to be aligned with the observed peaks, but there will always be some uncertainty with the simulated flows due to the above-described conditions.

3.1.7.2 Model Calibration for Year 2020

According to the Fraser River gauge data, of the recorded data set (2014-2022), 2020 had the longest duration of high Fraser River water levels that could flow back into Bell Slough.

The PCSWMM model was run for 2020 rainfall data, and the resulting simulated flow level was compared with the 2020 observed water level data as seen in **Figure 3.11**. The modeled depth pattern appears to be comparable in most cases. For 2020, the highest water level was observed in July.

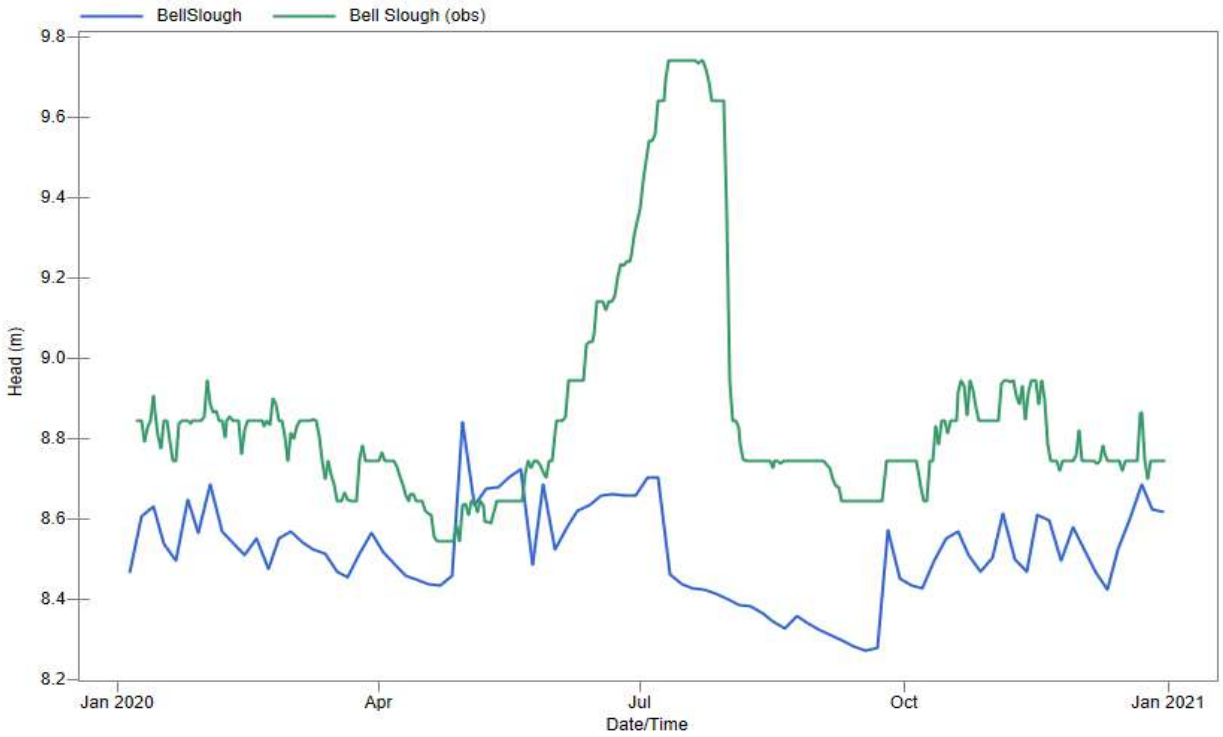

Figure 3.11: Model vs. Observed Data Comparison for the 2020 Water Levels at the Bell Slough Floodbox Culvert

However, as seen from the **Figure 3.11**, the calibrated model does not provide a good fit to observed data. The City of Chilliwack often opens the existing floodbox gate at the downstream end when the slough is high and the Fraser low. Similarly, staff pump the water from Bell Slough into the Fraser River if the slough is high and the floodbox is closed due to high Fraser Water Levels. The model peaks seem to be aligned with the observed peaks but there will always be some uncertainty with the simulated flows due to the above-described conditions.

3.1.8 Model Results

The existing model was run with a 10-year as well as 100-year 24-hour SCS design storm event. **Figure 3.12** shows a comparison of the simulated Hydraulic Grade Line (HGL) levels for the 10-year and 100-year design storm event when the floodbox culvert is closed. The model was run during the days with highest water levels within the Fraser River during the year 2020.The Hydraulic Grade Line represents the surface/profile of the water flowing in an open channel or a closed pipe conduit flowing partially full.

Note the ground surface elevations shown in the model figures throughout this report do not represent the actual ground surface elevation of the roadway/driveway. These ground elevations have been increased in the model to simulate overtopping of flows across roadways/driveways crossing the Bell Slough. The brown coloured land at the top of the profiles represent sections where overtopping of roadways can occur within the Bell Slough.

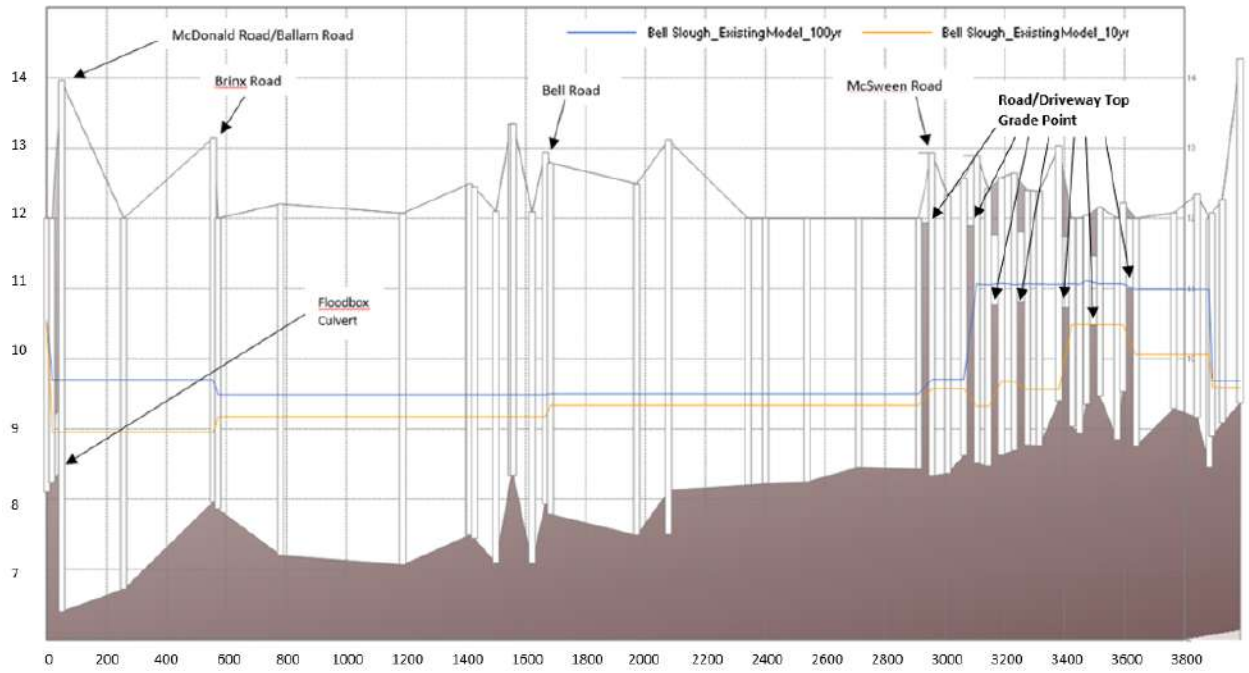

Figure 3.12: HGL Levels for 10-year (Orange HGL) and 100-year (Blue HGL) SCS Design Storm Event

As inferred from **Figure 3.12**, there are some hindrances in the continuous flow of water on the upstream end. The higher HGL levels are occurring due to the restrictions caused by the roadway/driveways across the slough with no culverts. During the survey completed in September 2022, a broken wooden culvert was identified on the most upstream end and another bent culvert on the roadway crossing close to the intersection of Brinx Road and McDonald Road which might be another factor adding to the higher HGL levels within the slough. Moreover, in some instances the water is overtopping the roadway/driveways and flooding onto the adjacent areas as well.

3.1.9 Climate Change Scenario under Existing Conditions Model

Climate change has an inevitable impact to the existing infrastructures, buildings, ecosystems, etc. including the stormwater drainage systems. The climate model selected for the analysis is PCIC – CMIP6 – RCP8.5. Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre at the University of Victoria that collaborates with climate researchers and regional stakeholders to provide information on the physical impacts of climate variability and change[34]. Coupled Model Intercomparison Project (CMIP) – 6 represents the sixth phase of the project initiated by the World Climate Research Programme (WCRP)[35]. CMIP model helps in a better understanding of the climate change and its variability. Moreover, Representative Concentration Pathways (RCP) represents the 21st century pathways of greenhouse gas (GHG) emissions and atmospheric concentrations, air pollutant emissions and land use, RCP8.5 representing the worst-case scenario with very high GHG emissions[36].

A PCSWMM model with the climate change factored 100-year SCS rainfall event was run for the existing conditions. As illustrated in **Figure 3.13**, the water levels in the Bell Slough upstream of McSween Road tend to rise above the existing roadway/driveway crossings resulting in flooding issues in the surrounding areas. There are surrounding residential and commercial buildings upstream of McSween Road which

[34] Pacific Climate Impacts Consortium (bloomberg.com)
[35] WRCP Coupled Model Intercomparison Project (CMIP) (wcrip-climate.org)
[36] Future Climate Changes, Risks and Impacts (ar5-syr.ipcc.ch)

could potentially get impacted with the rise in water levels within the slough. In the downstream section of the slough, the HGL level is flat and was simulated to be 9.73m. In comparison, the July 2020 Bell Slough water level data indicates a maximum water level of 9.74m within the slough (only a 0.01m difference). Therefore, the simulated and observed water levels are comparable.

According to LiDAR data, the developed lands surrounding the lower reach of Bell Slough have a minimum elevation of 10.00m. Since the HGL reaches only 9.74m here, modeled surface water does not appear to flow from the Slough to buildings and is unlikely to ingress into basements from an event of this magnitude. Additionally, during the public-open house conducted on September 22, 2022, and the subsequent public feedback collected from the City of Chilliwack residences (refer to **Appendix B)** there have been no reports of basement flooding recorded to-date since the late 1990's.

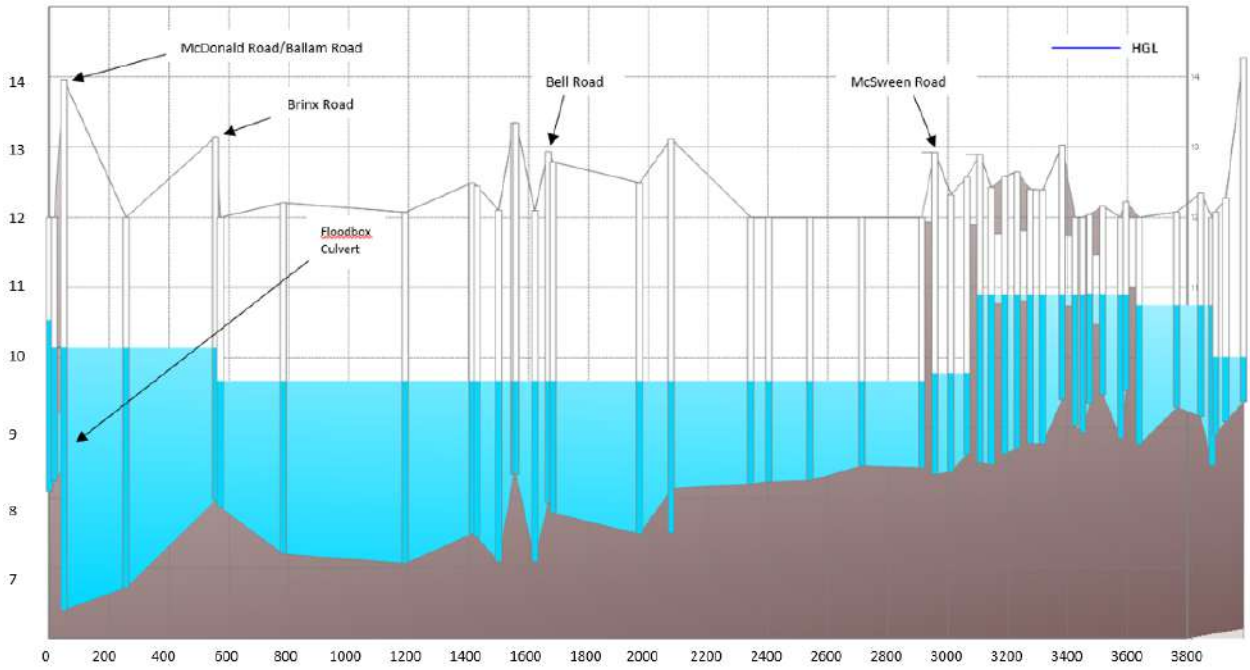

Figure 3.13: Bell Slough Hydraulic Profile for 100-Year Climate Change Scenario

3.2 Proposed Conditions Model

3.2.1 Model Methodology

The proposed conditions model (refer to **Figure 3.14**) was built on top of the existing conditions model. Different modeling scenarios were run to determine the possible options for improving the hydraulics within the Bell Slough.

Figure 3.14: Post Conditions Base Model

The proposed conditions models were simulated with 100-Year Climate Change scenario for testing potential climate change impact. Flow discharge will be regulated to the levels where there will be no flooding and the flows will be contained within the slough.

The post upgrades modeling results can be found in Section 5.2 & 5.3 within the report. The results include modeling analysis for the Hydraulic Infrastructure Improvements and Operational Improvements for the Bell Slough.

4.0 NON-PHYSICAL IMPROVEMENT OPTIONS

The key non-physical improvement option recommended is the development of a long-term management plan and improved adherence of relevant legislation, bylaws and codes of practice to protect the Bell Slough. The success of any physical improvement measures will be contingent on successful education, outreach, and compliance of applicable best practices, legislation and codes.

4.1 Eutrophication Management

To address the source of the eutrophication and nutrient contamination outlined in **Section 2.4**, the following regulations, lines of investigation, and potential solutions are presented:

- Federal, provincial, and municipal legislation, code of practice and bylaws protect watercourses from nutrient pollution:
    - Under section 34 of the *Fisheries Act* it is illegal to deposit deleterious substances to fish habitat.
    - The BC *Environmental Management Act – Code of Practice for Agricultural Environmental Management* states that for general storage of manure (34) "A person who stores agricultural by-products must ensure [that] if contaminated runoff, leachate, wastewater or solids escape from storage, they do not enter a watercourse, cross a property boundary, or go below the water table". For short term field storage of manure 37 (1) "field storage is not located in any area in which there is standing water or water-saturated soil".
    - City of Chilliwack Bylaw No. 168 a bylaw to Protect Watercourses – "No person shall cause or permit the fouling, obstructing, impeding of any watercourse except by permit from the Ministry of Environment, or the filling up thereof, whether or not it is situated on private property; and without limiting the generality of the foregoing, no person who is the owner of livestock shall cause or permit such livestock to foul, obstruct, or impede the flow of any watercourse"
- Provincial and federal legislation to protect public health and the environment from sewerage effluent:
    - Under the *Fisheries Act – Wastewater Systems Effluent Regulation* which sets effluent standards (e.g., BOD) levels that are considered deleterious to fish and fish habitat.
    - The BC *Public Health Act – Sewerage System Regulation* for sewerage systems with a combined design daily domestic sewage flow of less 22,700 L/day of effluent to surface waters, states that "a person commits an offence if the person does any of the following… fails to repair or maintain a holding tank or sewerage system, in a manner that causes a health hazard… operates a holding tank for which no permit has been issued… or a sewerage system for which no letter of certification has been filed".

Although there is evidence of nutrient pollution within the Bell Slough, the point source has not been clearly identified. As such, it is recommended that:

- Due to the general location of fouling being situated around where the livestock are observed; that the City can educate the public regarding Bylaw No. 168.
- The City work with the Ministry of Agriculture and Fraser Health for education and outreach regarding livestock grazing, manure management and septic system maintenance.
- The City develops a comprehensive water quality and flow monitoring program to track long-term trends across the wetted portion of the slough. It is recommended for a program to be initiated as soon as possible to maximize the amount of data collected and analyzed. A program would aid the City in identifying point-source contamination in the watercourse, confirm that improvement efforts

are effective hydraulically and environmentally, and aid in detailed design of hydraulic infrastructure improvements.

- The City develops a rehabilitation and protection plan for the Bell Slough.
- Residential landowners limit use of fertilizers and storage of compost within 30m of the Slough .
- Farmers are encouraged to engage with stewardship organizations to reduce environmental impacts. For example, funding may be available through Investment Agriculture Foundation's Environmental Farm Plan program and Beneficial Management Practices program, which is a complementary, on-farm, cost-sharing incentive program to assist farm and ranch operations to mitigate environmental risks.[37]

4.2 Fisheries Inventory

A fisheries inventory for the Bell Slough was completed by Pearson Ecological in April, June and August 2022 – this habitat report card information is included in **Appendix E.** It is recommended that this program is continued. During the inventory any exotic species captured can be euthanized. Updated fish presence and abundance data will have the advantages of identifying the presence of native and non-native fish to establish baseline conditions, and, if native species are present, these data may inform further fish habitat improvements within the slough. Note that these programs would require permits from DFO and the Province, as well as the involvement of QEPs to complete sampling effort.

[37] Investment Agriculture Foundation - Environmental Farm Plan (iafbc.ca)

5.0 PHYSICAL IMPROVEMENT OPTIONS

Proposed physical improvement options have been described below as follows: ecological and habitat improvements, hydraulic infrastructure works, and operational improvement options. The following sections provide descriptions of the identified options.

5.1 Ecological and Habitat Improvement Options

5.1.1 Option 1A: Mechanical Aerator

Bell Slough is characterized as an anoxic environment leading to inhabitable conditions for aquatic species. A mechanical aerator such as a fountain, oxygenator, or recirculation pump, installed throughout the slough may improve the oxygen levels within the watercourse. Mechanical aeration improves oxygen levels by mixing volumes of water, allowing circulation and turbulence to transfer oxygen into the watercourse – therefore preventing oxygen deprived environments. This option has the following advantage and disadvantages:

Advantages

- Eliminates stagnant water and therefore reduces/eliminates anoxic conditions within the slough, creating a better environment for aquatic species
- Better to oxygenate current water within the slough rather than mixing other water sources into the slough, which could introduce unknown environmental impacts to the slough
- Turbulences helps keep the water's surface clear of biofilm such as anaerobic sludge and therefore reducing phosphates
- Constant movement of water will reduce the smell and odour from water

Disadvantages

- Initial capital expense to purchase and install equipment through the slough
- Operation and maintenance costs associated with keeping the equipment permanently running and well-maintained

5.1.2 Option 2A: Plantings Along Slough and Vegetation Clearing

Planting of trees/vegetation across the slough would provide more tree shade and capture the runoff from commercial, agriculture, and residential developments, subsequently leading to bringing pH levels towards neutrality, reducing metals, and reducing eutrophication conditions within the slough. Mechanical removal of algae, clearing of dead vegetation, and removal of overgrown invasive vegetation is also recommended as an overabundance of decomposing matter leads to unwanted increased nutrient loading. This option has the following advantage and disadvantages:

Advantages

- Increased canopy cover will help shade the slough, which cools the water to an appropriate temperature for the survival of fish and aquatic life.
- Fully grown plants help slow the speed of overland flows by providing enough resistance to allow some of the water to seep into the soil, which helps to recharge groundwater supplies

- Roots from plantings stabilize banks and reduces erosion into the slough
- Some species (i.e., cattails) can filter runoff and reduce nutrient loading in sloughs
- Less decomposing organic matter in the slough will reduce eutrophication

Disadvantages

- On-going maintenance required to remove invasive species and control eutrophication
- May require riparian land tenure resolution
- Shade may not reach across the slough, and tree growth can be slow
- Can be costly to install plantings (but costs can be reduced with more environmental volunteering initiatives)

5.1.3 Option 3A: Design of Habitat Features for Wildlife Species

5.1.3.1 Native Amphibian Ephemeral Pools

Under current conditions, native Pacific chorus frogs inhabit the upstream ephemeral section of the slough; whereas non-native green and bull frogs live in the permanently wetted downstream section of the slough. This distribution pattern is likely due to green frogs and bull frogs having longer aquatic life history phases, which excludes them from surviving in ephemeral ponds. Chorus frogs are an important part of food webs, creating a link in nutrient transfer between terrestrial and aquatic systems, including consuming insects and keeping their abundance in check. Recent studies in Saanich BC, have found that the largest impacts on wetland occupancy by chorus frog are availability of terrestrial habitat (which includes farm fields), impervious surfaces (roadways are causes of mortality), and presence of non-native predators (bull frogs and fish)[38]. As the Bell Slough is surrounded by large expanses of terrestrial habitat, efforts should focus on creating some habitat with hydroperiods that allow metamorphosis of native amphibian species while not supporting the permanent wetted conditions that bull frogs and fish require. Therefore, if is suggested that wet benched pools be designed into the banks of the slough to create a niche habitat for native amphibians. Programs to euthanize non-native species (e.g., bull frog) are also an option but require on-going maintenance. This option has the following advantage and disadvantages:

Advantages

- Increased long term native biodiversity
- Reduced insect abundance around the slough

Disadvantages

- Cost of construction and design
- May require geotechnical investigation efforts prior to construction
- Difficult to ensure sufficient water retention to meet hydroperiods for native amphibians

[38] Multiscale Determinants of Pacific Chorus Frog Occurrence in a Developed Landscape (link.springer.com)

5.1.3.2 *Western Painted Turtle Habitat Features*

Western painted turtle have critical habitat throughout the Fraser Valley. There have not been any documented observations of turtles in the slough, nor is the slough classified as critical habitat. However, during this study, it was communicated by a resident of the Bell Slough that a western painted turtle had been observed on their property – photographs of this observation were provided and communicated to Stantec. Therefore, it is recommended that if any future encounters are made, they should be registered with Report Sightings — Coastal Partners in Conservation. Education to the public regarding such encounters with species at risk is also recommended, as promoting the awareness of these species would add further protection to the biodiversity of species within the slough. In addition to documentation and reporting such occurrences, efforts can proactively be made to enhance both terrestrial and aquatic habitat for western painted turtles. These features include:

- Placing and retaining large woody debris for basking habitat
- Creating nesting habitat on south facing banks with loose sandy soils
- Installing deterrents along roadways to prevent mortalities
- Improvements outlined above for riparian habitat

This option has the following advantage and disadvantages:

Advantages

- Create habitat for a threatened species
- Increase native biodiversity within the slough

Disadvantages

- Residents will be required to practice care in land use with consideration for this species
- Future developments will require care and planning to not impact population. For example, turtles may lay eggs in sand stockpiles, limiting use of materials until the turtles hatch

5.1.3.3 *Fish Habitat Features*

The Bell Slough has potential to become quality off channel habitat for migratory fish (i.e., juvenile salmon) and year-round habitat for a variety of other native fish species. The following are some recommendations that can be done to promote such migration:

- The highest priority for fish habitat improvements should be improvements to flow (such as installation of culverts at barriers to allow for conveyance) and reduction in nutrient pollution
- Riparian vegetation is key in fish habitat quality; crown closure reduces water temperatures, reduces aerial predation, increases food (i.e., insects) and creates refugia when trees fall and become large woody debris
- Connectivity is also an important feature. Culverts should be embedded in the substrate and kept clear of debris
- It is recommended that fisheries inventory information outlined in **Section 4.2** be used to inform any species-specific designs
- It is also recommended that the creation of fish habitat features should be completed in concert with water quality improvements

This option has the following advantage and disadvantages:

Advantages

- Enhance native biodiversity
- Potential to create recreational angling opportunities

Disadvantages

- Costs for culvert installation and maintenance requirement

5.1.4 Option 4A: Physical Barriers for Livestock

Implementation of a physical barrier such as fencing or barbwire along the perimeter of the Bell Slough at areas with free-roaming livestock. Creating a barrier and preventing livestock from entering riparian buffer zones would restrain livestock from fouling the slough. This option has the following advantage and disadvantages:

Advantages

- Restrain livestock from fouling the slough
- Restrain livestock from feeding on new plantings along the slough

Disadvantages

- Cost to survey and confirm legal property parcel boundaries, and supply and install

5.2 Hydraulics Infrastructure Improvement Options

To increase water flow through the Bell Slough, water must be allowed to pass through the entire system. Currently, flow is evidently being blocked by physical barriers such as damaged/crushed culverts and private driveways and roads with no culverts. Therefore, the following hydraulic infrastructure improvements are proposed. Sizing and material selection of these culverts were based on the output results from the hydraulic model conducted during this study. Additional improvement options which could be implemented during the low water input years in the Bell Slough have been discussed in **Section 6.4**.

5.2.1 Option 1B: Replacement/Removal of Existing Damaged Culverts C1 and C5

During the survey conducted on September 27th, 2022, two existing culverts appeared to be damaged as previously illustrated in **Figure 3.2**:

- C1: 650 mm CSP located at the McDonald Road and Brinx Road intersection, adjacent to property parcel #10824, that appears to have been crushed and is no longer functioning
- C5: 600 mm wooden culvert on the most upstream end of the slough, adjacent to property parcel #11310 and #11288, which has completely caved-in with earth and is no longer functional

As a result, these damaged culverts have created blockages and are preventing flow conveyance through the slough. Therefore, a 900 mm (Culvert C1) high-density polyethylene (HDPE) dual-walled culvert complete with riprap armoring or log drops is recommended to replace the damaged culvert. Culvert C5 is

proposed to be removed along with the earthen berm as well as flap gate and channel regrading would be needed for a positive conveyance of water.

The modelling analysis was done with 400mm diameter culverts as well but due to better hydraulic conductivity and more flow conveyance, 900mm diameter culverts were selected. **Figure 5.1** illustrates that replacing the damaged culvert C1 and removing the damaged culvert C5 would support in reducing the HGL levels over the Bell Slough.

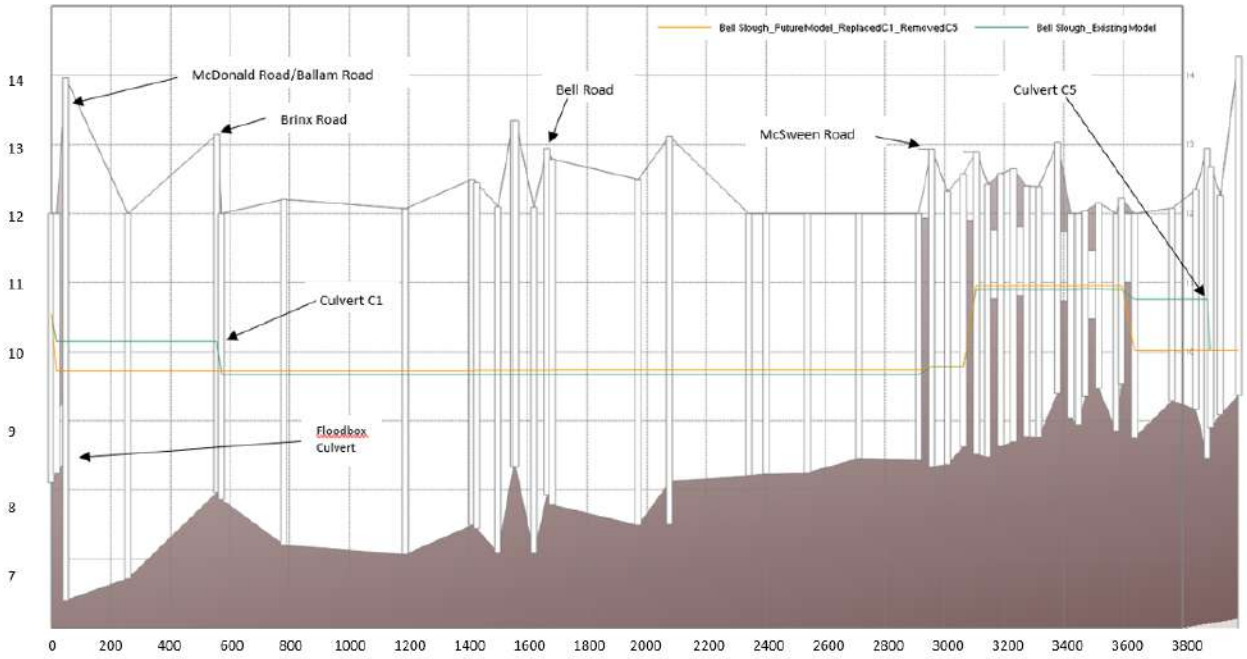

Figure 5.1: HGL Level Comparison for the 100-year Climate Change Design Storm Event of the Replaced C1 & Removed C5 Culvert Scenario (Yellow HGL) with the Existing Conditions (Green HGL)

Advantages

- Installation of a culvert would provide unrestricted flow of water within the slough
- Provide better connectivity of the Bell Slough with the upstream Camp-Nelson Slough
- Better aquatic habitat conditions

Disadvantages

- If only this solution is implemented, the model has simulated that driveway crossings will be overtopped.
- Replacement of culvert C1:
    - This crossing is the only entrance into property parcel #10824, which is a farm that delivers daily commercial goods – temporary access crossing and temporary roads would need to be implemented during construction to allow for daily vehicular traffic
    - Close proximity to live overhead cables would need to be taken into consideration during construction
- Removal of culvert C5:

- Would require a significant amount of earthworks efforts as there is approximately 2.50m of heavily vegetated cover above the pipe
- This culvert is located in a secluded area with limited access and significant vegetation and tree canopy cover, which can increase removal costs
- Approval for a temporary access road along the perimeters of property parcel #11310 may need to be considered if access through the City's right-of-way is not feasible

5.2.2 Option 2B: Installation of a Flap Gate & Headwall at Upstream Culvert

A flap gate installed onto the first upstream culvert in the Bell Slough on the south side would allow water to flow into the Bell Slough from Camp-Nelson but prevent water from spilling from Bell Slough into the Camp-Nelson Slough. Additionally, due to the possibility of water piping around the culvert in either direction, a headwall has been proposed. This flap gate could be installed at the proposed culvert C6 instead. It is assumed that the crushed culvert C5 will have to be removed and the flow obstruction earthworks will be removed as well. **Figure 3.2** illustrates the locations of the above-mentioned culverts. Even with modeling of the flap gate in the 100 year climate change scenario, water levels do not reach the top of the driveway at Culvert C6 location (11.1m) which is the first driveway obstruction downstream of Culvert C5, and are held back by the flap gate. However, it is to be noted that if the driveways/roadway crossing are not retrofitted with the culverts on the upstream section of the Bell Slough, then there are higher possibilities of flooding occurring during the major storm events.

Advantages

- Allow water to flow from Camp-Nelson Slough into Bell Slough when Camp-Nelson water levels are higher than those in the Bell. Increased water quantity and connectivity can help to improve water quality.
- Prevention of backflow from Bell Slough to Camp-Nelson Slough keeps water in the Bell system, increasing available quantity and improving quality.

Disadvantages

- New culvert would need to be installed first, with high capital cost.
- The City would require agreements with the landowners to install and maintain the new culvert C6 if the location is chosen for a flap gate install.
- This culvert is located in a secluded area with limited access and significant vegetation and tree canopy cover, which can increase construction costs due to site preparation and decreased productivity.
- Approval for a temporary access road along the perimeters of property parcel #11310 may need to be considered if access through the City's right-of-way is not feasible.

5.2.3 Option 3B: Installation of Culverts at Blocked Crossings

During the public consultation (refer to **Appendix B**) and meetings with the City, it was communicated that there have been instances of flooding across the upstream extent of the Bell Slough due to overtopping during major storm events. Throughout the Bell Slough it is apparent that there are road crossings and private driveways with no culvert to allow for flow conveyance. The culvert data from the City[13], in conjunction with the topographic survey completed on September 27, 2022, confirmed that a total of seven crossings would require a culvert installation – this is illustrated in the following **Figure 5.2** and detailed in

Table 5.1. These culverts can be 900mm (except Culvert C7 – 525mm) high-density polyethylene (HDPE) dual-walled culverts complete with riprap armoring on the banks or log drops.

Bigger sized culverts have been selected for better embedment, animal passage, and blockage reduction. The modelled simulation was analysed with smaller sized (400mm diameter) culverts as well, but the results indicated that bigger diameter culverts would reduce the HGL levels in the upstream section without much impact on the downstream section of the Bell Slough. The inverts considered for the proposed culverts are based on the existing slough grading. As per the technical note by ADS for the corrugated HDPE pipe (see **Appendix D**), the minimum cover required for 100-1200mm diameter HDPE pipe is 300mm.

Culvert C7 can be maximum 525mm in size because of insufficient depth at the Property Parcel #11244 driveway from McSween Road. The driveway elevation is 10.3m and Bell Slough bottom invert is 9.43m resulting in a depth 0.87m. For a 900mm culvert with minimum cover a minimum required depth is 1.2m.

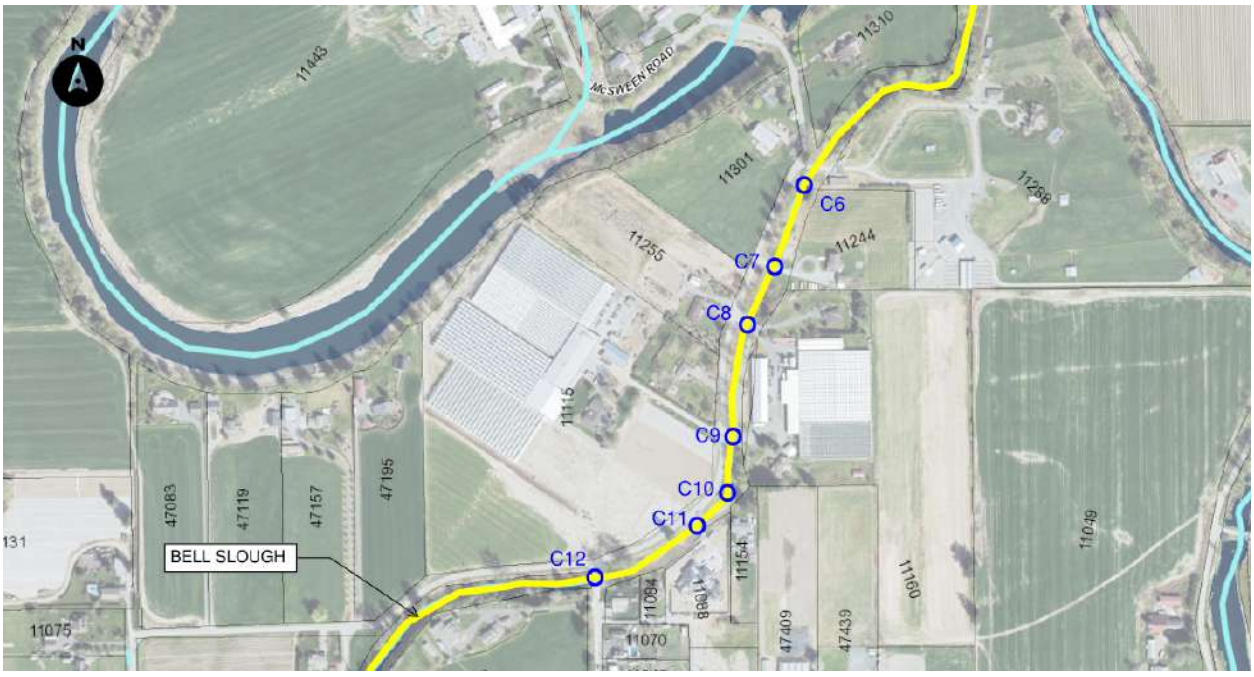

Figure 5.2: Proposed Culvert Locations within the Bell Slough

Table 5.1: Operational Improvements Evaluation Matrix

Proposed Culvert #	Crossing Location Description
C6	McSween Road and Property Parcel #11288
C7	McSween Road and Property Parcel #11244
C8	McSween Road and Property Parcel #11160 (Northern Entrance)
C9	McSween Road and Property Parcel #11160 (South Entrance)
C10	McSween Road and Property Parcel #11154
C11	McSween Road and Property Parcel #11088
C12	Bell Road and McSween Road

Figure 5.3 depicts the scenario with the proposed culverts installed within the Bell Slough. It can be observed that water levels would be significantly reduced at the upstream end, reducing the risks of flooding to properties north of McSween Road. Additionally, the HGL is relatively increased on the downstream end, allowing for better hydraulic connectivity throughout the Bell Slough. Therefore, the HGL levels are increased at the upstream and downstream end during the low flow scenarios and low-input rainfall events due to the above-mentioned installations of culvert crossings resulting in the entire length of the Bell Slough remaining wet during the inflow of summer low flows.

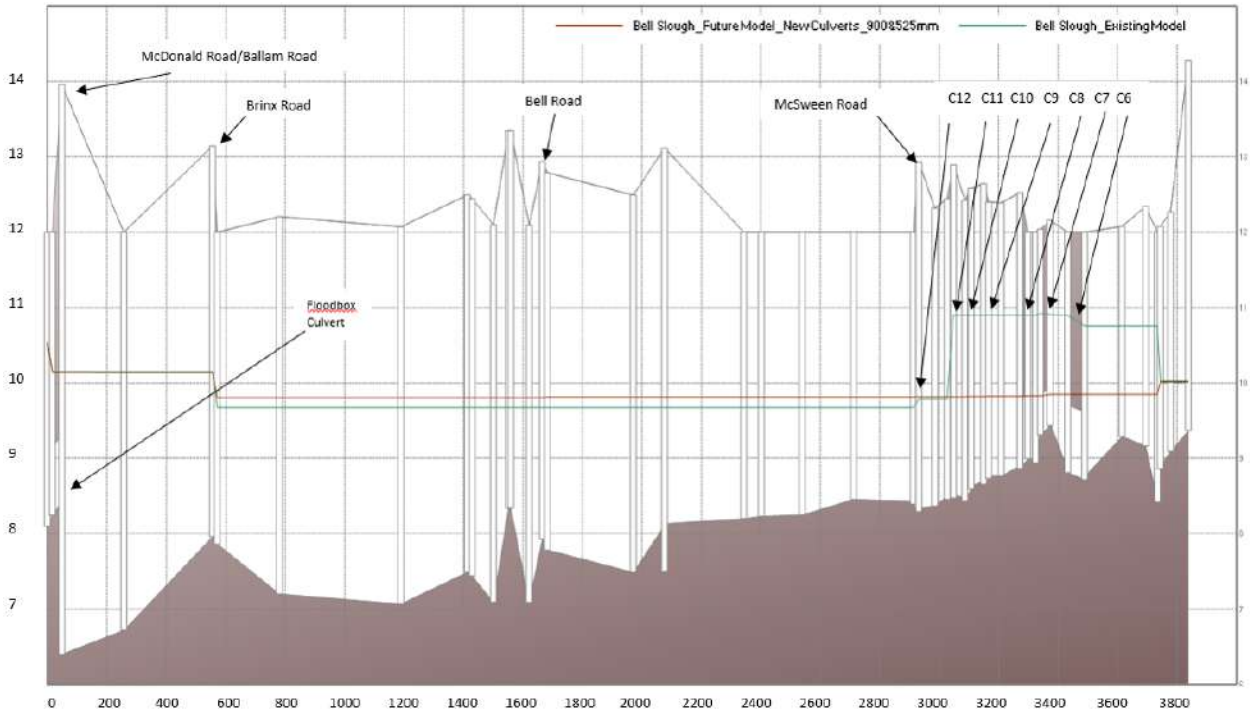

Figure 5.3: HGL Level Comparison for the 100-year Climate Change Design Storm Event of the Proposed Culverts (Green HGL) with the Existing Conditions Model (Brown HGL)

Advantages

- Improved hydraulics due to unrestricted flow
- Better connectivity within the slough leading to improved fish passage
- Increased water velocity leading to reduced sediment deposits upstream of the crossings
- Water temperature reduction
- Less blockages within the slough leading to reduced chances of overflowing and flooding
- Reduced instances of flooding to properties north of McSween Road

Disadvantages

- Capital cost for construction of culverts and efforts to dewater/bypass water
- Due to the least risk window for fish, construction is limited to take place only from July 15th to September 15th
- Potential for surcharge through the culverts

- Disturbance to the public and inability to access McSween Road, and subsequently increased costs due to traffic control and temporary access measures
- Disturbance to the residences along Bell Slough due to the inability to access private driveways during construction, and subsequently increased costs due to traffic control and temporary access measures

5.3 Operational Improvement Options

It is important to take into consideration comprehensive design solutions to address the complex constraints within the Slough system. As such, there should be a balance between adding water to Bell Slough to improve water quality issues versus flood mitigation efforts to protect the adjacent private properties. The following options could potentially improve and introduce more flows into the Bell Slough, while also reducing the risk of flooding to adjacent properties during major storm events. The modelling scenarios within this section are based on the proposed scenario model with all hydraulic improvement options added i.e., all new and replaced culverts (including a flap gate on culvert C5).

It is important to note that the aerial extent for flooding shown on the images in the report reflects flooding from surrounding channels and sloughs as well and not just the Bell Slough. Therefore, caution needs to be taken in evaluating the flooding extent at different elevations from the imagery.

5.3.1 Option 1C: Raise Pump Start Level

As described previously in **Section 3.1.4.2**, historically the pump start level for the Bell Slough has been 8.82m. Based on the existing model analysis, the HGL levels within the slough for the 100-year plus (inclusive of climate change) are still within the slough in most instances. Based on the LiDAR data, it is apparent that the lowest elevation at the downstream vicinity of the Bell Slough is 10.15m. **Figure 5.4, Figure 5.5,** and **Figure 5.6**, illustrate some different elevation gradients. For flooding to become induced in the downstream surrounding areas, the water level within the slough would need to surpass this 10.15m level. As described previously**,** historically the water level within the slough reached a maximum elevation of 9.74 m from 2014-2022. Therefore, it was calculated and hydraulically modelled that the pumping start level could be increased to 9.40m.

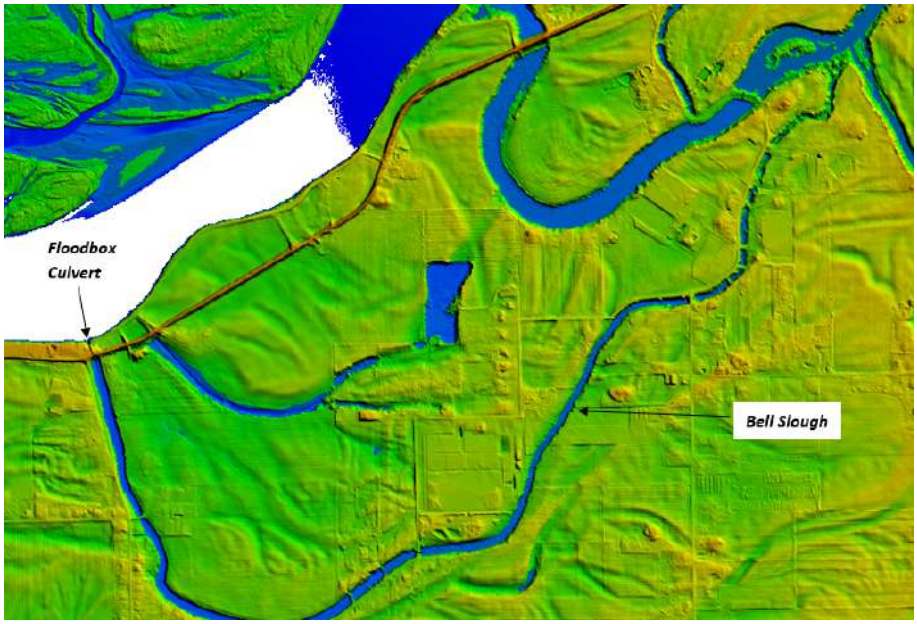

Figure 5.4: Water Level in The Bell Slough and Surrounding Area at 9.50m Elevation

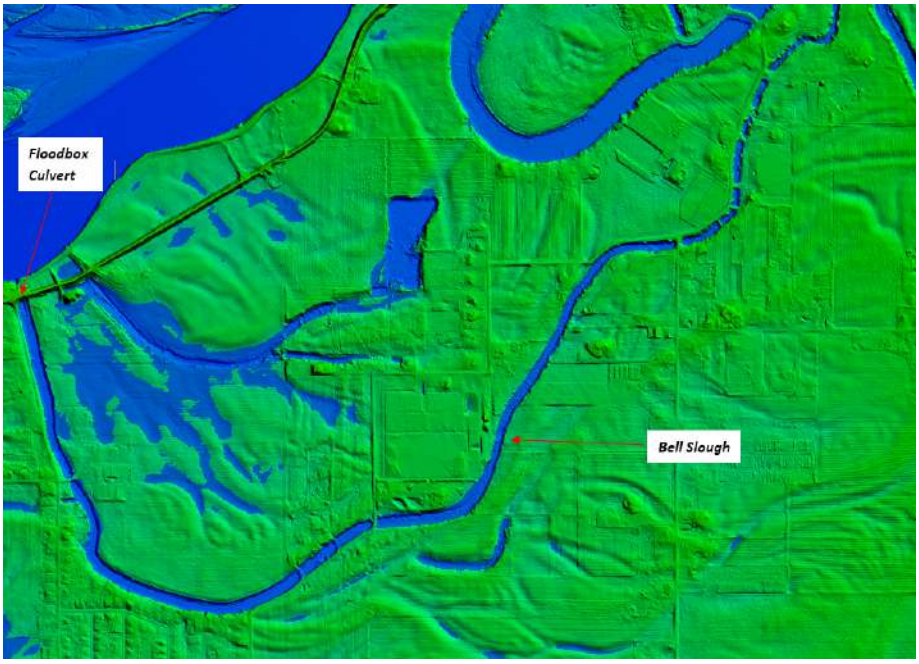

Figure 5.5: Water Level in the Bell Slough and surrounding area at 10.15m Elevation

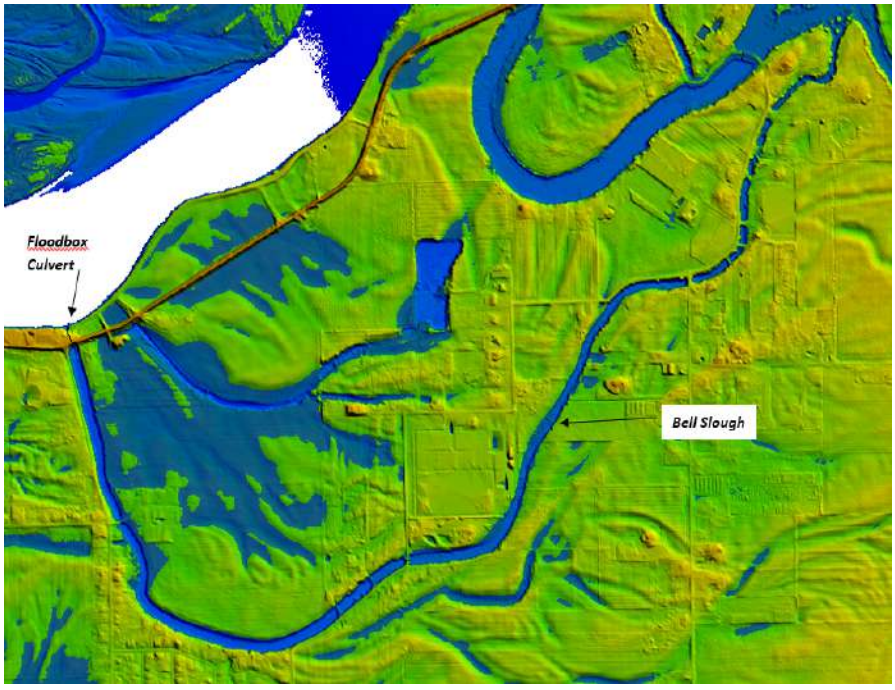

Figure 5.6:Water Level in the Bell Slough and surrounding area at 10.50m Elevation

As illustrated in **Figure 5.7**, the increased pump start level would increase the overall HGL levels within the Bell Slough.

According to the Bell Slough Study 1989, the lowest basement elevation is at 10760 McDonald Road which is 9.42m (fixed to CGVD28 datum). Therefore, the proposed new pump start level at 9.40m is ideal as the Bell Slough water level would stay below the lowest basement elevation along the slough and would not promote any basement flooding.

However, while the highest water level in the slough was 9.74m and there have been no reports of basement flooding recorded to-date during these years, it is recommended that changing the pumping start level to the proposed 9.40m should be considered with caution. After the change to the start level operations have been made, especially at the downstream portion of the Bell Slough, water levels and the surrounding areas should be carefully monitored for any signs of flooding, at least for the first year to determine the suitability. If there are occurrences of any flooding, then a new pump start elevation would need to be investigated and implemented.

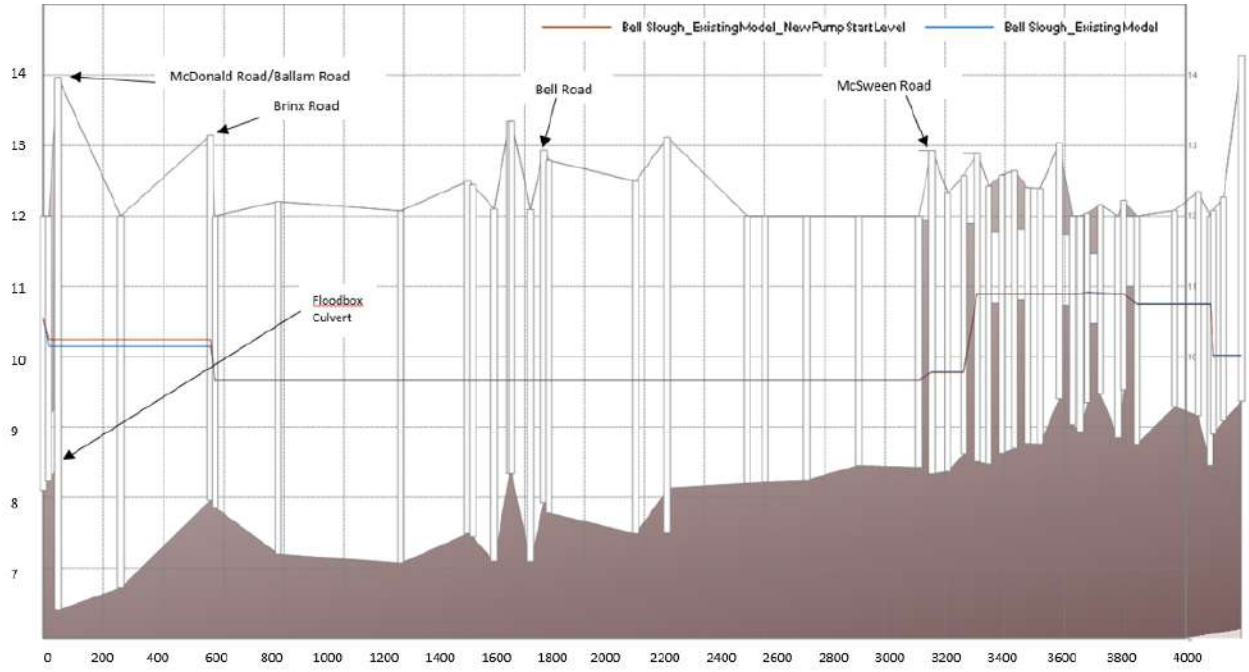

Figure 5.7: HGL Levels Comparison for the 100-year Climate Change Design Storm Event of the Existing Conditions Model with Existing (Blue HGL) and Proposed Pump Start Levels (Brown HGL)

Figure 5.8 illustrates the HGL levels of the existing against the proposed pump start levels if there were no physical conveyance barriers throughout the slough (i.e., no damaged culverts, culverts installed at blocked private driveways, etc.). It was noted that the pump start stop levels have a minimal impact on the slough water levels.

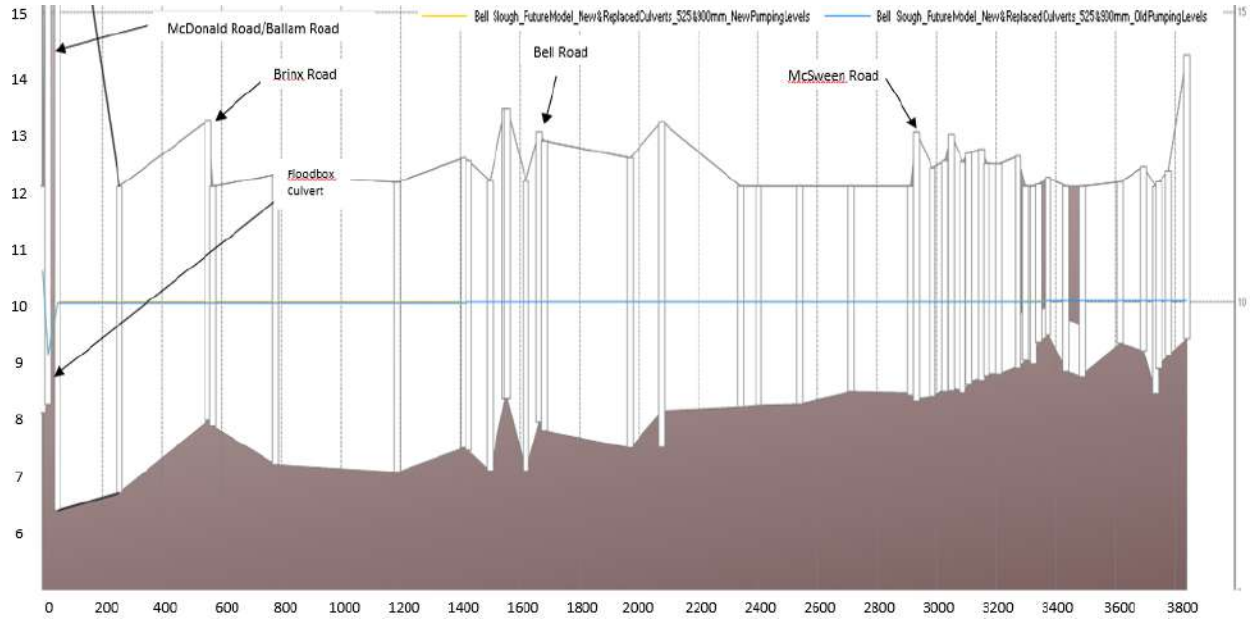

Figure 5.8: HGL Levels Comparison for the 100-year Climate Change Design Storm Event of the Proposed Culverts Model with Existing (Blue HGL) and Proposed Pump Start Levels (Yellow HGL)

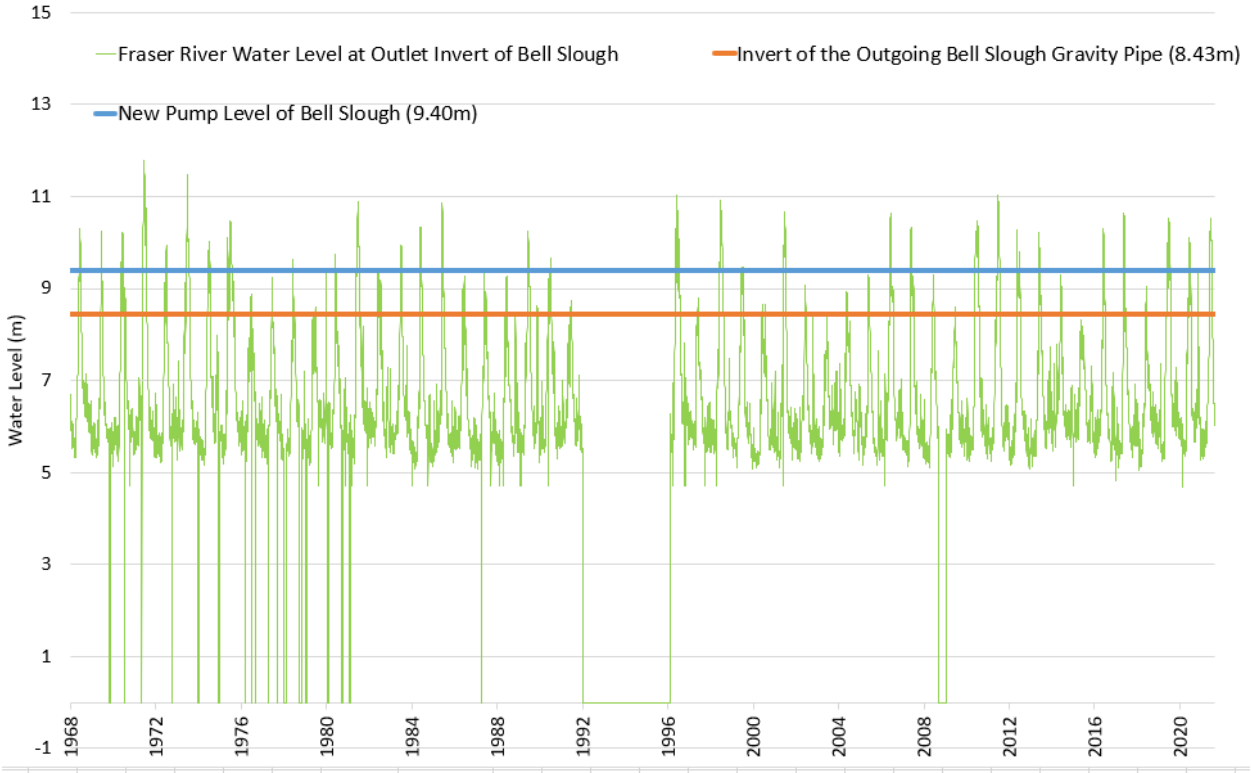

Figure 5.9: Fraser River Water Level Comparison with the Bell Slough for New Pump Start Level (9.40m)

Based on the data referenced from 1968-2022, and as inferred from **Figure 5.9**, the water levels for the Fraser River have been below the new pump start level (9.40m) for the most part. Refer to **Figure 5.10**, for the percentages.

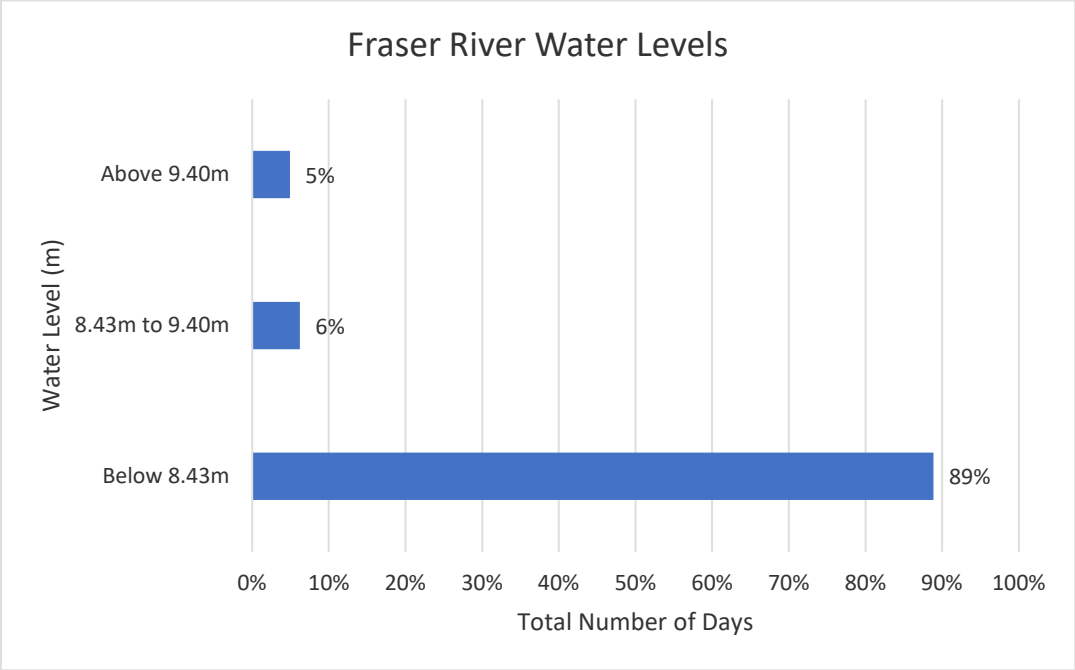

Figure 5.10: Fraser River Water Level Comparison from 1968 to 2022 with the Bell Slough Bottom Level and New Pumping Start Level

Advantages

- Increased retained volume within the slough
- Increased water levels within the slough
- Assisted improved environment for the aquatic species

Disadvantages

- Increased ground water table in the surrounding areas
- Increased surcharging/flooding in the upstream area in the 100-year event
- Increased pump start level could potentially lead to flooding if there is a storm greater than 1 in a 100-year event
- Bell Slough water levels and the surrounding areas should be carefully monitored for any signs of flooding, at least for the first year to determine suitability
- Possibility of adverse impacts on the bank vegetation
- Further survey, calibrations, and analysis would be needed before deciding to implement this option

5.3.2 Option 2C: Implement Pump Stop Level and Floodbox Culvert Gate Operations

As described previously in **Section 3.1.4.2**, historically there have been no operating procedures for the pump stop level for the Bell Slough. Water levels will drop by gravity down to 8.43m based on the invert of the outflowing gravity pipe to the Fraser River. Levels can drop even lower during dry periods when evaporation occurs and when interflow and exfiltration to the groundwater table happen. Based on the existing model, an analysis was conducted to determine the appropriate stopping level for the pump such that more water could be maintained within the slough while reducing the potential for flooding.

As mentioned in the previous section, the downstream surrounding area of the Bell Slough has lower elevations (~10.15m) which are more susceptible to flooding. Therefore, a maximum allowable flooding elevation of 10.15m was used for the modeling analysis (see **Figure 5.11** for illustration). Different scenarios were run to determine the elevation level at which the floodbox culvert should be closed when a major rainfall event occurs so that the water level rise does not exceed 10.15m – these elevations are described in **Table 5.2**.

For instance, when the floodbox culvert closes at an elevation of 9.10m, with the 100 year climate change design storm event occurring, the maximum modeled water levels resulting are 10.04m with pumping from the slough. **Figure 5.11** illustrates that at this elevation, water would remain within the Bell Slough and would likely not overtop to the surrounding areas. Therefore, 10.04m elevation would act as an appropriate stopping level to allow more volume in the Slough while limiting the risk of flooding to an acceptable level.

Table 5.2: If and Then Scenarios for Floodbox Closure Trigger Elevations in Comparison to the Bell Slough Maximum Water Levels for the 100-Year Climate Change Design Storm Event

If Floodbox Closure Trigger Elevation (m)…	Then Bell Slough Maximum Water Level (m) =
8.70	9.87
8.80	9.89
8.90	9.93
9.00	9.98
9.10*	**10.04**
9.20	10.09
9.30	10.17
9.40	10.24
9.50	10.32
*Recommended floodbox open-close water level.	
Note: Pumping from the slough occurs during the modelling analysis	

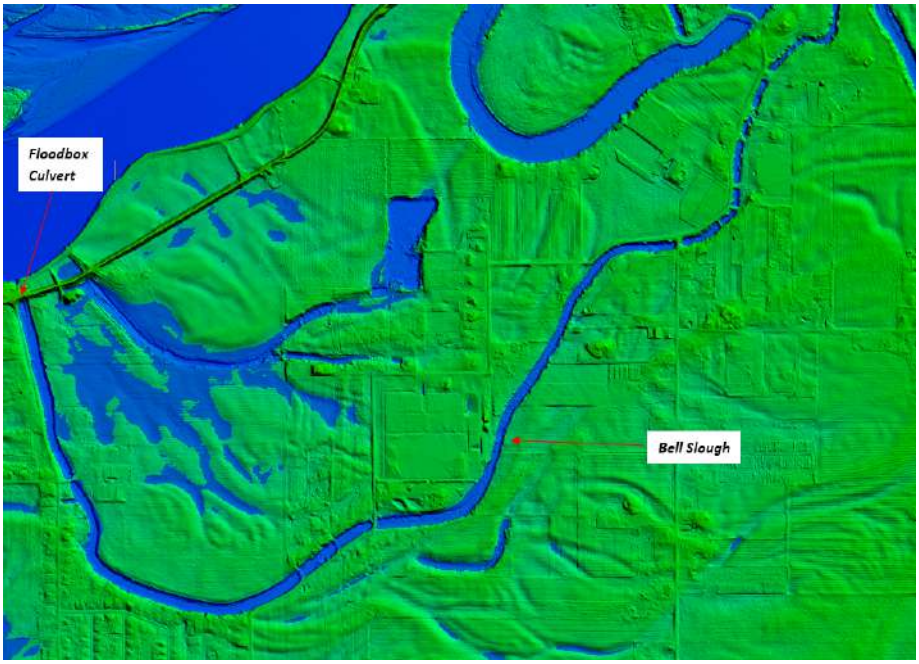

Figure 5.11:Water Level in the Bell Slough and Surrounding area at 10.15 m Elevation

Decisions on opening and closing the floodbox gate valve and when to initiate pumping and stop pumping can be complex and depend on the water levels in both the Upstream Bell Slough and the downstream Fraser River. Stantec has divided the Bell and Fraser water level conditions up into four zones each, as illustrated in **Figure 5.12.** The Bell contains Zones 1-4 and the Fraser Zones A to D, each divided vertically by the three important vertical points of 8.43m (invert of gravity outflow pipe), 9.10m - pump stop level, and 9.40m - pump start level.

Updating the start and stop levels have a potential risk factor of flooding and to address the concern, another modelling exercise was run considering that the 100 year with climate change event begins at the point where the water level is just below the pump start level. The exercise confirmed that a maximum water level of 10.15m would be attained in the downstream section and 10.16m in upstream section of the Bell Slough. Therefore, confirming that the flooding would still not occur.

Table 5.3 uses the zones in that figure to indicate the recommended operation of the gate and pump for various combinations of water levels.

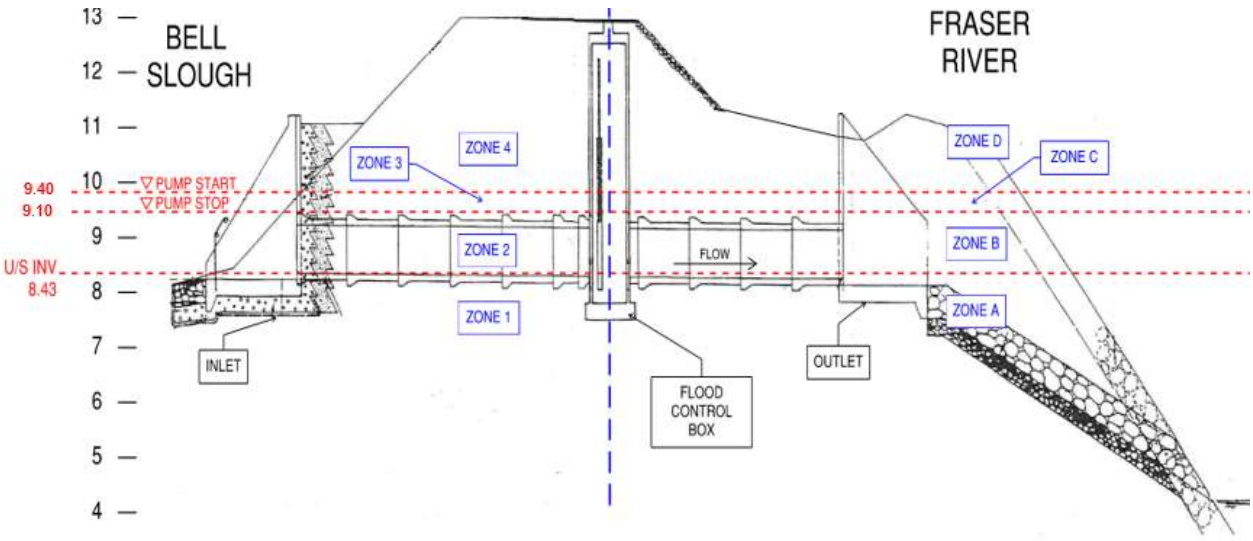

Figure 5.12: Pump and Floodbox Gate Operational Zones

Table 5.3: Recommended Gate and Pump Operation based on Upstream Bell Slough and Downstream Fraser River Water Levels

		If Fraser River Water Level is in…			
		Zone A WL < 8.43m	**Zone B 9.10>WL>8.43m**	**Zone C 9.40>WL>9.10m**	**Zone D WL > 9.40m**
If Bell Slough Water Level is in:	**Zone 1 WL < 8.43m**	Gate Closed Pump Off	Gate Open Pump Off	Gate Open Pump Off	Gate Open Pump Off
	Zone 2 9.10m < WL < 8.43m	Gate Closed Pump Off	If Bell > Fraser – Gate Closed, If Bell < Fraser – Gate Open Pump Off	Gate Open Pump Off	Gate Open Pump Off
	Zone 3 9.40m < WL < 9.10	Gate Open Pump Off	Gate Open Pump Off	If Bell > Fraser – Gate Open, If Bell < Fraser – Gate Closed Pump Off	Gate Closed Pump Off
	Zone 4 WL > 9.40m	Gate Open Pump Off	Gate Open Pump Off	Gate Closed Pump On	Gate Closed Pump On

City Operations staff can use this table to make manual operational decisions, or an alternative, but more expensive option, could be to add a real-time control system with connected to the Bell and Fraser water level monitors, install automatic actuators on the gate and tie-in to the City's SCADA system, and install a permanent pump to allow the system to operate automatically and also allow remote manual intervention.

After the change to the pump stop level operations have been made, especially at the downstream portion of the Bell Slough, water levels and the surrounding areas should be carefully monitored for any signs of flooding, at least for the first year to determine suitability. If there are occurrences of any flooding, then a new pump stop level would need to be investigated and implemented.

Advantages

- Implementation of an actual pump stop operating procedure rather than inaccurate visual-based operations – this would increase the accuracy of any future hydraulic modeling and provide more reliable water level data

Disadvantages

- Bell Slough water levels and the surrounding areas should be carefully monitored for any signs of flooding, at least for the first year to determine suitability
- Increased ground water table in the surrounding areas
- Possibility of adverse impacts on the bank vegetation
- Further survey, calibration and analysis should be completed before implementing this option

5.3.3 Option 3C: Leaving the Existing Floodbox Gate Open

The amount of water flowing from the Fraser River into the Bell Slough could be increased by leaving the floodbox culvert open, and subsequently allowing backflow of fresh water. This recommendation would be preferable to pumping water from the Bell Slough into the Fraser River as it is a passive measure. Through 1-D modeling (refer to **Figure 5.13**), it was determined that keeping the floodbox gate open during a 100-year event (inclusive of climate change) would drastically increase the HGL of the slough downstream of McSween Road.

However, with this scenario, the model indicated occurrences of potential flooding around the downstream end of the slough due to the backflow of water from the Fraser River. Therefore, to move forward with this option, a levee would be needed along the slough to hold the water during the major storm events, however this would create complications with land drainage, perhaps requiring additional flap gates. During the modelling analysis, to determine the maximum water levels within the slough while keeping the floodbox gate open, the maximum witnessed water level (9.743m between 2014-2022) within the Fraser River was chosen as the downstream water level for the Bell Slough to account for the maximum backflow possible.

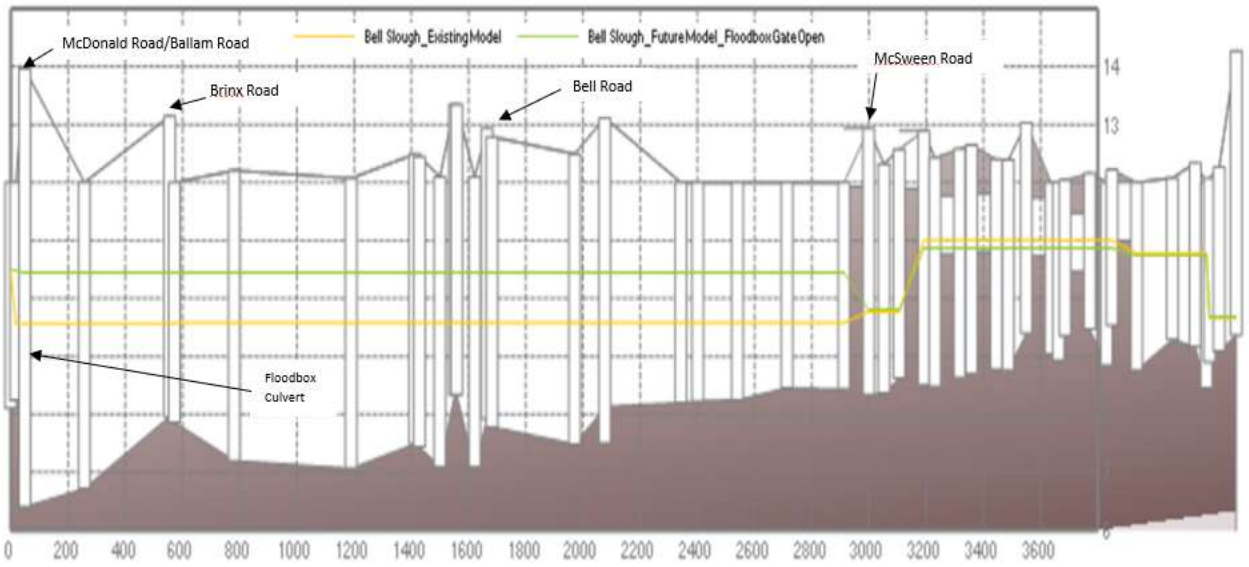

Figure 5.13: HGL Level Comparison for the 100-year Climate Change Design Storm Event of the Floodbox Remaining Open During the 100-year+20% (Green HGL) with the Existing Conditions Model (Yellow HGL)

Figure 5.14 depicts the comparison of the modelling scenario in which the floodgates remain open during the major storm events. The red line depicting the water levels for the recommended new culverts option within the Bell Slough system and the green line depicts the HGL levels without the recommended culverts.

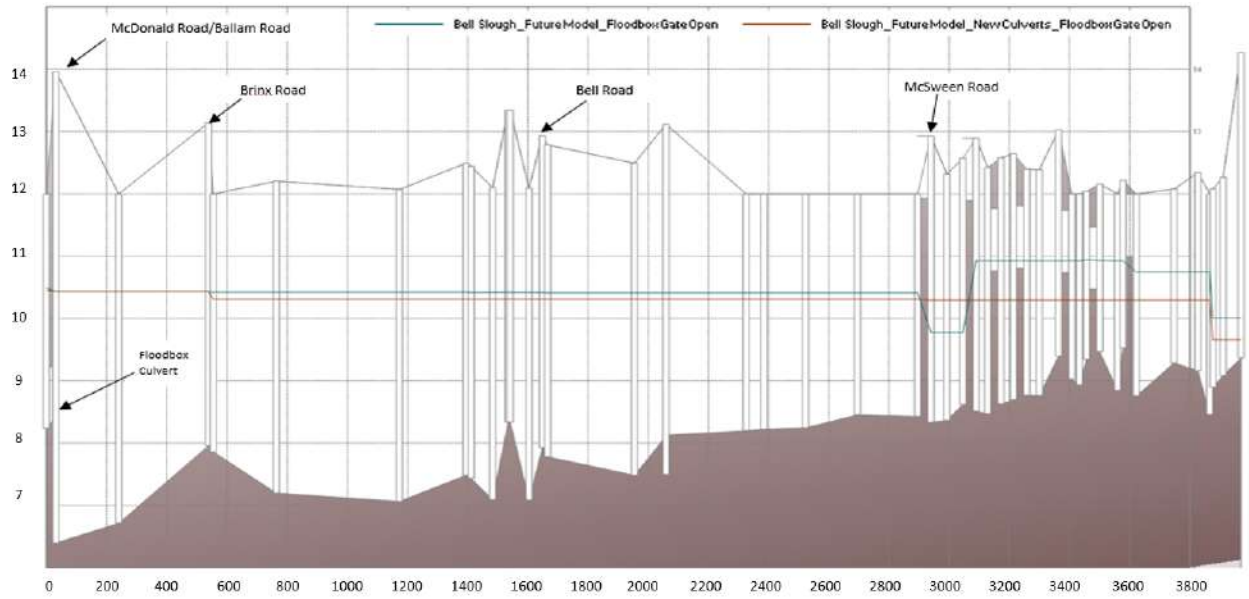

Figure 5.14: HGL Level Comparison for the 100-year Climate Change Design Storm Event for the Floodbox Remaining Open With (Brown HGL)/Without (Green HGL) the New Culvert Scenario

Advantages

- Improved ecological conditions within the slough.
- Better flow and improved water levels within the slough.
- Less chances of anoxic conditions

- Improved habitat conditions for the aquatic species
- Colder temperatures within the slough
- Would eliminate the need to pump water from the Bell Slough into the Fraser River

Disadvantages

- Flooding events in the surrounding areas, possible very rarely whenever the fraser river levels are higher (as evidenced by historical newspaper reports – see **Appendix B**)
- Backflow from Fraser River
- May allow fish to pass into slough and get stuck when levels drop
- Increased ground water table in the surrounding areas
- Possibility of adverse impacts on the bank vegetation
- Further survey, calibration and analysis should be completed before implementing this option

5.3.4 Option 4C: Pumping from Fraser River/Nelson-Camp Slough to the Bell Slough

Bell Slough water levels could be increased by pumping water from either the Camp-Nelson Slough or the Fraser River.

If water were to be pumped from the Camp-Nelson Slough, then 48,640m^3 of volume would be required to top up the Bell Slough to 9.50m (i.e. the same elevation targeted in Option 1C) from the existing water levels set by outflow culverts (e.g. 8.43m, meaning a 1.07m increase at the downstream end). This withdrawal from the Camp-Nelson Slough would lower its water level by approximately 0.49m if taken all at once (although the water is likely to be withdrawn gradually via pumping and would be replenished from its upstream connectivity to other sloughs/waterways). As hydraulic conductivity and groundwater assessment were not part of this study, these levels are purely surface water level elevations and do not factor in impacts associated with groundwater flow. It is important to note that option 1B and 3B should all be installed prior to this consideration (new culverts should be installed at all blockages) to allow water to physically transverse through the Bell Slough.

If water were to be pumped from the Fraser River, then similarly, 27,820m^3 of volume would be required to top up the Bell Slough to 9.10m. In contrast, this would impose little to no effect on the Fraser River due to the sheer magnitude of volume in the Fraser River compared to the Bell Slough. It is important to note that options 1B and 2B should be installed prior to this consideration (i.e. flap gate should be installed at the first upstream culvert) to prevent water from backflowing into the Camp-Nelson Slough.

As mentioned previously in **Section 2.3.2**, water samples of the Camp-Nelson Slough had indicated poor water quality parameters beyond the standard BC-WQG guidelines such as high temperatures and low dissolved oxygen levels. Therefore, if considering the option for pumping fresh water into Bell Slough, water from the Fraser River would be more beneficial in quality compared to water from the Camp-Nelson Slough. Pumping water from the Fraser River would induce possibly more colder water and increase the amount of oxygen in the Bell Slough. However, it is important to note that mixing higher quality water with the lower quality water only leads to dilution, and the beneficial improvements to the Bell Slough would be minimal.

Consideration of pumping different water sources into the Bell Slough should primarily only be considered if the slough were to be “jump-started”. This means allowing the Bell Slough to be completely emptied, manually cleared of decayed vegetation from the slough bottom, and then refilled with fresh water from a

cleaner water source such as the Fraser River. This would likely allow the slough to be jump-started and have a stronger impact in rejuvenation of the Bell Slough.

Advantages

- Better water quality within the slough due to more freshwater intake
- Colder temperatures would create a better and more suitable environment for the aquatic species
- Should only be considered to “jump-start” the Bell Slough

Disadvantages

- Increased risk of flooding at properties north of the Bell Road and McSween Road intersection
- Increased aeration leading to more accumulation of algae throughout the slough
- Camp-Nelson Slough has poor water quality parameters and would have a minimal impact to the water quality in Bell Slough
- Additional capital, operations, and maintenance costs from pumping equipment
- Pumping of water from Camp-Nelson Slough would lead to lowering of the water levels
- The pumps would need to be fish friendly, such as a screw pump, which would be more costly; or, other methods of fish passage would need to be accommodated in conjunction with inlet screens
- Mixing higher quality water with the lower quality water in the Bell Slough would only lead to dilution, and the beneficial improvements to the Bell Slough would be minimal

6.0 IMPROVEMENT OPTIONS

While all the improvement options will primarily provide beneficial properties to the ultimate health of the Bell Slough, it is important to understand where efforts should be prioritized.

6.1 Evaluation Matrix

Tables 6-1 to **6-3** provide evaluation matrixes to guide prioritization of the options. These tables show an evaluation of the different improvement options against a category of different criteria, which each table having a unique criteria. Criteria were established based on ecological health and financial considerations. Each criterion is weighted on a rating scale from 1-5, with 5 being the most advantageous.

Table 6.1: Ecological and Habitat Improvement Options

Option #	1A	2A	3A	4A
Description	Mechanical Aerator	Plantings Along Slough	Design of Habitat Features for Species	Physical Barriers for Livestock
Long-Term Sustainable Solution	1	5	5	5
Effectiveness to Improve Aquatic Life	4	5	3	5
Effectiveness to Improve Ecological Conditions	4	4	2	5
Service Life	2	5	5	5
Capital Cost	1	2	1	5
Operation and Maintenance Cost	1	5	5	5
Total	**13**	**26**	**21**	**30**

Table 6.2: Hydraulics Infrastructure Improvement Options

Option #	1B	2B	3B
Description	Replacement/Removal of Existing Culverts C1 and C5	Installation of Flap Gate at Upstream Culvert	Installation of Culverts at Blocked Crossings
Effectiveness to Improve Hydrology	5	5	5
Long-Term Sustainable Solution	5	5	5
Constructability	2	4	2
Service Life	5	5	5
Capital Cost	1	3	1
Operations and Maintenance Cost	2	3	2
Total	**20**	**25**	**20**

Table 6.3: Operational Improvement Options

Option #	1C	2C	3C	4C
Description	Raise Pump Start Level	Updated Pump Stop Level & Floodbox Gate Elevation	Leaving the Existing Floodbox Gate Open	Pumping from Fraser River/Camp-Nelson Slough to the Bell Slough
Effectiveness to Improve Hydrology	4	4	4	2
Long-Term Sustainable Solution	5	5	3	1
Risk of Flooding	3	3	1	5

Option #	1C	2C	3C	4C
Description	Raise Pump Start Level	Updated Pump Stop Level & Floodbox Gate Elevation	Leaving the Existing Floodbox Gate Open	Pumping from Fraser River/Camp-Nelson Slough to the Bell Slough
Service Life	2	2	5	1
Capital Cost	5	5	5	1
Operations and Maintenance Cost	4	4	3	1
Total	**23**	**23**	**21**	**14**

6.2 Description of Combined Infrastructure and Operational Option

Stantec recommends that all the hydraulic infrastructures described in **Section 5.2** should be installed (Option 1B, 2B and 3B). To sum up these options: culvert C1 should be replaced, culvert C5 should be removed, a flap gate at the culvert furthest upstream (C6) should be installed, and culverts should be installed at every blocked crossing. These culverts can be 900mm (with exception of culvert C7 – 525mm diameter) high-density polyethylene (HDPE) dual-walled culverts complete with riprap armoring on the banks or log drops. The installation of culverts would allow for better connectivity throughout the slough, and installation of the flap gate would help prevent backflow and reduce the risk of flooding to properties north of McSween Road.

After further investigation and analysis is completed, Stantec recommends that operational changes be undertaken comprising Stantec's recommended pump start level, pump stop level, and overall flap gate operations of the floodbox culvert (Option 1C and 2C). Based on the available LiDAR data, areas surrounding the downstream vicinity of the Bell Slough have a minimum elevation of ~10.15m – therefore the pump start level could be increased to 9.40m to allow more water to enter the Bell Slough. It is to be noted that the neighbouring field have lower elevations so groundwater seepage to those areas is expected. The pump stop level could be implemented at 9.10m. When water levels drop to 9.10m, the pump should stop. Operation of the floodbox gate is more complex and is dependant on both the upstream Bell Slough and downstream Fraser River water levels; recommended gate operation is explained further in the content below.

6.3 Hydraulic Performance of Combined Improvements

As per the 100-year hydraulic model scenario (inclusive of climate change), the model results indicates that the water level remain contained within the slough and the model does not show flooding of the surrounding properties assuming that all proposed culverts have been installed at the recommended elevations. **Figure 6-1** and **Figure 6-2** illustrates that the water levels within the slough on the downstream end have increased from the existing conditions with a maximum HGL level of 9.99m (**Figure 6-3**). Thus, leading to more water retained in the slough and promoting better habitat conditions. Furthermore, on the upstream end of the slough the connectivity is significantly improved with the insertion of culverts on existing roadways/ driveways with the maximum HGL level of 10.02m (See **Figure 6-3**). Overall, with these proposed operations, the HGL for the water levels is more consistent throughout the slough.

It is important to note that the aerial extent for flooding shown on the images in the report reflects flooding from surrounding channels and sloughs as well and not just the Bell Slough. The aerial figures represent illustration of the flooding level and in no case represent the modelled results. Therefore, caution needs to be taken in evaluating the flooding extent at different elevations from the imagery.

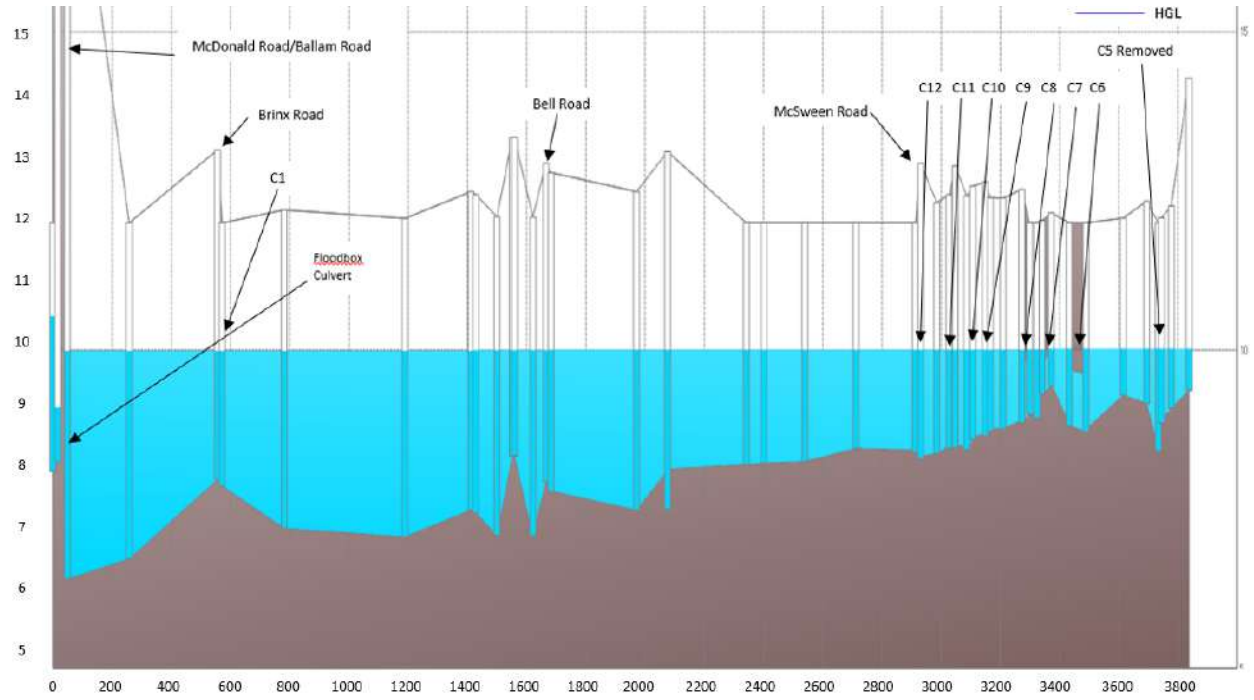

Figure 6-1: HGL levels of the Recommended Model for the 100-year Climate Change Design Storm Event

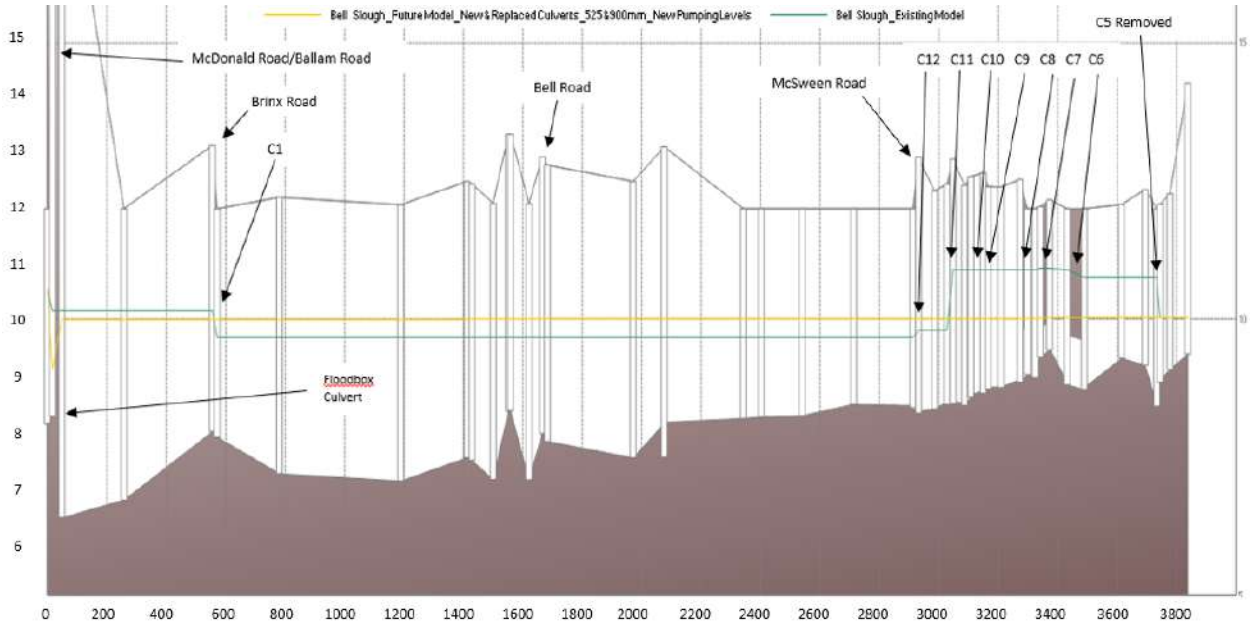

Figure 6-2: Water Level Comparison for the 100-year Climate Change Design Storm Event of the Recommended Conditions Model (Green HGL) with the Existing Conditions Model (Yellow HGL)

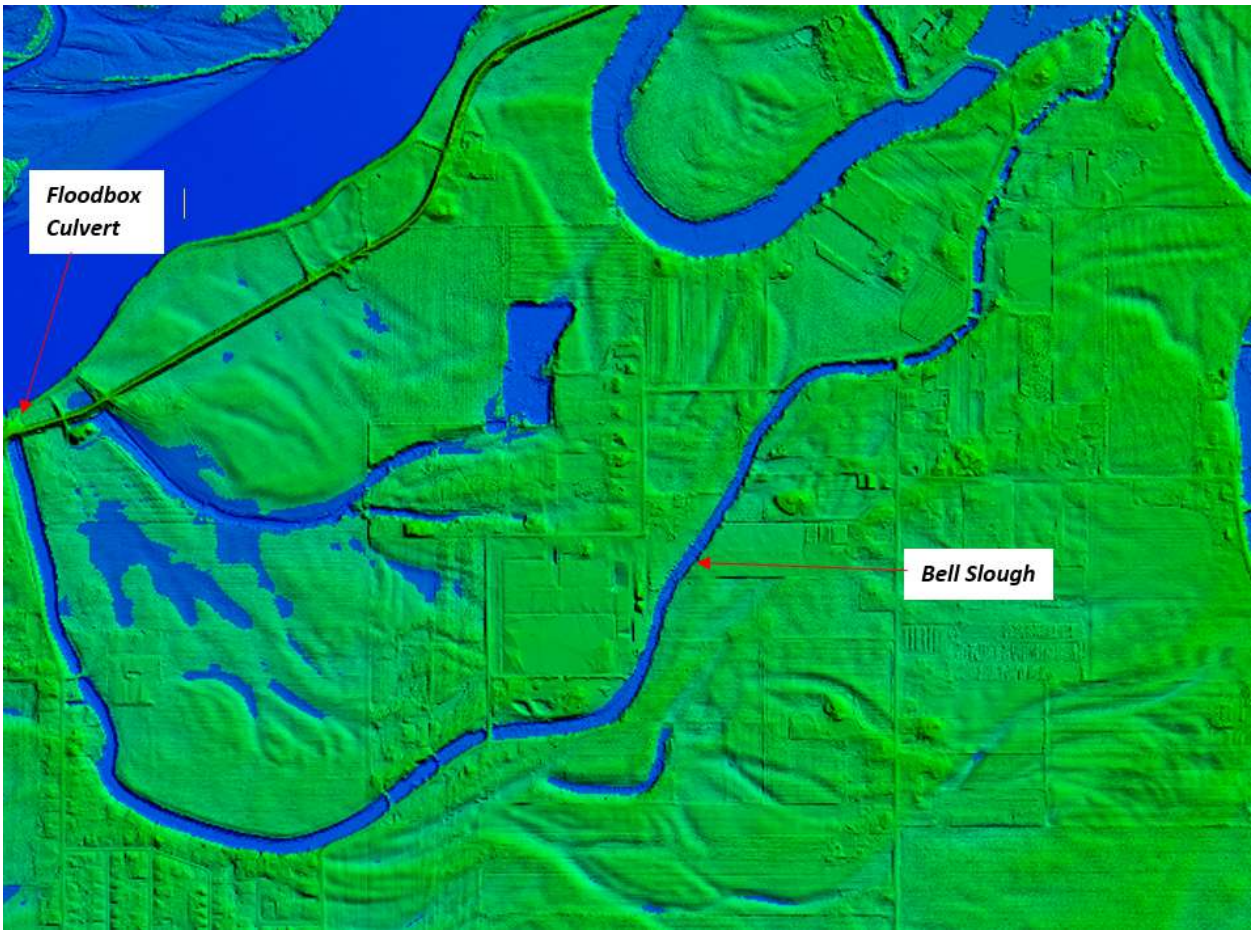

Figure 6-3: Water Level in Bell Slough and Surrounding Area at 10.00m Elevation

6.3.1 Comparison of Existing versus Upgraded System 2016 & 2020 Scenarios

A modelling analysis was completed to compare the existing calibrated model results for the year 2016, having the minimum (zero) number of backflows from Fraser River into the Bell Slough and year 2020, having the maximum number of backflows for the duration between 2014-2022 with the proposed recommended upgrades as discussed in **Section 5.0.**

Figures 6-4 to **6-9** provides comparison of the model simulation results for the existing and proposed upgraded Bell Slough system for year 2016 and 2020 rainfall. As can be seen in the **Figures 6-4** and **6-7**, for the existing system during the years 2016 & 2020 rainfall events, the HGLs are significantly higher at the upstream part of the Slough mainly due to the lack of connectivity resulting in instances of overtopping of the roadway/driveway crossings of the Slough. With the improved connectivity, i.e. recommended culvert upgrades, the upgraded system HGLs are lower in the upstream part of the system resulting in consistent level within Bell Slough. **Figures 6-5** and **6-8** illustrates the water levels upstream of the Floodbox Culvert for the year 2016 and 2020, respectively. As expected for the upgraded system, the HGLs are higher in the downstream end of system due to improved connectivity within the upstream part of the system.

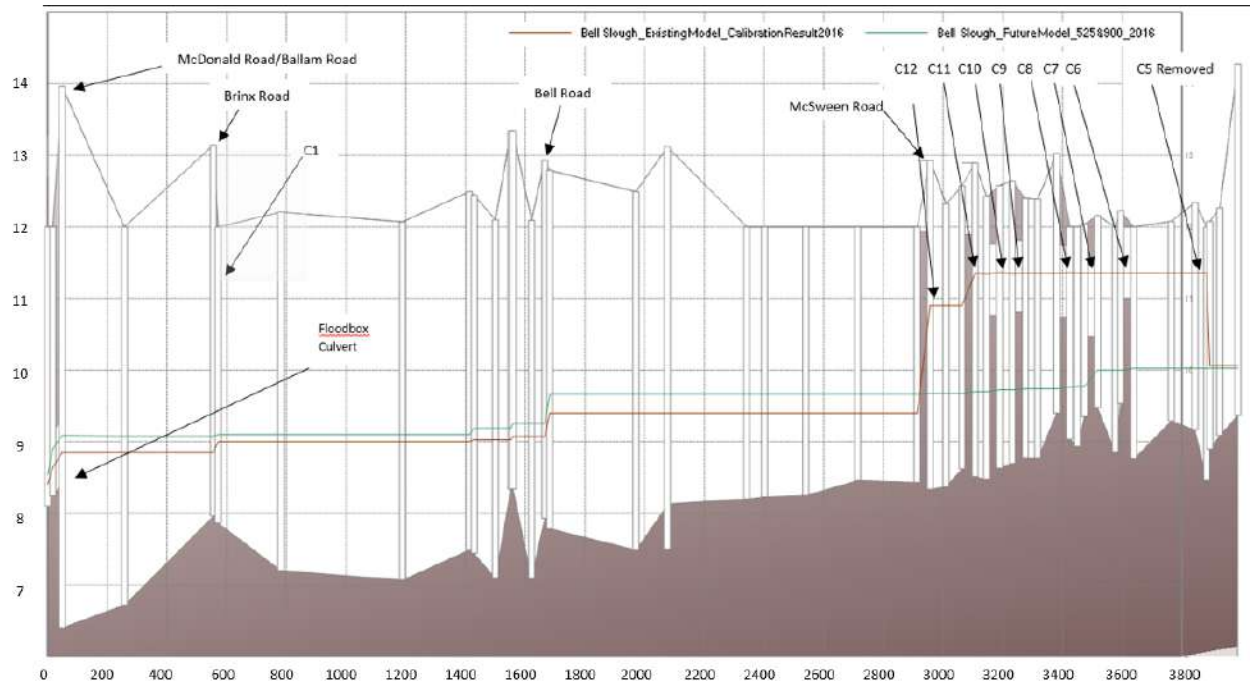

Figure 6-4: HGL Level Comparison for the Year 2016 Storm Event (low rainfall event of year 2016) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

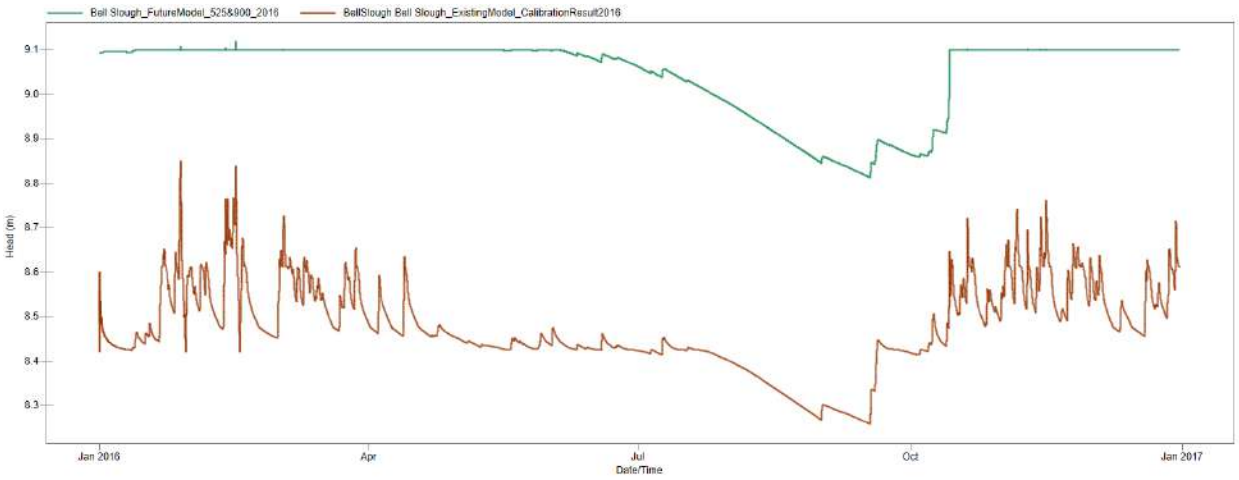

Figure 6-5: Head Level Comparison for the Year 2016 Storm Event (low rainfall event of year 2016) at the most downstream point of the Bell Slough (close to the Floodbox Culvert) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

Figures 6-6 and **6-9** are duration-exceedance plots, representing the percentage of time that the water level at the downstream end of the Bell Slough is above any given level for the existing and the proposed upgraded systems under the 2016 and 2020 rainfall, respectively. It can be seen that the recommended upgrades scenario (green line) results in higher water levels than under the existing infrastructure scenario. During the dry year, 9.1m was the maximum water level and the Slough maintained this water level for about 65% of the year. During 2020 (the wet year), the peak water level was 9.6m. 20% of the time the

level was above 9.1m, 60% of the year it was around 9.1m, and 20% of the year the water level was below 9.1m.

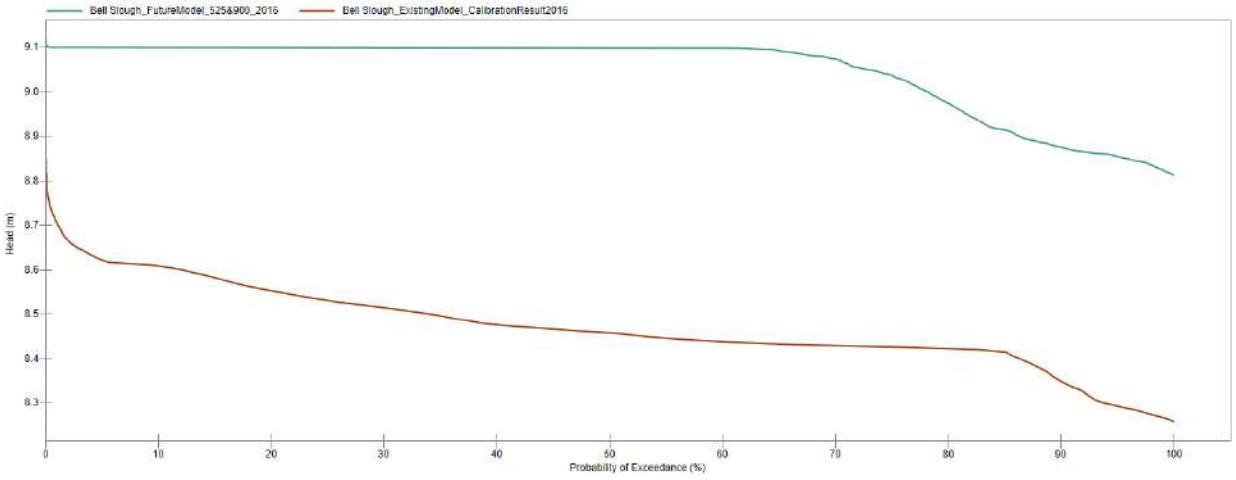

Figure 6-6: Duration-Exceedance (%) Comparison based on the Head Level for the Year 2016 Storm Event (low rainfall event of year 2016) at the most downstream point of the Bell Slough (close to the Floodbox Culvert) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

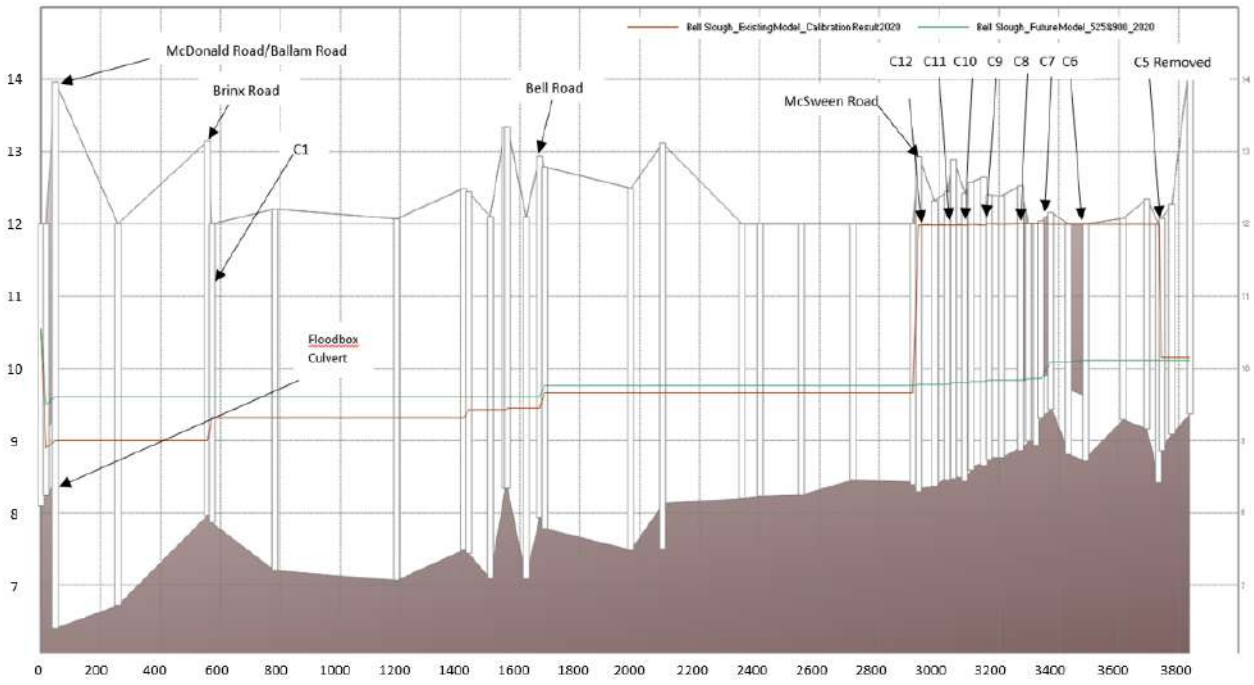

Figure 6-7: HGL Level Comparison for the Year 2020 Storm Event (high rainfall event of year 2020) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

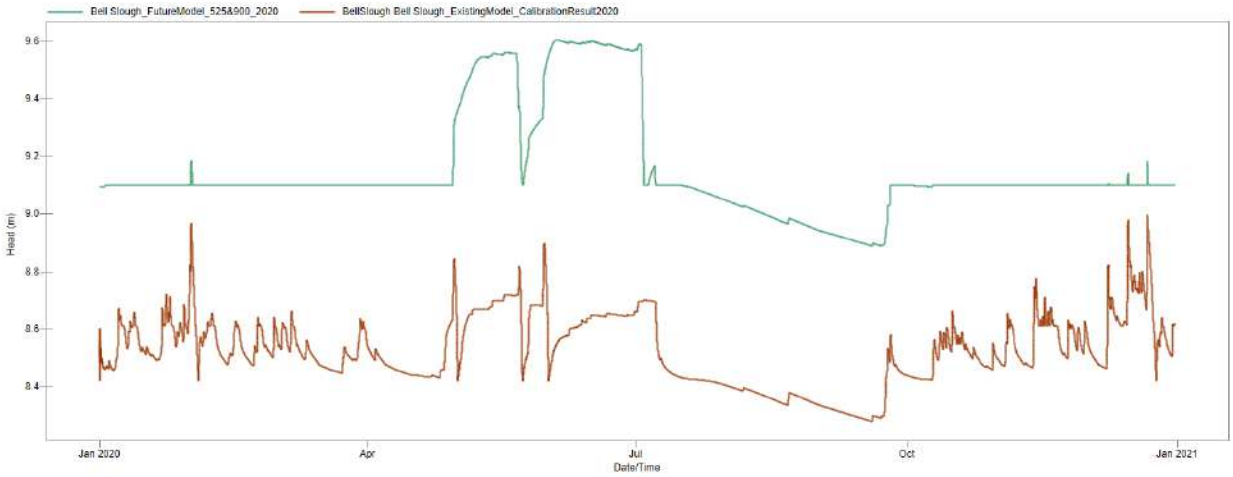

Figure 6-8: Head Level Comparison for the Year 2020 Storm Event (high rainfall event of year 2020) at the most downstream point of the Bell Slough (close to the Floodbox Culvert) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

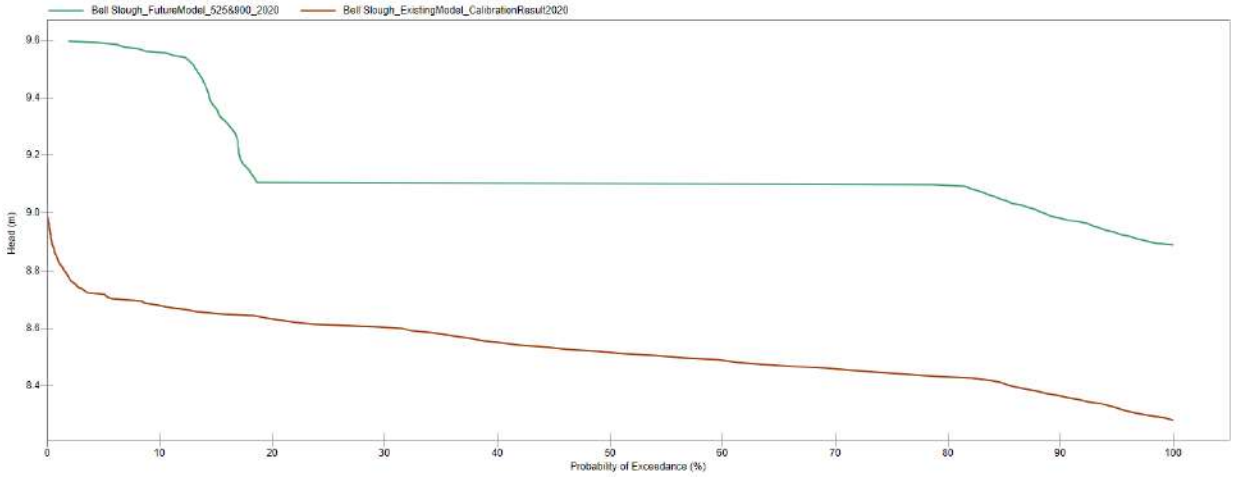

Figure 6-9: Duration-Exceedance (%) Comparison based on the Head Level for the Year 2020 Storm Event (high rainfall event of year 2020) at the most downstream point of the Bell Slough (close to the Floodbox Culvert) of the Calibrated Model (Brown HGL) with the Recommended Model (Green HGL)

6.4 Additional Improvement Options

There are some miscellaneous improvement options which are not limited to environmental and hydraulics improvements which could potentially improve the health of the Bell Slough specially during the low flow/ low water input events. The options are as follows-

- Mechanical Removal of Algae – Algae are the green froth seen floating above the water surfaces and are usually found in freshwater, seawater and damp places like soils and rocks. Mechanical removal is an effective approach and chemical-free approach of clearing algae. Equipment like remote control weed cutters, rakes or other machinery could be used to clear the algae from the Bell Slough.

- Low Impact Development (LID) – Implementing LID measures across the banks and public right of ways surrounding the Bell Slough to intercept and improve the quality of the surface water runoff coming from the surrounding agricultural areas for improving the health of the slough. Other potential benefits

of implementing LID strategy are reduced potential flood impacts, cost effectiveness, multi-functional usage including serving as a public amenity like a bioswale or wetland.

- Mechanical Treatment Devices – These devices can be installed on certain concentrated collection points to treat water with mechanical screens to provide filtration to the surface drainage water prior to entering the slough.

- Cooling Pump – A heat pump can be installed in reverse direction within the slough to lower the temperatures and provide more favourable environment for the aquatic species. However, the running and maintenance costs associated with this option would need to be considered.

- Shadow Analysis – A shadow analysis can be performed across the Bell Slough to analyse the areas which gets more sun during the summer to see where artificial vegetation can be implanted for a limited time till the natural vegetation has had time to grow and provide shade.

- Solar Panels – Solar panels can be installed across the slough which can potentially provide the shade for cooling the water temperatures and provide power to various pumps facilitating Bell Slough. Higher input costs and maintenance costs afterwards might be a concern with this option.

7.0 RECOMMENDATIONS

The report analyzed a series of potential solutions to address the problems within the Bell Slough to identify the options which would be worth pursuing. With input from community stakeholders and the City, a broad variety of designs were conceptualized, developed, and evaluated. The objective was to find long-term sustainable solutions that offer the most value in terms of a range of social, environmental, and economic factors.

7.1 Infrastructure and Operational Recommendations to the Existing System

As mentioned previously, it is important to take into consideration comprehensive design solutions to address the complex hydraulic constraints within the slough system. The need for increased water volumes entering and flowing through the Bell Slough versus the requirement to maintain flood mitigation efforts for the adjacent private properties must be balanced. Therefore, our recommendations for improving the hydraulics through the Bell Slough are combined with operational and hydraulics infrastructure improvements.

In summary, our recommendations are condensed into the following, and a PCSWMM model was run based on this scenario:

- Seven (7) new 900mm diameter HDPE dual walled culverts (including new and replaced)
- One (1) new 525mm diameter HDPE dual walled culvert
- Flap gate on the new Culvert C6
- Removal of Culvert C5 and regrading the section (Including the earthen berm)

These operational levels to start/stop the pump and open/close the floodbox culvert are illustrated in the following **Figure 7.1** and detailed in **Table 7.2**

It is to be noted that the floodbox culvert and pump should be operated according to the **Table 7.1**: Recommended Gate and Pump Operation based on Upstream Bell Slough and Downstream Fraser River Water Levels.

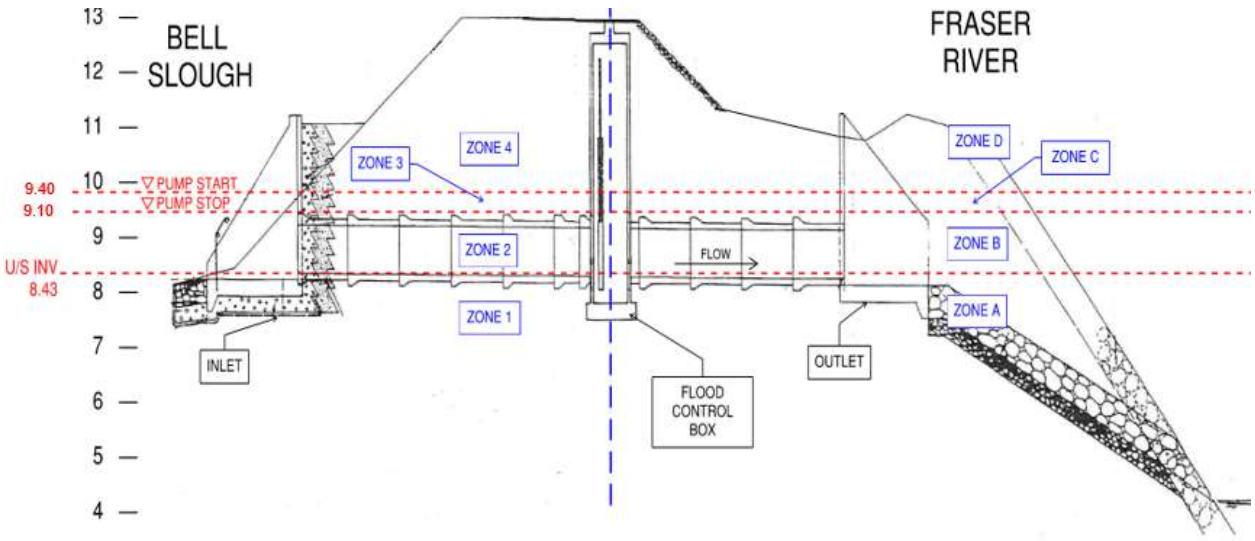

Figure 7.1: Pump and Floodbox Culvert Gate Operational Water Levels[29]

Table 7.1: Recommended Gate and Pump Operation based on Upstream Bell Slough and Downstream Fraser River Water Levels

		If Fraser River Water Level is in…			
		Zone A WL < 8.43m	**Zone B 9.10<WL<8.43m**	**Zone C 9.40<WL<9.10m**	**Zone D WL > 9.40m**
If Bell Slough Water Level is in:	**Zone 1 WL < 8.43m**	Gate Closed Pump Off	Gate Open Pump Off	Gate Open Pump Off	Gate Open Pump Off
	Zone 2 9.10m < WL < 8.43m	Gate Closed Pump Off	If Bell > Fraser – Gate Closed, If Bell < Fraser – Gate Open Pump Off	Gate Open Pump Off	Gate Open Pump Off
	Zone 3 9.40m < WL < 9.10	Gate Open Pump Off	Gate Open Pump Off	If Bell > Fraser – Gate Open, If Bell < Fraser – Gate Closed Pump Off	Gate Closed Pump Off
	Zone 4 WL > 9.40m	Gate Open Pump Off	Gate Open Pump Off	Gate Closed Pump On	Gate Closed Pump On

These proposed culverts are illustrated in the following **Figure 7.2**, and the details of the locations are detailed in **Table 7.2**.

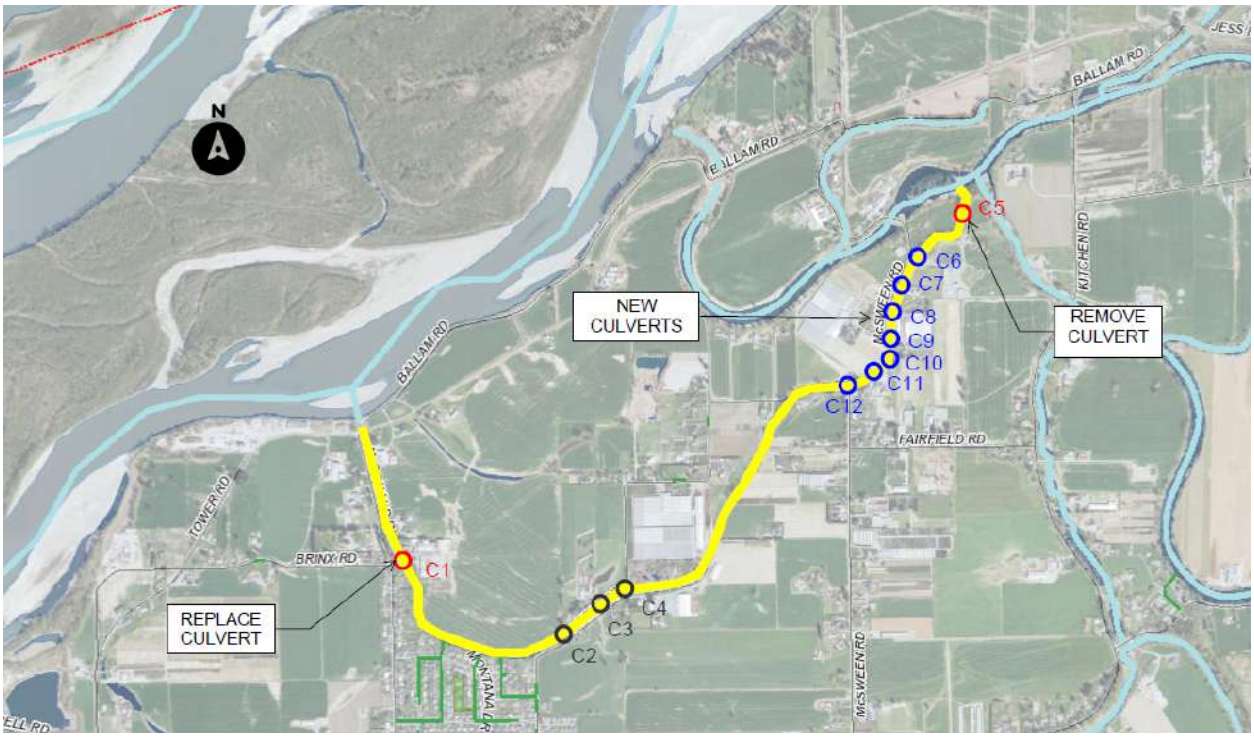

Figure 7.2: Proposed (Including New and Replaced) and Removed Culverts

Table 7.2: Operational Improvements Evaluation Matrix

Culvert #	Type	Size and Material	Length	Crossing Location Description
C1	Replace	900mm HDPE	16m	Brinx Road and Property Parcel #10824
C5*	Remove	N/A	10m	Between Property Parcel #11310 and #11288
C6**	New	900mm HDPE	30m	McSween Road and Property Parcel #11288
C7	New	525mm HDPE	32m	McSween Road and Property Parcel #11244
C8	New	900mm HDPE	26m	McSween Road and Property Parcel #11160 (Northern Entrance)
C9	New	900mm HDPE	17m	McSween Road and Property Parcel #11160 (South Entrance)
C10	New	900mm HDPE	21m	McSween Road and Property Parcel #11154
C11	New	900mm HDPE	21m	McSween Road and Property Parcel #11088
C12	New	900mm HDPE	19m	Bell Road and McSween Road
*Would require removal of existing culvert, earthen berm and channel regrading to facilitate positive drainage.				
**Would require regrading of watercourse downstream of culvert for ~80m to facilitate positive drainage.				

During winter seasons (November-March), Stantec recommends Option 3C in leaving the existing floodbox culvert gate open and subsequently allowing backflow of fresh water from the Fraser River to be introduced into the Bell Slough. This recommendation would eliminate the need to pump water from the Bell Slough into the Fraser River during this period. As these operations would be implemented during non-Freshet seasons, the risk of flooding at the downstream segment of the Bell Slough is lower.

The City needs to be cautious in implementing the recommended new operational levels as it adds a level of uncertainty on the chances of flooding in comparison to the current operation levels. After the change to the start level operations have been made, especially at the downstream portion of the Bell Slough, water levels and the surrounding areas should be carefully monitored for any signs of flooding, at least for the first year to determine the suitability. If there are occurrences of any flooding, then the proposed pump operations should be investigated.

7.1.1 Class C Cost Estimate

As defined by the Professional Engineers and Geoscientists of British Columba (EGBC), a "Class C cost estimate (±25-40%): An estimate prepared with limited site information and based on probable conditions affecting the project. It represents the summation of all identifiable project elemental costs and is used for program planning, to establish a more specific definition of client needs and to obtain preliminary project approval."[39] As the improvement options for the physical operational improvements and ecological and habitat improvement do not have a capital cost/are not tangible to estimate, a Class C estimate has only been developed for the hydraulic infrastructure improvement options. The detailed estimates can be found in **Appendix F**. A summary of the estimate is provided in the following **Table 7.3.**

Table 7.3: Hydraulic Infrastructure Improvement Options Class C Cost Estimate

Description	Cost
C1 - Replace Culvert at Brinx Road and Property Parcel #10824	
General Requirements	$83,000
Earthworks	$52,800
Road and Site Improvements	$22,000
Utilities	$92,800
Contingency (30% of Construction Subtotal)	$75,180
Engineering and Approval Fees (10% of Construction Subtotal)	$25,060
TOTAL	**$350,840**
C5 - Remove Culvert Between Property Parcel #11310 and #11288	
General Requirements	$87,500
Earthworks	$75,000
Utilities	$40,000
Contingency (30% of Construction Subtotal)	$60,750
Engineering and Approval Fees (10% of Construction Subtotal)	$20,250
TOTAL	**$283,500**
C6-C11 Install New Culverts at Private Driveway Crossings	
General Requirements	$145,000
Earthworks	$407,800
Road and Site Improvements	$83,220
Utilities	$632,500
Contingency (30% of Construction Subtotal)	$380,556

[39] EGBC Budget Guidelines for Consulting Engineering Services (egbc.ca)

Engineering and Approval Fees (10% of Construction Subtotal)	$126,852
TOTAL	**$1,775,928**
C12 - Install New Culvert at Bell Road and McSween Road	
General Requirements	$92,500
Earthworks	$110,700
Road and Site Improvements	$24,200
Utilities	$110,200
Contingency (30% of Construction Subtotal)	$101,280
Engineering and Approval Fees (10% of Construction Subtotal)	$33,760
TOTAL	**$472,640**
GRAND TOTAL	**$2,410,391**

7.2 Ecological and Environmental Recommendations

To return the Bell Slough to its original conditions, efforts will need to be made not only in the context of hydraulic connectivity, but also in context of ecological and environmental improvements. As discussed previously in **Section 2.4.1,** environmental sampling results have indicated that Bell Slough has poor water quality indicative of eutrophication. Ecosystems within the slough are sensitive to the effects of stormwater and agricultural runoff entering the system, as these are generally rich in phosphorous, organic and non-organic nitrogen and other nutrients. This overload in nutrients could be facilitating the growth of algae in the slough, reducing the oxygen levels, causing eutrophication, and ultimately affecting the quality of aquatic habitat in Bell Slough. The following recommendations that the City can consider improving water quality and aquatic habitat within the slough are described from highest to lowest priority:

1. Public education on relevant legislation and bylaws as described in **Section 4.0** and identify the source location of contaminations in the Bell Slough to find the instances of suspected pollution. Sources of contamination may require assessing manure storage or conducting septic system inspections.
2. Develop a comprehensive seasonal water quality and flow monitoring program to track long-term trends across the wetted portion of the slough. Stantec recommends this program to be initiated as soon as possible to maximize the amount of baseline data collected available to support the City in identifying point-source contamination in the watercourse, confirm the effectiveness of improvement efforts, and aid in detailed design of hydraulic infrastructure improvements. The in-situ water quality parameters that were sampled in this study (refer to **Section 2.4.1.1**) can be used as the sampling basis for the future program.
3. Develop a rehabilitation and protection plan for the Bell Slough.
4. Residential landowners should limit use of fertilizers within 30m of the Slough and not store compost next to the slough.
5. Farmers should be encouraged to engage with stewardship organizations to reduce environmental impacts. For example, funding may be available through Investment Agriculture Foundation's Environmental Farm Plan program and Beneficial Management Practices program, which is a complementary, on-farm, cost-sharing incentive program to assist farm and ranch operations to mitigate environmental risks.
6. Install physical barriers to prevent livestock from grazing in the riparian zones.
7. Install plantings along the slough and manual removal of decayed vegetation.

7.2.1 Class C Cost Estimate

A Class C cost estimate has been provided for an annual water quality program, annual flow monitoring program and developing a rehabilitation and protection plan. The detailed estimates can be found in **Appendix F**. A summary of the estimate is provided in the following **Table 7.4.**

Table 7.4: Environmental Improvement Options Class C Cost Estimate

Description	Cost
Annual Water Quality Monitoring Program	$18,718
Annual Flow Monitoring Program	$23,800
Bell Slough Rehabilitation and Protection Plan	$25,029

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Appendix A
Photographic Log

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Photographic Log

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 1

Photo Location:
Upstream extent of the Bell Slough

Direction:
Facing upstream

Survey Date:
9/22/2022

Comments:
No connectivity observed between the Bell Slough and Camp-Nelson Slough.

Photograph ID: 2

Photo Location:
Upstream extent of the Bell Slough

Direction:
Facing downstream

Survey Date:
9/22/2022

Comments:
Dense vegetation growing in and around the channel. Himalayan blackberry present.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 3 **Photo Location:** Upstream extent of the Bell Slough **Direction:** Facing downstream **Survey Date:** 9/22/2022 **Comments:** Existing Damaged and Non-Functioning 600mm Wooden Culvert	
Photograph ID: 4 **Photo Location:** Camp-Nelson Slough upstream of the McSween Road culvert **Direction:** Facing upstream **Survey Date:** 9/14/2022 **Comments:** Riparian vegetation includes a mix of water tolerant species and canoping forming large trees.	

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 5

Photo Location:
Camp-Nelson Slough upstream of the McSween Road culvert

Direction:
Facing upstream

Survey Date:
9/14/2022

Comments:
Cattails and rushes surround the fringe of the slough.

Photograph ID: 6

Photo Location:
Camp-Nelson Slough downstream of the McSween Road culvert

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Open water with patches of lilies. Tall trees present for crown closure.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 7 **Photo Location:** Camp-Nelson Slough downstream of the McSween Road culvert **Direction:** Facing down **Survey Date:** 9/14/2022 **Comments:** Dead juvenile carp (exotic species) found at outflow of culvert.	
Photograph ID: 8 **Photo Location:** Midstream Bell Slough at McSween Road **Direction:** Facing upstream **Survey Date:** 9/14/2022 **Comments:** Dry with large woody debris and crown closure.	

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 9

Photo Location:
Midstream Bell Slough at McSween Road

Direction:
Facing cross-stream

Survey Date:
9/14/2022

Comments:
High crown closure with Himalayan blackberry and reed canary grass.

Photograph ID: 10

Photo Location:
Midstream Bell Slough at McSween Road

Direction:
Facing upstream

Survey Date:
9/14/2022

Comments:
Channel restoration efforts underway with ground water filling channel. Private driveway is without a culvert.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 11

Photo Location:
MidStream Bell Slough at McSween Road

Direction:
Facing cross-stream

Survey Date:
9/22/2022

Comments:
Private driveway is without a culvert.

Photograph ID: 12

Photo Location:
Midstream Bell Slough at McSween Road

Direction:
Facing cross-stream

Survey Date:
9/22/2022

Comments:
Private driveway is without culvert.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 13

Photo Location:
Midstream Bell Slough between McSween Road and Bell Road crossing

Direction:
Facing downstream from aerial perspective

Survey Date:
9/7/2022

Comments:
Dry channel bed with tall canopy coverage in riparian habitat.

Photograph ID: 14

Photo Location:
Midstream Bell slough upstream of Bell Road crossing

Direction:
Facing upstream from Bell Road access

Survey Date:
9/14/2022

Comments:
Cattails present in wetland area and tall trees in riparian habitat.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 15 **Photo Location:** Midstream Bell Slough at Bell Road crossing **Direction:** Facing downstream from Bell Road **Survey Date:** 9/7/2022 **Comments:** Himalayan blackberry bushes and large trees line the banks of the slough. Smartweed mats float on slough surface.	
Photograph ID: 16 **Photo Location:** Midstream Bell Slough at Bell Road **Direction:** Facing cross-stream **Survey Date:** 9/7/2022 **Comments:** Culverted driveway across slough. Dense riparian vegetation with crown closure on right bank. Himalayan blackberry on road side bank.	

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 17

Photo Location:
Midstream Bell Slough at Bell Road

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Smart weed patches with some open water.

Photograph ID: 18

Photo Location:
Midstream Bell Slough behind residences of Montana Drive

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Dense aquatic vegetation mats, floating grass stands, and Himalayan blackberry along right bank. Large trees seen along left bank downstream from photo.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 19

Photo Location:
Midstream Bell Slough behind residences of McDonald Road

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Dense aquatic vegetation mats, floating grass stands and Himalyan blackberry lining right bank. Native riparian vegetation and shade producing trees on left bank.

Photograph ID: 20

Photo Location:
Midstream Bell Slough driveway from McDonald Road

Direction:
Facing down/cross-stream to left bank

Survey Date:
9/7/2022

Comments:
Goats fenced into riparian habitat surrounding slough.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

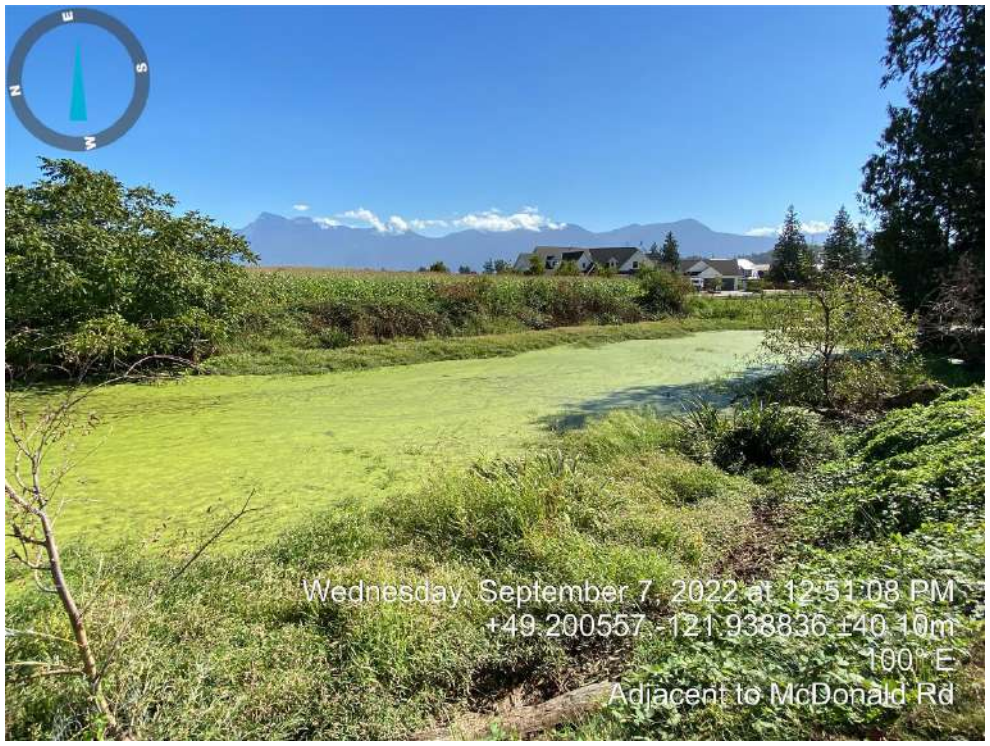
Photograph ID: 21

Photo Location:
Midstream Bell Slough at McDonald Road

Direction:
Facing up/cross-stream towards right bank

Survey Date:
9/7/2022

Comments:
Dense aquatic vegetation mat across slough surface.



Photograph ID: 22

Photo Location:
Downstream Bell Slough at Ballam Road crossing

Direction:
Facing upstream

Survey Date:
9/7/2022

Comments:
Green algal mats across water surface. Reed canary grass on both banks. Efforts on right (facing downstream) bank to plant native vegetation.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 23

Photo Location:
Downstream Bell Slough at Ballam Road crossing

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Duck weed dominates the water surface. Himalayan blackberry and reed canary grass surround the culvert headwalls.

Photograph ID: 24

Photo Location:
Downstream Bell Slough at Ballam Road crossing

Direction:
Facing down

Survey Date:
9/14/2022

Comments:
Water level sensor in well.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 25

Photo Location:
Downstream Bell Slough at Ballam Road crossing

Direction:
Facing downstream

Survey Date:
9/14/2022

Comments:
Overflow pumpout pipe used under flooding scenarios in slough.

Photograph ID: 26

Photo Location:
Downstream Bell Slough at Fraser River

Direction:
Facing instream

Survey Date:
9/14/2022

Comments:
Green frog (invasive) in shallows surrounded by duck weed.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 27

Photo Location:
Downstream Bell Slough at Fraser River

Direction:
Facing cross-stream

Survey Date:
9/14/2022

Comments:
Dead Japanese knotweed stem post herbacide treatment.

Photograph ID: 28

Photo Location:
Downstream Bell Slough at Fraser River

Direction:
Facing upstream

Survey Date:
9/14/2022

Comments:
Basin of flood culvert with garbage present on shoreline.

Client:	**City of Chilliwack**	**Project:**	**Bell Slough Feasibility Study**
Site Name:	**Bell Slough**	**Site Location:**	**Chilliwack, British Columbia**

Photograph ID: 29

Photo Location:
Fraser River at Bell Slough interface

Direction:
Facing cross-stream

Survey Date:
9/14/2022

Comments:
Sockeye salmon anglers present during September visit. Fire pit present at pull out on side of Ballam Road.

Appendix B

Chilliwack Bell Slough Study

Open House Background Resources

Do you recall a period (year) in which there was suddenly significant signs and degradation to the Bell Slough? If yes please describe and provide as much information if you can.	Have you ever experienced flooding (overland or basement) at your property from the Bell Slough? Please provide the location and a description of the event, extents, impacts, and months / years if possible.	Have you ever experienced the Bell Slough being completely dry? Please provide the location, extent, and month/years if possible. If it does not, do you remember the month and years and low water levels?	Have you ever experienced the Camp/Nelson Slough being completely dry? Please provide the location, extent, and month/years if possible. If it does not, do you remember the month and years and low water levels?	Have you observed any aquatic species or fish activity in the slough and can you list the species that you have seen?	Please select all the issues and concerns that apply to you, regarding the condition of the Bell Slough: - Overgrowth of invasive weeds - Inability to transverse the slough via boat due to low/no flows - Decline of fish - Algae bloom - Lack of buffer zon	Reports from 1989 describe water level fluctuations throughout the day due to water withdrawal from greenhouses, cooling systems and other users. Do you have information on users who may have a water withdrawal permits for the slough?	What possible solutions or ideas would you suggest to help improve the ecological condition of the Bell Slough?
3 years all of a sudden there was overgrowth and infestation of weeds. 2019.	No basement flood at this area, in the ground far away, never experiences any overland or basement flood. Across the road was flooded. From this property it's on the east side that had considerable flooding - this is a farm area.	Never complete dry. August and September the water levels are usually very low.	Unknown.	Carp.	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Decline of fish;Algae bloom;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;	Unknown	Water coming in from the Fraser coming in.
No i just moved in in January of 2022	No	Yes jan to may this year and again September	No	Frogs only	Overgrowth of invasive weeds;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;	No	Connect it from end to end
Gradually gotten worse as the years progressed. The worst is this year - last year the water was so low, the grass couldn't grow. But this year it's been the worst.	Bell Road and along the slough, first driveway on the left. Recently added a culvert. Back in 1948 the basement had flooded at the property close to Bell Road. Last november there was flooding from the rain.	Never completely dry. The lower reaches it has been low water. Upper reach did get completely dry.	Before they dredged it - the Camp/Nelson slough used to get dry. McSween west of the bridge always dried. East side always had flows.			Back then there were areas using irrigation - this did not last too long. Back then the greenhouse gases said that they used their own water. They don't think there is anyone using or drawing the water now.	
2020					Overgrowth of invasive weeds;Algae bloom;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;Decline of fish;Inability to transverse the slough via boat due to low/no flows;		Open blocked or restricted water flow from culverts and crossings. Remove excess vegetation and all invasive plants that create water flow restrictions Plant more native shrubs and trees to control erosion and create natural habitat and more uptake of nutrients Monitor runoff from surrounding land into the slough that increase nutrient levels in the water. Develop a method to restrict and control nutrients leaching into the slough. Create better access to the slough from the Fraser River. I believe that this would help create better water flow and increased oxygen levels in the slough. It would in turn create more spawning area for the Fraser River salmon
The deterioration has been gradual.	No, but the water level did get quite high last fall.	No	No	I have seen Blue Herons catch fish, but I can't definitively say which species. They look like some type of bottom dwelling cat fish or such. I've heard and seen Green Frogs and Bullfrogs which are invasive, but in years past we did have many Pacific Tree Frogs which have diminished recently.	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Decline of fish;Algae bloom;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;	No	Ideally, connection to the Fraser River would increase flow which should allow oxygenated water to enter the slough to improve water quality, although this may not be possible. Connectivity with the Nelson Slough may allow water to flow through the slough at freshet by opening the floodgates at the opposite end of the slough to regenerate and flush the old stagnant water out. Also, planting more native shrubs and trees to shade the water.
We have lived here since 2012. Within a couple years of living here we started having an algae bloom that would last the whole summer. But I would say in the last 5-6 years, the slough has rapidly deteriorate. The last 2 years the weed and lilly pads have grown from bank to bank in sections on each side of our property. Making water circulation nearly impossible at the surface. This year we have a small patch of open water behind our property.	No flooding in our home. During the storms of Nov/Dec 2021 we had a portion of our back yard sluff out in to the slough.	Summer of 2020, 2021 the water was the lowest we had seen since 2012. Probably only 2-3' deep. Summer of 2012 we measured the water to be about 5-6' deep behind our property. The level seemed to be consistent year after year until recent years.	N/A to our property so I'm not sure.	Frogs, tadpoles, fish (catfish, yellow perch (i think), stickleback) muskrats, beavers, otters	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Decline of fish;Algae bloom;	No	I would like to see the weed mechanical removed, improve water quality and flow.
5-10 years	No flooding in home.	Not completely dry. In the late 90's water was really low. Cows could stand in the slough to their belly's.	Few years ago it stopped running only water pooling.	Catfish, carp, stickle back, frogs	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Decline of fish;Algae bloom;	Not aware of anyone with withdrawal permits.	Clean out the weeds, open driveways (put in culverts) up to Nelson Slough.
I believe there were changes made to the flood box at Ballam and the new sensor installed, maybe around 2012. We have had trouble maintaining enough water in the slough year round since then (except for this summer where for some reason, it remained high). The change in farm owner, and the building of the new barn and manure pit so close to the slough have also had a big impact. Prior to this there was a small size operation of maybe 80 cows for decades.	No. Not in this house and not in my childhood house two doors down. Both do not have in ground basements.	Not completely dry, but last summer was the lowest I've ever seen it. At least 3 ft lower than this summer. Last year 2021 it remained low for May, June, July. I can send photos if you like. This process began last year because of the low water.	No	Invasive fish species, including at one time carp. In 2004, when we wanted to build a shop on our property, we had to have DFO come out as part of obtaining a building permit. We were told at that time by DFO that there were Salmon in the slough. I wasn't convinced. At one time we had an abundance of chorus frogs (terrestrial mostly), but those remain only in specific landlocked portions of the slough. Now mostly green frogs and bull frogs (semi aquatic). Recent discovery of a western painted turtle.	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Decline of fish;Algae bloom;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;Putrid water, no flow, reduction of animals living on the slough, including otters.;	No. Wish I did.	Opening the slough from Nelson, including putting culverts in where there isn't any (beginning with the lack of a city culvert at McSween), and allowing there to be flow through to the Fraser when conditions are safe to do so. Examine/inspect all current culverts to ensure they are not blocked. Requesting implementation of safe practices for all landowners living on the slough. Ie. Manure, pesticides etc. Continuing to restore the riparian zone along Bell Slough, including recommendations to home owners and restoration on public land. As a stop gap measure, ensuring that new practices are in place as to when the flood box at the Fraser is opened or closed so that higher water levels are maintained in Bell Slough. This includes making new pumping threshold procedures. Monitor water quality now during the study and in the future, and make suggestions as to how to improve this.
2017- summer. The farm at 10824 McDonald Rd built a massive manure pit that is partially below ground level close to the slough and greatly increased the amount of cows with the addition of 2 large new barns. (the barns were built in 2016 and the manure pit in 2017.) We were concerned with this amount of manure that close to the slough and voiced these concerns to the city of chilliwack to no avail. Prior to the manure pit being operational we did have water samples taken from the slough at our location and another address further east of us by a group called "the streamkeepers" i believe. They said at the time that these samples would be registered with the bc govt for future comparisons. The slough has steadily declined since then.	we have had ground water in our basement from high water tables but none directly overland.	low water levels most summers but not completely dry at our property.	do not recall	there used to be carp but unsure if still there as waters are too murky to see anymore. We have had otter, beaver, muscrat, turtles through the years but for the past few years just the occasional beaver. There used to be more bird life as well.	Overgrowth of invasive weeds;Algae bloom;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;Decline of fish;	I am not sure what water source the farm at 10824 McDonald rd uses at this time but in the past 1990's through early 2000's at least) a previous owner drew water directly from the slough for irrigation of grazing fields for cows. There was a well digging company who did some work at that farm either in 2020 or 2021 so maybe they drilled wells for the current owner's use?	Stop the spreading of manure on the fields all along the slough in our area or at least have a set back where they cant spray it. During high rain events the dirt and animal feces on the fields run directlly into the slough The city of chilliwack allows for less set back for livestock from streams and riparian areas than is established in the bc regulations so my suggestion would be for chilliwack to follow the provincial guidelines. There are goats currently kept and grazing on the grasses in an area on the bank of the slough at the above mentioned farm so they could be relocated to a proper distance from the banks of the slough as they have taken the banks down to dirt from eating all the plant life.

Usually the summer, the slough is over taken by weeds	No	No	No	Yes I was the person that reported the fish die off last summer. We found the brown cat fish and sunfish	Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Algae bloom;Decline of fish;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;	Don't know	The weeds need to be cleared out, they are clogging up the waterway, I am sure it is almost impossible for wildlife and fish to get around. Some sort flow would help.
this year has been the worst , may be because of the heat	no	no	no	{fish}, {painted turtle 's,} {muskrat,} beaver, blue heron, many {spices of ducks} {frogs} Dragon flys, damsel fly ,mosquito, {bats} If you see this around wildlife { }, we do not have any more, we still have wood ducks, mallard duck redwing blackbirds	Decline of fish;Overgrowth of invasive weeds;Inability to transverse the slough via boat due to low/no flows;Algae bloom;less ducks;Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;	no	get the water moving again, install large culverts, {The water will clear upon iff you get moving , Homemade air windmills
The last 10 years approximately. The slough never use to be so stagnant or full of algae, weeds and plants. When I moved here 22 years ago the water was free of all of this overgrowth. The quality of the water, as the variety of water wildlife has been in decline. We use to have river otters, osprey, muscrat and a significant number of carp.	No, not in 22 years of living here.	I remember it being low enough to see old tires and other garbage sitting in the bottom of the slough, but I can't remember the year. 10-15 years ago	Sorry I can't recall.	There is a beaver living under a neighbour's dock a few doors down (West of my house). Heron, ducks, Canadian geese, frogs, and toads.	Lack of buffer zone along the slough from herbicides, pesticides, fertilizer, etc.;Algae bloom;Decline of fish;Overgrowth of invasive weeds;Decline in wildlife and beauty of the slough ;	No	Open up the water way so it can flow freely again. (find solutions for blockages such as driveways) Open the gate closing the slough off from the Fraser during times when flooding is not a threat Dredging it Let home owners who back on to the slough know what we can do (or not do) on our properties to help improve the quality of the slough and encourage the return of wildlife. We need laws to protect the slough
In the last three years I have noticed a proliferation of weeds in the slough	No	No		Pumpkin seed when we were counting fish during installation of culvert	Overgrowth of invasive weeds;Decline of fish;Algae bloom;The farmer to the west of us provides a wide buffer zone. We have a wide buffer zone with 50% native vegetation.;	No	Physical removal of invasives?

Stantec

CITY OF CHILLIWACK

City of Chilliwack
Public Open House
09/22/2022

Bell Slough Study

Agenda

- Introductions
- Project Background
  - History of Bell Slough
  - Bell Slough Flood Box
  - LiDAR and Aerial Imagery
  - Historical Information
- Project Objectives
- Photos from Site Visit
- Environmental Findings
- Water Quality Samplings
- Next Steps
- Comments? Questions?
- Public Questionnaire

Introductions

CITY PROJECT TEAM

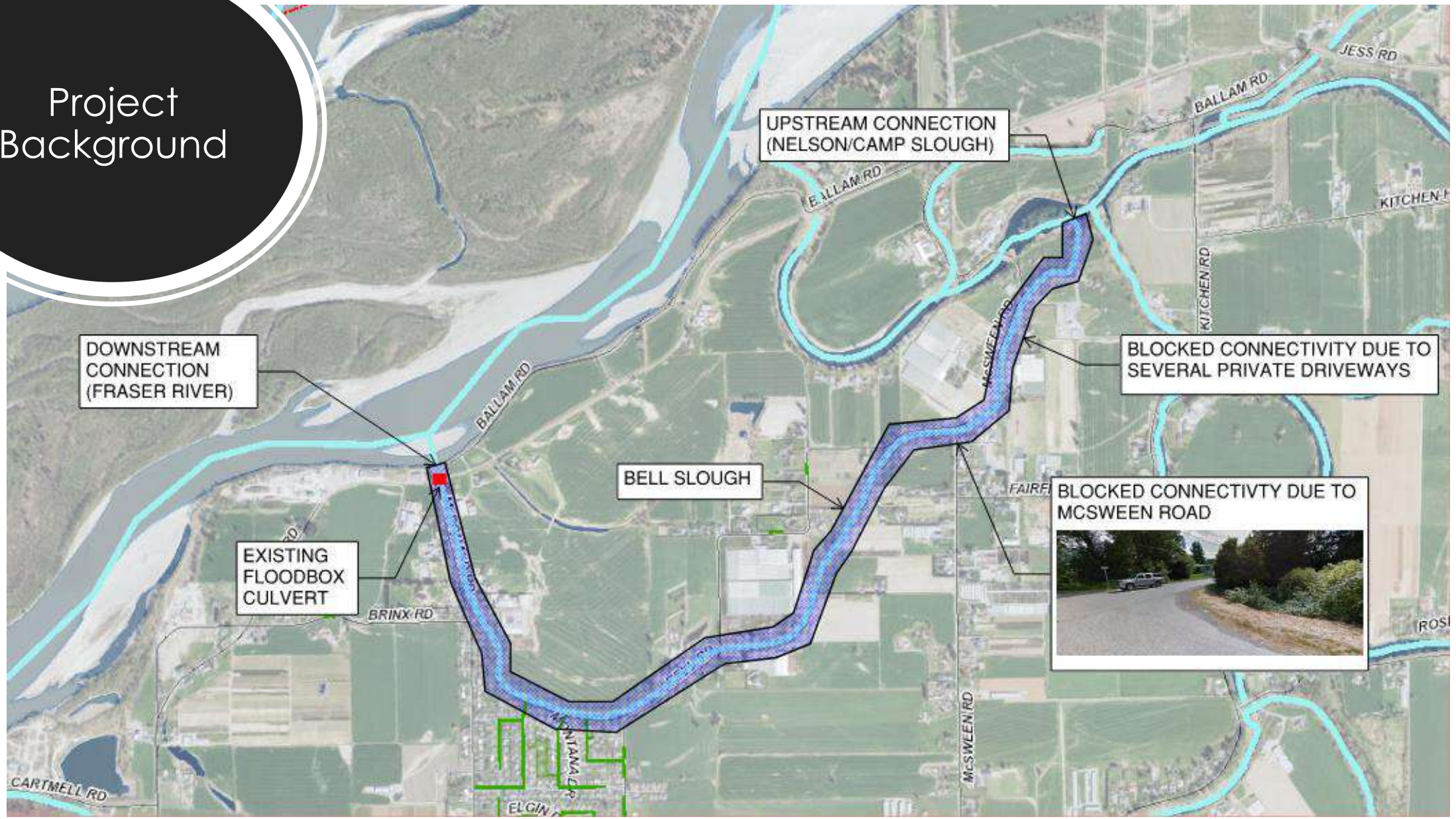
Name	Position
Kristian Biela	Drainage Technician
Tara Friesen	Manager of Environmental Services
Kara Jefford	Deputy Director of Engineering
Steve Clegg	Environmental Services Specialist

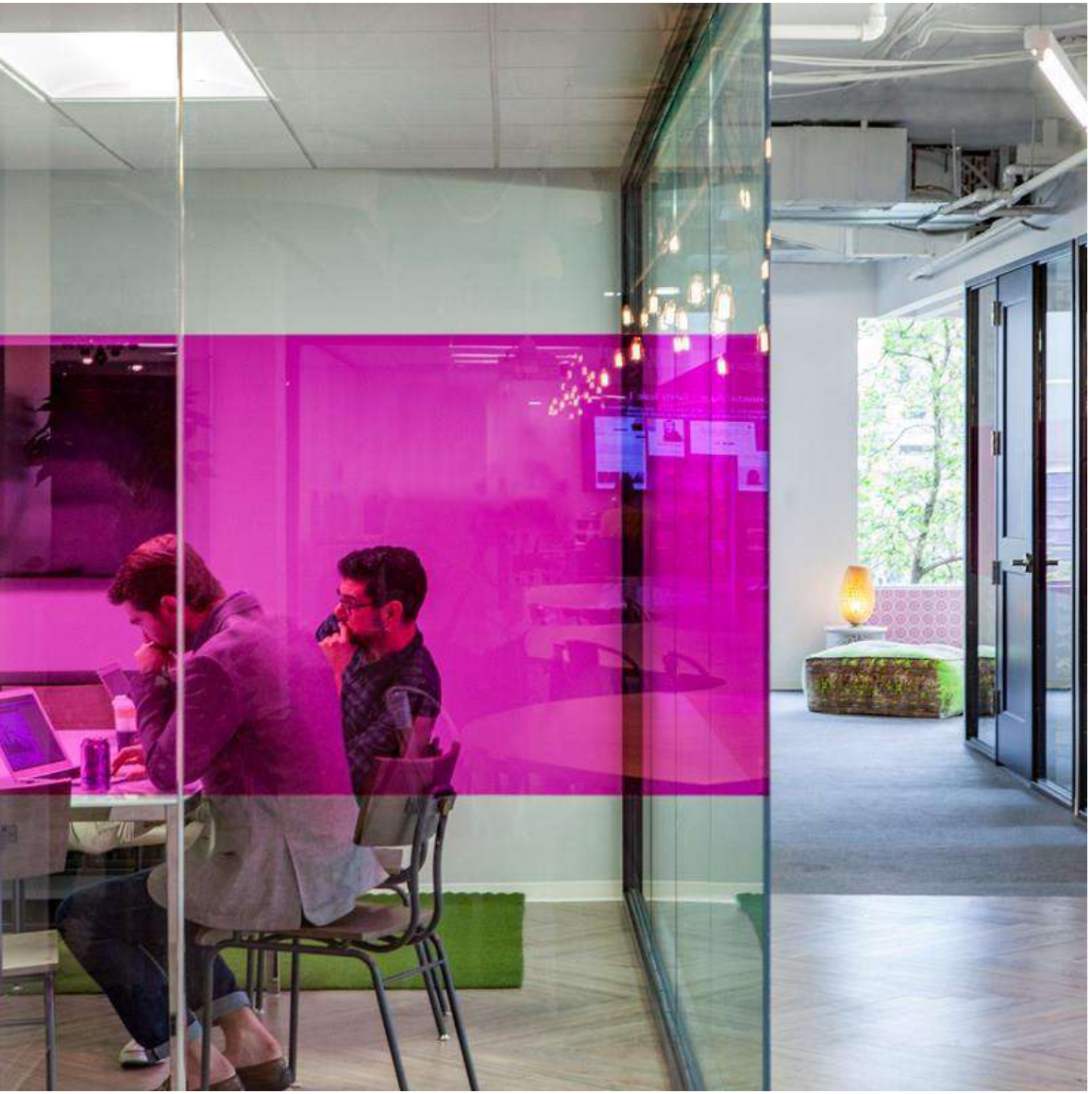
STANTEC PROJECT TEAM

Name	Position
Martine Francis	Project Manager
Lily Pham	Project Coordinator & Project Engineer
Neal Cody	Hydraulics Lead
Tara McBryan	Environmental Lead
Rashedul Islam	Hydraulics Engineer

Bell Slough History

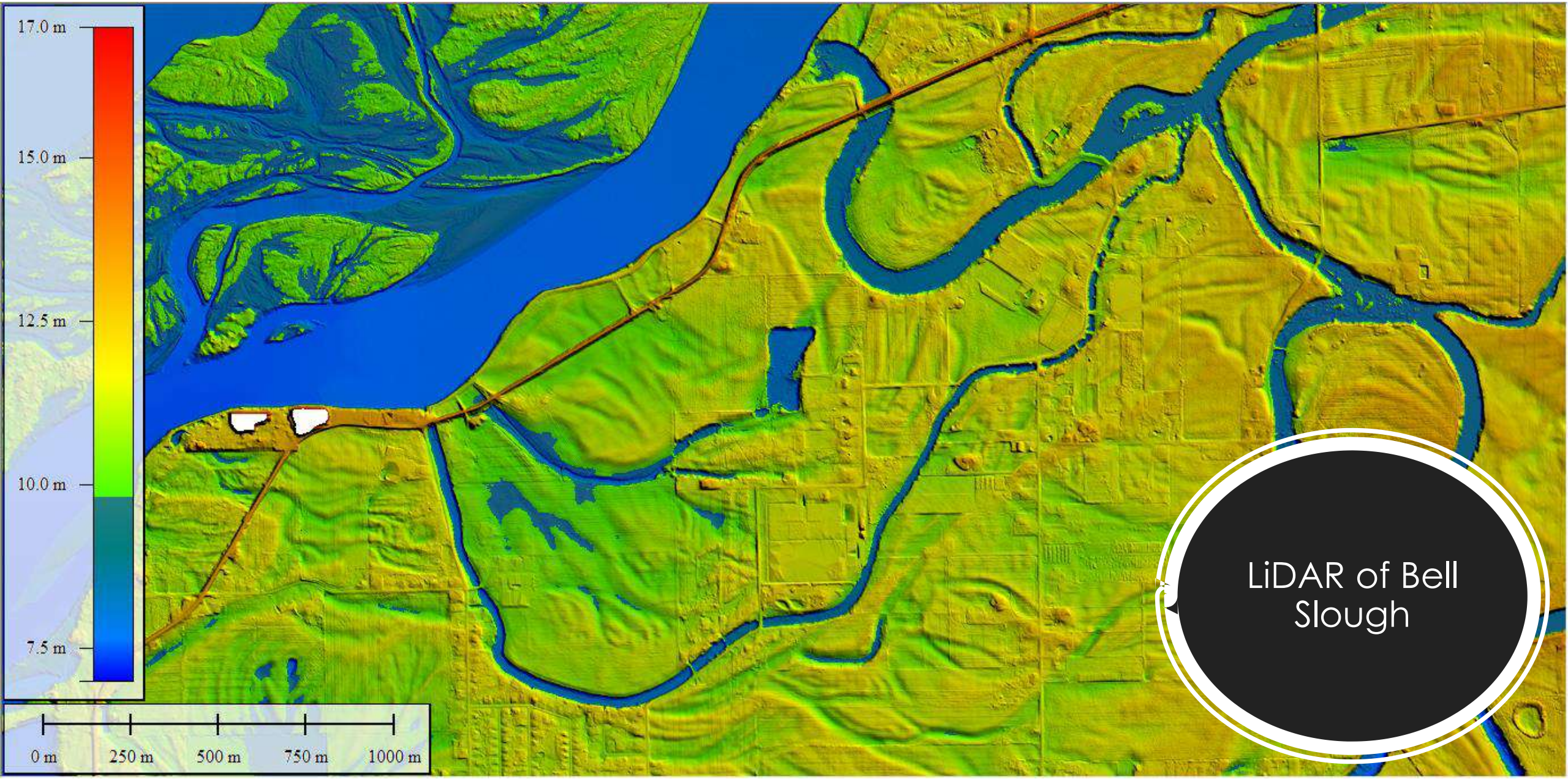
Project Background





Project Objectives

- Environmental site assessment
- Hydraulic model of the Bell Slough
- Public consultation meetings
- Feasibility Study to recommend:
  - Improvements to watercourse connectivity and potential infrastructure
  - Overall improvements to the channel and water quality (habitat enhancement, etc.)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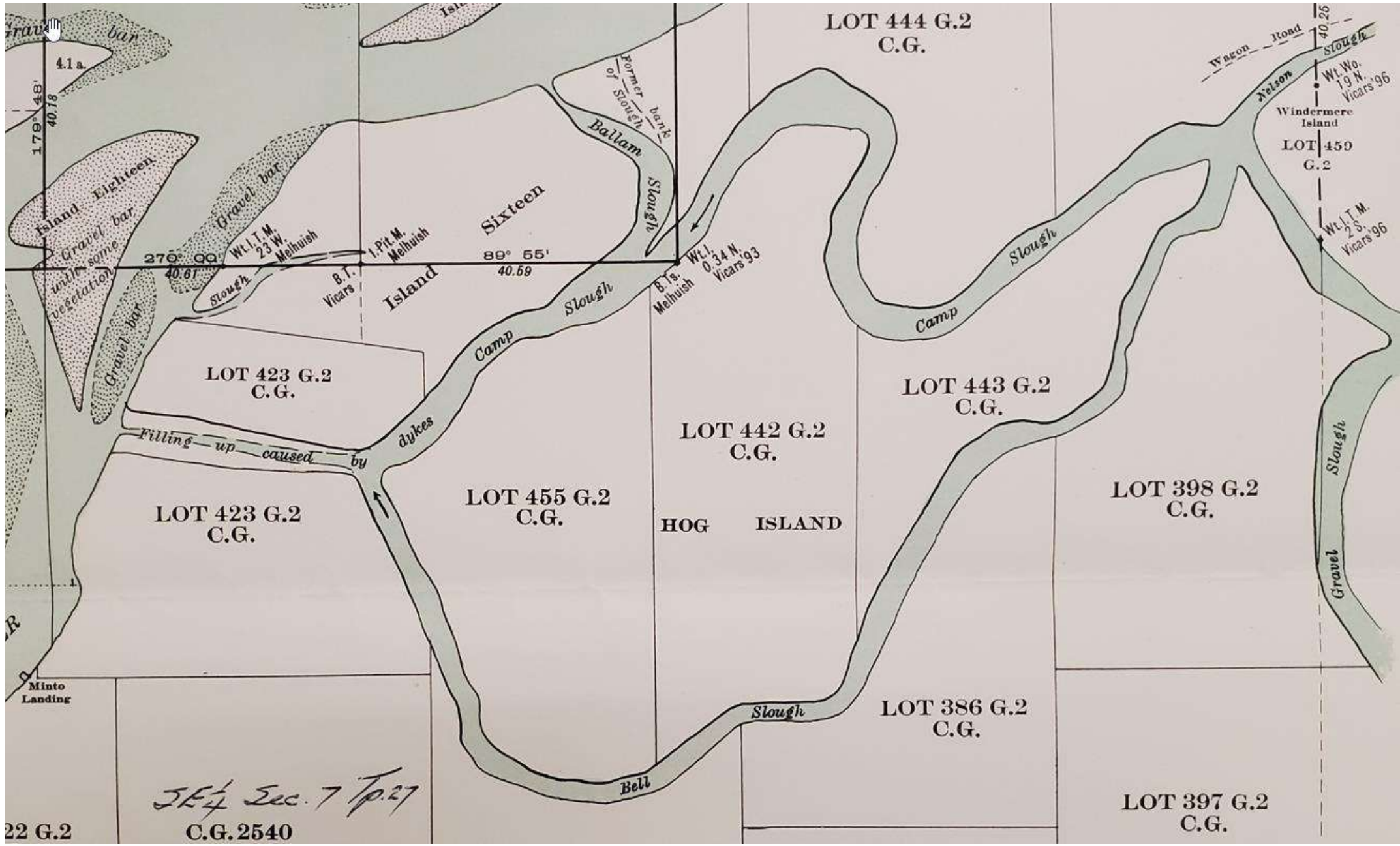
LiDAR of Bell Slough

2021 Aerial Photograph

1985 Aerial Photograph

1954 Aerial Photograph

1918 Map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Windermere
Island
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Vicars '96
Former bank of Slough
Ballam Slough
Island Eighteen
Gravel bar
with some vegetation
Gravel bar
Gravel bar
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270° 00'
40.61
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Melhuish
I. Pit. M.
Melhuish
Island Sixteen
89° 55'
40.59
Slough
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Vicars
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Camp Slough
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Filling up caused by dykes
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LOT 423 G.2
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LOT 455 G.2
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Slough
Gravel
Minto Landing
Slough
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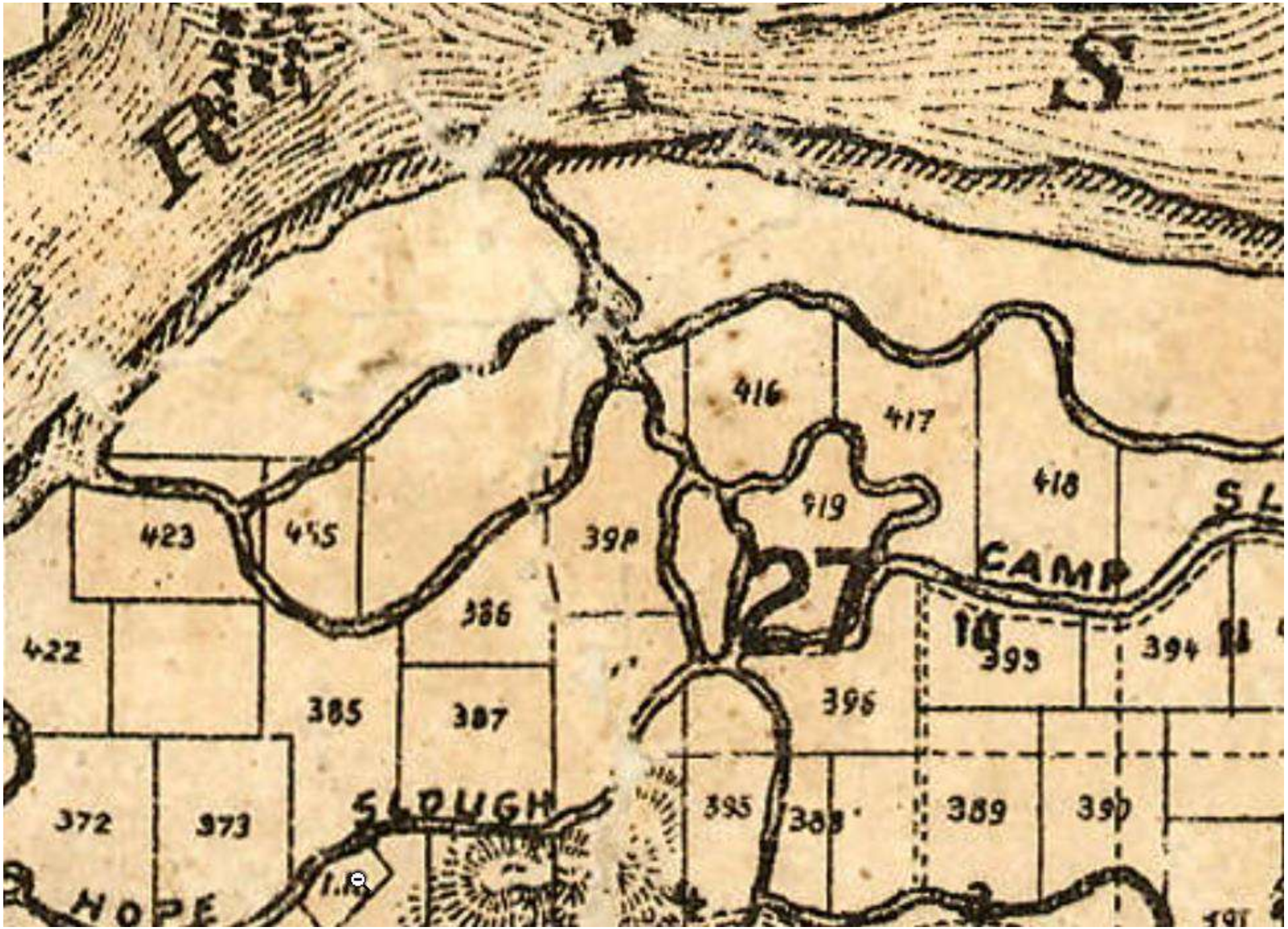
1893 Map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SLOUGH
HOPE
CAMP

10/22/1975

Rotary plans to 'transform' slough

Even at the best of times Bell Slough is a mass of weeds and mud . . . but it has potential.

By this time next year the slough could be a popular fishing spot for youngsters and senior citizens as Chilliwack Rotary Club plans to take the first step in its Hope River and Camp River beautification project.

The initial project involves dredging some 20,000 yards of material out of Bell Slough and creating a new bank and parking facilities. Hope River Development committee chairman Bernie Proft said the finished product will be a 150 foot by 700 foot fishing pond with a year-round minimum depth of six to eight feet.

Bell Slough is a natural area for Black Crappie, a small sport fish with no size catch or season limitations. This sunfish already inhabits Bell Slough but each fall as the water level drops most of the fish die. The dredging project would provide a series of clear ponds enabling greater numbers of the fish to survive during the winter.

Mr. Proft said work on the project could begin in January providing the committee's applications for government grants are well received. The committee has applied to the Public Conservation and Assistance Fund to offset the project costs and to the Local Initiatives Program for laborers. If approved the LIP grant would provide wages for 10 workers from January to March.

The club should be notified sometime this month if the grants have been approved. Mr. Proft indicated the club applied for grants so the project can move ahead with little or no cost to the municipality. Extra funds may be obtained by selling the surplus gravel and fill from the Bell Slough project.

The Rotary Club had originally intended to work only with the Hope River system. The committee began looking at Camp River as well, and realized the total project should take in both systems. In order to have an effective overall project it will be necessary to introduce Fraser River water into the system. Camp River is closer to the Fraser and is not densely populated.

The major project will involve cleaning out the systems from the mouth of Hope River to Jesperson Pool where the two rivers meet. The work will then continue to the upper end of Camp River.

Mr. Proft said he is optimistic the club's applications for grants will be well received. Both Chilliwack city and township councils have indicated their support for the Bell Slough project. The work now hinges on government approval for the funds. If the applications are approved the full plans, including graphics, for the project should be complete by early November.

Intent of the Bell Slough development is to let the public see that progress is being made on improvements to the Hope and Camp Rivers. If this phase of the total project is successful the club is hoping to gain support for continuation of the work.

Bell Slough is just a mess of weeds right now, said Mr. Proft, but it could be a natural fishing area for children and senior citizens.

B.C. housing official speaks here tonight

Ray Skelly, Vancouver regional manager with the provincial department of housing, will be the guest speaker tonight (Wednesday) at the annual meeting of the Upper Fraser Valley Mobile Home and Tenant Association.

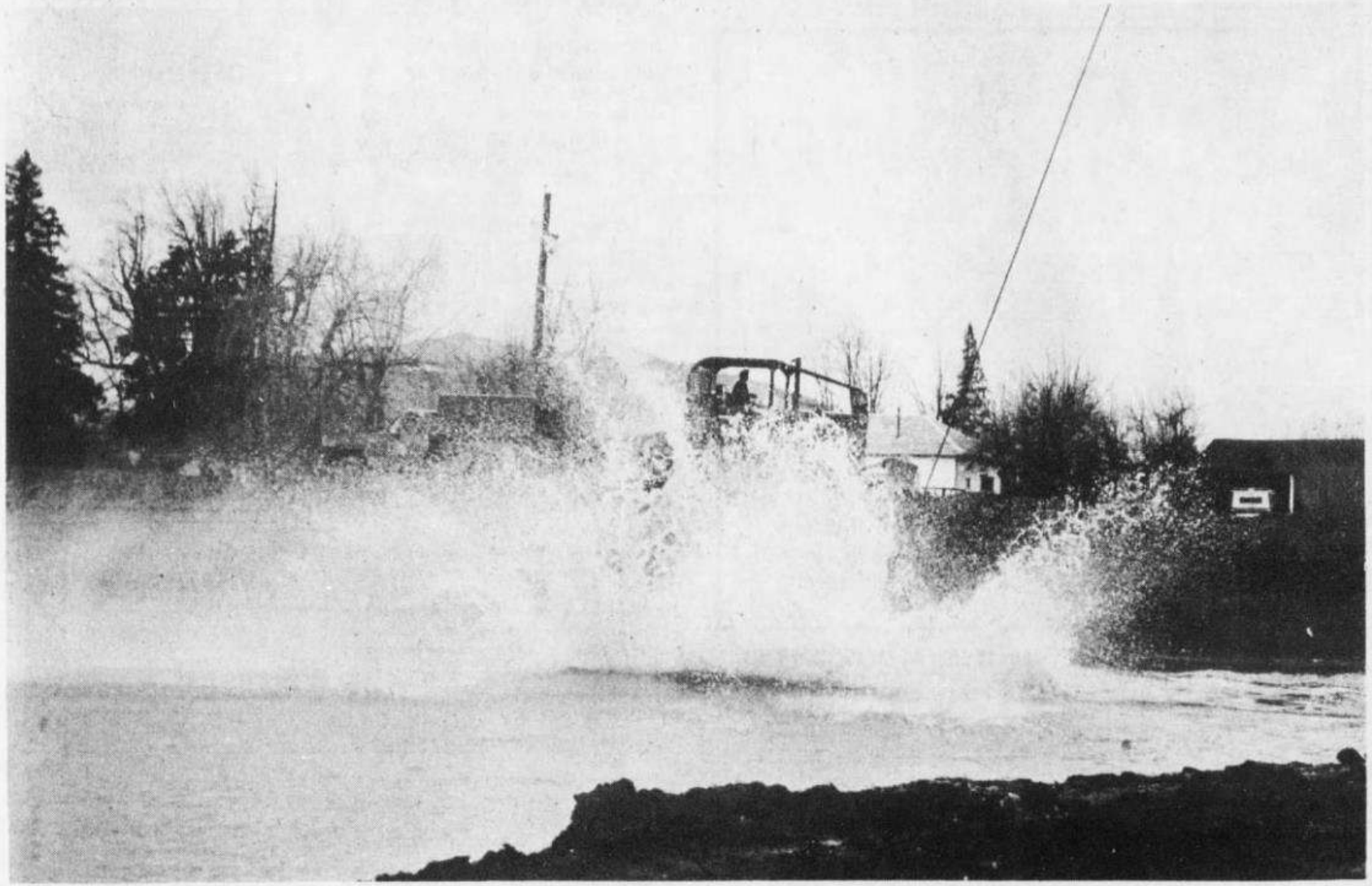
The meeting has been planned for 8 p.m. at Evergreen Hall. Election of officers for the ensuing term will also be on tonight's agenda. An association spokesman said the meeting is open to the public.

About 150 members are registered with the association. While most members are mobile home owners the spokesman stressed apartment dwellers are welcome to join.

Main purpose of the organization is to ensure both landlords and renters adhere to the provincial government's Landlord and Tenant Act.

02/25/1976

Pre-fishing splash



THE DRAG LINE — Canadian Forces Base Chilliwack has supplied the drag line and operators for the Rotary Club's Bell Slough project. Work is well under way now and officials are hopeful that the major part of the work will be finished this spring.

07/28/1976

Bell Slough — after and before

BEFORE AND AFTER? — Chilliwack Rotary Club's Bell Slough project is transforming a section of the waterway into a new park and fishing spot. Dredging is complete and the bank work is scheduled to begin soon. Top photo shows part of the recently cleared section. In the bottom photo is the section of the slough immediately across the road from the new park area, giving some indication of the progress made on the slough during the past few months. This site is being considered as the next step in the Rotary project.

06/22/1977

Heavy equipment section of Base Transport shown near completion of the Bell Slough project on Fairfield Island. In this project approximately 20,000 cubic yards of material were moved to make way for a senior citizens park.

12/19/1990

Flooding solutions vetted for Bell dike

Bell Slough dike improvements will be included in the 1991 district budget to ease flooding concerns of area residents.

Mayor John Les suggested a more certain — and more expensive — solution to drain the slough, but resident Gerard Janmaat said a simple outlet through the dike would keep the water flowing year round.

District engineer Keith Paisley recommended building a $45,000 floodbox through the dike to deal with major storm events outside periods of high water on the Fraser River.

He also recommended that as funding comes available, culverts be installed to drain Bell Slough to Nelson Slough when the Fraser River water levels are high.

Estimated cost of the culverts is $81,500.

Paisley's recommendations followed Janmaat's complaint to council last week that subdivisions and greenhouses approved by council had added to the amount of water draining into the slough, flooding area basements and threatening soil quality with continued flooding.

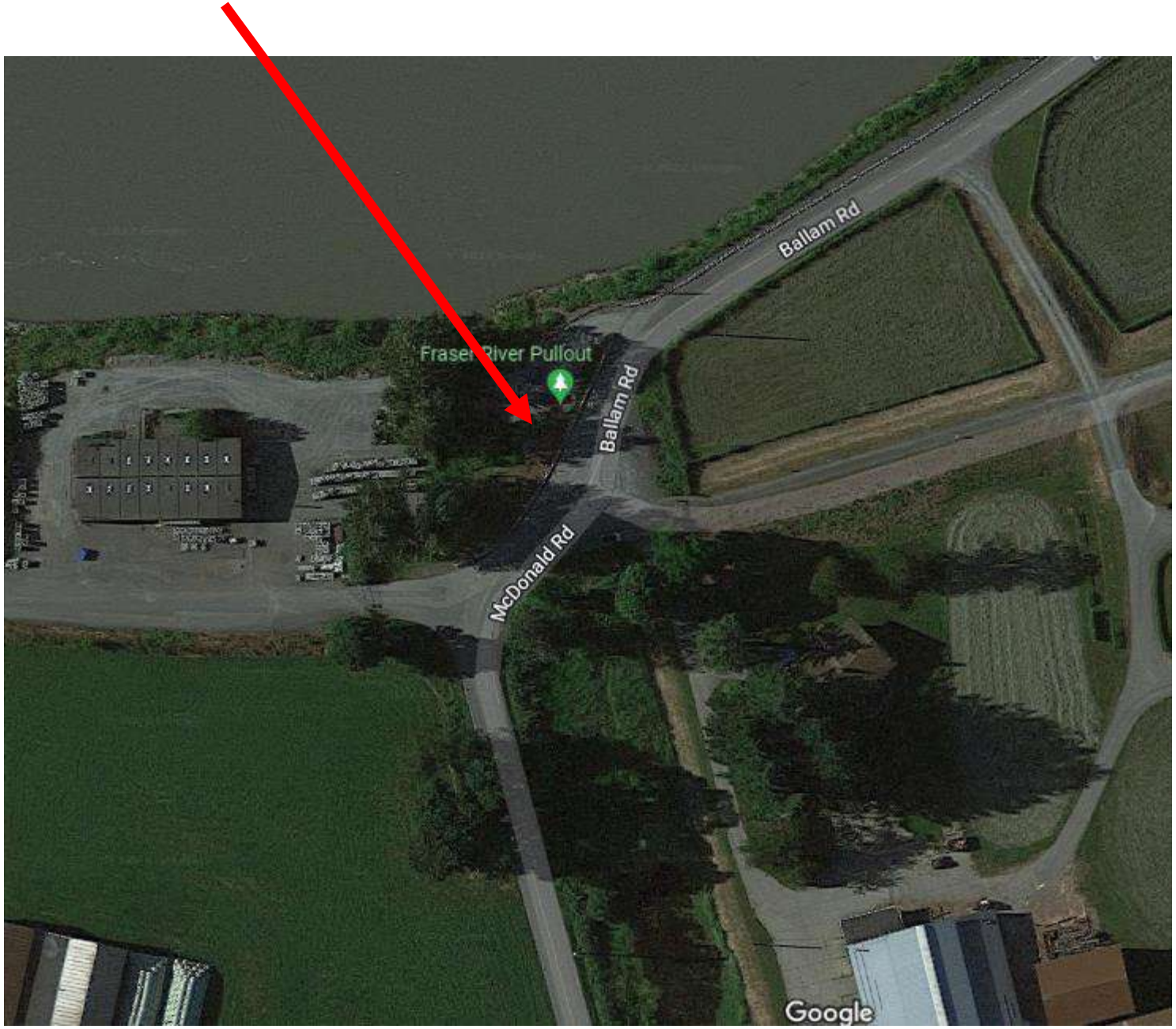
Paisley said the problem at the slough is the lack of a natural outlet to the Fraser River.

When the river is high, the only way for water to drain is "backward" toward the Nelson Slough.

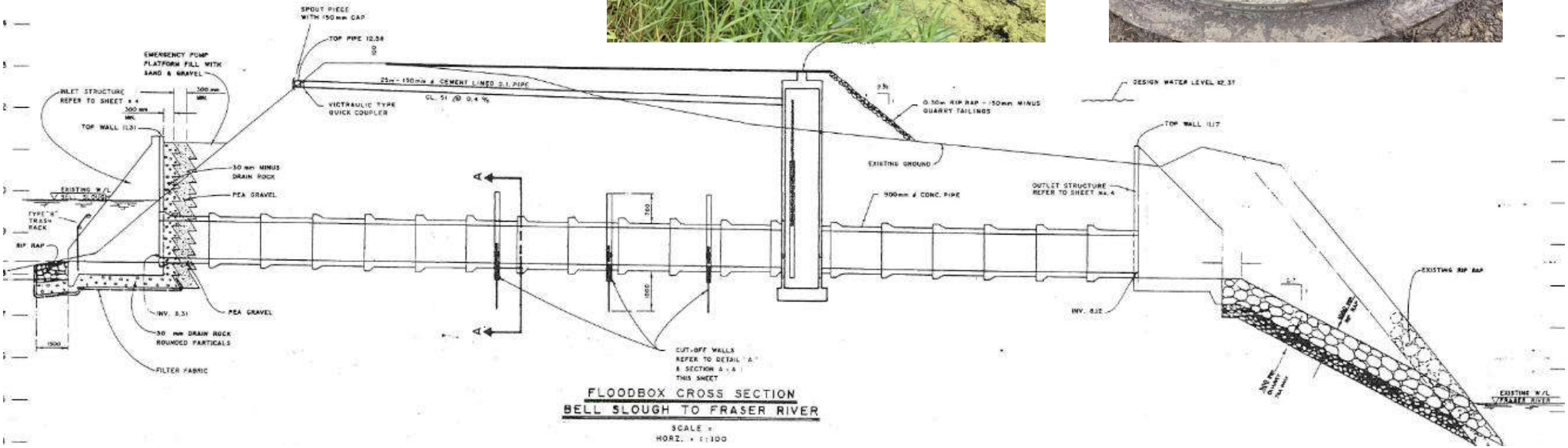
When both the river level and the Nelson Slough water level is high, the only way to drain water would be by pumping. Paisley suggested such a scenario would happen only rarely.

Les noted that spending more on the culvert solution would almost guarantee a solution while the flood box would only work when water levels in the Nelson Slough are low.

Bell Slough Flood Box

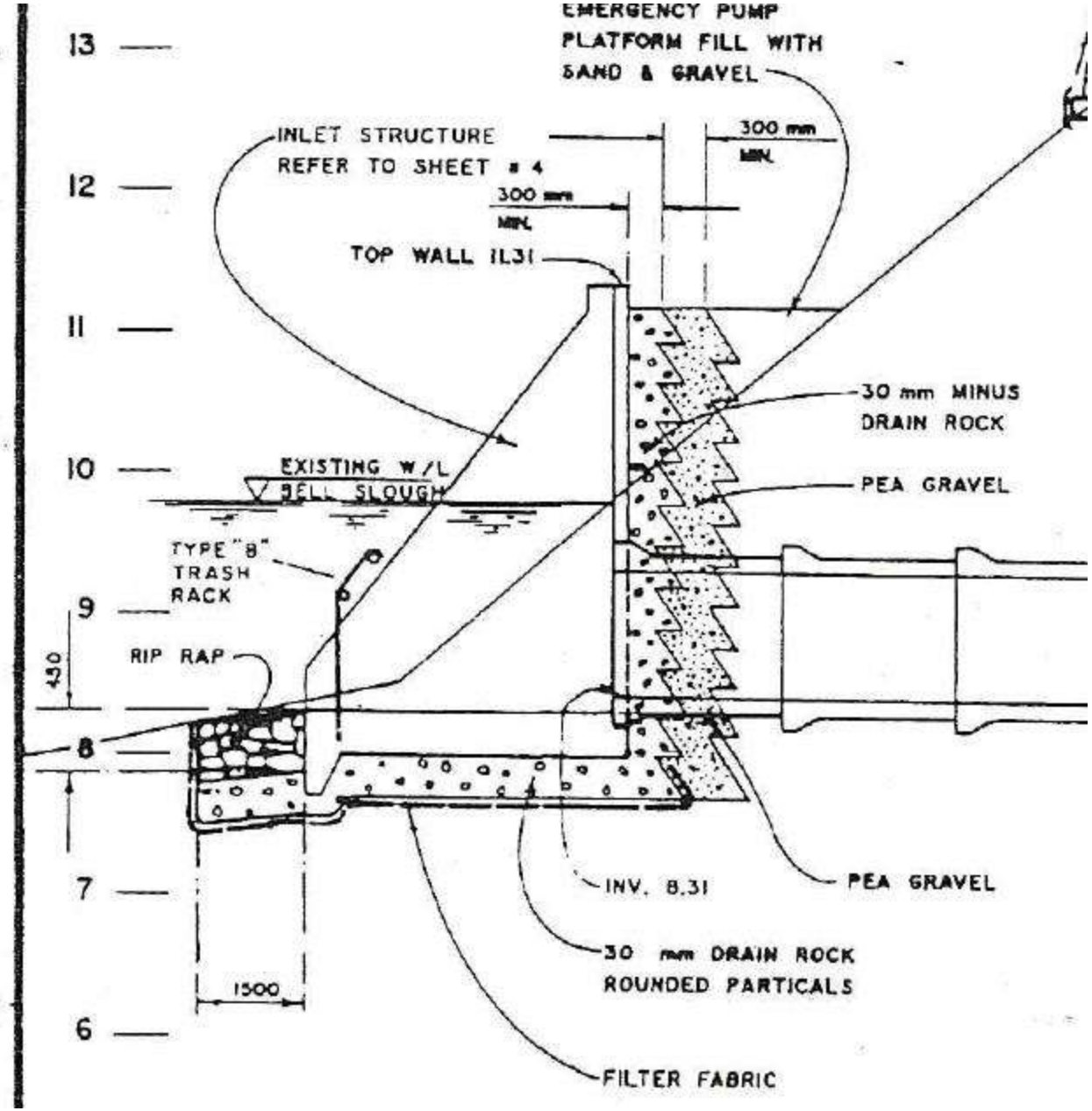


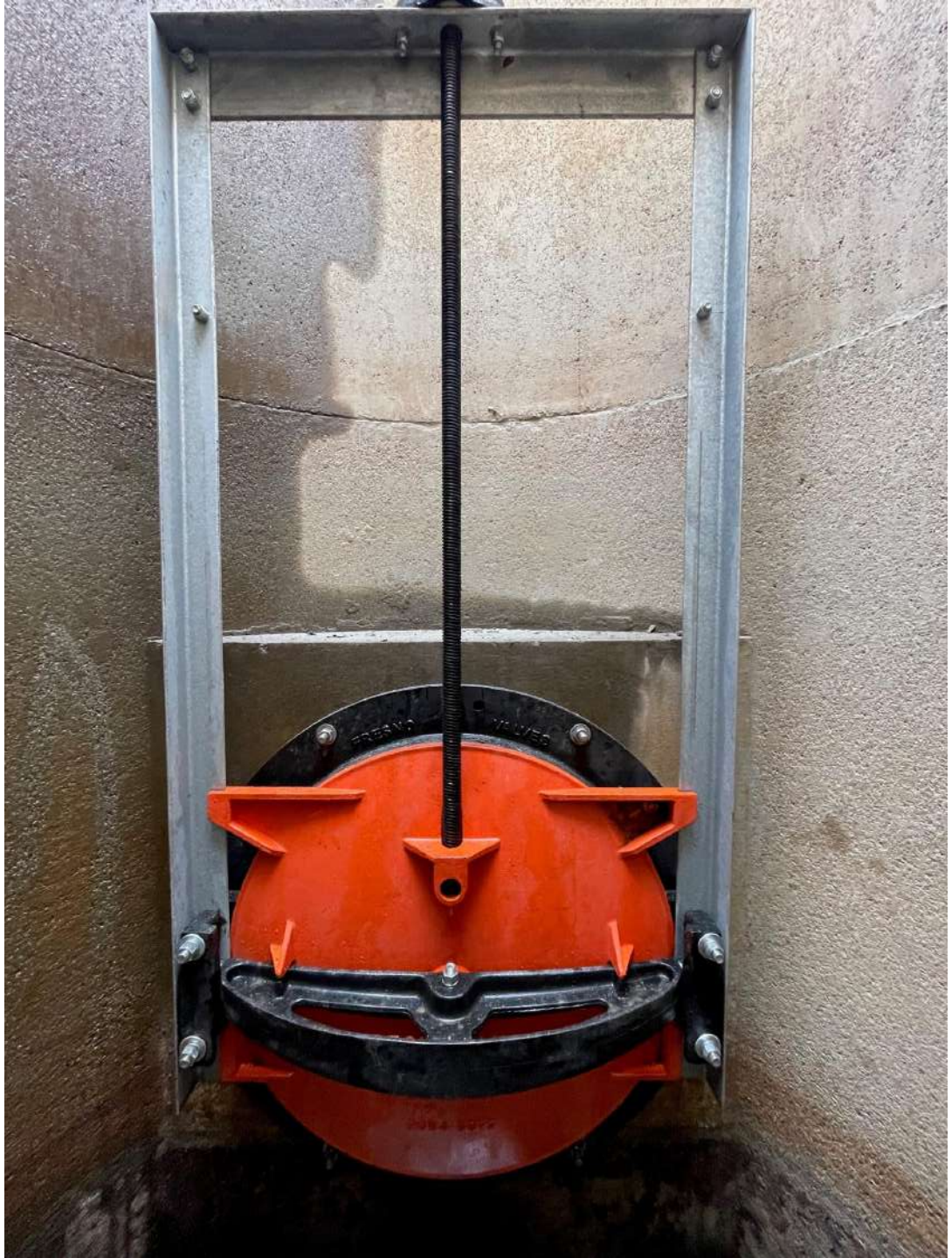
Bell Slough Flood Box



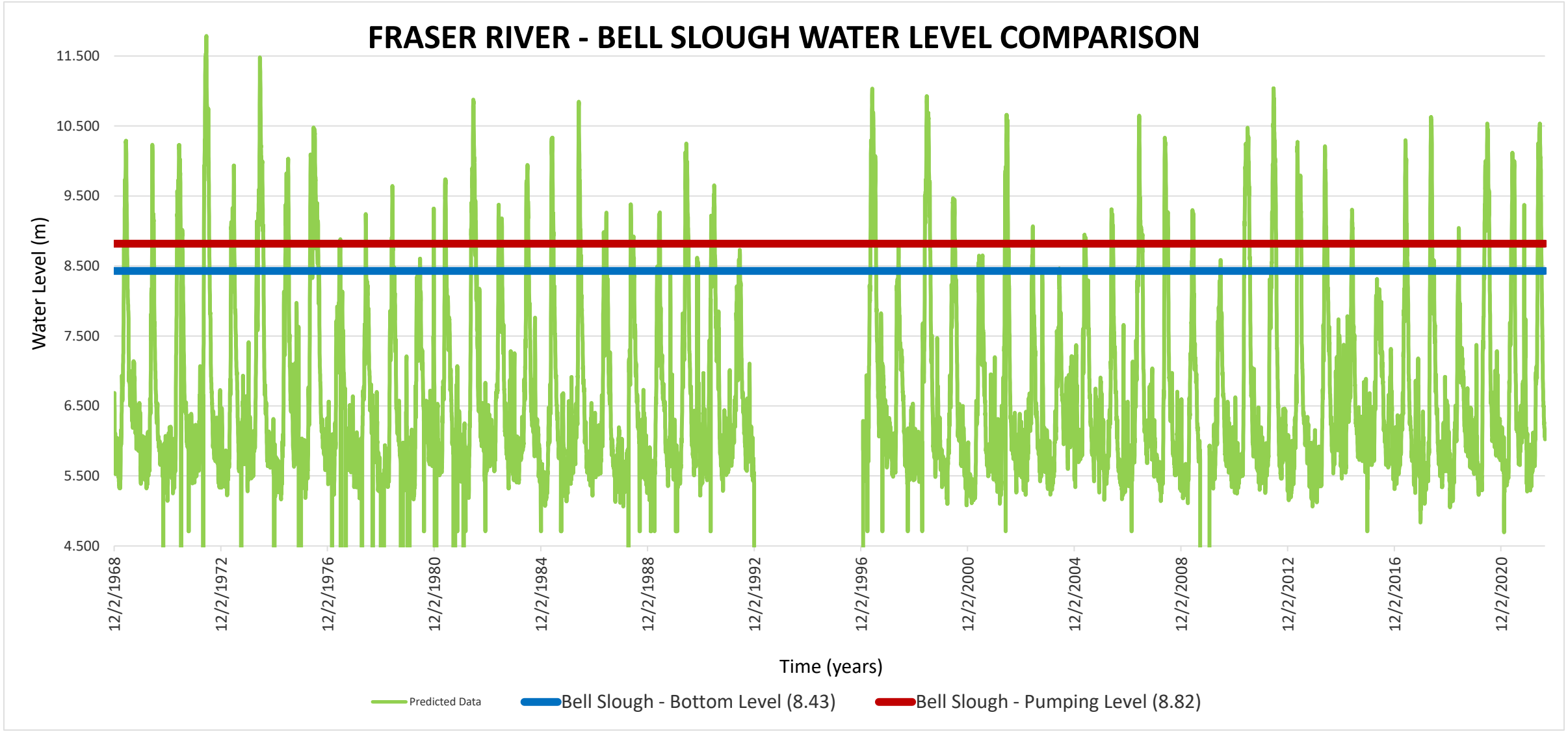
FLOODBOX CROSS SECTION
BELL SLOUGH TO FRASER RIVER

SCALE :
HORZ. : 1:100

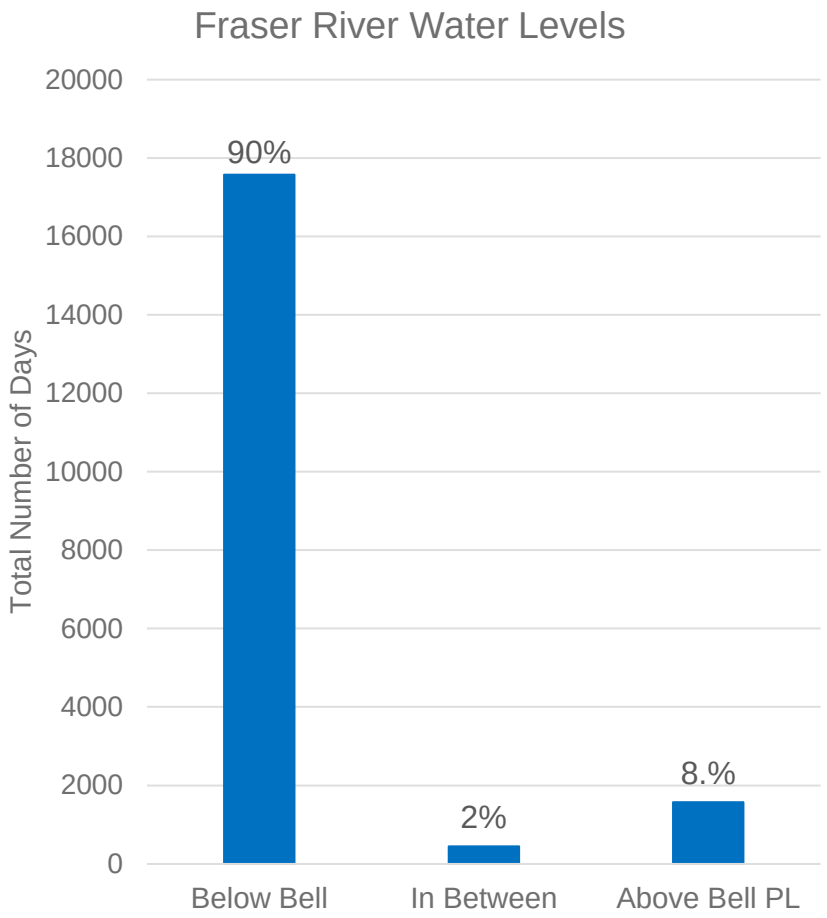

EMERGENCY PUMP
PLATFORM FILL WITH
SAND & GRAVEL
INLET STRUCTURE
REFER TO SHEET # 4
300 mm
MIN.
300 mm
MIN.
TOP WALL EL 31
13
12
11
10
9
8
7
6
EXISTING W/L
BELL SLOUGH
TYPE "B"
TRASH
RACK
RIP RAP
430
30 mm MINUS
DRAIN ROCK
PEA GRAVEL
INV. 8.31
PEA GRAVEL
30 mm DRAIN ROCK
ROUNDED PARTICALS
1500
FILTER FABRIC



Summary of Water Levels In Fraser River

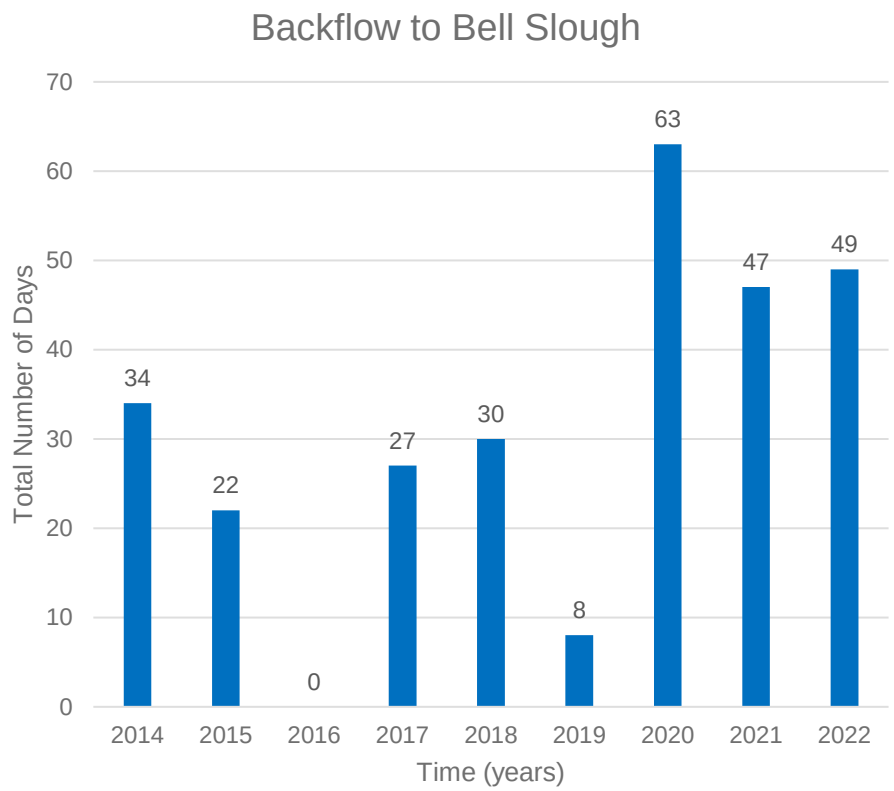


Summary of Statistical Analysis



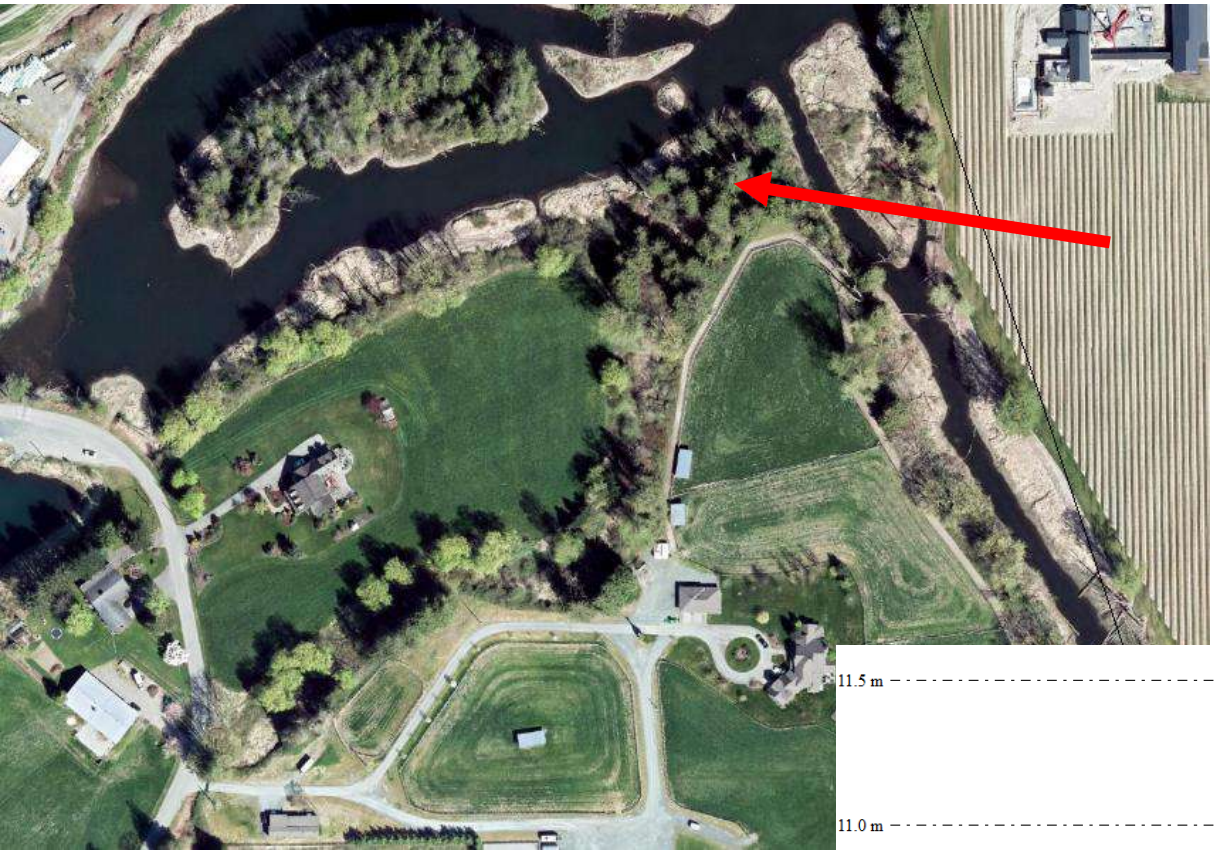
- Data referenced from 1968-2022 water levels for the Fraser River.
- As inferred from the graph, the Fraser River water levels have been lower than the bottom of the Bell Slough (8.43m) over the last half-century for most of the time period.
- The water levels rose to the pumping level of the Bell Slough (8.82m) just over 2% during the time period.
- The flooding events occurred roughly 8% of the time.

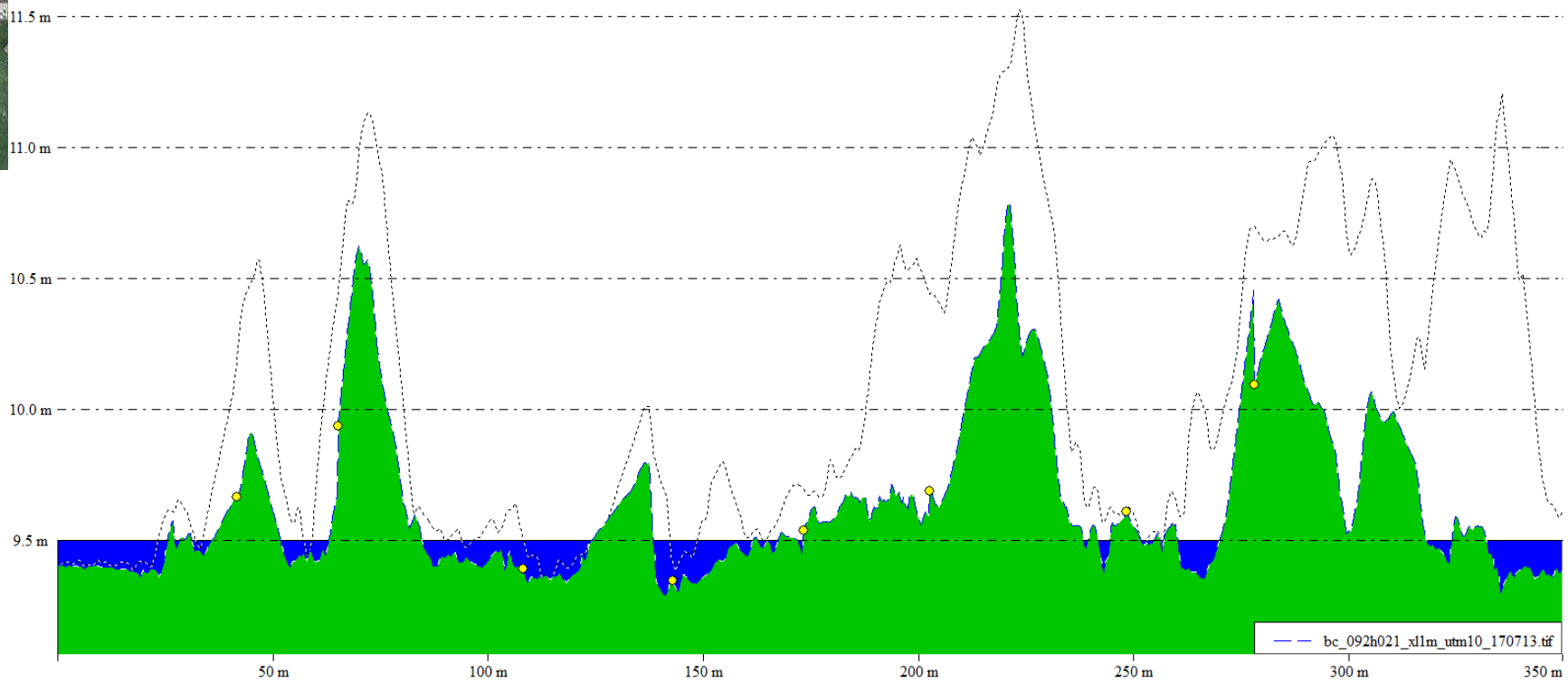
Summary of Statistical Analysis (cont..)



- Data referenced from 2014-2022 water levels for Bell Slough and Fraser River.
- The chart illustrates the number of days there has been a backflow on a yearly basis from Fraser River to Bell Slough.
- Over the last few years, there has been an increase in backflow frequencies from the Fraser River.
- The maximum water level attained in the Fraser River over the last few decades - 11.787m
- In 2020, the maximum recurrence in backflow events occurred.

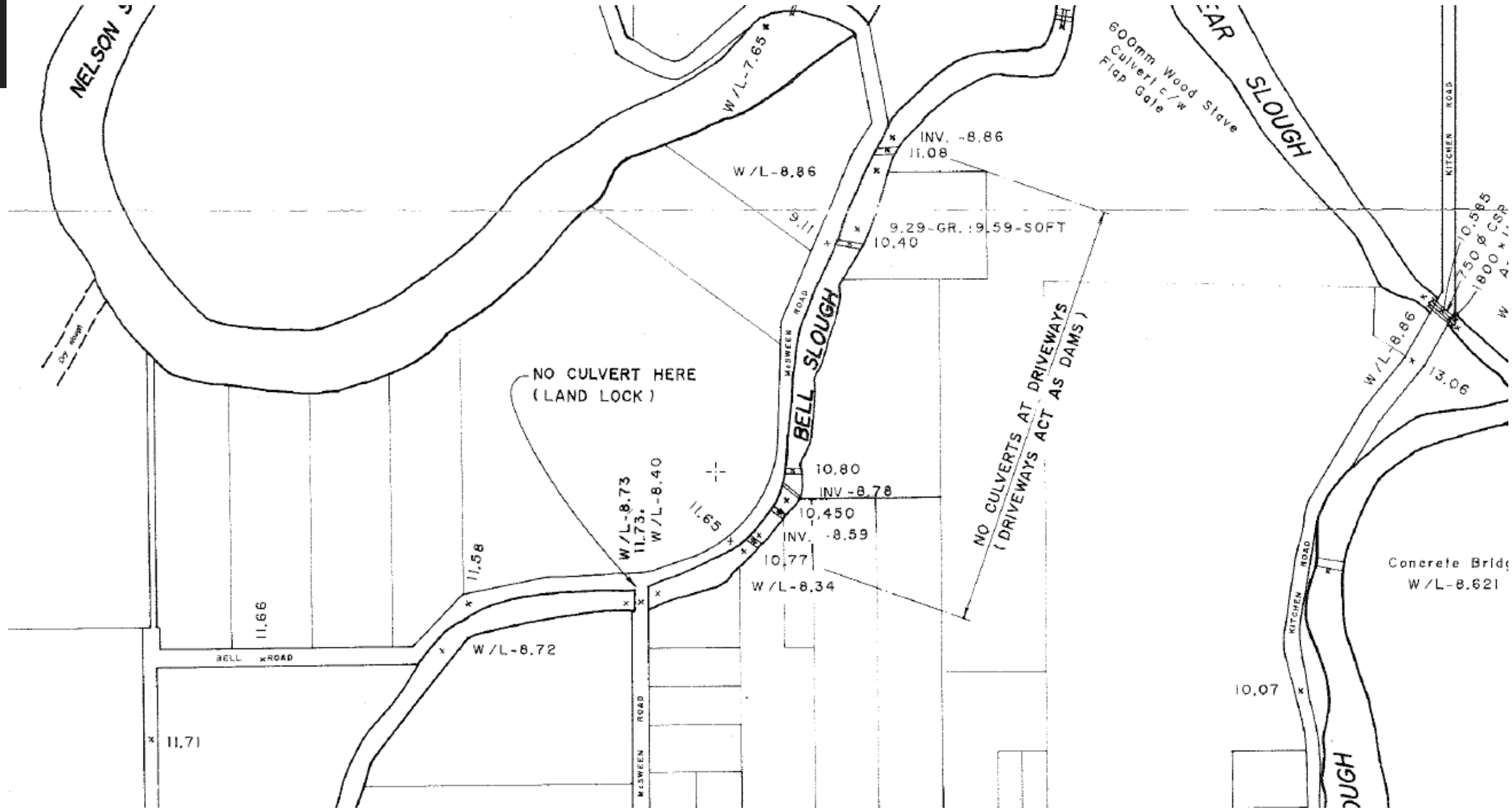
Bell & Camp-Nelson





Site Visit

Flow Obstructions



Environmental Findings

Wildlife

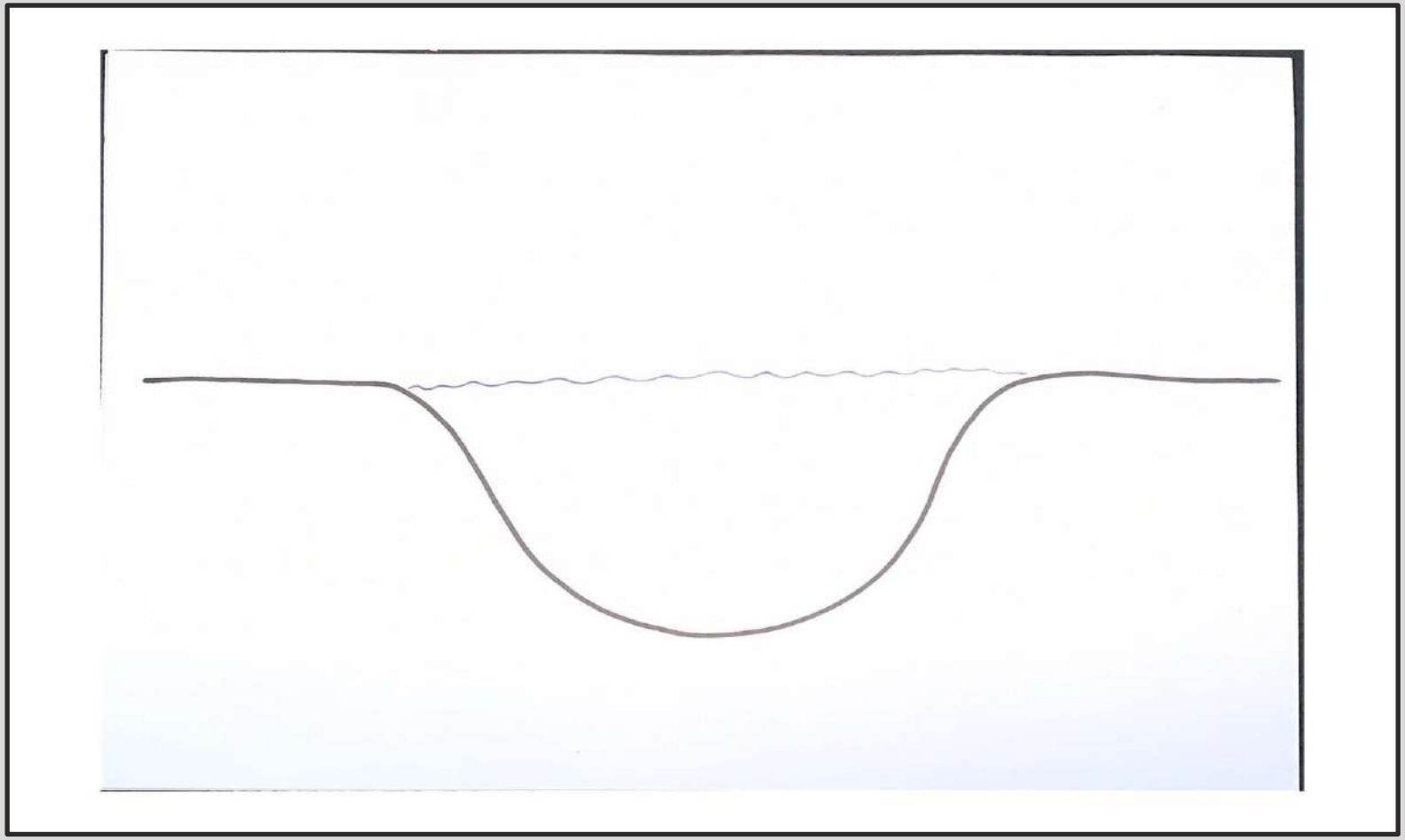
Riparian Vegetation

Aquatic Vegetation

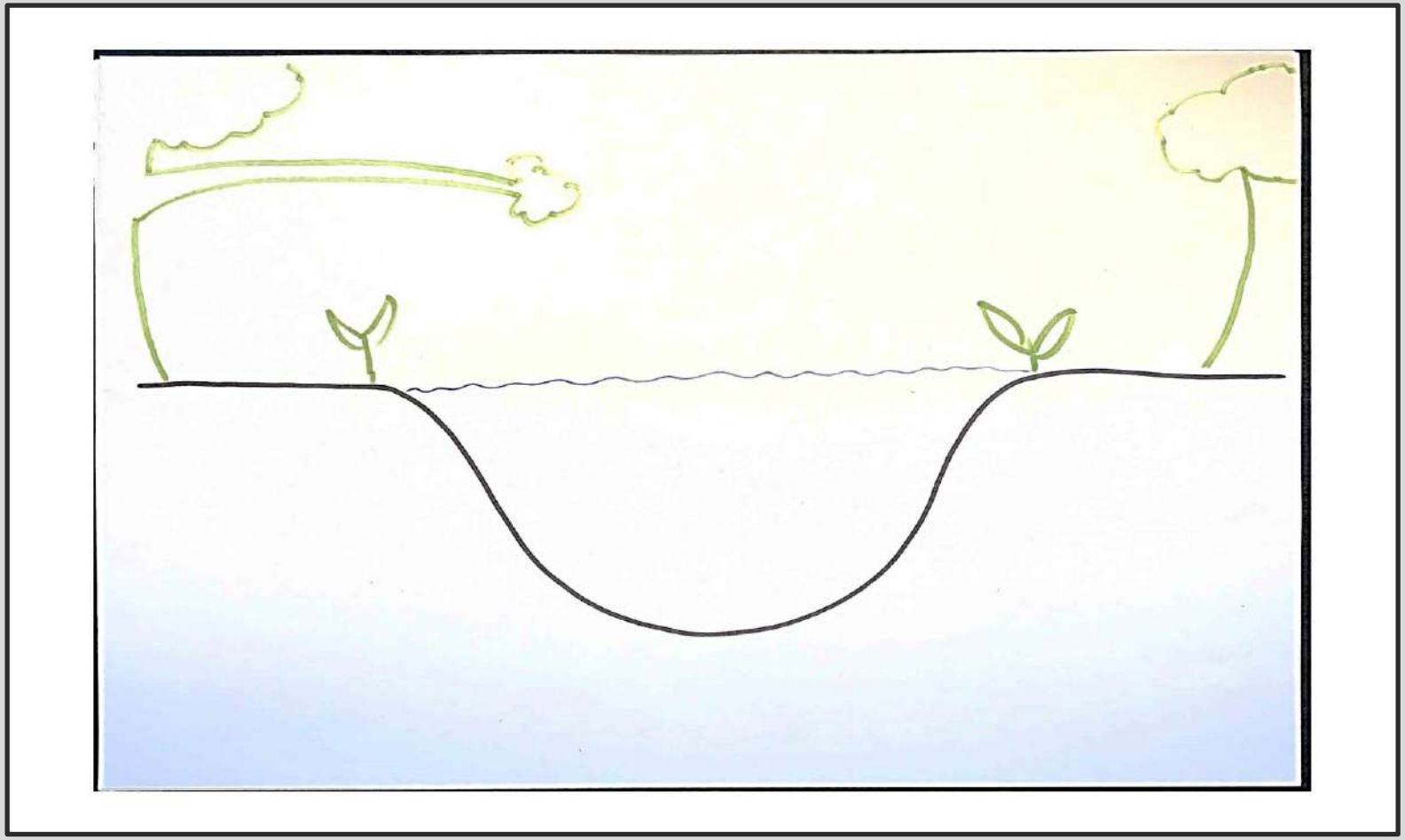
Hydrology

Water Quality

Water Quality Fundamentals



Water Quality Fundamentals



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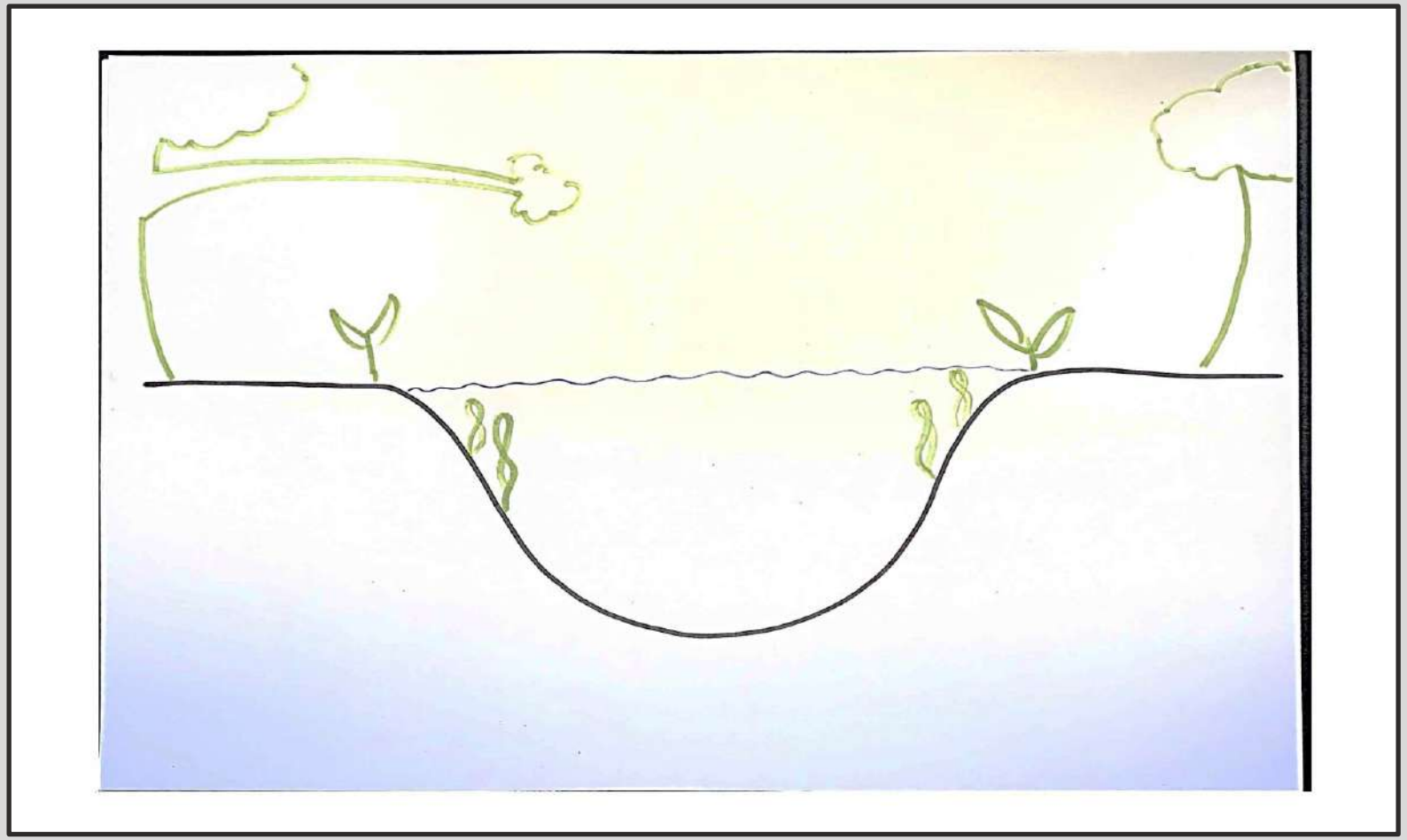

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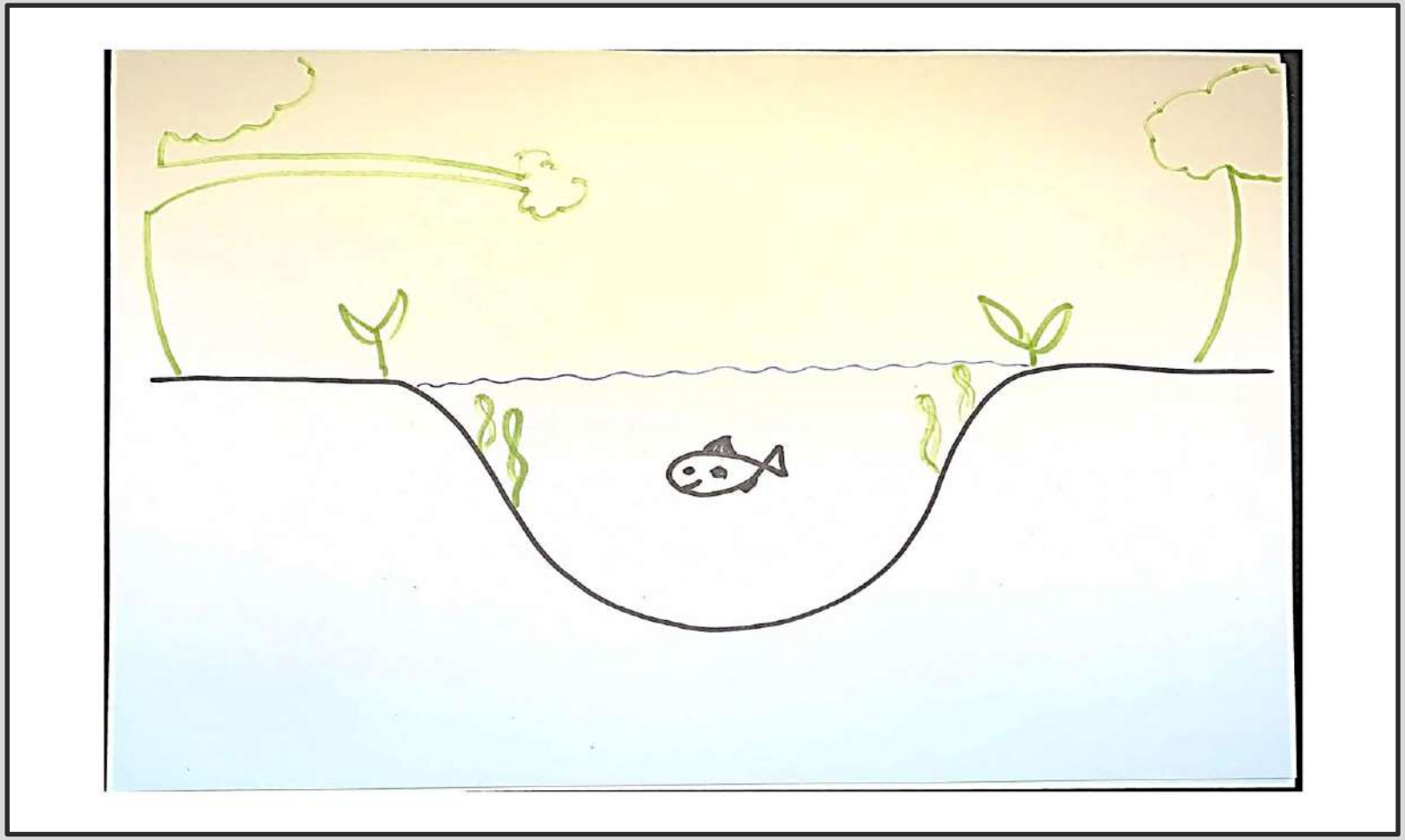

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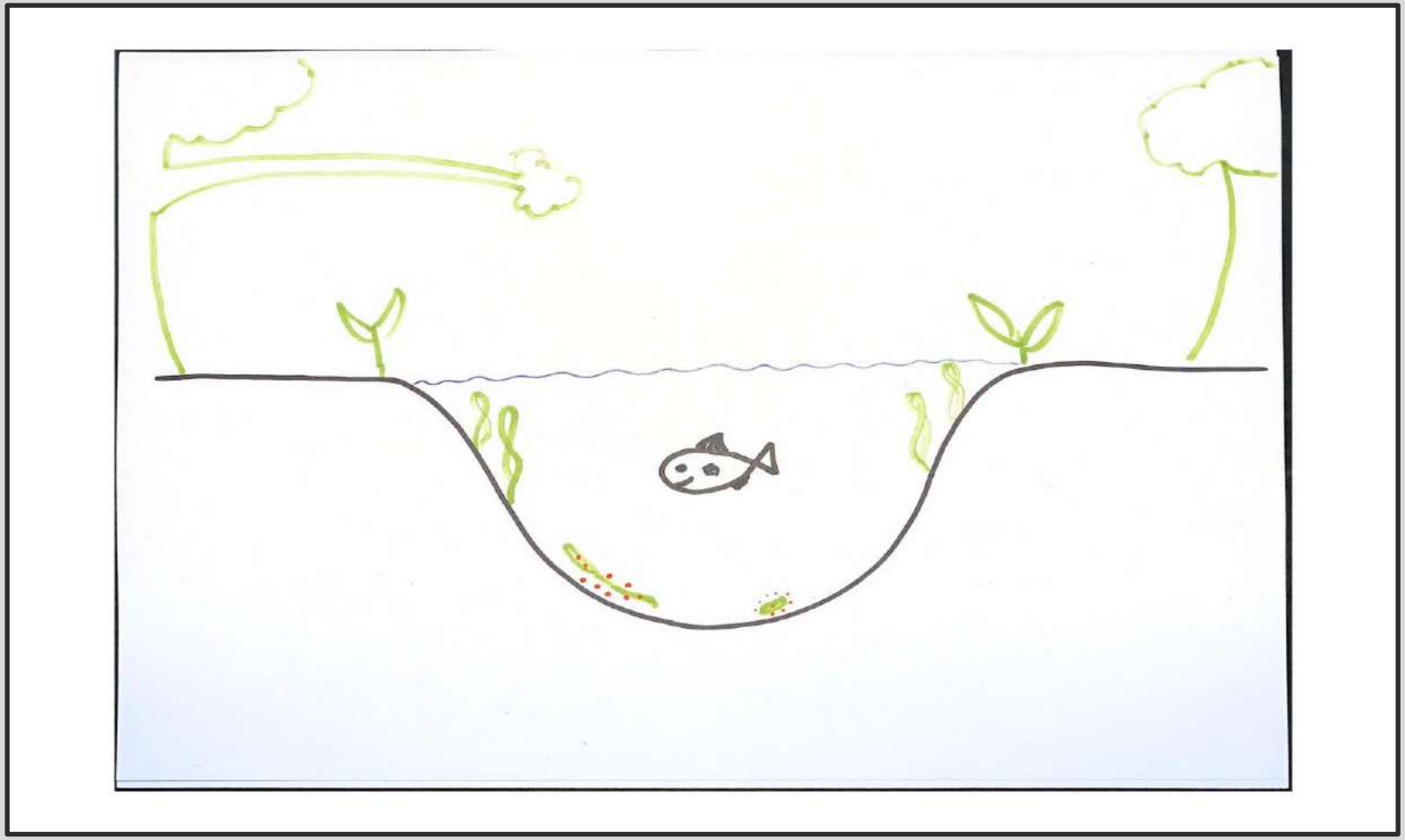

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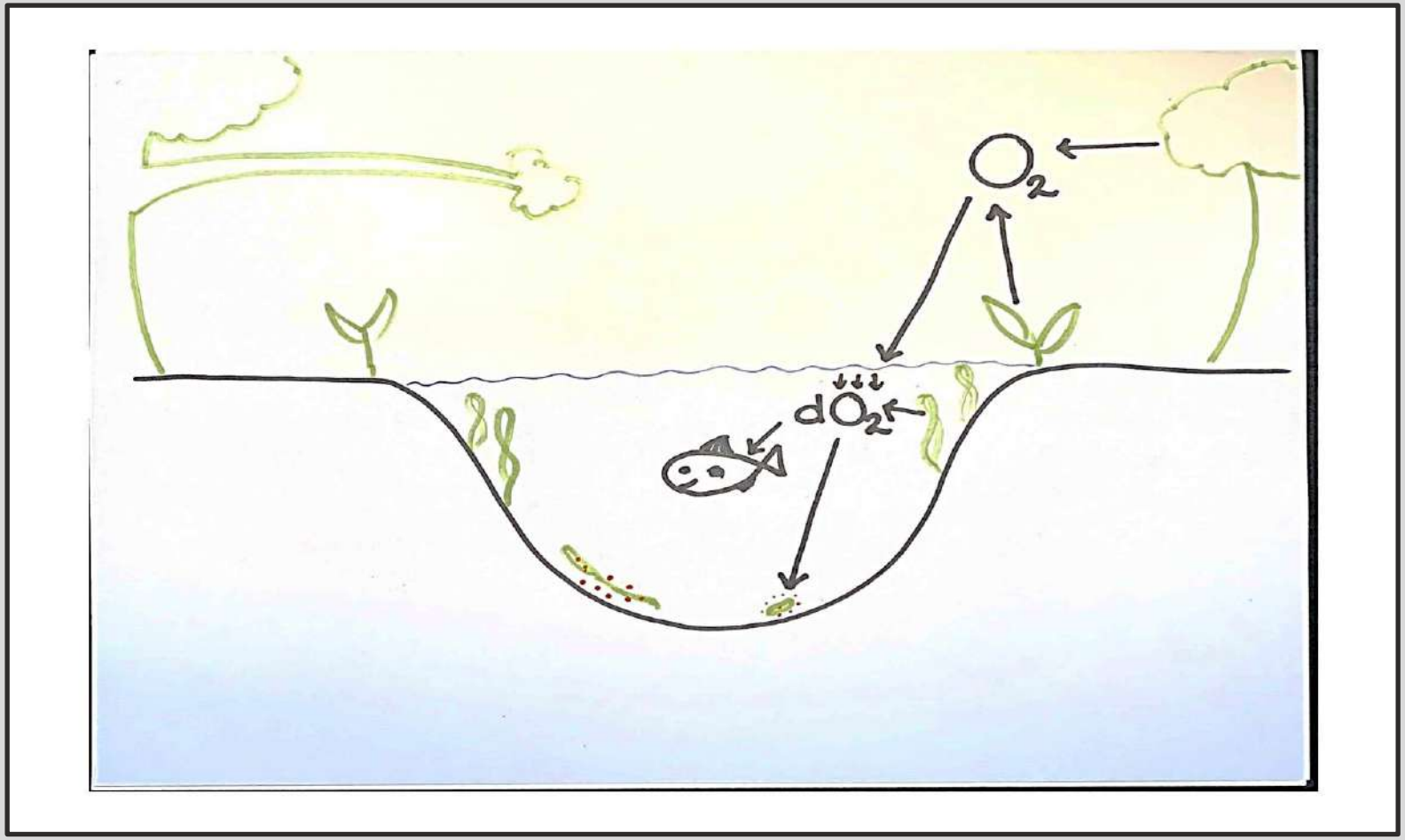

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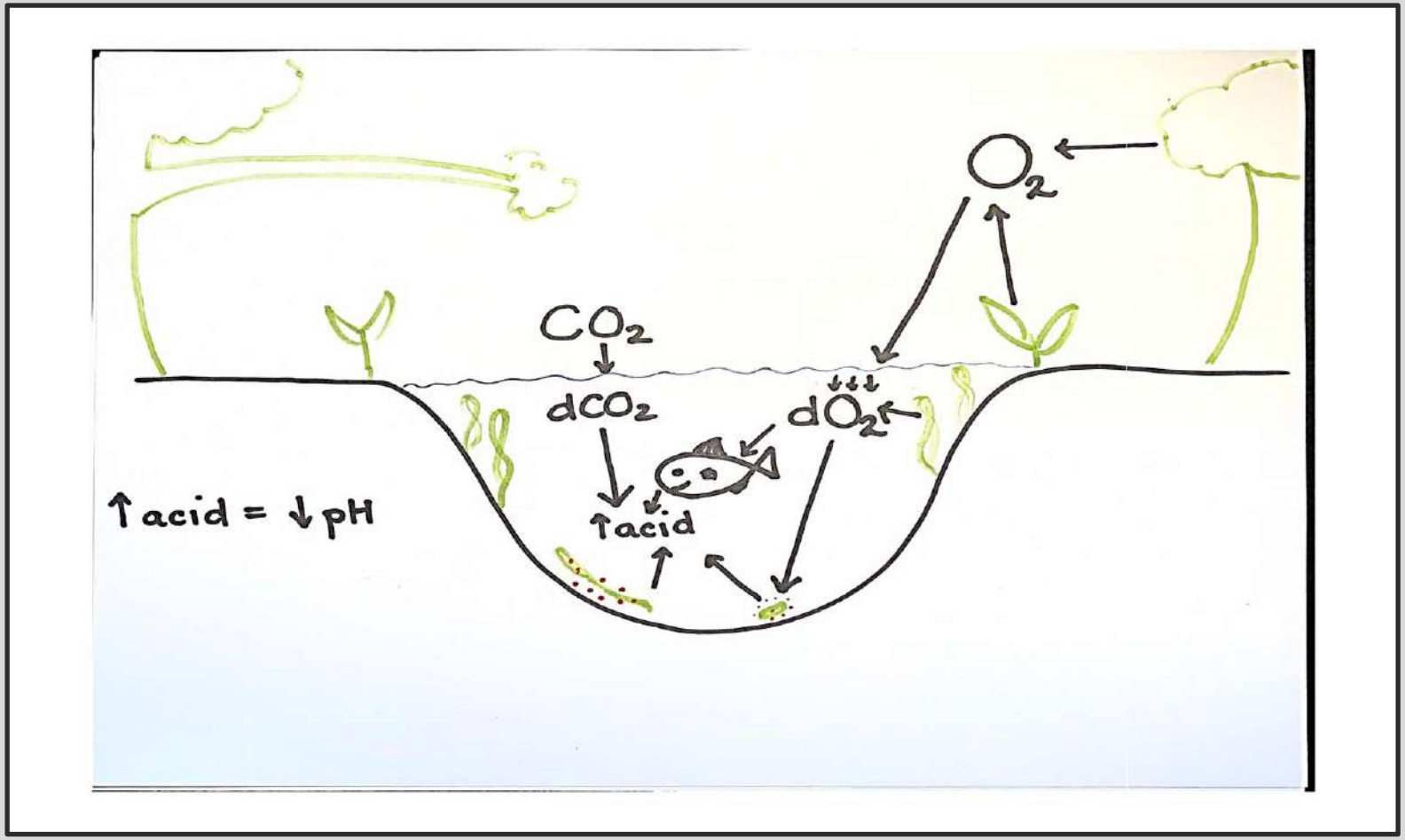

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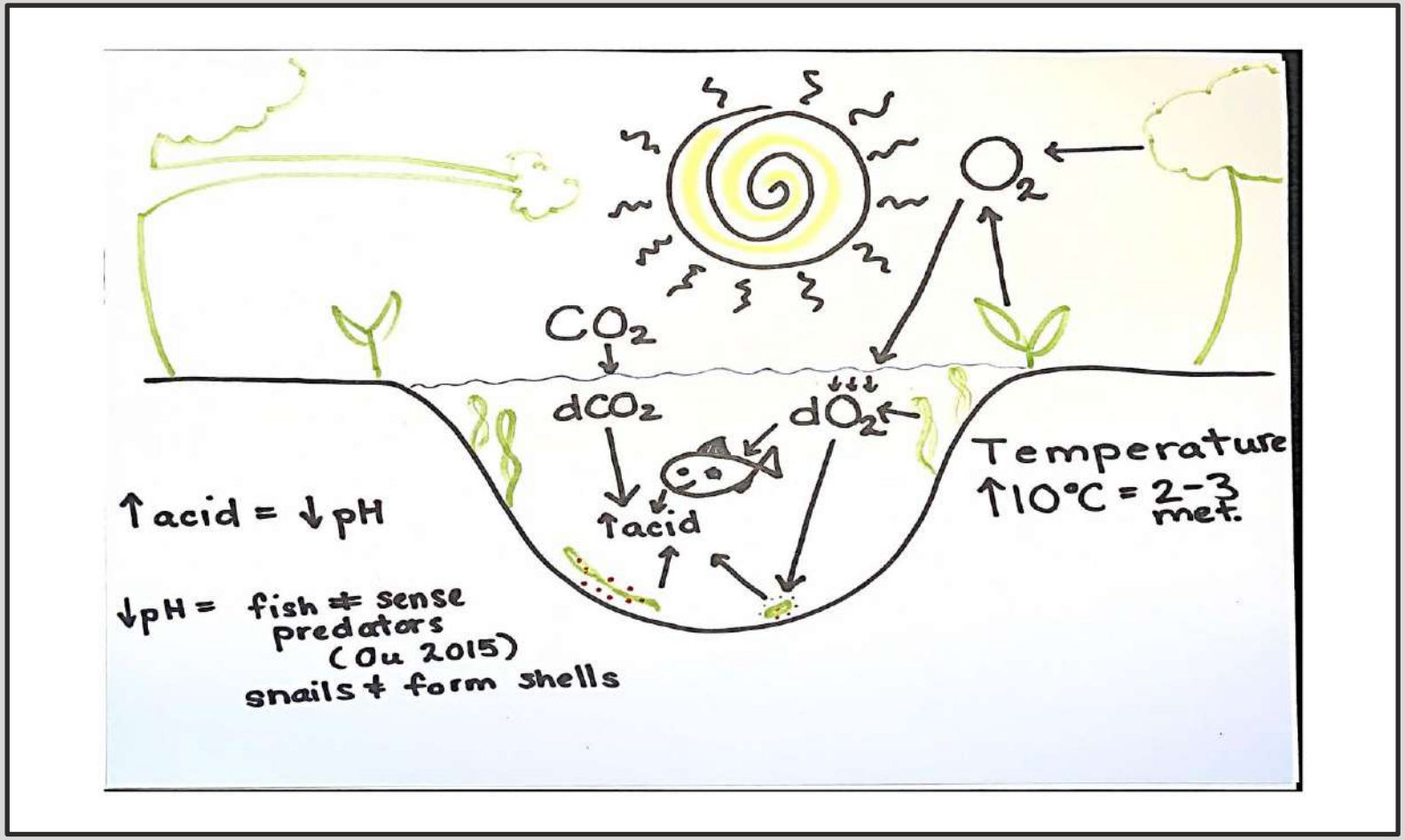

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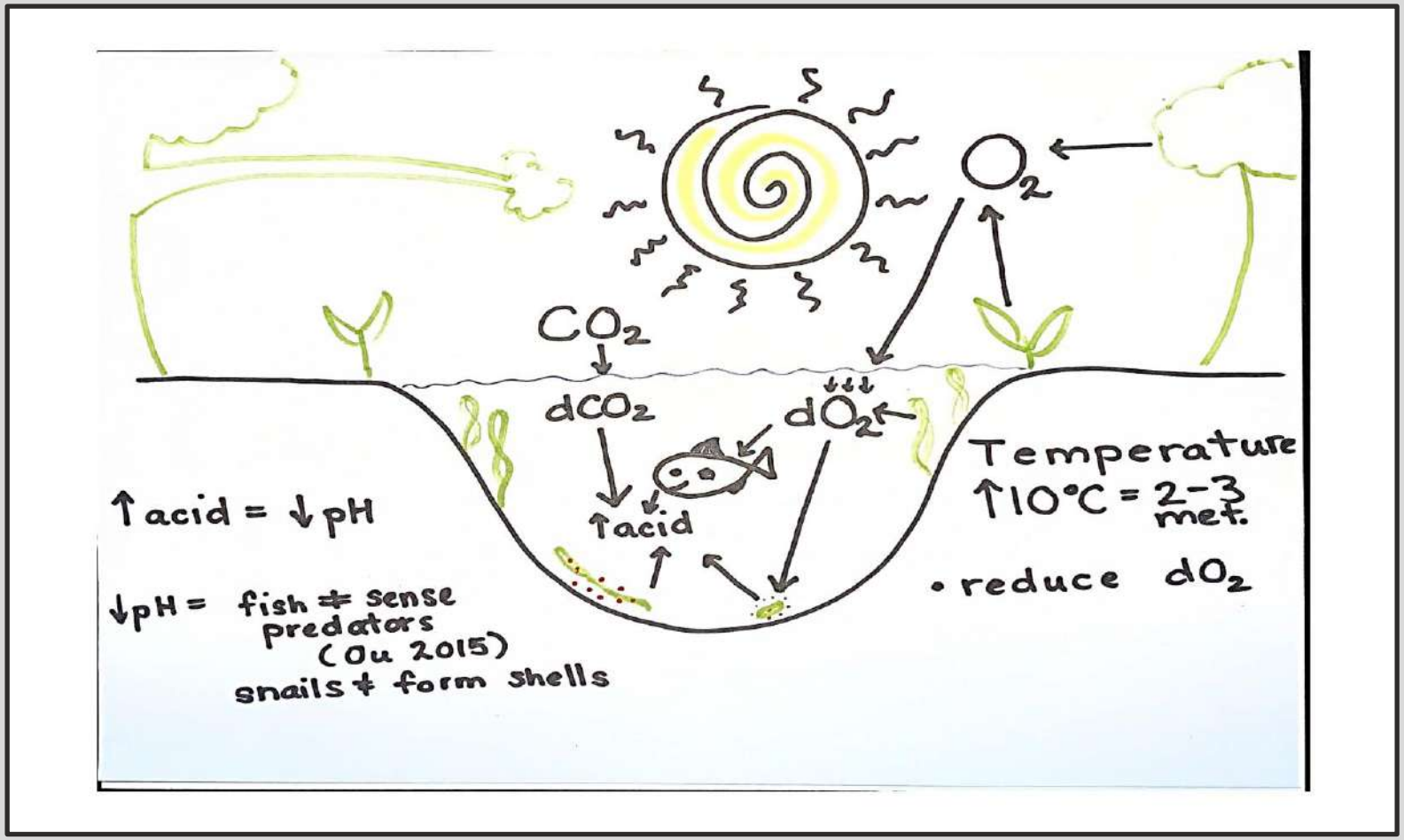

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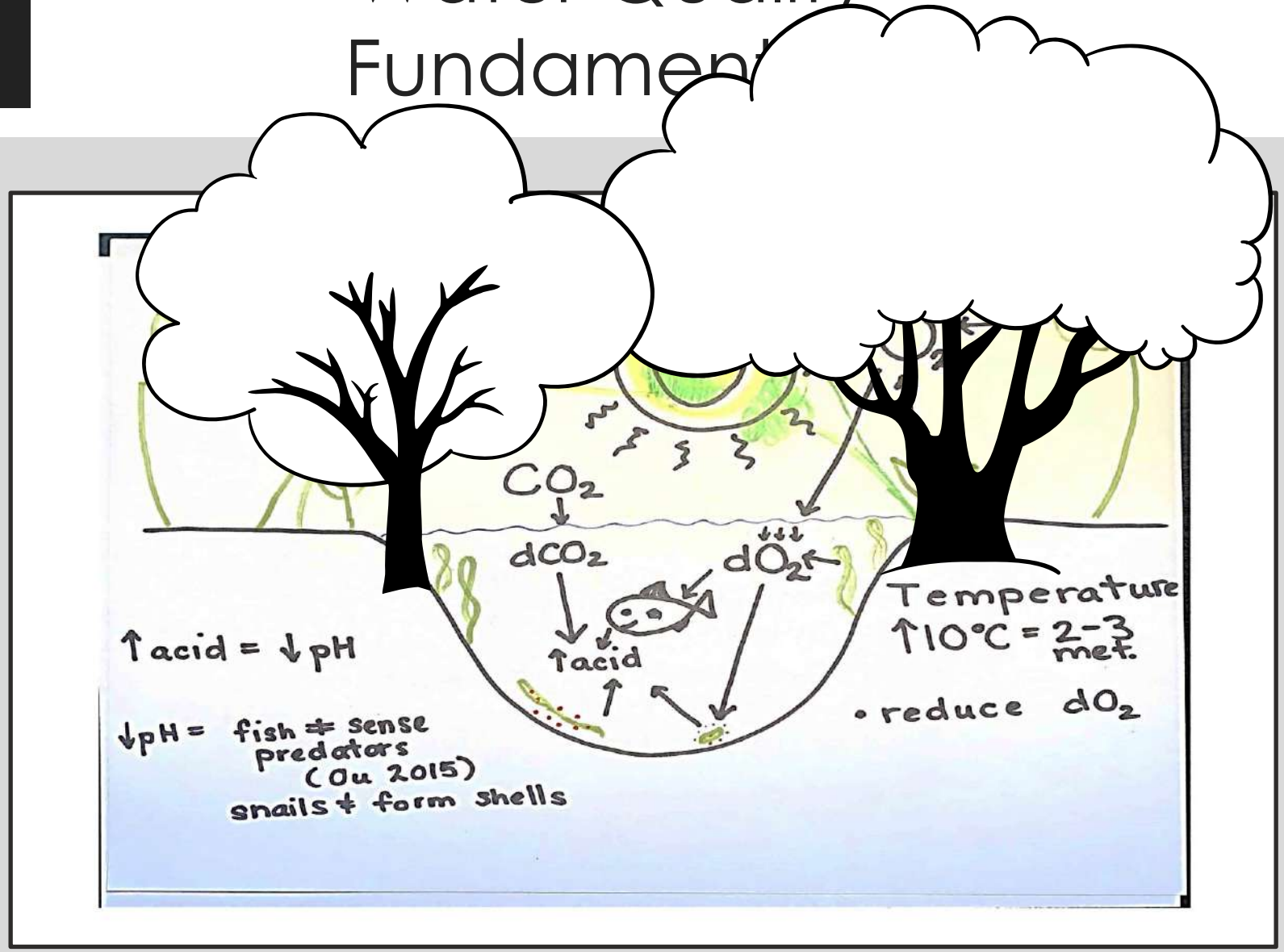


Water Quality Samplings

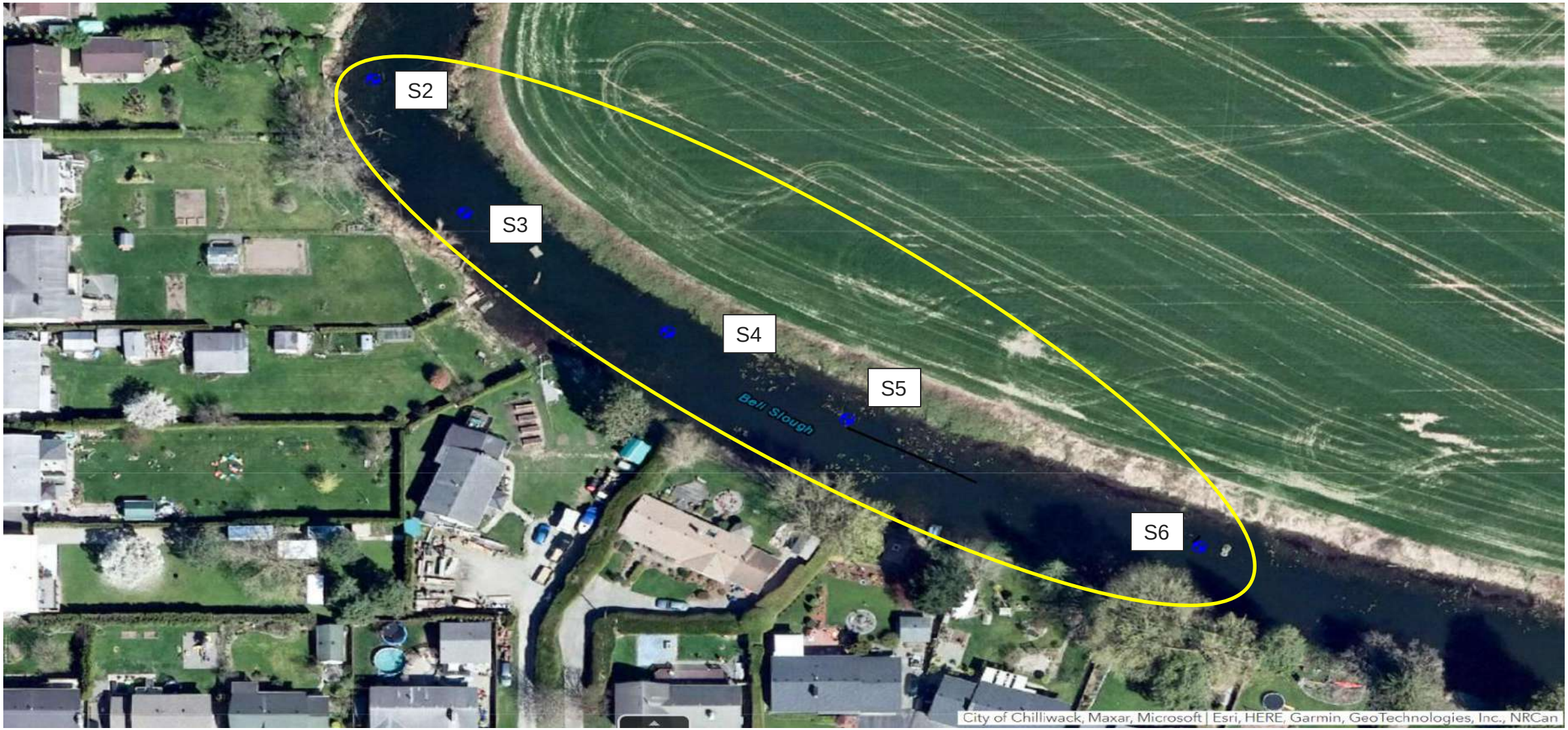
(What it should be)

BC Ambient Water Quality Guidelines for Aquatic Life			
	Temperature	**Lower Dissolved Oxygen**	**pH**
Long term	18 C	8 mg/L	6.5-9
Short term	19 C	5 mg/L	

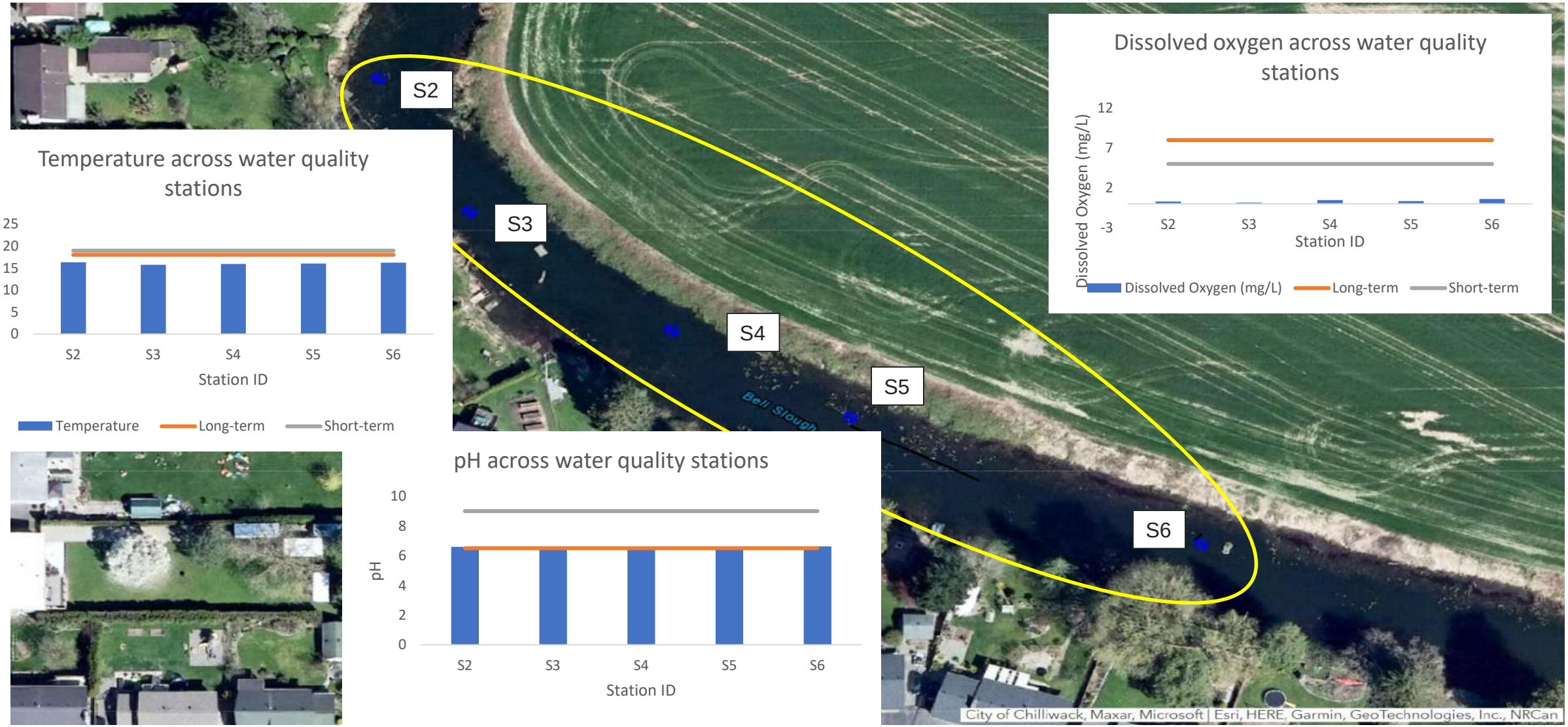
Station 1 (Fraser River Extent of the Slough)

Station 1 Water Quality Data			
	Temperature	**Dissolved Oxygen**	**pH**
	17 C	**2 mg/L**	6.82
Green algae with visible open water			

Stations 2–6 (Montana Drive Area)



Stations 2–6 (Montana Drive Area)



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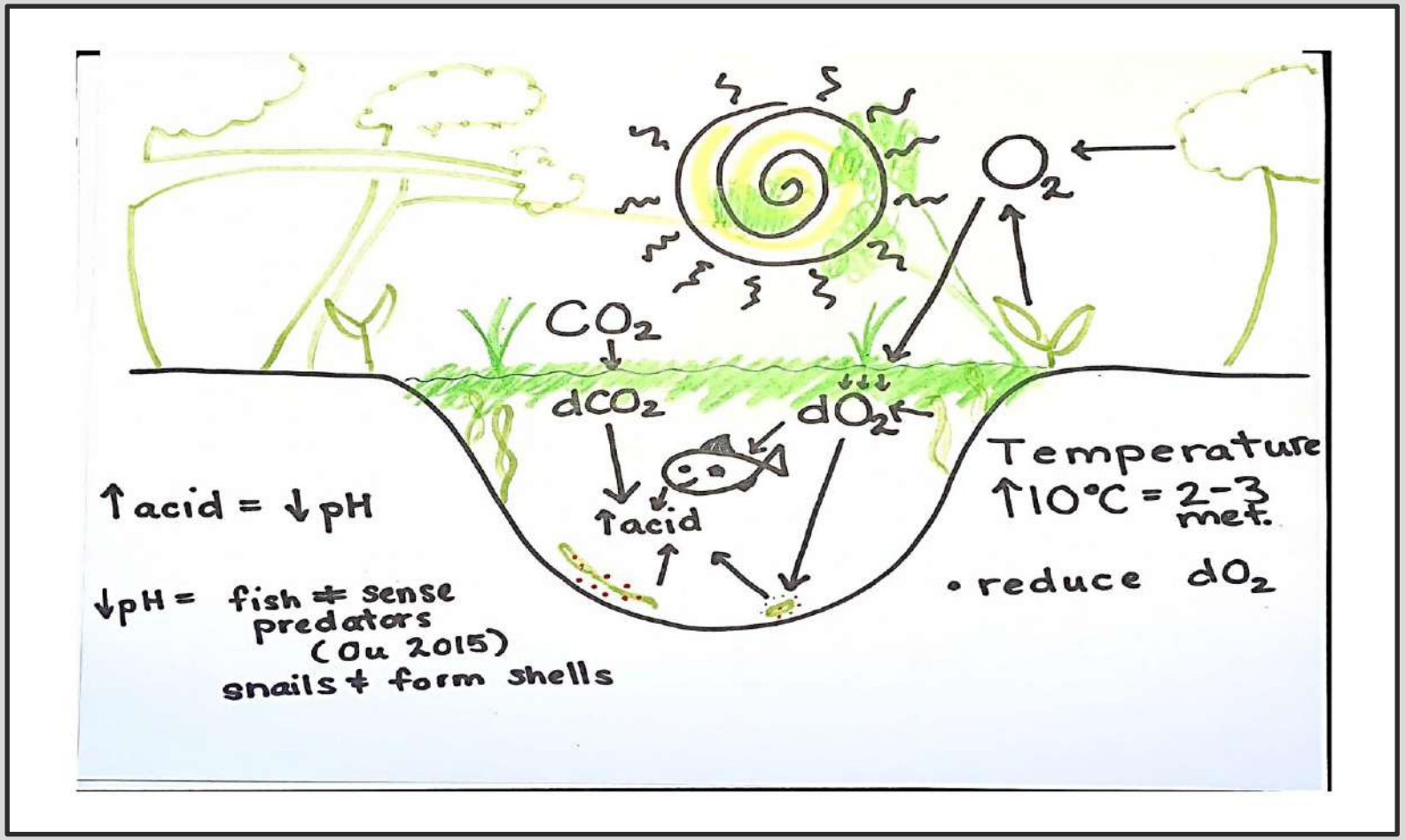

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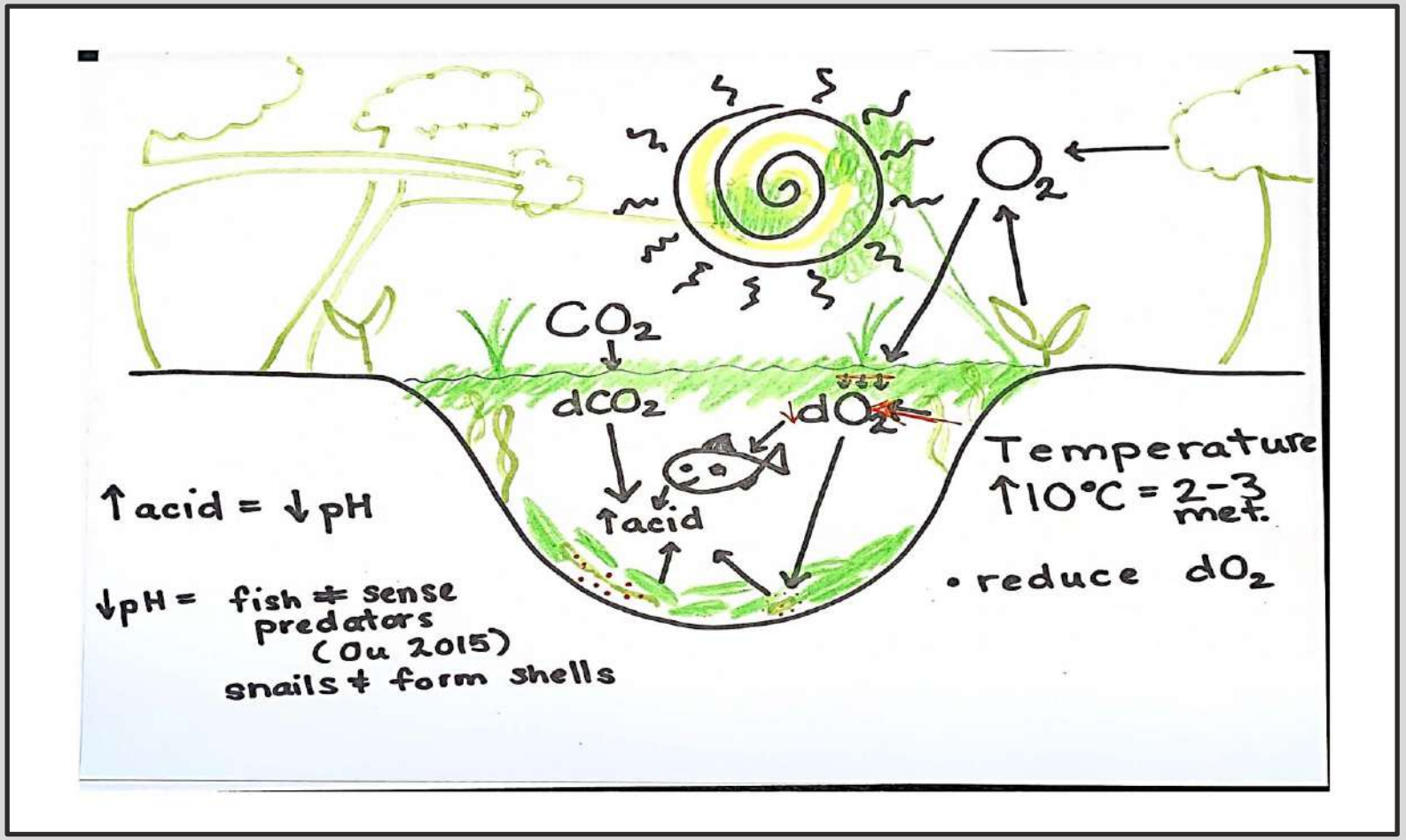

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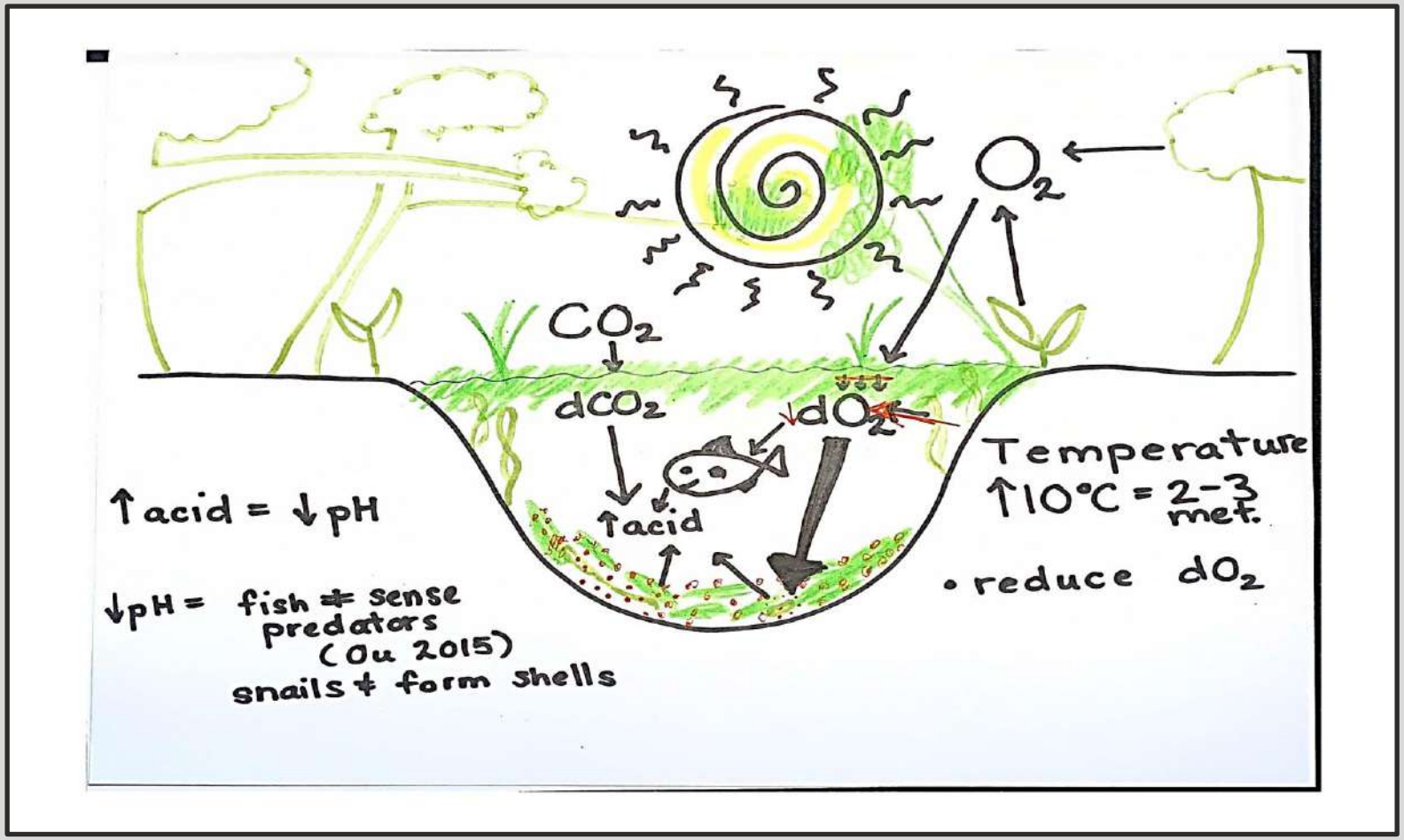


Stations 2–6 Water Quality Data (avg.)			
	Temperature	**Dissolved Oxygen**	**pH**
Long term	16 C	**3.5 mg/L**	6.56
Thick aquatic plant mats covering entire surface of slough			

Stations 7–9 (Bell Road)

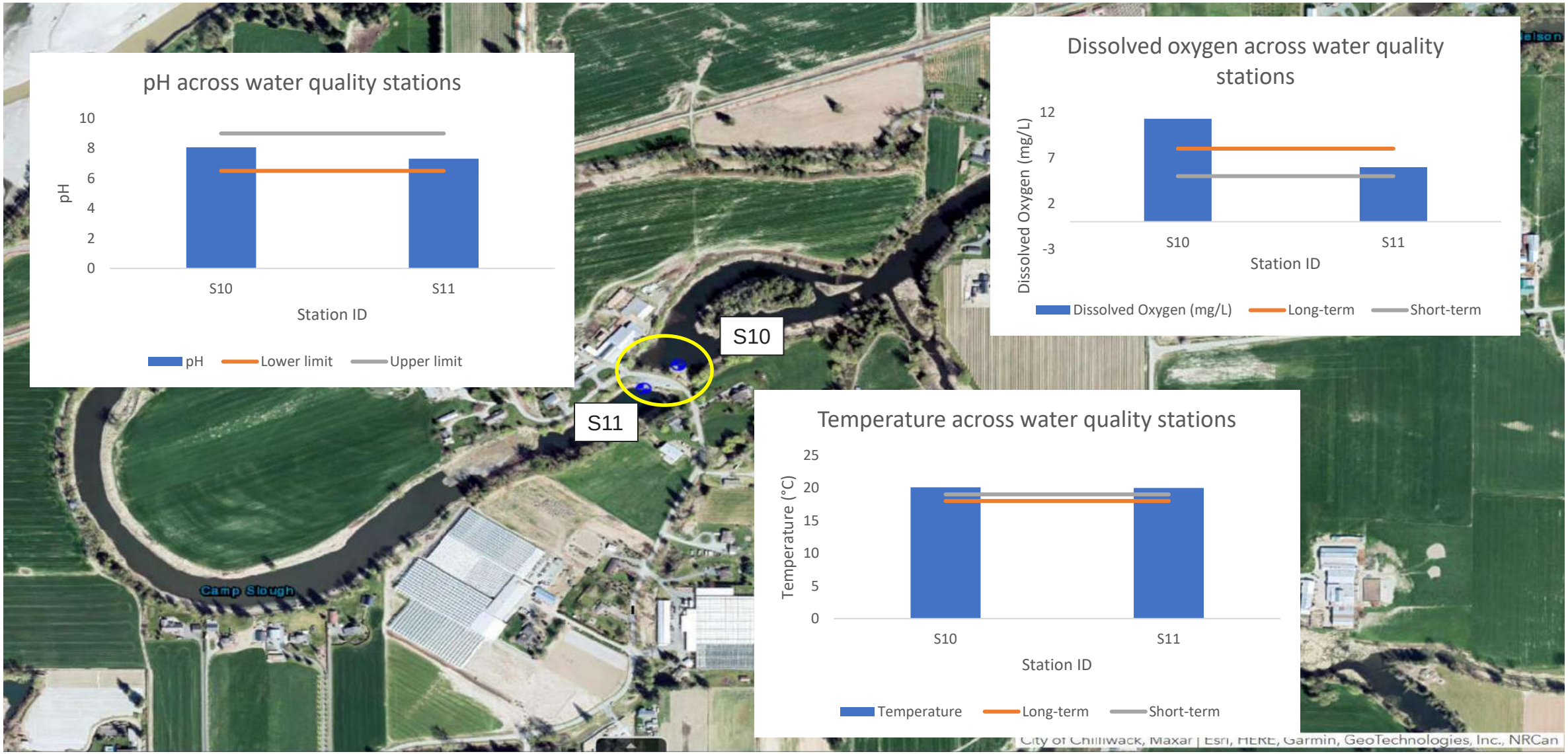
Stations 7–9 (Bell Road)

Stations 7–9 Water Quality Data (avg.)			
	Temperature	**Dissolved Oxygen**	**pH**
Long term	18 C	55.8 mg/L	6.53
Patches of smart weed, but also open water. Transitions between continuous wetted to pools.			

Upstream Bell Slough: Headwaters

Stations 10 and 11 (Nelson Slough)

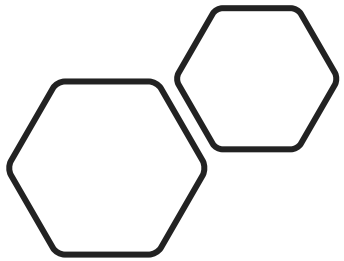
Stations 10 and 11 (Nelson Slough)

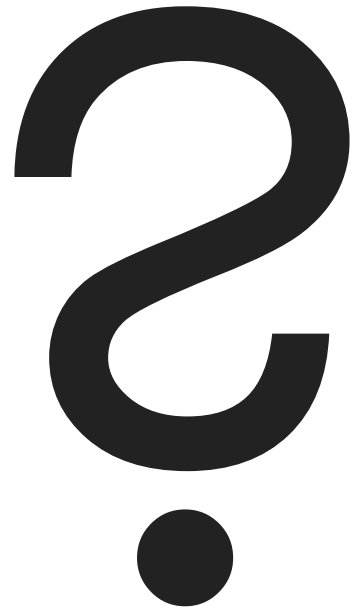


Stations 10 and 11 Water Quality Data (avg.)			
	Temperature	**Dissolved Oxygen**	**pH**
Long term	20 C	92.9 mg/L	7.7
Open water with some lily pads around edges. Dead juvenile carp at culvert outfall.			

Next Steps

Comments?
Questions?





Resources

- Fraser Valley Conservancy, Nature Stewards Program.
- Native Plant Nursery: NATS Nursery
- Invasive Species Information: FVISS
- Citizen Science: iNaturalist
- BC Bat Program
- Fraser Valley Conservancy: Frog Finders Program
- BCWF: Wetlands Education

Chilliwack Bell Slough
Public Feedback Questionnaire

Water Quality Samplings

Moved by Mr. Evans, seconded by Mr. Mercer that the reeve and clerk be authorized to sign the plans of the subdivisicn of part of lot 334, group 2, owned by C. E. Eckert.

Mr. W. J. Glanville addressed the council in reference to the proposed bridge across Bell Slough and on the motion of Mr. Evans, seconded by Mr. Iarrs it was decided that the council hould furnish the material for a 60 oot bridge across the slough, it be- ng understood that Mr. Glanville is o haul the material, put in the fills t each end and build the bridge, sub- ject to the approval of the Board of Works appointed by the city council.

At the request of D. W. Johnson and on the motion of Mr. Evans, sce- onded by Mr. Merger, the appropria- tion for the McSween road was in- creased to $75.

the other places on the Lower Mainland are similarly situated. They are dependent on the lumbering or fishing industries or were living on the constant rising of real estate.

Mr. Rummel met the fire, water aud light committee of the council Tuesday evening regarding the installation of the new lighting system. He advised the location at once of all extra lights, and impressed upon the committee the importance of having the business section of the city well illuminated. His advice will undoubtedly be acted upon.

AUCTION SALE

Under instructions from Mr. Geo. Bell, of Fairfield Island, Chilliwack, B. C., I will sell by Public Auction on

Thursday, April 16th, 1914

on his farm situated on the McDonald Road and Bell Slough, commencing at 2 p.m. sharp, the following described Farm Stock, Implements, etc.:

HORSES—One team of mares, 7 and 8 years old, weight 1350 lbs.

CATTLE—One grade Guernsey, 8 years old, just freshened. One grade Guernsey, 8 years old, due Sept. 12th. One grade cow, 3 years old, in full milk. One grade cow, 3 years old, due July 15. One 2-year-old heifer, just fresh. One 2-year-old heifer, due October. One Holstein heifer calf.

PIGS—Three sows, one bred.

FOWL—A number of hens, including Campines, Black Orpingtons and about one dozen Plymouth Rocks; also a few hens with week-old chicks.

IMPLEMENTS—One Massey-Harris mowing machine, in good order. One hay rake, in good order. One farm wagon, in good order. One one-seated light rig. One plow. One new spray pump. One Planet Jr. seeder. One new wheel barrow. Two bull yokes. One grain cradle. One DeLaval separator, in good order, No. 2 size. Four milk cans and other articles.

A quantity of good seed oats, and mixed hay (timothy and clover).

TERMS—All sums of $25.00 and under cash; over that amount three months' credit will be given on furnishing approved joint note, bearing interest at the rate of 8 per cent. per annum.

Wm. Atkinson, Auctioneer

Address 506 Vancouver Block, Vancouver, B. C., or Box 34, Chilliwack, B. C.

capability of our resources to adequately serve that area."

● Referred to the engineer and public works department for further study, an inquiry from G. C. Janmaat regarding drainage into Bell Slough from the McDonald-Barkland subdivision. Mr. Janmaat pointed out that because the slough has no outlet anywhere, drainage from the subdivision will undoubtedly raise the level of the slough and consequently flood the lower parts of his farm which are located along the slough.

Rotary plans to 'transform' slough

Even at the best of times Bell Slough is a mass of weeds and mud . . . but it has potential.

By this time next year the slough could be a popular fishing spot for youngsters and senior citizens as Chilliwack Rotary Club plans to take the first step in its Hope River and Camp River beautification project.

The initial project involves dredging some 20,000 yards of material out of Bell Slough and creating a new bank and parking facilities. Hope River Development committee chairman Bernie Proft said the finished product will be a 150 foot by 700 foot fishing pond with a year-round minimum depth of six to eight feet.

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B.C. housing official speaks here tonight

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About 150 members are registered with the association. While most members are mobile home owners the spokesman stressed apartment dwellers are welcome to join.

Main purpose of the organization is to ensure both landlords and renters adhere to the provincial government's Landlord and Tenant Act.

Bell Slough project awaits impact study

Chilliwack Rotary Club's plans to clean out Bell Slough have been held up pending completion of an environmental impact study.

Project spokesman Bernie Proft said the study has been on order for about two weeks and will take about two months to complete. A fish and wildlife branch biologist will be conducting the study. The Rotary Club is hoping to transform Bell Slough into a fishing pond for senior citizens and youngsters.

Mr. Proft explained the club did not expect a study to be ordered as the fish and wildlife branch was involved in setting up the initial plans. Bell Slough is apparently a natural habitat for Black Crappie, a small game fish.

The impact study must be complete before the provincial government will grant any funds to the project.

For Bell Slough

Project endangered by missing grant

"Unless we find alternate financing, or some way of completing the project at a cost considerably less than originally anticipated, the Black Crappie project is stalemated."

That statement was made by Bernie Proft, chairman of the Rotary Club's ways and means committee, in an up-dated report to city council on the club's "Hope River Development Plan."

In his three-page report Mr. Proft outlined the work being carried out to date and said progress toward the provision of the Black Crappie fishery at Bell Slough has been delayed because of financial difficulties.

Two of the three projected sources of funds, a LIP grant for $16,000 which has been received and gravel sales of about $5,000 which are still considered feasible, are still open, but the third source, a provincial grant of $10,000, did not materialize "because of lack of environmental impact data."

Because of the situation and the danger of losing the LIP grant unless the work is carried out, Mr. Proft asked council to suggest ways in which the project could proceed, or ways in which the LIP grant can be utilized to improve parts of Hope and Camp Rivers.

Council referred the matter for study and agreed to have it placed on the agenda for the next inter-municipal committee meeting.

In conclusion Mr. Proft wrote, "our committee is receiving excellent co-operation from a variety of interested and concerned groups.

Entertainers wind up year

Members of the Golden Age Entertainment Club wound up the 1975 season on the weekend with performances at two Chilliwack area rest homes.

Bob Cook was master of ceremonies at the show held for residents of Hazelwood Home in Jake Wiens, Jimmy Peters, Lorena Strohmaeir and Melina Peterson. A Christmas program was presented with several traditional music selections. Mrs. Sylvia Reagan thanked the group for coming and lunch was served.

Work to provide new community park

Summer completion for Bell Slough project?

If work continues according to plans there should be a new community park and fishing spot in Chilliwack by early this summer.

The Bell Slough project has been underway for three weeks. Officials are optimistic the major part of the work will be finished before the water begins to rise in May.

The project, which will convert the slough into a fishing spot and community park, is sponsored by the Chilliwack Rotary Club. It is the first step in the Rotary's major plan to beautify the Hope River and Camp River systems.

Spokesman for the project Bernie Proft said the drag lines were brought into the Bell Slough at the end of January and have started the long job of cleaning out the debris.

The drag line and men to operate it have been supplied by Canadian Forces Base Chilliwack. "If it wasn't for the base the project would have been a dead issue," said Mr. Proft. There is no way the community could have afforded to have the drag lining done commercially. Cost of the work would have been close to $100,000 if the armed forces had not stepped in and offered its services, he said.

Other workers on the project have been supplied by a federal government Local Initiatives Program grant.

There will be no need to stock the Bell Slough fishing spot once the project is complete. The pond is a natural habitat for a small sport fish called Black Crappie. Each winter when the slough water recedes the fish die off in great numbers. The Rotary project will clean out the debris and provide a free flowing, year-round pond that will be able to support the fish through the winter.

The Rotary Club is hoping to eventually see the entire Hope and Camp River systems developed into park land. Mr. Proft noted the potential of the two systems is high but it will take a great deal of time and money to put the plan into action.

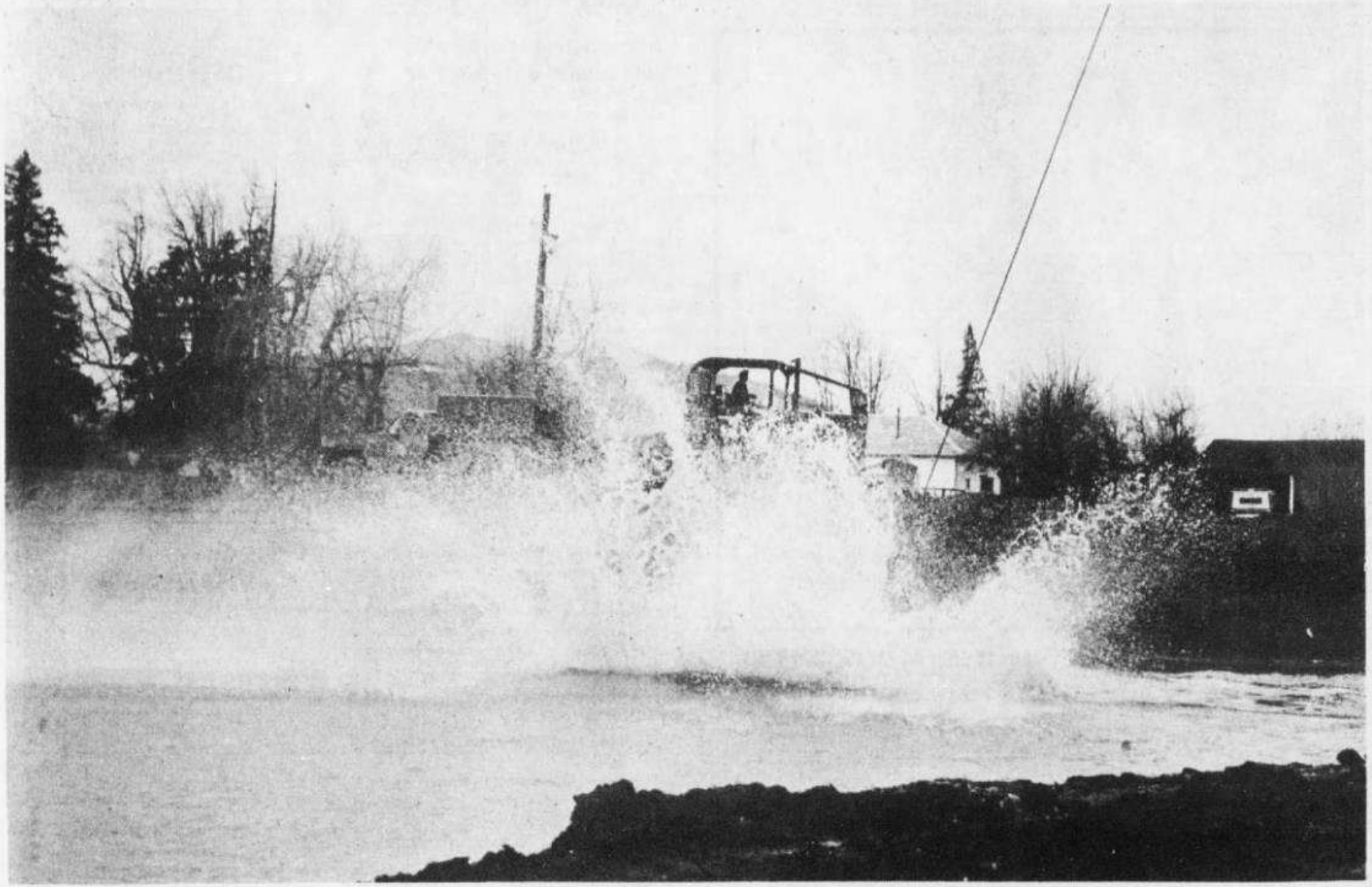
Mr. Proft said the Rotary is almost ready to let a contract to an engineering firm to draw up plans for the remainder of the project. There are many questions that must be answered he said. The plan must include proposals for establishing a permanent flowing water supply. If the rivers are improved many of the crossings will have to be altered also. No doubt the water in the rivers will have to be raised and the engineering plans will hopefully provide proposals for that phase of the project as well.

The Rotary Club spokesman believes the only way the major project will be completed is for other organizations to take on certain phases. This community just does not have the tax base to do the project itself, he said. Other non-publicly-funded bodies will have to pitch in and help. Hopefully other federal or provincial program grants will be available to supply workers for other phases of the proposal.

Mr. Proft said once the Rotary Club has finished its report on the proposed river development a presentation will be made to the councils seeking their support for the concept.

FROM SLOUGH TO FISHING SPOT — Chilliwack Rotary Club's Bell Slough project will transform this section of the waterway into a community park and fishing spot. Workers for the project have been supplied through a federal government Local Initiatives Program grant. The drag line was provided by CFB Chilliwack.

Pre-fishing splash



THE DRAG LINE — Canadian Forces Base Chilliwack has supplied the drag line and operators for the Rotary Club's Bell Slough project. Work is well under way now and officials are hopeful that the major part of the work will be finished this spring.

Work nears final stages at new Bell Slough park

Bell Slough has been getting a much-needed face lift through a Chilliwack Rotary Club project designed to transform the Hope and Camp River systems into a recreational area.

Bernie Proft, spokesman for the sponsoring committee, said work on the Bell Slough is progressing well. The dredging is now complete and once the water has receded work will begin on stabilizing the pond banks.

Mr. Proft said the committee will soon be meeting with the township parks superintendent and parks committee chairman Alderman Dorothy Kostrzewa to determine at what state the township would want the park turned over to them.

Once the Bell Slough project is complete the Rotary Club is hoping to tackle a similar site on the opposite side of Bell Road. The slough is a natural habitat for Black Crappie, a small sport fish. Each winter literally thousands of the fish die off, he said, because the water level recedes too far. The new fishing spot will be in use for next year's fishing season.

The Bell Slough work is the initial step in the club's long range project for both the Hope and Camp River systems. This stage of the work has been strongly supported by Canadian Forces Base Chilliwack with some funding provided through the federal government's Local Initiatives Program grant.

This year an engineering study will be held to determine the flow and levels of the river throughout the seasons. The year-long project will also pin-point the pollution sources along the waterway. That study should be complete in early 1977.

Mr. Proft explained if the river was being used only for recreation purposes there would be few problems. However the waterway borders many farms in the district so the committee must ensure this farm land is not jeopardized by drastically altering the river level.

The overall plan will aim at using the river for the best possible recreation purposes. Uses can vary from canoe routes and fishing sports to picnic areas and peaceful park settings as the river winds its way through the Chilliwack area. Chilliwack is fortunate to have a natural waterway running right through the centre of the community, he said. It should be put to good use.

Ideally the committee would like to see the river high enough and constantly moving so the water will stay clean and clear. How that can best be accomplished will be known after the engineering study is complete.

Chilliwack Rotary Club ways and means committee has been handling the initial work. A new committee has now been struck charged only with the responsibility of co-ordinating this project.

07/28/1976

Bell Slough — after and before

BEFORE AND AFTER? — Chilliwack Rotary Club's Bell Slough project is transforming a section of the waterway into a new park and fishing spot. Dredging is complete and the bank work is scheduled to begin soon. Top photo shows part of the recently cleared section. In the bottom photo is the section of the slough immediately across the road from the new park area, giving some indication of the progress made on the slough during the past few months. This site is being considered as the next step in the Rotary project.

February a time for changes . . .

New ideas, new plans were a major part of February in Chilliwack. Work was well under way for the Rotary Club's Bell Slough clean up program and YM-YWCA headquarters sent Ed Ewen to the community to assist in the Chilliwack Y's building campaign. Also during the month Jacques Trividic arrived to pave the way for opening the student Manpower centre. Protests were launched in the Chilliwack area over the increased car insurance rates and local motorists took part in a protest cavalcade to Vancouver.

BELL SLOUGH CLEAN UP

Helping to preserve a way of life

by JUDY WILLIAMS

Gone fishing!

A sign over a door that used to mean a way of life. According to Chilliwack fisheries officer Bruce Usher it's a way of life that is fast disappearing.

Bruce, formerly a Chilliwack school student and now a provincial government Fish and Wildlife officer, says unless the general public becomes concerned with providing future sports fishing and encourages programs promoting it, fishing will continue to deteriorate.

After a decade of working in fisheries projects, he has been involved with federal and provincial departments in all facets of salmon and fresh water fish.

He says there are two main goals for fisheries people . . . ensuring future fish for commercial ventures and sports recreation.

"Although there are only two major fish systems in the province, the Skeena and the Fraser, there are literally hundreds of tributaries," Bruce explained. "Some of these large tributaries are really access channels to the spawning grounds. Cut-throat trout, for instance, spawn in very small, shallow waterways hardly large enough to accommodate them. It is the destruction of these backwaters that has caused a good portion of the fish population to decrease."

He added that logging, an industry that has been so responsible for the economic growth of British Columbia, has until recently worked in direct opposition to fishing by inadvertently destroying spawning grounds.

"Today, they are just as aware of habitat protection as we are and are adopting better management programs," he pointed out.

This in essence, is Bruce's job . . . management of species of fish other than salmon. (However, as all fish use the same water, he does become somewhat involved with salmon.)

His territory extends from Sumas Way in Abbotsford to Spuzzum in the Fraser Canyon, from the Harrison drainage area in the north to the United States border in the south. Under his care are a number of fresh water species including steelhead, rainbow trout in lakes, white fish varieties, sturgeon, Dolly Varden char and a relatively unknown fish called a black crappie.

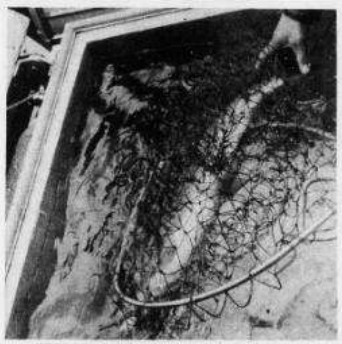
Black crappies, well known back east as a top quality pan fish, rarely weigh much; the world's record is five pounds and they run to about eight to 10 inches in length.

"Because there are relatively few people to maintain our areas," Bruce said, "the job doesn't home in on fish management as much as I'd like. I deal with other things such as habitat protection. Creel census work, float counts, egg takes, as a 'pure fisheries' work."

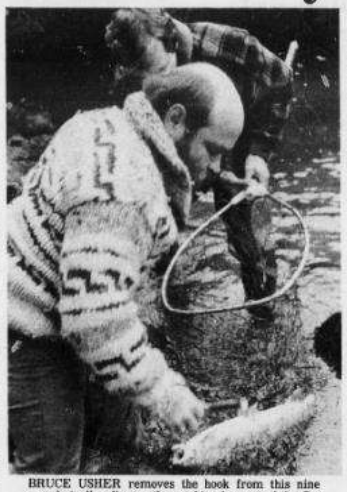
Since Fish and Wildlife officials now are called in to inspect permits for water licences, logging operations, subdivision applications, and any other project which might endanger wildlife and/or fish, things have been a bit easier. Dredging, in many rivers requires a permit. Sometimes things get hot under the collar as they have done with the dredging being done this year on the Vedder River.

Bruce explained, "The whole thing gets out of proportion when an operation like this is held up so that we can provide alternatives to protect fish. It somehow becomes man against fish. This is not the case at all. Flood protection has to be done and we know it, but it should be handled in such a way that when the first freshet pours down the Vedder, it doesn't take all the fresh spawn with it. Fisheries can always find a compromise to any problem because there is a solution that is acceptable to everyone."

Compromise comes in many forms. To fisheries officers like Bruce, it can result in rearing ponds being built by companies which realize that their work will make inroads on local fish populations. Such a situation resulted on the Coquihalla River east of Hope. An oil company putting through a pipeline created a large holding pond for steelhead fry. This has become a major steelhead management program which will, in future, benefit sports fishermen.



AFTER REMOVAL from her Coquihalla River home, this female steelhead has been transferred into a holding tank for transportation to the Abbotsford Hatchery. After a few moments of being gently moved about in the tank, she began swimming about as though it were the most natural place in the world for her to be. When the full complement of steelhead have been caught, they will represent the first management program of this kind at the Abbotsford Hatchery.



BRUCE USHER removes the hook from this nine pound steelhead's mouth on taking her out of the Coquihalla River to place here in a hatcheries holding tank. Later, she and about 17 to 20 other female steelhead will be placed in spacious quarters in the Abbotsford Hatchery where they will stay until next spring. Then, their eggs will be stripped, fertilized, and after hatching, the young fry will be returned to the Coquihalla River. In the background, Laird Siemens, fish culturist at the Abbotsford Hatchery, holds the net taut so the fish will not be bruised.

Co-operation between various branches of the government achieves prominent results also. A recent instance, was the dynamiting of some old beaver dams near Ford Mountain in the Chilliwack River area and the building of a new fish channel. This joint project of federal and provincial fisheries should help to increase future steelhead and coho runs.

A federally funded salmon enhancement program places its major emphasis on improving natural habitat. This appears to be the cheapest and most suitable method of fisheries enhancement. When natural sites are improved for spawning, fresh water fish as well as salmon benefit. A common estimate is that for every two salmon that spawn, five fish will return later to spawn again. Three of these will be taken by commercial fisheries and two will spawn thus continuing the circle. Bruce says this theory doesn't quite work out that way.

Another method of ensuring fish for the future is hatchery rearing. In Bruce's territory, steelhead are being taken live from the Coquihalla, transported in tanks to the Abbotsford Hatchery, and kept until spring at which time the eggs will be stripped from the females. Then, the eggs will be cared for until they hatch. The fry stay at the hatchery for a year and are then returned to the rearing pond on the Coquihalla River. It is hoped that this program will ensure the continuation of the summer runs in that area.

To Bruce, this represents "pure fisheries work" . . . this and projects such as the black crappie fishing pond on Bell Slough on Fairfield Island, Chilliwack. In co-operation with the local Rotary club members, Canadian Forces Base Chilliwack and Frank Cizhadia of the ministry of lands, gravel removal office, they dredged out a large 'fishing hole' and stocked the area with black crappies.

"These are wonderful fish for children's fishing," said Bruce. "And children who learn to love fishing and find it a good sport, will grow up to be adults who love fishing and care about retaining it."

He has also had two similar children's fishing ventures in the Sardis area which were for a short time only. He feels both were very successful in introducing children to the joys of sports fishing.

Bruce's other method of educating the public to fish is to enlist the aid of as many private individuals as possible for his annual float counts. Just as it sounds, this is a method of counting fish while floating down stream (wearing a wet suit, as our local streams are cold).

"The Vedder River float count in February is a major event," he stated. "For this, I need about 60 or 70 people and it takes about two days to plan. Forestry, federal and provincial people and members of local clubs all help out."

"Each two-man team is assigned about two miles of river to float down. They are accompanied by a tender-truck which is in radio contact with the base. His object is to get their counts as often as possible and relay them to the base."

Ideally, the entire river would be covered in one day, but so far the priority has been the main river from Chilliwack Lake to Slesse Creek. Below that, if the water is high, the river discolors and men cannot count fish. Other counts are taken in his district from December to May but are of a lesser nature.

Bruce says he likes to involve a great many non-branch personnel in his projects because it serves to educate them about fish.

"Once people become aware of fish, their life cycles, their habitat and so on, they become our allies. Then, they become aware of what we are up against. There are people in Vancouver who have never caught a fish. They have never experienced the thrill involved, the quiet, the relaxation of fishing, and we would like to change that.

"You can do a lot of mental therapy just fishing and that's an asset, especially in a fast society such as we live in."

Service club-township co-operate

Rotary Club LIP grant given two shots in arm

By BILL LILLICRAP

Chilliwack Rotary Club was told last week that its federal Local Initiatives Program (LIP) funds were being boosted in what amounted to two giant steps.

Rotary had planned its initial grant of $14,280 for continuing its earlier work on Bell Slough northeast of Chilliwack city.

Word released through the local Canada Manpower office in Chilliwack last Thursday indicated the grant would be increased by $85,680 (equal to 504 man-weeks) for a total grant of $99,960.

Then Chilliwhack township Mayor Bill Simpson confirmed with Mr. Proft and The Progress that the municipality's LIP grant for slough clearance was being added to the Rotary Club's funds in an effort to consolidate the funds from two similar projects into one.

Chairman of the Rotary Club's slough cleanup project Bernie Proft said the total grant funds, estimated at about $175,000, will enable them to hire workers through Manpower to continue the slough improvements this winter and spring on a number of fronts.

He said they hope to be able to finish a park at Bell Slough with picnic tables and other amenities for a family public park. Canoeing would also be a natural recreation addition to the area.

Plans are to embark on a cleanup of Camp River east of Rose Road for about three miles upstream as it meanders with Camp River Road.

Mr. Proft said work on channel clearing and spot clearing of underbrush will be started. He added that widening and possible raising of some low bridges would enable the use of about three miles of waterbody for canoeing on Camp River.

Further downstream in Hope River Mr. Proft said he has discussed with Chilliwack Kinsmen the possibility of that service club spearheading a cleanup on the north side of the river nearer Fairfield Island Hall and using labor provided by the Rotary LIP grant. Mr. Proft specified this would not involve the hall in any way. Those suggestions are still under discussions.

Mr. Proft said the total LIP funds to which Rotary Club has access represents close to 600 man weeks of work. He added, "we are grateful for the association and co-operation of the municipality in this venture."

Key staff members in the Rotary project were hired last week and it is believed others will be hired very soon. Project could begin in the next week or two.

$15,000 for Bell Slough park project

Chilliwack Rotary Club has alloted $15,000 for completion of a park area at Bell Slough.

Expenditure was approved last week at a club assembly. Expenditure is over and above Rotary-administered federal money being used for Camp-Hope Improvement project (CHIP) and will be raised through a variety of Rotary funding projects.

Heavy equipment section of Base Transport shown near completion of the Bell Slough project on Fairfield Island. In this project approximately 20,000 cubic yards of material were moved to make way for a senior citizens park.

Dike invites flood

A dike on the Bell Slough on Fairfield Island is causing flood problems, area residents say, and they want the district to correct it before spring.

Council in the past has approved subdivisions and greenhouses which are draining into the slough and increasing water levels, said residents spokesman Gerard Janmaat, who came to council Dec. 10 with a petition signed by 11 residents.

Residents want an outlet made in the dike which blocks the slough's original course.

High water levels have caused flooding in basements and on at least two acres of sloughbank, irrigation line and a well on Bell Creek Farms.

Janmaat also said continued flooding damages soil structure which results in a loss of crop yields.

"I believe the municipality can be held responsible for any compensation," he said, adding that residents want to have a say in any solution to the problem.

"We have to live with the consequences thereafter," he said, of so-called experts who think they know better than residents.

Ald. Clint Hames said there is also a problem with mosquitoes in the area due to the standing water.

Ald. Casey Langbroek asked staff to study the issue and bring a report to the next council meeting.

"I think there is cause for concern here and it should be addressed, but I think the appropriate way is through staff," Langbroek said.

Engineer Keith Paisley said staff have already collected some information and recommendations can be expected at the next council meeting.

Flooding solutions vetted for Bell dike

Bell Slough dike improvements will be included in the 1991 district budget to ease flooding concerns of area residents.

Mayor John Les suggested a more certain — and more expensive — solution to drain the slough, but resident Gerard Janmaat said a simple outlet through the dike would keep the water flowing year round.

District engineer Keith Paisley recommended building a $45,000 floodbox through the dike to deal with major storm events outside periods of high water on the Fraser River.

He also recommended that as funding comes available, culverts be installed to drain Bell Slough to Nelson Slough when the Fraser River water levels are high.

Estimated cost of the culverts is $81,500.

Paisley's recommendations followed Janmaat's complaint to council last week that subdivisions and greenhouses approved by council had added to the amount of water draining into the slough, flooding area basements and threatening soil quality with continued flooding.

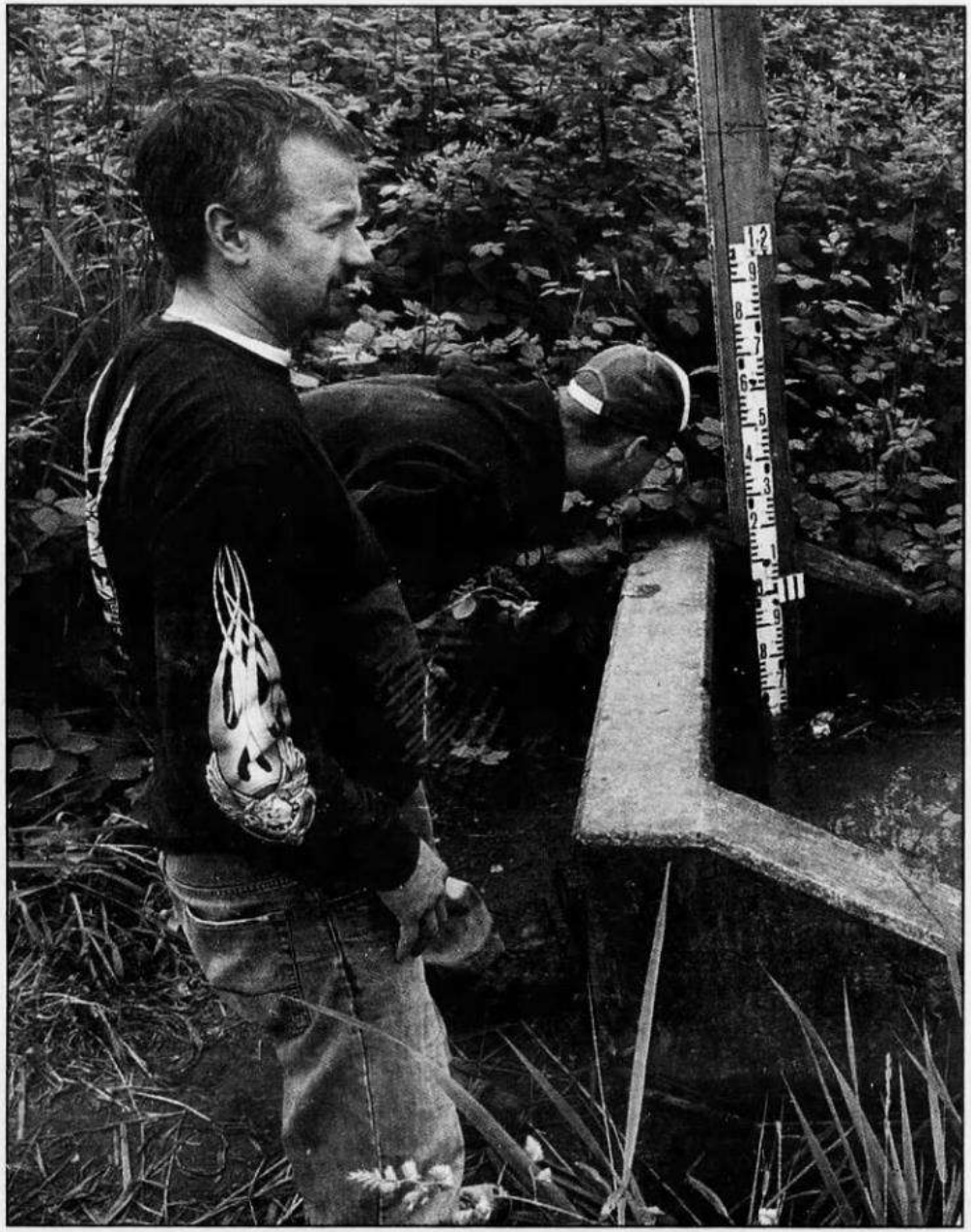
Paisley said the problem at the slough is the lack of a natural outlet to the Fraser River.

When the river is high, the only way for water to drain is "backward" toward the Nelson Slough.

When both the river level and the Nelson Slough water level is high, the only way to drain water would be by pumping. Paisley suggested such a scenario would happen only rarely.

Les noted that spending more on the culvert solution would almost guarantee a solution while the flood box would only work when water levels in the Nelson Slough are low.

JUST CHECKING



Kurt Buhl gets a close look at the Bell Slough gauge as Perry Dueck looks out over the Fraser River at Ballam and McDonald roads. JENNA HAUCK/ PROGRESS

District Contracts: An Island 22 Campground management contract was awarded to W.A. Webster who had the lowest qualifying bid of $72,000 for three years.

A one-ton truck, cab and chassis tender was accepted from low bidder Mertin Pontiac Buick GMC Ltd. for $17,908.

A 1½-ton truck, cab and chassis tender was accepted from Cherry Ford Sales Ltd. for $18,333. A turfsweeper, expected to save labor costs in park cleaning, was purchased from low bidder Fallis Equipment Ltd. for $18,226.

A contract to reduce dust on district roads was awarded to General Chemical Canada Ltd. to apply 390,000 litres of calcium chloride to district roads for $61,893.

An organic method using tree sap was tested on a section of Ballam Road last year but it was found to quickly wash away and was not recommended by staff. A road marking contract was awarded to Active Traffic Markers Ltd. for $58,801.

A contract to build a floodbox at Bell Slough was awarded to Genesis Enterprises Ltd. for $57,213.

Appendix C
ALS Laboratory Results

ALS Canada Ltd.

right solutions. right partner.

CERTIFICATE OF ANALYSIS

Work Order	: **VA22C6866**	Page	: 1 of 7
Client	: **City of Chilliwack**	Laboratory	: Vancouver - Environmental
Contact	: Tara Friesen	Account Manager	: Heather McKenzie
Address	: 8550 Young Road Chilliwack BC Canada V2P 8A4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: Bell Slough	Date Samples Received	: 04-Nov-2022 14:50
PO	: OP 10441	Date Analysis Commenced	: 04-Nov-2022
C-O-C number	: 20-1016081	Issue Date	: 16-Nov-2022 14:58
Sampler	: ----		
Site	: ----		
Quote number	: VA20-GMCK100-001		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Benjamin Oke	Lab Assistant	Metals, Burnaby, British Columbia
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Caitlin Macey	Team Leader - Inorganics	Microbiology, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.
Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no unit
µg/L	micrograms per litre
µS/cm	microsiemens per centimetre
mg/L	milligrams per litre
MPN/100mL	most probable number per 100 ml
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Workorder Comments

Water samples for mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

“Sample va22C6866-002 in this report was observed to have large, biological particulates (plant matter?) that could not be representatively subsampled during analysis for total organic carbon (TOC).
It is expected excluding the solids will add a potentially significant negative bias to the reported results.”

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*
HTD	*Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.*
RRR	*Refer to report comments for issues regarding this analysis.*

Analytical Results

Sub-Matrix: **Surface Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	N1	N3	N6	N8	N9
					Client sampling date / time	03-Nov-2022 09:30	03-Nov-2022 10:30	03-Nov-2022 12:00	03-Nov-2022 11:20	03-Nov-2022 11:00
						VA22C6866-001	VA22C6866-002	VA22C6866-003	VA22C6866-004	VA22C6866-005
						Result	Result	Result	Result	Result
Physical Tests										
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L		55.6	70.4	27.2	35.8	23.5
conductivity	----	E100	2.0	µS/cm		153	182	82.0	96.7	111
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L		54.1	64.1	23.7	29.2	23.0
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.60	mg/L		57.4	74.5	28.2	31.8	24.8
pH	----	E108	0.10	pH units		7.62	7.59	7.32	7.43	7.06
solids, total dissolved [TDS]	----	E162	10	mg/L		103	122	60	67	86
turbidity	----	E121	0.10	NTU		6.11	16.4	19.4	2.38	2.81
Anions and Nutrients										
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L		0.0114	0.100	0.0861	0.0330	0.0062
bromide	24959-67-9	E235.Br-L	0.050	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050
chloride	16887-00-6	E235.Cl	0.50	mg/L		9.28	9.73	5.26	5.99	14.8
fluoride	16984-48-8	E235.F	0.020	mg/L		0.043	0.044	<0.020	0.023	<0.020
Kjeldahl nitrogen, total [TKN]	----	E318	0.050	mg/L		1.38	10.5	4.62	0.739	0.783
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L		<0.0050 HTD	<0.0050 HTD	0.0172	0.0320	<0.0050
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L		<0.0010	<0.0010 HTD	<0.0010	0.0012	<0.0010
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		0.0629	0.158	0.110	0.0548	0.0448
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		0.187	1.95	0.699	0.116	0.162
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L		3.92	0.75	<0.30	<0.30	3.42
Organic / Inorganic Carbon										
carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L		8.01	11.8	6.78	6.03	8.50
carbon, total organic [TOC]	----	E355-L	0.50	mg/L		7.89	40.7 RRR	10.2	6.37	7.54
Microbiological Tests										
coliforms, thermotolerant [fecal]	----	E010.FC	1	MPN/100mL		21	145	435	52	44
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL		11	16	435	31	42
Total Metals										
aluminum, total	7429-90-5	E420	0.0030	mg/L		0.0840	0.0630	0.237	0.0376	0.0308
antimony, total	7440-36-0	E420	0.00010	mg/L		0.00026	0.00011	0.00012	<0.00010	<0.00010
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.00240	0.00189	0.00143	0.00065	0.00066
barium, total	7440-39-3	E420	0.00010	mg/L		0.0302	0.0347	0.0270	0.0120	0.0139

Analytical Results

Sub-Matrix: **Surface Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	N1	N3	N6	N8	N9
					Client sampling date / time	03-Nov-2022 09:30	03-Nov-2022 10:30	03-Nov-2022 12:00	03-Nov-2022 11:20	03-Nov-2022 11:00
						VA22C6866-001	VA22C6866-002	VA22C6866-003	VA22C6866-004	VA22C6866-005
						Result	Result	Result	Result	Result
Total Metals										
beryllium, total	7440-41-7	E420	0.000100	mg/L		<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	7440-42-8	E420	0.010	mg/L		<0.010	0.037	0.013	<0.010	<0.010
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000113	0.0000163	0.0000202	<0.0000050	0.0000071
calcium, total	7440-70-2	E420	0.050	mg/L		14.0	18.5	7.33	8.82	6.74
cesium, total	7440-46-2	E420	0.000010	mg/L		<0.000010	<0.000010	0.000017	0.000013	<0.000010
chromium, total	7440-47-3	E420	0.00050	mg/L		<0.00050	<0.00050	0.00073	<0.00050	<0.00050
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00061	0.00208	0.00098	0.00022	0.00116
copper, total	7440-50-8	E420	0.00050	mg/L		0.00126	0.00104	0.00176	0.00073	0.00062
iron, total	7439-89-6	E420	0.010	mg/L		1.99	5.98	2.52	0.917	1.79
lead, total	7439-92-1	E420	0.000050	mg/L		0.000151	0.000312	0.000459	0.000215	0.000100
lithium, total	7439-93-2	E420	0.0010	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
magnesium, total	7439-95-4	E420	0.0050	mg/L		5.45	6.87	2.40	2.37	1.95
manganese, total	7439-96-5	E420	0.00010	mg/L		0.104	0.541	0.197	0.0109	0.137
mercury, total	7439-97-6	E508	0.0000050	mg/L		<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.000234	0.000299	0.000219	0.000149	0.000100
nickel, total	7440-02-0	E420	0.00050	mg/L		0.00260	0.00289	0.00203	0.00147	0.00808
phosphorus, total	7723-14-0	E420	0.050	mg/L		0.207	1.90	0.956	0.126	0.177
potassium, total	7440-09-7	E420	0.050	mg/L		10.9	17.0	9.04	7.30	10.3
rubidium, total	7440-17-7	E420	0.00020	mg/L		0.00327	0.00629	0.00300	0.00263	0.00312
selenium, total	7782-49-2	E420	0.000050	mg/L		0.000086	0.000117	<0.000050	<0.000050	<0.000050
silicon, total	7440-21-3	E420	0.10	mg/L		1.67	3.08	0.99	1.18	2.82
silver, total	7440-22-4	E420	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	7440-23-5	E420	0.050	mg/L		4.63	5.54	3.04	4.30	7.29
strontium, total	7440-24-6	E420	0.00020	mg/L		0.0650	0.0866	0.0393	0.0462	0.0251
sulfur, total	7704-34-9	E420	0.50	mg/L		1.73	1.27	<0.50	<0.50	1.50
tellurium, total	13494-80-9	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	7440-28-0	E420	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	7440-29-1	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	7440-31-5	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

Analytical Results

Sub-Matrix: **Surface Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	N1	N3	N6	N8	N9
					Client sampling date / time	03-Nov-2022 09:30	03-Nov-2022 10:30	03-Nov-2022 12:00	03-Nov-2022 11:20	03-Nov-2022 11:00
						VA22C6866-001	VA22C6866-002	VA22C6866-003	VA22C6866-004	VA22C6866-005
						Result	Result	Result	Result	Result
Total Metals										
titanium, total	7440-32-6	E420	0.00030	mg/L		0.00291	0.00206	0.00861	0.00163	0.00088
tungsten, total	7440-33-7	E420	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000047	0.000014	0.000019	<0.000010	<0.000010
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00084	0.00050	0.00093	0.00056	<0.00050
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0122	0.0133	0.0132	0.0047	0.0210
zirconium, total	7440-67-7	E420	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0204	0.0167	0.0371	0.0279	0.0235
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00021	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00173	0.00105	0.00083	0.00058	0.00049
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0276	0.0180	0.0127	0.0115	0.0126
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, dissolved	7440-42-8	E421	0.010	mg/L		<0.010	<0.010	<0.010	<0.010	<0.010
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		0.0000065	0.0000058	<0.0000050	0.0000065	0.0000142
calcium, dissolved	7440-70-2	E421	0.050	mg/L		13.6	16.1	6.36	8.17	6.38
cesium, dissolved	7440-46-2	E421	0.000010	mg/L		<0.000010	<0.000010	<0.000010	0.000011	<0.000010
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00046	0.00077	0.00032	0.00019	0.00091
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00092	0.00043	0.00052	0.00072	0.00058
iron, dissolved	7439-89-6	E421	0.010	mg/L		1.02	2.83	0.950	0.796	1.33
lead, dissolved	7439-92-1	E421	0.000050	mg/L		0.000067	0.000123	0.000128	0.000202	0.000083
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L		4.90	5.80	1.89	2.15	1.72
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.0788	0.192	0.0697	0.00974	0.108
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.000254	0.000125	0.000135	0.000126	0.000115
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.00218	0.00213	0.00097	0.00153	0.00691
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L		0.121	0.536	0.340	0.118	0.110
potassium, dissolved	7440-09-7	E421	0.050	mg/L		9.87	12.0	7.08	6.59	8.98

Analytical Results

Sub-Matrix: **Surface Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	N1	N3	N6	N8	N9
					Client sampling date / time	03-Nov-2022 09:30	03-Nov-2022 10:30	03-Nov-2022 12:00	03-Nov-2022 11:20	03-Nov-2022 11:00
						VA22C6866-001	VA22C6866-002	VA22C6866-003	VA22C6866-004	VA22C6866-005
						Result	Result	Result	Result	Result
Dissolved Metals										
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L		0.00308	0.00406	0.00211	0.00230	0.00284
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000075	0.000064	<0.000050	<0.000050	<0.000050
silicon, dissolved	7440-21-3	E421	0.050	mg/L		1.50	2.76	0.600	1.10	2.58
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, dissolved	7440-23-5	E421	0.050	mg/L		4.15	4.91	2.77	3.92	6.22
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		0.0600	0.0713	0.0263	0.0399	0.0230
sulfur, dissolved	7704-34-9	E421	0.50	mg/L		1.44	<0.50	<0.50	<0.50	1.20
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, dissolved	7440-29-1	E421	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, dissolved	7440-32-6	E421	0.00030	mg/L		0.00066	<0.00090 DLM	0.00137	0.00130	0.00067
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000036	<0.000010	<0.000010	<0.000010	<0.000010
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
zinc, dissolved	7440-66-6	E421	0.0010	mg/L		0.0084	0.0055	0.0056	0.0035	0.0141
zirconium, dissolved	7440-67-7	E421	0.00020	mg/L		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
dissolved mercury filtration location	----	EP509	-	-		Field	Field	Field	Field	Field
dissolved metals filtration location	----	EP421	-	-		Field	Field	Field	Field	Field
Plant Pigments										
chlorophyll a	479-61-8	E870	0.010	µg/L		60.1	224	2010	10.5	7.48

Please refer to the General Comments section for an explanation of any qualifiers detected.

ALS Canada Ltd.

QUALITY CONTROL REPORT

Work Order	: **VA22C6866**	Page	: 1 of 18
Client	: City of Chilliwack	Laboratory	: Vancouver - Environmental
Contact	: Tara Friesen	Account Manager	: Heather McKenzie
Address	: 8550 Young Road Chilliwack BC Canada V2P 8A4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	:	Telephone	: +1 604 253 4188
Project	: Bell Slough	Date Samples Received	: 04-Nov-2022 14:50
PO	: OP 10441	Date Analysis Commenced	: 04-Nov-2022
C-O-C number	: 20-1016081	Issue Date	: 16-Nov-2022 14:57
Sampler	: ---- ----		
Site	: ----		
Quote number	: VA20-GMCK100-001		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Matrix Spike (MS) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Vancouver Metals, Burnaby, British Columbia
Benjamin Oke	Lab Assistant	Vancouver Metals, Burnaby, British Columbia
Caitlin Macey	Team Leader - Inorganics	Vancouver Inorganics, Burnaby, British Columbia
Caitlin Macey	Team Leader - Inorganics	Vancouver Microbiology, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Vancouver Inorganics, Burnaby, British Columbia
Owen Cheng		Vancouver Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Vancouver Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Vancouver Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 731594)											
VA22C6866-003	N6	pH	----	E108	0.10	pH units	7.32	7.32	0.00%	4%	----
Physical Tests (QC Lot: 731595)											
VA22C6866-003	N6	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	27.2	29.2	7.14%	20%	----
Physical Tests (QC Lot: 731596)											
VA22C6866-003	N6	conductivity	----	E100	2.0	µS/cm	82.0	82.8	0.971%	10%	----
Physical Tests (QC Lot: 732061)											
FJ2203139-001	Anonymous	turbidity	----	E121	0.10	NTU	22.5	21.5	4.27%	15%	----
Physical Tests (QC Lot: 732062)											
VA22C6866-003	N6	turbidity	----	E121	0.10	NTU	19.4	18.4	5.50%	15%	----
Physical Tests (QC Lot: 732155)											
VA22C6729-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	312	295	5.77%	20%	----
Anions and Nutrients (QC Lot: 731598)											
VA22C6866-001	N1	fluoride	16984-48-8	E235.F	0.020	mg/L	0.043	0.042	0.0008	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 731599)											
VA22C6866-001	N1	chloride	16887-00-6	E235.Cl	0.50	mg/L	9.28	9.27	0.128%	20%	----
Anions and Nutrients (QC Lot: 731600)											
VA22C6866-001	N1	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 731601)											
VA22C6866-001	N1	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 731602)											
VA22C6866-001	N1	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 731603)											
VA22C6866-001	N1	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	3.92	3.96	0.887%	20%	----
Anions and Nutrients (QC Lot: 731605)											
VA22C6866-001	N1	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0100	mg/L	0.0629	0.0657	0.0028	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 733595)											
VA22C6840-001	Anonymous	Kjeldahl nitrogen, total [TKN]	----	E318	0.050	mg/L	0.139	0.155	0.016	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 733598)											
VA22C6840-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0033	0.0030	0.0003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 733599)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Anions and Nutrients (QC Lot: 733599) - continued											
VA22C6840-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Organic / Inorganic Carbon (QC Lot: 733596)											
VA22C6840-001	Anonymous	carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L	4.48	4.70	0.22	Diff <2x LOR	----
Organic / Inorganic Carbon (QC Lot: 733597)											
VA22C6840-001	Anonymous	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	4.75	5.13	0.39	Diff <2x LOR	----
Microbiological Tests (QC Lot: 730764)											
VA22C6829-001	Anonymous	coliforms, thermotolerant [fecal]	----	E010.FC	1	MPN/100mL	<1	<1	0	Diff <2x LOR	----
Microbiological Tests (QC Lot: 730985)											
VA22C6848-001	Anonymous	coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	<1	0	Diff <2x LOR	----
Total Metals (QC Lot: 734010)											
VA22C6670-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cesium, total	7440-46-2	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	2.00	mg/L	<2.00	<2.00	0	Diff <2x LOR	----
		rubidium, total	7440-17-7	E420	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Total Metals (QC Lot: 734010) - continued											
VA22C6670-001	Anonymous	silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	<0.10	0	Diff <2x LOR	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	7440-23-5	E420	2.00	mg/L	<2.00	<2.00	0	Diff <2x LOR	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		sulfur, total	7704-34-9	E420	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
		tellurium, total	13494-80-9	E420	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		thorium, total	7440-29-1	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		tungsten, total	7440-33-7	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
		zirconium, total	7440-67-7	E420	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
Total Metals (QC Lot: 739716)											
VA22C6811-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 737456)											
VA22C6806-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0200	mg/L	<0.0200	<0.0200	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00200	mg/L	0.00508	0.00528	0.00020	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00200	mg/L	0.0185	0.0182	0.00033	Diff <2x LOR	----
		beryllium, dissolved	7440-41-7	E421	0.000400	mg/L	<0.000400	<0.000400	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.200	mg/L	4.41	4.08	7.82%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	1.00	mg/L	626	595	5.11%	20%	----
		cesium, dissolved	7440-46-2	E421	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		chromium, dissolved	7440-47-3	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00400	mg/L	<0.00400	<0.00400	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.200	mg/L	<0.200	<0.200	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0200	mg/L	0.0446	0.0425	0.0022	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 737456) - continued											
VA22C6806-001	Anonymous	magnesium, dissolved	7439-95-4	E421	0.100	mg/L	3770	3590	4.98%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00200	mg/L	0.00439	0.00387	0.00053	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.00100	mg/L	0.0448	0.0420	6.44%	20%	----
		nickel, dissolved	7440-02-0	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	1.00	mg/L	359	350	2.59%	20%	----
		rubidium, dissolved	7440-17-7	E421	0.00400	mg/L	0.0453	0.0433	4.47%	20%	----
		selenium, dissolved	7782-49-2	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		sodium, dissolved	7440-23-5	E421	1.00	mg/L	4680	4500	3.81%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00400	mg/L	11.7	11.3	3.25%	20%	----
		sulfur, dissolved	7704-34-9	E421	10.0	mg/L	8620	8210	4.82%	20%	----
		tellurium, dissolved	13494-80-9	E421	0.00400	mg/L	<0.00400	<0.00400	0	Diff <2x LOR	----
		thallium, dissolved	7440-28-0	E421	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		thorium, dissolved	7440-29-1	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00600	mg/L	<0.00600	<0.00600	0	Diff <2x LOR	----
		tungsten, dissolved	7440-33-7	E421	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000200	mg/L	0.0154	0.0142	7.68%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0200	mg/L	<0.0200	<0.0200	0	Diff <2x LOR	----
		zirconium, dissolved	7440-67-7	E421	0.00400	mg/L	<0.00400	<0.00400	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 738230)											
VA22C6666-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 731595)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 731596)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 732061)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 732062)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 732155)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 731598)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 731599)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 731600)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 731601)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 731602)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 731603)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 731605)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 733595)						
Kjeldahl nitrogen, total [TKN]	----	E318	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 733598)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 733599)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Organic / Inorganic Carbon (QCLot: 733596)						
carbon, dissolved organic [DOC]	----	E358-L	0.5	mg/L	<0.50	----
Organic / Inorganic Carbon (QCLot: 733597)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Organic / Inorganic Carbon (QCLot: 733597) - continued						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----
Microbiological Tests (QCLot: 730764)						
coliforms, thermotolerant [fecal]	----	E010.FC	1	MPN/100mL	<1	----
Microbiological Tests (QCLot: 730985)						
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	----
Total Metals (QCLot: 734010)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	MBRR
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cesium, total	7440-46-2	E420	0.00001	mg/L	<0.000010	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
rubidium, total	7440-17-7	E420	0.0002	mg/L	<0.00020	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 734010) - continued						
tellurium, total	13494-80-9	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
thorium, total	7440-29-1	E420	0.0001	mg/L	<0.00010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
tungsten, total	7440-33-7	E420	0.0001	mg/L	<0.00010	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
zirconium, total	7440-67-7	E420	0.0002	mg/L	<0.00020	----
Total Metals (QCLot: 739716)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 737456)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cesium, dissolved	7440-46-2	E421	0.00001	mg/L	<0.000010	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 737456) - continued						
rubidium, dissolved	7440-17-7	E421	0.0002	mg/L	<0.00020	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
tellurium, dissolved	13494-80-9	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
thorium, dissolved	7440-29-1	E421	0.0001	mg/L	<0.00010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
tungsten, dissolved	7440-33-7	E421	0.0001	mg/L	<0.00010	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	<0.00020	----
Dissolved Metals (QCLot: 738230)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Plant Pigments (QCLot: 742488)						
chlorophyll a	479-61-8	E870	0.01	µg/L	<0.010	----

Qualifiers

Qualifier	Description
MBRR	*Initial MB for this submission had positive results for flagged analyte (data not shown). Low level samples were repeated with new QC (2nd MB results shown). High level results (>5x initial MB level) and non-detect results were reported and are defensible*

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 731594)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 731595)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 731596)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	95.0	90.0	110	----
Physical Tests (QCLot: 732061)									
turbidity	----	E121	0.1	NTU	200 NTU	102	85.0	115	----
Physical Tests (QCLot: 732062)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 732155)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	103	85.0	115	----
Anions and Nutrients (QCLot: 731598)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	97.1	90.0	110	----
Anions and Nutrients (QCLot: 731599)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 731600)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	97.4	85.0	115	----
Anions and Nutrients (QCLot: 731601)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 731602)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 731603)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 731605)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	92.5	80.0	120	----
Anions and Nutrients (QCLot: 733595)									
Kjeldahl nitrogen, total [TKN]	----	E318	0.05	mg/L	4 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 733598)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	94.3	80.0	120	----
Anions and Nutrients (QCLot: 733599)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	99.7	85.0	115	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Organic / Inorganic Carbon (QCLot: 733596)									
carbon, dissolved organic [DOC]	----	E358-L	0.5	mg/L	8.57 mg/L	102	80.0	120	----
Organic / Inorganic Carbon (QCLot: 733597)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	102	80.0	120	----
Total Metals (QCLot: 734010)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	103	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	110	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	100	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	106	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
cesium, total	7440-46-2	E420	0.00001	mg/L	0.05 mg/L	103	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	104	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	106	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	107	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
rubidium, total	7440-17-7	E420	0.0002	mg/L	0.1 mg/L	109	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	110	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	106	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	99.2	80.0	120	----
sodium, total	7440-23-5	E420	0.05	mg/L	50 mg/L	108	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
sulfur, total	7704-34-9	E420	0.5	mg/L	50 mg/L	102	80.0	120	----
tellurium, total	13494-80-9	E420	0.0002	mg/L	0.1 mg/L	99.3	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 734010) - continued									
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	107	80.0	120	----
thorium, total	7440-29-1	E420	0.0001	mg/L	0.1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	103	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	100	80.0	120	----
tungsten, total	7440-33-7	E420	0.0001	mg/L	0.1 mg/L	103	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	109	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	107	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
zirconium, total	7440-67-7	E420	0.0002	mg/L	0.1 mg/L	104	80.0	120	----
Total Metals (QCLot: 739716)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	96.4	80.0	120	----
Dissolved Metals (QCLot: 737456)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	95.7	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	95.5	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.0	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	96.6	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	90.0	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	92.6	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.1	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	97.5	80.0	120	----
cesium, dissolved	7440-46-2	E421	0.00001	mg/L	0.05 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	92.4	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	91.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	93.5	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	98.7	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	96.3	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	95.5	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	94.5	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	92.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	100	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	93.4	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	93.8	80.0	120	----
rubidium, dissolved	7440-17-7	E421	0.0002	mg/L	0.1 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 737456) - continued									
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	100	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	97.3	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	90.4	80.0	120	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	50 mg/L	92.9	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.5	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	83.1	80.0	120	----
tellurium, dissolved	13494-80-9	E421	0.0002	mg/L	0.1 mg/L	100	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	96.2	80.0	120	----
thorium, dissolved	7440-29-1	E421	0.0001	mg/L	0.1 mg/L	97.9	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	95.5	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	89.9	80.0	120	----
tungsten, dissolved	7440-33-7	E421	0.0001	mg/L	0.1 mg/L	95.6	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	105	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	95.9	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	90.5	80.0	120	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	0.1 mg/L	98.5	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	99.7	80.0	120	----
Plant Pigments (QCLot: 742488)									
chlorophyll a	479-61-8	E870	0.01	µg/L	5 µg/L	88.4	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 731598)										
VA22C6866-002	N3	fluoride	16984-48-8	E235.F	0.948 mg/L	1 mg/L	94.8	75.0	125	----
Anions and Nutrients (QCLot: 731599)										
VA22C6866-002	N3	chloride	16887-00-6	E235.Cl	98.3 mg/L	100 mg/L	98.3	75.0	125	----
Anions and Nutrients (QCLot: 731600)										
VA22C6866-002	N3	bromide	24959-67-9	E235.Br-L	0.496 mg/L	0.5 mg/L	99.2	75.0	125	----
Anions and Nutrients (QCLot: 731601)										
VA22C6866-002	N3	nitrate (as N)	14797-55-8	E235.NO3-L	2.48 mg/L	2.5 mg/L	99.0	75.0	125	----
Anions and Nutrients (QCLot: 731602)										
VA22C6866-002	N3	nitrite (as N)	14797-65-0	E235.NO2-L	0.460 mg/L	0.5 mg/L	92.0	75.0	125	----
Anions and Nutrients (QCLot: 731603)										
VA22C6866-002	N3	sulfate (as SO4)	14808-79-8	E235.SO4	98.0 mg/L	100 mg/L	98.0	75.0	125	----
Anions and Nutrients (QCLot: 731605)										
VA22C6866-002	N3	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	ND mg/L	0.03 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 733595)										
VA22C6840-002	Anonymous	Kjeldahl nitrogen, total [TKN]	----	E318	2.91 mg/L	2.5 mg/L	116	70.0	130	----
Anions and Nutrients (QCLot: 733598)										
VA22C6840-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0469 mg/L	0.05 mg/L	93.8	70.0	130	----
Anions and Nutrients (QCLot: 733599)										
VA22C6840-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.102 mg/L	0.1 mg/L	102	75.0	125	----
Organic / Inorganic Carbon (QCLot: 733596)										
VA22C6840-002	Anonymous	carbon, dissolved organic [DOC]	----	E358-L	4.94 mg/L	5 mg/L	98.8	70.0	130	----
Organic / Inorganic Carbon (QCLot: 733597)										
VA22C6840-002	Anonymous	carbon, total organic [TOC]	----	E355-L	5.10 mg/L	5 mg/L	102	70.0	130	----
Total Metals (QCLot: 734010)										
VA22C6670-002	Anonymous	aluminum, total	7429-90-5	E420	0.199 mg/L	0.2 mg/L	99.4	70.0	130	----
		antimony, total	7440-36-0	E420	0.0210 mg/L	0.02 mg/L	105	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 734010) - continued										
VA22C6670-002	Anonymous	beryllium, total	7440-41-7	E420	0.0393 mg/L	0.04 mg/L	98.2	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00961 mg/L	0.01 mg/L	96.1	70.0	130	----
		boron, total	7440-42-8	E420	0.099 mg/L	0.1 mg/L	98.8	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00408 mg/L	0.004 mg/L	102	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cesium, total	7440-46-2	E420	0.0102 mg/L	0.01 mg/L	102	70.0	130	----
		chromium, total	7440-47-3	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0195 mg/L	0.02 mg/L	97.4	70.0	130	----
		copper, total	7440-50-8	E420	0.0189 mg/L	0.02 mg/L	94.3	70.0	130	----
		iron, total	7439-89-6	E420	1.99 mg/L	2 mg/L	99.4	70.0	130	----
		lead, total	7439-92-1	E420	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		lithium, total	7439-93-2	E420	0.0950 mg/L	0.1 mg/L	95.0	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	0.0391 mg/L	0.04 mg/L	97.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.7 mg/L	10 mg/L	107	70.0	130	----
		potassium, total	7440-09-7	E420	3.91 mg/L	4 mg/L	97.7	70.0	130	----
		rubidium, total	7440-17-7	E420	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		selenium, total	7782-49-2	E420	0.0432 mg/L	0.04 mg/L	108	70.0	130	----
		silicon, total	7440-21-3	E420	9.53 mg/L	10 mg/L	95.3	70.0	130	----
		silver, total	7440-22-4	E420	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, total	7440-23-5	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, total	7704-34-9	E420	ND mg/L	20 mg/L	ND	70.0	130	----
		tellurium, total	13494-80-9	E420	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		thallium, total	7440-28-0	E420	0.00394 mg/L	0.004 mg/L	98.5	70.0	130	----
		thorium, total	7440-29-1	E420	0.0209 mg/L	0.02 mg/L	105	70.0	130	----
		tin, total	7440-31-5	E420	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		titanium, total	7440-32-6	E420	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		tungsten, total	7440-33-7	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		uranium, total	7440-61-1	E420	0.00414 mg/L	0.004 mg/L	103	70.0	130	----
		vanadium, total	7440-62-2	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, total	7440-66-6	E420	0.387 mg/L	0.4 mg/L	96.7	70.0	130	----
		zirconium, total	7440-67-7	E420	0.0423 mg/L	0.04 mg/L	106	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 739716)										
VA22C6811-002	Anonymous	mercury, total	7439-97-6	E508	0.0000966 mg/L	0.0001 mg/L	96.6	70.0	130	----
Dissolved Metals (QCLot: 737456)										
VA22C6806-002	Anonymous	aluminum, dissolved	7429-90-5	E421	3.75 mg/L	4 mg/L	93.8	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.395 mg/L	0.4 mg/L	98.7	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.378 mg/L	0.4 mg/L	94.6	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.395 mg/L	0.4 mg/L	98.7	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.766 mg/L	0.8 mg/L	95.8	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.182 mg/L	0.2 mg/L	91.0	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.0772 mg/L	0.08 mg/L	96.5	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	80 mg/L	ND	70.0	130	----
		cesium, dissolved	7440-46-2	E421	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.741 mg/L	0.8 mg/L	92.6	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.360 mg/L	0.4 mg/L	90.1	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.350 mg/L	0.4 mg/L	87.4	70.0	130	----
		iron, dissolved	7439-89-6	E421	37.2 mg/L	40 mg/L	93.1	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.359 mg/L	0.4 mg/L	89.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	1.94 mg/L	2 mg/L	96.9	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.354 mg/L	0.4 mg/L	88.4	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.405 mg/L	0.4 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.708 mg/L	0.8 mg/L	88.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	204 mg/L	200 mg/L	102	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	80 mg/L	ND	70.0	130	----
		rubidium, dissolved	7440-17-7	E421	0.378 mg/L	0.4 mg/L	94.5	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.794 mg/L	0.8 mg/L	99.3	70.0	130	----
		silicon, dissolved	7440-21-3	E421	180 mg/L	200 mg/L	90.0	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0738 mg/L	0.08 mg/L	92.2	70.0	130	----
		sodium, dissolved	7440-23-5	E421	ND mg/L	40 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.4 mg/L	ND	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	ND mg/L	400 mg/L	ND	70.0	130	----
		tellurium, dissolved	13494-80-9	E421	0.774 mg/L	0.8 mg/L	96.7	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0714 mg/L	0.08 mg/L	89.3	70.0	130	----
		thorium, dissolved	7440-29-1	E421	0.373 mg/L	0.4 mg/L	93.3	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.386 mg/L	0.4 mg/L	96.6	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 737456) - continued										
VA22C6806-002	Anonymous	titanium, dissolved	7440-32-6	E421	0.743 mg/L	0.8 mg/L	92.9	70.0	130	----
		tungsten, dissolved	7440-33-7	E421	0.379 mg/L	0.4 mg/L	94.8	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.0794 mg/L	0.08 mg/L	99.2	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	1.90 mg/L	2 mg/L	95.1	70.0	130	----
		zinc, dissolved	7440-66-6	E421	7.00 mg/L	8 mg/L	87.5	70.0	130	----
		zirconium, dissolved	7440-67-7	E421	0.811 mg/L	0.8 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 738230)										
VA22C6666-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.000106 mg/L	0.0001 mg/L	106	70.0	130	----

ALS Canada Ltd.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22C6866**	Page	: 1 of 23
Client	: **City of Chilliwack**	Laboratory	: Vancouver - Environmental
Contact	: Tara Friesen	Account Manager	: Heather McKenzie
Address	: 8550 Young Road Chilliwack BC Canada V2P 8A4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: Bell Slough	Date Samples Received	: 04-Nov-2022 14:50
PO	: OP 10441	Issue Date	: 16-Nov-2022 14:57
C-O-C number	: 20-1016081		
Sampler	: ----		
Site	: ----		
Quote number	: VA20-GMCK100-001		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) N1	E298	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) N3	E298	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) N6	E298	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) N8	E298	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) N9	E298	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE N1	E235.Br-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE N3	E235.Br-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE N6	E235.Br-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE N8	E235.Br-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE N9	E235.Br-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE N1	E235.Cl	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE N3	E235.Cl	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE N6	E235.Cl	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE N8	E235.Cl	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE N9	E235.Cl	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE N1	E378-U	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE N3	E378-U	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE N6	E378-U	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE N8	E378-U	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE N9	E378-U	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE N1	E235.F	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE N3	E235.F	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE N6	E235.F	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE N8	E235.F	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE N9	E235.F	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE N1	E235.NO3-L	03-Nov-2022	05-Nov-2022	3 days	2 days	✓	05-Nov-2022	3 days	0 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE N3	E235.NO3-L	03-Nov-2022	05-Nov-2022	3 days	2 days	✓	05-Nov-2022	3 days	0 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE N6	E235.NO3-L	03-Nov-2022	05-Nov-2022	3 days	2 days	✓	05-Nov-2022	3 days	0 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE N8	E235.NO3-L	03-Nov-2022	05-Nov-2022	3 days	2 days	✓	05-Nov-2022	3 days	0 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE N9	E235.NO3-L	03-Nov-2022	05-Nov-2022	3 days	2 days	✓	05-Nov-2022	3 days	0 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE N1	E235.NO2-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE N3	E235.NO2-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE N6	E235.NO2-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
N8	E235.NO2-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
N9	E235.NO2-L	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
N1	E235.SO4	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
N3	E235.SO4	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
N6	E235.SO4	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
N8	E235.SO4	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
N9	E235.SO4	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Anions and Nutrients : Total Kjeldahl Nitrogen by Fluorescence (Low Level)										
Amber glass total (sulfuric acid)										
N1	E318	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Total Kjeldahl Nitrogen by Fluorescence (Low Level)										
Amber glass total (sulfuric acid)										
N3	E318	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Kjeldahl Nitrogen by Fluorescence (Low Level)										
Amber glass total (sulfuric acid)										
N6	E318	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Total Kjeldahl Nitrogen by Fluorescence (Low Level)										
Amber glass total (sulfuric acid)										
N8	E318	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Total Kjeldahl Nitrogen by Fluorescence (Low Level)										
Amber glass total (sulfuric acid)										
N9	E318	03-Nov-2022	07-Nov-2022	----	----		15-Nov-2022	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (0.002 mg/L)										
Amber glass total (sulfuric acid)										
N1	E372-U	03-Nov-2022	07-Nov-2022	----	----		08-Nov-2022	28 days	5 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (0.002 mg/L)										
Amber glass total (sulfuric acid)										
N3	E372-U	03-Nov-2022	07-Nov-2022	----	----		08-Nov-2022	28 days	5 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (0.002 mg/L)										
Amber glass total (sulfuric acid)										
N6	E372-U	03-Nov-2022	07-Nov-2022	----	----		08-Nov-2022	28 days	5 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (0.002 mg/L)										
Amber glass total (sulfuric acid)										
N8	E372-U	03-Nov-2022	07-Nov-2022	----	----		08-Nov-2022	28 days	5 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (0.002 mg/L)										
Amber glass total (sulfuric acid)										
N9	E372-U	03-Nov-2022	07-Nov-2022	----	----		08-Nov-2022	28 days	5 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
HDPE dissolved (nitric acid)										
N6	E509	03-Nov-2022	10-Nov-2022	0.06 hrs	4 hrs	× EHTR-FM	10-Nov-2022	-154.19 hrs	0.06 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
HDPE dissolved (nitric acid) N8	E509	03-Nov-2022	10-Nov-2022	0.06 hrs	5 hrs	✖ EHTR-FM	10-Nov-2022	-154.19 hrs	0.06 hrs	✖ EHTR-FM
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
HDPE dissolved (nitric acid) N9	E509	03-Nov-2022	10-Nov-2022	0.06 hrs	5 hrs	✖ EHTR-FM	10-Nov-2022	-154.19 hrs	0.06 hrs	✖ EHTR-FM
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
HDPE dissolved (nitric acid) N3	E509	03-Nov-2022	10-Nov-2022	0.06 hrs	6 hrs	✖ EHTR-FM	10-Nov-2022	-154.19 hrs	0.06 hrs	✖ EHTR-FM
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
HDPE dissolved (nitric acid) N1	E509	03-Nov-2022	10-Nov-2022	0.06 hrs	7 hrs	✖ EHTR-FM	10-Nov-2022	-154.19 hrs	0.06 hrs	✖ EHTR-FM
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) N1	E421	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) N3	E421	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) N6	E421	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) N8	E421	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) N9	E421	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Microbiological Tests : Thermotolerant (Fecal) Coliform (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N6	E010.FC	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	29 hrs	✓
Microbiological Tests : Thermotolerant (Fecal) Coliform (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N8	E010.FC	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	29 hrs	✓
Microbiological Tests : Thermotolerant (Fecal) Coliform (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N3	E010.FC	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	30 hrs	× EHTL
Microbiological Tests : Thermotolerant (Fecal) Coliform (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N9	E010.FC	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	30 hrs	✓
Microbiological Tests : Thermotolerant (Fecal) Coliform (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N1	E010.FC	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	31 hrs	× EHTL
Microbiological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N6	E010	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	29 hrs	✓
Microbiological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N8	E010	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	29 hrs	✓
Microbiological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N3	E010	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	30 hrs	× EHTL
Microbiological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N9	E010	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	30 hrs	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Microbiological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate) N1	E010	03-Nov-2022	----	----	----		04-Nov-2022	30 hrs	31 hrs	× EHTL
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) N1	E358-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) N3	E358-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) N6	E358-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) N8	E358-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) N9	E358-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) N1	E355-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) N3	E355-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) N6	E355-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) N8	E355-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) N9	E355-L	03-Nov-2022	07-Nov-2022	----	----		07-Nov-2022	28 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE N1	E290	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE N3	E290	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE N6	E290	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE N8	E290	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE N9	E290	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE N1	E100	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE N3	E100	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Conductivity in Water										
HDPE N6	E100	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE N8	E100	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE N9	E100	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE N1	E108	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	0.25 hrs	9.25 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE N3	E108	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	0.25 hrs	9.25 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE N6	E108	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	0.25 hrs	9.25 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE N8	E108	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	0.25 hrs	9.25 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE N9	E108	03-Nov-2022	05-Nov-2022	----	----		05-Nov-2022	0.25 hrs	9.25 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE N1	E162	03-Nov-2022	----	----	----		05-Nov-2022	7 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE N3	E162	03-Nov-2022	----	----	----		05-Nov-2022	7 days	2 days	✓
Physical Tests : TDS by Gravimetry										
HDPE N6	E162	03-Nov-2022	----	----	----		05-Nov-2022	7 days	2 days	✓
Physical Tests : TDS by Gravimetry										
HDPE N8	E162	03-Nov-2022	----	----	----		05-Nov-2022	7 days	2 days	✓
Physical Tests : TDS by Gravimetry										
HDPE N9	E162	03-Nov-2022	----	----	----		05-Nov-2022	7 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE N1	E121	03-Nov-2022	----	----	----		05-Nov-2022	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE N3	E121	03-Nov-2022	----	----	----		05-Nov-2022	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE N6	E121	03-Nov-2022	----	----	----		05-Nov-2022	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE N8	E121	03-Nov-2022	----	----	----		05-Nov-2022	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE N9	E121	03-Nov-2022	----	----	----		05-Nov-2022	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
N1	E870	03-Nov-2022	05-Nov-2022	2 days	2 days	✓	14-Nov-2022	672 hrs	9 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
N3	E870	03-Nov-2022	05-Nov-2022	2 days	2 days	✓	14-Nov-2022	672 hrs	9 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
N6	E870	03-Nov-2022	05-Nov-2022	2 days	2 days	✓	14-Nov-2022	672 hrs	9 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
N8	E870	03-Nov-2022	05-Nov-2022	2 days	2 days	✓	14-Nov-2022	672 hrs	9 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
N9	E870	03-Nov-2022	05-Nov-2022	2 days	2 days	✓	14-Nov-2022	672 hrs	9 days	✓
Total Metals : Total Mercury in Water by CVAAS										
HDPE total (nitric acid)										
N6	E508	03-Nov-2022	10-Nov-2022	0.01 hrs	4 hrs	× EHTR-FM	10-Nov-2022	-171.68 hrs	0.01 hrs	× EHTR-FM
Total Metals : Total Mercury in Water by CVAAS										
HDPE total (nitric acid)										
N8	E508	03-Nov-2022	10-Nov-2022	0.01 hrs	5 hrs	× EHTR-FM	10-Nov-2022	-171.68 hrs	0.01 hrs	× EHTR-FM
Total Metals : Total Mercury in Water by CVAAS										
HDPE total (nitric acid)										
N9	E508	03-Nov-2022	10-Nov-2022	0.01 hrs	5 hrs	× EHTR-FM	10-Nov-2022	-171.68 hrs	0.01 hrs	× EHTR-FM
Total Metals : Total Mercury in Water by CVAAS										
HDPE total (nitric acid)										
N3	E508	03-Nov-2022	10-Nov-2022	0.01 hrs	6 hrs	× EHTR-FM	10-Nov-2022	-171.68 hrs	0.01 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
HDPE total (nitric acid) N1	E508	03-Nov-2022	10-Nov-2022	0.01 hrs	7 hrs	✖ EHTR-FM	10-Nov-2022	-171.68 hrs	0.01 hrs	✖ EHTR-FM
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid) N1	E420	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid) N3	E420	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid) N6	E420	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid) N8	E420	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid) N9	E420	03-Nov-2022	10-Nov-2022	----	----		11-Nov-2022	180 days	8 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	731595	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	733599	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	731600	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	731599	1	16	6.2	5.0	✓
Conductivity in Water	E100	731596	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	738230	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	737456	1	16	6.2	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	733596	1	13	7.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	731605	1	16	6.2	5.0	✓
Fluoride in Water by IC	E235.F	731598	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	731601	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	731602	1	20	5.0	5.0	✓
pH by Meter	E108	731594	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	731603	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	732155	1	18	5.5	5.0	✓
Thermotolerant (Fecal) Coliform (Enzyme Substrate)	E010.FC	730764	1	9	11.1	10.0	✓
Total Coliforms and E. coli (Enzyme Substrate)	E010	730985	1	20	5.0	10.0	✗
Total Kjeldahl Nitrogen by Fluorescence (Low Level)	E318	733595	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	739716	1	9	11.1	5.0	✓
Total metals in Water by CRC ICPMS	E420	734010	1	20	5.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	733597	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (0.002 mg/L)	E372-U	733598	1	13	7.6	5.0	✓
Turbidity by Nephelometry	E121	732061	2	40	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	731595	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	733599	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	731600	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	731599	1	16	6.2	5.0	✓
Chlorophyll-a by Fluorometry	E870	742488	1	5	20.0	5.0	✓
Conductivity in Water	E100	731596	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	738230	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	737456	1	16	6.2	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	733596	1	13	7.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	731605	1	16	6.2	5.0	✓
Fluoride in Water by IC	E235.F	731598	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	731601	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	731602	1	20	5.0	5.0	✓
pH by Meter	E108	731594	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	731603	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	732155	1	18	5.5	5.0	✓
Total Kjeldahl Nitrogen by Fluorescence (Low Level)	E318	733595	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	739716	1	9	11.1	5.0	✓
Total metals in Water by CRC ICPMS	E420	734010	1	20	5.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	733597	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (0.002 mg/L)	E372-U	733598	1	13	7.6	5.0	✓
Turbidity by Nephelometry	E121	732061	2	40	5.0	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	731595	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	733599	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	731600	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	731599	1	16	6.2	5.0	✓
Chlorophyll-a by Fluorometry	E870	742488	1	5	20.0	5.0	✓
Conductivity in Water	E100	731596	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	738230	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	737456	1	16	6.2	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	733596	1	13	7.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	731605	1	16	6.2	5.0	✓
Fluoride in Water by IC	E235.F	731598	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	731601	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	731602	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	731603	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	732155	1	18	5.5	5.0	✓
Thermotolerant (Fecal) Coliform (Enzyme Substrate)	E010.FC	730764	1	9	11.1	5.0	✓
Total Coliforms and E. coli (Enzyme Substrate)	E010	730985	1	20	5.0	5.0	✓
Total Kjeldahl Nitrogen by Fluorescence (Low Level)	E318	733595	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	739716	1	9	11.1	5.0	✓
Total metals in Water by CRC ICPMS	E420	734010	1	20	5.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	733597	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (0.002 mg/L)	E372-U	733598	1	13	7.6	5.0	✓
Turbidity by Nephelometry	E121	732061	2	40	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	733599	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	731600	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	731599	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	738230	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Metals in Water by CRC ICPMS	E421	737456	1	16	6.2	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	733596	1	13	7.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	731605	1	16	6.2	5.0	✓
Fluoride in Water by IC	E235.F	731598	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	731601	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	731602	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	731603	1	20	5.0	5.0	✓
Total Kjeldahl Nitrogen by Fluorescence (Low Level)	E318	733595	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	739716	1	9	11.1	5.0	✓
Total metals in Water by CRC ICPMS	E420	734010	1	20	5.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	733597	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (0.002 mg/L)	E372-U	733598	1	13	7.6	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Coliforms and E. coli (Enzyme Substrate)	E010 Vancouver - Environmental	Water	APHA 9223 (mod)	The enzyme substrate test simultaneously detects Total Coliforms and E. coli in a 100 mL sample after incubation at 35.0 ±0.5°C for either 18 or 24 hours (dependent on reagent used).
Thermotolerant (Fecal) Coliform (Enzyme Substrate)	E010.FC Vancouver - Environmental	Water	APHA 9223 (mod)	The enzyme substrate test detects Thermotolerant Coliforms in a 100 mL sample after an 18 hour incubation at 44.5 ±0.2°C.
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	Method Fialab 100, 2018	Ammonia in water is determined by automated continuous flow analysis with membrane diffusion and fluorescence detection, after reaction with OPA (ortho-phthalaldehyde). This method is approved under US EPA 40 CFR Part 136 (May 2021)
Total Kjeldahl Nitrogen by Fluorescence (Low Level)	E318 Vancouver - Environmental	Water	Method Fialab 100, 2018	TKN in water is determined by automated continuous flow analysis with membrane diffusion and fluorescence detection, after reaction with OPA (ortho-phthalaldehyde). This method is approved under US EPA 40 CFR Part 136 (May 2021).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Dissolved Organic Carbon by Combustion (Low Level)	E358-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Dissolved Organic Carbon (Non-Purgeable), also known as NPOC (dissolved), is a direct measurement of DOC after a filtered (0.45 micron) sample has been acidified and purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of DC (dissolved carbon) is comprised of IC (which is common), this method is more accurate and more reliable than the DOC by subtraction method (i.e. DC minus DIC).
Total Phosphorus by Colourimetry (0.002 mg/L)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chlorophyll-a by Fluorometry	E870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll a is determined by solvent extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for TKN in water	EP318 Vancouver - Environmental	Water	APHA 4500-Norg D (mod)	Samples are digested at high temperature using Sulfuric Acid with Copper catalyst, which converts organic nitrogen sources to Ammonia, which is then quantified by the analytical method as TKN. This method is unsuitable for samples containing high levels of nitrate. If nitrate exceeds TKN concentration by ten times or more, results may be biased low.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion
Preparation for Dissolved Organic Carbon for Combustion	EP358 Vancouver - Environmental	Water	APHA 5310 B (mod)	Preparation for Dissolved Organic Carbon
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.
Chlorophyll-a Extraction	EP870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll-a solvent extraction.
Chlorophyll-a Extraction (Field Filtered)	EP870A Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll-a solvent extraction.

ALS www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

COC Number: 20 - 1016081

Page of

Report To — Contact and company name below will appear on the final report

Company:	City of Chilliwack
Contact:	Tara Friesen
Phone:	
Company address below will appear on the final report	
Street:	8550 Young Road
City/Province:	Chilliwack, BC.
Postal Code:	V2P 8A4

Invoice To Same as Report To ☑ YES ☐ NO

Copy of Invoice with Report ☑ YES ☐ NO

Company:

Contact:

Reports / Recipients

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☑ YES ☐ NO ☐ N/A

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax tfriesen@chilliwack.com

Email 2 Clegg@chilliwack.com

Email 3 Biela@chilliwack.com

Invoice Recipients

Select Invoice Distribution: ☑ EMAIL ☑ MAIL ☐ FAX

Email 1 or Fax

Email 2

Turnaround Time (TAT) Requested

☑ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-routine tests

AFFIX ALS BARCODE LABEL HERE (ALS use only)

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm am/pm

For all tests with rush TATs requested, please contact your AM to confirm availability.

Project Information

ALS Account # / Quote #:

Job #: Bell Slough

PO / AFE:

LSD:

ALS Lab Work Order # (ALS use only):

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Contact: | Sampler: Brecons.

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers	Chlorophyll a	General/TSS/TDS	Metals	Microbi	Nut/DOC/DKN	Nut/Tot/Col	Samples on Hold	Extended Storage Required	Suspected Hazard (see notes)
	N1	03-Nov-22	09 30	SW		R	R	R	R	R	R			
	N3	03-Nov-22	10 30	SW		R	R	R	R	R	R			
	N6	03-Nov-22	12 00	SW		R	R	R	R	R	R			
	N8	03-Nov-22	11 20	SW		R	R	R	R	R	R			
	N9	03-Nov-22	11 00	SW		R	R	R	R	R	R			

Environmental Division
Vancouver
Work Order Reference
VA22C6866
Telephone: +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human consumption/ use? ☐ YES ☑ NO

Notes / Specify Lir... below

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☐ ICE ☑ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Intact: ☐ YES ☐ N/A Sample Custody Seals Intact: ☐ YES ☐ N/A

INITIAL COOLER TEMPERATURES °C: 6 | FINAL COOLER TEMPERATURES °C: 6.8°C

SHIPMENT RELEASE (client use)

Released by: Brecons | Date: Nov-4-2022 | Time: 0900

FINAL SHIPMENT RECEPTION (ALS use only)

Received by: M/S | Date: 11/4/22 | Time: 2:50 pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

BC and YUKON Drinking Water Declaration Form

In British Columbia, the Drinking Water Protection Act requires laboratories to immediately report positive results fo
Coliform and Escherichia coli in drinking water samples directly to the Water Supplier, the Drinking Water Officer,
Medical Health Officer in the region the water samples were taken. Immediate reporting is not required if the sample is
which a public advisory to boil for drinking water has been issued, or if the sample is not a drinking water.
In Yukon Territories, the Public Health and Safety Act requires the laboratory to immediately report any results that exc
acceptable concentration for any health-related parameter set out in the Guidelines for Canadian Drinking Water C
Environmental Health Services.

Water Suppliers are required by the Act to ensure the laboratory conducting the testing is aware of the applicable standards

Please submit this completed form and an ALS Chain of Custody with your sa

1. **Are your samples currently used for human consumption in BC or the Yukon?**

   ☐ YES ☒ NO

   If you selected YES, proceed to #2. If you selected NO, proceed to #5.

2. **Are your samples from a water supply system that either:**
   a) **serves more than 1 single family residence in BC, or**

   ☐ YES ☐ NO

   b) **serves more than 15 connections, or is trucked to more than 5 sites in the Yukon Territory**

   ☐ YES ☐ NO

   If you selected YES to either a) or b), proceed to #3. If you selected NO, proceed to #5.

3. **Is your water supply under a boil water advisory?**

   ☐ YES ☐ NO

   If you selected NO, proceed to #4. If you selected YES, proceed to #5.

4. **Please indicate (√) which Health Authority Region your samples were collected in, and provide the details for the applicable Drinking Water and Medical Health Officers:**

   ○ *Northern* ○ *Vancouver Coastal*
   ○ *Interior* ○ *Fraser*
   ○ *Vancouver Island* ○ *Yukon*

Water Supplier Name	*Phone & Email*
Drinking Water Officer:	*Phone:*
Medical Health Officer:	*Phone:*

5. *Name of Sampler:* Brecon Satchell *Phone:* 604-378-8200

   Released by (signature): [signature] *Date:* Nov 4 2021

ALS Vancouver can receive samples Monday to Friday (24 hours) and Saturday and Sunday (8:00am to 4:00pm). Plea contact ALS for testing limitations around statutory holidays.

Appendix D

Technical Memo

IDF_CC Tool IDF Curves

MEMORANDUM

Date:	March 16, 2018
To:	Kyle St. Amour, City of Chilliwack
cc:	Rod Sanderson, City of Chilliwack
From:	Taylor Swailes, E.I.T., Glen Shkurhan, P.Eng.
File:	CD1036.000.00
Subject:	Updated IDF Curves for the City of Chilliwack

1. Background

This memo presents updated IDF (Intensity-Duration-Frequency) curves for use in the City of Chilliwack. The updated IDF curves reflect precipitation monitoring undertaken by the City, as well as climate change projections.

The City of Chilliwack currently uses two IDF curves for design purposes; Agassiz for areas north of Highway 1, and Sardis-Vedder for areas to the south. The source of information for these curves is unknown, and Environment Canada's (EC) IDF information in Chilliwack is limited.

According to EC, the station at Agassiz is approximately 32 km northeast from the centre of Chilliwack and has recorded only 23 years of data between 1955 – 1994. There is only one published EC IDF curve within the municipal boundary, Chilliwack Microwave. This station has data between only 1964 – 1980, and does not have sub-hourly data, which limits its use for drainage design where short-duration peak intensities are important.

There is a concern that these curves do not reflect recent weather patterns and are too old to provide reliable projections for the future due to climate change.

The City of Chilliwack has undertaken precipitation monitoring in 5 locations throughout the City:

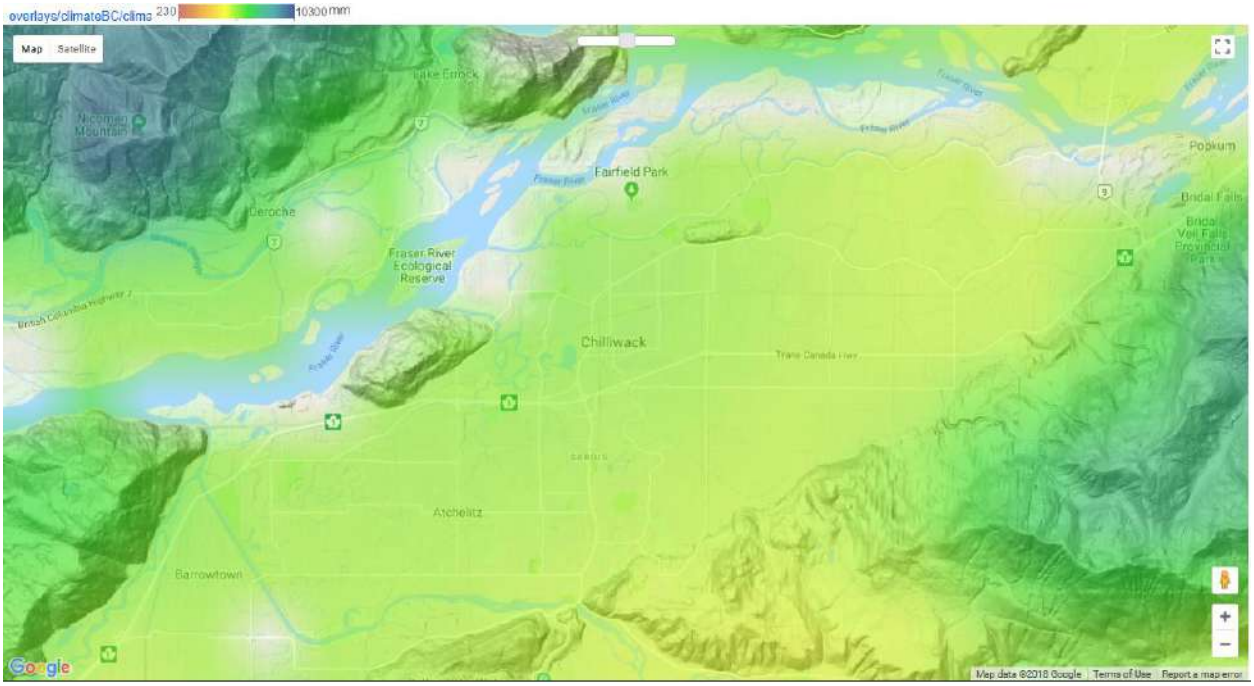
- Airport
- Annis Road
- Promontory
- Mt Shannon
- Chilliwack Mountain

All of the precipitation gauges were installed in 2006-2008, and therefore have 11-13 years of data recorded in 5-minute increments.

3. Updated Combined IDF Curves

There is a significant time gap in data from the historic EC stations to what the City has collected. Combining the data may skew the results below what we expect them to currently be. As such, we have taken an approach of using only the current data collected by the City.

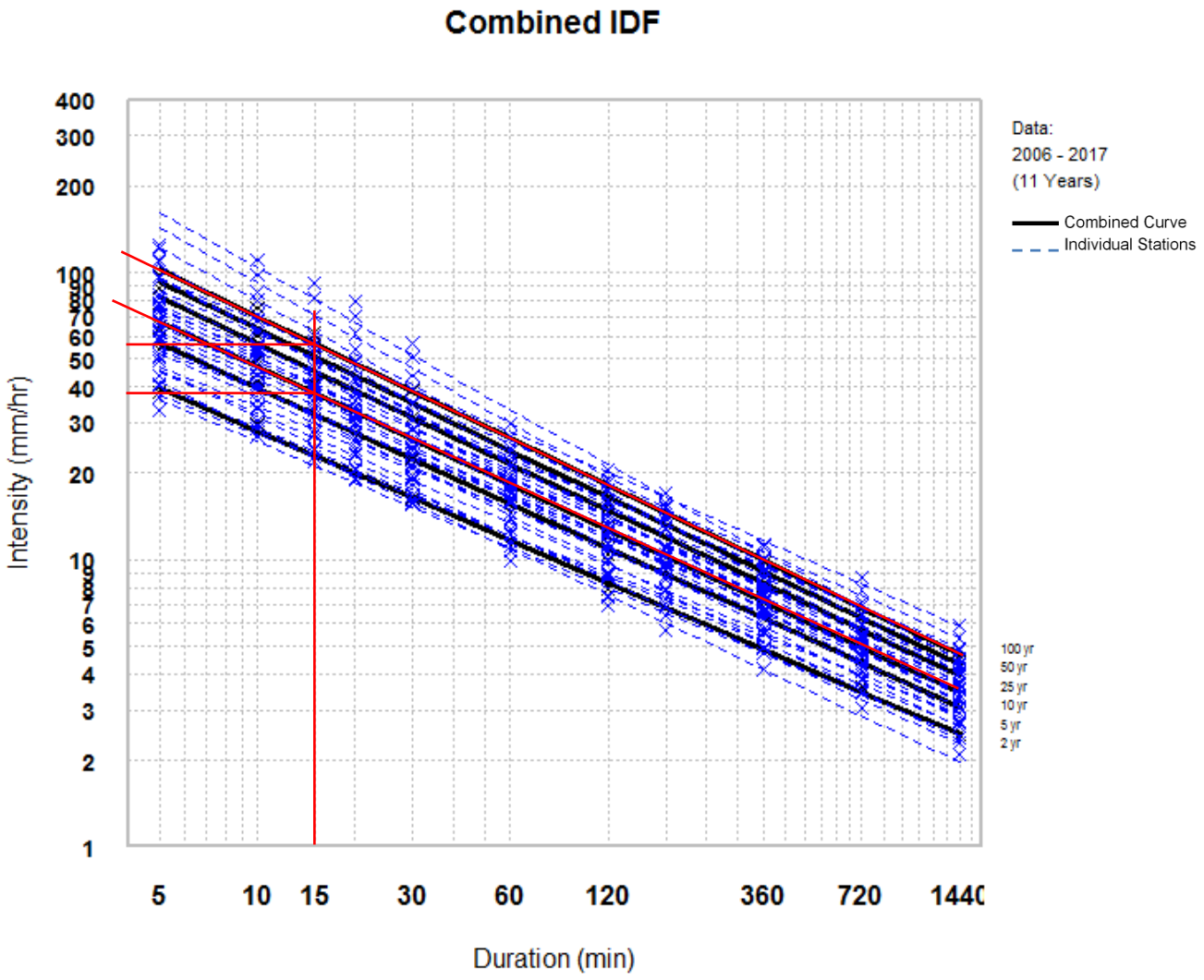
Additionally, climate maps available from Climate BC show that precipitation within the valley surrounding Chilliwack is relatively uniform compared to variations observed between the precipitation gauges (see following figure). The more significant differences are between the valley and the mountainous areas. Therefore, instead of creating IDF curves for each station, the rainfall data from all the stations was combined to create a single, more regional set of IDF curves. We feel that creating a regional set of curves produces more reliable estimates applicable to the City as a whole, and is easier to apply in City criteria documents.



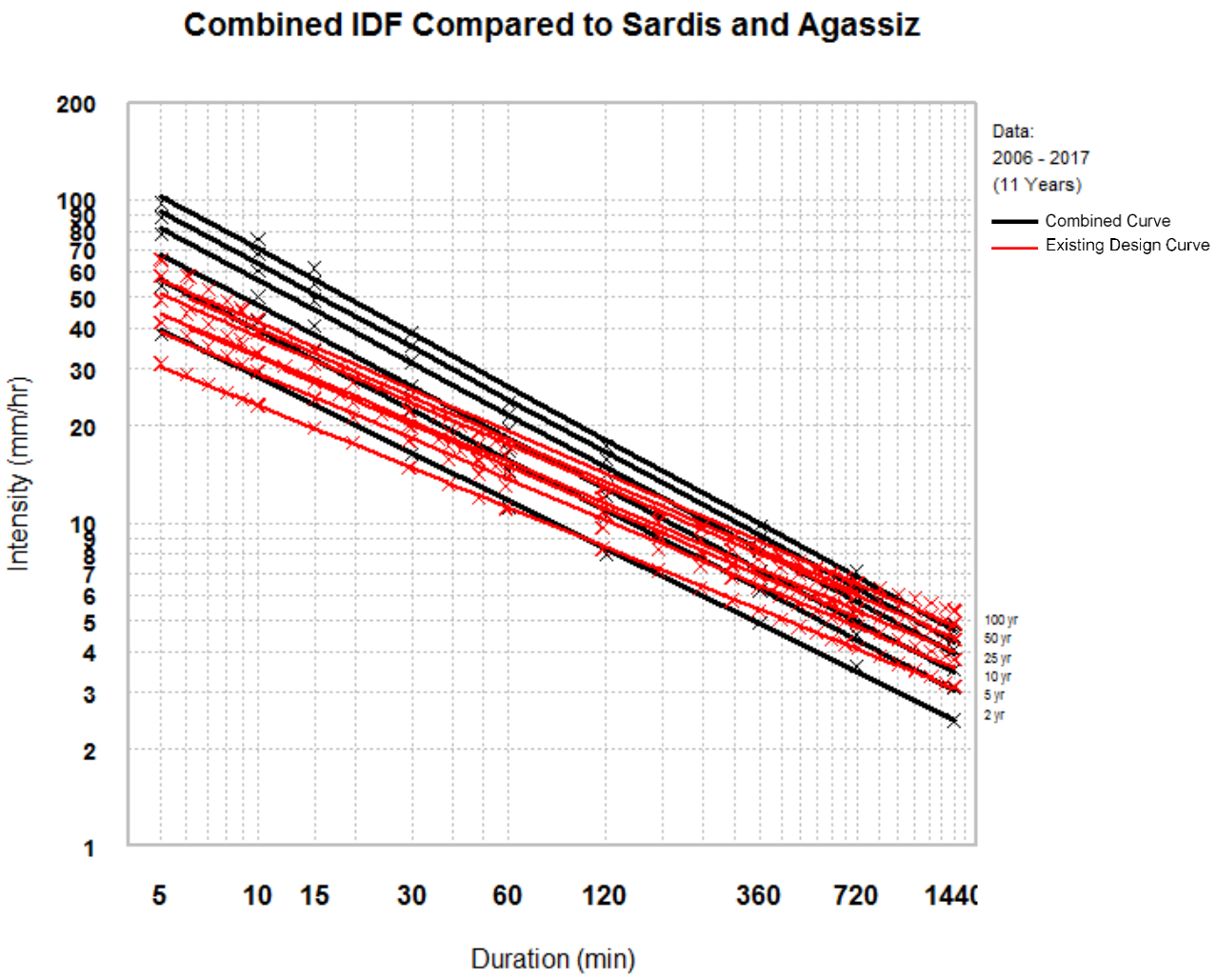
Using the City recorded data, a new set IDF curves was created using the Environment Canada method published by the Canadian Standards Association (2012). The largest rainfall events from each year are extracted for each duration and are statistically analyzed to project the rainfall intensities of more extreme events, up to the 1:100 year return period.

Each station has 11-13 years of data. Statistically, there is significant uncertainty when extrapolating data to more than 4 times the record length (Watt, et al. 1989), which in this case would be greater than the 1:50 year event. Therefore, the confidence in projected values with return periods less than 50 years is higher than the confidence in values with return periods greater than 50 years. However, the full set of values was still computed. The resulting combined IDF curves are shown in black in the following figure.

The resulting IDF curves from each individual station are superimposed in blue to show the variability between stations, compared to the combined set of curves.



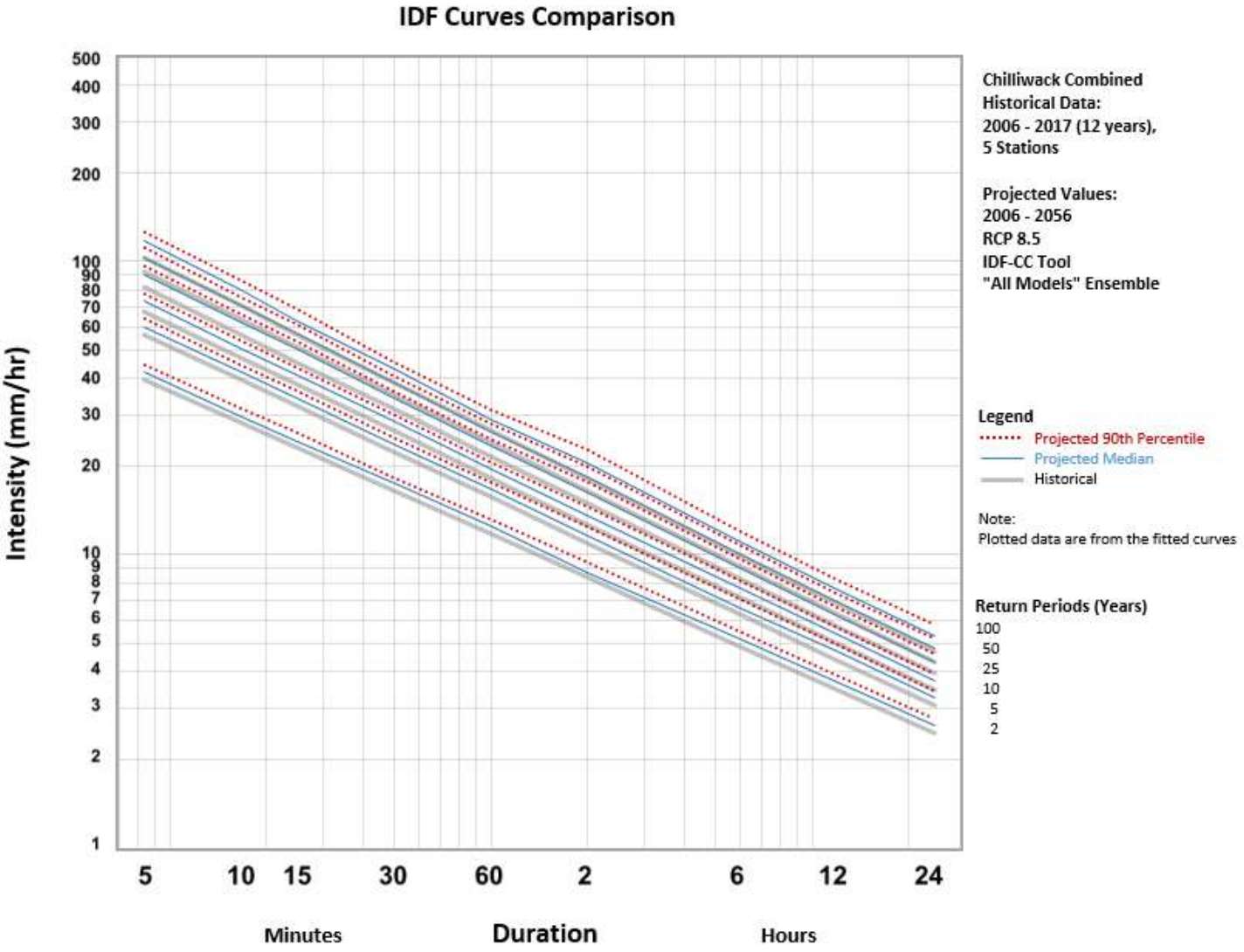
The new combined curves (in black) are compared to the existing City design curves (Agassiz and Sardis-Vedder in red) in the figure below:



Compared to the original City IDF Curves, the updated curves show higher intensities for durations less than 12 hours, but similar intensities for durations greater than 12 hours. This steepening of the curves is consistent with IDF curves updated for other locations in the Fraser Valley.

5. Climate Change Projections

The updated combined IDF curves were then used to generate climate change projections using the IDF-CC tool from Western University (Simonovic 2018). This tool estimates precipitation increases using 24 General Circulation Models (GCM's) that simulate long-term climate values. The resulting IDF curves based on the median and 90th percentile output from the GCM's are compared to the current combined curve in the figure below:



Values have been projected to the year 2056. The results show an increase for the 1:2 year return period curve of 6% for the median and 13% for the 90th percentile. The 1:100 year return period curve increases 14% for the median and 23% for the 90th percentile.

6. Conclusions

The combined updated IDF curve shows a significant increase in short-duration intensities compared to the current design curves being used by the City of Chilliwack, although the longer duration intensities are similar.

The future climate-change adjusted IDF curves reflect a significant increase in rainfall intensity over the next 38 years. This is similar to patterns projected for other municipalities in the Fraser Valley, and suggests that storms are likely to become more frequent and more intense.

Sincerely,

URBAN SYSTEMS LTD.

Taylor Swailes, E.I.T.
Water Resources EIT

Glen Shkurhan, P.Eng.
Senior Engineer, Partner

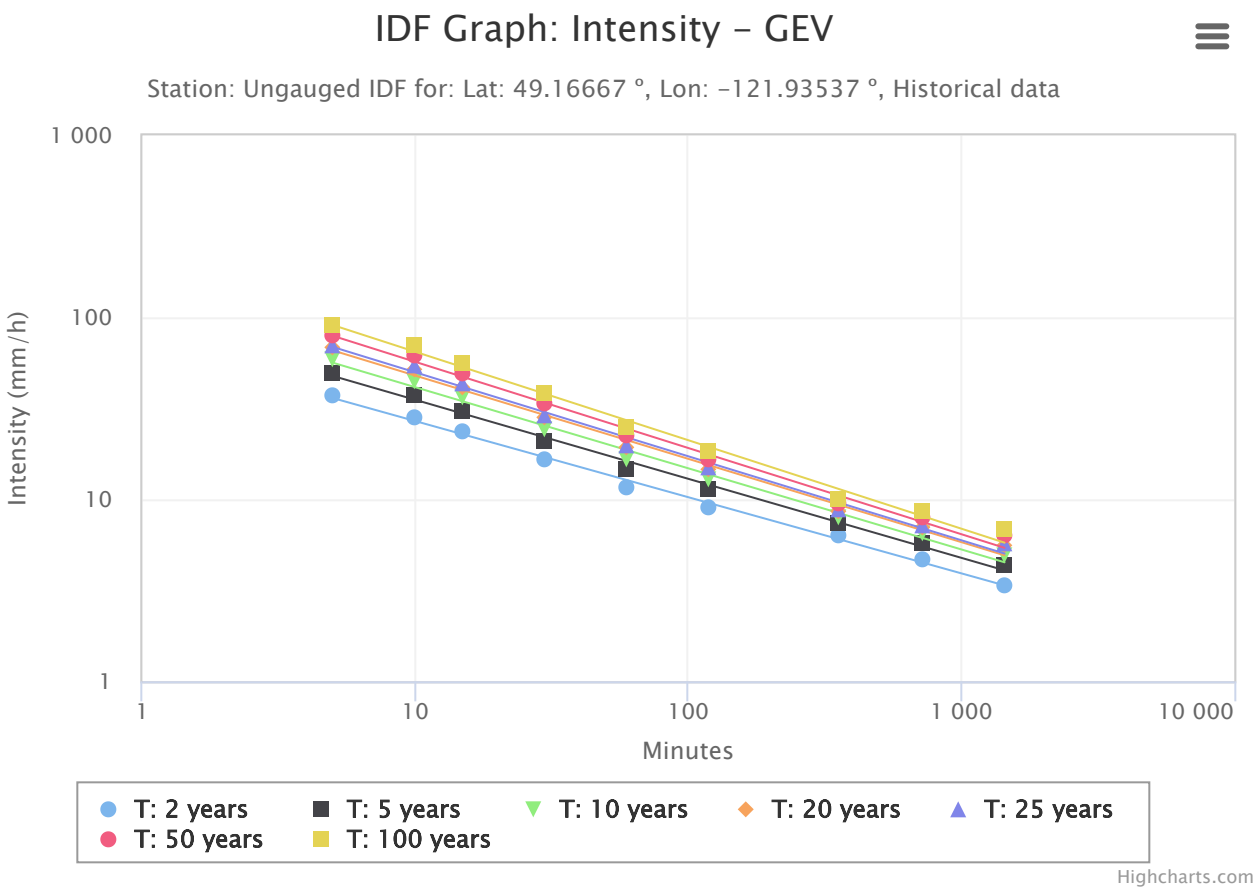
/ts

7. References

Canadian Standards Association. 2012. *TECHNICAL GUIDE: Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners.* Mississauga: Canadian Standards Association.

Simonovic, S.P. 2018. *IDF_CC Tool 3.0.* Accessed 03 12, 2018. http://www.idf-cc-uwo.ca/home.

Watt, W. Edgar, Keith W. Lathem, Charles R. Neill, T. Lloyd Richards, and Jean Rousselle. 1989. *Hydrology of Floods in Canada: A Guide to Planning and Design.* Ottawa: National Research Council of Canada, Associate Committee on Hydrology.


IDF Graph: Intensity - GEV
Station: Ungauged IDF for: Lat: 49.16667 °, Lon: -121.93537 °, Historical data
1 000
100
10
1
Intensity (mm/h)
1
10
100
1 000
10 000
Minutes
T: 2 years
T: 5 years
T: 10 years
T: 20 years
T: 25 years
T: 50 years
T: 100 years
Highcharts.com

The table below provides coefficients for the interpolation equations fitted to the IDF curve using the GEV distribution.

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	12.7	-0.418	0.000
5	16.2	-0.434	0.000
10	18.6	-0.446	0.000
20	21.1	-0.457	0.000
25	21.8	-0.461	0.000
50	24.4	-0.473	0.000
100	27.1	-0.486	0.000

Use the coefficients provided in the table above with the following equation:

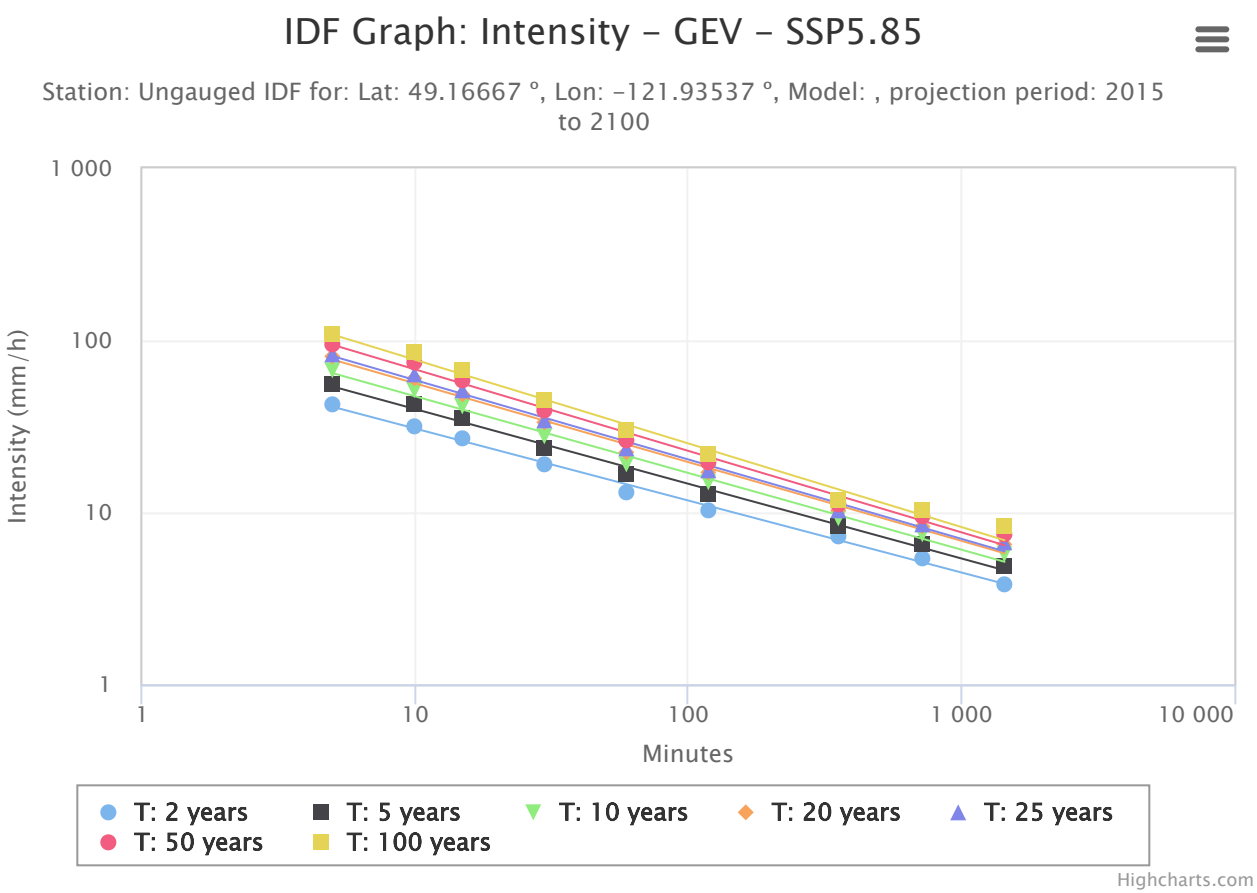
$$i\left(\frac{mm}{h}\right) = A \cdot (t + t_0)^B$$

Where:

i is the precipitation intensity rate in $\frac{mm}{h}$

A, B and t_0, are the coefficients for each return period (T) in years

t, the time (duration) of the precipitation event in hours (h)


IDF Graph: Intensity - GEV - SSP5.85
Station: Ungauged IDF for: Lat: 49.16667 °, Lon: -121.93537 °, Model: , projection period: 2015 to 2100
1 000
100
10
1
Intensity (mm/h)
1
10
100
1 000
10 000
Minutes
T: 2 years
T: 5 years
T: 10 years
T: 20 years
T: 25 years
T: 50 years
T: 100 years
Highcharts.com

The table below provides the coefficients for the interpolated equations fitted to the average IDF for future scenario RCP 8.5

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	14.5	-0.418	0.000
5	18.3	-0.434	0.000
10	29.8	-0.592	0.336
20	24.7	-0.457	0.000
25	25.7	-0.461	0.000
50	29.0	-0.473	0.000
100	33.3	-0.520	0.018

Use the coefficients provided in the table above with the following equation:

$$i\left(\frac{mm}{h}\right) = A \cdot (t + t_0)^B$$

Where:

i is the precipitation intensity rate in $\frac{mm}{h}$

A, B and t_0, are the coefficients for each return period (T) in years

t, the time (duration) of the precipitation event in hours (h)

Appendix E

2022 Fish Inventory

Fish Report Card

Site	**Bell Slough**		Year Date		**2022** **April 7**	
Participants	Natasha Wilbrink, Mike Leon – Pearson Ecological Danya Douglas – Stó:lō Guardian					
Effort	Feddes Trap	12	Gee Trap	1	Seine Net	0

Indicators

	Reach			
Indicator	**All**	**BS1**	**BS2**	**BS3**
Number Indigenous Fish Species	0	0	0	0
% Catch Indigenous Species	7	0	0	67
% Catch Salmonid	0	0	0	0
Average # Salmonids per Trap	0	0	0	0
Fish Species at Risk Present	0	0	0	0
% Catch Threespine Stickleback	0	0	0	0
Average # Salmonid Predators per Trap*	1.0	1.4	0	0
Number Introduced Fish Species	2	2	0	0
% Catch Introduced Fish Species	85.7	96.0	0	0
% Traps Empty	52.2	47.1	100	0

* Includes all individuals of fish and amphibian species that, as adults, prey on juvenile salmonids

Note: 'Catch' includes both fish and amphibians.

Note: Traps, seines, fyke nets and gill nets all have different, but unknown, capture rates for each species, which also vary with habitat conditions. Combining data from different methods may skew results to some extent. Data should be separated by capture method before making quantitative comparisons between sites

Species Encountered

English Name	Halq'emeylem Name	Scientific Name	Status
Red-legged Frog	Wexés	*Rana aurora*	Indigenous, BC Blue-list, SARA Special Concern
Northwest Salamander	Pí:txel	*Ambystoma gracile*	Indigenous
Pumpkinseed		*Lepomis gibbosus*	Introduced
Brown Catfish	Mó:txw	*Ameiurus nebulosus*	Introduced
Bullfrog	Weléx	*Rana catesbeiana*	Introduced
Green Frog	Weléx	*Rana clamitans*	Introduced

Fish Sampling and Salmonid Capture Locations

Interpretation

- No native fish species were caught in Bell Slough.
- Two introduced fish species, Pumpkinseed and Brown Catfish, were found. These species are commonly found throughout the Lower Fraser watershed.
- Two native and two introduced amphibians were observed in Bell Slough.
- Specific conductivity was fairly low, but slightly elevated in Reach BS1
- Water temperatures were well within the tolerance range for salmonids as expected for spring sampling.
- Dissolved oxygen in BS3 was not sufficient to support fish. In reaches BS2 and BS1 dissolved oxygen levels varied from well within tolerance ranges of salmonids to stressfully low, suggesting deteriorating oxygen levels throughout the summer is likely.
- Dissolved oxygen recorded by a data logger in BS1 remained at 0% for 20 hours. Spot sampling before removing the logger measured at 5.38mg/L with a temperature of 12.3^{o}C at the surface, indicating that water column stratification has occurred with warmer, oxygenated water overlying cooler (8^{o}C) anoxic water underneath.
- The logger in BS2 showed high levels of dissolved oxygen over 20 hourly measurements.

Catch Summary Table

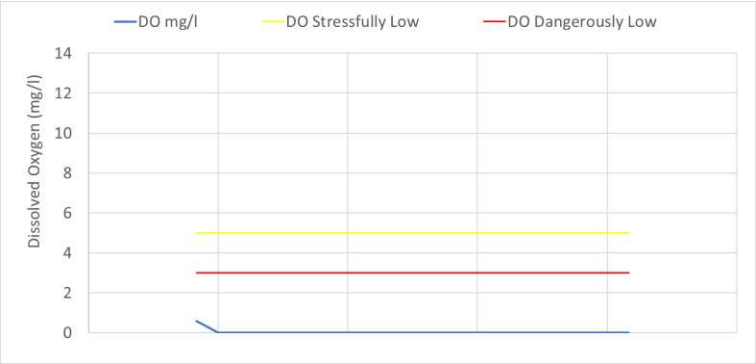
Species	Reach Effort	All 23	BS1 17	BS2 4	BS3 2
Red-legged Frog		1			1
Northwestern Salamander		1			1
Pumpkinseed		14	14		
Brown Catfish		10	10		
Bullfrog		1	1		
Green Frog		1			1
All Species		28	25	0	3

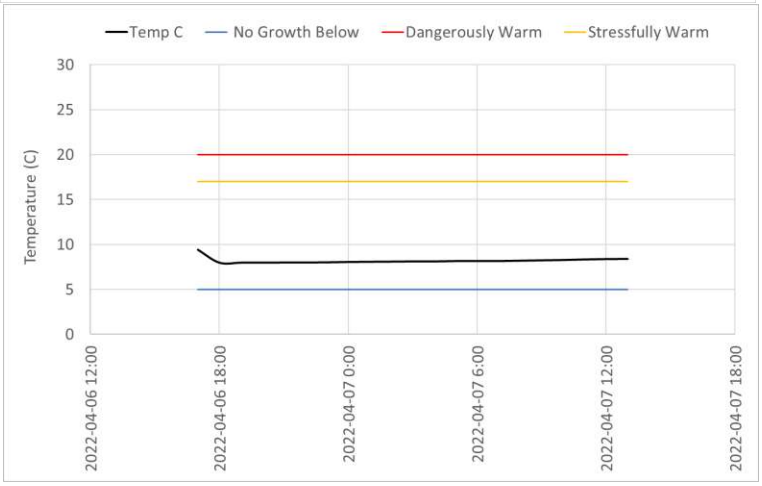
Water Quality Summary

Site	Temperature ˚C			Dissolved Oxygen (mg/L)			Specific Conductivity (μS)		
	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.
All	12	8.9	12.3	12	2.32	9.5	12	40.6	134.7
BS1	9	10	12.3	9	4.47	9.5	9	77.1	134.7
BS2	2	8.9	10.1	2	4.81	8.53	2	40.6	54
BS3	1	9	9	1	2.32	2.32	1	51.9	51.9

Dissolved Oxygen Logger Results

Dissolved Oxygen Logger BS1

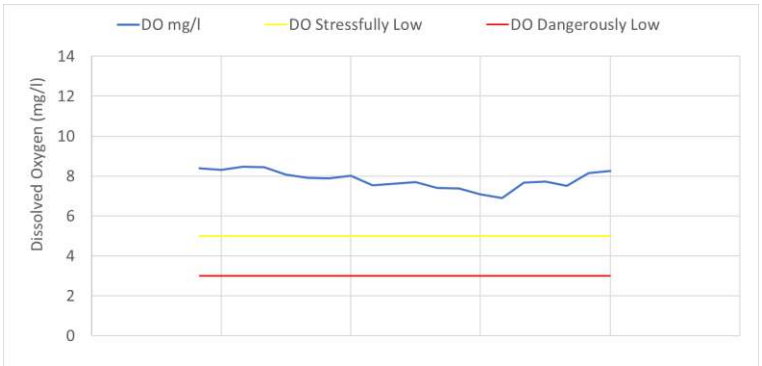


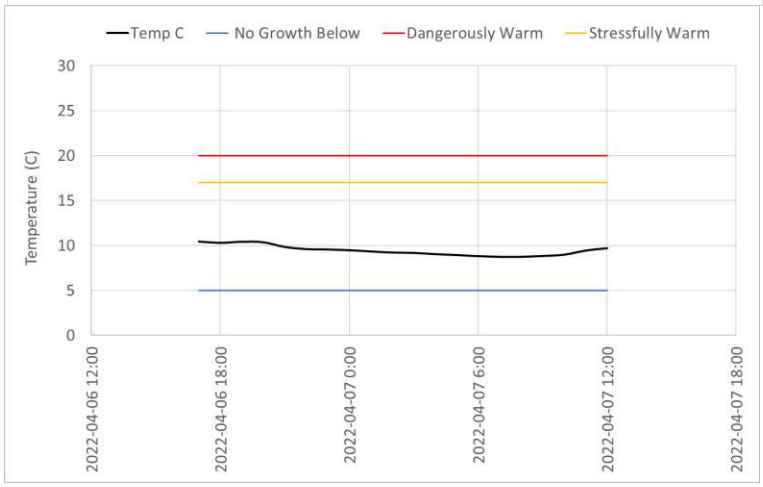


Start Date	6-Apr-22
End Date	7-Apr-22
Sampling Interval (h)	1
Number of Days	0.9
Number Measurements	21
Max DO	0.6
Min DO	0.0
Max. Temperature	9.4
Min. Temperature	8.0

DO	Days	Hours	% Time
Below 5 mg/l	0.9	21	100.0
Below 4 mg/l	0.9	21	100.0
Below 3 mg/l	0.9	21	100.0
Below 2 mg/l	0.9	21	100.0
Below 1 mg/l	0.9	21	100.0

Dissolved Oxygen Logger BS2

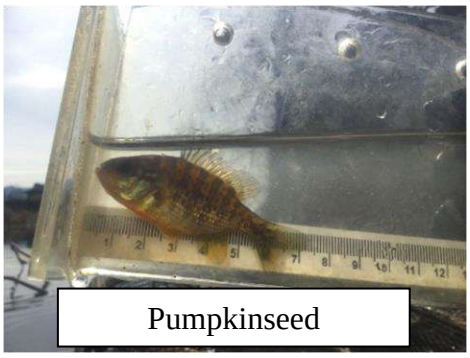




Start Date	6-Apr-22
End Date	7-Apr-22
Sampling Interval (h)	1
Number of Days	0.8
Number Measurements	20
Max DO	8.5
Min DO	6.9
Max. Temperature	10.4
Min. Temperature	8.7

DO	Days	Hours	% Time
Below 5 mg/l	0.0	0	0.0
Below 4 mg/l	0.0	0	0.0
Below 3 mg/l	0.0	0	0.0
Below 2 mg/l	0.0	0	0.0
Below 1 mg/l	0.0	0	0.0

Species Photos

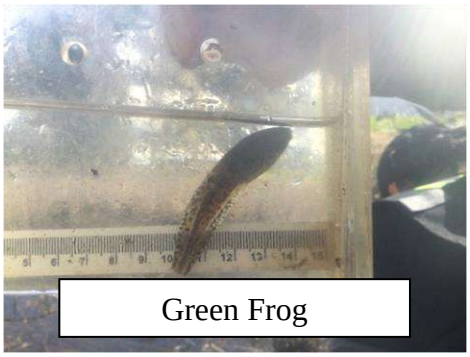


Pumpkinseed

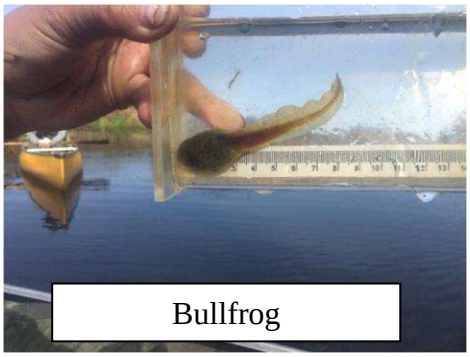
Brown Catfish

Northwestern Salamander

Northern Red-legged Frog



Green Frog



Bullfrog

Fish Report Card

Site	Bell Slough		Year Date	2022 June5-6
Participants	Natasha Wilbrink, Spencer Schlatter, Oskar Von Wahl			
Effort	**Feddes Trap**	15	**Gee Trap**	15	**Seine Net**	

Indicators

	North Nicomen Slough			
Indicator	All	BS1	BS2	BS3
Number Indigenous Fish Species	2	1	1	0
% Catch Indigenous Species	11.7	0.9	11.1	65.2
% Catch Salmonid	0.00	0.00	0.00	0.00
Average # Salmonids per Trap	0.00	0.00	0.00	0.00
Fish Species at Risk Present	1	0	1	0
% Catch Threespine Stickleback	0.53	0.90	0.00	0.00
Average # Salmonid Predators per Trap*	3.93	3.50	11.75	1.00
Number Introduced Fish Species	2	2	2	1
% Catch Introduced Fish Species	62.77	56.76	87.04	34.78
% Traps Empty	30.00	38.89	0.00	25.00

Encountered

English Name	Halq'emeylem Name	Scientific Name	Status
Brassy Minnow	Sqíqemlò	*Hybognathus ankinsoni*	Indigenous, BC Blue-list
Threespine Stickleback	Smó:txw	*Gasterosteus aculeatus*	Indigenous
Northwest Salamander	Pí:txel	*Ambystoma gracile*	Indigenous
Rough-skinned Newt	Pí:txel	*Taricha granulosa*	Indigenous
Pumpkinseed		*Lepomis gibbosus*	Introduced
Brown Catfish	Mó:txw	*Ameiurus nebulosus*	Introduced
Bullfrog	Weléx	*Rana catesbeiana*	Introduced
Green Frog	Weléx	*Rana clamitans*	Introduced

Catch Summary Table

	Reach			
Species	**All**	**BS1**	**BS2**	**BS3**
Brassy Minnow	**2**		**2**	
Threespine Stickleback	**1**	**1**		
Northwestern Salamander	**18**		**4**	**14**
Rough-skinned Newt	**1**			**1**
Pumpkinseed	**96**	**49**	**39**	**8**
Brown Catfish	**22**	**14**	**8**	
Bullfrog	**14**	**14**		
Green Frog	**34**	**33**	**1**	
All Species	**188**	**111**	**54**	**23**

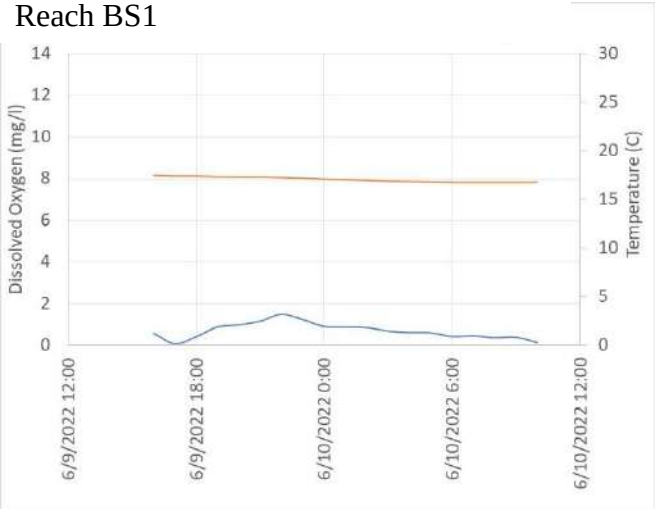
Fish Sampling and Salmonid Capture Locations

Water Quality Summary

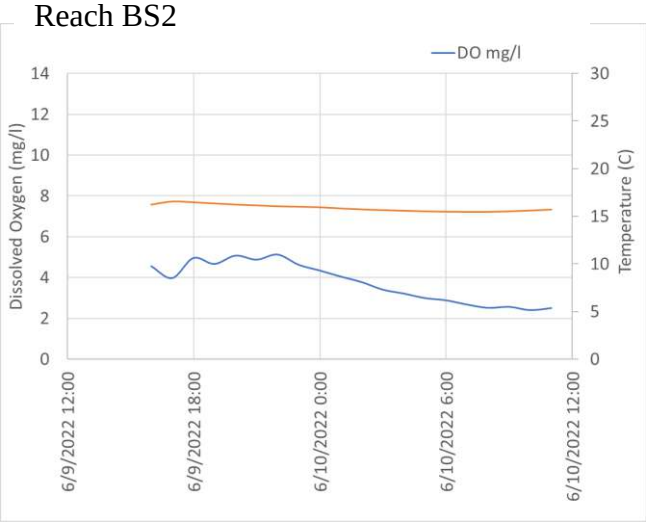
Site	Temperature ˚C			Dissolved Oxygen (mg/L)			Specific Conductivity (μS)		
	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.
All	15	14.1	16.9	15	0.33	3.73	15	43.8	332.9
BS1	9	16.6	16.9	9	0.33	3.49	9	52.7	332.9
BS2	2	16	16.1	2	3.35	3.73	2	43.8	60.4
BS3	4	14.1	16.6	4	0.6	2.11	4	45.6	61.6

Dissolved Oxygen

Reach BS1



Reach BS2



Start Date	9-Jun-22
End Date	10-Jun-22
Sampling Interval (h)	1
Number of Days	0.8
Measurements	19
Max DO	1.5
Min DO	0.1
Max. Temperature	17.5
Min. Temperature	16.7

DO	Days	Hours	% Time
Below 5 mg/l	0.8	19	100.0
Below 4 mg/l	0.8	19	100.0
Below 3 mg/l	0.8	19	100.0
Below 2 mg/l	0.8	19	100.0
Below 1 mg/l	0.7	16	84.2

Start Date	9-Jun-22
End Date	10-Jun-22
Sampling Interval (h)	1
Number of Days	0.8
Measurements	20
Max DO	5.1
Min DO	2.4
Max. Temperature	16.5
Min. Temperature	15.5

DO	Days	Hours	% Time
Below 5 mg/l	0.8	18	90.0
Below 4 mg/l	0.5	11	55.0
Below 3 mg/l	0.3	6	30.0
Below 2 mg/l	0.0	0	0.0
Below 1 mg/l	0.0	0	0.0

Interpretation

- Only 2 indigenous fish species were captured, although one was a species at risk (Brassy Minnow)
- No salmonids were caught.
- The majority of the catch consisted of introduced species and a high proportion of traps were empty.
- Water temperature was ideal for salmonids, but dissolved oxygen levels were too low to support them
- Specific conductivity was significantly elevated in reach BS1 relative to BS2 and BS3, suggesting a local source of pollution there..

Species Photos


Brassy Minnow


Green Frog

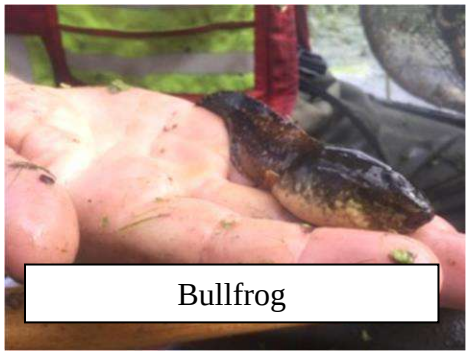

Threespine Stickleback


Pumpkinseed


Northwestern Salamander


Brown Catfish


Roughskin Newt


Bullfrog

Fish Report Card

Site	Bell Slough				Year Date	2022 August 12
Participants	Mike Leon, Sherry Miller, Spencer Schlatter					
Effort	**Feddes Trap**	10	**Gee Trap**	10	**Seine Net**	0

Indicators

	Bell Slough		
Indicator	All	BS1	BS2
Number Indigenous Fish Species	1	1	1
% Catch Indigenous Species	40	8	88
% Catch Salmonid	0.00	0.00	0.00
Average # Salmonids per Trap	0.00	0.00	0.00
Fish Species at Risk Present	0	0	0
% Catch Threespine Stickleback	10.00	8.33	12.50
Average # Salmonid Predators per Trap*	0.20	0.19	0.25
Number Introduced Fish Species	2	2	1
% Catch Introduced Fish Species	20.00	25.00	12.50
% Traps Empty	70.00	81.25	25.00

Species Encountered

English Name	Halq'emeylem Name	Scientific Name	Status
Threespine Stickleback	Smó:txw	*Gasterosteus aculeatus*	Indigenous
Northwest Salamander	Pí:txel	*Ambystoma gracile*	Indigenous
Pumpkinseed		*Lepomis gibbosus*	Introduced
Brown Catfish	Mó:txw	*Ameiurus nebulosus*	Introduced
Bullfrog	Weléx	*Rana catesbeiana*	Introduced

Catch Summary Table

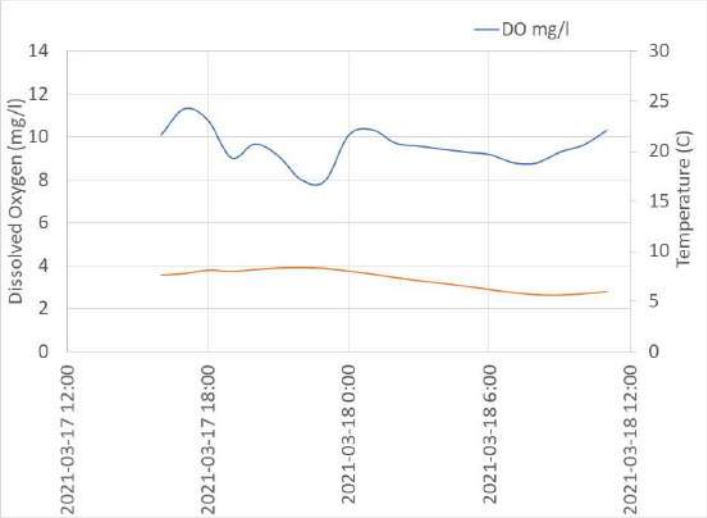
Species	All	Reach BS1	BS2
Threespine Stickleback	2	1	1
Northwestern Salamander	6		6
Pumpkinseed	3	2	1
Brown Catfish	1	1	
Bullfrog	8	8	
All Species	20	12	8

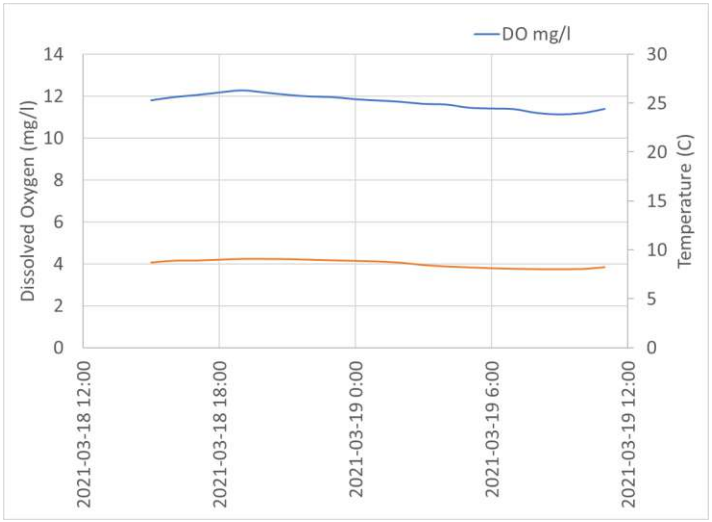
Fish Sampling and Salmonid Capture Locations

Water Quality Summary

Site	Temperature ˚C			Dissolved Oxygen (mg/L)			Specific Conductivity (μS)		
	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.
All	10	15.7	19.7	10	0.23	1.09	10	118	242
BS1	8	17.8	19.6	8	0.23	0.57	8	135	242
BS2	2	15.7	19.7	2	0.45	1.09	2	118	140

Dissolved Oxygen





Start Date	
End Date	
Sampling Interval (h)	
Number of Days	
Measurements	
Max DO	
Min DO	
Max. Temperature	
Min. Temperature	

DO	Days	Hours	% Time
Below 5 mg/l			
Below 4 mg/l			
Below 3 mg/l			
Below 2 mg/l			
Below 1 mg/l			

Start Date	
End Date	
Sampling Interval (h)	
Number of Days	
Measurements	
Max DO	
Min DO	
Max. Temperature	
Min. Temperature	

DO	Days	Hours	% Time
Below 5 mg/l			
Below 4 mg/l			
Below 3 mg/l			
Below 2 mg/l			
Below 1 mg/l			

Interpretation

- Threespine stickleback was the only indigenous fish species captured
- No salmonids were caught.
- The majority of the catch consisted of introduced species and a the majority of traps were empty.
- Water temperature was adequate for salmonids, but dissolved oxygen levels were too low to support them
- Specific conductivity was significantly elevated in reach BS1 relative to BS2 and BS3, suggesting a local source of pollution there..

Species Photos

Brassy Minnow

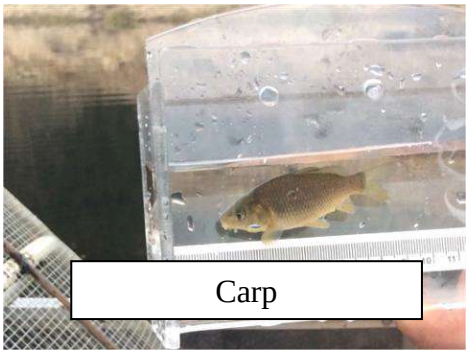
Northern Pikeminnow

Threespine Stickleback

Pumpkinseed

Coho Salmon

Brown Catfish



Carp

Appendix F

Detailed Class C Cost Estimate

Chilliwack Bell Slough
Culvert Installation
Class C Cost Estimate (+/-30%)

C1 - Replace Culvert at Brinx Road and Property Parcel #10824			
	General Requirements	$	83,000
	Earthworks	$	52,800
	Road and Site Improvements	$	22,000
	Utilities	$	92,800
	Contingency (30% of Construction Subtotal)	$	75,180
	Engineering and Approval Fees (10% of Construction Subtotal)	$	25,060
	TOTAL	**$**	**350,840**
C5 - Remove Culvert Between Property Parcel #11310 and #11288			
	General Requirements	$	87,500
	Earthworks	$	75,000
	Utilities	$	40,000
	Contingency (30% of Construction Subtotal)	$	60,750
	Engineering and Approval Fees (10% of Construction Subtotal)	$	20,250
	TOTAL	**$**	**283,500**
C6-C11 Install New Culverts at Private Driveway Crossings			
	General Requirements	$	145,000
	Earthworks	$	407,800
	Road and Site Improvements	$	83,220
	Utilities	$	632,500
	Contingency (30% of Construction Subtotal)	$	380,556
	Engineering and Approval Fees (10% of Construction Subtotal)	$	126,852
	TOTAL	**$**	**1,775,928**
C12 - Install New Culvert at Bell Road and McSween Road			
	General Requirements	$	92,500
	Earthworks	$	110,700
	Road and Site Improvements	$	24,200
	Utilities	$	110,200
	Contingency (30% of Construction Subtotal)	$	101,280
	Engineering and Approval Fees (10% of Construction Subtotal)	$	33,760
	TOTAL	**$**	**472,640**
	GRAND TOTAL	**$**	**2,882,908**

NOTES:

1. Costs are in 2023 Canadian dollars
2. Supply and install costs will vary depending on market conditions at the time of tender, the Engineer has no control over those conditions
3. Contingency 30% of subtotal costs
4. Engineer fees 10% of subtotal costs
5. Costs exclude taxes

C1 - Replace Culvert at Brinx Road and Property Parcel #10824

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	General Requirements				
	Mobilization and Demobilization	LS	1	$ 20,000	$ 20,000
	Traffic Management Plan	LS	1	$ 18,000	$ 18,000
	Environmental Protection	LS	1	$ 25,000	$ 25,000
	In-Stream Temporary Bypass	LS	1	$ 20,000	$ 20,000
	Subtotal				**$ 83,000**
	Earthworks				
	Common Excavation (2.5m Depth) c/w Disposal of Existing Culvert	m3	140	$ 350	$ 49,000
	Supply and Install Riprap for Culvert Apron and Bank Armoring (Assume 25kg Riprap)	m2	20	$ 190	$ 3,800
	Subtotal				**$ 52,800**
	Road and Site Improvements				
	Reinstate Paved Road Structure	m2	100	$ 220	$ 22,000
	Subtotal				**$ 22,000**
	Utilities				
	Supply and Install New 900mm HDPE Culvert c/w Flared End, Geotextiles, Pipe Bedding and Pipe Surround Materials, and Imported Backfill	m	16	$ 5,800	$ 92,800
	Subtotal				**$ 92,800**
	Sub-Total				**$ 250,600**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Construction Subtotal)	LS	1	$ 75,180	**$ 75,180**
	Engineering and Approval Fees (10% of Construction Subtotal)	LS	1	$ 25,060	**$ 25,060**
	Sub-Total				**$ 100,240**

SUMMARY OF COST ESTIMATE

C1 - Replace Culvert at Brinx Road and Property Parcel #10824	$ 250,600
Contingency (30% of Construction Subtotal)	$ 100,240
Engineering and Approval Fees (10% of Construction Subtotal)	$ 25,060
TOTAL	**$ 375,900**

C5 - Remove Culvert Between Property Parcel #11310 and #11288

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	General Requirements				
	Mobilization and Demobilization	LS	1	$ 45,000	$ 35,000
	Traffic Management Plan	LS	1	$ 5,000	$ 5,000
	Environmental Protection	LS	1	$ 30,000	$ 30,000
	In-Stream Temporary Bypass	LS	1	$ 17,500	$ 17,500
	Subtotal				**$ 87,500**
	Earthworks				
	Common Excavation to Remove Earthen Bank C/W Regrading Slope and Disposal (Assume 15m Wide)	m3	150	$ 500	$ 75,000
	Subtotal				**$ 75,000**
	Utilities				
	Supply and Install New HDPE Culvert c/w Flared End, Flap Gate, Headwalls, Geotextiles, Pipe Bedding and Pipe Surround Materials, and Imported Backfill	m	10	$ 4,000	$ 40,000
	Subtotal				**$ 40,000**
	Sub-Total				**$ 202,500**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Construction Subtotal)	LS	1	$ 60,750	**$ 60,750**
	Engineering and Approval Fees (10% of Construction Subtotal)	LS	1	$ 20,250	**$ 20,250**
	Sub-Total				**$ 81,000**

SUMMARY OF COST ESTIMATE

C5 - Remove Culvert Between Property Parcel #11310 and #11288	$ 202,500
Contingency (30% of Construction Subtotal)	$ 81,000
Engineering and Approval Fees (10% of Construction Subtotal)	$ 20,250
TOTAL	**$ 303,750**

C6-C11 Install New Culverts at Private Driveway Crossings

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	General Requirements				
	Mobilization and Demobilization	LS	1	$ 45,000	$ 45,000
	Traffic Management Plan	LS	1	$ 27,500	$ 27,500
	Environmental Protection	LS	1	$ 40,000	$ 40,000
	In-Stream Temporary Bypass	LS	1	$ 32,500	$ 32,500
	Subtotal				**$ 145,000**
	Earthworks				
	Common Excavation (2.5m Depth) c/w Regrading Creek from C6 to C7	m3	1100	$ 350	$ 385,000
	Supply and Install (x6) Riprap for Culvert Apron and Bank Armoring (Assume 25kg Riprap)	m2	120	$ 190	$ 22,800
	Subtotal				**$ 407,800**
	Road and Site Improvements				
	Reinstate Paved Road Structure	m2	331	$ 220	$ 72,820
	Reinstate Gravelled Road Structure	m2	80	$ 130	$ 10,400
	Subtotal				**$ 83,220**
	Utilities				
	Supply and Install (x5) New 900mm HDPE Culvert c/w Flared End, Geotextiles, Pipe Bedding and Pipe Surround Materials, and Imported Backfill	m	115	$ 5,500	$ 632,500
	Supply and Install (x1) New 525mm HDPE Culvert c/w Flared End, Geotextiles, Pipe Bedding and Pipe Surround Materials, and Imported Backfill	m	32	$ 2,800	$ 89,600
	Subtotal				**$ 632,500**
	Sub-Total				**$ 1,268,520**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Construction Subtotal)	LS	1	$ 380,556	**$ 380,556**
	Engineering and Approval Fees (10% of Construction Subtotal)	LS	1	$ 126,852	**$ 126,852**
	Sub-Total				**$ 507,408**

SUMMARY OF COST ESTIMATE

C6-C11 Install New Culverts at Private Driveway Crossings	$ 1,268,520
Contingency (30% of Construction Subtotal)	$ 507,408
Engineering and Approval Fees (10% of Construction Subtotal)	$ 126,852
TOTAL	**$ 1,902,780**

C12 - Install New Culvert at Bell Road and McSween Road

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	General Requirements				
	Mobilization and Demobilization	LS	1	$ 22,500	$ 22,500
	Traffic Management Plan	LS	1	$ 25,000	$ 25,000
	Environmental Protection	LS	1	$ 25,000	$ 25,000
	In-Stream Temporary Bypass	LS	1	$ 20,000	$ 20,000
	Subtotal				**$ 92,500**
	Earthworks				
	Common Excavation (3.5m Depth)	m3	300	$ 350	$ 105,000
	Supply and Install Riprap for Culvert Apron and Bank Armoring (Assume 25kg Riprap)	m2	30	$ 190	$ 5,700
	Subtotal				**$ 110,700**
	Road and Site Improvements				
	Reinstate Paved Road Structure	m2	110	$ 220	$ 24,200
	Subtotal				**$ 24,200**
	Utilities				
	Supply and Install New 900mm HDPE Culvert c/w Flared End, Geotextiles, Pipe Bedding and Pipe Surround Materials, and Imported Backfill	m	19	$ 5,800	$ 110,200
	Subtotal				**$ 110,200**
	Sub-Total				**$ 337,600**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Construction Subtotal)	LS	1	$ 101,280	**$ 101,280**
	Engineering and Approval Fees (10% of Construction Subtotal)	LS	1	$ 33,760	**$ 33,760**
	Sub-Total				**$ 135,040**

SUMMARY OF COST ESTIMATE

C12 - Install New Culvert at Bell Road and McSween Road	$ 337,600
Contingency (30% of Construction Subtotal)	$ 135,040
Engineering and Approval Fees (10% of Construction Subtotal)	$ 33,760
TOTAL	**$ 506,400**

Chilliwack Bell Slough
Environmental Program and Planning Costs
Class C Cost Estimate (+/-30%)

Annual Water Quality Sampling Program			
Annual Water Quality Sampling Program		$	13,370
Contingency (30% of Annual Water Quality Sampling Program Sub-Total)		$	4,011
Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)		$	1,337
	TOTAL	**$**	**18,718**
Annual Flow Monitor Sampling Program			
Annual Flow Monitor Sampling Program		$	17,000
Contingency (30% of Subtotal)		$	5,100
Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)		$	1,700
	TOTAL	**$**	**23,800**
Rehabilitation Plan Report			
Rehabilitation Plan Report		$	17,878
Contingency (30% of Subtotal)		$	5,363
Engineering Fees (30% of Sub-Total)		$	1,788
	TOTAL	**$**	**25,029**

NOTES:

1. Costs are in 2023 Canadian dollars
2. Supply and install costs will vary depending on market conditions at the time of tender, the Engineer has no control over those conditions
3. Contingency 30% of subtotal costs
4. Engineer fees 10% of subtotal costs
5. Costs exclude taxes

Annual Water Quality Sampling Program

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	Water Quality Sampling (1 Time - 5 Sampling Locations)				
	Field Sampling	HRS	8	$ 135	$ 1,080
	Lab Services	LS	1	$ 1,250	$ 1,250
	Data Analysis Lab Results and Reporting	HRS	8	$ 135	$ 1,013
	1 Time Water Quality Sampling Sub-Total				**$ 3,343**

Item No.	Specification and/or Description	Unit Price			Amount
	Frequency of Sampling - Assume Seasonal (4 Times a Year)	EA	4	$ 3,343	**$ 13,370**
	Annual Water Quality Sampling Program Sub-Total				**$ 13,370**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Annual Water Quality Sampling Program Sub-Total)	LS	1	$ 4,011	**$ 4,011**
	Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)	LS	1	$ 1,337	**$ 1,337**
	Sub-Total				**$ 5,348**

SUMMARY OF COST ESTIMATE

Annual Water Quality Sampling Program	$	13,370
Contingency (30% of Annual Water Quality Sampling Program Sub-Total)	$	4,011
Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)	$	1,337
TOTAL	**$**	**18,718**

Annual Flow Monitor Sampling Program

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	Flow Monitoring Sampling (1 Time)				
	Field Visit	HRS	16	$ 135	$ 2,160
	Equipment Costs (Rental of ADCP/day and survey equipment rental)	Daily	1	$ 500	$ 500
	Data Analysis- Establishing Rating Curve	HRS	4	$ 135	$ 540
	1 Time Water Quality Sampling Sub-Total				**$ 3,200**

Item No.	Specification and/or Description	Unit Price			Amount
	Frequency of Sampling - Assume 5 visits per year to meet hydrometric standard	EA	5	$ 3,200	**$ 16,000**
	Hydrology Station Materials and Depth Sensor (1 time cost for 1 station)				
	Hardware	Unit Price	1	$ 200	$ 200
	Depth sensor and vented cable	Unit Price	1	$ 800	$ 800
					$ 1,000
	Annual Flow Monitoring Sampling Program Sub-Total				$ 17,000

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Subtotal)	LS	1	$ 5,100	**$ 5,100**
	Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)	LS	1	$ 1,700	**$ 1,700**
	Sub-Total				**$ 5,100**

SUMMARY OF COST ESTIMATE

Annual Flow Monitor Sampling Program	$	17,000
Contingency (30% of Subtotal)	$	5,100
Engineering Fees (30% of Annual Water Quality Sampling Program Sub-Total)	$	1,700
TOTAL	**$**	**23,800**

Rehabilitation Plan Report

Item No.	Specification and/or Description	UOM	Qty	Unit Rate	Amount
	Preparation and Finalizing a Rehabilitation Plan				
	Desktop Review	HRS	18	$ 135	$ 2,430
	Report	HRS	80	$ 135	$ 10,800
	QR/ Technical Direction	HRS	12	$ 160.00	$ 1,920.00
	IR	HRS	2.5	$ 180.00	$ 450.00
	Documentation	HRS	2	$ 115.00	$ 230.00
	CAD	HRS	8	$ 141.00	$ 1,128.00
	GIS	HRS	8	$ 115.00	$ 920.00
	GIS QR	HRS	4	$ 147.00	$ 588.00
	Sub-Total				**$ 17,878**

Item No.	Specification and/or Description	Unit Price			Amount
	Contingency (30% of Subtotal)	LS	1	$ 5,363	**$ 5,363**
	Engineering Fees (30% of Sub-Total)	LS	1	$ 1,788	**$ 1,788**
	Sub-Total				**$ 7,151**

SUMMARY OF COST ESTIMATE

Rehabilitation Plan Report	$	17,878
Contingency (30% of Subtotal)	$	5,363
Engineering Fees (30% of Sub-Total)	$	1,788
TOTAL	**$**	**25,029**