KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
300 – 4185 Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088

South Port Coquitlam Integrated Watershed Management Plan

Final Report

December 13, 2024
KWL Project No. 646.043-300


Broadway Creek

Prepared for:

CITY OF PORT COQUITLAM


Brown Creek


Baker Creek

Contents

Figures

Tables

Appendices

Executive Summary

Introduction

The City of Port Coquitlam (City) initiated an Integrated Watershed Management Plan (IWMP) for the Brown Creek, Baker Creek, and Fraser River watersheds collectively referred to as the South Port Coquitlam IWMP. The study was initiated in 2021 and completed in 2024.

The goal of the South Port Coquitlam IWMP is to develop a comprehensive and technically grounded IWMP for improvement of all three watersheds by:

- Minimizing the risk of flooding
- Mitigating the impact of development
- Preserving aquatic and riparian habitats
- Recommending practical and effective improvements for watershed health

Land Acknowledgement

Brown Creek, Baker Creek, and the Fraser River watersheds are within the core territory of kʷikʷəƛ̓əm First Nation (kʷikʷəƛ̓əm) and as such, kʷikʷəƛ̓əm is vitally concerned that its cultural, heritage, economic, environmental, and other interests are adequately considered and reflected in the IWMP planning and implementation process.

- In accordance with United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP; United Nations General Assembly, 2007), Article 18 and 19, kʷikʷəƛ̓əm must be consulted and included in any decision-making processes which may affect them.
- In accordance with UNDRIP Article 26, 29, and 32, kʷikʷəƛ̓əm has the right to the above-mentioned lands, their conservation, and the right to develop priorities and strategies for the use of those lands. Therefore, it is critical that kʷikʷəƛ̓əm is included and consulted in all land use decision making processes.

kʷikʷəƛ̓əm has provided input for the development of the IWMP and will be involved in the implementation.

Study Area Location and Drainage

The 650-ha study area is bounded by the Canadian Pacific Railyard to the northeast, the Pitt River to the southeast, the Fraser River to the south, and the high ground of Mary Hill to the west. The area generally drains east and south via storm sewers, ditches, culverts, and watercourses. The Brown Creek watershed, which mostly consists of flat low-lying lands, discharges to the Pitt River via the Harbour St Storm Pump Station site and floodbox. There are currently five pumps housed at three pump stations at this site. The Baker Creek and Fraser River watersheds drain via gravity to the Fraser River.

Existing and Future Land Use

Approximately 30% of the study area is residential use, the majority of which is low density single family residential. Commercial and industrial uses are 31% of the study area. The light to heavy industrial use is concentrated in the eastern portion of Brown Creek watershed. This area is highly impervious. Baker Creek and Fraser River watersheds have little to no industrial areas. The remaining land in the study area is composed of parks, institutional, comprehensive development zones, and highway and road rights-of-way. Future development will include some densification with total impervious area only expected to change in the Brown Creek watershed (from 63% to 68%).

Environmental Values and Watershed Health

There are 3.6 km of Class A and 0.1 km of Class B streams in the Fraser, Brown Creek, and Baker Creek watersheds. All watersheds have poor watershed health at the time of the study. Brown and Baker Creek have a measured B-IBI score of 16 which indicates heavily impacted watersheds. All three watersheds have high impervious area (>60%). Baker and Fraser Creek also have low riparian forest cover (<50%). Remaining riparian forest cover is fragmented and discontinuous along the stream channels. It is notable that the measured B-IBI is higher than the predicated B-IBI for these watersheds (based on their riparian forest integrity and effective impervious area) potentially indicating influence of local aquifers to moderate urbanization impacts to creek hydrology and water quality.

There is poor water quality in Baker and Brown Creeks with the largest issue being high bacteria concentrations in Brown Creek. Further sampling and investigations to identify and address the sources of contamination is recommended. Despite this, four native salmon and trout species (Coho, Chum, Cutthroat Trout, and Steelhead/Rainbow Trout) and two native non-salmonid fish species (Prickly Sculpin and Threespine Stickleback) have been recorded in the creeks. Hybridization between Cutthroat Trout and Rainbow Trout has also been recorded within the watersheds. Moderate to extensive spawning gravel as well as good rearing habitat is present in sections of Brown Creek and Baker Creek.

There are two confirmed species at risk present in the study area: Great Blue Heron and Streambank Lupine. Currently, no continuous wildlife corridor, either a riparian corridor along a creek or an upland forest corridor, connects the Brown Creek watershed to the Baker Creek and Fraser River watersheds.

Hydraulic Model Update and Drainage Assessment

The City’s existing Stormwater Hydraulic Model (KWL, 2015) was updated within the study area and used to assess the conveyance capacity of the City’s storm sewers, culverts, ditches, and watercourses. A 2D component was added to the model to assess lowland flooding and pump station capacity. As per the City’s Hydraulic Level of Service rating system, 35% of the entire assessed length of pipes and culverts does not meet the City’s level of service requirements. The deficiency increases to 52% with future land use (as per the City’s Official Community Plan) and climate (as per the City’s updated IDF curves). The City’s updated climate change IDF curves result in a 15% increase in rainfall from the historic conditions IDF curve for the 10-year event and 17% increase for the 100-year event. Pump station capacity upgrades are required to prevent flooding under existing and future conditions.

The Watershed Plan

The South Port Coquitlam Integrated Watershed Management Plan for the watersheds of Brown Creek, Baker Creek, and Fraser River was developed in consultation with the Advisory Committee, and provides recommendations for:

- Flood management:
  - Storm main and culvert upgrades
  - Ditch maintenance
  - Pump station decommissioning and upgrades
- Environmental enhancement:
  - Conveyance and fish passage
  - In-stream enhancements
  - Riparian areas and habitat corridors
  - Water quality
  - Fish sampling
  - Education and outreach
- Development impact mitigation
- Bylaws and policies
- First nation consultation
- Monitoring and adaptive management

Table E-1 lists the recommended actions with cost estimates, timelines and responsibilities for implementation.

Table E-1: South Port Coquitlam Watersheds IWMP – Implementation Strategy

	Plan Components	Priority	Cost Estimate	Responsibility
Flood Management				
1	**Storm Mains and Culverts**			
	Upgrade major system mains and culverts that are likely to flood in *existing* conditions: • Upgrade 107 Grade F major system mains.	1–10 Years	$41.5M	City
	Upgrade major system mains and culverts that are likely to surcharge in *existing* conditions: • Upgrade 19 Grade E major system mains. Upgrade 2 Grade E culverts.	10–20 Years	$4.2M $611K	City
	Upgrade minor system pipes that are likely to surcharge or flood in *existing* conditions, as they are due for replacement: • Upgrade 156 Grade E & F minor system mains.	1–50 Years	$21.5M	City
	Upgrade minor and major system pipes and culverts that are likely to surcharge or flood in *future* conditions, with redevelopment or in coordination with other capital projects: • Upgrade 109 Grade E and F minor system mains. • Upgrade 44 Grade E & F major system mains.	With Re-development or Capital Projects	$12.1M $6.2M	Developer/ City
	Upgrade pipes and culverts owned by the Province: • Upgrade 3 culverts under the Mary Hill Bypass that restrict flow to the pump station (DM06776, DM06767, DM06768) • Upgrade 3 Grade F culverts (DM06771, DM06775, DM06776). • Upgrade 1 Grade F 900 mm pipe (DM06779).	1–10 Years 10–20 Years 1–10 Years	$1.8M $840K $460K	Province
2	**Ditch Maintenance**			
	• Remove vegetation/sedimentation in roadside ditches on the Mary Hill Bypass to convey maximum flow.	1–5 Years	$5–10K	Province
3	**Pump Station**			
	• Upgrade Harbour 1 Pump Station and flood box to provide adequate capacity for existing and future conditions, climate change, and to improve fish passage.	1–10 Years	$13M	City
	• Decommission the Harbour Old Pump Station.	1–5 Years	$100K	City

	Plan Components	Priority	Cost Estimate	Responsibility
Environmental Enhancement				
4	**Conveyance and Fish Passage**			
	• Conduct detailed barrier assessments to confirm barriers and the conditions under which they are barriers.	1–10 Years	$5K–$15K	City
	• Remove channel obstructions and fish passage impediments such as fences.	1–20 Years	$1K–$10K per location	City
	• Remove channel obstructions and clean out overgrown vegetation to improve conveyance and fish passage.	1–20 Years	$1K–$5K per location	City
	• Work with private property owners to remove fish passage impediments.	1-20 Years	N/A	City/Property Owners
5	**In-stream Enhancements**			
	• Install boulders and large wood, to the extent that it will not increase flood or erosion risk.	1–20 Years	$50K–$100K	City
	• Add imported spawning gravels at strategic locations within Brown, Broadway, and Baker Creek including Marian Kroeker Park, the outfall behind 2012 Leggatt Place, and 1254 Yarmouth Street (bottom of waterfall).	1–20 Years	$200K–$300K	City
6	**Riparian Areas and Habitat Corridors**			
	• Use the existing Invasive Species Program to treat, manage, and/or eliminate priority invasive species, specifically: English Ivy, Himalayan Blackberry, and Japanese Knotweed.	Ongoing	$30 per m^2	City
	• Restore the habitat enhancement project in Brown Creek to its former condition, with regular monitoring and maintenance to ensure adequate functioning.	1-10 Years	$50K–$100K	City
	• Remove invasives, re-establish riparian vegetation and forest cover, and stabilize banks on public properties through riparian planting, specifically: ○ Replace the 400 m2 of lawn with riparian plants in Marian Kroeker Park on the east bank of Baker Creek. ○ Improve riparian forest along the left bank of Brown creek. Add fencing to protect riparian area. ○ Remove blackberries in Broadway Creek corridor and replace with native vegetation.	1–20 Years	$30 per m^2 (Invasive removal) $30 per m^2 (native planting)	City
	• Increase native tree cover in the Broadway creek riparian corridor. • Enhance the habitat corridor by planting trees through City-owned properties at 1300 and 1305 Eastern Drive, 1300 Western Drive, and 1397 Pitt River Road.	1–20 Years	$500 per tree	City

	Plan Components	Priority	Cost Estimate	Responsibility
7	**Water Quality**			
	• Conduct additional monitoring at Brown Creek to identify the cause(s) of poor water quality.	1–10 Years	$40K	City
	• Inspect condition of 450mm concrete GVSD sanitary main within the Brown Creek riparian corridor to ensure there is no sanitary exfiltration.	1–10 Years	$1–5K	Metro Vancouver
8	**Fish Sampling**			
	• Complete fish sampling within Baker Creek, Brown Creek, Broadway Creek, and Fraser watershed to confirm fish populations within the watersheds.	1–10 Years	$50K–$75K	City
9	**Education and Outreach**			
	• Promote the "Help Stop the Spread of Invasive Plants" program through City website, events and in-person information sessions.	Ongoing	$1–5K	City/ Streamkeepers
	• Develop and distribute education and outreach materials (website, pamphlet, etc.) on stream and watershed health for private property owners with watercourses.	1–10 Years	$5–10K	City/ Streamkeepers
	• Collaborate with streamkeepers on education and outreach materials, tree planting, invasive species removal, educational/informational signage, creek cleanups, flow obstruction removal, "adopt-a-spot" program, and school engagement.	1–20 Years	Varies	City/ Streamkeepers
10	**Development Impact Mitigation**			
	• Require stormwater source controls in the Brown Creek and Baker Creek sub-watersheds to infiltrate to maintain baseflows. Size to capture 90% of average annual runoff (approximately 72% of the 2-year, 24-hour event which is 54 mm).	With Re-development and Capital Projects *after bylaw updates	Varies	City/ Developers
	• Require stormwater source controls in all sub-watersheds to provide water quality treatment. Size to treat 90% of average annual runoff (approximately 72% of the 2-year, 24-hour event which is 54 mm). • Require infiltration/detention facilities in upland watersheds (mainly Baker Creek) to minimize downstream erosion and habitat degradation. Size to detain 24-hr duration 6-months, 2year, and 5-year post-development flow rates to pre-development flow rates.			
	• Require and enforce erosion and sediment control measures during construction with redevelopment and City works.	Ongoing	Varies	City/ Developers

	Plan Components	Priority	Cost Estimate	Responsibility
	• Continue and expand City rain barrel program	Ongoing	\$200/barrel \$150/barrel (City) \$50/barrel (Resident)	City/ Residents
11	**Bylaws and Standards**			
	Update the Subdivision Servicing Bylaw with: • requirements for source controls and rainwater management criteria prescribed in individual IWMPs (after completion of all plans); • stormwater volume capture, water quality treatment, and environmental detention criteria; • climate change considerations for drainage design criteria; • erosion and sediment control measures; and • design criteria and specifications for stormwater source controls.	1–10 Years	\$25K	City
	Update the Official Community Plan (OCP) to include watercourse classifications as presented in Table 5-4 once confirmed with fish sampling within Baker, Brown, and Broadway Creeks and Fraser watershed.			
12	**First Nation Consultation**			
	• In accordance with UNDRIP, include meaningful consultation with kʷikʷəƛ̓əm First Nation on projects prior to proceeding and ensure that their right to the land and its use are respected and upheld. • Provide opportunities for a kʷikʷəƛ̓əm First Nation member to oversee environmental and archaeological monitoring activities in the watershed. Forward all monitoring documentation to kʷikʷəƛ̓əm First Nation.	Ongoing	Subject to Guardianship Program Funding	City/ kʷikʷəƛ̓əm
13	**Monitoring and Adaptive Management Framework**			
	• Conduct routine monitoring of Brown, Baker and Fraser Creeks for water quality, flow, and benthic invertebrates per Monitoring and Adaptive Management Framework.	Every 5 Years	\$50K	City

Table E-2: South Port Coquitlam Watersheds AMF Performance Indicators

Performance Indicator	Indicator Type	Short-term Trend/Target	Long-term Target
Water Quality Performance Indicators			
Dissolved Oxygen	Primary	Increasing	Good or Satisfactory as per AMF classification levels
Water Temperature		Decreasing in dry season	
Turbidity		Decreasing in wet season	
Nutrients (Nitrate as N)		Decreasing	
Bacteriological Parameters (*E. coli* and fecal coliform)		Decreasing, esp. in wet season	
Metals (Fe, Cd, Cu, Pb, Zn)		Decreasing, esp. in wet season	
pH	Secondary	Stable	
Conductivity		Decreasing	
Flow Monitoring Performance Indicators			
T_{Qmean}	Primary	Stable or increasing	Same as short-term
High Pulse Duration (days)			
Low Pulse Duration			
Winter Baseflow (L/s)			
High Pulse Count		Stable or decreasing	
Low Pulse Count			
Summer Baseflow (L/s)		Stable	
Benthic Invertebrate Biomonitoring Performance Indicators			
B-IBI Scores	Primary	Stable or increasing	AMF Fair or higher Category
Mean Taxa Richness			
Additional Recommended Performance Indicators			
No. of Erosion Sites	Supplemental	Decreasing	No high consequence sites
No. of Fish Passage Barriers			No human-made passage barriers
Effective Impervious Area (EIA)		n/a (for tracking only)	n/a (for tracking only)
Riparian Forest Integrity (RFI)		Stable or increasing	Increasing
No. of Species / Locations of Spawners			Increase in spawners from current levels

1. Project Introduction and Background

The City of Port Coquitlam (City) retained Kerr Wood Leidal Associates Ltd. (KWL) to complete an Integrated Watershed Management Plan (IWMP) for the South Port Coquitlam area which includes the Brown Creek, Baker Creek, and Fraser River watersheds and totals 650 ha. Refer to Figure 1-1 for the study area.

Brown Creek, Baker Creek, and the Fraser River watersheds are within the core territory of kʷikʷəƛ̓əm First Nation (kʷikʷəƛ̓əm) and, as such, kʷikʷəƛ̓əm is vitally concerned that its cultural, heritage, economic, environmental, and other interests are adequately considered and reflected in the IWMP planning and implementation process. In accordance with United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP; United Nations General Assembly, 2007), Article 18 and 19 kʷikʷəƛ̓əm must be consulted and included in any decision-making processes which may affect them. In accordance with UNDRIP Article 26, 29, and 32, kʷikʷəƛ̓əm has the right to the above-mentioned lands, their conservation, and the right to develop priorities and strategies for the use of those lands. Therefore, it is critical that kʷikʷəƛ̓əm is included and consulted in all land use decision making processes.

The **Brown Creek** watershed includes upland area north of Eastern Drive and Pooley Avenue, but a large proportion of the catchment is lowland area that lies within the 200-year Fraser River flood level that inundates the Pitt River floodplain. Brown Creek drains south from the corner of Pooley Avenue and Connaught Drive merging with Broadway Creek near Eureka Avenue. The City's GIS system labels the creek below the confluence as Broadway Creek rather than Brown Creek. After the confluence, the creek drains to the Harbour St Storm Pump Station site where five pumps (housed at three pump houses) and a floodbox drain the flows through the dike to the Pitt River.

The **Baker Creek** watershed is largely an upland area with a small area within the 200-year Fraser River floodplain near where Baker Creek drains under the Mary Hill Bypass and Argue Street. Baker Creek drains uncontrolled to the Fraser River.

The **Fraser River** catchment includes mainly upland area above the Mary Hill Bypass and drains through several outfalls directly to the Fraser River.

The IWMP process strives to preserve watershed health as a whole while meeting community needs and allowing development and redevelopment to occur. It allows for trade-offs so that environmental losses in one area within a watershed can be offset by gains in others, thereby meeting the regulatory guiding principle of no-net-loss.

The key to successful integrated watershed management planning is having a framework that provides direction for the technical analyses and study process. This section outlines the study framework, watershed goals and objectives, key issues, regulatory requirements, and the applicable stormwater criteria.

1.1 Goal of the IWMP

The goal of the South Port Coquitlam IWMP is to develop a comprehensive and technically grounded IWMP for improvement of all three watersheds by:

- Minimizing the risk of flooding
- Mitigating the impact of development
- Preserving aquatic and riparian habitats
- Recommending practical and effective improvements for watershed health

1.2 Scope of Assignment

The following table summarizes the major tasks in this study.

Table 1-1: Engineering Work Program

Phase	Major Tasks	
Phase 1 Reconnaissance and Documentation of Existing Conditions	1.	Establish Framework
	2.	Engineering and Environmental Inventory
	3.	Land Use Assessment
	4.	Environmental Assessment
	5.	Existing Model Review
	6.	Phase 1 Reporting and Meetings
Phase 2 Evaluation and Identification of Key Issues and Opportunities	7.	Model Update with Calibration and Validation
	8.	Environmental Parameters Assessment and Ecological Health Analysis
	9.	Phase 2 Reporting and Meetings
Phase 3 Options to Address Key Issues and Support Watershed Health	10.	Policy and Action Alternatives
	11.	Option Development
	12.	Phase 3 Reporting and Meetings
Phase 4 Implementation Strategy with Recommendations and Costs	13.	Detailed Implementation Plan
	14.	Funding Strategy
	15.	Quality Assurance Program
	16.	Draft and Final Report

1.3 Background Information

The following background information has been reviewed and incorporated into the assessments for the IWMP:

- Port Coquitlam Floodplain Mapping (WMC, 2010)
- Stormwater Hydraulic Model (KWL, 2015)
- IDF Curve Assessment (Urban Systems, 2021)
- IDF Curve Update Memo #2 (Urban Systems, 2023)

1.4 Watershed Management Initiatives

The following have been identified as existing watershed management initiatives that are within or overlap with the South Port Coquitlam IWMP study area:

- Brown Creek Streamkeepers is a volunteer stewardship group that formed in the early 2000s and is focused on the health of Brown Creek. This group has identified and reported water quality issues throughout the years and have also previously worked with the City's Manager of Parks and Planning to get sensitive habitat signage installed along the Brown Creek Trail (pedestrian pathway).

- Baker Creek Streamkeepers is an active volunteer stewardship group formed in 2023. A member of the Pacific Streamkeepers Federation, the group is focused on the health of the Baker Creek. The group has been collaborating with the City's Environmental Coordinator to remove invasive species in Baker Creek, adopt streets in the creek catchment, clear stream obstructions, cleanup the creek, conduct fish sampling, and raise awareness of the fish-bearing stream to private property owners. Current projects include:
  - Ivy removal from trees – Ongoing (90% complete)
  - Debris removal from creek throughout Marian Kroeker Park – February 2024
  - Ivy removal conducted with Hazelwood Early Learning Centre in Marian Kroeker Park (100 m^2) – April 2024
  - Adopt-a-SPOT established covering all adjacent streets to Baker Creek – Ongoing
  - Creek-side cleanup conducted in Marian Kroeker Park and adjacent City property – March 2024
  - Ivy removal scheduled with Hazelwood Early Learning Centre – June 2024
  - Storm drain marking (as per DFO guidelines) – July 2024
- EnviroPlan was created in 2011 and provides an environmental framework for the City, identifies environmental goals and objectives, and describes strategies to reach these goals. An Implementation Plan accompanies this EnviroPlan as a complementary internal working document to guide the City's activities and plans. Two goals from the plan that will align well with potential restoration opportunities that may be recommended within this report are the following:
  - To create a network of healthy natural, semi-natural, and managed green spaces at a variety of scales
  - To develop an efficient system of water distribution and consumption and protect waterways
- Development of the City's Climate Action Plan is currently underway and is building on the City's 2010 Corporate and Community Climate Action Plan. The plan will provide new greenhouse gas emissions inventories and targets, corporate and community actions to achieve emissions targets, identify key partnerships for climate action planning and implementation, provide a vulnerability and risk assessment, and identify ways (i.e., green infrastructure) for the City to adapt to the effects of climate change and reduce its overall risk. The plan will also include a detailed implementation plan.

1.5 Stormwater Bylaws and Drainage Criteria

Existing municipal bylaws relevant to the IWMP are summarized below.

Subdivision Servicing Bylaw No. 2241, 1987:

- Provides design criteria and considerations for minor and major storm system design.
- Contains the intensity-duration-frequency (IDF) curves to be used for all design calculations.
- Outlines parameters and additional sources to be used in the hydraulic calculations for sizing.
- Provides design and construction guidelines for storm sewers.

Soil Removal and Deposit Bylaw No. 3331, 2002:

- Contains soil removal and deposit requirements.
- Provides overview of permit requirements.

Water Ways Protection Bylaw No. 917, 1969:

- Outlines the restriction of pollution and obstruction for all streams, creeks, waterways, watercourses, waterworks, ditches, drains, and sewers.

Zoning Bylaw No. 3630, 2008:

- Provides the existing land use zones for lots in the City of Port Coquitlam.
- Outlines the description and regulations for each zone to aid in determining impervious areas for each catchment.

Official Community Plan Bylaw (adopted in 2005 with No. 3467 and updated in 2013 with No. 3838):

- Provides the planned land use zones for future development in the City.
- Outlines the description for each land use in the future zones to aid in determining impervious areas for each catchment.
- Defines Watercourse Development Permit areas within the City.

Development Procedures Bylaw No. 3849, 2013:

- Define development procedures within the City including application procedures, fees, notifications and signage, permit procedures, development variance permit procedures, and watercourse development permit procedures.

Maple Creek IWMP (KWL, 2021) recommends the following updates to the City's bylaws:

- Update the Subdivision Servicing Bylaw No. 2241, 1987:
  - add volume capture target (6-month, 24-hour event); and
  - include climate change and sea level rise considerations.
- Develop, implement, and enforce an Erosion and Sediment Control Bylaw.
- Develop green road standards for stormwater treatment and volume reduction.
- Develop examples and standards for Stormwater Source Controls to aid with implementation.

1.6 Summary of Drainage Assessment Criteria

The drainage assessment criteria used for the South Port Coquitlam IWMP was developed in collaboration with the City and is summarized in Table 1-2. The City is in the process of updating its Subdivision Servicing Bylaw to include climate change and sea level rise considerations. For this study, the City provided KWL with two studies by Urban Systems (2021 IDF Curve Assessment and 2023 IDF Curve Update Memo #2) and identified which intensity-duration-frequency curves from the Urban Systems studies should be used for assessing the impact of climate change.

Table 1-2: Summary of Drainage Assessment Criteria

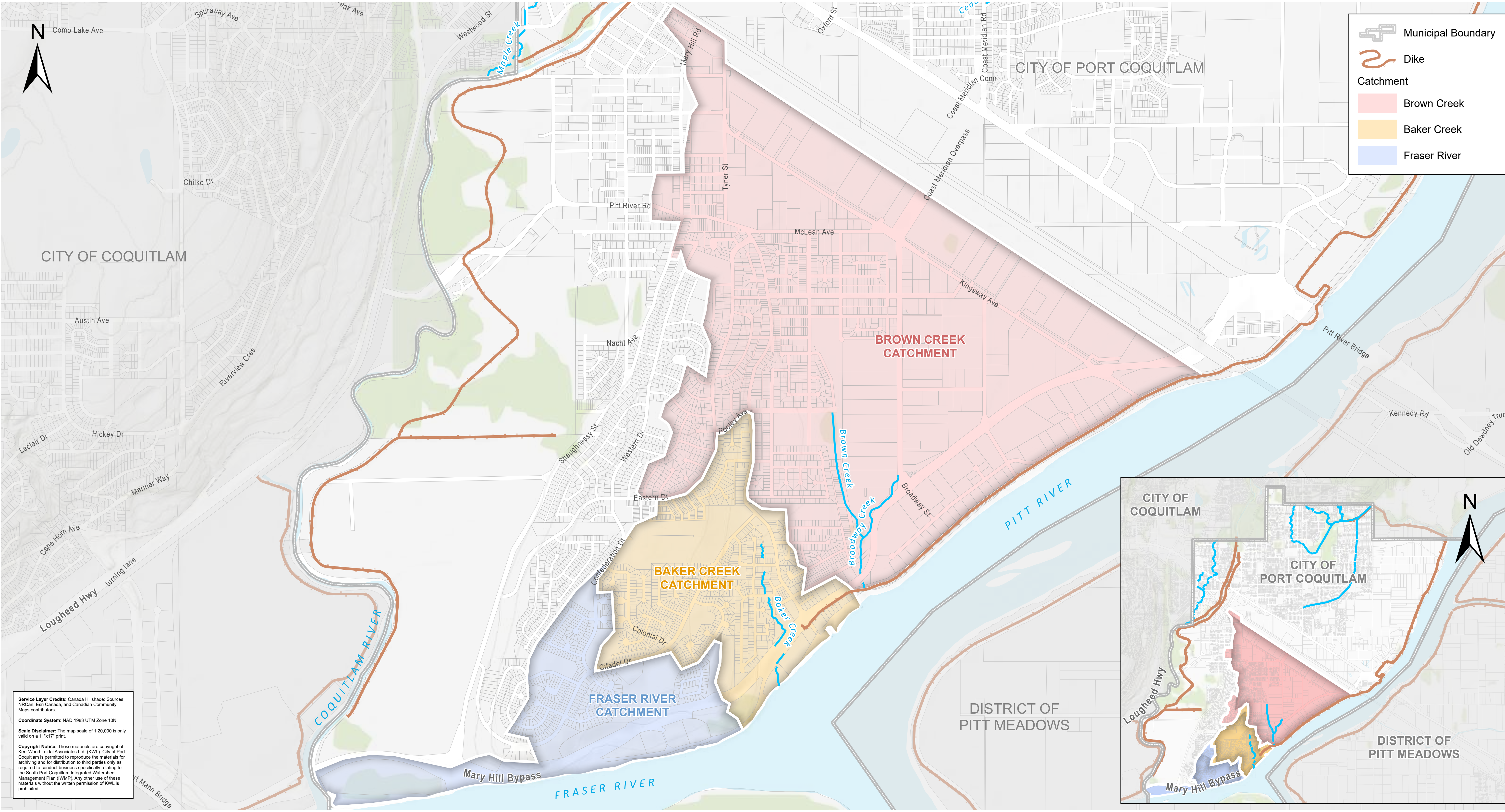
Application	Criteria/Methodology
Storm System Capacity	• Minor system pipes assessed for 10-year return period Canadian Atmospheric Environment Service (AES) design storm of 1-hr, 6-hr, and 12-hr duration. Includes ditches. • Major system pipes assessed for 100-year return period AES design storm of 1-hr, 6-hr, and 12-hr duration. Includes culverts. • Pipe and culvert performance evaluated using the Hydraulic Level of Service (HLoS) rating system for pipes and culverts (see Section 4.3).
Large Drainage Watercourses and Pump Station Assessment	• Large drainage courses such as creeks, rivers, ponds, or pump stations assessed with 100-year return period AES design storm of 6-hr and 12-hr duration and the 2.5-day design storm. • Capacity is exceeded if there is overland flooding in developed areas. Undeveloped areas are permitted to flood.
Downstream Boundary Conditions	• Free outfalls to generate peak flows for sizing. • 100-year winter Fraser River water levels with/without sea level rise (SLR) for the lowland flooding and pump station capacity assessment.
Impact of climate change on rainfall was included by using the City's SSP8.5 Median Intensity-Duration-Frequency Curves (2070–2100).	

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Study Area

Figure 1-1

2. Watershed Information and Background

2.1 Drainage

The three watersheds (Brown Creek, Baker Creek, and Fraser River) are in the City of Port Coquitlam and are bounded by the Canadian Pacific Railyard to the northeast, the Pitt River to the southeast, the Fraser River to the south, and the high ground of Mary Hill to the west. The following points further describe the watersheds:

- Watershed areas are approximately 440 ha for Brown Creek, 115 ha for Baker Creek, and 95 ha for Fraser River.
- Drainage direction is generally toward the east and south via storm sewers, culverts, creeks, and ditches.
- The Brown Creek watershed discharges to the Pitt River through the Harbour St Storm Pump Station and a floodbox.
- A large portion of Brown Creek and a small portion of Baker Creek lie within the 200-year Fraser River flood level that inundates the Pitt River floodplain and are protected by the Pitt River dike.
- The Baker Creek and Fraser River watersheds discharge to Fraser River through gravity outfalls.

Figure 2-1 provides an overview of the drainage system. City staff indicated that there are potential or recurring areas of localized flooding and drainage concerns within the study area. The following are key staff observations:

- Marian Kroeker Park area has flooded before; flat areas may need additional drainage.
- The Brown Creek watershed floods in some areas near Langan Avenue.
- The water levels are high in the culverts going under the Mary Hill Bypass.

Drainage Field Inventory

The drainage field inventory was completed on March 10 and 11, 2022 for the three watersheds. Field inventory work included:

- Locating the hydraulic structures and confirming sizes (with a tape measure where possible).
- Checking for obstructions.
- Documenting signs of erosion and deposition.
- Documenting sedimentation and blockages of drainage infrastructure.

Outfalls, headwalls, culverts, and channels were initially located using the City's GIS database. The creek beds were traversed on foot where possible. Locations of interest were identified, and measurements, photographs, and additional observation were made. Due to dense brush, many sections of the creek were unreachable. Figure 2-2 shows the field inventory locations and notes obstructions that could potentially impact the hydraulic behaviour of the creek. Appendix D summarizes the field observations and includes a photo overview. Section 5 provides a summary of observed erosion as well as sedimentation and blockage sites.

Drainage Pump Stations

There is one location within the study area where stormwater is pumped into the Pitt River. The "Harbour St Storm Pump Sation" includes three generations of pump houses:

- "Harbour Old" is a 1940s (estimated) wooden structure that has a single shaft impeller pump.
- "Harbour 1" is a 1970–1980 era station housing two submersible impeller pumps. There are two side-mounted flood gates for all three stations that are part of the Harbour 1 structure.
- "Harbour 2" is the lead pump station as the Harbour 1 and the Harbour Old stations only run when the Harbour 2 station cannot keep up with inflows. The Harbour 2 station is from the early 2000s and has two screw pumps.

City staff believe that the combined pumping capacity of the Harbour pumps is insufficient for the inflows that can be experienced during heavy rainfall events. City staff provided the following comments on the pump stations and their condition:

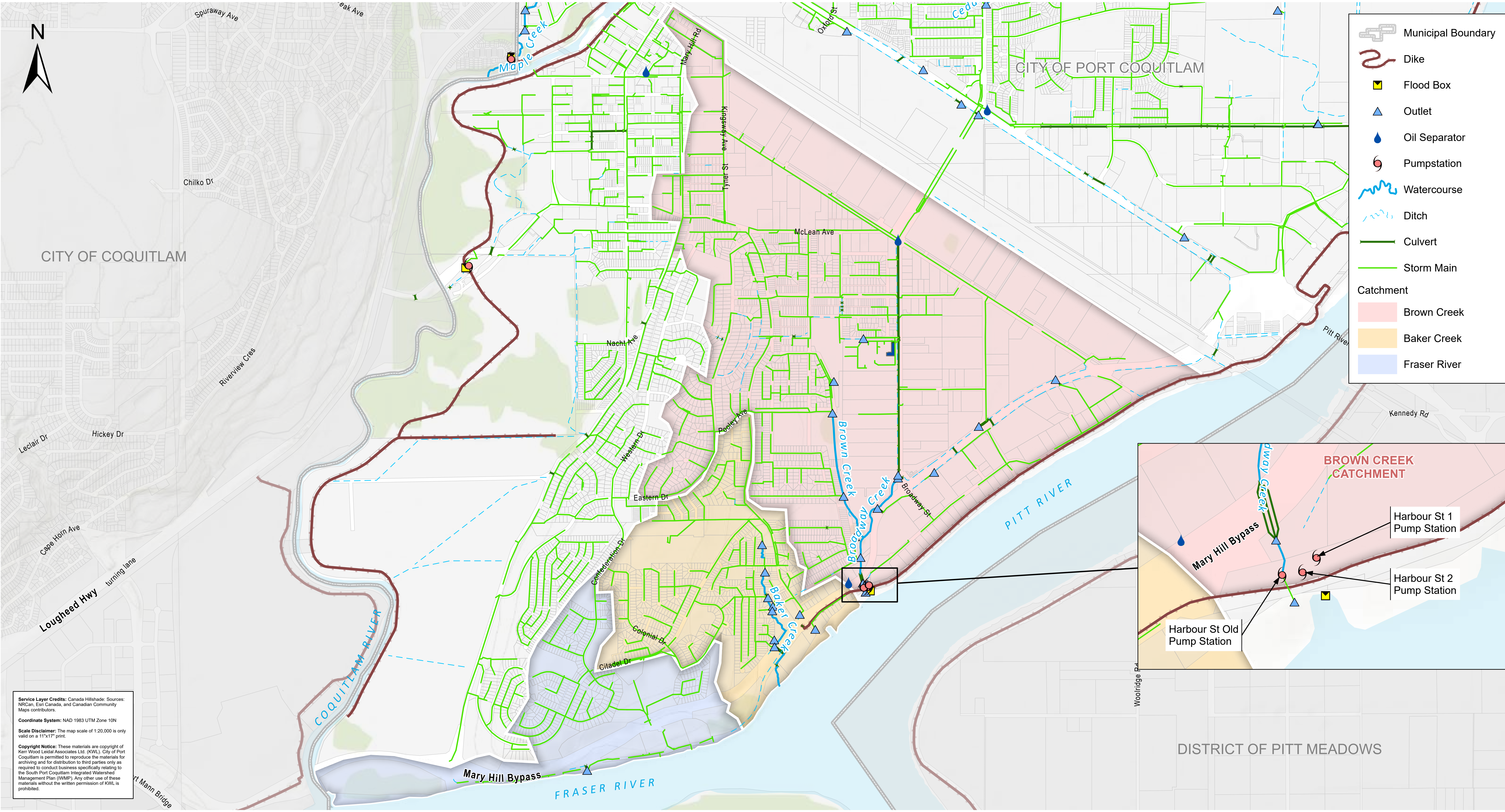
- Harbour Old – This station is at the end of its life. The structure is dilapidated. The pump is not fish-friendly nor in good working order. The discharge pipe though the dike is showing signs of corrosion and could potentially compromise the dike structure in the not-too-distant future. The pump station is still in service and can still be turned on, if necessary, but this is only done in extreme rain events when the Harbour 2 and Harbour 1 pump stations cannot keep up during high flows.
- Harbour 1 – This station is becoming dated. While the pumps are in good mechanical condition, the building is showing signs of deterioration, the electrical system is nearing the end of its expected life, and the flood gates have some mechanical issues. There have been ongoing issues with the flood gates being held open by debris. The flood gates no longer produce a good seal to the wall causing upstream flow which leads to additional pump run times, excess energy consumption, and lowering the site's net discharge capacity.
- Harbour 2 – This station overall is in very good condition. The upper and lower bearings for both screw pumps are planned for replacement in 2024.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

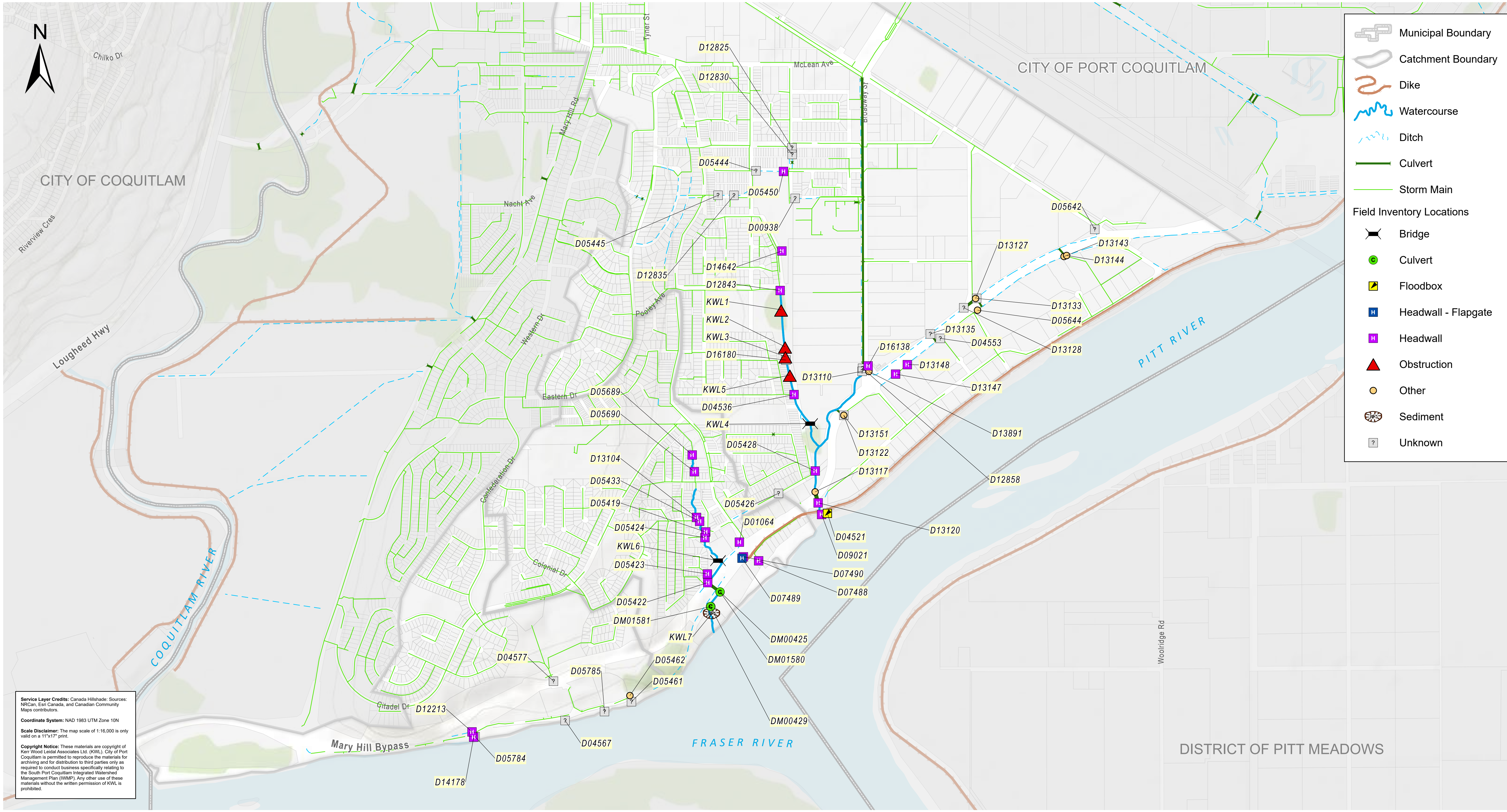
Project No. 646.043
Date December 2024
Scale 1:20,000
0 200 400 800 m

Drainage Overview

Figure 2-1

City of Port Coquitlam
South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Project No. 646.043
Date December 2024
Scale 1:16,000
0 100 200 400 m

Field Inventory Locations

Figure 2-2

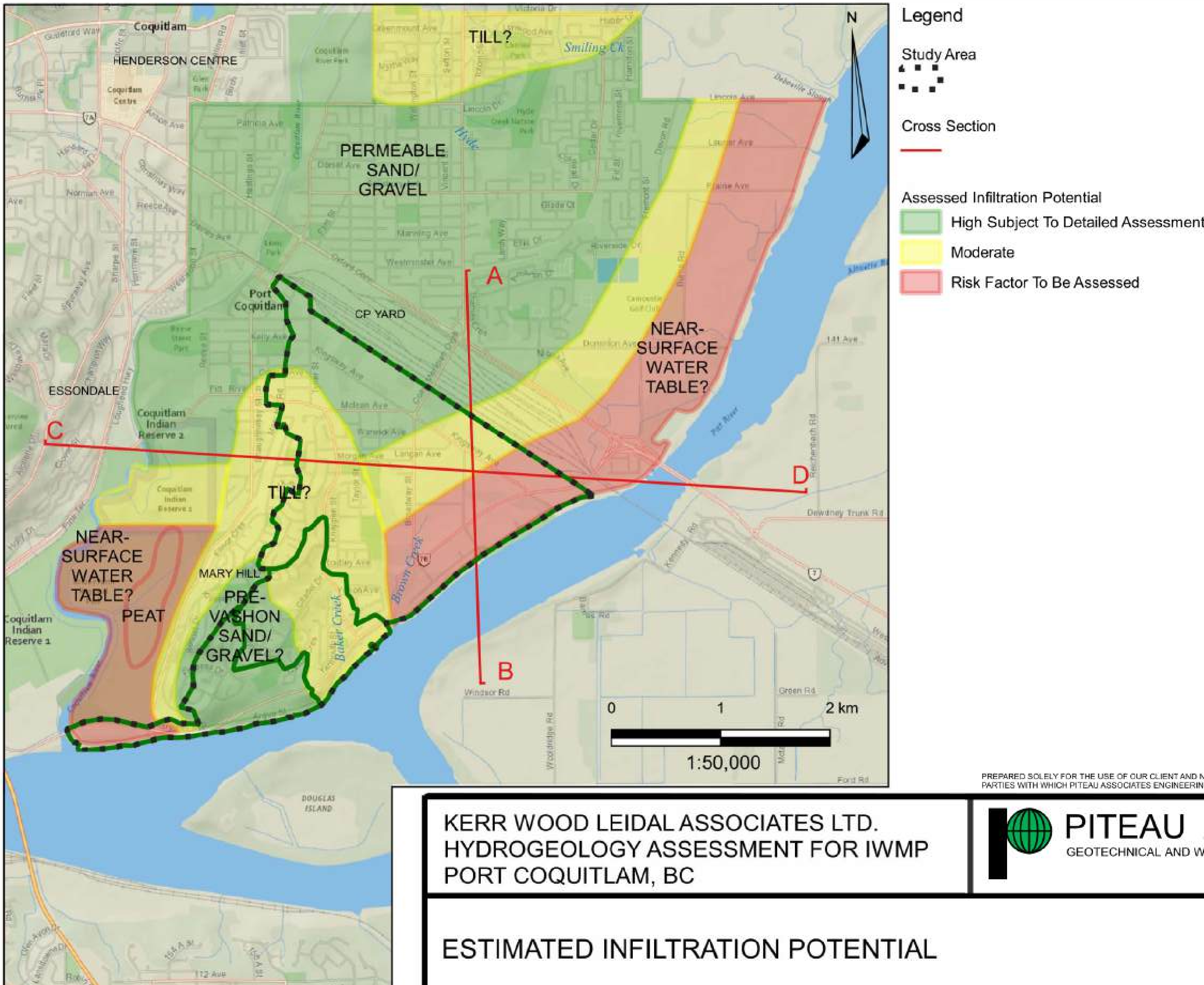
2.2 Hydrogeology

A hydrogeological desktop assessment of the South Port Coquitlam watersheds was completed by Piteau Associates Geotechnical and Water Management Consultants (Piteau) to review the subsurface conditions. The report is provided in Appendix A.

The assessment resulted in the following conclusions:

- The north and northeastern portion of the study area are underlain by channel fill (sand and gravel) and fluvial (silty sand) deposits. Mary Hill is underlain by sand and gravel deposits covered with till.
- The soils and sediments underlying a large part of the lowland plain are relatively permeable and offer good potential for infiltration of stormwater provided that the depth to the water table exceeds approximately 5 m. However, much of the lowlands is at risk of near surface water table as identified in Figure 2-3. Additional hydrogeological assessments should be carried out by qualified professionals in areas prospective for infiltration.
- Infiltration into the soils in the upland area on Mary Hill also appears feasible, but where till is exposed potential infiltration rates will be constrained.
- Enhanced infiltration can help provide recharge to aquifers (specifically Aquifers 70 and 71 as shown in Figure 2 of Appendix A), which in turn provide baseflows to Brown Creek.
- Possible source control measures that could be implemented to minimize stormwater runoff and/or augment groundwater recharge include perforated storm pipes in shallow trenches, seepage basins, soak-away pits, infiltration chambers, absorbent landscapes, rain gardens, vegetated swales, and pervious paving. It is generally preferred to have wide distribution of systems introducing water into different areas and material types, rather than a few concentrated areas discharging into one material type. This will increase the potential for infiltration works to intersect permeable zones while reducing the potential for water table mounding and the potential for slope instability.
- Systems that collect and store stormwater runoff for eventual infiltration to ground should have adequate storage volume and provide for a clarification/treatment system to eliminate sediments and floating detritus that can cause clogging of the infiltrative surface. Depending on local conditions, infiltration systems can be designed to manage the runoff volume associated with a typical storm, with a bypass for larger flows to the storm sewer system.
- Additional hydrogeological assessments should be carried out by qualified professionals in areas prospective for infiltration. These would typically involve excavating test pits or trenches to observe soil types and to facilitate installation of standpipes for water table monitoring during the wet seasons (winter and spring), and infiltration testing.
- Sandy sediments in the watershed offer opportunities for passive renovation of storm water, and enhanced infiltration is not expected to have any noticeable effect on aquifer water quality.

Figure 2-3 shows the approximate extent of areas appearing to show high to low infiltration potential for stormwater.



PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.

KERR WOOD LEIDAL ASSOCIATES LTD.
HYDROGEOLOGY ASSESSMENT FOR IWMP
PORT COQUITLAM, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

ESTIMATED INFILTRATION POTENTIAL

BY:	DATE:
AB	MAR 24
APPROVED:	FIG:
DJT	2-3

2.3 Land Use

The types, locations, and densities of land use in the watershed have a direct bearing on the quality and quantity of runoff. Each type of land use is associated with a percentage of pervious and impervious cover that affects rainwater capture, absorption, and infiltration, depending on building coverage and surface materials. Land use also affects the amount of pollutant generating surfaces and the specific pollutants that may be of concern. Various stormwater management best practices are suggested for different types of land use.

Land use information including existing zoning and future Official Community Plan (OCP) conditions was examined from a variety of sources, including municipal GIS data, ortho-photography, Google Earth, and staff observation. From the City's GIS data, a series of maps and tables were generated that summarize existing and future land use characteristics and associated land areas and zoning.

Existing Land Use

The watersheds are currently comprised of a mix of land uses as illustrated in Figure 2-4 and summarized in Table 2-1. Approximately 30% of the study area is residential while 31% is commercial and industrial land uses. The remaining land is comprised of parks, institutional, comprehensive development zones, highways, and road rights-of-ways (ROWs):

- Approximately 25% of the study area is currently single-family residential, while only 5% is high-density residential comprising apartments, duplexes, and townhouses. The Baker Creek and Fraser River watersheds consist of 54% and 41% respectively of residential areas while the Brown Creek watershed has 22% residential areas on the west side.
- The light to heavy industrial use is concentrated in the Brown Creek watershed along the eastern portion of the watershed, adjacent to the Pitt River. These areas typically have high site impervious coverage with large, paved areas. Baker Creek and Fraser River have little to no industrial areas.
- Commercial uses comprise less than 1% of the area but typically have high site impervious coverage with large, paved areas for parking or services.
- Comprehensive Development Zones comprise less than 2% of the entire area.
- Approximately 7.5% of the total study area consists of park space.

Future Land Use

The OCP (future) land use (Figure 2-5) shows a slight increase in impervious area from the existing land use in the Brown Creek and Fraser River watersheds, but Baker Creek remains relatively unchanged. A slight decrease overall in residential and institutional areas with a similar increase in industrial and commercial areas is expected with buildout to the OCP.

Comparison of Existing and Future Land Uses

The percentage of land use coverage for each watershed for both existing and future conditions is summarized in the following table.

Table 2-1: Percentage of Land Use Types for Existing and Future Land Use

Land Use	Existing		Future	
	Area (ha)	% of Total Area	Area (ha)	% of Total Area
Baker Creek Watershed				
Commercial	0.4	0.3%	5.0	4.4%
Institutional	9.9	8.6%	9.8	8.6%
Industrial	0.0	0.0%	0.0	0.0%
Residential	61.9	53.9%	57.2	49.7%
Agriculture and Parks	9.1	7.9%	10.1	8.8%
Road ROWs	32.8	28.6%	32.8	28.6%
Comp. Dev. Zone	0.8	0.7%	0.0	0.0%
Total	**115.0**	**100%**	**115.0**	**100%**
Brown Creek Watershed				
Commercial	5.4	1.2%	7.2	1.6%
Institutional	32.0	7.3%	18.2	4.1%
Industrial	200.2	45.5%	215.7	49.0%
Residential	98.4	22.4%	98.9	22.5%
Agriculture and Parks	15.6	3.5%	23.4	5.3%
Road ROWs	76.4	17.4%	76.5	17.4%
Comp. Dev. Zone	11.8	2.7%	0.0	0.0%
Total	**439.9**	**100%**	**439.9**	**100%**
Fraser River Catchment				
Commercial	0.0	0.0%	0.0	0.0%
Institutional	1.5	1.6%	1.5	1.6%
Industrial	0.0	0.0%	0.0	0.0%
Residential	39.0	40.9%	38.3	40.2%
Agriculture and Parks	23.9	25.1%	24.6	25.9%
Road ROWs	30.9	32.4%	30.9	32.4%
Comp. Dev. Zone	0.0	0.0%	0.0	0.0%
Total	**95.3**	**100%**	**95.3**	**100%**

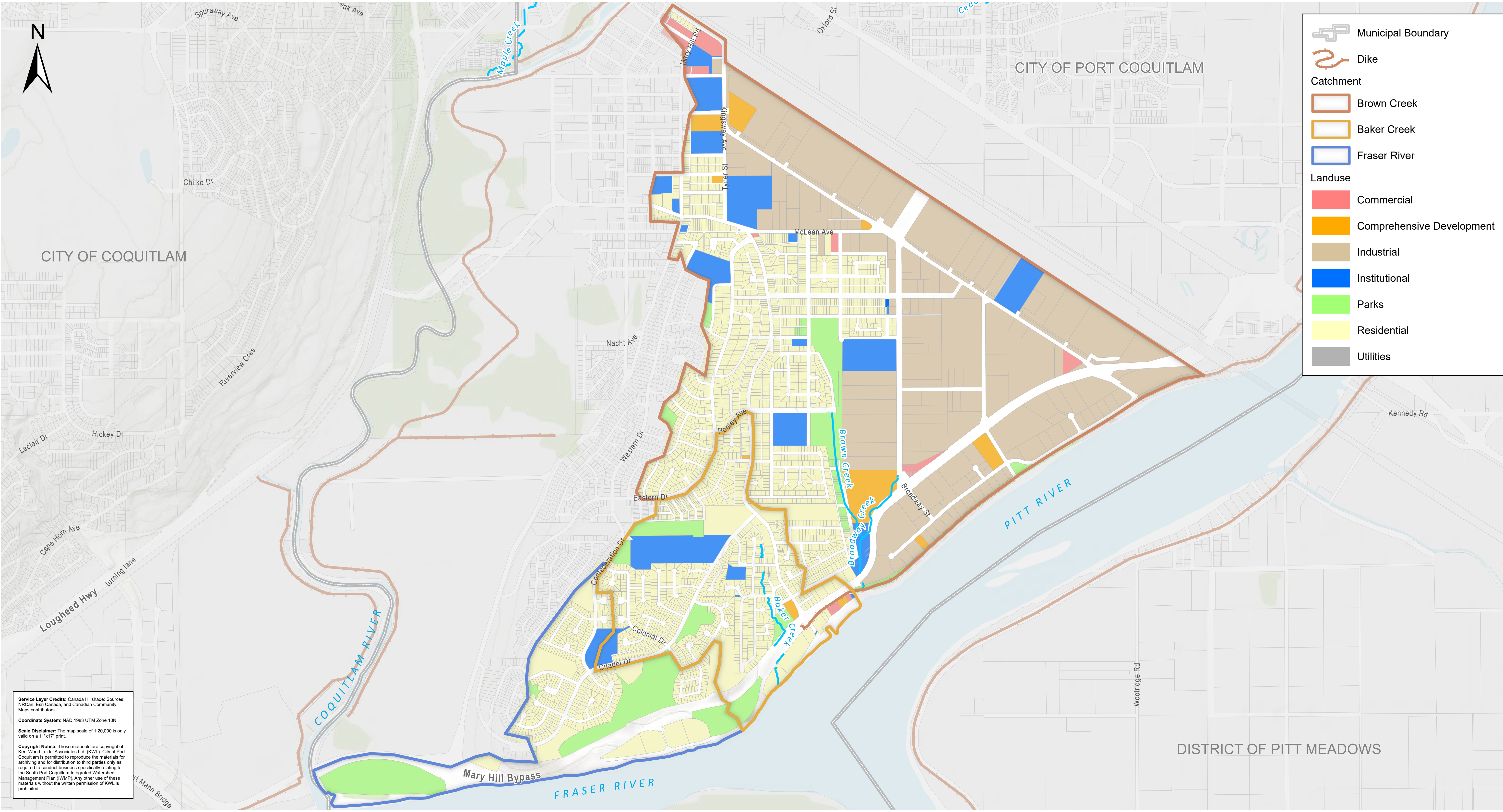
Red shading = increasing >1% of a land use between existing to future conditions.
Green shading = decreasing >1% of a land use between existing to future conditions.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Land Use

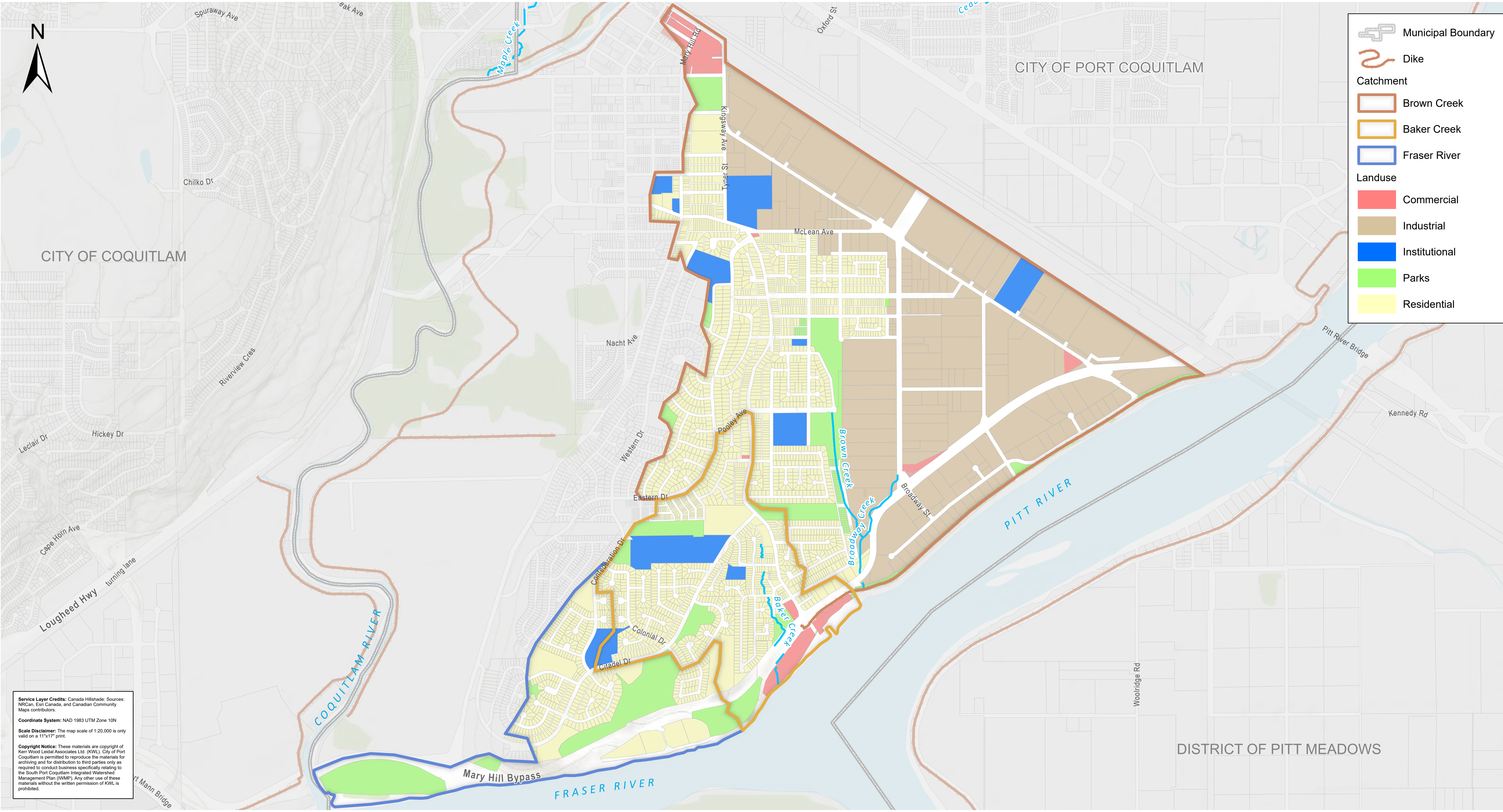
Figure 2-4

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Land Use

Figure 2-5

Total Impervious Areas

Total impervious area (TIA) represents impervious areas that drain directly to the drainage system and do not allow rainfall runoff to infiltrate into the ground. TIA percentages were estimated using total lot coverage in the 2008 Zoning Bylaw (No. 3630) and orthophotos to identify previous/impervious areas for each parcel. Figure 2-6 and Figure 2-7 show existing and future impervious areas. Table 2-2 shows the TIA values for each land use type and Table 2-3 shows the TIA for each watershed. Future land use TIAs were determined from the OCP.

Table 2-2: Existing and Future Land Use Types and Percent Impervious

Land Use Types	Existing Land Use		2013 OCP Future Land Use	
	Land Use Types (Zoning) [1]	Average Impervious %	OCP Land Type [2]	Average Impervious %
Commercial	Community, District, Neighbourhood, and Service Station	93%	Downtown, Local, Marine, Marine Traditional, Highway	90%
Institutional	Institutional and Light / facility Institutional	54%	Institutional, School	56%
Industrial	General, Heavy, and Light	90%	Light, General, Heavy	90%
Residential	Apartment (1), Duplex, Single Dwelling (1,2,3,4), and Townhouse (1,2,3)	56%	Apartment, Residential, Small Lot, Townhouse, High Density Apartment	69%
Agriculture and Parks [3]	Agriculture, Parks, and Natural Areas	5%	Park and Recreation, Park Reserve	5%
Roads and ROWs	Road and ROW Areas	90%	Road and ROW Areas	90%
Comp. Dev. Zone	Comprehensive Development zones 5, 7, 9, 11, 14, 20, 23, 24, 28, 35.	95%	N/A	N/A

Notes:
1. Land use codes in the watershed and TIA% as per 2013 Zoning Bylaw.
2. OCP Land Types impervious percentages taken from zoning bylaws comparative land use

Table 2-3: Total Impervious Areas for Existing and Future Land Uses

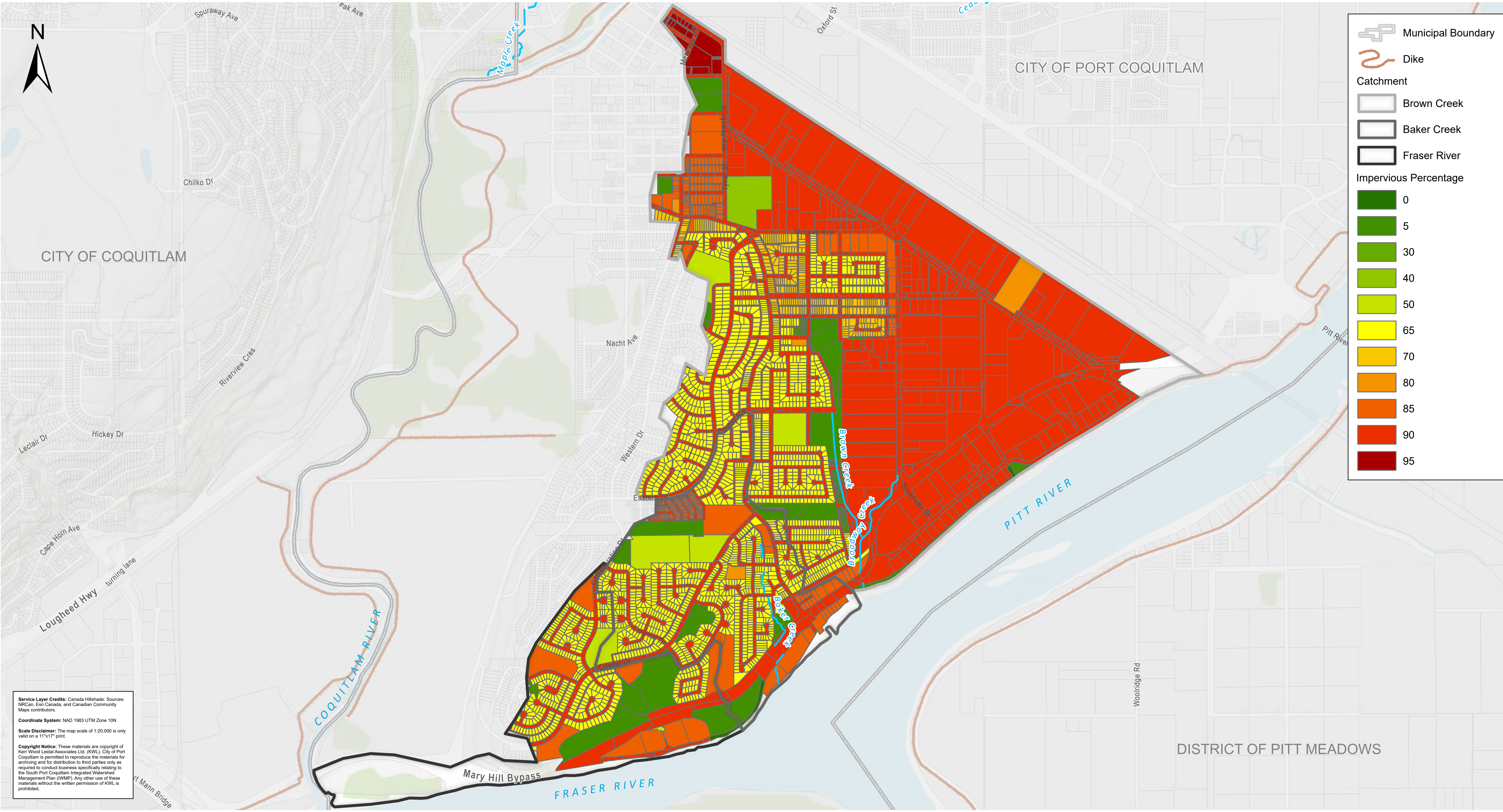
Watershed	Area (ha)	Existing Land Use % TIA	Future Land Use % TIA
Brown Creek	440	63%	68%
Baker Creek	115	75%	75%
Fraser River	95	30%	30%
Total	**650**	**60%**	**64%**

The existing TIA is high in the Brown (63%) and Baker (75%) watersheds and moderately high in the Fraser River watershed (30%). TIA increases in the Brown watershed by 5% for the future conditions. The other watersheds remain unchanged.

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Land Use Impervious Percentages

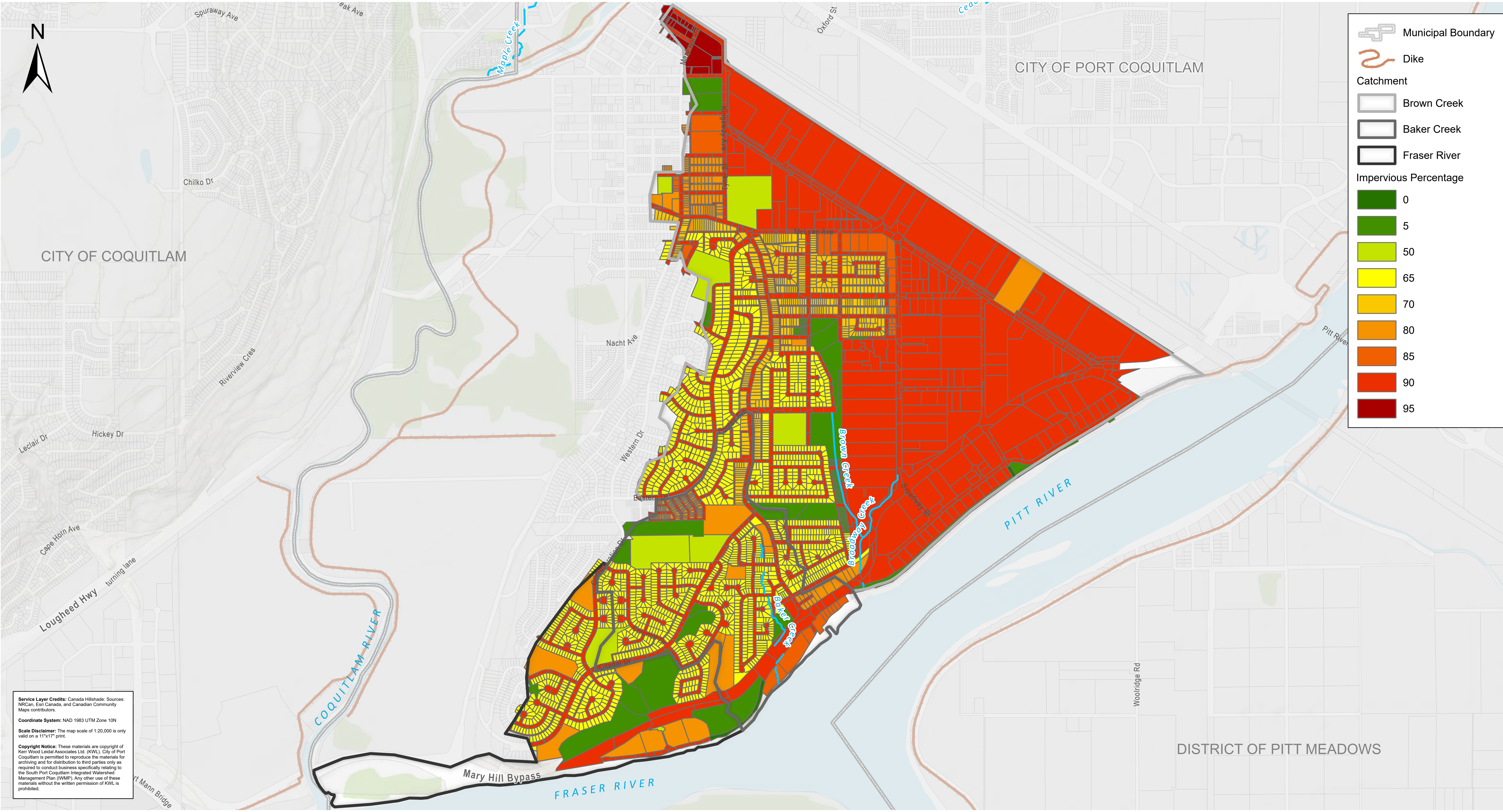
Figure 2-6

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Impervious Percentage

Figure 2-7

3. Hydrologic/Hydraulic Model

3.1 Background

KWL updated the City's 2015 storm sewer system hydraulic model to conduct a storm sewer system assessment as well as a lowland flooding assessment. The drainage assessment included evaluating the existing sewer's hydraulic performance using the Hydraulic Level of Service (HLoS) rating system, identifying flooding issues in the lowland area, and recommending conveyance upgrades.

This section summarizes the updates to the stormwater hydraulic model. The model was only updated within the study area. The updated model provides the basis for determining the required infrastructure to meet the expected demands of the City's Official Community Plan and climate change.

The scope of modelling work is listed below:

- Conducting a field site visit to confirm the condition of culverts and outfalls and to check for obstructions and debris.
- Updating the storm sewer model based on new GIS data supplemented by the survey data, pump station inventory data, and existing and future land use data provided by the City.
- Updating the catchment boundaries, land use, and runoff outlets.
- Confirming the model calibration after model update.
- Conducting modelling analysis for the existing and future development conditions.
- Identifying and prioritizing required pipe and culvert upgrades using the HLoS rating system.
- Adding a 2D component to the model in the lowland areas to examine flood extent, routing issues, and pump capacity.

Additional model-build methodology is included in Appendix B.

3.2 Model Overview

Drainage catchments are defined by the storm sewer network and major outfall locations and their upstream tributary areas. The total project area and three main catchments are shown on Figure 1-1.

Subcatchments

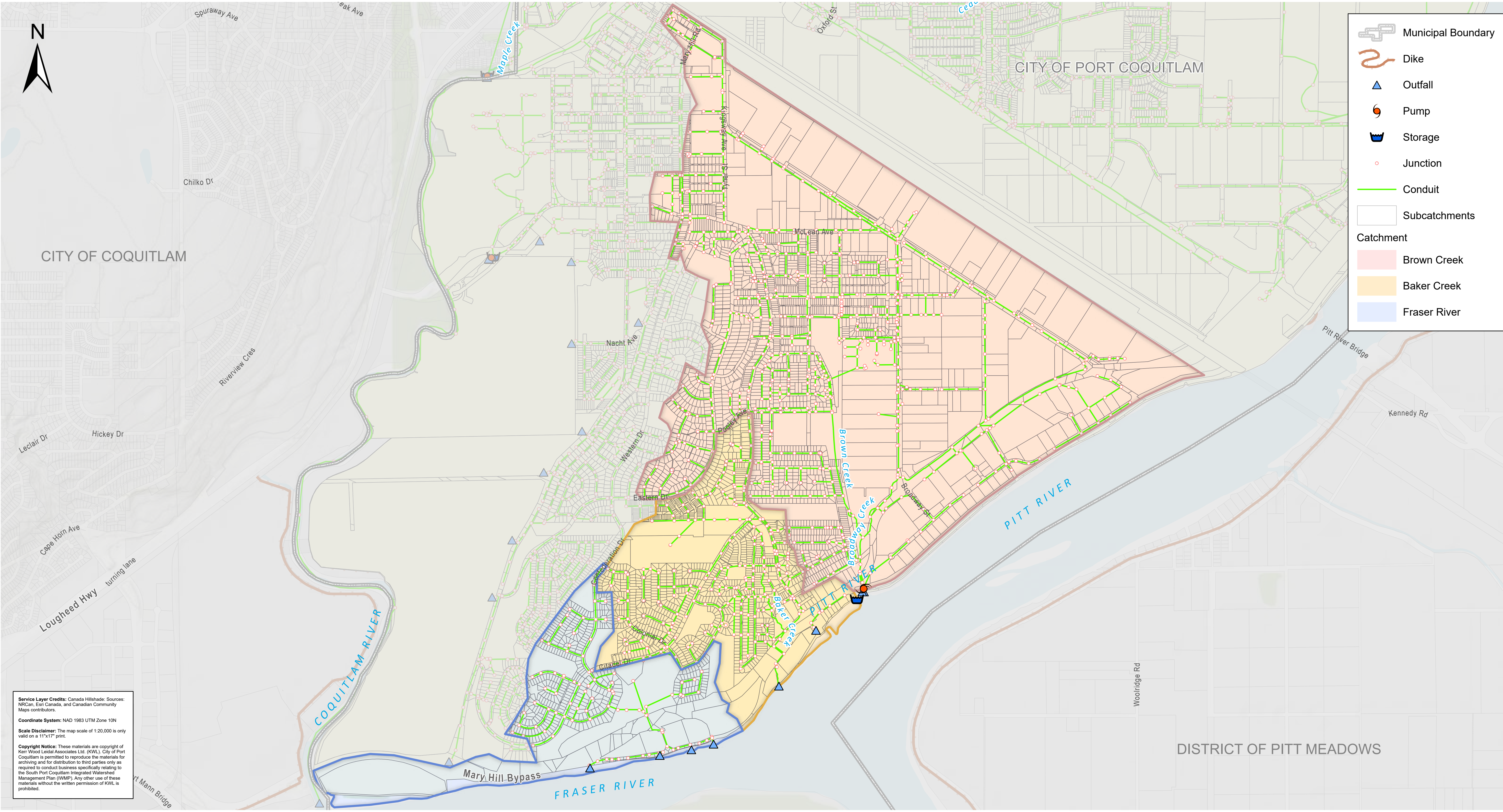
The existing model subcatchments were reviewed to determine if any edits were needed from the 2015 model. The catchment flow lengths, slopes, and outlets were updated based on up-to-date GIS data (land use, ortho photos, and LiDAR). Large catchments were split into smaller catchments if the updated contours showed that each area would flow to different outlets.
In total, 3936 subcatchments were updated and included in the model. A modelling schematic showing the subcatchments and storm sewer network is shown in Figure 3-1.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Modelling Schematic

Figure 3-1

Existing and Future Land Use

Impervious percentages were applied for each land use, as summarized in Table 2-2. Existing land use data was based on the zoning data and the future land use was based on the OCP data (received from the City). The 650-ha study area has an existing total percent impervious area of 60%, which is expected to increase to 64% total impervious area once built-out to the OCP. The TIA values for each of the three watersheds are shown in Table 2-3.

Channel Sections

Some creek channel sections were measured (estimated with a tape measure and not surveyed) during the field visits. Updated properties such as bank height, bed width, and current roughness values were incorporated into the hydrologic/hydraulic model.

Soil Parameters

The groundwater portion of the modelling software estimates the groundwater and interflow portions of the flow hydrograph. The infiltration and groundwater parameters used in the citywide stormwater hydraulic model (KWL, 2015) were based on KWL's database of calibrated model parameters for similar soil conditions. For the South Port Coquitlam model, Piteau provided a desktop hydrogeological and soil assessment which was used to confirm the model soil and aquifer information prior to the model validation.

2D Model Component

To assess the lowland flooding and pump station capacity, a 2D overland flow component was added to the 1D model. A 2D mesh was added to the 1D network throughout the lowland area, covering the area where the 1D model showed potential flooding to the ground surface in the 10-year and 100-year events. The mesh extent is shown in Appendix B.

The 2D mesh, added to determine flooding extent, was overlayed on top of the 1D network but the channels were reduced in depth to ensure volume was not duplicated in both the 1D and 2D networks. This was done by editing the channel cross-sections so that the highest point of the cross-section matched the invert at the connection point in the 2D mesh. Details of the 2D model development can be found in Appendix B.

Boundary Conditions

Outfall Boundary Conditions

The three watersheds outlet to the Fraser River and Pitt River via outfalls, the Harbour St Storm Pump Station, and a floodbox. Depending on the modelling scenario, the water level in the rivers at outfalls, pumps, and floodbox were set to either:

1) allow free-flow conditions likely preventing the pumps from turning on – used for the conveyance capacity assessments; or
2) use a tidal series peaking at 100-year river water levels – used for pump station capacity and lowland flooding assessment.

Figure 3-2 shows the two tidal conditions used for the existing and future model scenarios. The peak water elevations were obtained from *Simulating the Effects of Sea Level Rise and Climate Change on Fraser River Flood Scenarios* report from the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO, 2014). The tidal series was shifted for each of the rainfall durations to match the peak outflow at the Harbour St outfall with the peak tidal water level.

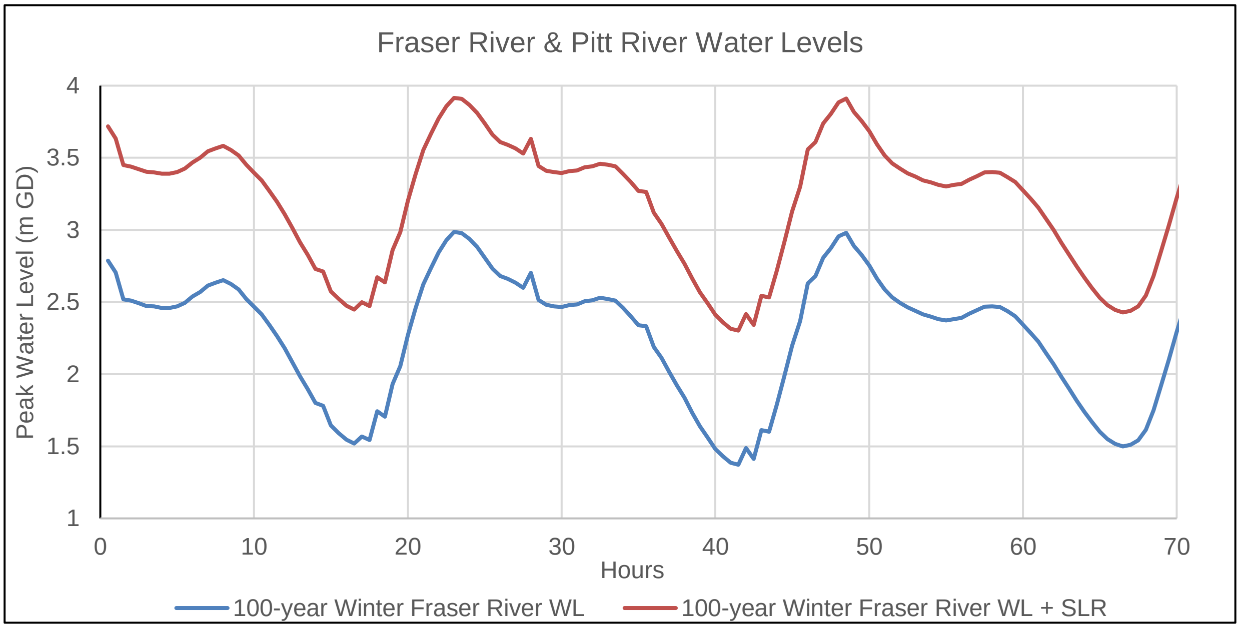


Figure 3-2: Tide Peak Water Levels

Drainage Pump Stations

Two of the pump stations (Harbour 1 and Harbour 2) were modelled. Harbour Old was not modelled as it is expected to be decommissioned soon. Each of the modelled stations have two pumps with different on/off levels. Pump curves were examined to determine the pump rates. Pump on/off settings were provided by the City and are summarized in Table 3-1.

Table 3-1: Pump On/Off Settings

Pump	Pump Type	Start Level (m)	Stop Level (m)	Peak Capacity (m^3/s)
Harbour 1 Pump Station				
1	Flygt (Sump pump)	0.66	0.48	1.27
2		0.55		1.27
Harbour 2 Pump Station				
1	Spaans (Screw pump)	0.50	-0.25	1.25
2		0.55		1.25
Note: Pump On/Off settings are provided by the City of Port Coquitlam.				

3.3 Rainfall IDF

Port Coquitlam recently updated its historic climate intensity-duration-frequency curves as per the IDF Curve Assessment (Urban Systems, 2021). The updated IDF is based on 1994 to 2020 data from the Metro Vancouver rain gauge at the Port Coquitlam Pump Station (station PQ38). Table 3-2 shows the rainfall intensity values for historic climate.

Table 3-2: Historic Climate Rainfall IDF (Metro Vancouver Station PQ38)

	Rainfall Intensity (mm/hr)					
Duration	2-year	5-year	10-year	25-year	50-year	100-year
1-hour	13.5	17.9	20.7	24.3	26.9	29.5
2-hour	9.7	12.5	14.4	16.6	18.3	20.0
6-hour	5.8	7.2	8.0	9.2	10.0	10.8
12-hour	4.2	5.0	5.6	6.3	6.8	7.3
24-hour	3.0	3.5	3.9	4.3	4.6	5.0
Note: Based on Station PQ38 Historical Data (1994-2020).						

Climate change was considered with the future land use scenario. Climate change was considered by using the SSP8.5 Median Curve (2070-2100) climate change factors recommended by the City and described in the IDF Curve Update Memo *#2* (Urban Systems, 2023). This results in an approximate 15% increase to the 10-year and 17% increase to the 100-year historic IDF values. Table 3-3 shows the climate change IDF values.

Table 3-3: Climate Change Rainfall IDF (SSP8.5 Median Curve (2070–2100))

	Rainfall Intensity (mm/hr)					
Duration	2-year	5-year	10-year	25-year	50-year	100-year
1-hour	15.4	20.6	24.0	28.2	31.3	33.3
2-hour	11.1	14.5	16.7	19.4	21.4	22.7
6-hour	6.6	8.3	9.4	10.7	11.7	12.4
12-hour	4.7	5.8	6.5	7.4	8.0	8.4
24-hour	3.4	4.1	4.5	5.1	5.5	5.7
Note: Using SSP8.5 Median Curve (2070-2100).						

3.4 Flow Monitoring

The Pooley and Kingsway stations were installed temporarily to collect flow data for the stormwater hydraulic model developed in 2015. The data was collected from October 2014 to December 2016. It is the only monitoring data available for the study area and is used for:

- Water balance analysis to help characterize the study watershed.
- Baseflow analysis to support the desktop hydrogeological assessment.
- Model validation after recent updates.

The findings of the water balance and base flow analysis are described below but are not used in the model update. Model validation results are described in Appendix B.

Water Balance

For a month-long period between December 25, 2014 and January 25, 2015, during which both flow monitoring and rainfall data was available, a water balance was completed to compare the flow monitoring data from each station with the total rainfall on their respective catchment areas. The total rainfall collected over the two station catchment areas were determined using data from the Metro Vancouver PQ38 rainfall station. The total rainfall depth recorded over the month-long period was 255 mm. Table 3-4 shows the comparison between the volume of flow recorded at the stations and the total rainfall.

Table 3-4: Water Balance

Monitoring Stations	Kingsway	Pooley
Catchment Area (ha)	63	30.2
Percent of Catchment Impervious (%)*	80%	70%
Total Rainfall Depth PQ38 (mm)	255	255
Total Rainfall Volume (m^3)	160,650	77,010
Total Flodar Volume (m^3)	127,337	43,663
Percent of Rain Volume Recorded (%)	79%	57%
*Assumes existing land use		

In the Kingsway catchment, 79% of the rainfall volume reached the station location while only 57% of the rainfall volume in the Pooley catchment reached the flow monitoring station. This is due, at least in part, to the higher impervious coverage of the Kingsway catchment.

Baseflow

Due to limited information regarding groundwater and baseflows, the month-long recorded data was examined to see if a winter baseflow could be identified. During the recorded period, the longest period between two rain events was over four days and two others were greater than three days. During those periods without rain, the Kingsway and Pooley stations recorded minimum flows of approximately 7.5 L/s and 1.5 L/s, respectively. Figure 3-3 shows the flows at these stations during these drier winter periods.

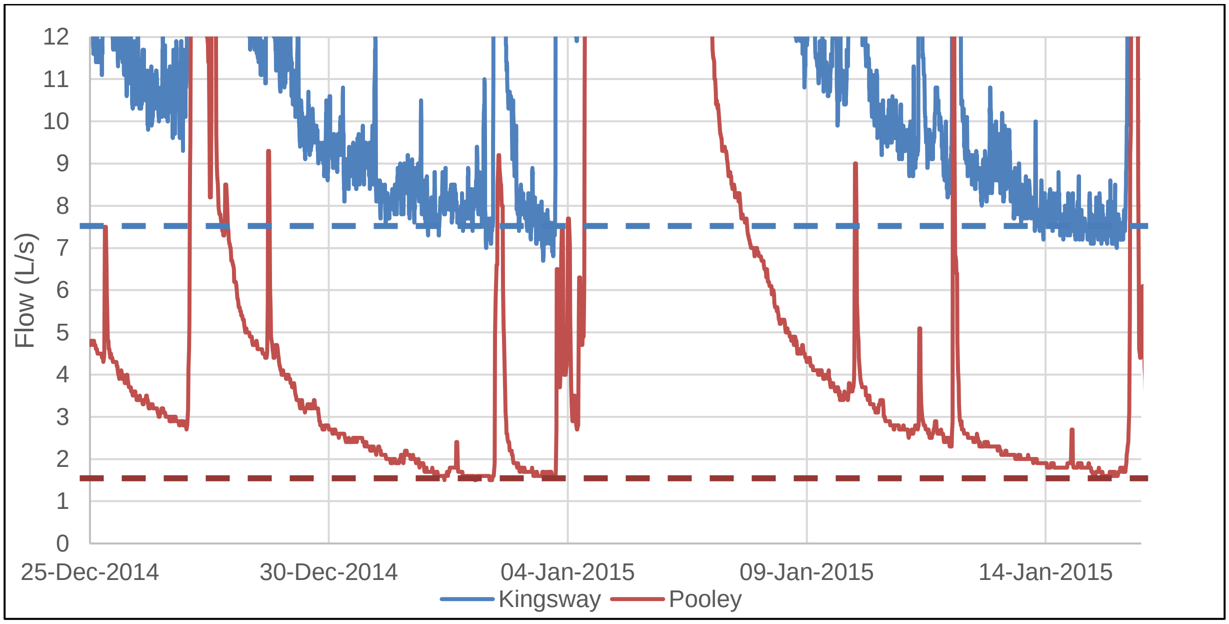


Figure 3-3: Recorded Winter Baseflows

4. Drainage System Assessment

4.1 Introduction

This section summarizes the hydrotechnical assessments to evaluate the conveyance capacity of:

- Minor and major storm sewers.
- Culverts.
- Ditches and watercourse.

It also summarizes the hydrotechnical assessment completed to evaluate:

- Lowland flooding and pump station capacity.

The assessments did not include pipe condition or age and used instantaneous peak flows.

4.2 Modelled Scenarios

Flows used for analyzing system capacity are peak instantaneous flows of either a 10-year (minor) or 100-year (major) return period with existing and future IDF curves and for existing and future Official Community Plan land use. All upgrades are sized for future land use with climate change flows.

The model was used to complete a storm sewer system conveyance capacity assessment as well as a lowland flooding and pump capacity assessment. Table 4-1 provides a summary of modelled scenarios. Results are provided in the following sections.

Table 4-1: Summary of Modelled Scenarios

Scenario	Design Storms and IDF	Land Use
Storm Sewer Conveyance Capacity Assessment Boundary Condition: Free Outfall		
Minor System Assessment HLoS Ranking	10-year, 1-, 6-, 12-hour Historic IDF	Existing Land Use
	10-year, 1-, 6-, 12-hour Climate Change IDF	Future Land Use
Major System Assessment HLoS Ranking	100-year, 1-, 6-, 12-hour Historic IDF	Existing Land Use
	100-year, 1-, 6-, 12-hour Climate Change IDF	Future Land Use
Lowland Flooding and Pump Capacity Assessment Boundary Condition: Tidal Series Peaking at 100-year Winter Fraser River Water Level + SLR		
Existing Land Use Flooding	100-year 1-, 6-, 12-hour & 2.5-day Historic IDF	Existing Land Use
Future Land Use Flooding	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use
Future Land Use Flooding Upgraded Pipes	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use
Future Land Use Flooding	100-year 1-, 6-, 12-hour & 2.5-day	Future Land Use

Scenario	Design Storms and IDF	Land Use
Upgraded Pipes Increased Pump Capacity by 50%	Climate Change IDF	
Future Land Use Flooding Upgraded Pipes Increased Pump Capacity by 100%	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use

4.3 Capacity Assessment Criteria

Hydraulic Level of Service Rating for Pipes and Culverts

The 986 storm sewer segments and 15 culverts in the model were assessed for capacity using the City's Hydraulic Level of Service rating system. The minor system was assessed using the 10-year design storms and the major system and culverts were assessed using the 100-year design storms.

Storm sewers of varying sizes and locations within the system have different requirements for conveyance capacity. For instance, the laterals and collectors at the upstream end of the system are generally designed to run half-full and not surcharge because service connections can be backed up and basements may flood. Surcharging may be allowable or even necessary to delay costly system upgrades.

The HLoS system assigns a rating to each pipe based on three criteria categories:

1. Hydraulic Capacity – q/Q ratio and/or friction slope in surcharged pipes.
2. Hydraulic Grade Line – modelled HGL with respect to pipe crown and ground elevation.
3. Velocity – whether minimum scouring velocity is achieved at peak flow.

Pipes have been classified in three categories with different requirements for HLoS criteria:

1. Laterals/Collectors – 250 mm diameter and smaller.
2. Trunks – larger than 250 mm diameter.
3. Culverts.

Table 4-2 describes the HLoS criteria for each pipe class. A score of 1 to 3 is assigned to each criterion, with '1' indicating adequate performance, '2' indicating marginal performance and '3' indicating a failure condition.

Table 4-2: **Hydraulic Level of Service Scoring**

Criteria/Scores	Lateral/Collector	Trunk	Culverts
	≤ 250 mm	>250 mm	
Hydraulic Capacity			
q/Q ≤ 0.8	1	1	1
q/Q < 1.0	2	2	2
q/Q ≥ 1.0	3	3	2
Friction Slope > Pipe Slope + 0.5%	-	-	3
HGL			
HGL < Crown	1	1	1
HGL ≤ 0.3 m above Crown	2	1	1
HGL ≤ Ground Elevation	3	2	2
HGL > Ground Elevation	3	3	3

Criteria/Scores	Lateral/Collector ≤ 250 mm	Trunk >250 mm	Culverts
Velocity			
v < 0.6 m/s	Pass	Fail	Fail
v ≥ 0.6 m/s	Pass	Pass	Pass
Note: Friction Slope (HGL Slope) = Inlet HGL max (m) – Outlet HGL (m) / Conduit Length			

A letter-grade indicating the HLoS rating is assigned based on the above criteria scores. The letter grades are described below in Table 4-3.

Table 4-3: Hydraulic Level of Service Ratings

Grade	Capacity	HGL	Velocity	Description
A	1	1	Pass	Pipe performing as designed.
B	1	1	Fail	Adequate capacity, low velocity may indicate potential sedimentation.
C	1	2 or 3	N/A	Adequate capacity, downstream condition causing backwater.
D	2	1, 2 or 3	N/A	Marginal capacity.
	3	1	N/A	
E	3	2	N/A	Capacity exceeded.
F	3	3	N/A	Capacity exceeded and overflow likely.

In general, ratings A–D will not trigger an immediate upgrade as there is capacity in the pipe to convey flows. A pipe receiving an E or F rating requires an upgrade as the pipe is flowing full or at risk of flooding. Ratings of C indicate a critical downstream condition (likely an E or F pipe) causing poor performance upstream, increasing the priority of the upgrade at the critical point.

Ditches and Watercourses Capacity Assessment Criteria

Roadside ditch channels, for the collection of road runoff, are included in the minor system and they were checked for their capacity to convey the 10-year flows. Ditches are assumed to be undersized if flooding is observed during the 10-year storm using the existing ditch cross sections.

Main watercourse channels along the three main creeks are part of the major system and were assessed for their ability to convey 100-year flows. The watercourses are assumed to be undersized if flooding outside of the watercourse is observed during the 100-year storm.

Lowland Flooding and Pump Capacity Assessment Criteria

The lowland area was assessed to determine the extent of flooding during the 100-year storm and to evaluate impact of pipe upsizing and/or pump capacity upgrades on overland flooding.

The pump station capacity was assessed to determine whether the pump station can drain the design flow without backwatering and flooding upstream developed areas. For this study, a pump station's capacity is exceeded when the upstream water level cannot be kept lower than the ground level in developed areas. Undeveloped areas are permitted to flood.

4.4 Capacity Assessment Results

Minor System – Storm Sewer Capacity Assessment

The drainage system was assessed to determine its ability to convey the minor flow, generated by the 10-year return period rainfall events. The HLoS criteria and the existing pipe diameter were used to determine whether each pipe is undersized (Grade E or F).

Figure 4-1 and Figure 4-2 show the capacity assessment results from the 10-year event models for the historic conditions IDF and existing land use and future climate change IDF and future land use scenarios, respectively.

Minor System – Existing Condition

Figure 4-1 schematically shows the pipes (in orange and red) that scored Grade E and Grade F during the existing conditions 10-year event model runs. Table C-1 in Appendix C lists the pipes that fail the minor system HLoS criteria in the existing conditions and the upgrade sizes based on future condition flows. In total, 16 pipes were rated Grade E and 140 pipes were rated Grade F of the total 703 minor pipes in the study area.

Minor System – Future Condition

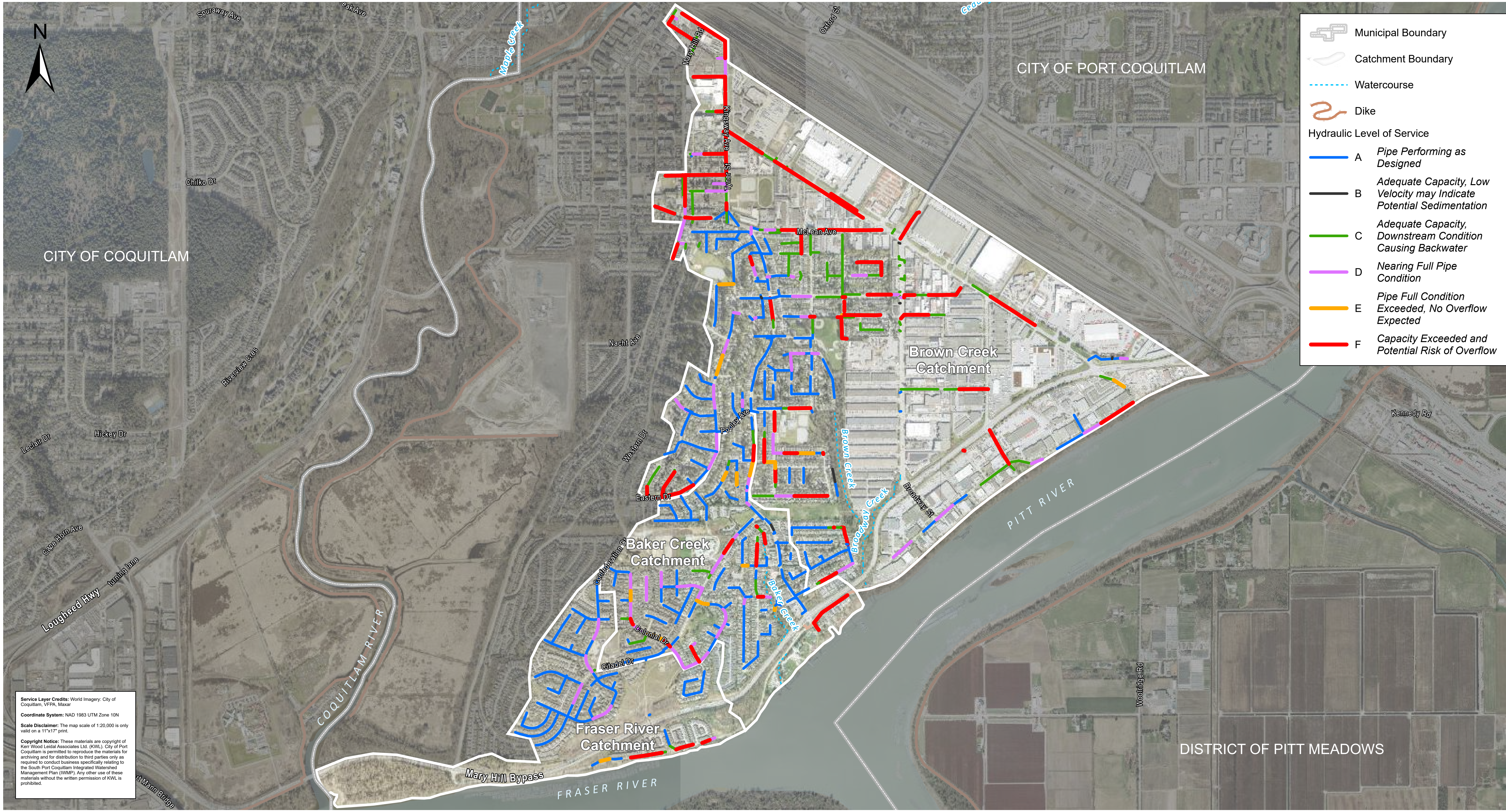
Figure 4-2 schematically shows the pipes (in orange and red) that scored Grade E and Grade F during the future conditions 10-year event model runs. Table C-2 in Appendix C lists the pipes that fail the minor system HLoS criteria in future conditions and the upgrade sizes based on future condition flows. In total, 18 pipes were rated Grade E and 247 pipes were rated Grade F of the total 703 minor pipes in the study area. The future conditions models did not account for potential future detention or infrastructure that may be implemented as part of ongoing development in the watershed.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Minor System Pipe HLoS Ranking

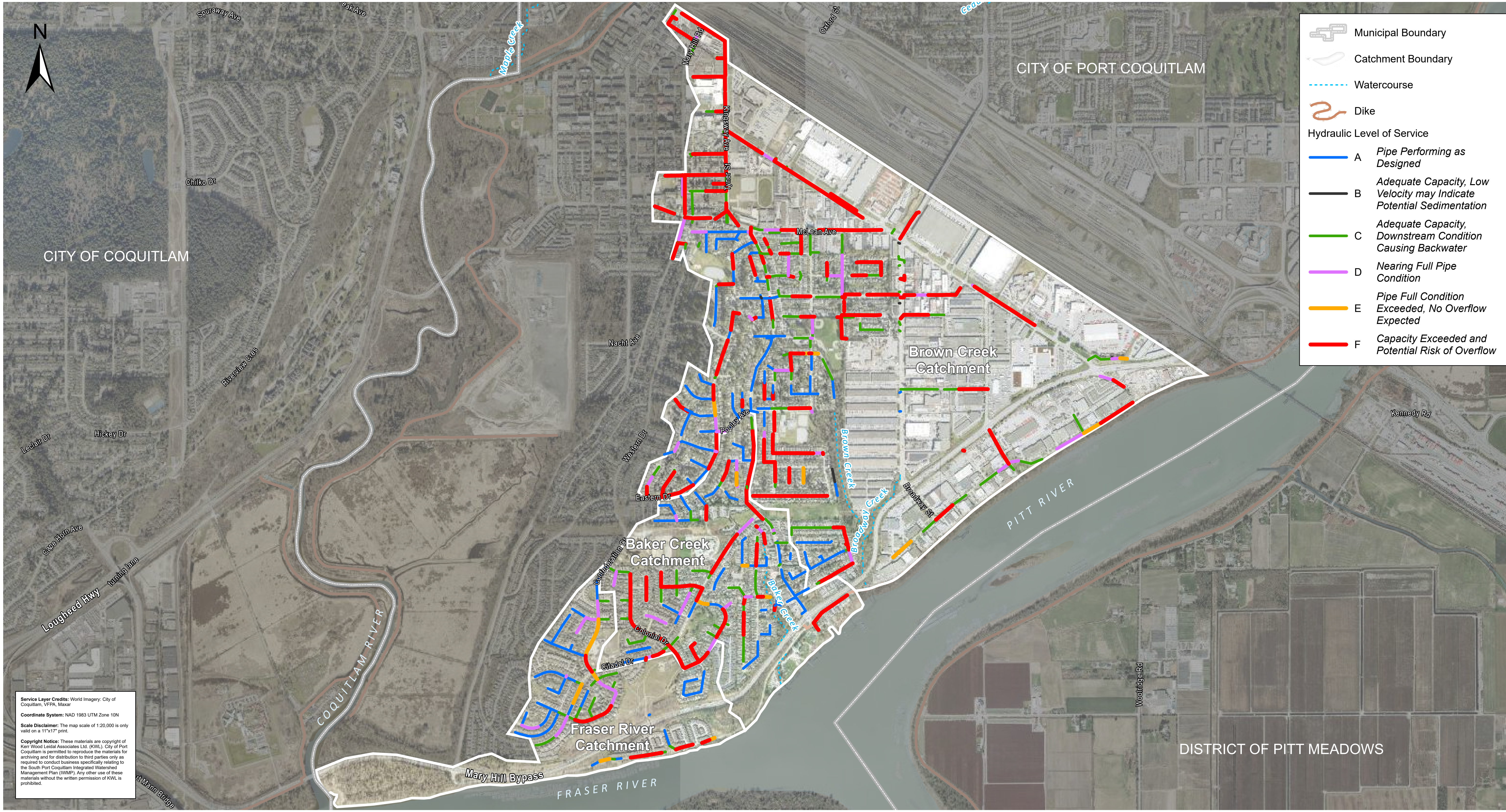
Figure 4-1

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Minor System Pipe HLoS Ranking

Figure 4-2

Major System – Storm Sewer Capacity Assessment

The major system is the conveyance system that carries large storms, greater than the 10-year event and up to the 100-year event. Storm sewers are designated as part of the major system when they cross either emergency response routes or parcels without an easement or right-of-way. This is to ensure that major overland flows have a safe and contiguous major flow route, avoiding emergency route flooding and damage to properties.

The first step was to confirm that all pipes crossing private property or located in between residential lots have associated easements or rights-of-way to determine which pipes would be classified as Major. It is standard industry practice to construct an overland swale for major flow path that parallels the minor pipe in the easement/rights-of-way.

The HLoS criteria and the existing pipe diameter were used to determine whether each sewer is undersized (Grade E or F). Figure 4-3 and Figure 4-4 show the capacity assessment results from the 100-year event models for historic climate IDF with existing land use and future climate change IDF with future land use scenarios.

Major System – Existing Condition

Figure 4-3 schematically shows the pipes (in orange and red) that scored Grade E and Grade F during the existing conditions 100-year event model runs. Table C-3 in Appendix C lists the pipes that fail the major system HLoS criteria in the existing conditions and the upgrade sizes based on future condition flows. In total, 19 pipes were rated Grade E and 108 pipes were rated Grade F of the total 265 major pipes in the study area.

Major System – Future Condition

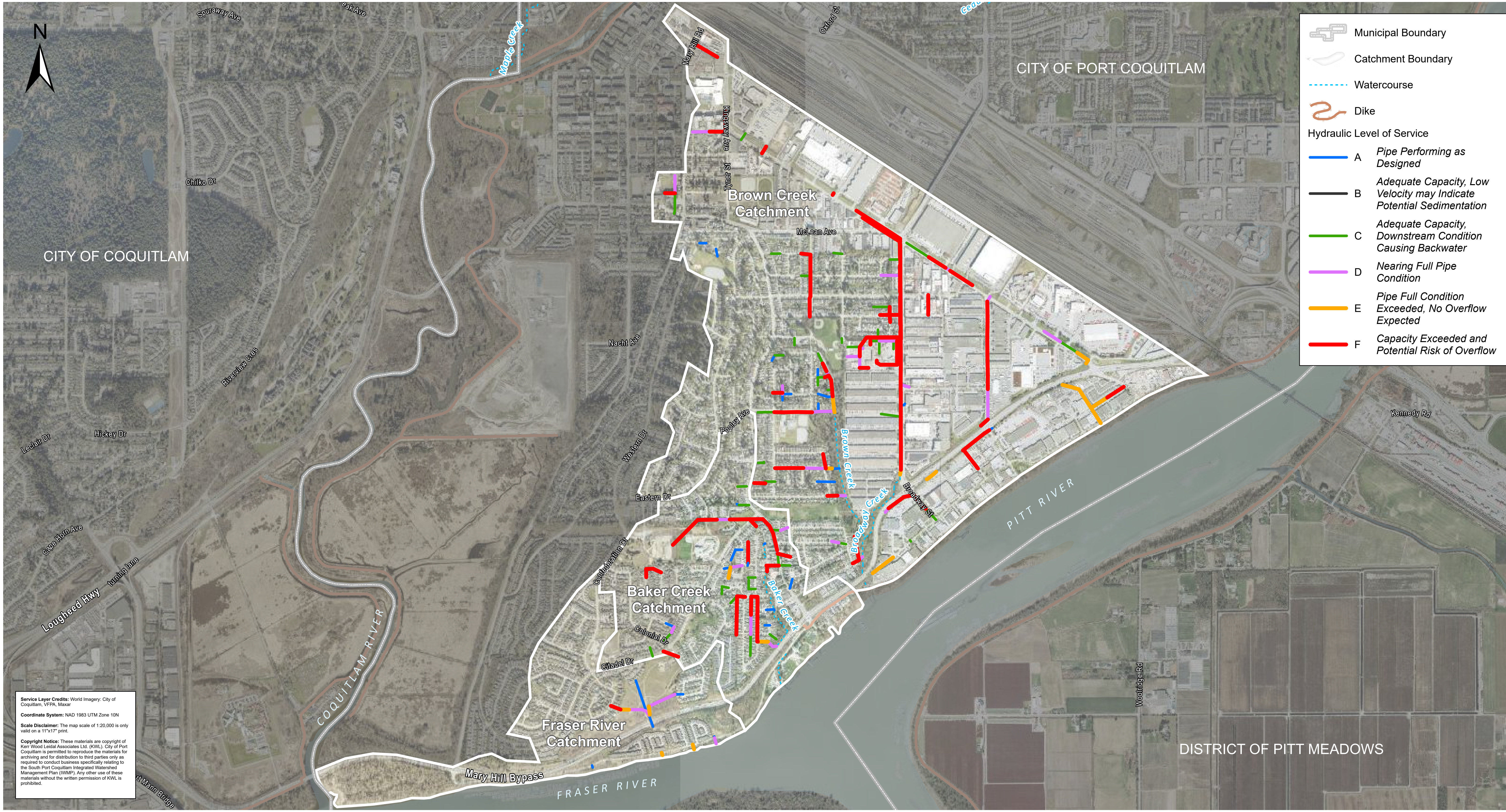
Figure 4-4 schematically shows the pipes (in orange and red) that scored Grade E and Grade F during the future conditions 100-year event model runs. Table C-4 in Appendix C lists the pipes that fail the major system HLoS criteria in future conditions and the upgrade sizes based on future condition flows. In total, 10 pipes were rated Grade E and 161 pipes were rated Grade F of the total 265 major pipe in the study area.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Major System Pipe HLoS Ranking

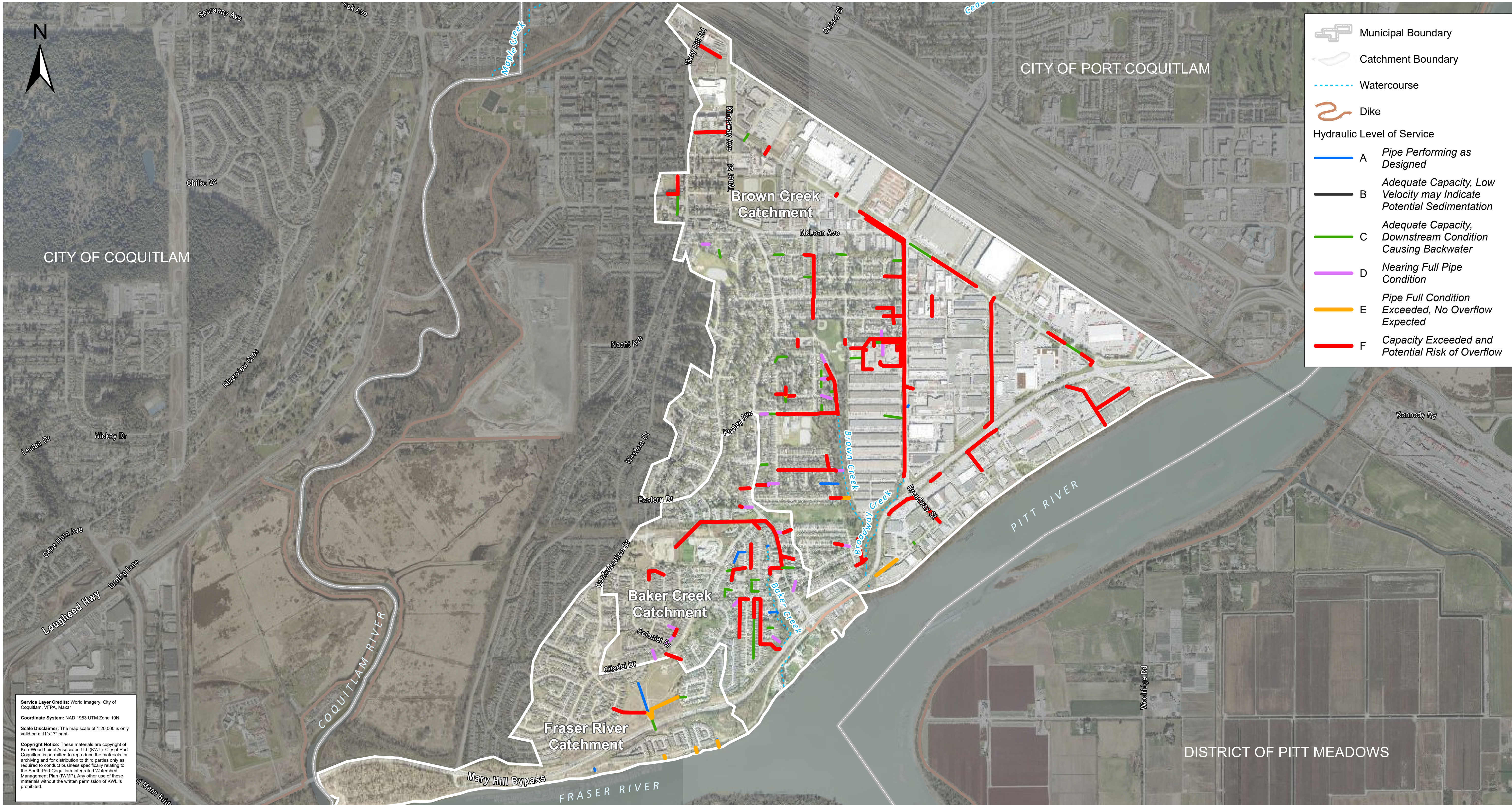
Figure 4-3

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Major System Pipe HLoS Ranking

Figure 4-4

Culvert Capacity Assessment

Culverts – Existing Condition

Figure 4-5 schematically shows the undersized culverts (in orange and red) that were undersized (Grade E or F) in the existing conditions 100-year event model runs. Table C-5 in Appendix C shows the undersized culverts and the upgrade sizes based on future condition flows. In total, 2 culverts were rated Grade E and no culverts were rated Grade F of the total 15 culverts in the study area.

Culverts – Future Condition

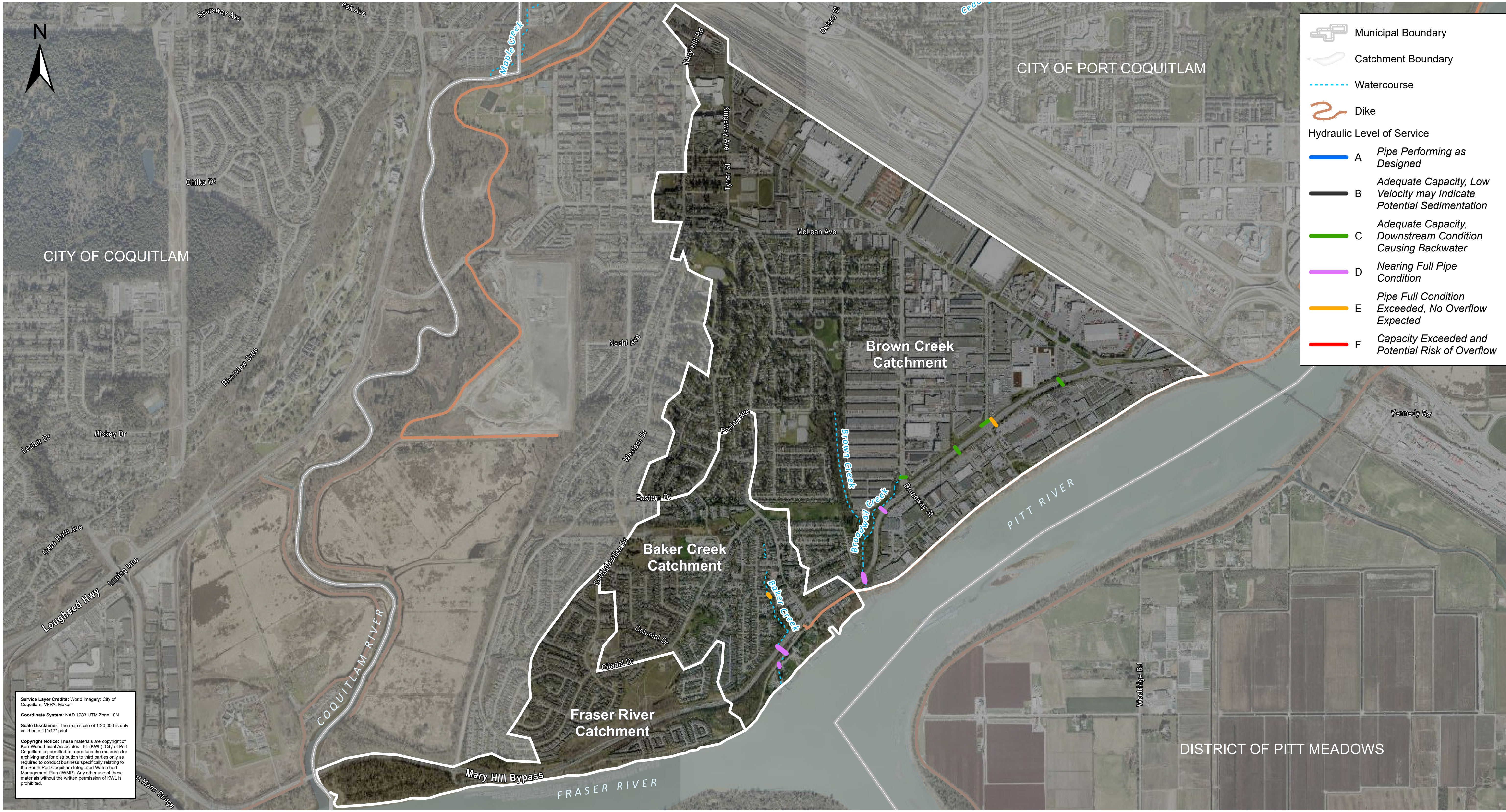
Figure 4-6 schematically shows the undersized culverts (in orange and red) that were undersized (Grade E or F) in the future conditions 100-year event model runs. Table C-6 in Appendix C shows the undersized culverts and the upgrade sizes based on future condition flows. In total, 4 culverts were rated Grade E and 3 culverts were rated Grade F of the total 15 culverts in the study area.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Condition Culvert Ranking

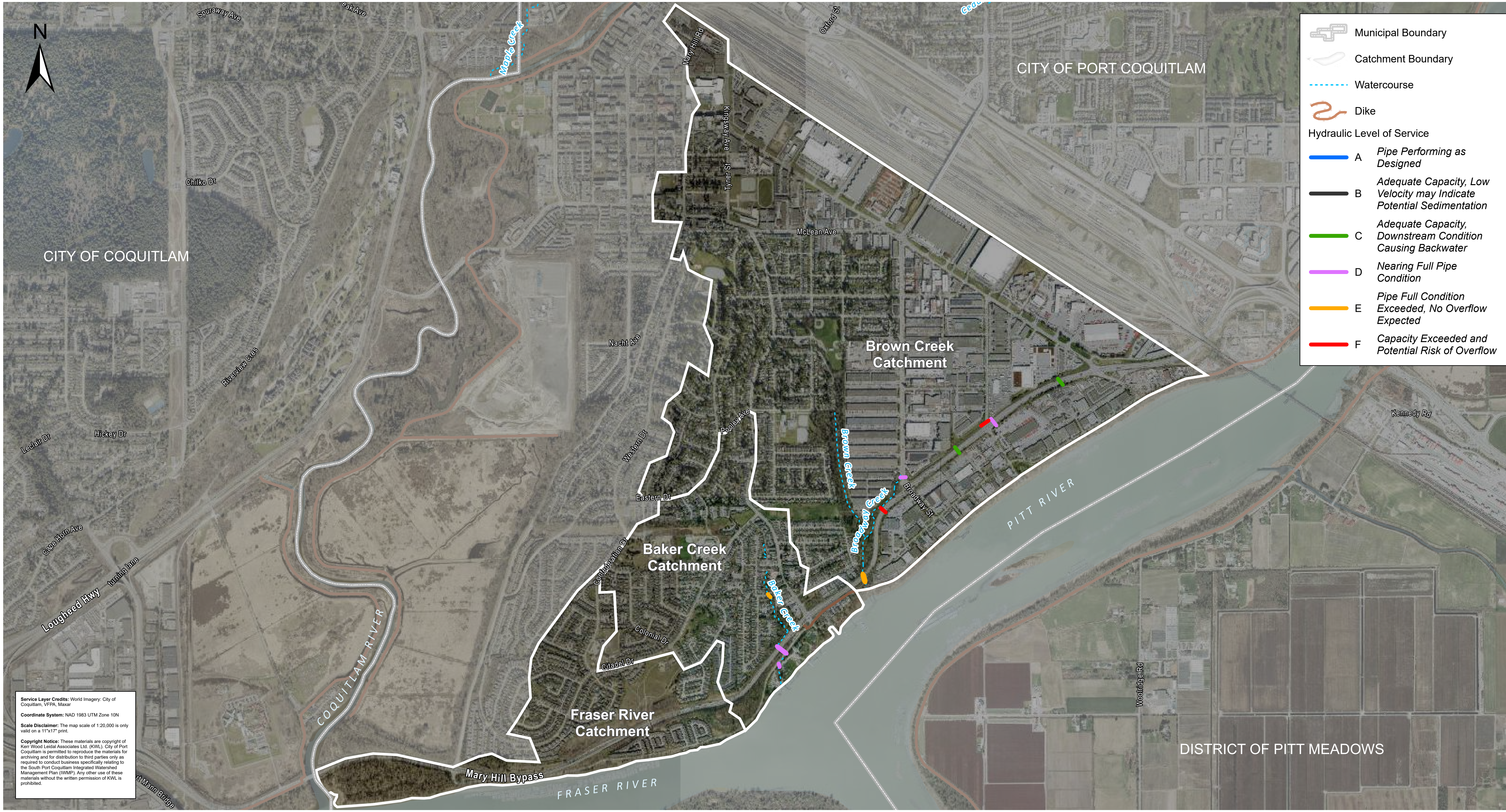
Figure 4-5

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Condition Culvert Ranking

Figure 4-6

Table 4-4 summarizes the number of storm sewer segments and culverts that were found to have a HLoS Grade E or F in the existing and future conditions. A detailed list of all undersized pipes is included in Appendix C.

Table 4-4: Segments of Undersized Pipes

F Scenario	Number & Length of Pipe Segments with HLoS Rating		Total Length of Pipe (km)	% of Total Length of Pipe	
	E	F		E	F
Existing Minor	16 (1.0 km)	140 (8.6 km)	38.7	2.5%	22%
Future Minor	18 (1.2 km)	247 (15.3 km)		3.0%	40%
Existing Major	19 (1.1 km)	108 (8.3 km)	15.4	7.2%	54%
Future Major	10 (0.5 km)	161 (11.2 km)		3.3%	73%
Existing Culverts	2 (0.1 km)	0 (0 km)	0.6	11%	0%
Future Culverts	4 (0.2 km)	3 (0.1 km)		29%	15%
Note: Values in brackets are total length of pipe under that HLoS rating.					

Ditch and Watercourse Capacity Assessment

Ditch channels are included in the minor system and were therefore checked for their capacity to convey the 10-year flows. Watercourses are part of the major system and were therefore assessed for their ability to convey 100-year flows.

Table 4-5 outlines the main stretches of ditches that were analyzed assuming free outfall conditions. The modelled cross-sections were obtained from the available LiDAR, but site visits have shown large amounts of vegetation and sediment that would reduce the ditch capacity further.

The 10-year future models show that the ditches along the Mary Hill Bypass fill in the 10-year events due to backwatering from downstream as shown by the percent of full flow capacity being less than 100%.

It is recommended that the ditches be cleared of any vegetation and/or sedimentation to ensure maximum flow capacity.

Table 4-5: 10-year Ditch Capacities (Future Climate IDF, Future Land Use & Free Outfall)

Ditch locations	Max. Flow (m^3/s)	Percent of Full Capacity	Percent of Full Depth
MHB, North Side, Between Kingsway and Coast Meridian Road	1.6	19%	65%
MHB, South Side, Between Kingsway and Coast Meridian Road	1.3	63%	100%+
MHB, North Side, Between Coast Meridian Road and Broadway Street	4.1	34%	100%+
MHB, South Side, Between Coast Meridian Road and Broadway Street	1.1	11%	100%+
Note: Mary Hill Bypass (MHB)			

Table 4-6 outlines the main stretches of major system watercourses that were analyzed using free outfall conditions. The modelled cross-sections were obtained from the available LiDAR, but site visits have shown large amounts of vegetation and sediment that would reduce the channel capacity further.

Table 4-6: 100-year Watercourse Capacities (Future Climate IDF, Future Land Use & Free Outfall)

Watercourse locations	Max. Flow (m^3/s)	Percent of Full Capacity	Percent of Full Depth
Brown Creek upstream of Routley Avenue	5.7	36%	60%
Baker Creek between Nova Scotia Avenue and Saskatchewan Street	3.7	10%	39%
Baker Creek downstream of Saskatchewan Street	4.6	10%	59%
Downstream of Pitt River Road to MHB crossing	7.5	68%	62%
MHB crossing to Argue Street outfall along Argue Street	8.6	80%	37%
Fraser River Watershed, MHB crossing to Argue Street outfall	6.0	45%	56%
Note: Mary Hill Bypass (MHB)			

Lowlands Flooding & Pump Assessment

Extent of overland flooding in the lowland areas was assessed by adding a 2D mesh to the existing 1D model. The following results highlight areas where flooding is predicted to occur during the design events and where system improvements may be necessary to reduce flooding.

Lowland Assessment – Existing Conditions

The results of the existing land use scenario models for the historic climate IDF 100-year 1-hour, 6-hour, 12-hour, and 2.5-day storms combined with the 100-year Winter Pitt/Fraser River water level are presented in Figures C-8 to C-11 in Appendix C. The 100-year 1-hour and 6-hour storms were shown to cause the most inundation which are shown in Figures 4-7 and 4-8.

Lowland Assessment – Future Conditions

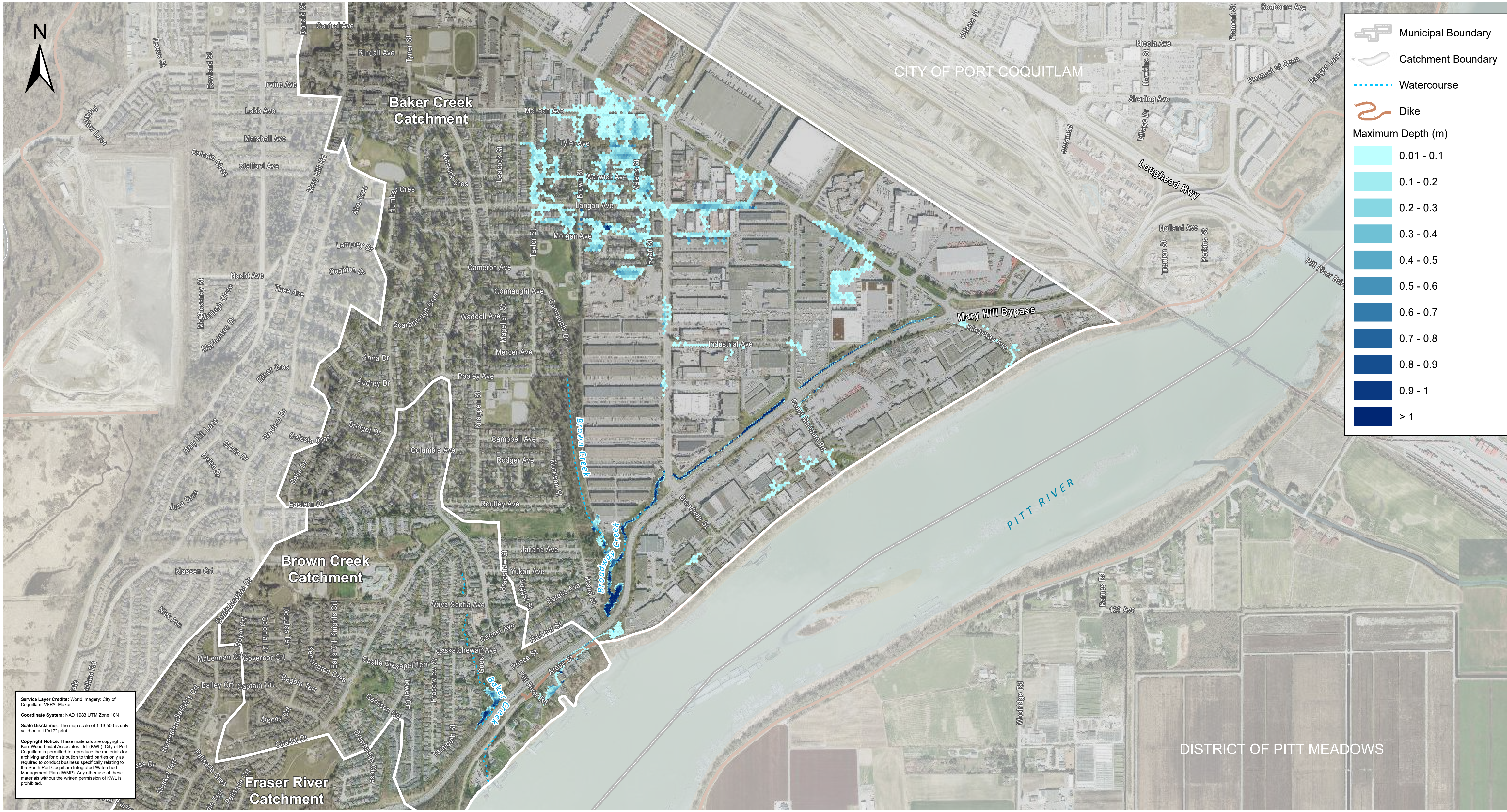
The results of the future land use scenario models for the future climate IDF 100-year 1-hour, 6-hour, 12-hour, and 2.5-day storms combined with the 100-year Winter Pitt/Fraser River water level plus 1 m sea level rise are presented in Figures C-12 to C-15 in Appendix C. The 100-year 1-hour and 2.5-day storms were shown to cause the most inundation which are shown in Figures 4-9 and 4-10.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

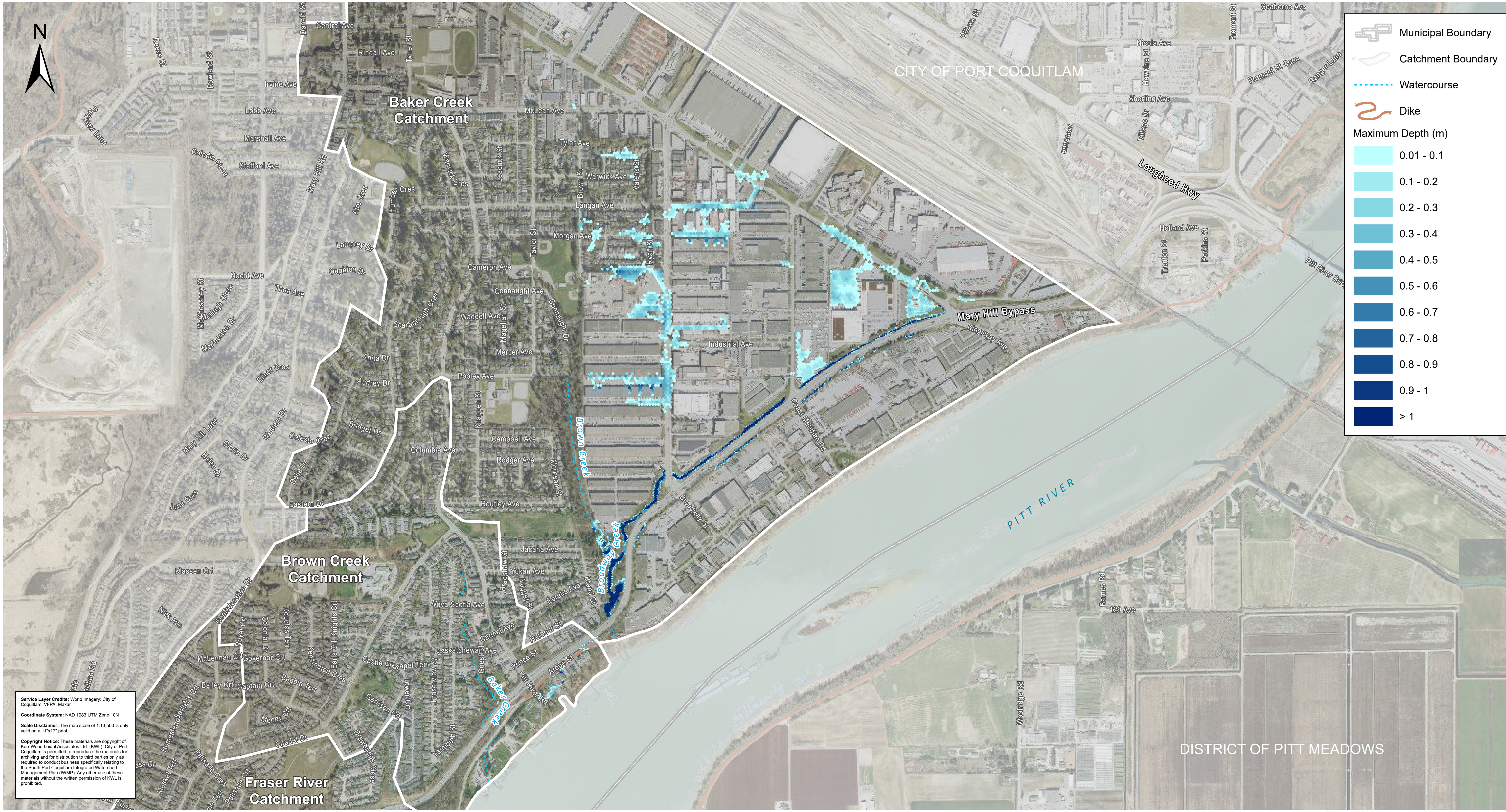
Existing Land use - 100-year 1-Hour Flooding

Figure 4-7

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Existing Land use - 100-year 6-Hour Flooding

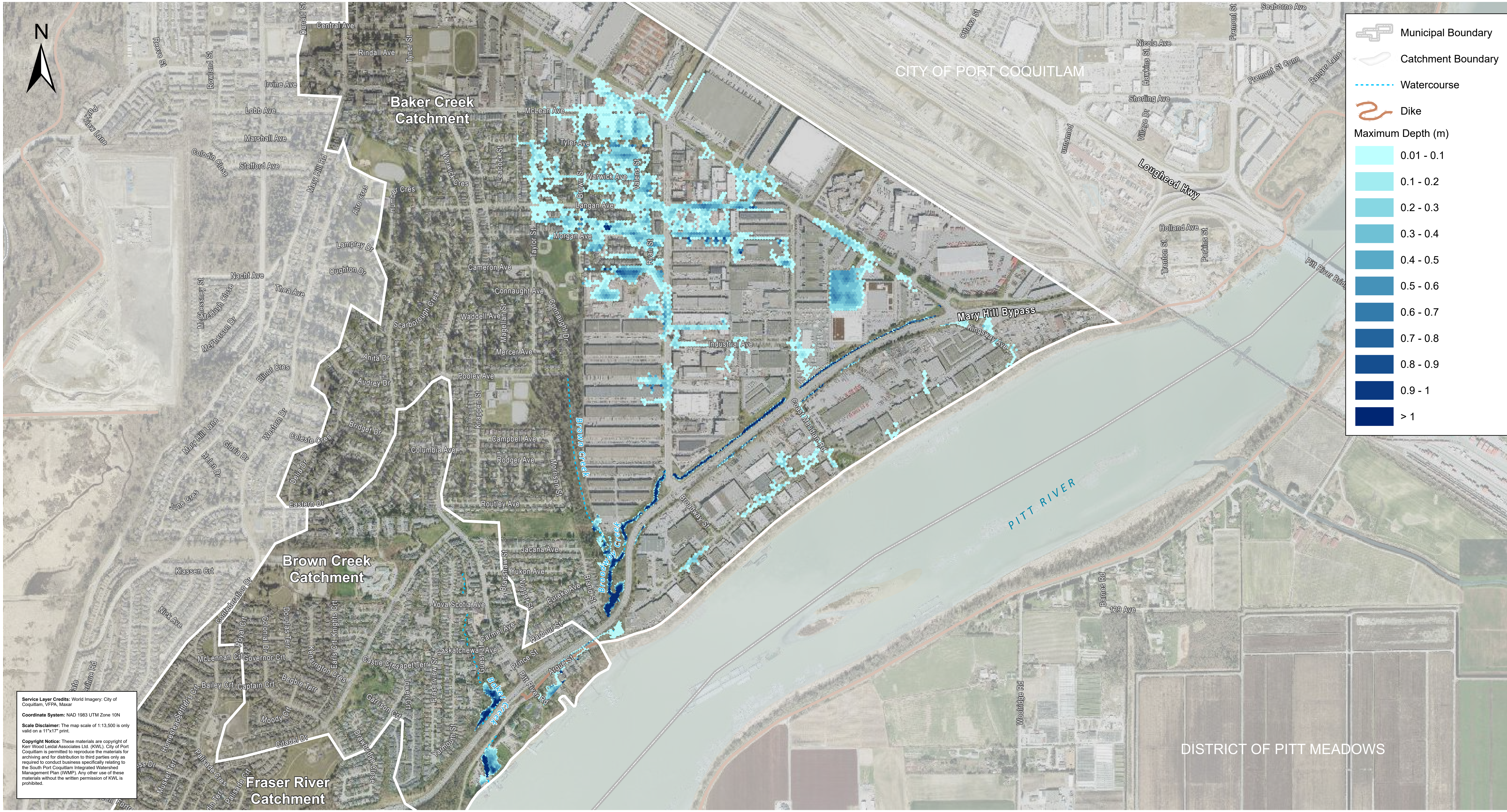
Figure 4-8

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Future Land use - 100-year 1-Hour Flooding

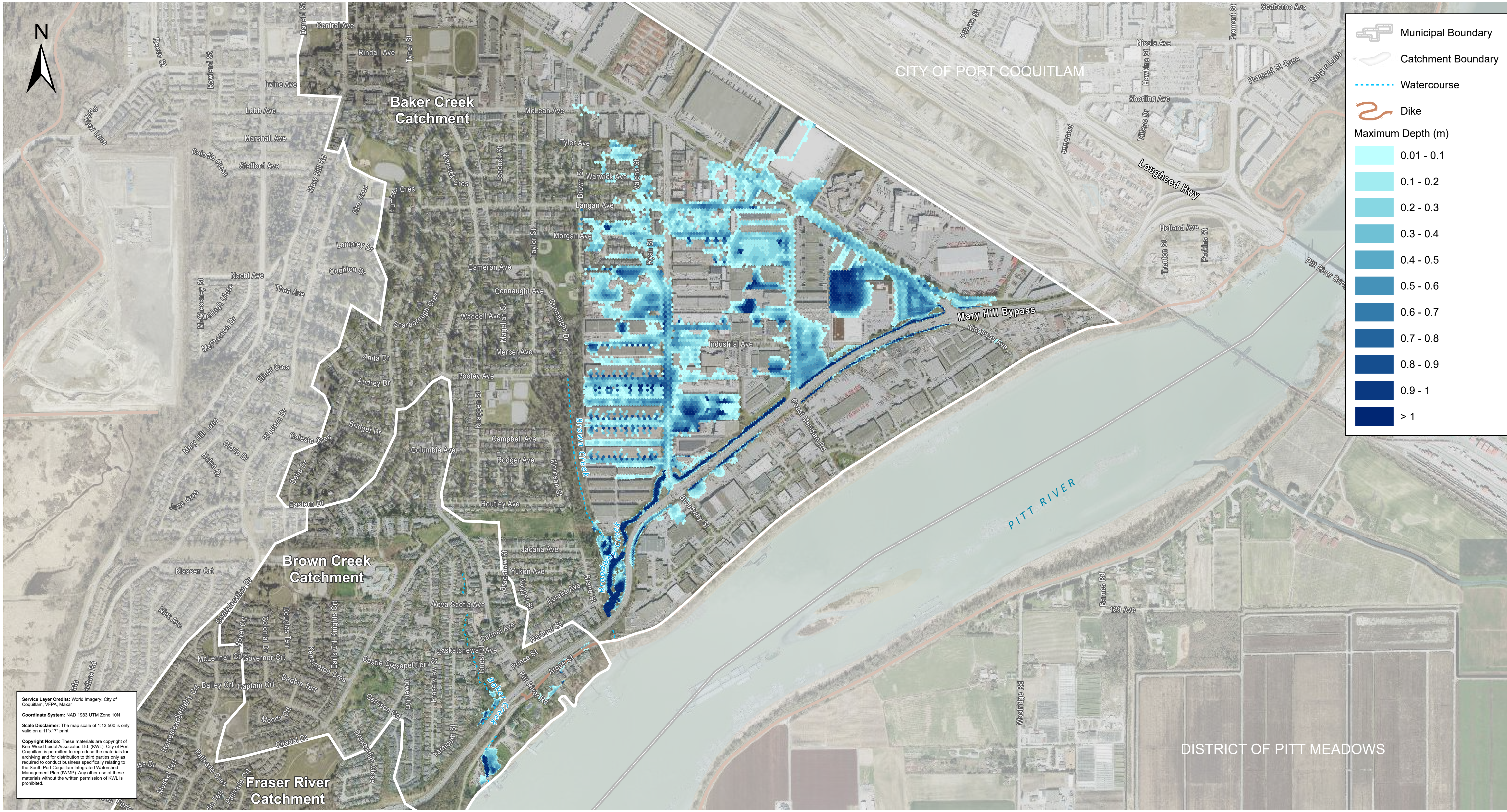
Figure 4-9

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Future Land use - 100-year 2.5-day Flooding

Figure 4-10

The existing and future conditions figures show extensive flooding in the lowland areas. Undersized pipes cause some of this flooding. However, due to the flat nature of this area, water does back up from the Harbour St pump stations. Table 4-7 shows the peak water elevation at the Harbour St pump stations during the existing and future conditions.

Table 4-7: 100-Year Peak Flood Elevations at Modelled Pump Stations

Storm Duration	Peak Flood Elevation (m)
Existing Land Use & Historic IDF	
1-hour	1.79
6-hour	2.42
12-hour	2.33
2.5 day	2.37
Future Land Use, Climate Change IDF & 1m SLR	
1-hour	2.13
6-hour	2.68
12-hour	2.65
2.5 day	2.88

Pump Capacity Assessment

The future condition scenario was run with **upsized** pipes to determine how much of the flooding was caused by the undersized pipes and by the backwatering. Figures C-16 to C-19 in Appendix C show the 100-year flooding in these scenarios.

The 100-year 2.5-day storm was shown to cause the most inundation which is shown in Figure 4-11.

Results show that even with the 1D network of pipes increased to their upgraded size (see Tables C-1 to C-6 in Appendix C), when the floodbox is closed due to high tides, the pump station is not able to reduce the upstream water level enough before upstream flooding occurs in the lowlands.

The 2D model was run with an increase in pump capacity to determine the required capacity to remove major flooding in the lowland area. Figures C-20 to C-23 in Appendix C show the extent of flooding under 100-year 6-hour and 2.5-day events with upgraded pipes and a 50% increase in pump capacity (additional 2.5 m^3/s) and a 100% increase in pump capacity (additional 5 m^3/s).

Lowland flooding is predicted in the 50% pump capacity increase scenario for both the 6-hour and 2.5-day runs. The 100-year 6-hour storm was shown to cause the most inundation which is shown in Figure 4-12.

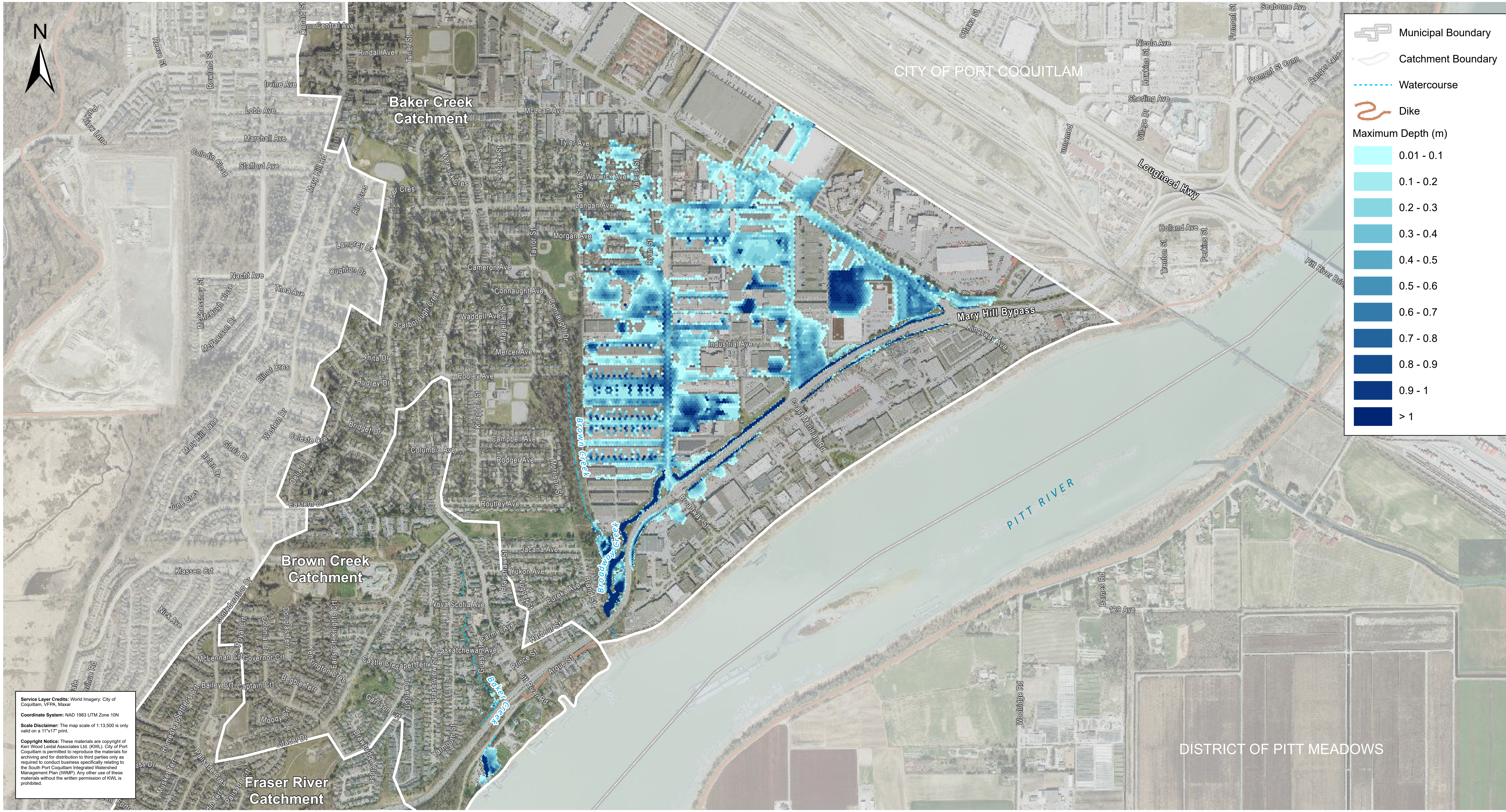
With the 100% pump capacity increase scenario, simulations show little to no flooding. The 100-year 6-hour storm was shown to cause the most inundation which is shown in Figure 4-13.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Upgraded Drainage System - Future Land use - 100-year 2.5 Days Flooding

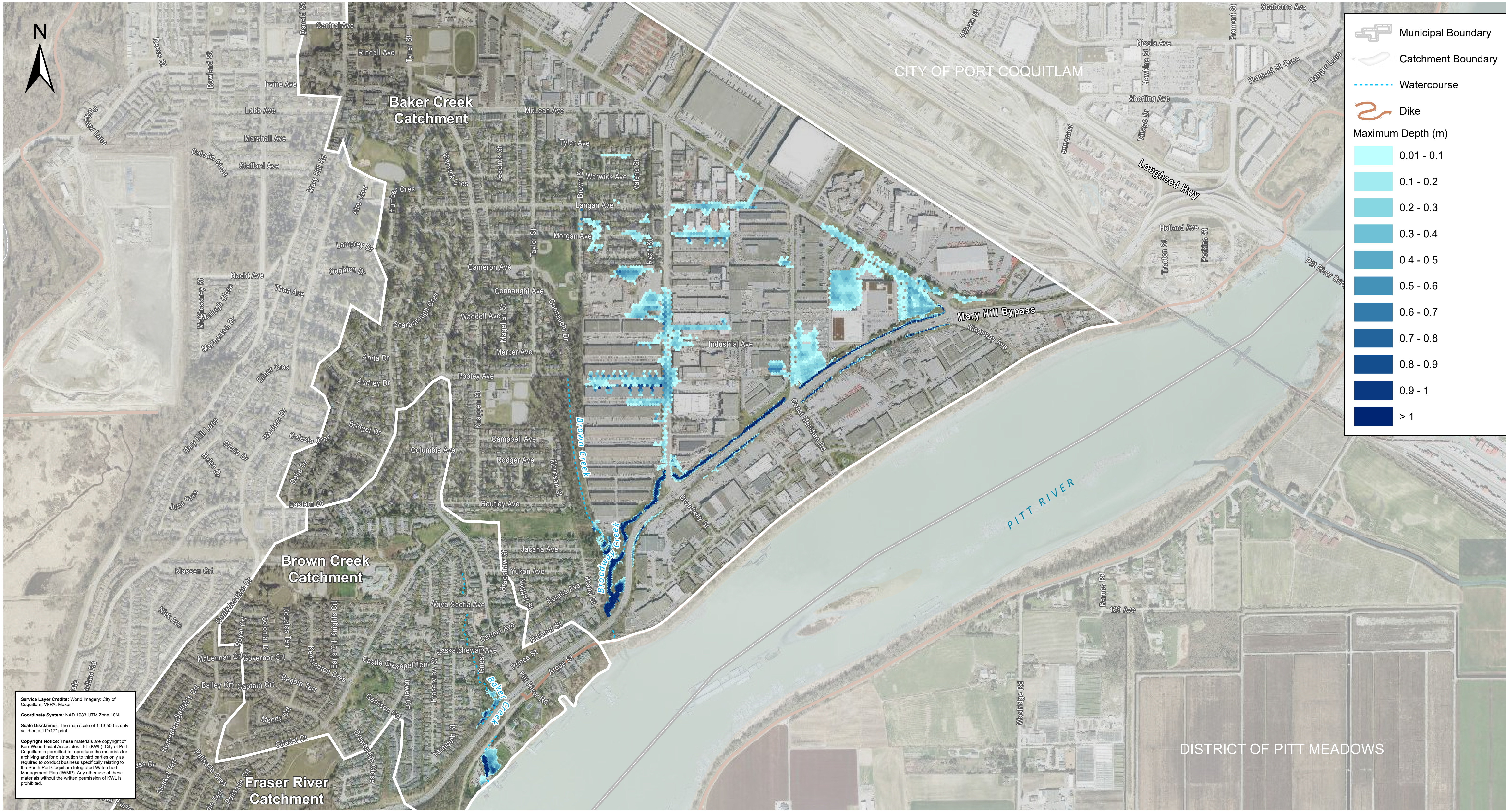
Figure 4-11

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

1.5 x Increased Pump Capacity – Future Land Use
100-year 6-Hour Flooding

Figure 4-12

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers

Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

2 x Increased Pump Capacity – Future Land Use
100-year 6-Hour Flooding

Figure 4-13

5. Environmental Inventory and Assessment

An environmental inventory was undertaken to document and assess the watershed conditions and the overall health of the Baker Creek, Brown Creek, and Fraser River watersheds. Through a combination of desktop review and field assessment, information was gathered on:

- Aquatic species and habitats.
- Watershed and riparian forest cover.
- Terrestrial species and habitats.
- Benthic invertebrate communities.
- Water quality.

The detailed findings of the environmental inventory and assessment are summarized in this section. This information was used to identify priority environmental issues and environmental enhancement opportunities to improve the health of the watershed.

As described in Section 2, an engineering drainage field inventory was completed for the IWMP which included (but was not limited to) identifying sites of erosion, sedimentation, and blockages. These sites are summarized in sections 5-1 and 5-2.

5.1 Erosion Locations

As part of the field inventory and the habitat assessment work, erosion sites were observed in the creeks and documented. Erosion can increase the risk of infrastructure failure and contribute to downstream sedimentation. Erosion and sedimentation, in excess, degrades fish habitat by decreasing water quality (increasing turbidity) and covering spawning gravels with fine sediment. Table 5-1 identifies the erosion sites. Figure 5-1 shows the locations of the erosion sites.

There are no recorded erosion locations in the Fraser River watershed as most of this watershed is piped.

The observed erosion locations within the Brown Creek and Baker Creek watersheds are relatively minor, and none of the observed locations have risk of severe impacts such as impending loss of infrastructure or property. This is consistent with comments from City staff that significant creek erosion sites have not been observed.

Table 5-1: Potential Erosion Locations Within Brown and Baker Watersheds

ID	Comments	Image
Brown Creek Catchment		
1	Undercut bank along the left bank of the Creek.	
Baker Creek Catchment		
2	Erosion along both banks.	
3	Erosion along both banks.	

ID	Comments	Image
4	Erosion along both banks	
5	Erosion along right bank.	
6	Undercut right bank beneath a tree.	
7	Undercut bank on right bank beneath footbridge.	

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers

Project No. 646.043
Date December 2024
Scale 1:16,000
0 100 200 400 m

Erosion Sites

Figure 5-1

5.2 Sedimentation and Blockages

Sedimentation and blockages were also observed in the creeks and documented. Sedimentation and blockages negatively impact conveyance capacity and pose flooding risks. Sedimentation and blockages can additionally prevent fish passage by physically blocking a culvert or decreasing the depth of the water so that it becomes impassable. Table 5-2 summarizes the pipes and culverts that were identified to have sedimentation/blockage issues during the site inspection. Figure 5-2 shows the location of sedimentation and blockages.

Table 5-2: Sedimentation and Blockages in the Brown, Baker, and Fraser Watersheds

ID	Comments	Image
Brown Creek Catchment		
D16138	Debris was seen piling up in front of headwall.	
D13127	Plant debris at inlet and partially filled with Sediment (300 mm deep).	
D13143	Inlet half filled with sediment (200 mm deep). Partially obscured by brush.	
D13147	Culvert buried. Only top of headwall can be seen.	

ID	Comments	Image
D12825	Culvert over half filled in with Sediment (400 mm deep).	
D12835	Culvert half filled in with Sediment (100 mm deep).	
D00938	Culvert partially filled with sediment (300 mm deep).	
D16180	Culvert partially filled with sediment (150 mm deep).	
Baker Creek Catchment		
D05689	Heavily brushed and obstructed.	

ID	Comments	Image
D13104	Partially filled with sediment (300 mm deep). Higher deposits of sediment 1 m upstream.	
D05149	Partially filled with sediment (200 mm deep). Sediment deposits seen downstream.	
D05423	Culvert mostly filled with sediment. Heavy brush at outlet.	
KWL7	Sediment deposition downstream of culvert at Baker Creek outlet.	
Fraser River Catchment		
D04567	Highly vegetated downstream of outlet.	

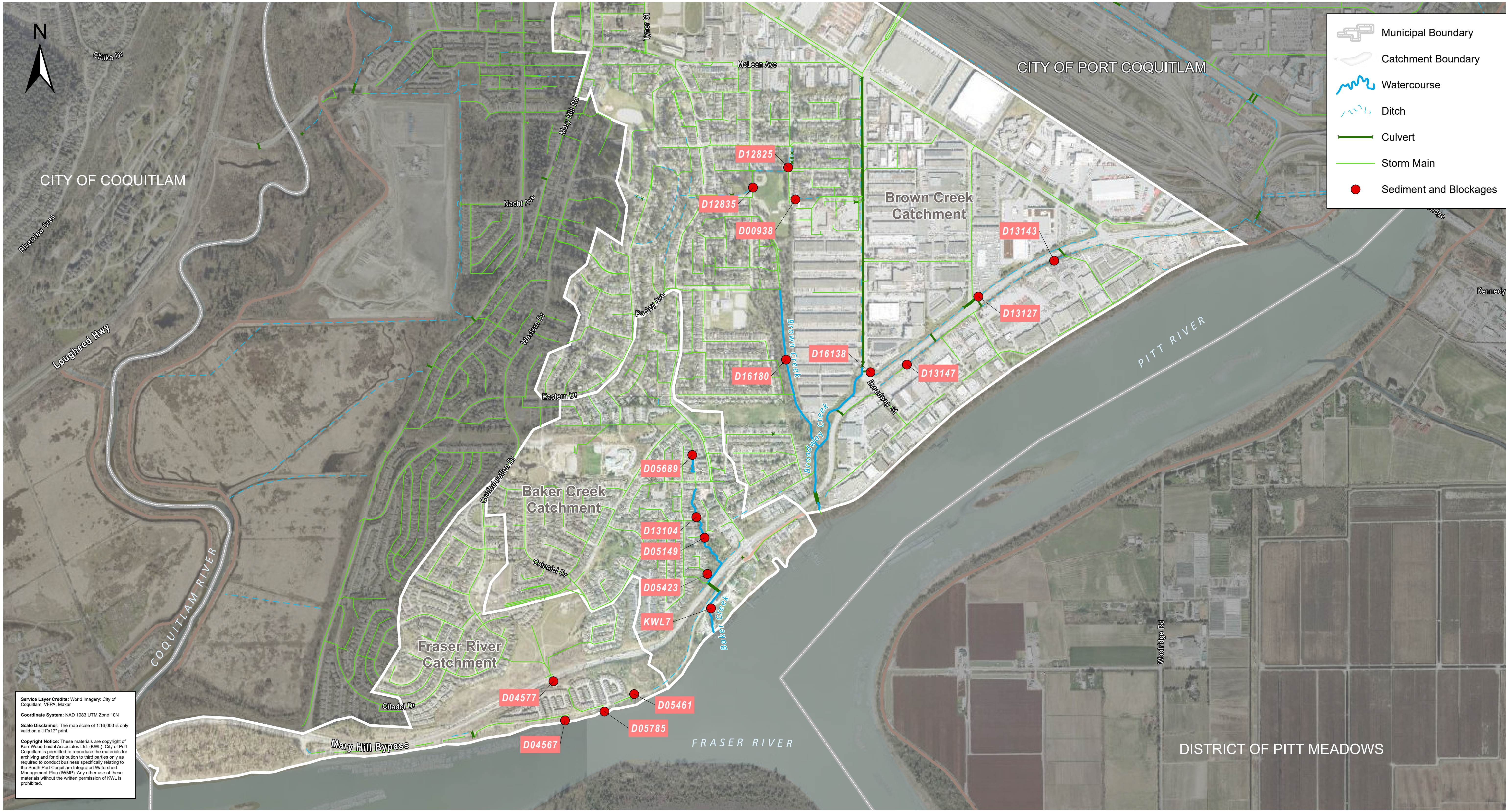
ID	Comments	Image
D04577	Minimal sediment along bottom. Sediment downstream rises 700 mm from culvert inlet (500 mm below crown).	
D05785	Heavily vegetated. Half full of sediment at outlet (200 mm deep). Downstream bed sediment higher than culvert crown.	
D05461	Half full of sediment (300 mm deep). Downstream bed sediment higher than culvert crown.	

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:16,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:16,000

0 100 200 400 m

Sedimentation and Blockage Sites

Figure 5-2

Staff Observations of Creek Blockages and Obstructions

In addition to the fieldwork for the IWMP, City staff have observed issues including the following:

- Beaver dams near the Harbour St Storm Pump Station and in the surrounding area upstream of the pump stations (in the creeks/ditches on Dominion Ave).
- Beaver issues near the intersection of Brown and Broadway creeks.
- Major obstructions and blockages cleared from Broadway Creek.

Beaver dams were not observed at the time of the KWL field assessment. However, signs of past beaver activity (chew marks on downed trees) were observed along the right bank of Broadway Creek approximately 40 m downstream of Broadway Street.

Streamkeeper Observations of Creek Blockages and Encroachments

Baker Creek Streamkeepers identified a number of locations with creek blockages and encroachments on Baker Creek. Most of these the sites are included in Appendix E with the KWL observations made in October 2021. More recent observations made by the Streamkeepers in October 2023 are also in Appendix E and include an additional site on Baker Creek, upstream of Nova Scotia Avenue.

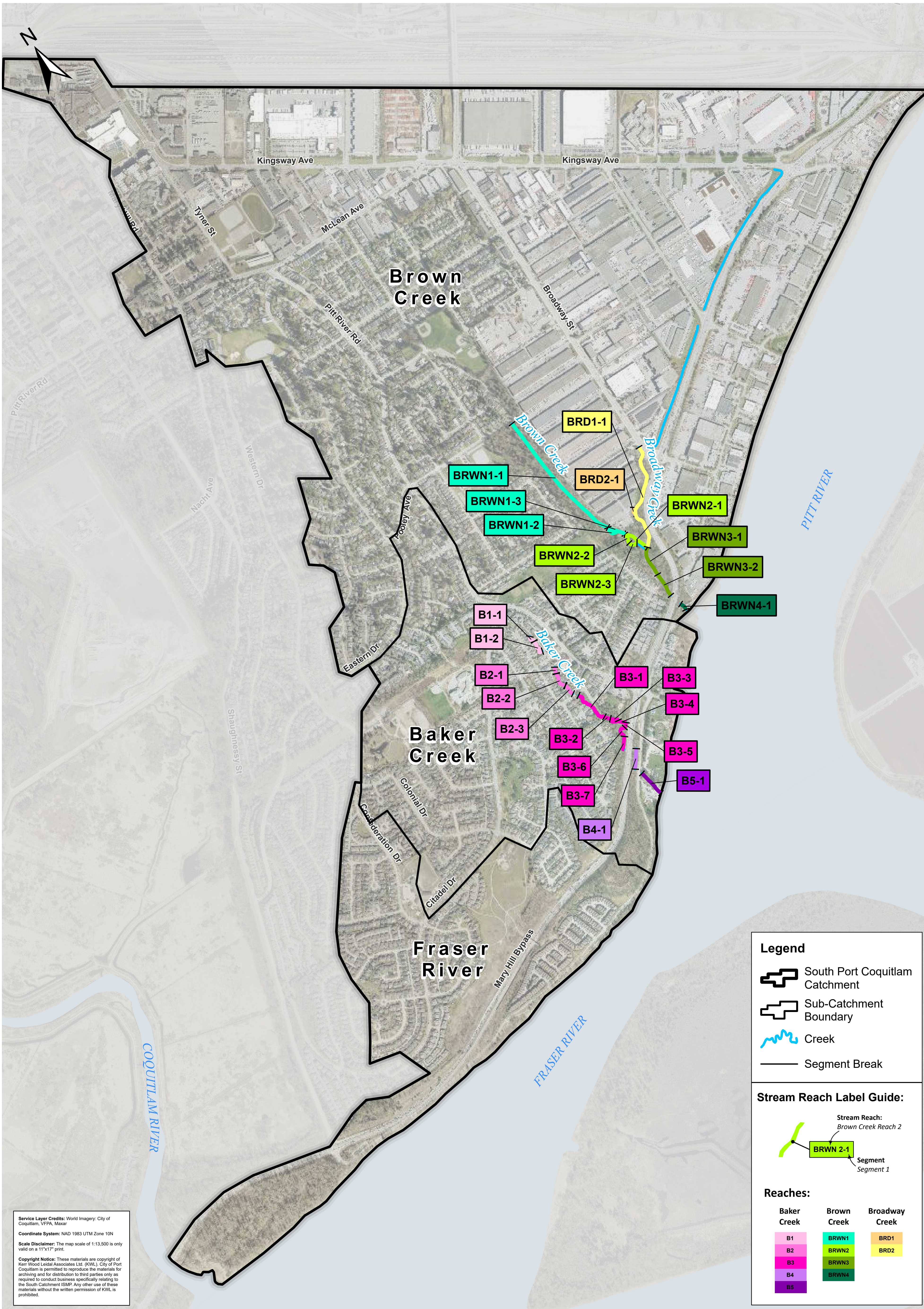
5.3 Aquatic Species and Habitat Inventory

Fish and aquatic habitat in the Baker Creek, Brown Creek, and Fraser River watersheds were assessed through a combination of field investigations and review of existing data and reports. As part of this assessment, segments of stream reaches were walked and important habitat features mapped and characterized, including channel characteristics, large wood, deep pools, and fish passage concerns. Field assessments were conducted for the full length of Baker Creek and Brown Creek, and a segment of Broadway Creek (Figure 5-3).

City of Port Coquitlam

Phase 2 - South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No. 646-043

Date December 2024

Scale 1:13,500

0 75 150 300 m

Stream Reaches and Assessed Segments

Figure 5-3

5.4 Stream Classification

A stream classification map was created using the classifications outlined in the Official Community Plan (Figure 5-4). Stream classification systems identify sections of stream that are fish-bearing (fish present or potentially present if introduced barriers or obstructions are removed or made passable for fish) which are classified as Class A and non-fish bearing (not inhabited by fish but provide water, food, and nutrients to a downstream fish bearing watercourse) which are classified as Class B.

The City uses the following classifications for watercourse protection:

- Class A: Inhabited by salmonids year-round or potentially inhabited year-round.
- Class A(O): Inhabited by salmonids primarily during the overwintering period or potentially inhabited during the overwintering period with access enhancement.
- Class B: Significant food/nutrient value. No fish documented.

KWL classified watercourses as Class A, B, and “Proposed Class C”. Class A(O) was not used to classify reaches at this time as use of Class A(O) would require multiple sampling events over a period of time to determine if it is inhabited by salmonids primarily during the overwintering period or potentially inhabited during the overwintering period with access enhancement. Until this sampling program is executed, it is not recommended that temporal salmonid presence or absence is assumed in any waterway with significant flow.

Class C watercourses are proposed solely based upon the City’s mapped ditch network, none of the ditches have been confirmed in the field or otherwise. They are intended to represent watercourses which provide insignificant food/nutrient value and do not contain fish at any time of year. Class C streams would primarily be constructed roadside ditches which collect and convey overland flow from surface runoff and are only wetted during or immediately after precipitation events. Proposed Class C is used as a preliminary classification at this time subject to more detailed investigation to confirm their low to nil habitat value. There are currently 3.7 km of proposed Class C watercourse within the watersheds.

Several Class B watercourses are recommended for removal based upon most recent available aerial imagery. The streams recommended for removal either overlap storm drains or do not overlap any water infrastructure or natural watercourse. Therefore, they should not be considered watercourses for planning purposes. These watercourses have been excluded from Figure 5-4. There are currently 0.1 km of proposed Class B watercourse within the watersheds.

Stream segments that are classified as Class A are not recommended for additional fish sampling as the presence of salmonids has already been determined. Although some of the creeks that are classified as Class A have potential or known man-made fish passage barriers, reclassification to Class B is not recommended as removal or modification of these barriers over time may be possible. The Riparian Areas Regulation Assessment Methods (MWLAP, 2006) requires that, if a man-made barrier can be made accessible, then the stream is to be considered fish-bearing. Rarely would these barriers be considered a “permanent” manmade barrier. Figure 5-4 excludes several areas identified as Class B streams in the OCP as no watercourses were observed in these areas, or the stream overlapped a storm main only. The creation of Class C waterways is recommended for all watercourses (including roadside ditches) that are not occupied by fish at any time of year and that provide insignificant food and nutrient inputs. There are currently 3.6 km of Class A watercourses within the watersheds.

A 450 m watercourse was identified within the Fraser River catchment following hydraulic modelling. This watercourse was verified in the field and may currently be or have historically been fish-bearing. It is recommended that further investigation, including fish sampling, occur in this watercourse to determine its recommended classification. For the purposes of this report, it will be assumed that it is or was capable of bearing fish and is thus assumed to be a Class A stream. The classification is preliminary and was used for the purposes of identifying riparian areas in the Fraser catchment. Due to the stage in the project when this watercourse was discovered, no stream morphology, water quality, or other data was recorded, and thus is generally not included in most of the following figures.

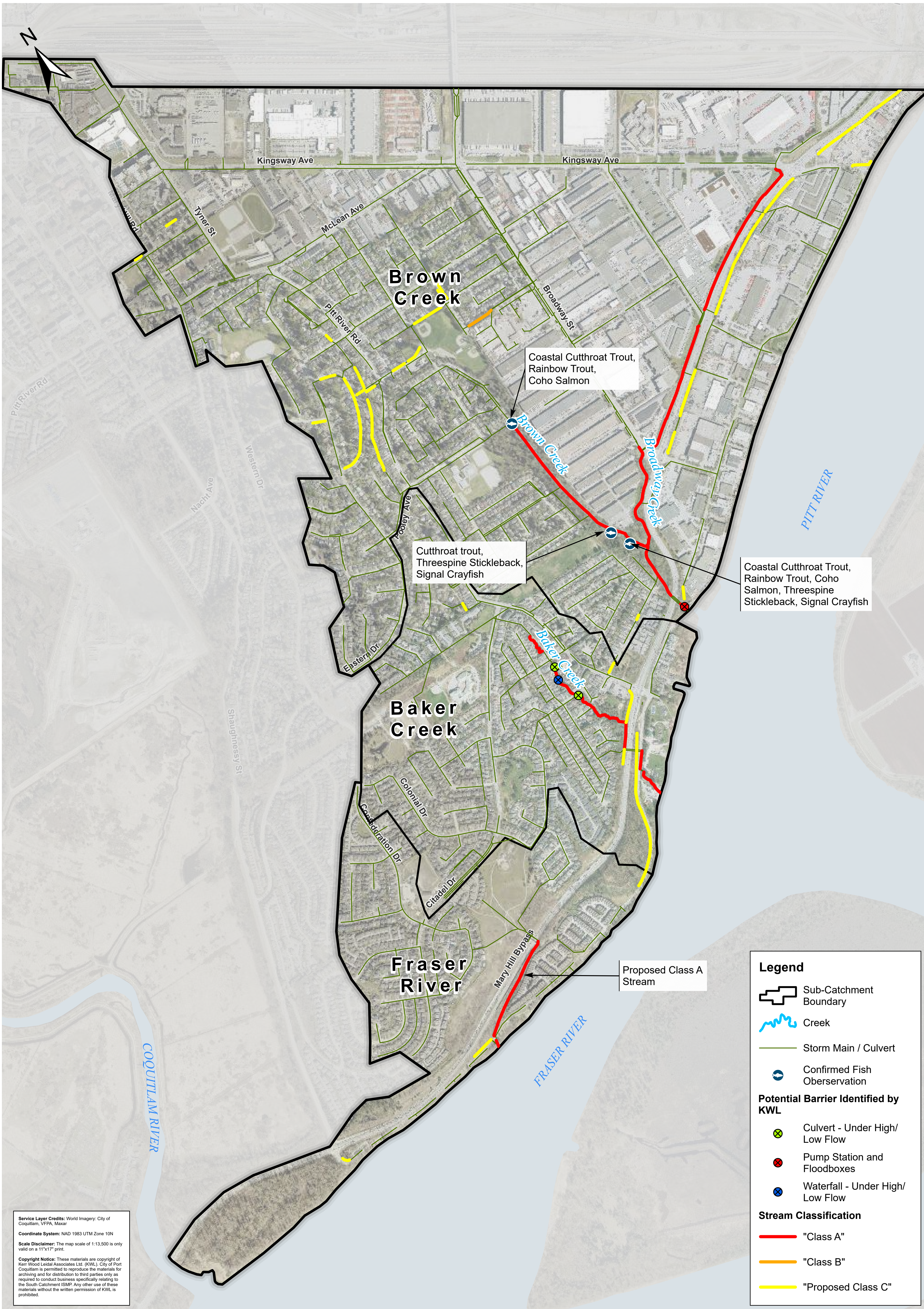
Detailed fish sampling methods to confirm fish absence are found in Appendix 3 of the Riparian Areas Regulation Assessment Methods. Generally, they require adequate sampling effort at different times of the year and under different stream conditions to ensure sufficient evidence to support the conclusion that fish do not occur in the stream reach in question. Figure 5-4 shows the stream classification, locations with confirmed fish presence, and potential barriers. There are no recommended downgrades to any Class A streams, several Class B streams are recommended for removal, and the creation of Class C streams is recommended.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_Rp_Figures\646043_Rp_Figures.aprx Date Saved: 2024-07-05 8:10 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No. 646-043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Stream Classification and Fish Passage Barriers

Figure 5-4

Fish Species

At least seven fish species are known to occur within the creeks in the study area, including four salmon and trout (salmonid) species, two native non-salmonid fish species, and one introduced fish species (Table 5-3, Table 5-4, Table 5-5). Limited fish sampling has been completed within the watersheds to date with most sampling occurring as part of salvage activities related to instream works. However, as of April 2024, the Baker Creek Streamkeepers have conducted fish sampling activities in both Baker Creek and Brown Creek, the results of which have been included in Table 5-3 and Table 5-4 below. In Baker Creek, all fish were caught between Guest Street and Mary Hill Bypass. In Brown Creek, all fish were caught between Pooley Avenue and Routley Avenue. The 2024 sampling identified hybridization between Rainbow Trout and Cutthroat Trout, which was previously unrecorded within the watershed.

Table 5-3: Documented Fish Species in Baker Creek

Code	Common Name	Scientific Name	Provincial / Federal Status[1]	Last Observation[2]
Salmon and Trout Species				
CO	Coho Salmon	*Oncorhynchus kisutch*	Yellow-listed (BC)	April 2024[4]
CM	Chum Salmon	*Oncorhynchus keta*	Yellow-listed (BC)	January 1994
CT/CCT	Coastal Cutthroat Trout	*Oncorhynchus clarkii*	Yellow-listed (BC)	January 1994
RB	Rainbow Trout/Steelhead[3]	*Oncorhynchus mykiss*	Yellow-listed (BC)	January 1994
Native Non-salmonid Fish Species				
CAS	Prickly Sculpin	*Cottus asper*	Yellow-listed (BC)	April 2024[4]

[1] No species are listed on Schedule 1 of the Species at Risk Act.
[2] Ministry of Environment – Habitat Wizard Streams Report: Baker Creek (2022a).
[3] Steelhead are an anadromous form of Rainbow Trout that migrate to sea and return to their home streams to spawn.
[4] Baker Creek Streamkeepers Trapping Report (2024).

Table 5-4: Documented Fish Species in Brown Creek

Code	Common Name	Scientific Name	Provincial / Federal Status[1]	Last Observation[2]
Salmon and Trout Species				
RB	Rainbow Trout/Steelhead[3]	*Oncorhynchus mykiss*	Yellow-listed (BC)	April 2024[4]
CT/CCT	Coastal Cutthroat Trout	*Oncorhynchus clarkii*	Yellow-listed (BC)	April 2024[4]
CO	Coho Salmon	*Oncorhynchus kisutch*	Yellow-listed (BC)	April 2024[4]
RB/CT	Cutbow Trout	*Oncorhynchus clarkii × mykiss*	NA	April 2024[4]
Native Non-salmonid Fish Species				
F-COAS	Prickly Sculpin	*Cottus asper*	Yellow-listed (BC)	May 2005[5]
TSB	Threespine Stickleback	*Gasterosteus aculeatus*	Yellow-listed (BC)	April 2024[4]

[1] No species are listed on Schedule 1 of the Species at Risk Act.
[2] Ministry of Environment – Habitat Wizard Streams Report: Brown Creek (2022b).
[3] Steelhead are an anadromous form of Rainbow Trout that migrate to sea and return to their home streams to spawn.
[4] Baker Creek Streamkeepers Trapping Report (2024).
[5] Envirowest, 2006.

Table 5-5: Documented Fish Species in Broadway Creek

Code	Common Name	Scientific Name	Provincial / Federal Status[1]	Last Observation[2]
Salmon and Trout Species				
CO	Coho Salmon	*Oncorhynchus kisutch*	Yellow-listed (BC)	February 2000
CT/CCT	Coastal Cutthroat Trout	*Oncorhynchus clarkii*	Yellow-listed (BC)	January 1999
Native Non-salmonid Fish Species				
TSB	Threespine Stickleback	*Gasterosteus aculeatus*	Yellow-listed (BC)	April 2011
Introduced Fish Species				
BNH	Brown Catfish (formerly Brown Bullhead)	*Ameiurus nebulosus*	-	February 2000

[1] No species are listed on Schedule 1 of the Species at Risk Act.
[2] Ministry of Environment – Habitat Wizard Streams Report: Broadway Creek (2022c)

Fish Spawning, Rearing and Migration

Instream fish habitat was assessed during field inventories of Baker Creek and Brown Creek and a segment of Broadway Creek (Figure 5-3).

To complete the assessment for spawning, rearing, and migration habitat, channel dimensions, substrate conditions, and instream cover were quantified for stream segments. Bank full width, wetted width, % boulder, % cobble, % gravel and % fines, numbers of large woody debris, and locations of deep pools and side and off-channel habitat were all recorded.

Salmonid spawning, rearing, and migration habitat conditions were evaluated based on field visits and the assessment of aerial photos. Habitat was categorized according to the diagnostics provided by Johnston and Slaney (1996).

Spawning habitat was assessed based on a combination of indicators including the number of large pools, abundance of large wood (pieces of wood larger than 10 cm in diameter and 2 m in length), boulder cover, overhead cover by vegetation, presence of off-channel habitat, and substrate (quantity of gravel/fines).

Juvenile rearing habitat was assessed based on the number of deep pools and the presence off-channel habitat. Spawning are rearing habitat quality are shown in Figure 5-5.

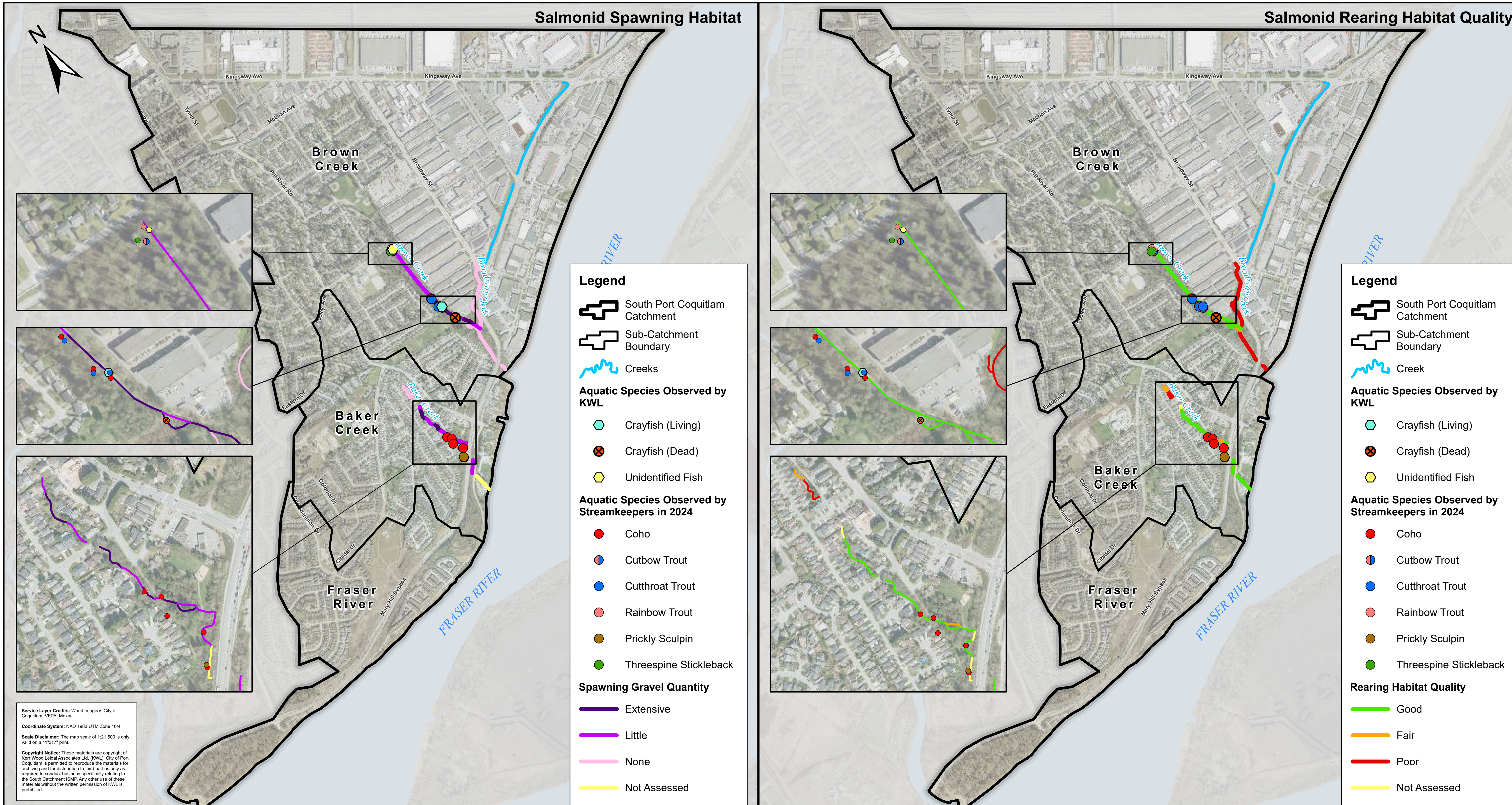
Adult migration habitat was assessed based on the number of deep pools available for holding as well as connectivity and access to spawning areas (i.e., no fish barriers present). Migration habitat and fish passage barriers are shown in Figure 5-6.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_Rp_Figures\646043_Rp_Figures.aprx Date Saved: 2024-07-05 8:10 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Project No. 646-043

Date December 2024

Scale 1:21,500

0 100 200 400 Metres

Spawning and Rearing Habitat Quality

Figure 5-5

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers

Project No. 646-043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Salmonid Migration Habitat and Fish Passage Barriers

Figure 5-6

Fish Passage Barriers

Potential barriers to fish passage were identified during the desktop review and verified in the field. During the field assessment, additional barriers were also identified. Fish passage barriers are detailed below, summarized in Table 5-6 and shown in Figure 5-6.

Broadway Creek

- Potential – Closed bottom culvert under Broadway Street (Masse Environmental Consultants Ltd., 2012).
- Potential – Dam at the entrance of Broadway Creek at the Pitt River (FISS, 1995).
- Potential – Harbour St Storm Pump Station and floodgates at the confluence of the Pitt River. Previously identified on FISS Database in 1995 (source not indicated).

Baker Creek

- Potential – Closed bottom culvert under Argue Street near Mary Hill Bypass (Masse Environmental Consultants Ltd., 2012).
- Known – Closed bottom culvert under Saskatchewan Avenue (Masse Environmental Consultants Ltd., 2012).
- Probable – Approximately 75 m long closed bottom culvert underneath Nova Scotia Avenue may be a barrier under all flow conditions.
- Probable – Approximately 25 m long closed bottom culvert underneath Saskatchewan Avenue may be a barrier under high and low flow conditions. Previously identified by Masse Environmental Consultants Ltd. in 2012.
- Potential – 1.2 m falls that are 1.0 m wide located between Saskatchewan Avenue and Nova Scotia Avenue may be a barrier under high and low flow conditions.

Two culverts identified in the field located within Baker Creek are listed as probable barriers. Based on the length and elevation difference, it is suspected that these culverts are full barriers to fish passage. However, a more detailed barrier assessment under varying flow conditions would need to be completed to confirm these are full barriers.

The Harbour St Storm Pump Station is partially “fish friendly” (causing reduced harm and increased passability to fish) due to its use of two Archimedes screw pumps as lead pumps. These pumps typically have a lower fish mortality rate than traditional axial pumps, although some injury and mortality likely still occur (Pauwels et al., 2022; Zielinski et al., 2022; Buysse et al., 2015). While these pumps allow fish to migrate out of Brown Creek, the associated floodgates likely impede inward migration of juvenile salmonids searching for off-channel rearing habitat and spawning salmon searching for suitable spawning gravels. Modified pump station operation, including opening gates outside of freshet and reducing pumping frequency, may increase fish passage and reduce mortality.

Instream Fish Habitat Characteristics

Instream fish habitat characteristics for stream segments are in Table 5-6 below. Key results are summarized below:

- **Beaver dams** were not observed within Baker, Brown, or Broadway Creek at the time of the field assessment. However, signs of past beaver activity (chew marks on downed trees) were observed along the river right of Broadway Creek approximately 40 m downstream of Broadway Street.
- **Channel dimensions** varied throughout the watershed. Wetted channel widths ranged from 0.3 to 3.8 m in Baker Creek, 1.6 m to 44.0 m in Brown Creek, and 4.0 to 5.5 m in Broadway Creek.
- **Substrate composition** varied between the headwaters, middle, and lower reaches. The headwaters of Baker Creek generally contained more cobble and boulders upstream of Saskatchewan Street. Downstream of Saskatchewan Street, the substrate transitioned to more gravel. Downstream of Mary Hill Bypass, the substrates become finer. No headwaters exist for Brown Creek as it has been piped due to urbanization. The upper reaches of Brown Creek contain more gravel and fines until its confluence with Broadway Creek. Below the confluence, substrates become predominantly fines. The assessment segment of Broadway Creek was predominantly fines for its entire length.
- **Large wood pieces** (greater than 10 cm in diameter and 2 m long) were generally lacking in abundance. Although still less abundant than is considered normal in natural streams, large wood is more common in Brown Creek where some instream restoration has been completed.
- **Deep pools** were present in the upper reaches of Baker Creek and Brown Creek but were largely absent from their lower reaches. The segment of Broadway Creek surveyed was absent of any deep pools.

Table 5-6: Fish Habitat & Stream Channel Characteristics in Baker, Brown, and Broadway Creeks

Stream Name	Stream Reach	Stream Segment	Average Bankfull Width (m)	Average Wetted Width (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Fines	% Organics	% LWD	Comments
Baker Creek	B1	B1-1	4.9	2.0	0	0	10	0	60	30	0	Reach starts at outfall, creek piped upstream.
		B1-2[1]	-	-	-	-	-	-	-	-	-	Could not be accessed due to private property.
	B2	B2-1	2.8	1.4	0	25	30	20	25	15	0	
		B2-2	3.0	1.4	0	25	30	25	15	5	0	
		B2-3	2.0	1.4	0	25	30	15	20	10	0	
	B3	B3-1	4.1	3.3	0	5	25	40	25	5	0	
		B3-2	5.3	3.5	0	0	5	0	60	35	0	Large pool feature.
		B3-3	4.4	3.5	0	0	5	35	30	30	0	Small tributary on creek left joins mainstem. Tributary appears to be from heavy rainfall.
		B3-5	3.8	2.1	0	1	5	5	50	39	1	Extensive blackberry along banks. Creek section area of fines deposition.
		B3-6	4.3	3.8	0	5	10	40	30	15	0	Break in blackberry where extensive gravel reach present.
		B3-7[1]	-	-	-	-	-	-	-	-	-	Extensive blackberry along banks and over creek. Could not access.
	B4	B4-1	1.5	0.32	0	10	25	25	30	10	0	
	B5	B5-1[1]	-	-	-	-	-	-	-	-	-	Could not access due to private property along Pitt River.
Brown Creek	BRWN1	BRWN1-1	1.6	0.14	0	1	20	50	19	10	0	Reach starts at outfall, creek piped upstream. Instream restoration (i.e., gravel placement) of creek has occurred previously.
		BRWN1-2	4.5	1.4	0	0	5	25	45	25	1	Includes side channel habitat with one large pool. Side channel appears to be a restoration site which rejoins mainstem downstream.
	BRWN2	BRWN2-1	3.0	1.0	0	1	5	10	60	24	5	
		BRWN2-2	2.0	1.4	0	0	10	40	30	20	0	Side channel splits off from mainstem of creek. Side channel appears to be a restoration site which rejoins mainstem downstream.
	BRWN3	BRWN3-1 [2,3]	11.0	9.0	-	-	-	-	-	-	-	Includes confluence of Broadway Creek with Brown Creek.
		BRWN3-2 [2,3]	44.0	43.0	-	-	-	-	-	-	-	Creek opens up into a large pond area upstream of Mary Hill Bypass.
	BRWN4	BRWN4-1 [2,3]	38.0	37.0	-	-	-	-	-	-	-	
Broadway Creek	BRD1	BRD1-1 [2,3]	8.0	4.0	-	-	-	-	-	-	-	Unable to walk due to water depth and extensive blackberry.
	BRD2	BRD2-1 [2,3]	6.0	5.5	-	-	-	-	-	-	-	Unable to walk due to water depth and extensive blackberry.

[1] Stream segment not walked due to access issues
[2] Stream substrate unknown due to wetted depth of creek
[3] Range finder used

The following is a summary of Baker, Brown, and Broadway Creek fish habitat based on the field assessment:

Baker Creek

The upper reaches of Baker Creek (upstream of Marian Kroeker Park) are impacted by high levels of encroachment. Limited riparian forest is present due to either property development backing onto the stream or the stream running through the yards of properties. Because of this, high densities of invasive plant species are found throughout the riparian area. Once the stream reaches Marian Kroeker Park, the riparian area generally increases in width and native vegetation becomes denser until Traboulay PoCo Trail, where riparian vegetation is confined to a narrow strip due to the commercial property along the Pitt River. Upstream of Nova Scotia Avenue, the stream generally has little to no spawning gravels and poor to fair rearing habitat. Downstream of Nova Scotia Avenue, the stream reaches generally have moderate to extensive spawning gravels and good rearing habitat. Multiple stream reaches downstream of Marian Kroeker Park were not assessed for spawning or rearing habitat due to access issues (private property, extensive blackberry overgrowth, or deep channel depth). See Photos 1-5 in Appendix F for representative photos of the creek.

Brown Creek

Brown Creek generally has a healthy riparian buffer (greater than 15 m) in most sections made up of young mixed forest (5–150 years). A gravel walking path (Brown Creek Trail) runs parallel along the left bank of Brown Creek through Kilmer Park for a length of approximately 600 m. Between the walking path and Brown Creek, little to no riparian vegetation is present but additional riparian forest is present to the east of the path. Brown Creek generally has moderate to extensive spawning gravels and good rearing habitat. Two previous restoration sites, one immediately upstream of the confluence with Broadway Creek and one approximately 20 m downstream of the Brown Creek Trail, were observed within Brown Creek. Both sites included the creation of side channel habitat. See Photos 6-8 in Appendix F for representative photos of the creek.

Broadway Creek

Broadway Creek has been altered from its historical course due to urban development and has been highly channelized for water conveyance. For the segments of Broadway Creek that were assessed, the average bank full width ranged from 6.0–8.0 m. The system is generally slow-moving due to the low gradient and widens out even further the closer the stream gets to Harbour St Storm Pump Station. The riparian habitat along Broadway Creek is highly disturbed and invasives are extensive around Broadway Street and the Mary Hill Bypass and along the length of the right bank behind the commercial complex. No spawning gravels are expected to be present and rearing habitat is anticipated to be poor due to the lack of side channel habitat and instream habitat complexing. See photos 9-12 in Appendix F for representative photos of the creek.

Beaver dams were not observed within Baker, Brown, or Broadway Creek at the time of the field assessment. However, signs of past beaver activity (chew marks on downed trees) were observed along the river right of Broadway Creek approximately 40 m downstream of Broadway Street.

Completed Instream Restoration Works – Brown Creek

In 2002, channel enhancement and habitat construction works were completed in Brown Creek, immediately upstream of the confluence with Broadway Creek. The works included the following:

- Construction of approximately 90 m of spawning channel with two online rearing pools.
- Construction of approximately 230 m of off-channel pool habitat.
- Enhancement of 60 m of existing channel with boulder weirs and Coho gravel.
- Riparian planting along the newly constructed and enhanced habitats.

Five years of post-construction monitoring was completed to ensure that the constructed and enhanced habitats were functioning as intended (Envirowest Consultants Ltd., 2004–2006). Monitoring reports for the first three years were obtained by KWL and reviewed. Monitoring included water quality (dissolved oxygen, temperature, and pH), channel flow velocities, fish utilization, stability of the works, and health of planted riparian vegetation. Generally, the works were found to be functioning as intended. The following summarizes the key findings of the monitoring:

- Some dissolved oxygen readings during the Year 2 and 3 summer assessments were found to be at a level (<6.0 mg/L) that could cause some distress to salmonids. The lowest recorded reading was 2.45 mg/L in Year 2.
- Greater than 80% of the planted riparian vegetation survived Year 1. Encroachment of Himalayan blackberry was observed in Year 2. Ongoing invasive species removal was recommended.
- Juvenile Coho Salmon, Cutthroat Trout, Rainbow Trout, Prickly Sculpin, Three-spine Stickleback, and crayfish (unidentified species) were captured in all three years.
- Minor stability issues, specifically bank erosion in the constructed spawning channel, missing boulders from the boulder weir, and accumulation of debris in the pools and enhanced channel, were observed over the three years.

During the habitat field inventory, this section of stream was walked (Appendix F – Photo 8). The following observations were made:

- Much of the constructed spawning channel has been infilled with fine sediment and organics.
- Riparian vegetation is established along the constructed spawning channel and enhanced existing channel, but some smaller patches of Himalayan blackberry are present.

5.5 Riparian and Watershed Forest Cover Assessment

Watershed and riparian forest cover are indicators of stream and watershed health and relate to the effect of changing land use can have on hydrology, water quality, and other components of stream ecosystems.

Watershed forest cover is strongly tied to the ability of a landscape to support biodiversity. There is evidence that protecting between 30–50% forest cover and at least one, and preferably several, large patches (>200 ha) are necessary to maintain even marginal levels of biodiversity and aquatic ecosystem health. Protection of 50% of watershed forest cover is recommended (Environment Canada, 2013).

Riparian forest integrity (RFI) is the amount of intact riparian forest corridor along a stream, expressed as a percentage of area within a 30 m setback on both sides of a watercourse over its entire length. Riparian (streamside) vegetation provides a source of large organic debris for fish habitat, stabilizes streambanks to reduce erosion, shades the channel to moderate water temperatures, and introduces food for aquatic life. Maintaining a 70–75% RFI is a recommended guideline for urban watersheds (Environment Canada, 2013).

To assess watershed and riparian forest cover, 2021 ortho-imagery from the Vancouver Fraser Port Authority was used to map current forest cover in GIS. For both watershed and riparian forest cover, the proportion of the catchment or riparian area covered by forest was calculated. Riparian forest integrity was calculated for the watershed by buffering a 30 m setback (60 m total width) from the creek's centerlines across all permanent streams. Forest cover and RFI were also calculated across the individual watersheds to compare forest cover within the different watersheds.

In addition to calculating the current watershed and riparian forest cover for the study area, an assessment was completed to determine future conditions. This included using the 2013 Official Community Plan (OCP), No. 3838 for information on watercourse protection and watercourse classification as well as data for future zoning within the study area.

The following are key assumptions used to determine future riparian forest conditions:

- All creeks or streams identified within the watersheds were assumed to be fish-bearing.
- Any existing riparian vegetation outside of the City's required riparian buffer widths, as outlined within the 2013 OCP - Watercourse Protection, is replaced by impervious area.

It is important to note that due to how the watershed was developed many existing properties have structures that encroach into the riparian zone. See photos in Appendix F for examples. City staff have observed that even though there are riparian setbacks in place, residents are not always following the rules in the bylaws. There are examples of residents extending their lawns or backyards all the way to the creek. As per the OCP, all new construction located within residentially zoned properties must have a riparian buffer of 15 m between the stream top of bank and a structure (i.e., house, retaining wall). However, many of these properties may not be able to fully adhere to the 15 m riparian buffer due to undue hardship. This occurs when a property is constrained by its size, location, and zoning bylaws, therefore, making it impossible to construct on the property unless the riparian buffer is encroached on. Therefore, future RFI as shown in Figure 5-7 is likely to not be achieved with the existing bylaws due to grandfathering in of structures and property constraints.

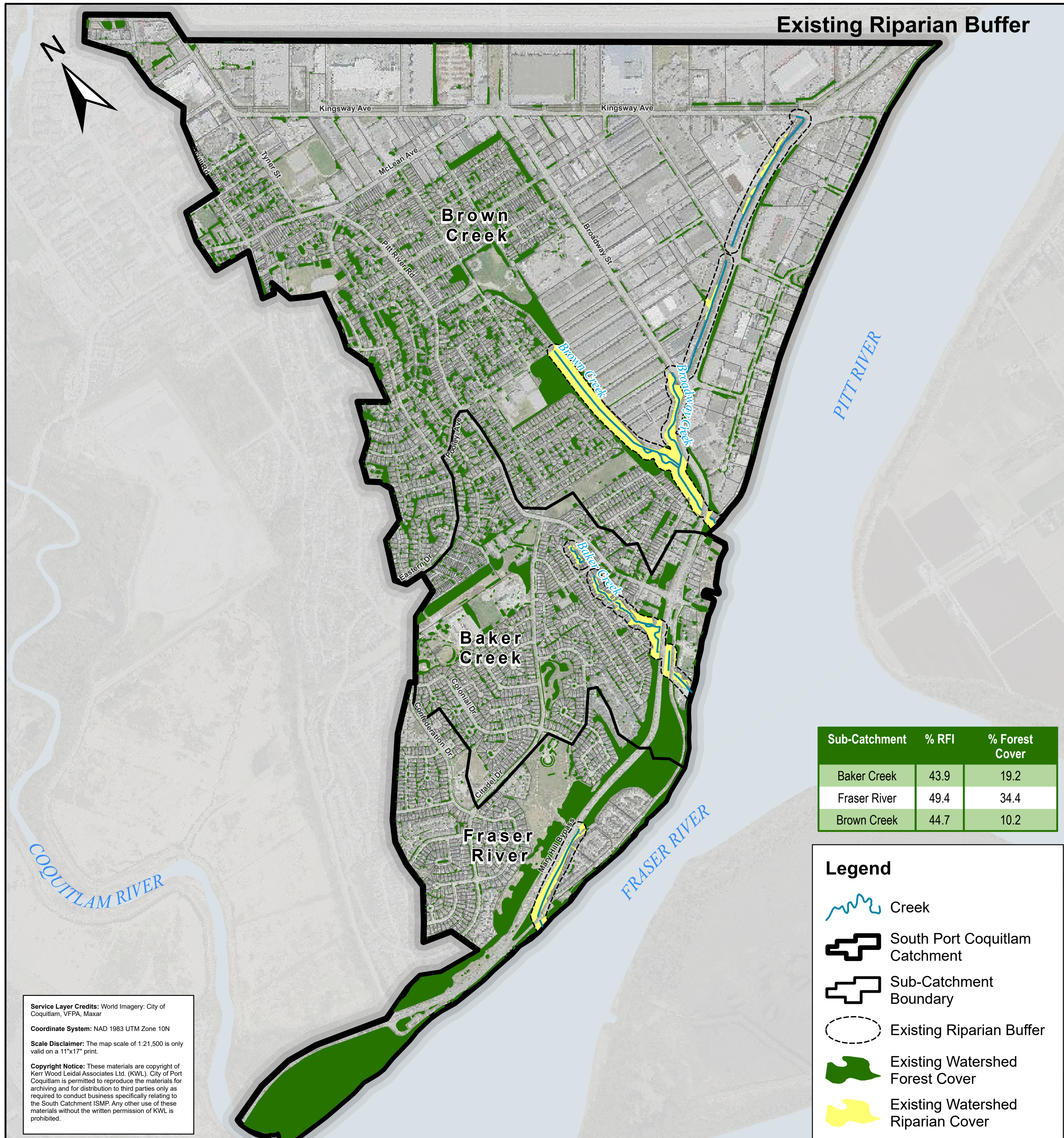
Figure 5-7 shows the existing and future riparian forest cover mapped for the study area and by watershed.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_Rp_Figures\646043_Rp_Figures.aprx Date Saved: 2024-07-05 8:10 PM | Author: JLau

City of Port Coquitlam

Phase 2 - South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers

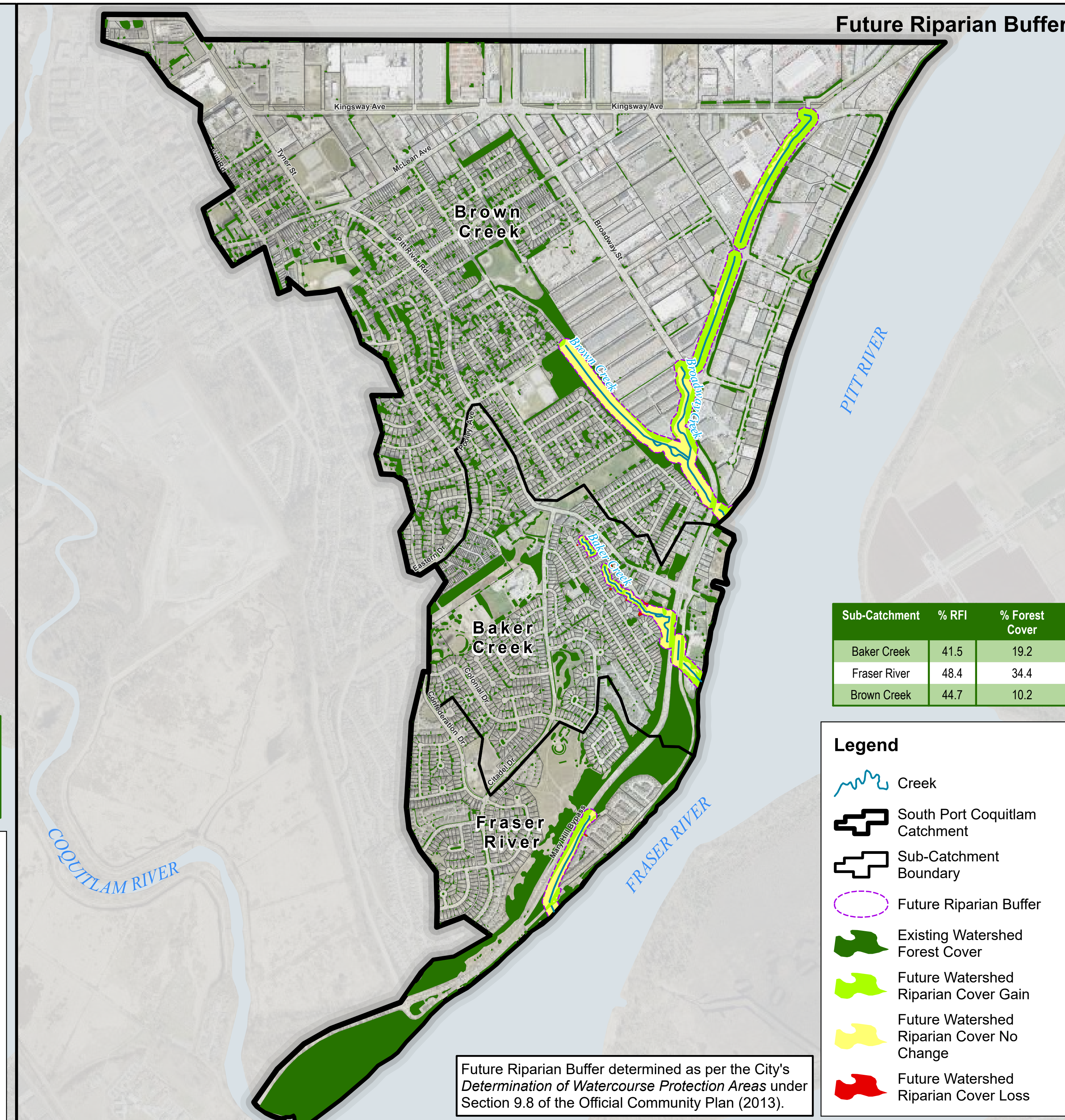


Sub-Catchment	% RFI	% Forest Cover
Baker Creek	43.9	19.2
Fraser River	49.4	34.4
Brown Creek	44.7	10.2

Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:21,500 is only valid on a 11"x17" print.



Sub-Catchment	% RFI	% Forest Cover
Baker Creek	41.5	19.2
Fraser River	48.4	34.4
Brown Creek	44.7	10.2

Future Riparian Buffer determined as per the City's *Determination of Watercourse Protection Areas* under Section 9.8 of the Official Community Plan (2013).

Project No. 646-043

Date December 2024

Scale 1:21,500

0 100 200 400 m

Existing and Future Watershed and Riparian Forest Cover

Figure 5-7

Overall forest cover within the study area is generally lacking due to urban development. Forest cover is particularly minimal in areas of commercial and industrial development (i.e., northern extent of Brown Creek watershed). Riparian forest cover within the study area is also generally lacking except for along Brown Creek. The upper reaches of Baker Creek have little riparian forest due to the residential developments which back onto the stream.

Key findings from the watershed forest cover analysis for the South Port Coquitlam IWMP study area include:

- A total of 13% (84 ha) of the study area (all three watersheds) is forested. This falls well below the recommended target to maintain at least 50% watershed forest cover.
- Watershed forest cover is highest in the Brown Creek watershed (38%) and lowest in Baker Creek watershed (19%).
- Within the Fraser River, Baker Creek, and Brown Creek watersheds, forest cover is predominantly concentrated within one portion of the watershed, within the eastern extent, southwestern extent, and eastern extent, respectively.
- The largest patch of forest in the watershed, located in the Fraser River watershed at the most southern extent is approximately 14 ha in size. Approximately five patches of forest exceed 5 ha and are distributed across all three watersheds.

Key findings from the riparian forest cover analysis for the South Port Coquitlam IWMP study area include:

- Overall RFI across the study area (all three watersheds) is 46%. This falls below the recommended 70–75% target for riparian forest cover in urban watersheds.
- None of the three watersheds meet or exceed the suggested guideline of 70–75% for riparian forest cover.
- RFI is highest in the Fraser River watershed (59%) and lowest in Baker Creek watershed (37%).

Future Riparian Forest Cover

Key findings from the future riparian forest cover analysis for the South Port Coquitlam IWMP study area include:

- Future RFI for the study area (all three watersheds) will be 44%. This falls below the recommended 70–75% riparian forest cover target for urban watersheds.
- No watersheds will meet or exceed the suggested guideline of 70–75% for riparian forest cover.
- Future RFI will be highest in the Fraser River watershed (57%) and lowest in the Baker Creek watershed (34%).

The future RFI is 2% less than the current RFI. This decrease in RFI is based on the City of Port Coquitlam's Future OCP Development land use designations and the existing Determination of Watercourse Protection Areas under Section 9.8 of the OCP. If all future zoning identified in the OCP occurs, there will be a general decrease in the watershed's riparian forest cover.

A summary of watershed and riparian forest cover is shown in Table 5-7.

Table 5-7: Watershed and Riparian Forest Cover

Watershed	Total Area (ha)	Watershed Forest Cover		Riparian Forest Cover					
				Existing			Future		Change Between Existing & Future RFI (%)
		Area (ha)	%	Total Riparian Area (ha)	Total Riparian Forest (ha)	RFI[1] (%)	Total Riparian Forest (ha)	RFI[1] (%)	
Baker Creek	111.6	21.5	19.2	5.3	2.3	43.9	2.2	41.5	Decrease (-5.5%)
Brown Creek	439.9	44.9	10.2	16.1	7.2	44.7	7.2	44.7	Insignificant Change
Fraser River	95.3	32.8	34.4	2.8	1.4	49.4	1.4	48.4	Decrease (-2.0%)
Overall	**646.8**	**99.2**	**21.3**	**24.2**	**10.9**	**46**	**10.8**	**44.9**	**-2.5%**

1. RFI = Riparian Forest Integrity

5.6 Terrestrial Species and Habitat Assessment

Upland terrestrial habitat in the Fraser River, Baker Creek, and Brown Creek watersheds support a variety of wildlife and plant species outside of riparian forested areas. Small forest patches, hedgerows, vegetated road embankments and medians, and some small areas of old field habitat, among other habitat types, form a habitat mosaic linking the watersheds within the study area. In general, upland areas in the upper watersheds (north of Mary Hill Bypass is dominated by urban and commercial land uses, lowland areas in the watersheds (south of Mary Hill Bypass) consist of more industrial land uses. The watersheds support native wildlife including amphibians, birds, and mammals, though urban areas generally support a less diverse assemblage of wildlife species than naturalized areas. The Baker, Broadway, and Brown Creek watersheds are also home to a number of species of conservation concern (see below for information on species of conservation concern). These species at risk may be impacted by human development and activities. Special planning and protection must be given to these species in order to protect their habitat and life-history needs.

Information to support this assessment was collected from citizen scientist records in iNaturalist, the Metro Vancouver Sensitive Ecosystem Inventory Mapping Tool, and expert opinion. The Fraser River, Baker Creek, and Brown Creek watersheds are located in the Coastal Western Hemlock (CWH) biogeoclimatic zone (Ministry of Forests and Range, 2019). This zone is characterized by cool summers and mild, wet winters. Common vegetation includes western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), coastal Douglas-fir (*Psuedotsuga menziesii*), red alder (*Alnus rubra*), and black cottonwood (*Populus trichocarpa*). Common shrubs and ferns include salmonberry (*Rubus spectabilis*), snowberry (*Symphoricarpos albus*), red osier dogwood (*Cornus stolonifera*), red elderberry (*Sambucus racemosa*), and sword fern (*Polystichum munitum*).

Terrestrial Habitat

Terrestrial habitat in the City of Port Coquitlam has been heavily impacted by urban and industrial development. Only 13% of land remains forested, and the remaining patches of forest are fragmented. The review of terrestrial habitat in the City resulted in the following key findings:

- Three sensitive ecosystem types have been identified within the watershed (Metro Vancouver, 2019): riparian, young forest, and wetland.
- Currently, no continuous wildlife corridor, either a riparian corridor along a creek or an upland forest corridor, connects the Brown Creek watershed to the Baker Creek and the Fraser River watersheds. This disconnection is due to residential and commercial development as well as the Mary Hill Bypass (Highway 7B).

Representative Wildlife

Terrestrial wildlife species make use of the mosaic of forest and urban habitats that are present in the South Port Coquitlam area. A selection of representative and common species found in the watershed and surrounding area is presented in Table 5-8. Many of these species are tolerant of humans and able to thrive in more urbanized landscapes. Limited information is available about population numbers or population trends for terrestrial wildlife.

Table 5-8: Representative and Common Wildlife Species

Common Name	Scientific Name
Mammals	
American Beaver[3]	*Castor canadensis*
Eastern Grey Squirrel[1]*	*Sciurus carolinensis*
Muskrat[1]	*Ondatra zibethiucus*
Coyote[2]	*Canis latrans*
Racoon[3]	*Procyon lotor*
Striped Skunk[3]	*Mephitis mephitis*
American Black Bear[1]	*Ursus americanus*
Amphibians/Reptile	
Common Garter Snake[1]	*Thamnophis sirtalis*
American Bullfrog[2]	*Lithobates catesbeianus*
Green Frog[4]	*Lithobates clamitons*
Birds	
Northern Flicker[2]	*Colaptes auratus*
American Crow*	*Corvus brachyrhynchos*
Bald Eagle[1]	*Haliaeetus leucocephalus*
Red-tailed Hawk[2]	*Buteo jamaicensis*
American Robin*	*Turdus migratorius*
Barred Owl[1]	*Strix varia*
Pileated Woodpecker[1]	*Dryocopus pileatus*
Anna's Hummingbird[1]	*Calypte anna*

Common Name	Scientific Name
Black-capped Chickadee*	*Poecile atricapillus*
Spotted Towhee[2]	*Pipilo maculatus*
Stellar's Jay*	*Cyanocitta stelleri*
Brown Creeper*	*Certhia americana*
*Indicates species observed during field assessments conducted by KWL. [1]iNaturalist (2022) [2]MOE (2022d) [3]City of Port Coquitlam (2022) [4]BC Frogwatch Atlas (2022)	

Species of Conservation Concern

The South Port Coquitlam IWMP study area contains a number of confirmed or potential terrestrial species at risk that should also be taken into consideration in land use planning. Species identified are listed below in Table 5-9 and shown in Figure 5-8. Several species are included which have been observed in the ƛ̓éxətəm Regional Park (formerly known as Colony Farm Regional Park) catchment. These have been included due to the increased potential of occurring in the adjacent Fraser River.

Table 5-9: Potential and Confirmed Terrestrial Species at Risk

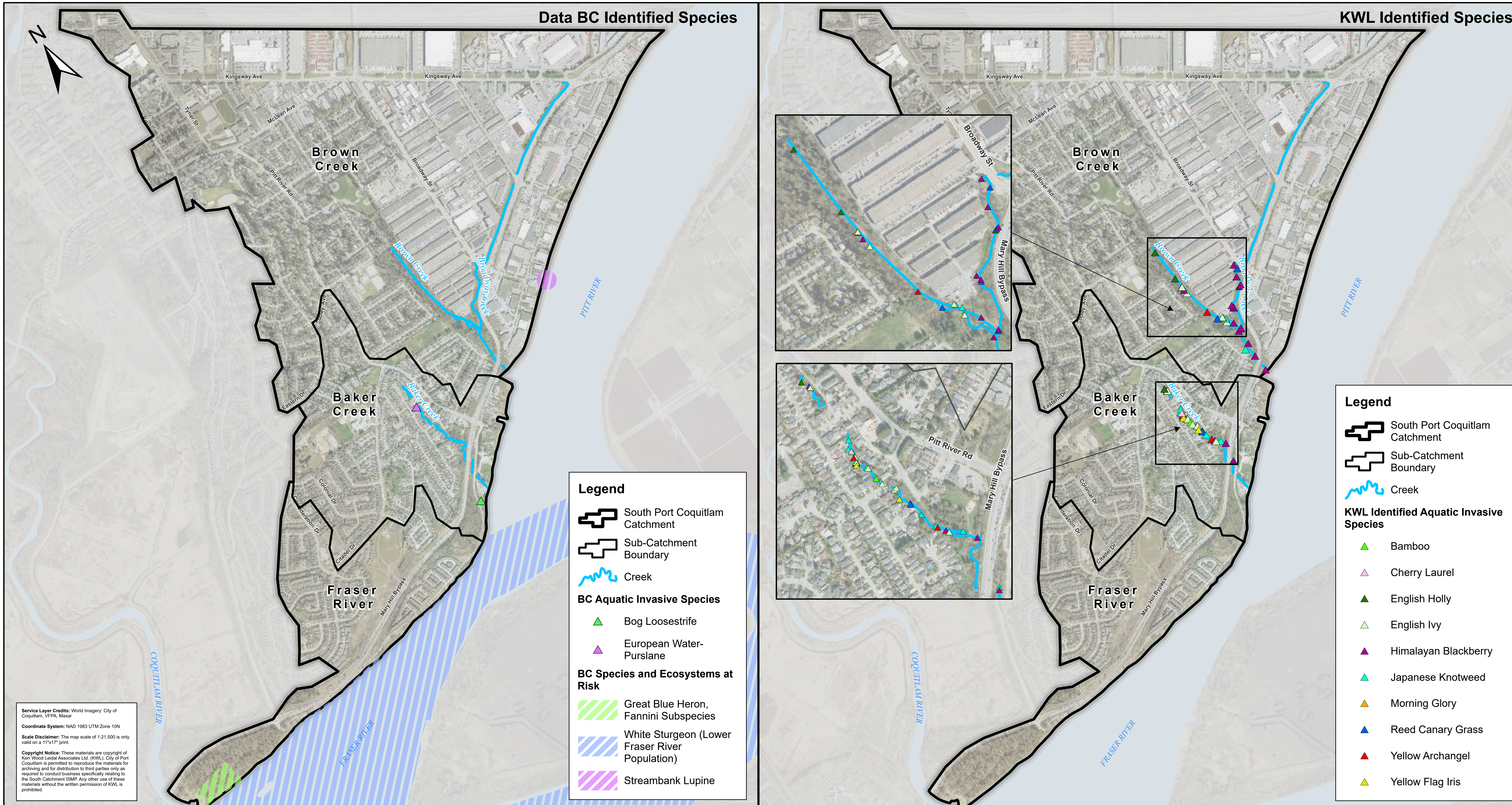
Taxa	Species	Comments	Likelihood
Birds	Barn Owl (*Tyto alba*)	Observed within ƛ̓éxətəm Regional Park. Proposed critical habitat polygon overlaps with the western extent of the Fraser River watershed.	Potential
	Great Blue Heron (*Ardea herodias fannini*)[1]	Observed within ƛ̓éxətəm Regional Park which is a part of the Fraser River watershed (western extent). Last colony observation was in 2010.	Confirmed
	Marbled Murrelet (*Brachyramphus marmoratus*)	Proposed critical habitat overlaps with the western extent of the Fraser River watershed.	Potential
Mollusc	Oregon Forestsnail (*Allogona townsendiana*)[1]	Observed within ƛ̓éxətəm Regional Park	Potential
Amphibians	Northern Red-legged Frog (*Rana aurora*)[1]	Observed within ƛ̓éxətəm Regional Park	Potential
	Western Toad (*Anaxyrus boreas*)[2]	Observed within ƛ̓éxətəm Regional Park	Potential
Plant	Streambank Lupine (*Lupinus rivularis*)[1]	Observed along the dike between Broadway Street and Coast Meridian Road. Last observation date was July 2013.	Confirmed
Animal	Western Painted Turtle, Western population (*Chrysemys picta* pop. 1)[1]	Observed within ƛ̓éxətəm Regional Park. Critical habitat overlaps with the western extent of the Fraser River watershed.	Potential
[1]Conservation Data Centre (2022) [2]BC Frogwatch Atlas (2022)			

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_Rp_Figures\646043_Rp_Figures.aprx Date Saved: 2024-07-05 8:10 PM | Author: JLau

City of Port Coquitlam

Phase 2 - South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No. 646-043

Date December 2024

Scale 1:21,500

0 100 200 400 m

Species at Risk and Invasive Species

Figure 5-8

Invasive Plant Species

A variety of invasive plant species are in the watershed. Identified species include Himalayan blackberry (*Rubus armeniacus*), English ivy (*Hedera helix*), reed canarygrass (*Phalaris arundiacea*), yellow flag iris (*Iris pseudacorus*), English holly (*Ilex aquifolium*), cherry laurel (*Prunus laurocerasus*), yellow archangel (*Lamium galeobdolon*), common bamboo (*Bambusa vulgaris*), morning glory (*Ipomoea purpurea*), and Japanese knotweed (*Fallopia japonica*). Locations of identified species can be found in Figure 5-8.

The two most abundant invasive plant species found throughout the watersheds are Himalayan blackberry and English ivy (see Photos 1-2 in Appendix G). Both species can form monocultures that exclude native species and reduce the overall biodiversity of a site. Japanese knotweed is also found throughout the Fraser River, Baker Creek, and Brown Creek watersheds and is a plant species of concern (see Photo 3 in Appendix G). Japanese knotweed is an aggressive species, capable of forming dense monotypic stands in riparian and moist sites and can damage infrastructure. It can reduce native plant diversity and can contribute to erosion along streambanks due to its fragile root system. This species is extremely difficult to control and eradicate once established. Japanese knotweed is present along the banks of Baker, Brown, and Broadway Creeks.

Another species of concern is yellow flag iris. This species tends to create large thickets in the water leading to reductions in the carrying capacity of water storage in wetlands and the blocking of stream channels. Contact with the plant's resins can cause skin irritation and if ingested can sicken livestock.

In Baker Creek, an area of high concern is in the upper reaches of the creek where encroachment from residential properties is pervasive. There is limited riparian forest and frequent disturbance from landowners, leading to establishment of invasive species.

Aquatic Invasive Plant Species

Two aquatic invasive species have been previously identified within the study area: European water-purslane (*Lythrum portula*) (MOE, 1990) and bog loosestrife (*Lysimachia terrestris*) (MOE, 1988), both found along Baker Creek. The locations of these aquatic invasive species are shown in Figure 5-8**.**

5.7 Benthic Community Sampling

Background

Aquatic invertebrate community composition is a useful indicator of habitat conditions within waterbodies. Some species are more tolerant than others to poor water quality conditions such as low dissolved oxygen or high nutrient levels while others are only found in areas of high water quality. The BC Ministry of Environment and the BC Ministry of Forests were contacted to identify previous benthic invertebrate sampling that occurred in Port Coquitlam. There were no known previous sampling programs within the Fraser, Brown, or Baker watersheds.

Methodology

Benthic invertebrate sampling sites were recommended by KWL and selected by the City. Site selection followed the methods outlined in Metro Vancouver's Monitoring and Adaptive Management Framework for Stormwater (AMF; Metro Vancouver, 2014). Sampling occurred in the dry season (September / October) as recommended. Samples were collected in the Baker and Brown watersheds; the exact locations are shown in Figure 5-9. The Fraser River watershed was not sampled due to a lack of suitable substrates for sampling (i.e., gravel or cobble riffles) (most of the stream is piped). The selected sites were in mid to lower-stream segments away from bridges/outfalls that had suitable gravel substrate and intact riparian forest.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_Rp_Figures\646043_Rp_Figures.aprx Date Saved: 2024-07-05 8:10 PM | Author: JLau

City of Port Coquitlam
South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers

Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646-043
Date December 2024
Scale 1:13,500
0 75 150 300 m

Water Quality and Benthic Invertebrate Sampling Sites

Figure 5-9

Sample Collection

Benthic invertebrates were sampled following procedures outlined in the AMF (Metro Vancouver, 2014). A Surber sampler with a 250 µm mesh size was placed within a random, shallow riffle, and the substrate was agitated for three minutes to dislodge benthic invertebrates and wash them into the Surber sampler. Three replicate samples (3 jars per stream) were collected consisting of a composite of three Surber placements in each jar.

Sample Analysis

The samples were analyzed using taxonomic levels recommended by the AMF and the Benthic Index of Biological Integrity (B-IBI) was calculated for each sample to assess stream health. The samples were analyzed by Biologica Environmental Services, Ltd. In Victoria, BC. Detailed methodology used in the sorting, identification, and calculations can be found in Appendix H.

Benthic Index of Biotic Integrity (B-IBI)

The Benthic Index of Biotic Integrity scoring system is a quantitative method for determining and comparing the biological condition of streams. It is based on the type and number of various benthic invertebrates found in a sample. B-IBI scores rate the stream on a scale of 10 to 50 as summarized in Table 5-10. Score ranges correspond to qualitative rankings ranging from “very poor” to “excellent”. Higher B-IBI scores are associated with healthier streams.

Table 5-10: Values and Rankings for B-IBI Scores

B-IBI Score	Rank	Comments
46–50	Excellent	Pristine, no habitat degradation
38–44	Good	-
28–36	Fair	-
18–26	Poor	-
10–16	Very Poor	Impacted watershed, heavily urbanized

Note: Table from Metro Vancouver Monitoring and Adaptive Management Framework guidelines (Metro Vancouver, 2014).

Results

Both Brown Creek and Baker Creek received a score of 16 or “very poor”, a detailed breakdown of the data and factors contributing to the score can be found in Appendix H.

The results for both creeks suggest that the watersheds are heavily urbanized and impacted. There is poor water quality in both systems that negatively impacts the habitat and the organisms that can live in the gravels of these streams.

5.8 Water Quality

Based on a desktop review of data received from the City and publicly available information from online databases, no publicly available reports for water quality are available for Baker, Brown, and Broadway creeks.

Although no water quality data was available, information regarding documented environmental incidents within Brown Creek provided by the Brown Creek Streamkeepers is listed below. Due to the number of incidents reported downstream of the Pooley and Connaught storm outfall, this site was included in the 2022 sampling program.

- **March 7, 2003:** Brown Creek Streamkeepers recorded finding two dead Cutthroat Trout and an odour coming from the creek immediately downstream of the Pooley and Connaught storm outfall. Possible substance was paint solvent/thinner.
- **June 2, 2003:** Brown Creek Streamkeepers called the Environment Canada Emergency number to report a fish kill immediately downstream of the Pooley and Connaught storm outfall. Over 100 fish were killed due to a chlorine discharge. Fish identified included Coho Salmon, Cutthroat Trout, and Rainbow Trout. An Environment Canada Regional Pollution Incident Report was submitted on June 4, 2003.
- **March 19, 2004:** Brown Creek Streamkeepers recorded finding six dead Cutthroat Trout in the creek immediately downstream of the Pooley and Connaught storm outfall. Possible substance was oil leaking from truck parked on Connaught Drive.
- **April 24, 2013:** Resident reported seeing sediment-laden water entering the creek immediately downstream of the Pooley and Connaught storm outfall. The City was notified and an investigation opened. Source of sediment was a construction activity upstream, with crew pumping silty trench water into the storm sewer which drains into Brown Creek. Once identified, the crew switched to pump the trench water to the sanitary system and the creek cleared within 20 minutes.
- **May 6, 2013:** Resident reported a fish kill in the creek immediately downstream of the Pooley and Connaught storm outfall. Approximately 50 fish were killed along a 300 m stretch of creek. Water quality sampling was completed but no known cause was determined.

Due to the number of incidents reported downstream of the Pooley and Connaught storm outfall, this site was included in the 2022 sampling program.

Methods

Six sampling sites were recommended by KWL and selected by the City as shown in Figure 5-9. These sites were selected at the most upstream non-piped points of Brown, Baker, and Broadway creeks and the most downstream point at the confluence of each creek with the Fraser River. The reasoning for these selected sites was to establish a baseline of water quality flowing into the streams from the surrounding storm system and measure the water quality discharging into the Fraser River. An additional AMF site was selected in the Fraser River watershed to analyze the quality of water discharging to the Fraser River. Therefore, three sampling sites were selected in the Brown watershed, two sites in the Baker watershed, and one site in the Fraser watershed.

Water quality sampling was completed in both the dry season (September/October) and wet season (November/December) in 2022. Representative photos of all of the sampling sites can be found in Appendix I. Sampling followed the protocols and guidance found in Metro Vancouver's Monitoring and Adaptive Management Framework for Stormwater (Metro Vancouver, 2014). Generally, sampling consisted of five sampling events over a period of 30 days at each sampling site in each season.

In-situ Water Quality Parameters and Method

In-situ water quality sampling is the measure of physical (e.g., temperature) and chemical (e.g., pH) properties of a water body at the time of sampling. During each grab General in-situ water quality parameters (dissolved oxygen (DO), pH, water temperature, conductivity, and turbidity) were measured in the field using a YSI Proplus Meter and a LaMotte 2020we Turbidimeter.

Water Sample Collection Method

Water samples for laboratory testing were collected using methods as outlined in the Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia (Cavanagh et al. 1998), the Ministry of Environment BC Field Sampling Manual (2013), and the lab sample collection protocols. At all sites, grab samples were collected directly from the watercourse.

Laboratory Water Quality Testing

Processing and laboratory analysis of water samples was completed by Metro Vancouver Laboratories and Caro Analytics, a CALA-certified lab (Richmond, BC) or their subcontractors. The water quality parameters monitored (*E. coli*, fecal coliforms, nitrogen as nitrate, total cadmium, copper, iron, lead, and zinc) are based on the AMF recommendations for monitoring watershed health.

Water Quality Guidelines

The water quality sampling results were assessed according to the approach recommended in Metro Vancouver: Monitoring and Adaptive Management Framework Water Quality Evaluation System. This assessment approach helps municipalities quickly identify, within a watershed, where water quality conditions are good and where there may be concerns that may need to be addressed. The general interpretation of individual categories is the following:

- Good Priority Indicator = suggests that water quality for this parameter, at least at the current monitoring location, is good. Based on this monitoring, no further monitoring for this parameter is required in the drainage system for five years. No adaptive management is required based on this monitoring.
- Satisfactory Priority Indicator = suggests that water quality is either closely approaching a level of concern for this parameter or is already in non-attainment with provincial water quality guidelines.

The level of the parameter result (relative to water quality guidelines and/or objectives) and the incidence of additional priority indicators of concern should be considered in the development of the city-wide Adaptive Management Plan. Consideration should be given to supplemental water quality monitoring and/or adaptive management actions.

- Needs Attention Priority Indicator = suggests that water quality is in non-attainment with provincial water quality guidelines. The level of the parameter result and the incidence of additional priority indicators of concern should be considered as part of the city-wide Adaptive Management Plan.

Supplemental water quality monitoring and/or adaptive management actions are recommended. Under the AMF, water temperature, dissolved oxygen, and turbidity are considered primary indicators.

Conductivity and pH are considered secondary indicators and provide supporting information for the interpretation of priority indicators and the identification of the source of an impact. See Metro Vancouver (2014) for more details.

The AMF thresholds for water quality classification (good, satisfactory, and need attention level) are found in Table 5-11.

Table 5-11: Classification of Water Quality Results (AMF)

Parameter (Unit)	Good Level	Satisfactory Level	Need Attention Level
Physical Water Quality Parameters			
Dissolved Oxygen (mg/L)	≥11	<11 to 6.5	<6.5
pH	6.5 to 9.0	<6.5 to 6.0 or >9.0 to 9.5	<6 or >9.5
Water Temperature (°C)	dry season: <16	dry season: 16-18	dry season: >18
	wet season: 7-12	wet season: 5-<7 or >12-14	wet season: <5 or >14
Conductivity (µS/cm)	<50	50-200	>200
Turbidity (NTU)	0-5	5-25	>25
Nutrients			
Nitrate, N-NO_3 (mg/L)	<2	2-5	>5
Microbiological			
E. coli (MPN/100 mL)	Geomean ≤77	Geomean 78-385	Geomean >385
Fecal Coliforms (MPN/100 mL)	Geomean ≤200	Geomean 201-1,000	Geomean >1,000
Metals			
Cadmium, total (mg/L)	<0.00006	0.00006-0.00034	>0.00034
Copper, total (mg/L)	<0.003	0.003-0.011	>0.011
Iron, total (mg/L)	<0.8	0.8-5	>5
Lead, total (mg/L)	<0.005	0.005-0.03	>0.03
Zinc, total (mg/L)	<0.006	0.006-0.04	>0.04

Water Quality Results

The water quality data were averaged for each sampling site over the five sampling events. Where data points were missing, averages were taken for the remaining four sampling events, omitting the missing sample. Mentions of “good/satisfactory/need attention’ water quality as well as specific exceedances all refer to the AMF classification (Table 5-11). Where detection limits were exceeded (for bacteria) the detection limit was used in calculating the average. Where a sample was below the detection limit the average was taken using half the detection limit as the value for the sample.

An evaluation of individual replicates was performed to identify potential outliers in the data. The October 3 and November 22, 2022, events at Broadway 5 (Brown watershed) showed elevated concentrations of certain parameters; however, the calculated averages are considered representative. Table 5-12 shows the average values for each parameter at each site over the five sample events during the Dry season, and Table 5-13 shows the same information for the wet season.

Table 5-12: Water Quality Values – Dry Season

Parameter (Unit)	Brown 1	Broadway 1	Broadway 5	Baker 3	Baker 7	Fraser 1
Physical Water Quality Parameters						
pH	7.7	7.0	7.6	7.5	7.8	8.1
Water Temperature (°C)	8.5	15.4	15.5	15.1	14.2	14.3
Conductivity (µS/cm)	203	223	139	202	196	268
Dissolved Oxygen (mg/L)	9.7	3.7	7.8	9.9	9.0	9.7
Turbidity (NTU)	0.5	11.8	11.5	0.9	0.8	11.2
Nutrients						
Nitrate, Total (as N) (mg/L)	1.6	0.3	0.4	2.0	1.2	1.6
Bacteria						
Fecal Coliforms (CFU/100 mL)	1605	1152	402	302	905	259
E. coli (CFU/100 mL)	1194	720	287	301	787	129
Total Metals						
Cadmium (mg/L)	All <DL	All <DL	0.00006	All <DL	All <DL	All <DL
Copper (mg/L)	0.0034	0.0024	0.0057	0.0020	0.0019	0.0036
Iron (mg/L)	0.229	3.58	3.41	0.150	0.290	4.55
Lead (mg/L)	All <DL	0.0005	0.0014	All <DL	All <DL	All <DL
Zinc (mg/L)	0.0034	0.017	0.022	0.012	0.0053	0.014

Cell colour indicates the classification of water quality results according to the Metro Vancouver Monitoring and Adaptive Management Framework for Stormwater; green = 'good' level, yellow = 'satisfactory' level, red = 'need attention' level.
<DL – below detection limit
Mean values are averaged over 5 samples; the geomean was calculated for microbial parameters. To calculate means, concentrations below detection limit were replaced by DL/2. Concentrations above detection limit (applicable for microbiological data) were set as the maximum detectable value.

Table 5-13: Water Quality Values – Wet Season

Parameter (Unit)	Brown 1	Broadway 1	Broadway 5	Baker 3	Baker 7	Fraser 1
Physical Water Quality Parameters						
pH	6.6	6.3	6.9	7.0	6.8	7.2
Water Temperature (°C)	8.5	7.5	4.7	9.3	8.1	7.7
Specific Conductivity (µS/cm)	332	658	303	333	314	361
Dissolved Oxygen (mg/L)	10.4	8.6	12.3	10.4	10.3	11.2
Turbidity (NTU)	11.6	15.7	11.4	3.8	3.9	9.4
Nutrients						
Nitrate, Total (as N) (mg/L)	1.7	0.6	0.2	1.5	1.2	1.2
Bacteria						
Fecal Coliforms (CFU/100 mL)	1428	2639	535	2151	781	917
E. coli (CFU/100 mL)	1038	2323	385	715	592	281
Total Metals						
Cadmium (mg/L)	0.000038	0.000068	0.000046	All <DL	All <DL	All <DL
Copper (mg/L)	0.0054	0.0103	0.0058	0.0029	0.0025	0.0040
Iron (mg/L)	1.07	2.73	1.45	0.223	0.415	1.82
Lead (mg/L)	0.00013	0.0095	0.0013	0.0004	0.0004	0.00038
Zinc (mg/L)	0.013	0.098	0.043	0.011	0.012	0.013

Cell colour indicates the classification of water quality results according to the Metro Vancouver Monitoring and Adaptive Management Framework for Stormwater; green = 'good' level, yellow = 'satisfactory' level, red = 'need attention' level.

<DL – below detection limit

Mean values are averaged over 5 samples; the geomean was calculated for microbial parameters. To calculate means, concentrations below detection limit were replaced by DL/2. Concentrations above detection limit (applicable for microbiological data) were set as the maximum detectable value.

Brown Watershed

There were exceedances for indicators including a “needs attention” (NA) rating for conductivity, fecal coliforms, and *E. coli*. as well as a “satisfactory” (S) rating for DO, copper, and iron. In the wet season, the NA threshold was again exceeded for conductivity, fecal coliforms and *E. coli*. and the S threshold exceeded for turbidity, DO, copper, iron, and zinc. In general, at this site, bacteria concentrations were elevated in most samples in both the dry and wet season.

Site Broadway 1 had similar water quality issues in the dry season including NA exceedances for DO, conductivity, and fecal coliforms, and S exceedances for turbidity, *E. coli*, zinc, and iron. Of note is the exceptionally low averaged DO at 3.71 mg/L. In the wet season, there were NA exceedances for fecal coliforms, *E. coli*, conductivity, and zinc. There were S exceedances for DO, pH, turbidity, and all metals. There was exceptionally high conductivity at the site (658 µS/cm) in the wet season, which may be due to the exceptionally cold and snowy conditions and the placement of road salt on Broadway Street. In general, at this site, bacteria concentrations were elevated in most samples in both dry and wet seasons.

Site Broadway 5 had slightly better water quality in the dry season than Broadway 1 but still had exceedances including NA exceedances for fecal coliforms and iron and S exceedances for turbidity, DO, *E. coli*, cadmium, copper, and zinc. At certain sampling events, DO levels fell below the NA threshold. In the wet season, there were NA exceedances for water temperature (colder than threshold), fecal coliforms, and zinc. There were S exceedances for turbidity, *E. coli*, cadmium, iron, and copper. The sampling events on October 3 and November 22, both in 2022, had poor water quality which influenced the averaged results. In general, at this site, bacteria concentrations were elevated in most samples in both dry and wet seasons.

Baker Watershed

In the dry season, there were S exceedances for DO, fecal coliforms, *E. coli*, and zinc. Only four bacteria samples were analyzed for this site due to a lab error, and four of the five zinc samples were below the detection limit. In the wet season, the NA threshold was exceeded for fecal coliforms and the S threshold exceeded for DO, *E. coli*, and zinc. In general, at this site, bacteria concentrations were elevated in the wet season. The dry and wet seasons both had NA exceedances for fecal coliforms and S exceedances for DO and *E. coli*. In general, at this site, bacteria concentrations were elevated in the wet season. Though there were elevated bacteria concentrations at both sites, they were not as high as in the Brown watershed.

Fraser Watershed

In the dry season, there were S exceedances for DO, turbidity, fecal coliforms, copper, iron, and zinc. In the wet season, the NA threshold was exceeded for fecal coliforms and the S threshold was exceeded for *E. coli*, copper, iron, and zinc. This watershed had the lowest bacteria concentrations of the three watersheds.

Discussion

Water quality is generally better at Baker 3 and Baker 7 (Baker watershed) while most AMF threshold exceedances were found at Broadway 1 and 5 (Brown watershed) in both the dry and wet seasons. The highest bacteria concentrations were observed at Broadway 1, which also showed unusually high averaged conductivity (660 mS/cm) in the wet season, possibly due to road salt impacts, and very low averaged DO levels in the dry season at 3.7 mg/L. Despite generally high concentrations of several monitored parameters at Broadway 5, the averaged DO level was highest at this location at 12.3 mg/L in the wet season.

All site visits measured “good levels” for water temperature, except for Broadway 5 in the wet season, pH, except for Broadway 1 in the wet season, nitrate, and generally few exceedances of the thresholds for cadmium and lead in both seasons.

There are generally larger water quality differences between the monitored sites in the wet season than in the dry season. Most sites show lower bacteria concentrations in the dry season compared to the wet season, but the concentrations are in the same order of magnitude in both seasons. The most commonly exceeded primary indicators in 2022 were DO and bacteria. The very low DO levels in Brown watershed in the dry season, mainly at Broadway 1 but also occasionally at Broadway 5, is likely a result of low water movement and deep pools, leading to limited aeration, and the presence of organic matter such as algae which consumes oxygen. Low DO levels may potentially impact resident fish, such as salmonids which are intolerant to reduced DO, and lead to loss of the most sensitive benthic taxa. Elevated bacteria concentrations could be a sign of contamination with human and animal (e.g., dog and wildlife) waste reaching the streams through surface runoff or cross-connections. All monitored sites show consistently elevated bacteria concentrations, which indicate potential issues with continuous discharges from bacteria sources, as opposed to temporary releases.

All sites also show elevated conductivity levels, which is very common in urban areas due to the multitude of potential sources. Conductivity is a “secondary” indicator and provides “supporting information” to the priority indicators. Typical “urban metals” such as copper, iron, and especially zinc (all “primary indicators”) are also elevated in many collected samples. Elevated concentrations of copper and zinc are common in waters affected by urban sources, such as traffic and exceedances of AMF thresholds are commonly observed. Based on the water quality exceedances, the focus should be on reducing *E. coli* and fecal coliforms levels in the streams, as well as increasing the DO levels.

It should be noted that the maximum detection limit for bacteria was raised as sampling progressed by diluting the samples. However, even with this method, concentrations were often greater than the maximum detection limit. The averages are therefore all potential underestimates of the true bacteria concentrations. The actual bacteria concentration may be greater especially where a lower maximum detection limit was used.

5.9 Watershed Health Tracking System

The goal of the IWMP is to achieve no net loss in ecological health for the watersheds as a whole and strive to maintain the indicators at 2022 levels. One way to define no net loss of ecological health is within the context of the watershed health tracking system (WHTS) – which is a way to determine the source controls, detention, and riparian areas protection and restoration that would be needed to mitigate the impacts of development in order to protect and potential enhance watershed health (Kerr Wood Leidal, 2005).

The WHTS uses two primary indicators to predict how watershed health will change due to the impacts of unmitigated development: (1) watershed imperviousness; and (2) riparian forest integrity. These land use-associated indicators have the strongest correlation with watershed health. Furthermore, maintaining riparian forests and minimizing imperviousness are the two best and most effective methods of preserving watershed health.

Importance of Imperviousness (Indicator #1)

Research shows a strong relationship between the impervious area in the watershed and a stream's health (based on its fish and benthic invertebrate community) as outlined in Table 5-14.

Table 5-14: Stream Health Relative to Impervious Area

Health	Total Impervious Area (%TIA)
Stressed (minor changes to watershed health)	1–10 %
Impacted (moderate changes to watershed health)	11–25 %
Degraded (severe changes to watershed health)	26–100%
The Importance of Imperviousness, 1994, by T.R. Schueler.	

Importance of Riparian Forest Integrity (Indicator #2)

Riparian areas are the transition zones between aquatic and upland habitats. They may be subject to temporary, frequent, or seasonal inundation, and typically support plant communities indicative of wetter soil conditions. Riparian areas provide important natural features, functions, and conditions that support fish communities and aquatic life. These features, functions, and conditions include:

- Multi-canopied forest and ground cover that:
  - moderates water temperature;
  - provides a source of food, nutrients, and organic matter;
  - stabilizes the soil with root systems, thereby minimizing erosion; and
  - filters sedimentation and pollution.
- Sources of large woody debris.
- Active floodplain areas.
- Side channels, intermittent streams.
- Infiltration that can aid in sustaining baseflows.

Figure 5-7 shows the Riparian Forest Integrity assessment areas on the permanent watercourses.

South Port Coquitlam Existing and Future Watershed Health Indicators

Watershed health indicators were used to quantify predicted changes between existing and future conditions and to define targets to be achieved. They are:

- Total Effective Impervious Area (TIA) and Effective Impervious Area (EIA) – TIA is the % of impervious area across a catchment. EIA is the % of impervious area that is directly connected to stream channels.
- Riparian Forest Integrity (RFI) – the % of intact forest within a 30 m buffer on either side of all permanent watercourses within a catchment or watershed.
- Benthic Index of Biotic Integrity (B-IBI) – a 10-metric scoring system used to assess stream health based on sampling of the benthic invertebrate community that lives in gravel riffles of a watercourse. Scores generally characterize the transition from pollution-sensitive (higher scores) to pollution-tolerant (lower scores) species as watersheds experience more impacts from development or, conversely, recover due to the implementation of mitigation measures. Scores can range from 10 (lowest) to 50 (highest).

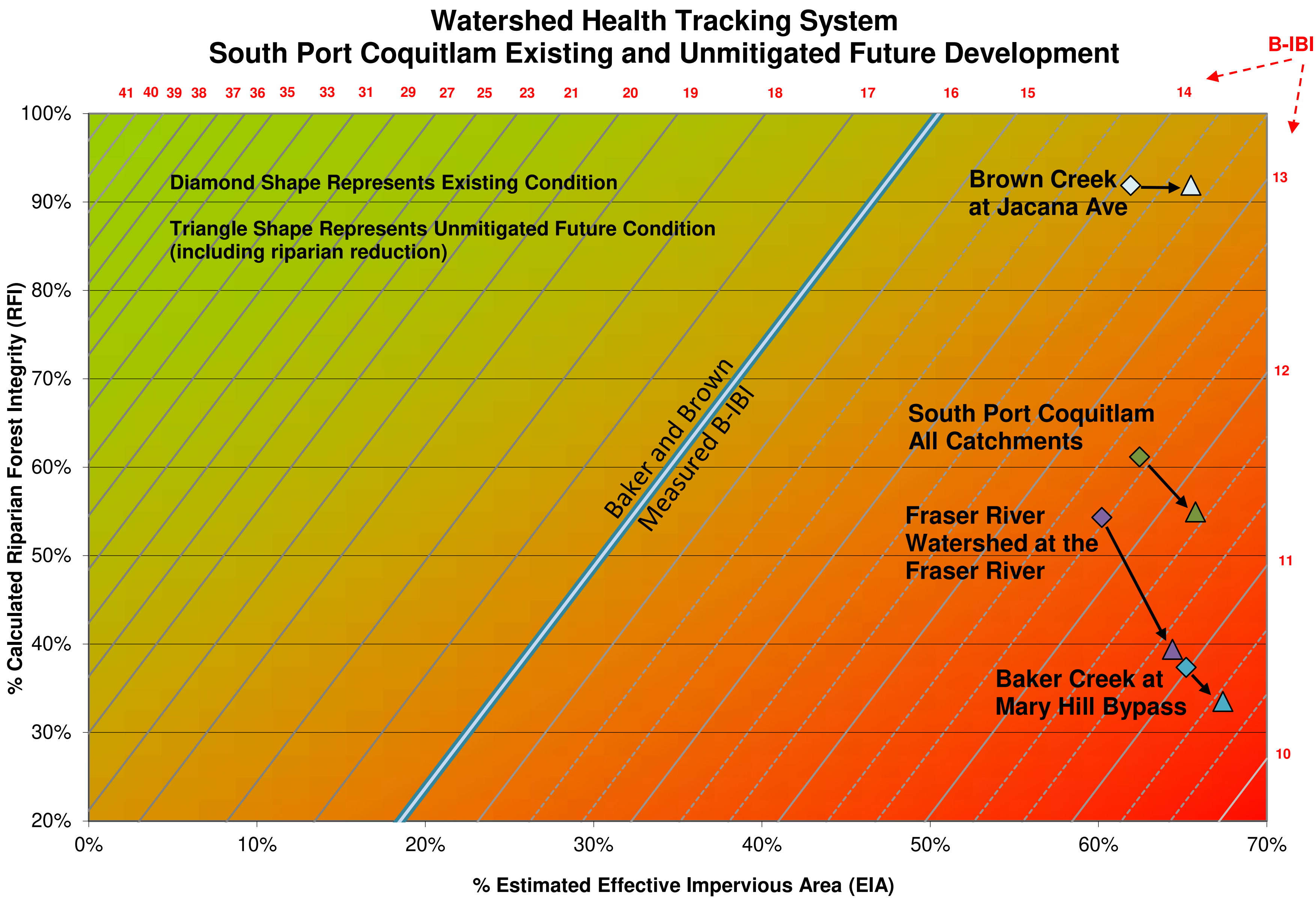
Methods

The existing and post-development values associated with the indicators are summarized in Table 5-15 and are shown in Figure 5-10 for multiple locations throughout the watershed. The EIA values were estimated from the hydrologic models (PCSWMM) where a year-long continuous simulation was run. The runoff from the catchments' impervious areas throughout that year were compared to the total precipitation on that catchment.

Table 5-15: Measured and Predicted Watershed Health Indicators

Site	2022 Measured B-IBI	Existing			Unmitigated Future		
		EIA	RFI	Predicted B-IBI	EIA	RFI	Predicted B-IBI
Brown Creek at Jacana Ave	**16**	61.1	91.9	14.0	64.8	91.9	13.3
Baker Creek upstream of Mary Hill Bypass	**16**	51.7	37.4	11.0	53.1	33.5	10.6
Fraser River Watershed at the Fraser River	**NA**	58.9	54.3	12.3	63.3	39.4	11.3

1. B-IBI rounded to the nearest 1/3.
2. Refer to Figure 6-1.


Watershed Health Tracking System
South Port Coquitlam Existing and Unmitigated Future Development
B-IBI
41 40 39 38 37 36 35 33 31 29 27 25 23 21 20 19 18 17 16 15 14
13
12
11
10
100%
90%
80%
70%
60%
50%
40%
30%
20%
% Calculated Riparian Forest Integrity (RFI)
0%
10%
20%
30%
40%
50%
60%
70%
% Estimated Effective Impervious Area (EIA)
Diamond Shape Represents Existing Condition
Triangle Shape Represents Unmitigated Future Condition (including riparian reduction)
Baker and Brown Measured B-IBI
Brown Creek at Jacana Ave
South Port Coquitlam All Catchments
Fraser River Watershed at the Fraser River
Baker Creek at Mary Hill Bypass

For each catchment, the RFI was calculated based on the position of the B-IBI sampling point. While generally indicative of the overall catchment, the overall predicted watershed may vary from the scores within Figure 5-10 and Table 5-15 because of other inputs and impacts downstream of these points that are not captured by the B-IBI sampling point, which is determined based on the lowest accessible sampling point in the watershed.

The WHTS accounts for potential riparian losses associated with applying the City's Watercourse Development Permit Area requirements. Calculations for the unmitigated future scenario assumed the loss of riparian habitat outside the areas protected by the riparian bylaws (0–30 m depending on watercourse classification)[1]. A large portion of the potential loss is due to the potential of riparian setbacks less than 30 m wide in forested "residential" zoned areas. A riparian setback width was assumed for the WHTS in residential areas based on OCP requirements of 15 m riparian setbacks.

Both existing and unmitigated future land use scores are predicted based on the relationship between EIA, RFI, and B-IBI. These predicted scores for existing land use are compared to the actual measured B-IBI values obtained from creek samples in 2022. As shown, the three catchments have higher measured B-IBI values than what would be predicted by the EIA and RFI values. This can be due to factors such as groundwater inflows to the creeks.

The future predicted B-IBI score changes assume the impacts of the proposed development:

- Without mitigation measures to reduce EIA.
- With minimum protection of RFI based on the City's Watercourse Development Permit Area requirements.

Results

The current and future predicted B-IBI scores for the catchments are both lower than the actual B-IBI scores based on EIA and RFI (Table 5-15, Figure 5-10). All catchments have current estimated B-IBI scores below 14 and future estimated B-IBI scores below 14. In all watersheds this is a result of high existing (>60%) and higher future EIA (>64%) indicating a severely degraded watershed. In Baker and Fraser catchments, it is also due to low existing riparian forest cover (<50%). In the Baker catchment only, the future degradation is due in large part to decreased RFI as well as increased EIA.

Discussion

Baker

The Baker Creek catchment has the lowest predicted existing and future B-IBI, the only watershed with a predicted value below 11. Although the predicted existing value is very low, the catchment only shows a small amount of watershed health degradation in an unmitigated future scenario. The decrease of a 30 m buffer in residential areas to 15 m is the main contributor to the predicted RFI decrease. There is also a small, predicated increase in EIA resulting from minor shifts in zoning designations which may allow higher-density buildings to be constructed closer to the watercourse with reduced green space.

[1] Riparian setbacks based on recommendations found in the City of Port Coquitlam's Official Community Plan Bylaw 2013 No. 3838.

Fraser

The Fraser catchment has the second lowest predicted existing and future B-IBI score, with both values at, or below 12.3. The existing forested riparian area in this catchment is primarily unzoned and is part of the Mary Hill Bypass lands, the remainder is currently zoned Residential Townhouse 3 (RT3) and is zoned Residential Townhouse (RT) in the OCP. It was assumed that the Mary Hill Bypass lands would not be developed or modified in a future scenario. Although much of the RT3 zoned land is fully developed, there are small areas of green space which could be retained through the implementation of a riparian buffer. The estimated B-IBI value is the second lowest of the three catchments and is projected to decrease further to 11.3.

Broadway

The Broadway Creek catchment has excellent RFI upstream of the B-IBI sample point (91.9%) which is entirely maintained in the future unmitigated scenario. However, there is still watershed health degradation due to the increase in EIA caused by potential residential densification. As with the Baker and Fraser catchments, this shift in EIA is due to the anticipated densification of residential areas and associated reduction in pervious areas.

Due to limitations in areas that could be sampled for benthic invertebrates, both the predicted and actual B-IBI values are only representative of conditions in Brown Creek, a watercourse that is surrounded primarily by residential areas. Broadway Creek, another major tributary of the catchment, runs through industrial and commercial areas, and is not included in the calculations as its confluence is downstream of the sample point. This can be seen in the discrepancy between the existing RFI for the entire Broadway Catchment (49.4%) and upstream of the B-IBI sample point (91.9%). In addition, because industrial and commercial areas have a greater impervious area, the EIA for the entire catchment is likely higher than 64.8%. Thus, the actual catchment conditions are likely closer to that of the Fraser and Baker catchments than what is predicted.

Key Issues

Overall, the key issues for the study area in an unmitigated future scenario are a decrease in RFI caused by residential densification and associated riparian forest loss and a decrease in EIA caused by combining the Residential 1, 2, 3, and 4 zones into residential and small lot residential. These two factors can work together to increase the density of residential buildings within 30 m of a watercourse with no requirements for vegetation protection. Even without such changes in these catchments, the existing conditions represent extremely degraded catchments that are already in very poor condition.

The goal of the IWMP is to propose works that will protect or enhance watershed health by mitigating the impacts of future development, i.e., future impervious area increases and/or riparian forest losses. The minimum objective of an IWMP is to maintain watershed health. Given the degraded state of each catchment being addressed in this study, the objective of improving watershed health compared to current conditions should be considered.

5.10 Monitoring and Adaptive Management

Condition 7 of the BC Minister of Environment's approval of the Integrated Liquid Waste Resource Management Plan (ILWRMP) requires that municipalities, with the coordination of Metro Vancouver, develop a monitoring and adaptive management framework for assessing watershed health and the effectiveness of Integrated Stormwater Management Plans (ISMPs).

In addition to fulfilling provincial requirements, monitoring watershed health may be useful in achieving other objectives such as meeting recreational water quality objectives in receiving waters for public health and providing baseline data for climate change adaptation.

This Monitoring and Adaptive Management Framework (AMF) is intended for Metro Vancouver and member municipalities. It is anticipated that the AMF would be adopted by municipalities as a guide to monitoring watershed health and assessing ISMP effectiveness in order to satisfy Condition 7.

The focus of the framework is on adaptive management in order to stimulate continuous improvement in watershed health. As such, monitoring results which indicate a watershed health issue should trigger adaptive management practices aimed at mitigating the problem. As opposed to prescribing specific adaptive management practices, the AMF will refer to a menu of options which municipalities may use as a reference tool for selecting appropriate actions. If available, recommendations from an ISMP should also be implemented since they are customized to the specific needs of a drainage system. The framework can then be used following implementation of adaptive management practices to monitor effectiveness.

The primary goal of the AMF is to:

1. Monitor and protect watershed health.
2. Assess the implementation and effectiveness of ISMPs.

Additional goals are to:

- Avoid imposing an unreasonable financial burden on municipalities.
- Use a weight-of-evidence approach to monitoring watershed health.
- Prescribe a monitoring framework for data directly related to watershed health.
- Include monitoring indicators which provide useful information in the absence of long-term data records and/or calibrated watershed models.
- Provide guidance for technically sound and consistent monitoring practices.
- Link monitoring outcomes to relevant adaptive management practices (AMPs).
- Stimulate continuous improvements in watershed health.

Overall Approach

The Adaptive Management Framework provides an approach for:

- Monitoring watershed health.
- Tracking ISMP implementation and effectiveness.
- Identifying impacts/threats to watershed health.
- Selecting adaptive management practices.
- Tracking the effectiveness of adaptive management practices.
- Reporting out on all components listed above.

The intent of the AMF is to help inform municipal land use and stormwater management planning to effectively reduce stressors to aquatic health. Aquatic life, including salmon, is susceptible to the impacts of urban stormwater. Salmon rearing and spawning occur in many urban streams within this region. Even streams that are not directly inhabited by salmon often contribute flow to fish-bearing waters. Streams can be impacted by contaminants carried from developed areas in urban runoff and/or by changes in flow regimes brought on by urban development. Where urban streams and piped systems flow to sensitive foreshore environments, there can be localized impacts from urban runoff, particularly related to non-point source (diffuse) pollution.

As a management tool, the AMF provides a screening assessment of aquatic health to help municipalities make informed decisions. The AMF provides key information to help identify whether adaptive management is needed and to help prioritize where to focus limited resources to gain the most benefit for aquatic health if impacts are detected.

The focus of the AMF is on working toward continuous improvement in stormwater management processes and outcomes. The AMF is not meant to focus negative attention on the efforts of municipalities, and the MOE does not expect municipalities to address all detected aquatic health impacts immediately. Rather, the MOE expects that municipalities will give appropriate focus and attention to watercourses where aquatic health impacts are detected. The MOE expects that aquatic health impacts, detected through the monitoring, will be considered by municipalities in a prioritization process that allows for both short-term and long-term actions to be completed to help address priority issues.

Protecting this region’s waterways and aquatic life from the pressures of urban development is a challenge. The AMF provides an opportunity for municipal actions to fit together into a regional approach for protection. It allows for more consistency, efficiency, and cooperation in efforts to protect the region’s valuable aquatic resources.

An important feature of the AMF is that it enables municipalities to show they are taking measurable and defensible steps to protect watershed health. To this end, the Minister has required that a ‘weight of evidence’ approach be taken. Multiple interpretations of the term ‘weight of evidence’ exist, ranging from qualitative to quantitative. At the qualitative end of the spectrum, the term indicates an informal weighting of various lines of evidence to develop an overall assessment of conditions. The more quantitative approaches use a formal matrix which quantitatively weights the scores of various indicators to generate an amalgamated score.

Weight of Evidence means:

- Indicators must be quantifiable and scientifically defensible.
- Categories or thresholds should be used to simplify assessment of monitoring results where possible.
- Overall synthesis of the various indicators should be qualitative.

Additionally, each indicator is to be evaluated independently, and not rolled up. Different watersheds are not to be compared to each other, but rather each watershed will be compared to itself over time in terms of monitoring results for each of the indicators.

6. Key Findings, Issues, and Opportunities

6.1 Summary of Watershed Characteristics

Key characteristics of the watershed are summarized in Table 6-1.

Table 6-1: Key Watershed Characteristics – South Port Coquitlam Watersheds

Characteristic	Description
Drainage Areas	650-ha study area made up of: • 440 ha Brown Creek watershed. • 115 ha Baker Creek watershed. • 95 ha Fraser River watershed.
Drainage System	• Network of storm sewers, culverts, creeks, and ditches. • Discharges to Fraser River and Pitt River via gravity outfalls, a floodbox, and pump stations.
Topography	• Flat lowlands are a large portion of Brown Creek watershed and a small portion of the other watersheds. • Mary Hill occupies the west side of the study area. Ground elevation generally rises to the west.
Hydrogeology	• Subsurface soils with moderate to high infiltration potential are present in most of the study area (subject to further investigation). • Near surface water table is a risk factor for infiltration in lowland areas adjacent to the rivers. • Enhanced infiltration can recharge local aquifers which provide baseflow to Brown creek.
Land Use	• Existing land use is 30% residential and 31% commercial and industrial. • Low density single family residential is 25% of the study area. • Light to heavy industrial use is concentrated in the Brown Creek watershed. • Future OCP shows an increase in commercial, industrial, and park land. • Brown Creek watershed total impervious area increases from 63% to 68%.
Forest Cover	• 13% of the study area is forested. Recommended target is 50%. • Existing Riparian Forest Integrity (RFI) is 46%. Projected future RFI is 44%. Recommended target is 70-75%. • Remaining patches of riparian forest are fragmented and discontinuous. No continuous wildlife corridor connects the study area watersheds.
Stream Classification	• 3.6 km of Class A watercourses. • 0.1 km of Class B watercourses. • 3.7 km of Class C watercourses.

Characteristic	Description
Fish Species	At least seven fish species are known to occur within the creeks in the study area, including: • Four salmon and trout (salmonid) species. • Two native non-salmonid fish species. • One introduced fish species.
Terrestrial Species & Habitat	• Upland terrestrial habitat supports wildlife and plant species outside of riparian forested areas. • Small forest patches, hedgerows, vegetated road embankments and medians form a habitat mosaic linking the watersheds within the study area. • The watersheds support native wildlife including amphibians, birds, and mammals. Representative wildlife species are named in Section 5.
Species of Conservation Concern	• Two confirmed species at risk are present: Great Blue Heron (*Ardea herodias*, fannini subspecies) and Streambank Lupine (*Lupinus rivularis*). • Other potential species at risk are identified in the report.
Invasive Species	• Invasive plant species are common. • Himalayan blackberry and English ivy are most abundant and reduce biodiversity by forming monocultures. • Japanese knotweed and yellow flag iris are two species of concern.
In-Stream Habitat & Fish Passage Barriers	• Moderate to extensive spawning gravel in Brown Creek and Baker Creek downstream of Nova Scotia Ave. • Good rearing habitat in Brown Creek and Baker Creek downstream of Nova Scotia Ave. • The Harbour St Storm Pump Station site is the main fish passage barrier in Brown Creek. • Two culverts and a waterfall are notable fish passage barriers in Baker Creek.
Water Quality Sampling	Water quality sampling results show: • High bacteria concentrations at all sites (which indicates potential issues with continuous discharges from bacteria sources). • Low dissolved oxygen levels in all streams with very low DO at Broadway 1. • Elevated conductivity levels at all sites (which is very common in urban areas). • Elevated typical “urban metals” such as copper, iron, and especially zinc in several samples. Elevated concentrations of copper and zinc are common in urban runoff.
Benthic Invertebrate Sampling	• Baker and Brown Creek have a measured B-IBI of 16 or “very poor”. This suggests watershed are heavily urbanized and impacted.

6.2 Summary of Key Issues

The following key issues have been identified based on the findings and assessment:

Climate Change Impacts: The City's updated climate change IDF curves result in a 15% increase in rainfall from the historic conditions IDF for the 10-year event and 17% increase for the 100-year event.

Storm Sewer Pipes and Culvert Capacity: Conveyance capacity of 56 km of storm sewer and culverts were assessed. Under existing land use and climate, 30% of the entire assessed pipe network (including minor pipes, major pipes, and culverts) does not meet the City's level of service requirements. The deficiency increases to 49% with OCP land use and climate change.

Ditch Capacity: The ditches along the Mary Hill Bypass fill to capacity under 10-year design events and flood during the 100-year events.

Lowland Ditches: Lowland ditches, along with many outfall locations, were highly vegetated reducing system capacity.

Lowland Flooding and Pump Station: Under major rainfall events, significant flooding is simulated in the lowland area due to undersized pipes, the flat nature of the area, and insufficient pumping capacity. During high tide water levels in the Pitt River, the pump station does not have sufficient capacity to keep forebay water levels low enough to allow positive drainage toward the pump stations, resulting in flooding of the lowland area.

Sedimentation and Blockages: Sedimentation and blockages can negatively impact conveyance capacity and pose flooding risks. Sediment deposition in culverts and outlets were noted at several locations.

Beaver Management: Cirt of Port Coquitlam staff noted beaver dams and regular clearing of obstructions in Broadway Creek. Beaver dams were not observed during the field assessment. However, signs of past beaver activity (chew marks on downed trees) were observed along the river right of Broadway Creek approximately 40 m downstream of Broadway Street.

Fish Passage Barriers: Four fish barriers, three of which are manmade, were identified as probable or potential barriers to fish passage. Three of the barriers are located on Baker Creek and one is located on Brown Creek. Two of the barriers are culverts, one is a waterfall (potentially a barrier under high or low flows), and one is a water control structure (i.e., Harbour St Storm Pump Station and associated floodgates). Fish passage barriers can prevent the migration of fish to spawning grounds and valuable rearing habitats.

Lack of Riparian Forest Cover and Stream Encroachment: Riparian forest loss and stream encroachment is prevalent in the upper reaches of Baker Creek along residential properties. This encroachment has resulted in the removal of native riparian vegetation and sometimes constructed features (i.e., retaining walls, small footbridges over the creek) within the riparian area. Riparian forest cover is also limited in the upper reaches of Brown Creek between the creek and Brown Creek Trail (pedestrian pathway). The removal of riparian forests contributes to increased erosion and sedimentation, reduced filtration of pollutants from runoff, elevated water temperatures, and lower food and nutrient inputs, all of which lead to reduced habitat suitability for fish species.

Benthic Invertebrates: A reduction in the B-IBI score for the study area watersheds is anticipated by the Watershed Health Tracking System. In the Brown and Baker Creek watersheds, where most development is expected to occur, the reduction is driven by an increase in impervious area. In the Fraser River catchment, where little development is expected, the reduction is driven by anticipated riparian forest cover loss.

Number and Extent of Invasive Species: Invasive plant species are common in the South Port Coquitlam IWMP study area. An extensive number of invasives are present along Baker Creek upstream of Mary Hill Bypass. This section of creek runs through residential properties where the riparian area is limited and heavily impacted due to encroachment. An extensive monoculture of Himalayan blackberry is also present in previously disturbed areas along Broadway Creek. Invasive plant species can lead to the exclusion of native plant species, alteration of habitat for native wildlife, increase streambank erosion, and reduce overall forest health. Japanese knotweed is present along the banks of Baker, Brown, and Broadway creeks. Japanese knotweed is an aggressive species, capable of forming dense monotypic stands in riparian and moist sites and can damage infrastructure. It can reduce native plant diversity and can contribute to erosion along streambanks due to its fragile root system. This species is extremely difficult to control and eradicate once established.

Fragmentation of Terrestrial Habitat: Although forest patches in the study area are fairly connected between the southern sections of the Fraser River and Baker Creek watersheds, little to no connection exists between the Brown Creek and Baker Creek watersheds. Major roads (i.e., Mary Hill Bypass and Broadway Street) and urban development (i.e., residential neighbourhoods and commercial properties) act as significant barriers to wildlife. Forested corridors and hedgerows are essential to provide pathways for wildlife movement and provide important bird habitat.

Maintenance of Previous Enhancement Projects: An enhancement project on Brown Creek was completed in 2002 and had five years of post-monitoring and maintenance. However, much of the constructed spawning channel has since been infilled with sediments and organics and some patches of Himalayan blackberry within the riparian area has established. As the goal of the project was to enhance an existing channel and create a spawning channel, it no longer appears to be fully functioning as intended. When future restoration and enhancement projects occur, long-term monitoring and maintenance are essential to ensure appropriate ecosystem function, especially in highly disturbed areas with invasive species presence.

Poor Water Quality: Water quality results from the wet and dry seasons as well as the benthic invertebrate results agree with reports of poor water quality from the Brown Creek Streamkeepers. Although there were elevated levels of some metals, the focus for management should be on the high bacteria levels in all watersheds and the low DO observed at Broadway 1.

Impacts of Future Development: Unmitigated development will result in increased effective impervious area in the study area watersheds which in turn results in increased runoff volumes, peak flows, and frequency of peak flows. These hydrological changes can cause flooding, erosion, and deterioration of fish habitat. Decreased infiltration (due to increase in effective impervious area) can reduce baseflows during dry weather periods, which reduces the fish supporting capacity of a watercourse. Untreated runoff from new impervious surfaces will increase pollutant loads to the creeks and can lead to higher water temperatures and lower dissolved oxygen levels. Increased risk of flooding and water quality issues are priority concerns for all three study watersheds while increased erosion and reduced baseflows are concerns for watersheds with open watercourses: Baker Creek and Brown Creek.

Monitoring Watershed Health: Monitoring and adaptive management is needed to measure watershed health is maintained and continuous improvement is achieved.

6.3 Opportunities for Addressing Key Issues

The following recommendations are made to address key issues identified in the South Port Coquitlam watersheds:

First Nation Consultation and Community Engagement

Consulting kʷikʷəƛəm First Nation: kʷikʷəƛ̓əm must be consulted and included in any decision-making processes which may affect the study area. Knowledge held within the community plays a vital role in determining historical conditions and determining beneficial management decisions.

Collaborating with Local Streamkeeper Groups: Local streamkeepers can spread knowledge throughout the community and potentially assist with tasks (education, riparian planting, invasive species removal, habitat enhancement monitoring, etc.). Current projects of the Baker Creek Streamkeepers include:

- Ivy removal from trees – Ongoing (90% complete).
- Debris removal from creek throughout Marian Kroeker Park – February 2024.
- Ivy removal conducted with Hazelwood Early Learning Centre in Marian Kroeker Park (100 m^2) – April 2024.
- Adopt-A-Spot established covering all adjacent streets to Baker Creek – Ongoing.
- Creek-side cleanup conducted in Marian Kroeker Park and adjacent City property – March 2024.
- Ivy removal scheduled with Hazelwood Early Learning Centre – June 2024.
- Storm drain marking (as per DFO guidelines) – July 2024.

Flood Management and Drainage System Improvements

Storm Main Capacity Upgrades: Include upgrades to pipes without capacity (HLoS of E or F) in the capital planning process and with development.

Culvert Capacity Upgrades: Include upgrades to culverts without capacity (HLoS of E or F) in the capital planning process.

Pump Station Capacity Upgrade: Include upgrades to the Harbour 1 Pump Station in the capital planning process.

Lowland Ditches: Clear lowland ditches of vegetation/sedimentation to ensure maximum flow.

Sedimentation and Blockages: Remove sediment in culverts and outlets to improve conveyance capacity and reduce flooding risks. Address erosion in upstream areas though bioengineering bank stabilization options.

Environmental Protection and Enhancement

Fish Sampling: Complete further fish sampling within Baker Creek, Brown Creek, Broadway Creek, and the watercourse within the Fraser watershed to gather additional information on existing fish populations within the watershed. Ensure that sampling occurs at various points throughout the year including when spawners are present using non-invasive techniques.

Fish Passage: More detailed barrier assessments to confirm barriers and the conditions under which they are barriers. The Harbour St Storm Pump Station should also be assessed to determine optimal operation for fish passage.

Fish Habitat: The watersheds are generally lacking in habitat complexity, reducing available hiding places and flow refugia for fish. Installing boulders and large wood, to the extent that it will not increase flood or erosion risk, would help return complexity to the lower creeks. Explore opportunities for side channel construction in Marian Kroeker Park.

Fish Habitat: Imported spawning gravels could be added at strategic locations within Brown Creek, Broadway Creek, and/or Baker Creek, especially in areas identified by Streamkeepers within Marian Kroeker Park including the outfall at 2012 Leggatt Place. Gravels would increase the availability and quality of spawning habitat.

Riparian Vegetation: Due to the proximity of major and urban development to the creeks, the current riparian vegetation buffer is quite narrow in some places. The creek corridor should be widened as much as possible through new riparian planting on both public (park) and private properties.

Riparian Vegetation – Public Property: Riparian plantings and restoration should be undertaken to increase riparian cover. Potential restoration sites and planting projects should be identified and prioritized on City-owned private properties.

Riparian Planting – Public Property: There is a small turf area in Marian Kroeker Park on the east bank of Baker Creek around 400 m^2 in size. This area is a suitable candidate for riparian planting in a high-profile area. The area is currently mowed turf which has poor capacity to retain moisture and very low habitat value.

Riparian Planting – Private Property: Use Watercourse Development Permits to protect and expand riparian buffer zones during land development and re-development.

Riparian Vegetation – Private Property: Re-establish riparian vegetation and forest cover on private properties, particularly along residential properties in the Baker Creek watershed by working with landowners. This can be done through letters to owners, information on the front page of the City of Port Coquitlam website, and in-person information sessions on the importance of riparian areas to streams. Collaborating with local Streamkeeper groups can help spread knowledge throughout the community and potentially assist with tasks.

Riparian Forest: In riparian areas where tree removal is required for development, native trees should be used as replacements whenever possible.

Riparian Forest – Brown Creek: Improve riparian forest along the left bank of Brown Creek. The riparian buffer between the Brown Creek Trail (pedestrian pathway) and Brown Creek is limited to non-existent. Interest from local stewardship groups could be utilized to complete this work. Fencing is also recommended along the riparian area to prevent human and dog access into the stream channel.

Riparian Forest – Broadway Creek: Increase native tree cover in Broadway Creek riparian corridor. Much of the riparian area vegetation consists of low shrubs and grasses. There is opportunity for Blackberry removal and native vegetation planting to improve RFI and riparian habitat condition.

Restoration Maintenance: Restore the habitat enhancement project on Brown Creek completed in 2002 to its former condition. This site should be regularly monitored and maintained to ensure adequate functioning.

Invasive Species Education: Build on the existing Help Stop the Spread of Invasive Plants program between Metro Vancouver and the City of Port Coquitlam by further increasing public awareness. This could include letters to the public, information on the front page of the City of Port Coquitlam website, in-person information sessions on the importance of invasive species removal, and group invasive species removal events.

Invasive Species Removal: Targeting removal of invasive species in riparian areas. Where knotweed is present, a management strategy should be developed to treat and eliminate the plants.

Habitat Corridors: Creation and maintenance of habitat corridors should be incorporated into future planning decisions. Connections are limited in the northern portion of the Baker Creek watershed and the southern portion of the Brown Creek watershed. An existing corridor could be enhanced through the planting of trees to improve this connection through City-owned properties at 1300 and 1305 Eastern Drive, 1300 Western Drive, and 1397 Pitt River Road as well as a private townhouse complex at 1355 Citadel Drive.

Forested Habitat Patches: It is important to protect and preserve existing watershed forest and riparian forest cover throughout the watershed. Protection of large contiguous natural areas is essential to species and ecological functions within the watershed. Key areas include the Fraser River, Mary Hill Bypass (Highway 7B), and streams.

Species at Risk: To maintain the presence of species at risk in the South Port Coquitlam area, wetlands, riparian vegetation, and forest cover should be retained and, where possible, expanded. Woody debris should be retained in forested, riparian, and aquatic habitats.

Water Quality – Brown Creek: Assessment of priority indicator parameters suggests potential issues in the Brown watershed, with exceedances of the “Satisfactory” and/or “Need Attention” thresholds noted for a majority of the monitored water quality parameters, especially at the Broadway 1 site. Additional monitoring should be initiated to further identify the cause of poor water quality.

Water Quality – Baker Creek and Fraser River: Follow the routine AMF protocol and re-visit the sampling locations in five years (2026) to collect water quality samples in the wet and dry seasons.

Water Quality – Risk Reduction: The Broadway Sanitary Pump Station is located directly adjacent to Broadway Creek at the intersection of Broadway Street and Mary Hill Bypass. Additionally, twin gravity sanitary sewer mains beneath the Brown Creek Trail are in very close proximity to Brown Creek (Asset IDs: SM02174, SM02170). When due for replacement, the sewer mains should be moved away from the creek to minimize future construction or maintenance disturbance to the creek and the risk of effluent entering the watercourse from a leak or spill.

Water Quality – **Spill Control**: Construct oil/grit separators, spill control devices for existing gas stations, high risk spill industry, and parking lots especially in industrial areas surrounding Brown and Broadway Creek. Educate and work with property owners to retrofit existing sites.

Mitigating Impacts of Future Development

Low Impact Development – Protect Existing Watershed Health: Protect and enhance existing natural assets that regulate the watersheds' hydrological cycle and stream water quality including forested areas, riparian areas, and mature trees:

- Forest cover should be protected and maintained as much as possible in conjunction with redevelopment. Construction should be staged and managed to retain existing trees, singly and in groups, wherever possible as large and mature trees provide significant interception and detention for rainfall whereas new landscape trees and shrubs provide very little until they mature.
- Riparian areas should be rigorously protected, and riparian setbacks increased where possible to provide shade and improve fish habitat.
- Impervious surfaces should be reduced where possible, such as road widths, surface parking requirements, and building footprints.

Low Impact Development – Stormwater Source Controls: To protect the health of watercourses, all efforts should be made to reduce impervious surfaces in planning stages of a development. Where impervious surfaces are unavoidable, capture and treat runoff from impervious surfaces near the source. Stormwater source controls slow down, infiltrate, and clean runoff from adjacent impervious surfaces (with absorbent topsoil, rain gardens, swales, pervious paving, or other treatment features) rather than discharging directly to watercourses.

As previously recommended in the Maple Creek IWMP, the City should update its Subdivision Servicing Bylaw to include stormwater volume capture and water quality treatment criteria. Section 7 of this report provides more detailed criteria for each of Brown Creek, Baker Creek, and Fraser River watersheds. To ensure successful implementation of the criteria, the City could develop supplementary standards that guide developers through planning, selection, design, construction, and monitoring of source controls.

In addition to hydrological and water quality benefits, source controls can provide other community amenities such as green space and urban heat island reduction. The City should consider opportunities for source control on City-owned and public lands (through both retrofits and redevelopment). As roads are one of the highest pollutant generating surfaces in urban areas, developing green road standards to capture and treat road runoff is recommended.

Detention – Environmental Protection: Fisheries and Oceans Canada (DFO) recommends detaining the 6-month, 2-year, and 5-year 24-hour post-development flows to pre-development flows for aquatic habitat protection and erosion reduction. It is recommended that the DFO detention requirement be added to the City's design criteria for areas draining to upland watercourses (mainly Baker Creek).

Construction Best Practices – Erosion and Sediment Control – Construction activities can be a significant source of sediment to the City's drainage network and open watercourses, simultaneously reducing conveyance capacity, impacting aquatic species, and degrading fish habitat. As previously recommended by the Maple Creek IWMP, the City should develop and enforce erosion and sediment control criteria for the construction phase of developments. Creating supplementary standards to guide developers through planning, design, implementation, and monitoring and Erosion and Sediment Control Plans would aid with successful implementation.

Monitoring and Adaptive Management

Monitoring and Adaptive Management Framework: Follow the Monitoring and Adaptive Management Framework for monitoring the watershed every five years at minimum. More frequent monitoring may be carried out as recommended by kʷikʷəƛ̓əm. Monitoring results which indicate a watershed health issue should trigger adaptive management practices aimed at mitigating the problem.

Archeological Monitoring: All future environmental or archaeological monitoring should be conducted under the oversight of a kʷikʷəƛ̓əm First Nation member.

7. Implementation Plan

7.1 Introduction

The overall IWMP for the South Port Coquitlam watersheds (Brown Creek, Baker Creek, and Fraser River watersheds), developed in consultation with the Advisory Committee, provides recommendations for:

- Flood management
- Aquatic and riparian improvements.
- Mitigating land development impacts.

Table 7-1 lists the recommended actions with cost estimates, timelines, and responsibilities for implementation. Although much of the implementation work will be done by the City, the various municipal divisions and personnel will have different roles to play, and the interactions between the City, kʷikʷəƛ̓əm First Nation, regulatory agencies, Streamkeepers, and other community members will be a large part of the successful implementation of the IWMP.

Table 7-1: South Port Coquitlam IWMP - Implementation Strategy

	Plan Components	Priority	Cost Estimate	Responsibility
Flood Management				
1	**Storm Mains and Culverts**			
	Upgrade major system mains and culverts that are likely to flood in *existing* conditions: • Upgrade 108 Grade F major system mains.	1–10 Years	$41.5M	City
	Upgrade major system mains and culverts that are likely to surcharge in existing conditions: • Upgrade 19 Grade E major system mains. Upgrade 2 Grade E culverts.	10–20 Years	$4.2M$611 K	City
	Upgrade minor system pipes that are likely to surcharge or flood in *existing* conditions, as they are due for replacement: • Upgrade 156 Grade E & F minor system mains.	1–50 Years	$21.5M	City
	Upgrade minor and major system pipes and culverts that are likely to surcharge or flood in *future* conditions, with redevelopment or in coordination with other capital projects: • Upgrade 109 Grade E and F minor system mains. • Upgrade 44 Grade E & F major system mains.	With Re-development or Capital Projects	$12.1M $6.2M	Developer/ City
	Upgrade pipes and culverts owned by the Province: • Upgrade 3 culverts under the Mary Hill Bypass that restrict flow to the pump station (DM06776, DM06767, DM06768) • Upgrade 3 Grade F culverts (DM06771, DM06775, DM06776). • Upgrade 1 Grade F 900 mm pipe (DM06779)	1–10 Years 10–20 Years 1–10 Years	$1.8M $840K $460K	Province
2	**Ditch Maintenance**			
	• Remove vegetation/sedimentation in roadside ditches on the Mary Hill Bypass to convey maximum flow.	1–5 Years	$5–10K	Province
3	**Pump Station**			
	• Upgrade Harbour 1 Pump Station and flood box to provide adequate capacity for existing and future conditions, climate change, and to improve fish passage.	1–10 Years	$13M	City
	• Decommission the Harbour Old Pump Station.	1–5 Years	$100K	City

	Plan Components	Priority	Cost Estimate	Responsibility
Environmental Enhancement				
4	**Conveyance and Fish Passage**			
	• Conduct detailed barrier assessments to confirm barriers and the conditions under which they are barriers.	1–10 Years	\$5K–\$15K	City
	• Remove channel obstructions and fish passage impediments such as fences.	1–20 Years	\$1K–\$10K per location	City
	• Remove channel obstructions and clean out overgrown vegetation to improve conveyance and fish passage.	1–20 Years	\$1K–\$5K per location	City
	• Work with private property owners to remove fish passage impediments.	1-20 Years	N/A	City/Property Owners
5	**In-stream Enhancements**			
	• Install boulders and large wood, to the extent that it will not increase flood or erosion risk.	1–20 Years	\$50K–\$100K	City
	• Add imported spawning gravels at strategic locations within Brown, Broadway, and Baker Creek including Marian Kroeker Park, the outfall behind 2012 Leggatt Place, and 1254 Yarmouth Street (bottom of waterfall).	1–20 Years	\$200K–\$300K	City
6	**Riparian Areas and Habitat Corridors**			
	• Use the existing Invasive Species Program to treat, manage, and/or eliminate priority invasive species, specifically: English Ivy, Himalayan Blackberry, and Japanese Knotweed.	Ongoing	\$30 per m^2	City
	• Restore the habitat enhancement project in Brown Creek to its former condition, with regular monitoring and maintenance to ensure adequate functioning.	1-10 Years	\$50K–\$100K	City
	• Remove invasives, re-establish riparian vegetation and forest cover, and stabilize banks on public properties through riparian planting, specifically: • Replace the 400 m2 of lawn with riparian plants in Marian Kroeker Park on the east bank of Baker Creek. • Improve riparian forest along the left bank of Brown creek. Add fencing to protect riparian area. • Remove blackberries in Broadway Creek corridor and replace with native vegetation.	1–20 Years	\$30 per m^2 (Invasive removal) \$30 per m^2 (native planting)	City
	• Increase native tree cover in the Broadway creek riparian corridor. • Enhance the habitat corridor by planting trees through City-owned properties at 1300 and 1305 Eastern Drive, 1300 Western Drive, and 1397 Pitt River Road.	1–20 Years	\$500 per tree	City

	Plan Components	Priority	Cost Estimate	Responsibility
7	**Water Quality**			
	• Conduct additional monitoring at Brown Creek to identify the cause(s) of poor water quality.	1–10 Years	$40K	City
	• Inspect condition of 450mm concrete GVSD sanitary main within the Brown Creek riparian corridor to ensure there is no sanitary exfiltration.	1–10 Years	$1–5K	Metro Vancouver
8	**Fish Sampling**			
	• Complete fish sampling within Baker Creek, Brown Creek, Broadway Creek and Fraser watershed to confirm fish populations within the watersheds.	1–10 Years	$50K–$75K	City
9	**Education and Outreach**			
	• Promote the “Help Stop the Spread of Invasive Plants” program through City website, events and in-person information sessions.	Ongoing	$1–5K	City/ Streamkeepers
	• Develop and distribute education and outreach materials (website, pamphlet, etc.) on stream and watershed health for private property owners with watercourses.	1–10 Years	$5–10K	City/ Streamkeepers
	• Collaborate with streamkeepers on education and outreach materials, tree planting, invasive species removal, educational/informational signage, creek cleanups, flow obstruction removal, “adopt-a-spot” program, and school engagement.	1–20 Years	Varies	City/ Streamkeepers
10	**Development Impact Mitigation**			
	• Require stormwater source controls in the Brown Creek and Baker Creek sub-watersheds to infiltrate to maintain baseflows. Size to capture 90% of average annual runoff (approximately 72% of the 2-year, 24-hour event which is 54 mm).	With Re-development and Capital Projects *after bylaw updates	Varies	City/ Developers
	• Require stormwater source controls in all sub-watersheds to provide water quality treatment. Size to treat 90% of average annual runoff (approximately 72% of the 2-year, 24-hour event which is 54 mm). • Require infiltration/detention facilities in upland watersheds (mainly Baker Creek) to minimize downstream erosion and habitat degradation. Size to detain 24-hr duration 6-months, 2year, and 5-year post-development flow rates to pre-development flow rates.			
	• Require and enforce erosion and sediment control measures during construction with redevelopment and City works.	Ongoing	Varies	City/ Developers

	Plan Components	Priority	Cost Estimate	Responsibility
	• Continue and expand City rain barrel program	Ongoing	$200/barrel: $150/barrel (City) $50/barrel (Resident)	City/ Residents
11	**Bylaws and Standards**			
	Update the Subdivision Servicing Bylaw with: • requirements for source controls and rainwater management criteria prescribed in individual IWMPs (after completion of all plans); • stormwater volume capture, water quality treatment, and environmental detention criteria; • climate change considerations for drainage design criteria; • erosion and sediment control measures; and • design criteria and specifications for stormwater source controls.	1–10 Years	$25K	City
	Update the Official Community Plan (OCP) to include watercourse classifications as presented in Table 5-4 once confirmed with fish sampling within Baker, Brown, and Broadway Creeks and Fraser watershed.			
12	**First Nation Consultation**			
	• In accordance with UNDRIP, include meaningful consultation with kʷikʷəƛ̓əm First Nation on projects prior to proceeding and ensure that their right to the land and its use are respected and upheld. • Provide opportunities for a kʷikʷəƛ̓əm First Nation member to oversee environmental and archaeological monitoring activities in the watershed. Forward all monitoring documentation to kʷikʷəƛ̓əm First Nation.	Ongoing	Subject to Guardianship Program Funding	City/ kʷikʷəƛ̓əm
13	**Monitoring and Adaptive Management Framework**			
	• Conduct routine monitoring of Brown, Baker and Fraser Creeks for water quality, flow, and benthic invertebrates per Monitoring and Adaptive Management Framework.	Every 5 Years	$50K	City

7.2 Flood Management Plan

To prevent flooding, the following works are proposed:

1. Complete storm main and culvert conveyance upgrades.
2. Clear lowland ditches of vegetation and sediment.
3. Upgrade and increase the capacity of the Harbour 1 Pump Station. This should be done in conjunction with upgrading the Mary Hill Bypass culverts immediately upstream.

The technical work in this study was completed in 2023 and included climate change considerations. Recommended major system drainage improvements should be reassessed with climate change considerations prior to design.

Proposed Conveyance Upgrades

Undersized storm mains and culverts, for existing and future conditions, are identified in Section 4. Pipes requiring upgrades are identified on Figures 4-1 to 4-6 with ratings E and F. Prioritized pipe upgrades are summarized in Table 7-1 and Section 7-8. Refer to Tables J-1, J-2, and J-3 in Appendix J for prioritized list of pipe upgrades and associated costs.

1.1.1 Conveyance Upgrades Prioritization

Upgrades are prioritized based on risk of overland flooding under major storm events:

- **Priority in 1–10 years** (highest priority upgrades):
  - Major system storm mains and culverts rated F under existing conditions. Under major design storms, these pipes are likely to contribute to unsafe overland flooding and should be upgraded in the next 10 years to ensure safe conveyance of major flows.
  - Culverts that would restrict flow to the Harbour 1 Pump Station once the pump station is upgraded. These should be upgraded at the same time as the pump station upgrade.
- **Priority in 10–20 years**:
  - Major system pipes and culverts rated E under existing conditions. Under major design storms, the pipe full condition is exceeded but no overflow to ground is expected.
- **Priority in 1–50 years**:
  - Minor system pipes rated E & F under existing conditions. Under minor design storm, pipe full condition is exceeded, and in the F rated pipes would result in safe overland flows. These pipes should be upgraded when due for age-based replacement when contributing to flooding or service connection backwatering issues, or in coordination with other roadworks and/or other underground utility works.
- **Priority at re-development**:
  - Major and minor system mains and culverts rated E & F under future conditions but not existing conditions. These pipes should be upgraded when their catchment is undergoing development to ensure adequate system capacity under future conditions.

1.1.2 Conveyance Upgrades Design Criteria

The following design criteria were used to size upgrades:

- **Minor System:** Minor system pipe upgrades were designed for the 1:10 year event under future conditions to be contained in the piped system without surcharge. Full pipe capacity was used to calculate a diameter, and the next nominal pipe size was recommended. If the pipe slope was less than 0.1%, then 0.1% was used to calculate capacity. This filters out flat pipes and adverse sloped pipes.
- **Major System Pipes and Culverts:** Major system pipe upgrades were designed for the 1:100 event under future conditions to be safely conveyed by pipes and designated surface flood paths to a suitable receiving watercourse. If the pipe slope was less than 0.1%, then 0.1% was used to calculate capacity. This filters out flat pipes and adverse sloped pipes. To size culvert upgrades, each culvert was assessed individually using nomographs. Culverts with a headwall were checked under both inlet-controlled and outlet-controlled conditions to determine which governs. When sizing, HW/D of 1 was assumed for inlet controlled, and a head loss of 0.3 m if outlet controlled.
- **Pump Stations:** Pump station upgrades were designed for no flooding in developed areas. Undeveloped areas are permitted to flood.

Sizing of the conveyance upgrades in the IWMP is conceptual and should be thoroughly assessed during pre-design.

Ditch Maintenance

The field inventory indicated that the lowland ditches were highly vegetated.

- **Priority in 1–5 Years**
  - Remove vegetation/sedimentation in roadside ditches on the Mary Hill Bypass to convey maximum flow.

Pump Station Upgrades

The following pump station projects are recommended:

- **Priority in 1–5 Years**
  - Due to age and deteriorating conditions, the City plans to decommission the existing Harbour Old Pump Station.
- **Priority in 1–10 Years**
  - Upgrade the Harbour 1 Pump Station to a new higher capacity fish-friendly pump and floodbox. The proposed pump station is based on the modelled scenario that resulted in no flooding upstream of the pump station. The proposed pump station would require between 2.5 m^3/s and 5 m^3/s of additional capacity. Therefore, the new pump station would require a capacity of between 5 m^3/s and 7.5 m^3/s once the existing 2.5 m^3/s Harbour 1 Pump Station is decommissioned. The sizing of the pump station is conceptual in nature and should be thoroughly assessed during pre-design.
  - Decommission the existing Harbour 1 Pump Station after the upgrades are complete.

7.3 Environmental Enhancements

To restore and enhance the aquatic habitat in Brown Creek and Baker Creek, the following works are proposed (see Table 7-1):

Conveyance and Fish Passage Improvements

- **Priority in 1–10 years:**
  - Conduct detailed barrier assessment to confirm barriers and the conditions under which they are barriers. In particular:
    - the culvert beneath Argue St on the Fraser watershed watercourse;
    - the culverts beneath Nova Scotia Ave and Saskatchewan Ave on Baker Creek; and
    - the waterfall behind 1254 Yarmouth St on Baker Creek.
- **Priority in 1–20 years:**
  - Remove channel obstructions and fish passage impediments such as fences.
  - Remove channel obstructions and clean out overgrown vegetation to improve conveyance and fish passage.
  - Work with private property owners to remove fish passage impediments.

In-Stream Enhancements

- **Priority in 1–20 years:**
  - Install instream boulders and large wood, to the extent that it will not increase flood or erosion risk.
  - Add imported spawning gravels at strategic locations within Broadway Creek and Baker Creek including Marian Kroeker Park, the outfall behind 2012 Leggatt Place, and 1254 Yarmouth Street (bottom of waterfall).

Riparian Areas and Habitat Corridor Improvements

To restore and enhance the riparian corridor / terrestrial habitat in the Baker Creek, Brown Creek, and Fraser River watersheds, the following works are proposed (see Table 7-1):

From an ecological health perspective, the most important improvement is to reduce stream and riparian encroachment and restore natural riparian vegetation. The following projects will widen riparian setbacks as redevelopment of the watershed occurs, with the long-term goal of implementing recommended streamside protection enhancement areas (SPEA) widths throughout the watershed.

- **Ongoing:**
  - Use invasive species program to treat, manage, and/or eliminate priority invasive species, specifically: English ivy, Himalayan blackberry, and Japanese knotweed.
- **Priority in 1–10 years:**
  - Restore the habitat enhancement project in Brown Creek to its former condition with regular monitoring and maintenance to ensure adequate functioning.

- **Priority in 1–20 years:**
  - Remove invasives, re-establish riparian vegetation and forest cover, and stabilize banks on public properties through riparian planting, specifically:
    - Replace the 400 m^2 of lawn with forest cover/riparian plants in Marian Kroeker Park on the east bank of Baker Creek;
    - Improve riparian forest along the left bank of Brown creek. Add fencing along riparian area; and
    - Remove blackberries in Broadway Creek corridor and replace with native vegetation.
  - Increase native tree cover in the Broadway creek riparian corridor.
  - Enhance tree coverage and habitat corridor by planting trees in City-owned properties at 1300 and 1305 Eastern Drive, 1300 Western Drive, and 1397 Pitt River Road

At sites not undergoing redevelopment, opportunities exist to work with private landowners to reduce bank hardening, channelization, remove invasive plant species and were possible, restore narrow riparian areas. Owners should be encouraged to use row plantings of overhanging shrubs or trees to help improve the riparian areas. There are opportunities to build on Metro Vancouver's Help Stop the Spread of Invasive Plants program by helping private landowners identify invasive species and areas that would benefit from replanting, while provide guidance and incentives to landowners. A landowner education program should also be developed in collaboration with Baker Creek Streamkeepers to educate the public on the importance of riparian areas. Problem areas located on private lands that have been identified by the Baker Creek Streamkeepers include:

- Along upper reaches of Baker creek at 1266 Yarmouth St, 1322 Yarmouth St, 2012 Leggatt Pl, 1253 Guest St, 1330 Yarmouth St.

Water Quality

- **Priority in 1–10 years:**
  - Conduct additional monitoring at Brown Creek to identify the cause(s) of poor water quality.
  - Inspect condition of 450 mm concrete GVSD sanitary main within the Brown Creek riparian corridor to ensure there is no sanitary exfiltration.

Fish Sampling

- **Priority in 1–10 years:**
  - Complete fish sampling within Baker Creek, Brown Creek, Broadway Creek, and Fraser watershed to confirm fish populations within the watersheds.

Education and Outreach

- **Ongoing:**
  - Promote the 'Help Stop the Spread of Invasive Plants' program through City website, events and in-person information sessions.
- **Priority in 1–10 years:**
  - Develop and distribute education and outreach materials (website, pamphlet, etc.) on stream and watershed health for private property owners with watercourses.
- **Priority in 1–20 years:**
  - Collaborate with Streamkeepers on education and outreach materials, tree planting, invasive species removal, educational/informational signage, creek cleanups, flow obstruction removal, "Adopt-a-SPOT" program, and school engagement.

7.4 Mitigation of Impacts of Future Development

Unmitigated development and redevelopment negatively affect watercourses and degrade fish habitat through changing stream hydrology and water quality. Unmitigated increase in impervious area can cause flooding, erosion, and reduced baseflows. Guidance to mitigate the impacts of development and redevelopment is one of the most important components of an IWMP.

Recommended Criteria for Study Area Watersheds

Table 7-2 outlines development guidance criteria recommended for the study area watersheds. The criteria apply to all development and redevelopment within all three study area watersheds with one exception. Volume capture is not required in the Fraser River catchment since there is no Class A or Class B watercourse in the catchment.

Table 7-2: Recommended Watershed Criteria

Category		Purpose/Criteria/Solutions	Application
Riparian Area/ Streamside Protection		**To Protect Watershed Health:** No development within Watercourse Protection Development Permit Areas (WPDPA) setbacks unless compensation is provided. Protection of riparian setbacks are critical to watershed health.	All Watersheds
Stormwater	**Water Quality Treatment**	**To Remove Pollutants from Stormwater prior to Discharge to Watercourses:** • Size to treat 90% of average annual runoff (equivalent to 72% of the 2-year, 24-hour event which is 54 mm) from paved surfaces exposed to vehicular traffic. • Construct rainwater management measures (rain gardens, vegetated swales, absorbent landscaping, etc.) to filter contaminants from roads and parking lots. • Construct oil/grit separators as spill control devices for gas stations, high risk spill industry, large parking lots. • Require and enforce Erosion and Sediment Control measures during construction.	All Watersheds
	Volume	**To Preserve Baseflows:**	Watersheds

Category	Purpose/Criteria/Solutions	Application
Capture	• Size rainwater management measures to capture 90% of average annual runoff (72% of the 2-year, 24-hour event which is 54 mm). • Maximize low impact development techniques. • Construct rainwater management measures (rain gardens, vegetated swales, absorbent landscaping, etc.). Rely on infiltration on well-draining soils. Where site constraints (poor draining soils, high water table, etc.) limit infiltration potential, use storge and slow release. Metro Vancouver Stormwater Source Control Design Guidelines (2012) recommends a slow-release rate of 0.25 L/s/ha to maintain base flows. This is an average value for the entire Metro Vancouver region.	with Class A & B Watercourses (Brown Creek & Baker Creek)
Detention - Environmental	**To Minimize Erosion and Habitat Degradation:** • Control post-development flows to predevelopment levels for 6-month, 2-year, and 5-year 24-hour events. • Construct on-site detention/infiltration facilities.	Watersheds with Upland Watercourses (Baker Creek)
Detention – Flood Control	**To Minimize Flooding and Erosion:** • As per the City's Subdivision Servicing Bylaw, provide detention as needed to ensure the downstream minor and major system capacities are not exceeded due to development. • Construct on-site detention facilities.	All Watersheds
Municipal Stormwater Program	**Develop, Adopt and Enforce:** • Stormwater volume capture, water quality treatment, and environmental detention criteria. • Erosion and Sediment Control Bylaw. • Stormwater Source Controls Standards. • Green Street Standards. • Guidelines for development and implementation of Erosion and Sediment Control Plans.	Citywide

Streamside Protection

Stream setbacks provide protection for both the stream channel and the adjacent riparian area which also provides important functions through provision of cover, organic matter, and wood debris. A secondary emphasis is to maintain wildlife populations including landscape-level connectivity.

Stream setbacks for redevelopment should follow the City of Port Coquitlam Official Community Plan (Bylaw No. 3838, 2013). This document outlines areas that are designated as Watercourse Protection Development Permit Areas (WPDPA) that are based on the former provincial Streamside Protection Regulations (SPR). These areas are not a setback area, but an area within which proposals to develop or otherwise alter land must be considered though a Development Permit process.

The SPR defines a streamside protection and enhancement areas (SPEA) which are also known as stream setbacks, buffers or leave strips. These widths are based on the existing or *potential* streamside vegetation conditions and are shown in Table 7-3 below. The WPDPA and the SPEA should represent overlapping areas, WPDPA is used in this report to refer to these areas.

Table 7-3: Streamside Protection Regulation Prescribed SPEA Widths

<table>
<tr><th rowspan="3">Existing or Potential Streamside Vegetation Conditions</th><th colspan="3">Streamside Protection and Enhancement Area Width*</th></tr>
<tr><th rowspan="2">Fish Bearing</th><th colspan="2">Non-Fish Bearing</th></tr>
<tr><th>Permanent</th><th>Non-Permanent</th></tr>
<tr><td>Continuous areas >30 m or discontinuous but occasionally >30 m to 50 m</td><td colspan="2">30 m</td><td>Minimum of 15 m</td></tr>
<tr><td>Narrow but continuous areas = 15 m or discontinuous but occasionally > 15 m to 30 m</td><td rowspan="2">Greater of:
- existing width or
- potential width or
- 15 m</td><td colspan="2">15 m</td></tr>
<tr><td>Very narrow but continuous areas up to 5 m or discontinuous but occasionally >5 m to 15 m</td><td colspan="2">Minimum of 5 m
Maximum of 15 m</td></tr>
<tr><td colspan="4">*SPEA is measured from top of bank</td></tr>
</table>

To mitigate future impacts of development on the watersheds, variances in the WPDPA should be limited to the highest degree possible, if variances are permitted they should be accompanied by a requirement for full offsetting of impacts, 30 m setbacks (or furthest possible setbacks) should be encouraged for all redevelopment, and zoning density/building footprints should not be increased (and preferably be decreased) within 30 m of any watercourse. Although the SPEA setbacks defined by provincial regulation may result in a WPDPA smaller than 30 m, applying a 30 m watercourse setback throughout the watersheds will significantly improve watershed condition.

It is also recommended that all watercourses identified as Class A, Class B, and Class C in Figure 5-4 be adopted as official classifications within the OCP, and associated setbacks be applied.

Tree Retention

Ordinary planted street trees can be a useful tool in a re-developing watershed. Trees provide interception of rainfall before it reaches the ground to become runoff, promoting evapotranspiration of rainfall and reducing the sharp runoff peaks seen in urban areas by slowing the intensity of the rainfall that lands on pavement below the trees. While trees do not replace source controls as they cannot provide water quality treatment for runoff, they aid source controls in mitigating the hydrologic impacts of impervious area. This is primarily an advantage for street trees and other trees that intercept rainfall before it reaches the impervious area on the ground. Trees over pervious soils also help to promote evapotranspiration of rainfall, but do not provide as much improvement in mitigating hydrologic impacts of development. Street trees are a useful tool for a municipality to employ in either a developed or a developing watershed for rainfall interception. A key consideration is that large and mature trees provide these significant benefits; planting smaller or decorative varieties of trees will not provide the same level of benefits and larger variety trees must be allowed to grow to maturity and high enough to be effective in this role. Similarly, preservation of existing healthy and mature street trees should be a priority for municipalities for their stormwater benefits in addition to other recognized benefits of mature trees.

Stormwater Source Controls

When assessing the applicability of source controls, several factors should be considered including but not limited to land use, soils, and the water table conditions. Metro Vancouver Stormwater Source Control Design Guidelines (MVSSCDG) (2012) and Metro Vancouver Region-wide Baseline for On-site Stormwater Management (2017) provide region-wide guidelines for planning, selection, and design of source controls. Municipalities often develop supplementary local standards that address their unique challenges and opportunities. Below are some of the considerations for the study area watersheds.

Source Controls for Different Soil and Water Table Conditions

Source controls provide hydrological and water quality benefits through stormwater infiltration, retention and slow release, and filtration (to remove pollutants).

In Brown Creek and Baker Creek watersheds, where site conditions are suitable, infiltration is the preferred method for achieving the proposed stormwater criteria. Example of potential source controls include infiltration rain garden, vegetated swale, and infiltration trench, as well absorbent landscaping. However, where site conditions limit the potential for infiltration, the stormwater criteria can also be achieved through retention, storage and slow release, and filtration.

The soils underlying a large portion of the lowlands are relatively permeable and offer good infiltration potential. However, near surface water table is a potential risk in much of the area (see Figure 2-3). The desktop hydrogeological assessment recommends infiltration only if the depth to the water table exceeds about 5 m. As per the *MVSSCDG (2012),* the bottom of an infiltration facility should be at least 600 mm above seasonally high water table. Where high water tables are expected, shallow infiltration facilities can be used to ensure adequate clearance from the water table and/or lined facilities (e.g. lined rain garden and swales) can be used to maintain filtration but prevent interactions with the water table. Where infiltration is not feasible, volume capture can be achieved through storage and slow release and/or stormwater harvesting and reuse. The harvesting and reuse (e.g. for toilet flushing) option may not be suitable for single family development and their use requires close coordination with the City's building department.

Infiltration into the soils in the upland area of Mary Hill appears feasible but where till is exposed potential infiltration rates will be constraint. Where low soil permeability is expected, source controls can rely on retention of runoff to achieve the volume reduction and water quality targets. Retention simply allows storage of the target volume of runoff that can then be infiltrated very slowly into till soils and/or released at baseflow rates into the conveyance system.

Additional hydrogeological assessment by qualified professionals should be undertaken prior to siting and designing infiltration facilities.

Wide Distribution of Infiltration / Retention Systems

It is generally preferred to have a wide distribution of infiltration systems introducing water into different areas and soil types, rather than a few concentrated areas discharging into one soil type. This will reduce the potential for water table mounding. Infiltration systems should be designed to have sufficient storage to release the required volumes, with a safe overflow for larger events into the drainage system.

Source Controls for Different Land Uses and Roads

The types of source controls recommended for the study area watersheds include on-site source control facilities to mitigate the runoff from a single site or lot. In-ground source controls such as rain gardens and swales are generally the default for a site, but they require space for in-ground installation. It may not be possible to mitigate a high-density development on-site given space, soils, slope, and other limitations. For these cases, regional facilities on separate dedicated land may be the solution or alternatives to in-ground source controls may be necessary.

Typical above-ground source controls include storage and re-use tanks located either on the ground or on the roof. Stormwater harvesting and re-use can be allocated to irrigation, but a more efficient non-potable usage would be a “purple pipe” or grey water system for residential, institutional, or industrial uses. This type of system is covered by the British Columbia Building Code, Section 7, and can be permitted and approved by municipalities similar to any other building system.

Another above-ground approach is a green roof to mitigate the impervious building footprint. A green roof is most cost-effective on mid- to high-rise structures in an urban setting, but could be applied in any commercial, industrial, or institutional context.

Roads makes up a significant portion of a city’s impervious areas and are one of the highest pollutant generating surfaces. It is recommended that the City develops green road standards to capture and treat stormwater runoff. Typical source controls include rain gardens, swales, infiltration trenches, and stormwater tree trenches (to capture and treat impervious area runoff); permeable paving for sidewalks and bike lanes; and absorbent landscaping for pervious areas.

Cost and Maintenance of Stormwater Source Controls

In the proposed approach, the costs and maintenance of most stormwater source controls are associated with private land. This is consistent with the philosophy of ‘polluter pays’, where in this case the ‘pollution’ is impervious developed area. For cases where source controls are not provided on private land, a mechanism is needed to provide funds for downstream mitigation by the City.

The exception to this is the installations on City roads and lanes. Construction of roads and lanes would be funded by the City, or in partnership through local improvement projects, by development cost charges, or by frontage improvement at time of redevelopment.

Maintenance of roads and lanes is to be done by the City. However, maintenance of boulevard vegetation is the responsibility of the property owner as per the City of Port Coquitlam *Boulevard Maintenance Bylaw* No. 2646, 1992 which typically include a requirement for boulevard maintenance. Maintenance for on-lot source controls is to be done by the property owner.

7.5 Performance Monitoring and Adaptive Management

Metro Vancouver's Monitoring and Adaptive Management

As described in Section 5.10, Metro Vancouver and its member municipalities developed a Monitoring and Adaptive Management Framework for Stormwater (AMF) (Metro Vancouver, 2014). The AMF takes a weight of evidence approach, using several types of monitoring and indicators to develop an overall assessment of watershed conditions. Through repeated sampling, watershed health and the response to specific watershed protection measures and management actions can be tracked over time.

The AMF recommends a monitoring framework and core parameters for higher gradient streams, grouped into three categories:

- Water quality monitoring indicators – selected general water quality parameters, nutrient, bacteriological parameters, and metals.
- Flow monitoring indicators – seven flow-related metrics characterizing watershed hydrology.
- Benthic invertebrates biomonitoring indicators – benthic index of biotic integrity (B-IBI) scores and mean taxa richness.

Table 7-4 summarizes the recommended parameters for monitoring implementation of the IWMP, as well supplemental performance indicators that may provide a more comprehensive assessment of watershed health and IWMP implementation over time depending on watershed values and issues. The table also indicates the priority of each parameter for measurement (primary or secondary) and sets short- and long-term targets for trends for different parameters.

Table 7-4: AMF & IWMP Performance Monitoring Indicators

Performance Indicator	Indicator Type	Short-term Trend/Target	Long-term Target
Water Quality Performance Indicators			
Dissolved Oxygen	Primary	Increasing	Good or Satisfactory as per AMF classification levels
Water Temperature		Decreasing in dry season	
Turbidity		Decreasing in wet season	
Nutrients (Nitrate as N)		Decreasing	
Bacteriological Parameters (*E. coli* and fecal coliform)		Decreasing, esp. in wet season	
Metals (Fe, Cd, Cu, Pb, Zn)		Decreasing, esp. in wet season	
pH	Secondary	Stable	
Conductivity		Decreasing	
Flow Monitoring Performance Indicators			
T_{Qmean}	Primary	Stable or increasing	Same as short-term
High Pulse Duration (days)			
Low Pulse Duration			
Winter Baseflow (L/s)			

Performance Indicator	Indicator Type	Short-term Trend/Target	Long-term Target
High Pulse Count		Stable or decreasing	
Low Pulse Count			
Summer Baseflow (L/s)		Stable	
Benthic Invertebrate Biomonitoring Performance Indicators			
B-IBI Scores	Primary	Stable or increasing	AMF Fair or higher Category
Mean Taxa Richness			
Additional Recommended Performance Indicators			
No. of Erosion Sites	Supplemental	Decreasing	No high consequence sites
No. of Fish Passage Barriers			No human-made passage barriers
Effective Impervious Area (EIA)		n/a (for tracking only)	n/a (for tracking only)
Riparian Forest Integrity (RFI)		Stable or increasing	Increasing
No. of Species / Locations of Spawners			Increase in spawners from current levels

Additional Performance Indicators

Several forms of ongoing monitoring could be implemented in addition to the Metro Vancouver baseline monitoring recommendations. They are:

Continuous water quality monitoring: Data analysis costs are approximately $20,000 per year depending on level of detail and data quality. Bacteriological contamination is an ongoing concern because of previously detected high levels at several locations in the watershed, additional monitoring in Brown Creek sites should be considered to identify sources. Future monitoring work should use the sites and methods used previously. Sampling should consist of five samples in 30 days and should occur every three to five years.

Sediment quality monitoring: As an additional monitoring tool, sediment sampling could be contemplated as additional monitoring tool to supplement the AMF monitoring protocols. The estimated annual cost for five sites is $2,400 for total metals ($900 for field sampling, $700 for lab analysis, and $800 for letter report). Sampling for PAHs or other contaminants will increase costs substantially.

Total watershed and riparian forest cover monitoring: Total watershed forest cover and riparian forest cover (within 30 m of permanently flowing streams) should be measured every 2–5 years (dependent on availability of orthophoto) as a broad indicator of hydrologic function and riparian-stream channel interactions. Forest is all woody vegetation greater than 5 m in height and a closed canopy. Forest cover should be measured by an experienced GIS technician using GIS software with recent orthophotos, with assistance from a biologist or forest ecologist. It should be expressed as a percentage and total amount of forest for the overall watershed and by municipality. The estimated cost per analysis is $6,000.

Fish population monitoring: Additionally, annual spawner counts should be conducted in accessible reference reaches (e.g., 500 m reach) on Baker and Broadway creeks to monitor fish populations over time. Counts could be carried out by the local Streamkeeper group.

All archaeological or environmental monitoring taking place should be completed with the presence of a kʷikʷəƛ̓əm First Nation member to provide oversight. All monitoring documentation should be forwarded to kʷikʷəƛ̓əm First Nation (fieldwork@kwikwetlem.com).

7.6 Operation and Maintenance

Regular drainage system and stormwater facility maintenance is required to effectively convey design flows, minimize flooding and erosion, and mitigate the impacts of development. The following general inspection and maintenance procedures are recommended.

Inspection	The drainage systems should be inspected annually during low flow conditions, ideally in the spring so that identified problems can be undertaken during the dry summer months. The purpose of the inspection is to assess the condition of the conveyance facilities including creek channels for erosion locations and hydraulic structures and identify the need for maintenance. The annual inspection should include all open channels, culverts, detention facilities, diversions, flow splitters, pump stations and floodboxes. An overall drainage system inspection should also be completed after major storm events.
Vegetation Maintenance	Conveyance channels should be maintained to prevent the growth of weeds, small trees, and bushes to maintain hydraulic conveyance capacities balanced with fish habitat requirements. Channel maintenance should occur annually.
Debris Control	Debris blockages at hydraulic structures can cause flooding problems. Regular debris removal (at least annually) from the ditches, culverts and floodbox is necessary.
Wet Pond	Inspect periodically during wet weather to observe function, clean sediment forebay every 5 to 7 years or when 50% capacity has been lost, remove accumulated sediment from pond bottom when 10 to 15% of pool volume is lost, inspect hydraulic and structural facilities annually and mow side-slopes, embankments and spillways as required to prevent overgrowth.
Detention Tanks	Inspect annually and remove floating debris and oil.
Grassed Swales	Inspect routinely, especially after large storm events. Correct erosion problems as necessary, mow to keep grass in the active growth phase, remove clippings to prevent clogging of outlets, and remove trash and debris.
Bioretention with Underdrain	Remove leaves each autumn, inspect overflow, hydraulic and structural facilities annually.

7.7 Capital Cost Estimates and Funding

Capital Cost Estimate

The sizing of facilities and infrastructure in the IWMP is conceptual in nature and should be thoroughly assessed during pre-design. The cost estimates of the overall proposed works in the IWMP are summarized in Table 7-1. The detailed capital cost estimates are included in Appendix J.

Class 'C' Cost Estimate and Assumptions

The cost estimates provided in this study are of Class 'C' accuracy. This means that the general requirements for upgrading including size and approximate depth of excavation, as well as some limited site conditions are known. The projects identified have not considered the following factors affecting construction:

- Relocation of adjacent services (gas, hydro, telephone, etc.).
- Special permitting requirements (fisheries windows, contaminated site, etc.).
- Geotechnical issues requiring special construction such as pile-supported piping, buoyancy problems or rock blasting.
- Critical market shortages of materials.

As the above factors have not been allowed for in estimating construction unit rates or project design, the following factors are applied to all projects:

- Mobilization/Demobilization – 6%
- Engineering – 10%
- Contingency – 40%

The unit prices were determined based on KWL's 2023/2024 experience with similar work and represented the best prediction of actual 2024 costs. Actual tendered costs would depend on such things as market conditions generally, remoteness factor, the time of year, contractors' workloads, any perceived risk exposure associated with the work, and unknown conditions. Costs do not account for inflation in future years; this should be calculated as projects are brought forward for implementation. Ongoing operation and maintenance costs are not included but should be considered with operational budgets as each project is implemented.

Funding Strategies

Funding opportunities from senior governments should be pursued for some of the items for example:

- Fish barrier removals and complexing – Pacific Salmon Foundation's Community Salmon Program (pursue in partnership with local Streamkeeper groups).
- Riparian enhancement and conservation areas – Environment and Climate Change Canada's EcoAction Community Funding Program (pursue in partnership with local Streamkeeper groups or other non-governmental organizations).
- Conveyance upgrades – Infrastructure Grant programs.

Submission

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Clayton McBride, P.Eng.
Stormwater Engineer
(Sealing Sections 1-4, and Non-environmental Components of Sections 6 and 7)

Sara Pour, P.Eng.
Project Manager

Oskar von Wahl, BIT
Junior Biologist

Larissa Low, M.Sc., RPBio
Project Biologist

Karin Bjorklund, PhD
Water Quality Specialist

Reviewed by:

David Zabil, P.Eng.
Technical Reviewer

COLLEGE OF APPLIED BIOLOGY
Patrick Lilley
December 13, 2024
R.P. Bio
#1969
CAB

Patrick Lilley, M.Sc., RPBio, BC-CESCL
Technical Reviewer
(Sealing Section 5, and Environmental Components of Sections 6 and 7)

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the intended recipient. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	December 13, 2024	FINAL	Final submission.	CHSM & OAVW
B	September 3, 2024	DRAFT	Issued for client review.	CHSM & OAVW
A	July 23, 2024	DRAFT	Issued for client review.	CHSM & OAVW

Literature Cited

BC Frogwatch Atlas. 2022. Amphibians, Reptiles, and Turtles. Retrieved from https://maps.gov.bc.ca/ess/hm/bcfa/. Accessed on May 4, 2022.

Buysse, D., Mouton, A. M., Baeyens, R., & Coeck, J. 2015. Evaluation of downstream migration mitigation actions for eel at an Archimedes screw pump pumping station. *Fisheries management and ecology*, *22*(4), 286-294.

City of Port Coquitlam. 2013. Development Procedures Bylaw No. 3849, 2013. Retrieved from https://www.portcoquitlam.ca/wp-content/uploads/2022/02/3849-Development-Procedures-Bylaw.pdf. Accessed on April 1, 2024.

City of Port Coquitlam. 2022. Official Community Plan Bylaw No. 3838. Retrieved from https://www.portcoquitlam.ca/wp-content/uploads/2017/01/3838-Official-Community-Plan.pdf. Accessed on May 15, 2022.

Conservation Data Centre (CDC). 2022. Species and Ecosystems at Risk. Retrieved from http://maps.gov.bc.ca/ess/hm/cdc/. Accessed on May 15, 2022.

Environment Canada. 2013. How Much Habitat is Enough? Retrieved from https://www.ec.gc.ca/nature/default.asp?lang=En&n=E33B007C-1#_02_2. Accessed on May 15, 2022.

Envirowest Consultants Limited. 2004. Brown Creek – Constructed Habitats and Channel Enhancement: Annual Post-Construction Monitoring Report, Year Three. Retrieved from https://a100.gov.bc.ca/pub/acat/documents/r55389/8_1543871069277_3859893681.pdf. Accessed on April 15, 2022.

Envirowest Consultants Limited. 2005. Brown Creek – Constructed Habitats and Channel Enhancement: Annual Post-Construction Monitoring Report, Year Three. Retrieved from https://a100.gov.bc.ca/pub/acat/documents/r55388/9_1543870868786_3859893681.pdf. Accessed on April 15, 2022.

Envirowest Consultants Limited. 2006. Brown Creek – Constructed Habitats and Channel Enhancement: Annual Post-Construction Monitoring Report, Year Three. Retrieved from https://a100.gov.bc.ca/pub/acat/documents/r55390/7_1543871226724_3859893681.pdf. Accessed on April 15, 2022.

Fisheries Inventory and Summary System. 1995. FISS Database: survey_id 9060. Retrieved from https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/search-fish-fish-habitat-data-information/fisheries-inventory-data-queries?keyword=fisheries&keyword=inventory. Accessed on May 15, 2022.

iNaturalist. 2022. Observations. Retrieved from https://inaturalist.ca/observations. Accessed on March 15, 2022.

Johnston, N.T., and P.A. Slaney. 1996. Fish Habitat Assessment Procedures. Retrieved from https://www.friendsofkootenaylake.ca/wp-content/uploads/2012/12/fishHabitatassessmentprocedures_1996.pdf. Accessed on April 15, 2019.

Kerr Wood Leidal (KWL). 2021. Maple Creek Integrated Watershed Management Plan Final Report. Received from the City of Port Coquitlam.

Kerr Wood Leidal (KWL). 2015. Stormwater Hydraulic Model Final Report. Received from the City of Port Coquitlam.

Kerr Wood Leidal (KWL). 2005. Template for Integrated Stormwater Management Planning 2005 - Terms of Reference Template.

Masse Environmental Consultants. 2012. Fish Passage Assessments – Lower Fraser Watershed Group. Retrieved from https://a100.gov.bc.ca/pub/acat/documents/r43012/Lower_Fraser_Fish_Passage_Report_1405029221164_5028243496.pdf. Accessed May 15, 2022.

Metro Vancouver. 2019. GIS - Sensitive Ecosystem Inventory (SEI). Retrieved from

https://gis.metrovancouver.org/maps/SEI. Accessed on March 10, 2022.
Metro Vancouver. 2014. Monitoring and Adaptive Management Framework for Stormwater. Retrieved from: http://www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/Monitoring_Adaptive_Management_Framework_for_Stormwater.pdf. Accessed on January 26, 2023.
Metro Vancouver. 2017. Region-wide Baseline for On-site Stormwater Management. Retrieved from https://metrovancouver.org/services/liquid-waste/Documents/region-wide-baseline-onsite-stormwater-management-report-2017-02.pdf. Accessed on January 26, 2024.
Metro Vancouver. 2012. Stormwater Source Control Design Guidelines 2012. Retrieved from https://metrovancouver.org/services/liquid-waste/Documents/stormwater-source-control-design-guidelines-2012.pdf. Accessed on January 26, 2024.
Ministry of Environment (MOE). 2022a. Habitat Wizard Streams Report – Baker Creek. rwservlet (gov.bc.ca). Accessed on March 30, 2022.
Ministry of Environment (MOE). 2022b. Habitat Wizard Streams Report – Broadway Creek. rwservlet (gov.bc.ca). Accessed on March 30, 2022.
Ministry of Environment (MOE). 2022c. Habitat Wizard Streams Report – Brown Creek. rwservlet (gov.bc.ca). Accessed on March 30, 2022.
Ministry of Environment (MOE). 2022d. iMapBC - Wildlife. Retrieved from https://maps.gov.bc.ca/ess/hm/imap4m/. Accessed on March 20, 2022.
Ministry of Environment (MOE). 1990. iMapBC – Invasive Aquatic Species. Retrieved from https://maps.gov.bc.ca/ess/hm/imap4m/. Accessed on March 5, 2022.
Ministry of Environment (MOE). 1988. iMapBC – Invasive Aquatic Species. Retrieved from https://maps.gov.bc.ca/ess/hm/imap4m/. Accessed on March 5, 2022.
Ministry of Forests and Range. 2019. Biogeoclimatic Ecosystem Classification Program. Retrieved from https://www.for.gov.bc.ca/hre/becweb/. Accessed on May 10, 2022.
Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). 2014. Simulating the Effects of Sea Level Rise and Climate Change on Fraser River Flood Scenarios. Retrieved from: https://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/Simulating_Effects_of_Sea_Level_Rise_and_Climate_Change_on_Fraser_Flood_Scenarios_Final_Report_May-2014.pdf.
Ministry of Water, Land and Air Protection (MWLAP). 2006. Schedule: Riparian Areas Regulation Assessment Methods (v. 3.3). (Note: Document does not indicate author or date; these were determined from file names.) Retrieved from: http://www2.gov.bc.ca/assets/gov/ environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/ rar_assessment_methods.pdf
Pauwels, I. S., Tuhtan, J., Coeck, J., Buysse, D., & Baeyens, R. (2022). Archimedes Screw—An Alternative for Safe Migration Through Turbines?. In *Novel Developments for Sustainable Hydropower* (pp. 125-133). Cham: Springer International Publishing.
Russo, N., Lofthouse D., and Gransden, R. 2003. Environment Canada Regional Pollution Incident Report. Retrieved from the City of Port Coquitlam. Dated June 4, 2003.
Schueler, T. 1994. The importance of imperviousness. *Watershed protection techniques*, *1*(3), 100-101.
UN General Assembly, United Nations Declaration on the Rights of Indigenous Peoples : resolution / adopted by the General Assembly, A/RES/61/295, 2 October 2007,
Urban Systems. 2021. IDF Curve Assessment Report, November 2021. Received from the City of Port Coquitlam.
Urban Systems. 2023. IDF Curve Update Memo #2, September 2023. Received from the City of Port Coquitlam.
Zielinski, D. P., Miehls, S., & Lewandoski, S. 2022. Test of a Screw-Style Fish Lift for Introducing Migratory Fish into a Selective Fish Passage Device. *Water*, *14*(15), 2298.

KERR WOOD LEIDAL
consulting engineers

Appendix A

Hydrogeological Assessment (Piteau Associates)

PITEAU
ASSOCIATES
Geotechnical and Water
Management Consultants
A TETRA TECH COMPANY

Suite 300 – 788 Copping Street
North Vancouver, BC, Canada V7M 3G6
TEL: +1.604.986.8551
www.piteau.com

FILE: 4604-TM1

TECHNICAL MEMORANDUM

FINAL: March 8, 2024

TO: Sara Pour, P.Eng.
Kerr Wood Leidal Associates Ltd.

FROM: Arnd Burgert, P.Geo., Senior Hydrogeologist
David Tiplady, P.Eng., Principal Hydrogeologist

RE: **Hydrogeological Assessment for Integrated Watershed Management Plan, South Port Coquitlam**

The City of Coquitlam retained Kerr Wood Leidal Associates Ltd. (KWL) to complete a drainage study for three watercourses in South Port Coquitlam. Piteau Associates Engineering Ltd. (Piteau) was retained as a subconsultant to KWL to conduct a hydrogeological assessment to provide information to support development of an Integrated Watershed Management Plan (IWMP) for this area.

INTRODUCTION

The Study Area includes the watersheds of Brown Creek, Baker Creek, and an area draining directly to the Fraser River (Figure 1). While most of the area is already developed and large-scale intensification of development is not imminent, the IWMP will assist planners in managing stormwater flows and ensuring local streams are protected as stormwater conveyance features are progressively renewed and upgraded.

Objectives

This assessment was conducted with the knowledge that, in many areas of British Columbia, ground infiltration of stormwater runoff can reduce peak flows and enhance summer low flows in local streams, and filter contaminants and suspended sediments prior to discharge to streams. The objectives of this hydrogeological assessment were to characterize the surficial sediments and identify water-bearing zones within the Study Area and assess the suitability of the various lithologies for enhanced groundwater infiltration.

Scope

The objectives were met by completing the following scope of work:

- A desktop review of:
    - Maps of topography, surficial geology, shallow soils, surface water drainage, aquifers, and current and future land use;

   - Local meteorological and stream gauging data; and
   - Relevant reports concerning surface and groundwater.
- Identify areas where enhanced stormwater infiltration would likely be feasible, and areas where ground conditions are not prospective for enhanced infiltration.

BACKGROUND

Geomorphology, Topography, and Land Use

The Study Area is situated in the southern portion of Port Coquitlam (Figure 1). It extends over 6.5 km^2 and includes the east side of Mary Hill and a lowland plain to the east. Elevations range from about 1 m-geod in ditches in the plain area near Pitt River to 84 m-geod at the crest of Mary Hill.

The plain slopes gently to the south and east, except where drainages have incised valleys of up to 3 m deep. The eastern Mary Hill sidehill slopes average about 15%.

Most of the Study Area is developed and includes residential, industrial, and commercial zones. Important transport corridors in or adjacent to the Study Area include Mary Hill Bypass and the CP Rail yard.

Climate

The Port Moody Glenayre climate station is situated about 8 km west of the Study Area at an elevation of 130 m-asl. Based on the normalized record for the period 1981 to 2010 (Table I), the station receives about 1,968 mm of precipitation annually. The highest monthly average occurs in November (316 mm), and the lowest in July (61 mm). The average annual temperature is 10.2 °C, and minimum and maximum average monthly temperatures are 3.3 and 18.1 °C in December and August, respectively.

Surficial Geology

Surficial geology in south Port Coquitlam (Figure 1) is dominated by glacial, fluvial, and marine deposits related to glacial retreat during late Pleistocene time[1]. The sequence is outlined in Table II.

The oldest exposed sediments are pre-Vashon deposits that were laid down by glacial and glacio-fluvial processes before the Fraser glaciation (pV unit on Figure 1). In portions of the lower Fraser Valley, these deposits include permeable sand and gravel beds that now host productive aquifers.

Vashon Drift deposits (VC) were laid down by meltwater rivers flowing off advancing glaciers, and include glaciofluvial sand and gravel beds. These were overlain by silty glacial moraine pushed in place and overridden by the advancing ice sheet.

Lacustrine or marine embayments that formed as the ice sheets retreated were filled by thick sequences of silty material, followed by sandy stream and delta deposits belonging to the Capilano Sediments (Cc). Raised beach deposits are often included in upper portions of the sequence.

Fraser River Sediments (Fc) consist of bedded silty fine to coarse-grained deposits, and thick layers of mixed silt and fine sand.

[1] Armstrong et al., 1976. Surficial Geology, Mission, British Columbia. Geological Survey of Canada, Map 1485A.

The youngest sediments in the map area are the Salish Sediments, deposited by mountain streams draining meltwater in relatively high-energy environments, and consist of stratified and cross-bedded sand and gravel (Saj,i). The Salish Sediments also include younger peat deposits (SAb).

Soils

Soil mapping[2] is available only for portions along the east and south ends of the Study Area. The mapped areas principally cover areas where the parent material is sand belonging to the Fraser River Sediments. Accordingly, the mapped soils include primarily Bonson, Alouette, and Pitt soils described as fine-textured silt loam, often with an organic overlay. They are generally poorly to imperfectly drained.

The majority of the Study Area is mapped as unclassified urban, indicating the soil profile has been substantially modified by development. Given the coarse-textured parent materials mapped across most of the Study Area (sand and gravel), the pre-development soils were likely comparable to the Bose, Chehalis, or Columbia soil types mapped in similar portions of the lower Fraser Valley. These soils are well-drained to rapidly drained.

Surface Water Hydrology

The Coquitlam River passes within 300 m of the northern end of the Study Area and is interpreted to influence conditions within it. The Water Survey of Canada has operated a gauging station on the river (yellow square on Figure 1) discontinuously since 1915. The reported average monthly low and high flows of 2.3 and 12.8 m^3/s occur in August and November, respectively. Although discharge is controlled by a dam at Coquitlam Lake, rapid responses to rainfall may reflect flashy mountain runoff and the limited potential for infiltration in the upper portion of the catchment where the depth to bedrock is thin. An extreme rainfall event in November 2021 generated a flow of 200 m^3/s.

Pitt River flows along the southeast Study Area boundary. This river is tidally influenced, and experiences short-term water level variation up to 2 metres.

Baker Creek and Brown Creek discharge to the Pitt River. A network of ditches and storm sewers controls drainage within the Study Area.

Aquifers and Water Table Conditions

Aquifer mapping completed by the province[3] for the south Port Coquitlam area is shown on Figure 2 together with reported locations of registered water wells. The two most prominent aquifers within the Study Area are described in this section.

Aquifer 70, present in the northern portion of the Study Area, covers an area of 25 km^2, and is hosted within sand and gravel deposits belonging to the Salish Sediments, Capilano Sediments, and possibly pre-Vashon deposits[4]. Although this aquifer is present in only the northernmost portion of the Study Area it may represent a substantial source of recharge to the adjacent aquifers 71 and 46 as it is highly permeable.

While the aquifer is reportedly unconfined, well logs suggest that confining layers comprising grey gravelly till are present in some areas. Water table levels within Aquifer 70 are typically within 3 m of ground level, and flowing artesian conditions are noted at Well 93379. The aquifer is

[2] Luttmerding, H.A., 1981. Soils of the Langley – Vancouver Map Area, B.C. Ministry of Environment RAB Bulletin 18.
[3] Kreye, R. and W. Wei. 1994. A proposed Aquifer Classification System for Groundwater Management in British Columbia. Ministry of Environment, Lands and Parks, Water Management Division, Province of British Columbia, Victoria.
[4] BC Ministry of Environment, 2007. Aquifer Classification Worksheet, Aquifer 70. October 18. Downloaded May 9, 2022 from https://s3.ca-central-1.amazonaws.com/aquifer-docs/00000/AQ_00070_Aquifer_Mapping_Report.pdf.

considered highly vulnerable to pollution from surface sources. Sediments are highly permeable and several wells have driller's rated well yields of over 6.3 L/s (100 USgpm). Aquifer productivity is rated as high. Recharge to the aquifer is interpreted to be derived from infiltrating precipitation, and leakage from the upper reaches of the Coquitlam River. Seepage from aquifers 49 and 927 may occur through intervening confining layers. The interpreted groundwater flow direction is generally southward, eventually discharging to the adjacent aquifers (46 and 71) and the lower reach of the Coquitlam River.

Aquifer 71 is mapped over a 15 km^2 extent.[5] It lies within sandy Fraser River Sediments, is unconfined, and in communication with surface watercourses including Pitt River. It is highly vulnerable to pollution from surface sources. The water table level is typically about 2 m below ground level. Productivity is rated as moderate, with typical well yields of 2 L/s (35 USgpm). Sources of recharge include infiltrating precipitation and lateral seepage from Aquifer 70. The groundwater flow direction is interpreted to be generally southeastward, and the flow discharges to the Pitt River.

Water table levels rise and fall annually, with the greatest seasonal changes occurring in the upland areas away from aquifer discharge zones, and the smallest seasonal changes occurring near spring lines or streams that drain the aquifer, thereby controlling water levels.

Lithology and groundwater conditions are depicted in the cross sections on Figure 3. The sections were created using lithology and water level information from water wells and surficial geology mapping.

DISCUSSION REGARDING INFILTRATION ENHANCEMENT WORKS

Potential Effects of Development on Aquifers and Hydrology

Impacts that may have resulted from development within the Study Area include diversion of rain water from soils as surfaces have been hardened by rooftops and paved areas. Reduced infiltration and groundwater recharge may result in less groundwater being stored to sustain creek base flows, particularly in the late summer and fall.

Direct discharge of stormwater to surface watercourses may also pose a risk of impacting water quality. This is particularly significant during the early stages of a runoff event when particulates and films that have accumulated on the ground surface (e.g., oil and grease, grit, metals, nutrients, and other low-level contaminants), concentrate in the initial flows (i.e., "first flush").

Traditional stormwater management approaches could result in degradation of streams and riparian areas associated with direct drainage of high flows from impermeable areas. Runoff from these areas can have shorter times of concentration compared to the undeveloped condition. The resulting flows can lead to scouring of stream banks, and removal of sand and gravel beds used by fish for spawning.

To help mitigate potential physical and water quality impacts, it is desirable to retrofit infiltration features in the Study Area as to attenuate peak flows and contaminant loading. The objective is to dissipate the stormwater via roadside swales, rain gardens, buffer strips, porous pavements, etc., that can be incorporated into lot grading plans, wherever possible. When the inflow rate exceeds their infiltrative capacity, these features can overflow to drainage systems leading to detention systems.

[5] BC Ministry of Environment, 2007. Aquifer Classification Worksheet, Aquifer 71. October 18. Downloaded May 9, 2022 from https://s3.ca-central-1.amazonaws.com/aquifer-docs/00000/AQ_00071_Aquifer_Mapping_Report.pdf.

Infiltration Measures

Where the upper layer of permeable weathered soil is relatively thin or the water table near surface, the optimal method for infiltrating stormwater is with shallow infiltration features that can be incorporated into lot grading plans such as swales, rain gardens, buffer strips, and porous pavements. Disconnected roof leaders and amended topsoil should be standard requirements for all new developments. Positioning features such as vegetated swales, and infiltration chambers or pits along road allows passive distribution of water to locations where infiltration can occur. Backfill in utility trenches could be designed to act as seepage trenches to provide temporal in-ground storage for stormwater, subject to the inclusion of check dams to prevent seepage along trenches. As these features will maximize the potential for stormwater infiltration across the developable area, it is not necessary to map areas having particularly high or low infiltration potential. Wide dispersion of infiltrated water will also help reduce the potential for geotechnical concerns related to formation of large water table mounds.

The fate of infiltrated stormwater must be considered, as it is likely to daylight as seepage further downhill. This effect may be favourable where such seepage sustains flows in ditches or streams, but could result in an undesirable condition if it increases seepage discharging on downslope properties. Lot grading design should therefore allow for near or at surface groundwater conditions. Building perimeter drains should be designed to intercept seepage and redirect it to infiltration features at a distance from the building footings.

Runoff that cannot be infiltrated should be detained for gradual release. To this end, surface water detention systems will be required.

Preventing Preferential Pathways

Permanent buried check dams must be incorporated in backfill in all utility trenches to prevent preferential seepage along backfill materials. Check dams should consist of a mixture of 20% granular (<3.2 mm or 1/8”) or powdered bentonite and 80% sand. They should be at least 0.3 m thick, extend across the entire width and depth of a trench, and come to within 0.6 m of ground surface. A check dam spacing of 10 to 12 m along trenches is recommended, with final locations to be field fit as convenient.

Site Suitability

Wherever possible it is desirable to infiltrate runoff. This will require sufficient soil permeability and unsaturated depth. While sandy soils are likely present over much of the Study Area, opportunities for stormwater infiltration will be restricted by the variably layered lithology or high water tables. Silty low-permeability layers result in perched water tables, and where the tops of these layers daylight, seepages and springs occur. Stormwater infiltration will not be feasible in areas with near-surface water tables.

Infiltration features will require a sufficient thickness of unsaturated sediments. The amount of stormwater that can be infiltrated during wetter months will likely be reduced in parts of the Study Area where the seasonal high water table is at or near surface. Water levels can be expected to pose constraints in the plain area near Pitt River. These occurrences can be identified by a combination of field reconnaissance, interviews with land owners, test pitting, and measuring water levels in slotted standpipes installed in the test pits.

Long-term infiltration capacities will be largely controlled by the dense parent materials that underly the upper loose soils, particularly in the northern portion of Mary Hill where glacial till is mapped. Stormwater infiltration will be most effective when distributed across a site as much as possible rather than concentrated in a few smaller areas. Infiltration features should be incorporated into lot grading plans and designed to allow overflow from each feature to decant to a downgradient feature, thus passively distributing infiltration capacity across as many of the underlying discontinuities as possible.

Where potential near-surface infiltration rates are restricted by the presence of glacial till, consideration could be given to assessing the potential to inject clarified stormwater into deeper sediments via injection wells. Artesian conditions are indicated in some areas, with piezometric levels rising above the top of the aquifer sediments. Under these conditions the lack of unsaturated material for storage would require infiltrated flow to be accommodated by lateral seepage away from a well. Accordingly, the artesian conditions indicated in aquifers underlying the till in several areas (Figure 3) may limit the capacity of injection wells. As a result, the cost per infiltrated volume for injection wells may be prohibitive.

The approximate extents of areas appearing to offer high and low potential for stormwater infiltration are outlined on Figure 4. In the southern portion of the Mary Hill upland, pre-Vashon gravels may be exposed, offering high infiltration potential. Detailed assessment is recommended to confirm suitability of prospective infiltration areas.

Potential Infiltration Rates

While infiltration testing has not been completed as part of this study, potential infiltration rates for preliminary design purposes have been estimated based on the expected soil and sediment types.

Recent infiltration tests completed by Piteau at till-covered sites in Vancouver indicate potential infiltration rates ranging from 0.6 to 30 m/day. The large range reflects the proximity of a test site to a permeable feature (till fracture or unconformity), and emphasizes the advantage of applying infiltration to dispersed or linear features rather than attempting to infiltrate concentrated flows at point features.

Potential infiltration rates into gravely or sandy units could be as high as 100 m/day provided that sufficient unsaturated thickness is available.

The aforementioned estimates of potential infiltration rates are based on interpretations of soils derived from underlying surficial geology, and experience with infiltration into similar soils at other sites. These estimates can be refined by testing proposed infiltration sites using a double-ring infiltrometer. To assess long-term infiltration capacity, additional testing could involve monitoring water levels while flooding a basin or trench for an extended duration (several weeks) during the rainy season. To allow for partial plugging or blinding of infiltration features over the long-term, design infiltration rates should be taken as 10% of the potential infiltration rates.

While the potential infiltration rates will be insufficient to infiltrate all stormwater, a good target may be to utilize a combination of infiltration plus surface detention to accommodate the typical storm, with overflows occurring during heavier storm events.

Aquifer Protection

Groundwater aquifers are important water sources for both human use and for maintaining base flows to aquatic habitats. Aquifers 70 and 71 are generally unconfined, and highly susceptible to pollution from surface sources. Management of these shared resources should seek to maintain or enhance aquifer recharge while preventing pollutants from making their way into the groundwater.

Infiltration into the sandy sediments in the Study Area will provide opportunities for runoff to be passively renovated by processes such as bacterial biodegradation, adsorption, and physical straining. Studies assessing the performance of passive infiltration systems have demonstrated their effectiveness in capturing suspended pollutants. Water seeping into the ground is typically renovated within a few centimetres or decimetres of an infiltration feature. Given the relatively low pollutant loading expected from roof tops, driveways, parking lots, and streets, infiltration of stormwater runoff into the shallow sediments in the Study Area is not expected to result in aquifer pollution.

Sites where the presence of soil or groundwater contamination is known or suspected should not be selected for enhanced infiltration to avoid potentially spreading pollutants. Industrial areas including rail yards should be evaluated for the potential presence of pollution prior to construction of infiltration works.

CONCLUSIONS AND RECOMMENDATIONS

1. The north and northeastern portions of the Study Area are underlain by channel fill (sand and gravel) and fluvial (silty sand) deposits. Mary Hill is underlain by sand and gravel deposits covered with till.
2. The soils and sediments underlying a large part of the lowland plain are relatively permeable and offer good potential for infiltration of stormwater provided that the depth to the water table exceeds about 5 m. Infiltration into the soils in the upland area on Mary Hill also appears feasible, but where till is exposed potential infiltration rates will be constrained.
3. Enhanced infiltration can help provide recharge to Aquifer 70, Aquifer 71, and other saturated zones which in turn provide baseflows to Baker Creek and Brown Creek.
4. Possible source control measures that could be implemented to minimize stormwater runoff and/or augment groundwater recharge include perforated storm pipes in shallow trenches, seepage basins, soak-away pits, infiltration chambers, absorbent landscapes, rain gardens, vegetated swales, and pervious paving. It is generally preferred to have wide distribution of systems introducing water into different areas and material types, rather than a few concentrated areas discharging into one material type. This will increase the potential for infiltration works to intersect permeable zones while reducing the potential for water table mounding and the potential for slope instability.
5. Systems that collect and store stormwater runoff for eventual infiltration to ground should have adequate storage volume and provide for a clarification system to eliminate sediments and floating detritus that can cause clogging of the infiltrative surface. Depending on local conditions, infiltration systems can be designed to manage the runoff volume associated with a typical storm, after which they bypass flows to the storm sewer system.
6. Additional hydrogeological assessments should be carried out by qualified professionals in areas prospective for infiltration. These would typically involve excavating test pits or trenches to observe soil types and to facilitate installation of standpipes for water table monitoring during the wet seasons (winter and spring), and infiltration testing.
7. Sandy sediments in the Study Area offer opportunities for passive renovation of stormwater, and enhanced infiltration is not expected to have any noticeable effect on aquifer water quality.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in BC. No warranty is expressed or implied.

This memorandum is prepared for the sole use of Kerr Wood Leidal Associates Ltd. and their client, the City of Port Coquitlam. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau Associates accepts no liability for such unauthorized use.

CLOSING

We trust the above is adequate for your current needs. If you have any questions regarding the above, or we can be of further service, please do not hesitate to contact us.

Respectfully submitted,

PITEAU ASSOCIATES ENGINEERING LTD.

PROFESSIONAL
PROVINCE OF
A. BURGERT
30284
BRITISH COLUMBIA
GEOSCIENTIST
11 Mar. 2024

Arnd Burgert, P.Geo.
Sr. Hydrogeologist

Reviewed by:

David J. Tiplady, P.Eng.
Principal Hydrogeologist
Vice President, Hydrogeology

AB/DJT/ld
Att.

PERMIT TO PRACTICE
PITEAU ASSOCIATES ENGINEERING LTD.
PERMIT NUMBER: 1001592
ENGINEERS AND GEOSCIENTISTS
BRITISH COLUMBIA

TABLES

TABLE I

CLIMATE NORMALS FOR ENVIRONMENT CANADA
PORT MOODY GLENAYRE STATION
1981 TO 2010

Latitude: 49° 16' 45" N   Longitude: 122° 52' 53" W   Elevation: 129.5 m
Climate ID: 1106CL2

Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	3.9	4.6	6.8	9.1	12.5	15.2	17.6	18.1	15	10.4	6	3.3	10.2
Standard Deviation	1.9	1.7	1.6	1.3	1.2	1.3	1.4	0.9	1.2	1.2	1.2	1.6	2.8
Daily Maximum (°C)	6.3	7.5	10.2	12.9	16.7	19.3	22.2	22.7	19.1	13.6	8.3	5.6	13.7
Daily Minimum (°C)	1.4	1.6	3.4	5.3	8.3	11	13	13.4	10.8	7.2	3.6	0.9	6.7
Extreme Maximum (°C)	16.5	19	24	28	34.5	33.5	33.5	34	32.5	28	19	15.5	
Date (yyyy/dd)	1981/20	1986/27	2004/29	1987/27	1983/29	1989/03	1994/20	1981/08	1996/02	1987/01	1981/02	1996/02	
Extreme Minimum (°C)	-14	-13	-7.8	-1	-1	4.4	-2.5	7.2	1	-7	-15.5	-16	
Date (yyyy/dd)	1979/01	1989/02	1976/03	1986/30	2002/06	1976/03	1999/28	1973/18	2000/04	1984/31	1985/27	1990/29	

Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	266.9	161.4	179.5	152.7	110.8	88.3	60.7	65.4	87.2	204.4	310.1	225.8	1913.2
Snowfall (cm)	18	9.5	6	0.2	0	0	0	0	0	0.2	6.1	15.6	55.6
Precipitation (mm)	285	170.9	185.5	152.9	110.8	88.3	60.7	65.4	87.2	204.5	316.2	241.4	1968.8
Extreme Daily Rainfall (mm)	110	82.3	92	59	60.3	49	96.8	70.1	69	138.6	96.4	112.3	
Date (yyyy/dd)	2005/17	1974/02	1997/18	1997/19	1989/17	1984/28	1972/11	1991/26	2005/29	2003/16	2003/28	1972/25	
Extreme Daily Snowfall (cm)	25.4	24	24	2	0	0	0	0	0	3	27	32.5	
Date (yyyy/dd)	1971/11	1995/14	2006/09	1982/03	1971/01	1971/01	1971/01	1971/01	1971/01	1984/31	2006/29	1971/13	
Extreme Daily Precipitation (mm)	110	82.3	92	59	60.3	49	96.8	70.1	69	138.6	96.4	112.3	
Date (yyyy/dd)	2005/17	1974/02	1997/18	1997/19	1989/17	1984/28	1972/11	1991/26	2005/29	2003/16	2003/28	1972/25	
Extreme Snow Depth (cm)	34	27	8	0	0	0	0	0	0	0	27	39	
Date (yyyy/dd)	1993/04	1990/01	1982/12	1981/01	1981/01	1981/01	1981/01	1981/01	1981/01	1980/01	2006/27	1990/31	

TABLE II

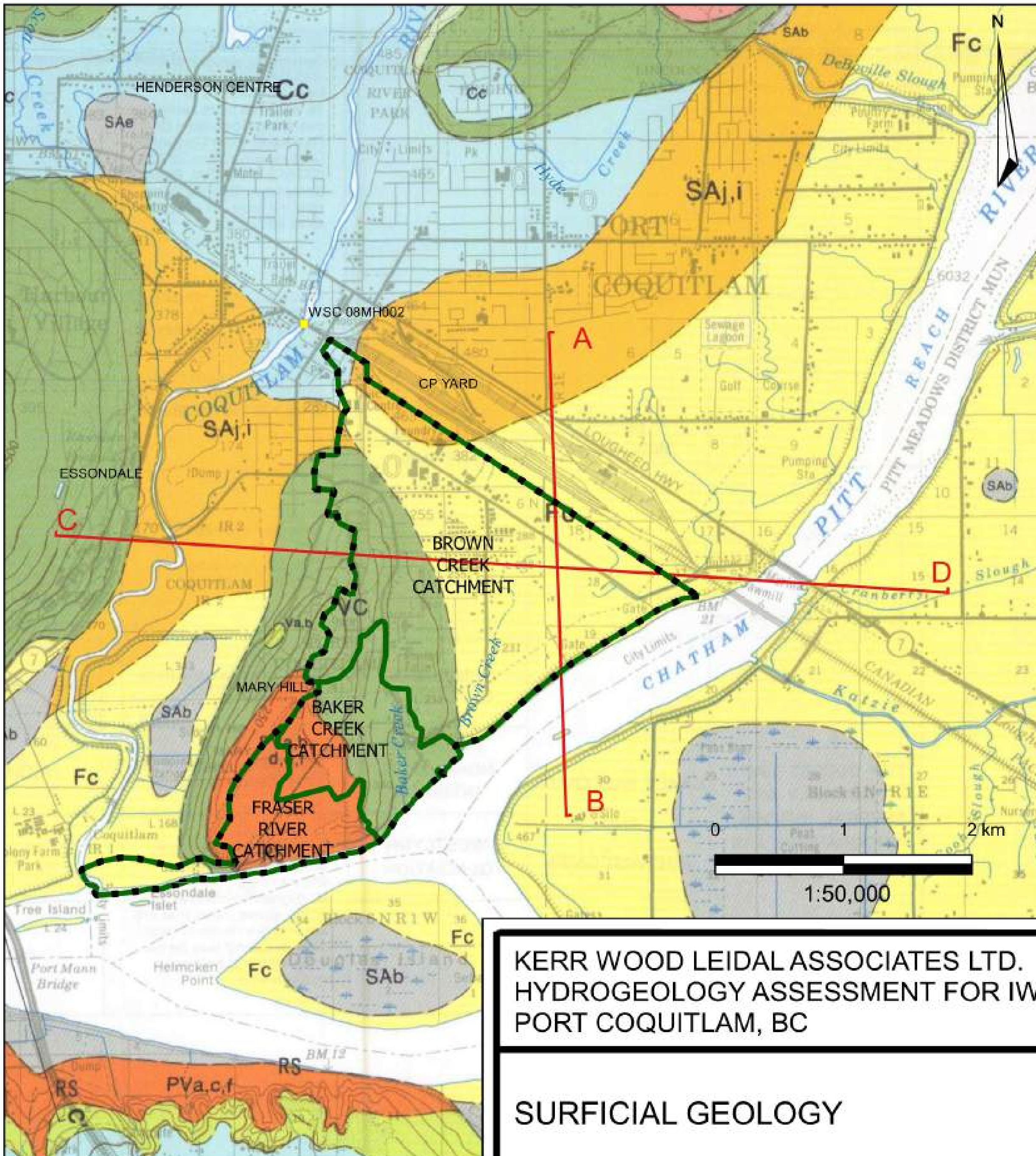
SURFICIAL GEOLOGY UNITS IN PORT COQUITLAM STUDY AREA

Unit Name[1] (in order of age)	Map Symbol[2]	Description	Age	Thickness	Formation	Infiltration Rating[3]
Peat	SAb	Lowland peat	Post-Glacial	up to 14 m	Salish Sediments	6
Peat	SAe	Upland peat		up to 8 m		6
Sand and gravel	SAi	Mountain sream delatic gravel and sand		up to 15 m		1
Sand and gravel	SAj	Mountrain stream channel fill sand and gravel		up to 8 m		1
Loam	Fc	Overbank silty to silt clay loam overlying deltaic and distributory channel fill		up to 2 m	Fraser River Sediments	3
Sand and gravel	Cc	Deltaic and channel fill sand to cobble gravel underlain by silty to silt clay loam	Pleistocene	up to 15 m	Capilano Sediments	2
Till	VC	Glacial drift containing sand and gravel, stony silt lenses and interbeds		up to 25 m usually <8 m	Vashon Drift and Capilano Sediments	4
Till	Va	Lodgement till and minor flow till containing stony silt lenses and interbeds		not defined	Vashon Drift	5
Sand and gravel	Vb	Glaciofluvial sandy gravel and gravelly sand deposits		not defined	Vashon Drift	2
Sand	PVa-f	Fluvial and glaciofluvial sands containing Quadra Sands and occasional till		not defined	Pre-Vashon Deposits	1
Undifferentiated	UPV	Till, glaciofluvial, glaciolacustrine, fluvial, marine, and organic sediments		not defined	Undifferentiated Pre-Vashon Deposits	5

Notes:
1. Based on Armstrong and Hicock, 1976.
2. See distribution of units on Figure 1.
3. The lowest infiltration rating number has the highest potential for sustained infiltration.

FIGURES

C:\Users\Arnd.Burgert\Documents\GIS\4604PoCo.qgz



Study Area

A B Cross Section

Water Survey of Canada Gauging Station

Surficial Geology

POSTGLACIAL

SALISH SEDIMENTS

SAb,e Bog, swamp, and shallow lake deposits: SAb, lowland peat up to 14 m thick; SAe, upland peat, may be over 8 m thick.

SAj,i Lowland and mountain stream deltaic, channel fill, and overbank sediments: SAi, mountain stream marine deltaicmedium to coarse gravel and minor sand up to 15 m or more thick; SAj, mountain stream channel fill sand and gravel up to 8 m thick.

FRASER RIVER SEDIMENTS

Fc Deltaic and distributory channel fill sediments overlying or cutting estuarine sediments: overbank silty to silt clay loam normally up to 2 m thick overlying deltaic and distributory channel fill.

PLEISTOCENE

CAPILANO SEDIMENTS

Cc Raised deltaic and channel fill medium sand to cobble gravel up to 15 m thick deposited by proglacial streams and commonly underlain by silty to silty clay loam.

VASHON DRIFT AND CAPILANO SEDIMENTS

VC Glacial drift including lodgement and minor flow till, lenses and interbeds of substratified glaciofluvial sand and gravel, and lenses and interbeds of glaciolacustrine laminated stony silt; up to 25 m thick but in most places less than 8 m thick.

VASHON DRIFT

Va,b Till, glaciofluvial, glaciolacustrine, and ice-contact deposits: Va, ledgment till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt; Vb, glaciofluvial sandy gravel and gravelly sand outwash and ice-contact deposits.

PRE-VASHON DEPOSITS

PVa-f Glacial, non-glacial, and glacio-marine sediments: fluvial and glaciofluvial sands including Quadra Sands and occasional till.

UNDIFFERENTIATED PRE-VASHON DEPOSITS

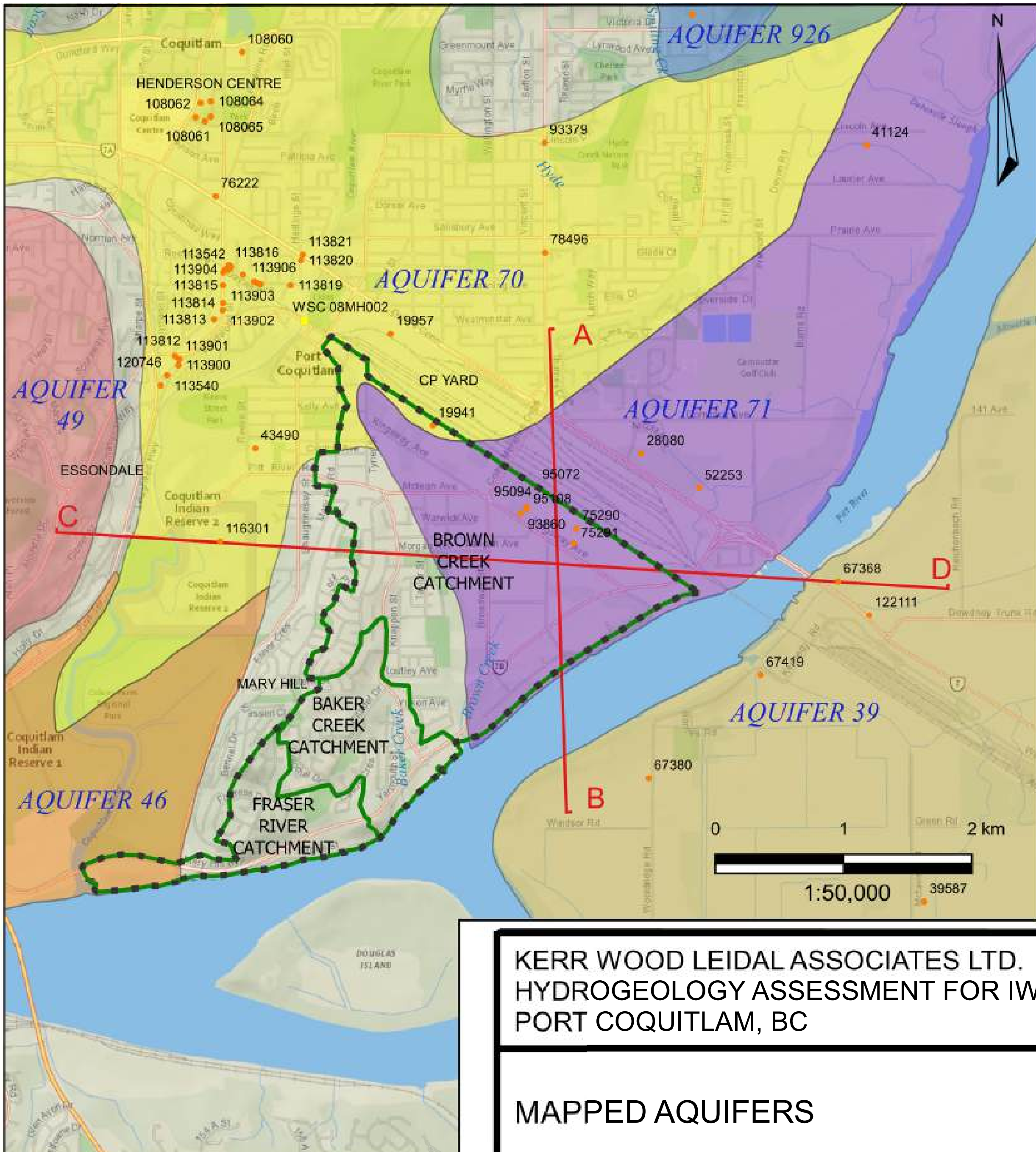
UPV Till, glaciofluvial, glaciolacustrine, fluvial, marine, and organic sediments.

KERR WOOD LEIDAL ASSOCIATES LTD.
HYDROGEOLOGY ASSESSMENT FOR IWMP
PORT COQUITLAM, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

SURFICIAL GEOLOGY

BY:	DATE:
AB	MAR 24
APPROVED:	FIG:
DJT	1



Legend

- Study Area
- A B Cross Section
- Water Survey of Canada Gauging Station
- Registered Well

Mapped Aquifers

- 39
- 46
- 49
- 70
- 71
- 926

KERR WOOD LEIDAL ASSOCIATES LTD.
HYDROGEOLOGY ASSESSMENT FOR IWMP
PORT COQUITLAM, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

MAPPED AQUIFERS

BY:	DATE:
AB	MAR 24
APPROVED:	FIG:
DJT	2

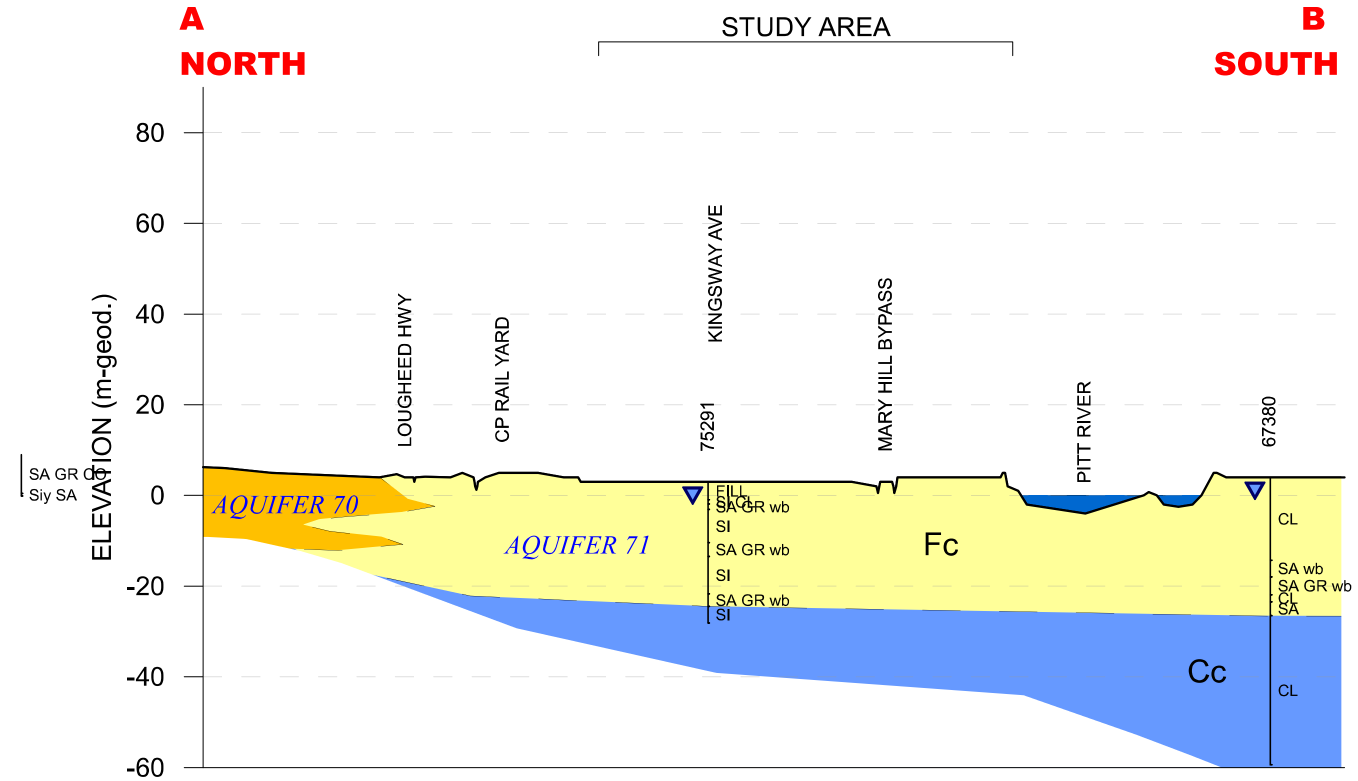
C:\Users\Arnd.Burgert\Documents\GIS\4604\Aquifers.axz

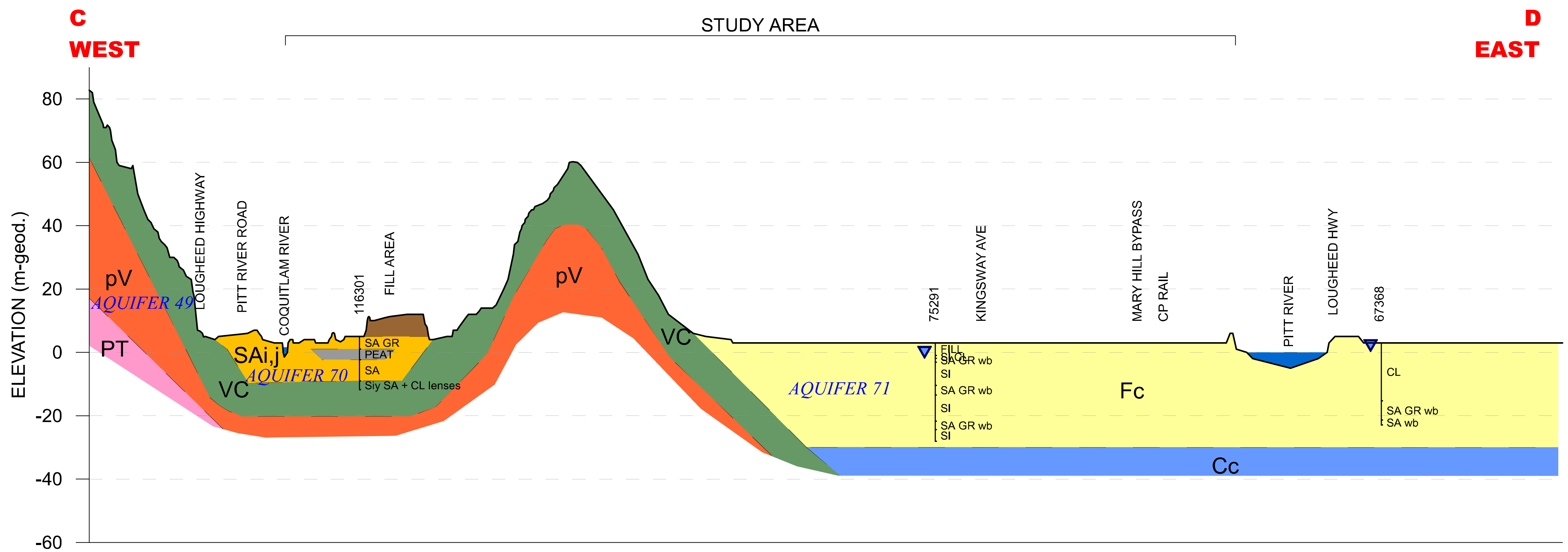
H:\Project\4604\XS\XS_A and C-r1.grf

SCALE 1 : 25,000

0 250 500 750 1000 m

VERTICAL EXAGGERATION 15X





LEGEND

Interpreted Lithology:

- SAi,j SALISH SEDIMENTS - mountain stream sand and gravel
- Fc FRASER RIVER SEDIMENTS - fluvial silty sand
- Cc CAPILANO SEDIMENTS - shallow marine sand and silt
- VC VASHON DRIFT AND CAPILANO SEDIMENTS - till and shallow marine
- pV PRE-VASHON - glaciofluvial sand and gravel
- PT PRE-TERTIARY - igneous bedrock

Registered Well with Well Tag No. 50419

Water Level

CL
TILL
SA
TILL
Siy SA

ABBREVIATIONS

BO boulder SA sand
CO cobble SI silt
GR gravel CL clay

NOTATIONS

wb water-bearing

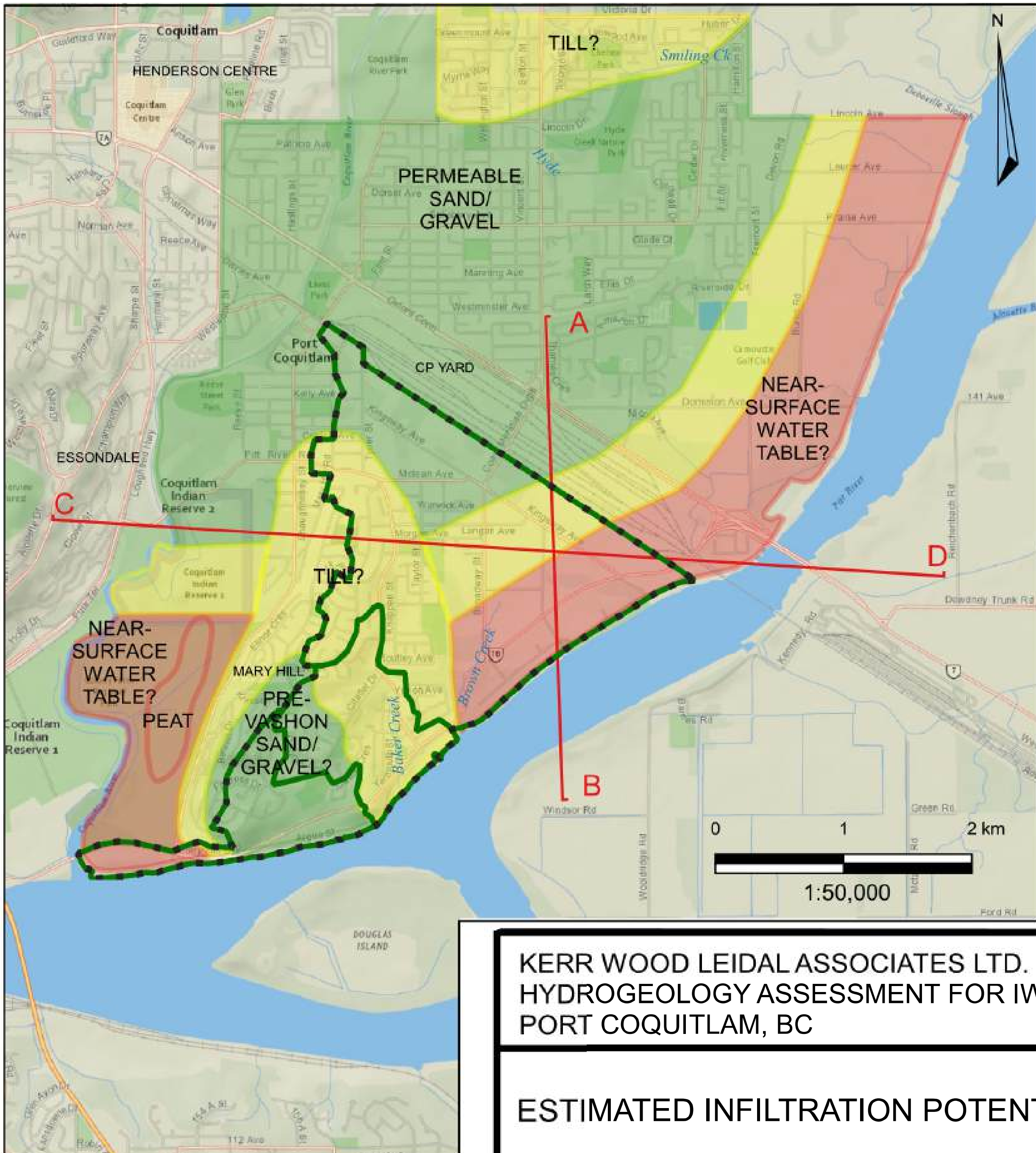
KERR WOOD LEIDAL ASSOCIATES LTD.
HYDROGEOLOGY ASSESSMENT FOR IWMP
SOUTH PORT COQUITLAM, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

CROSS SECTIONS A-B AND C-D

BY:	DATE:
AB	MAR 24
APPROVED:	FIG:
DJT	3

C:\Users\Arnd.Burgert\Documents\GIS\4604\Infiltration.qgz



Legend

Study Area

Cross Section

Assessed Infiltration Potential

- High Subject To Detailed Assessment
- Moderate
- Risk Factor To Be Assessed

PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.

KERR WOOD LEIDAL ASSOCIATES LTD.
HYDROGEOLOGY ASSESSMENT FOR IWMP
PORT COQUITLAM, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

ESTIMATED INFILTRATION POTENTIAL

BY:	DATE:
AB	MAR 24
APPROVED:	FIG:
DJT	4

KERR WOOD LEIDAL
consulting engineers

Appendix B

Hydrologic/Hydraulic Modelling

Appendix B – Modelling

Figures

Tables

1. Introduction

1.1. Background

The City of Port Coquitlam (the City) retained Kerr Wood Leidal Associates Ltd. (KWL) to:

- Update its 2015 storm sewer system hydraulic model within the South Port Coquitlam Integrated Water Management Plan study area.
- Conduct a comprehensive assessment of the storm sewer system as well as a lowland flooding and pump capacity.

Using the updated model, KWL evaluated the existing system hydraulic performance using the HLoS rating system for pipes and culverts, identified flooding issues in the lowland area, and recommended conveyance and pump upgrades.

This appendix summarizes the updates to the stormwater model that are not described in the main body of the report. The updated model provides the basis for determining the required infrastructure to meet the expected demands of the City's Official Community Plan (OCP).

The scope of modelling work included:

- Conducting field site visit to confirm the condition of culverts and outfalls and to check for obstructions and debris.
- Updating the storm sewer model based on new GIS data supplemented by the survey data, pump station inventory data, and existing and future land use data provided by the City.
- Updating the catchment boundaries, land use, and runoff outlets.
- Confirming the model calibration after model update.
- Conducting modeling analysis for the existing and future development conditions.
- Identifying and prioritizing upgrade requirements using the HLoS rating system.
- Adding a 2D portion to the model in the lowland area to examine flood routing issues and assess pump capacity.

The PCSWMM software was used to perform the hydrologic and hydraulic modelling of the South Port Coquitlam IWMP drainage system including:

- 3936 subcatchments
- 55 km of storm sewers
- 15 culverts
- 5.3 km of creek channels and ditches
- 950 manholes

Drainage catchments were defined by the storm sewer network and the major outfall locations and their upstream tributary areas. The total project area and three main catchments are shown on Figure B-1.

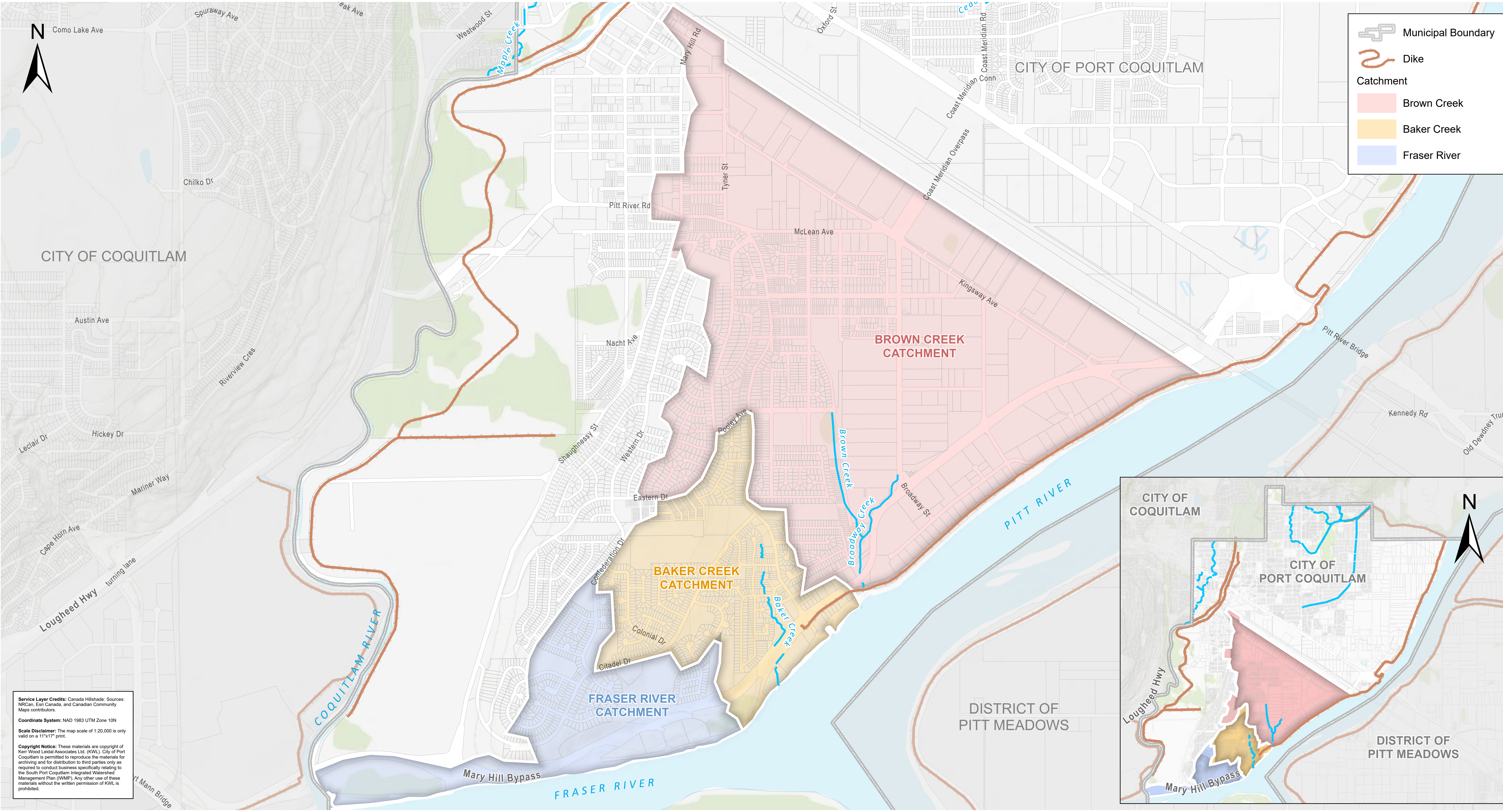
Modelling results are summarized in the main report as well as in Appendix C - Drainage Assessment.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Study Area

Figure B-1

2. Model Validation

The existing condition model calibration was checked after the model edits were complete to ensure the model results still matched the observed flow. The calibration flow monitoring data collected at the Kingsway and Pooley Flow Gauges (October 2014 – January 2016) was used with the real storm events from December 2014 to March 2015. Figure B-2 shows the locations of the monitoring stations and their catchments. The updated validation check results can be seen in Figure B-3 and B-4.

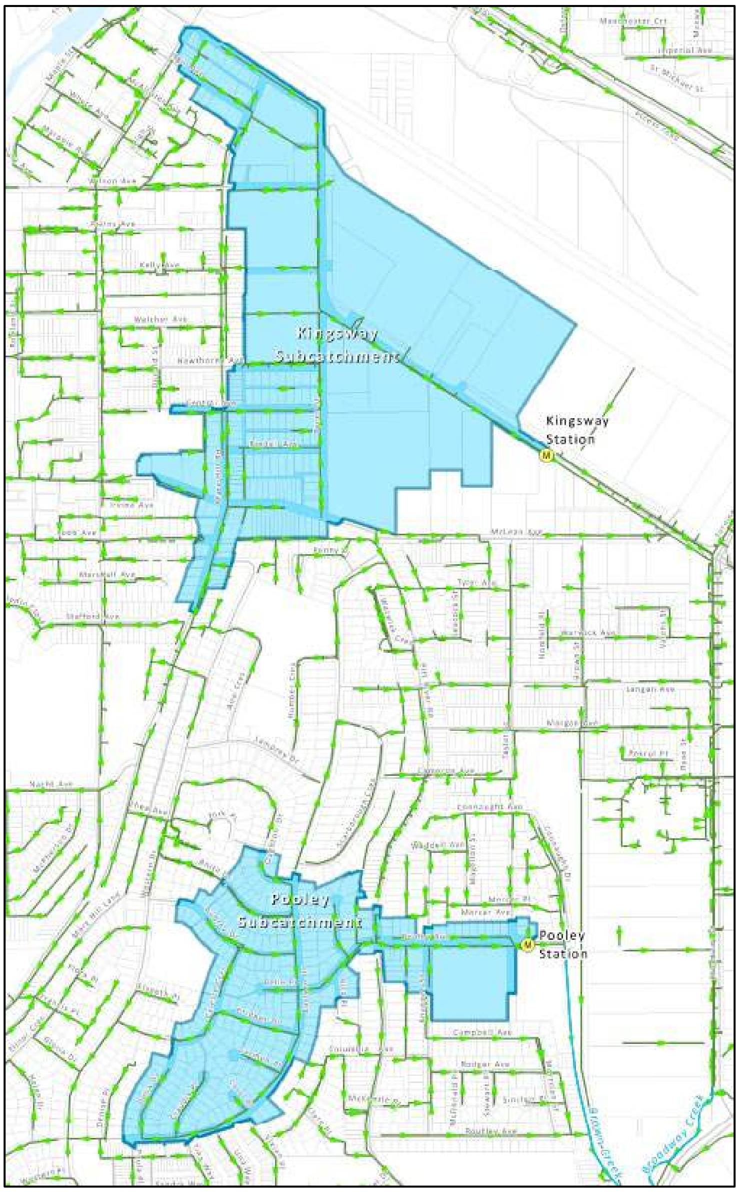


Figure B-2: Kingsway and Pooley Flow Gauges and Tributary Catchments

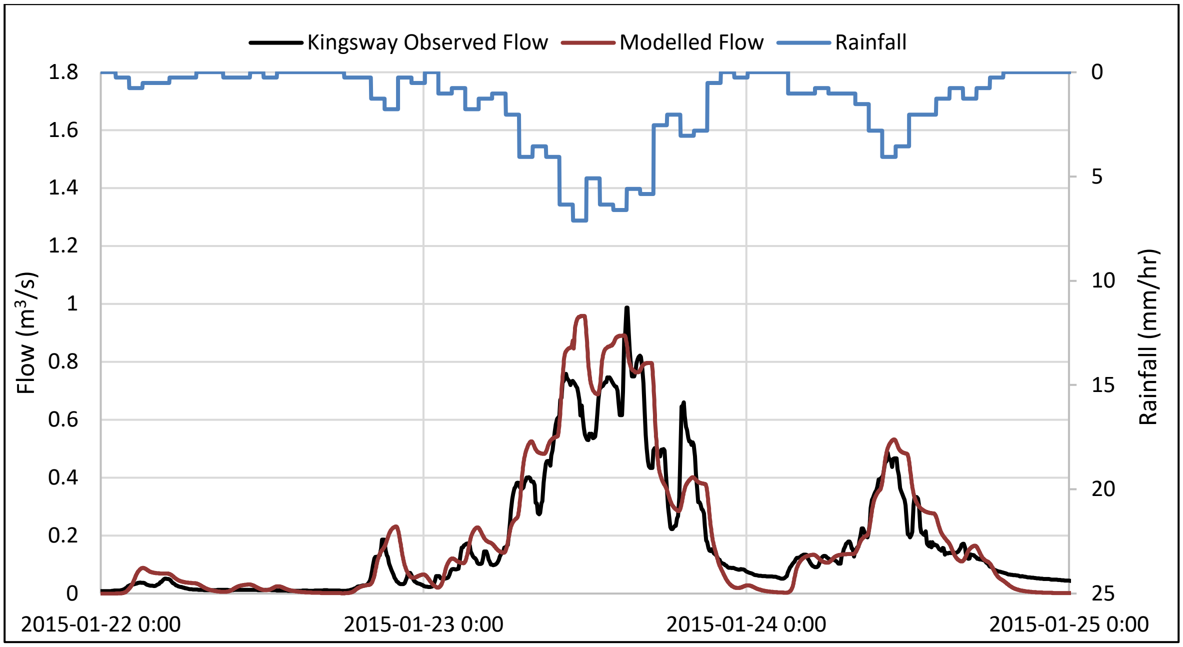


Figure B-3: Model Validation Result (December 25, 2014 to January 26, 2015)

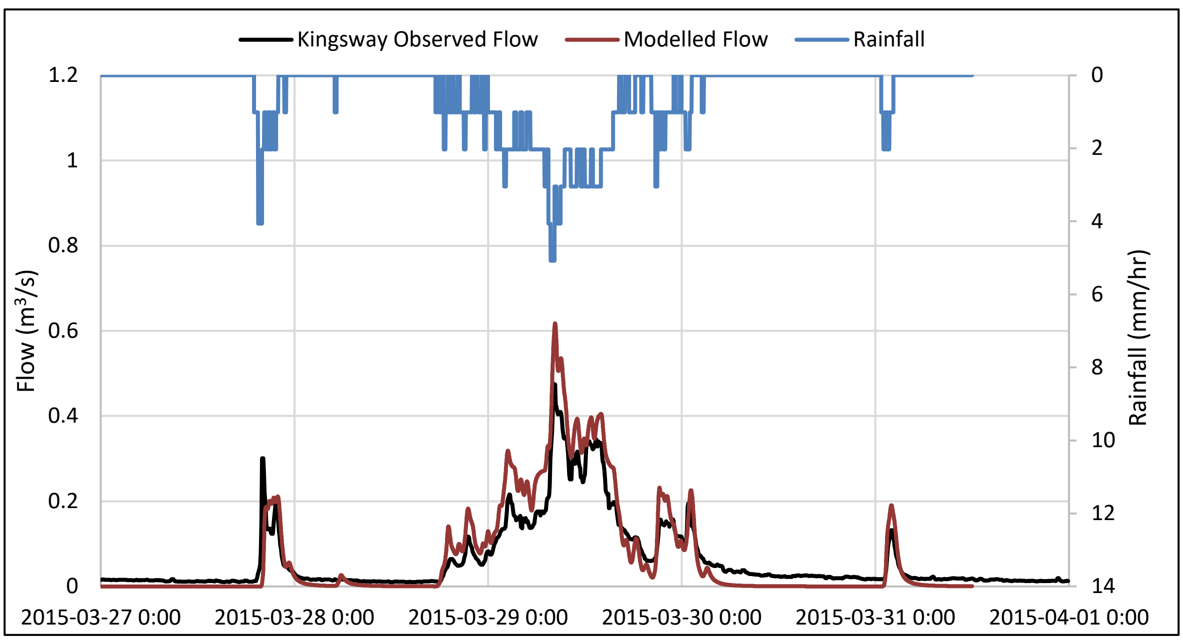


Figure B-4: Model Validation Result (March 26, 2015 to March 31, 2015)

Table B-1 shows the peak flow and total volume comparison between the observed and modelled flows. The modelled peak flows are within 97-98% of the observed flows and the volumes are within 89%-90% of the total volume.

Table B-1: Peak Flow and Total Volume Comparison Between Observed and Modelled Flows

Storm Event	Duration (days)	Peak Flow Modelled (m^3/s)	Peak Flow Observed (m^3/s)	Volume Modelled (m^3)	Volume Observed (m^3)
January 22 2015 - January 25 2015	3	0.959	0.988	51,750	46,760
March 26 2015 - March 31 2015	4	0.466	0.475	29,310	26,080

3. 2D Model Development

To assess lowland flooding and pump station capacity, a 2D overland component was added to the 1D existing model. A 2D mesh was added to the 1D network throughout the lowland area, covering the area where the 1D model showed potential flooding to the ground surface in the 10-year and 100-year events. The mesh extent is shown in Figure B-5.

The 2D mesh was overlayed on top of the 1D network but the channels were reduced in depth to ensure volume was not duplicated in both the 1D and 2D networks. This was done by editing the channel cross-sections so that the highest point of the cross-section matched the invert at the connection point in the 2D mesh.

The subcatchments were still connected to the 1D system and the water in the 2D mesh was overland flow from water surcharging in pipes. The 2D model surface along the roads and water conveyance channels used a smaller mesh size (5 m) while all other areas used a larger mesh size (10 m).

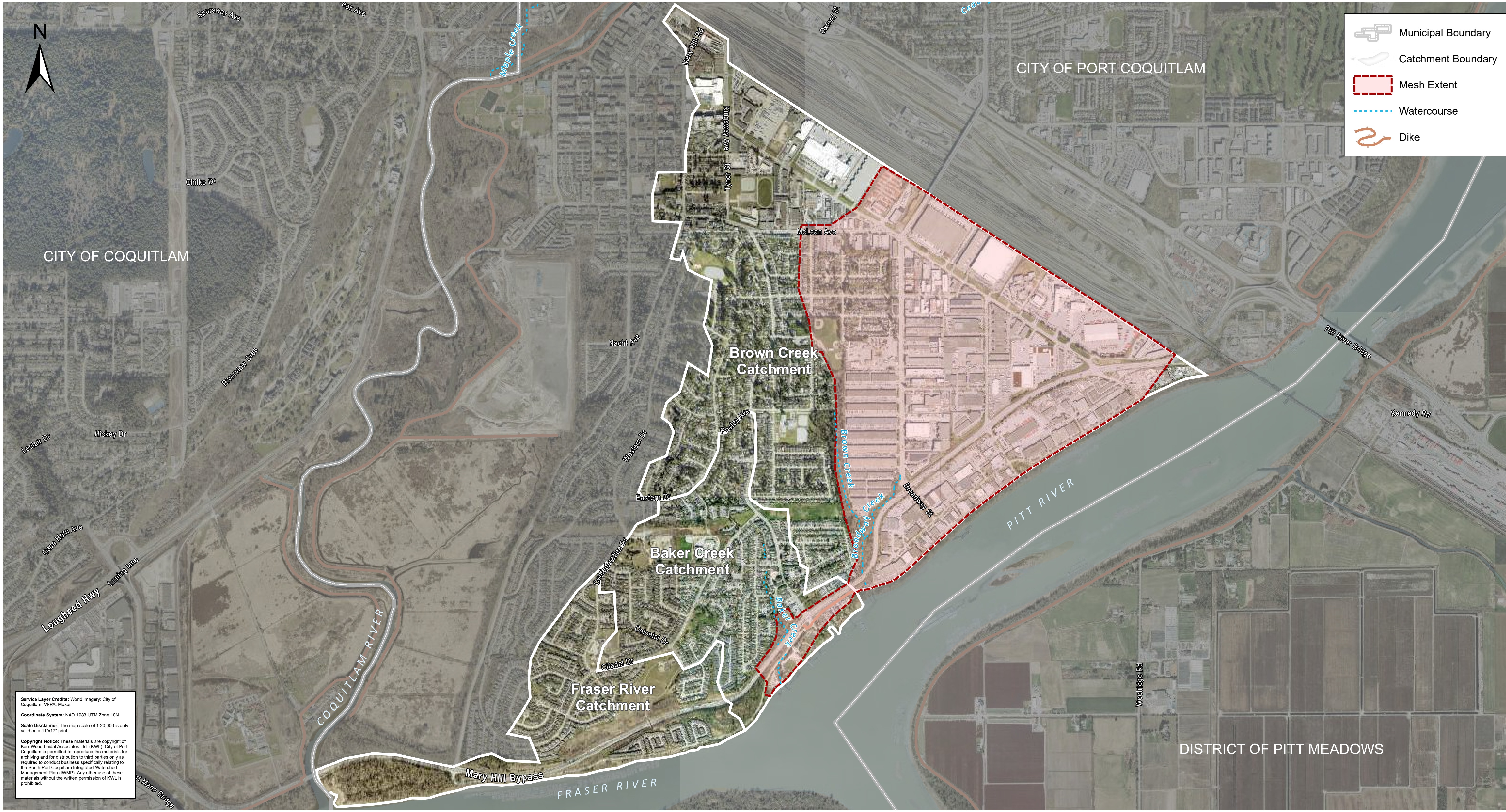
This 2D model was first used to determine flooding extent (in the lowland area) with existing infrastructure under existing and future land use and climate conditions. Then, all pipes were upgraded as per the conveyance assessment to determine which areas flooded due to pump capacity constraints and not due to undersized pipes. For the pump capacity scenarios, the total pump capacity of the Harbour St Storm Pump Station was increased until no major flooding in the lowlands was simulated. Table B-2 summarizes the modelled scenarios and Appendix C outlines the results of the lowland flood and pump assessment models.

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

2D Model Mesh Extent

Figure B-5

4. Modelling Scenarios

Table B-2 below outlines the list of modelling scenarios.

Table B-2: Summary of Modelling Scenarios

Scenario	Design Storms and IDF	Land Use
Storm Sewer Conveyance Capacity Assessment Boundary Condition: Free Outfall.		
Minor System Assessment HLoS Ranking	10-year, 1-, 6-, 12-hour Historic IDF	Existing Land Use
	10-year, 1-, 6-, 12-hour Climate Change IDF	Future Land Use
Major System Assessment HLoS Ranking	100-year, 1-, 6-, 12-hour Historic IDF	Existing Land Use
	100-year, 1-, 6-, 12-hour Climate Change IDF	Future Land Use
Lowland Flooding and Pump Capacity Assessment Boundary Condition: Tidal series peaking at 100-year Winter Fraser River Water Levels + SLR		
Existing Land Use Flooding	100-year 1-, 6-, 12-hour & 2.5-day Historic IDF	Existing Land Use
Future Land Use Flooding	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use
Future Land Use Flooding Upgraded Pipes	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use
Future Land Use Flooding Upgraded Pipes Increased Pump Capacity (1.5 x)	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use
Future Land Use Flooding Upgraded Pipes Increased Pump Capacity (2 x)	100-year 1-, 6-, 12-hour & 2.5-day Climate Change IDF	Future Land Use

The purpose of each scenario and key results are described in the main report. All results are included in Appendix C.

KERR WOOD LEIDAL
consulting engineers

Appendix C

Drainage System Assessment

Appendix C – Drainage Assessment

Figures

Tables

1. Drainage Assessment

This appendix summarizes the hydrotechnical assessment results in addition to what is included in Section 4 of the main report covering assessment of:

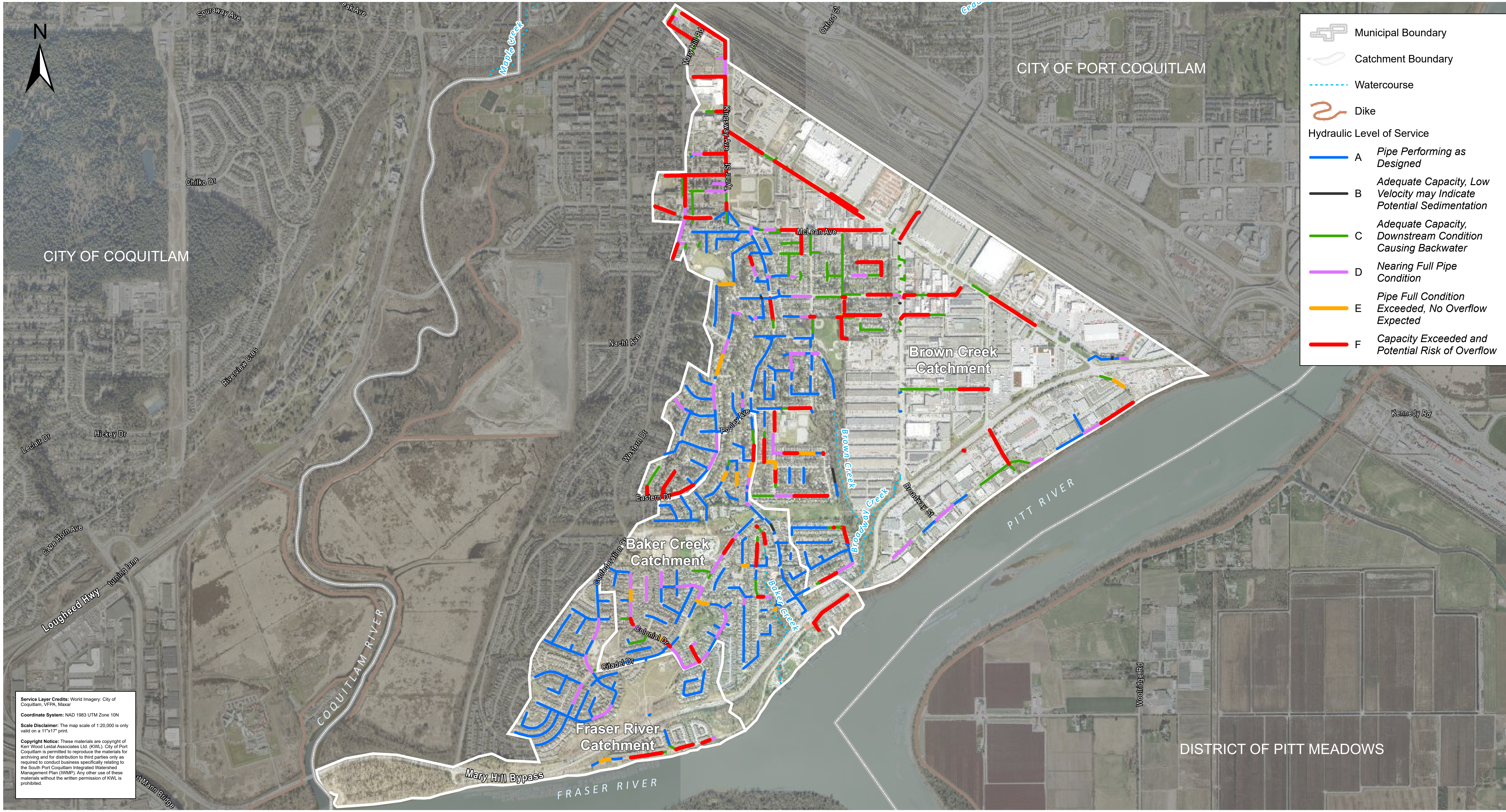
- Minor and major storm sewers;
- Culverts;
- Ditches and watercourse; and
- Lowland flooding and pump station capacity.

Section 4 of the main report includes the assessment criteria as well as additional details and interpretation of the results. The assessments did not include pipe condition or age and used instantaneous peak flows.

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No.	646.043
Date	December 2024
Scale	1:20,000

0 200 400 800 m

Existing Minor System Pipe HLoS Ranking

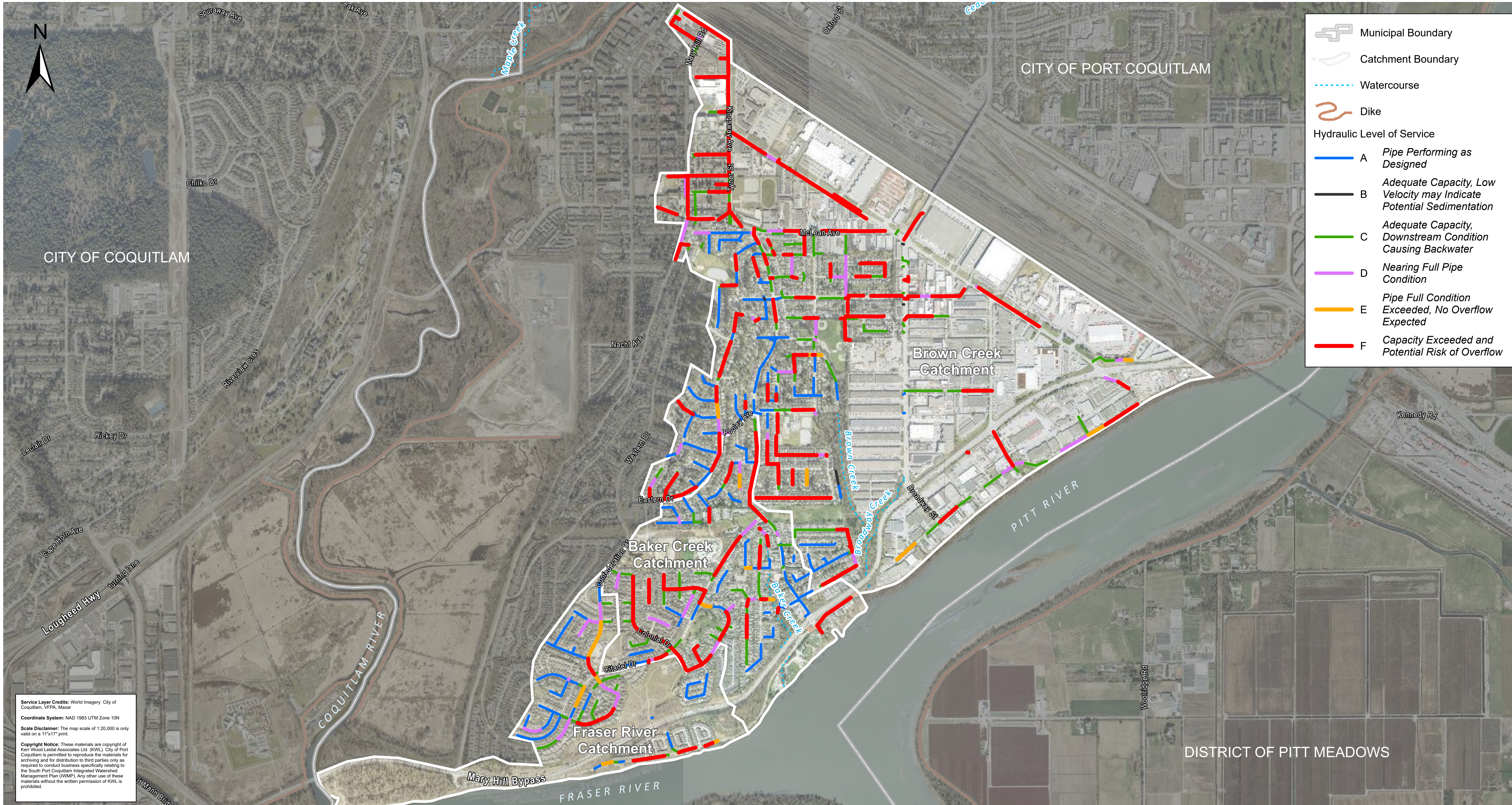
Figure C-1

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Minor System Pipe HLoS Ranking

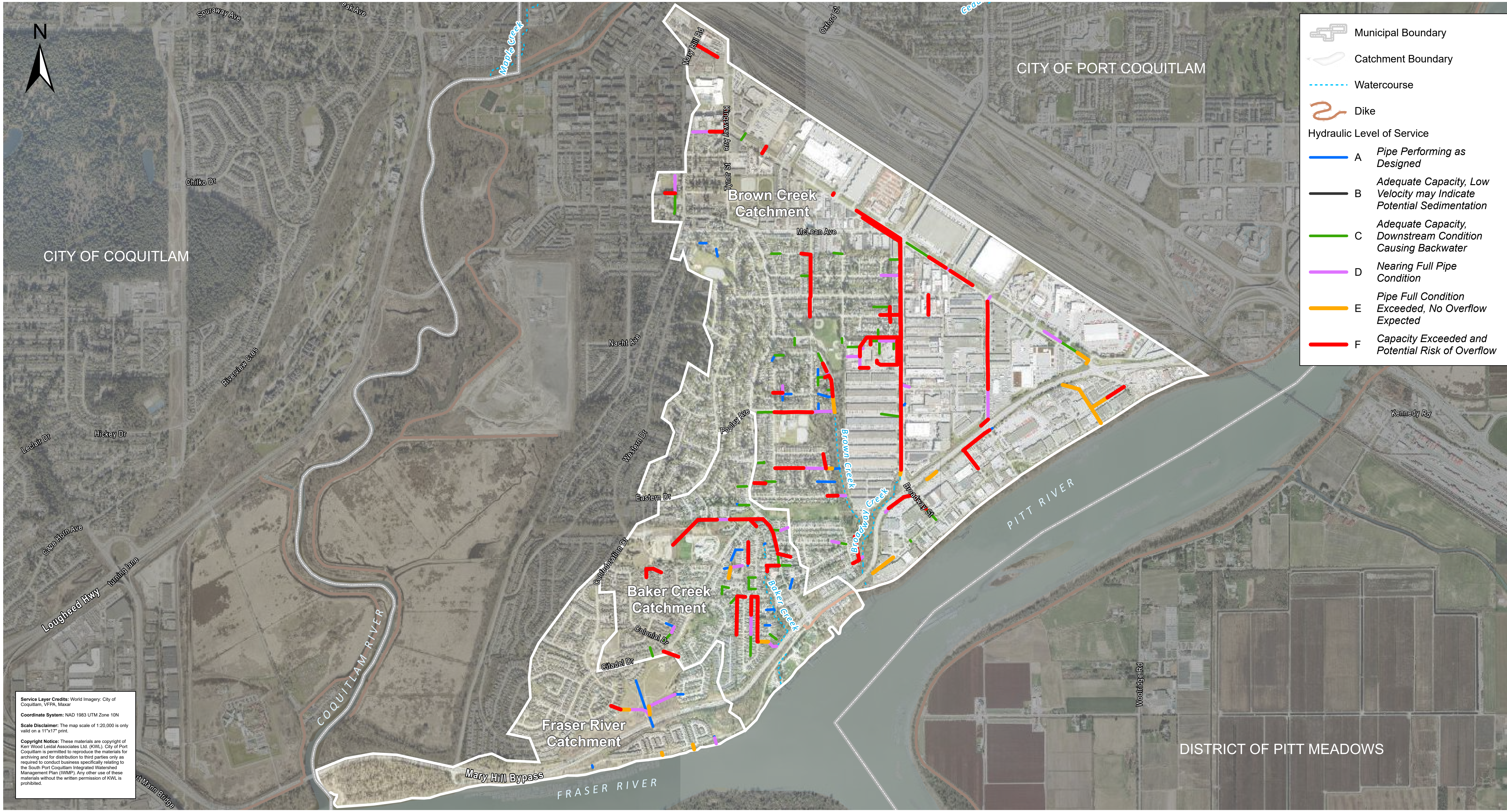
Figure C-2

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Major System Pipe HLoS Ranking

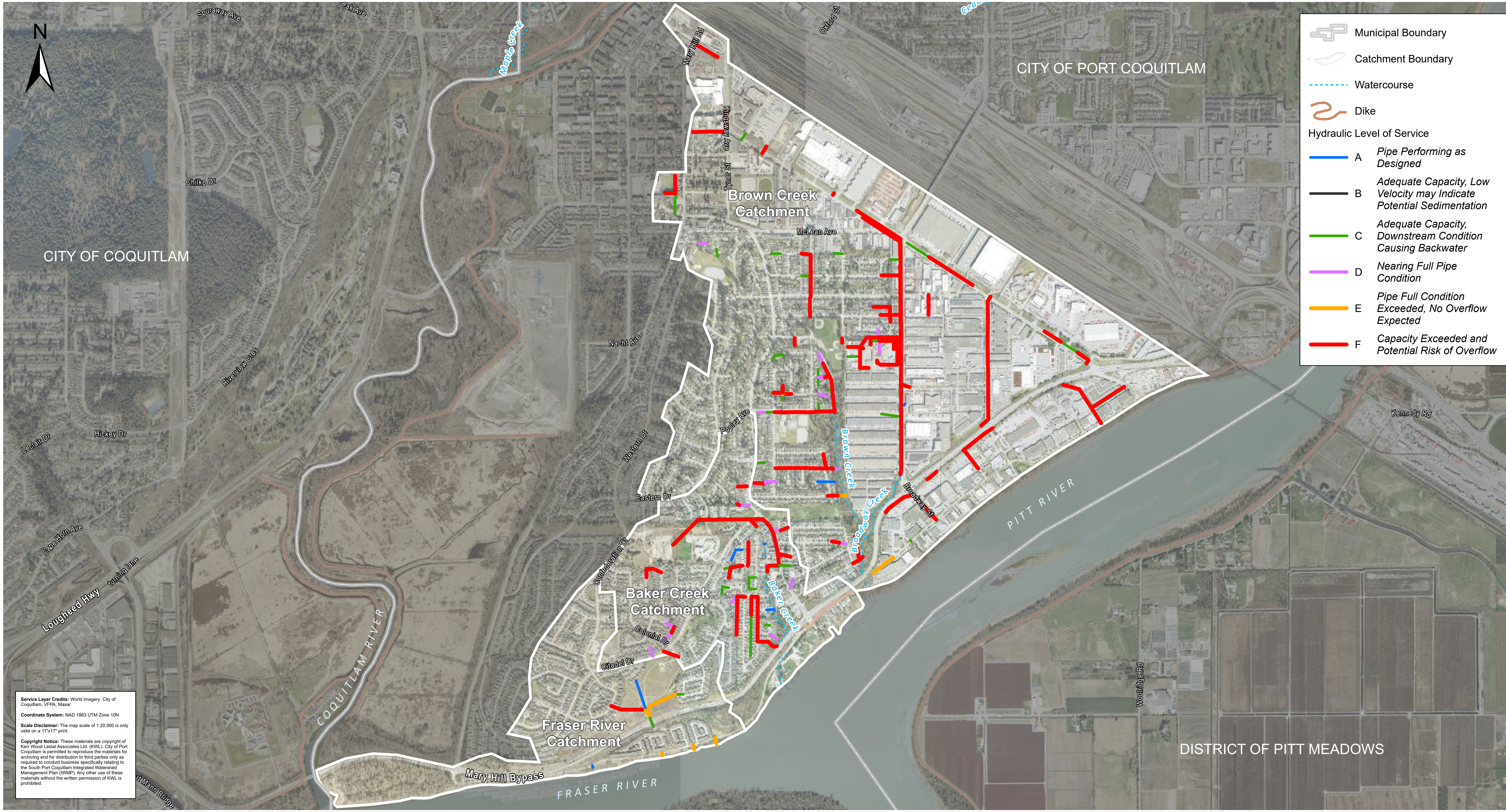
Figure C-3

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Major System Pipe HLoS Ranking

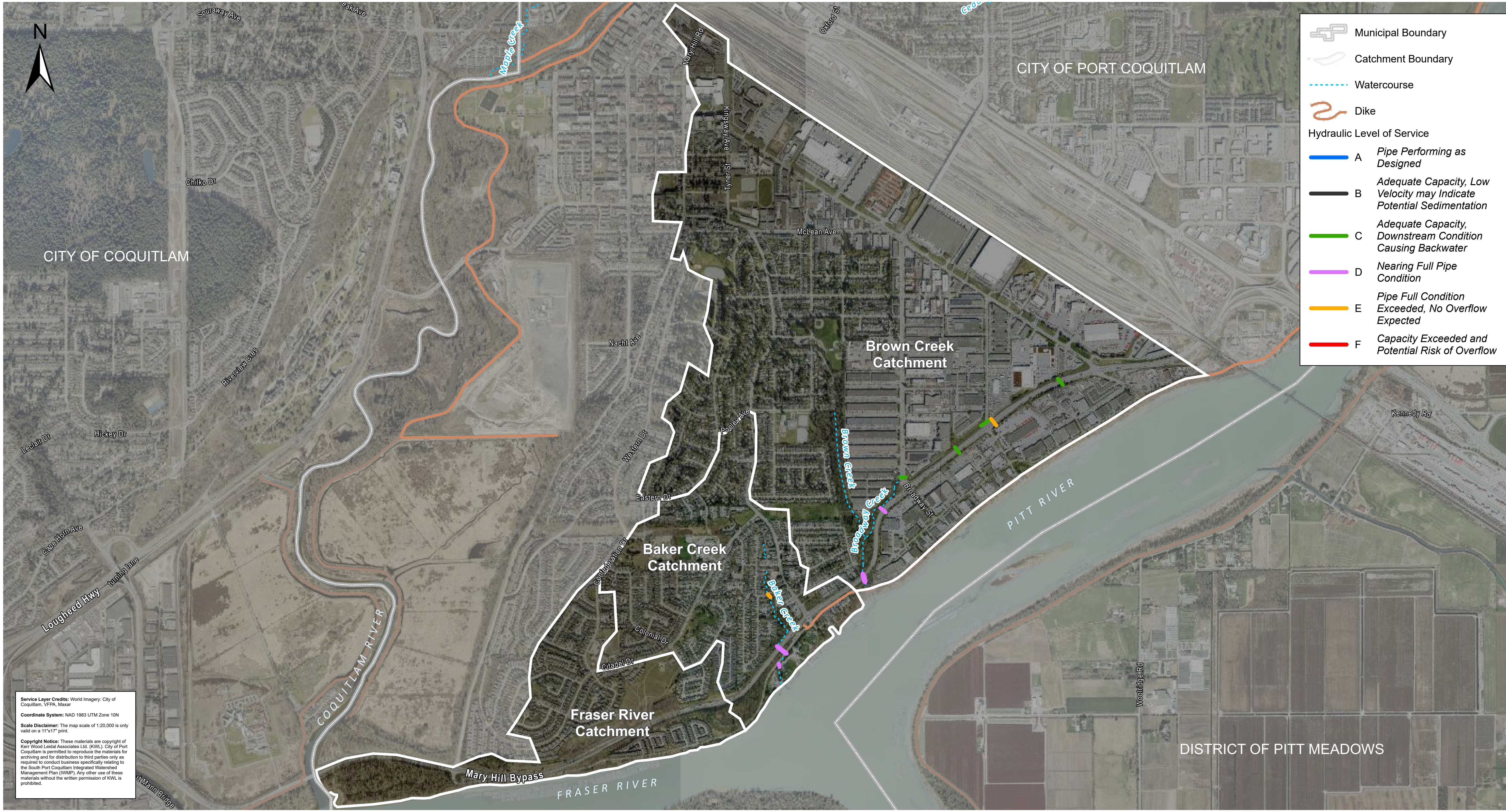
Figure C-4

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Existing Condition Culvert Ranking

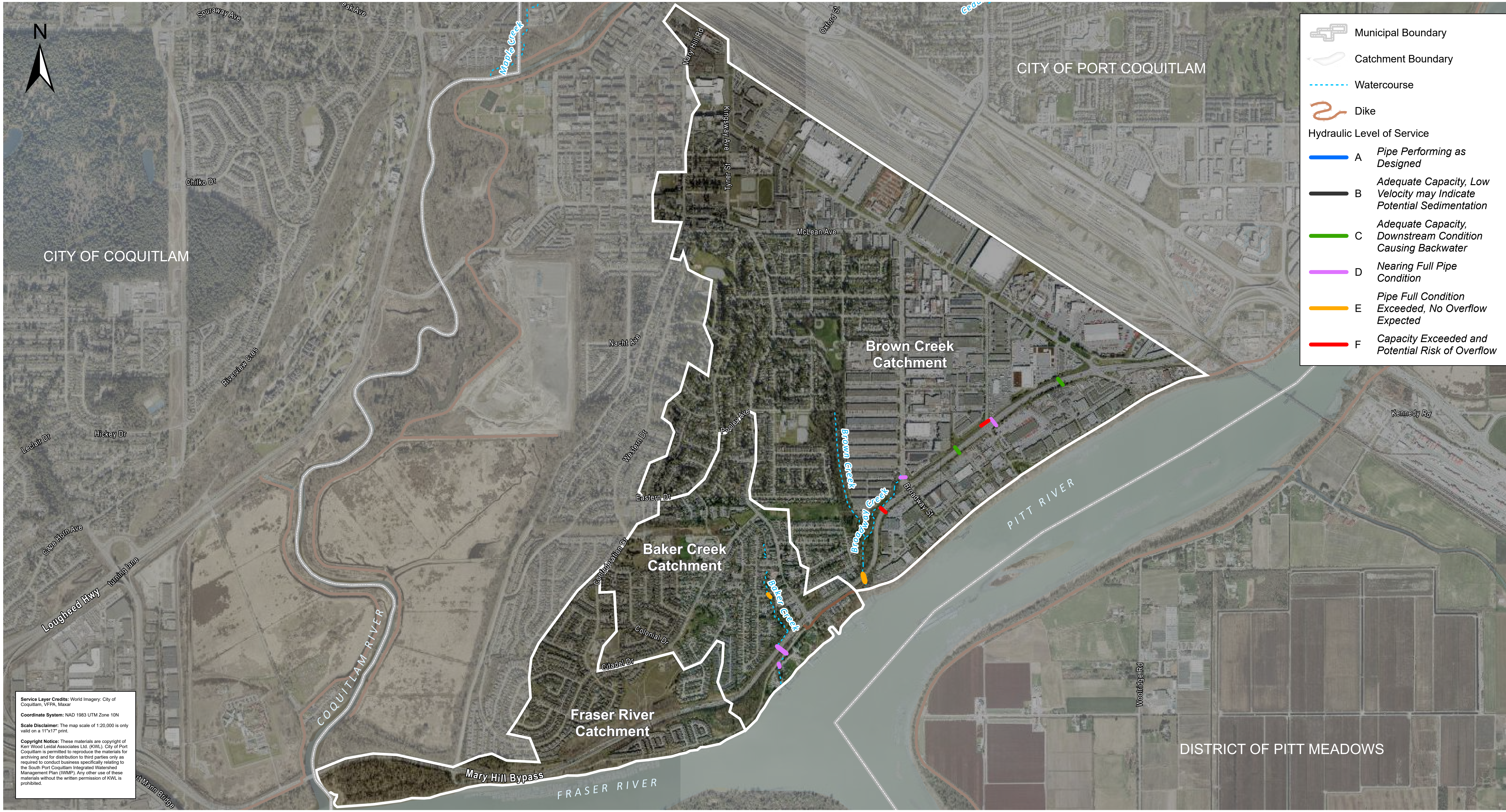
Figure C-5

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

Future Condition Culvert Ranking

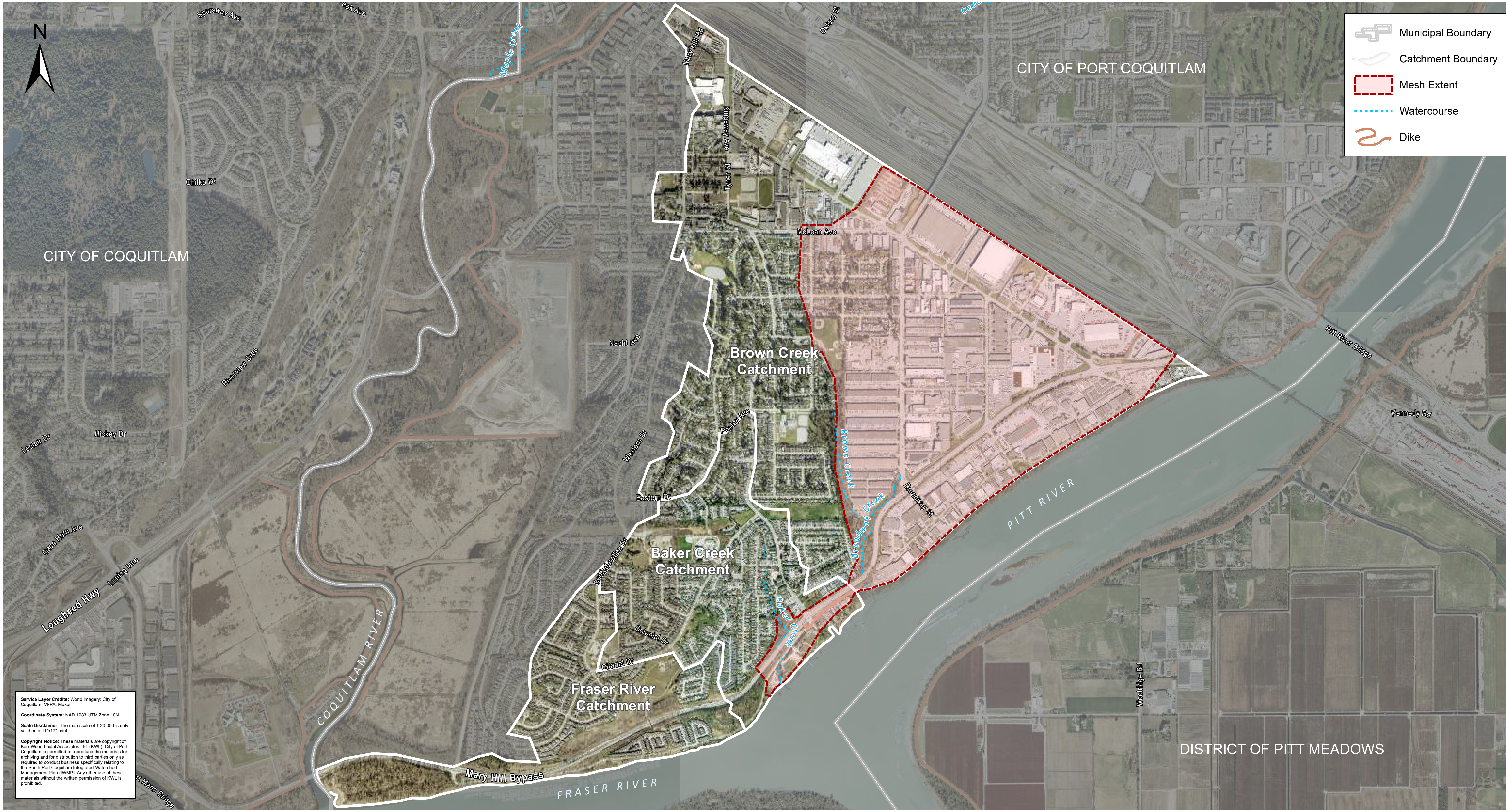
Figure C-6

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:20,000

0 200 400 800 m

2D Model Mesh Extent

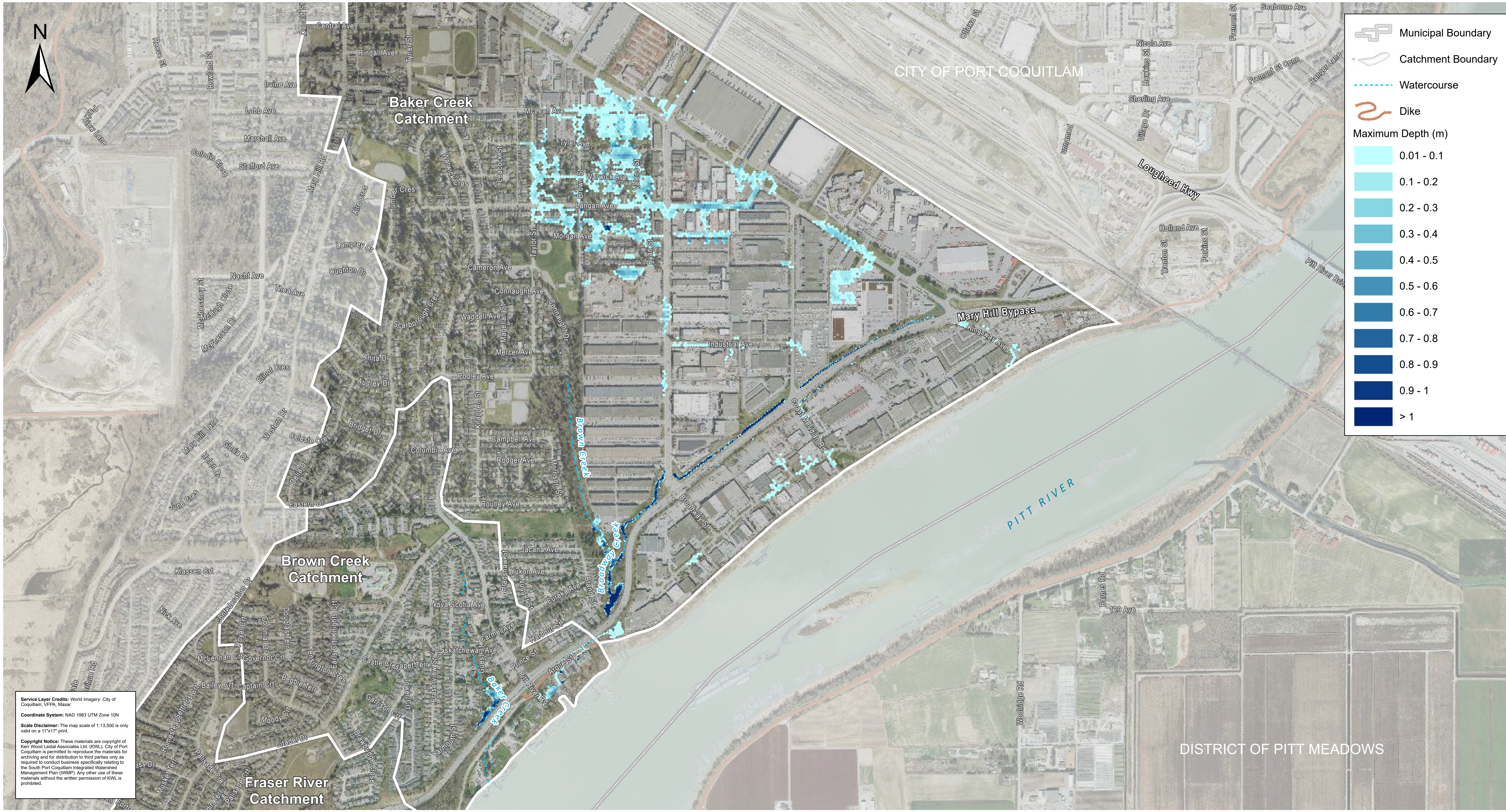
Figure C-7

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Municipal Boundary	
Catchment Boundary	
Watercourse	
Dike	
Maximum Depth (m)	
	0.01 - 0.1
	0.1 - 0.2
	0.2 - 0.3
	0.3 - 0.4
	0.4 - 0.5
	0.5 - 0.6
	0.6 - 0.7
	0.7 - 0.8
	0.8 - 0.9
	0.9 - 1
	> 1

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Existing Land use - 100-year 1-Hour Flooding

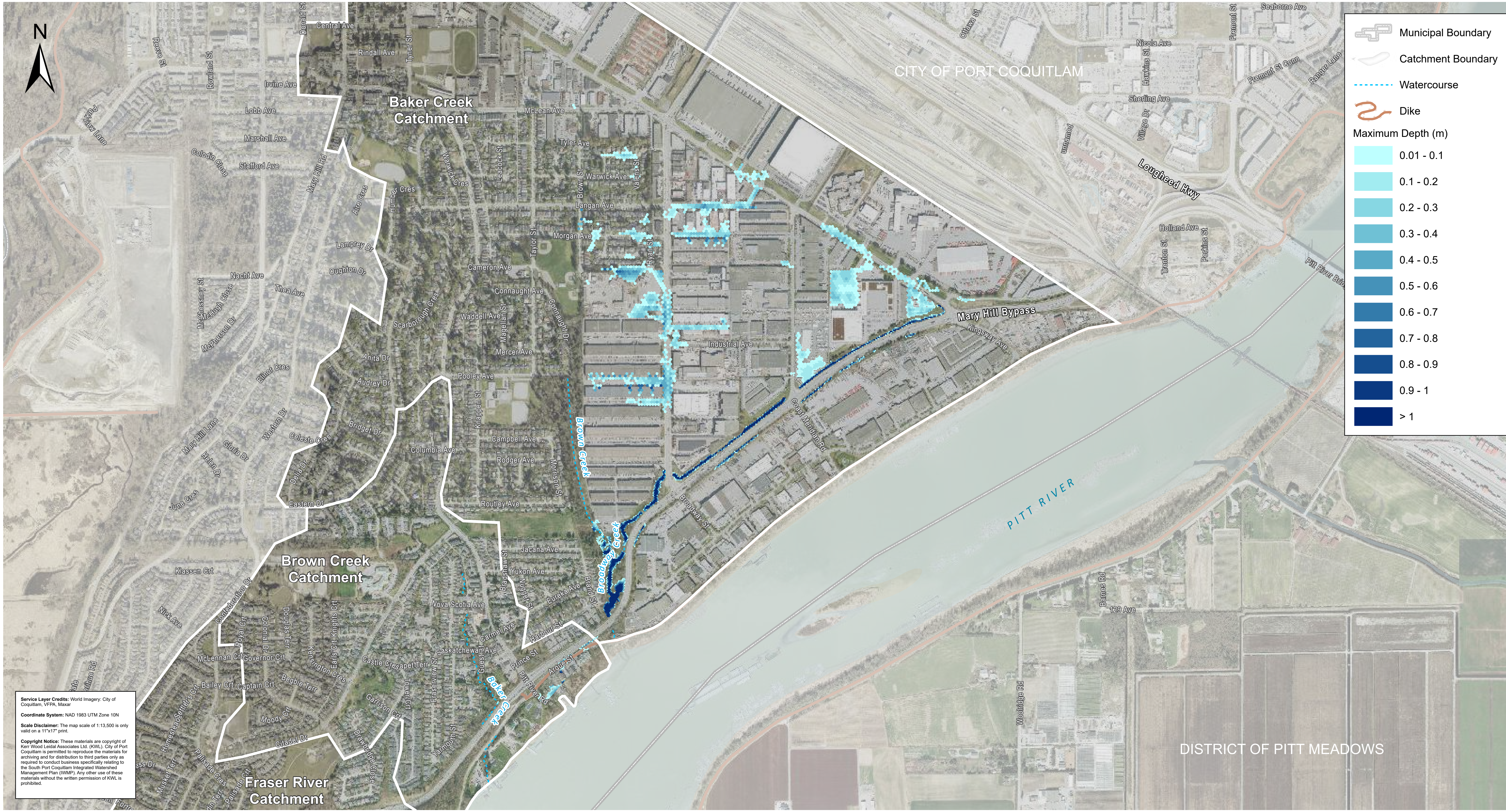
Figure C-8

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Existing Land use - 100-year 6-Hour Flooding

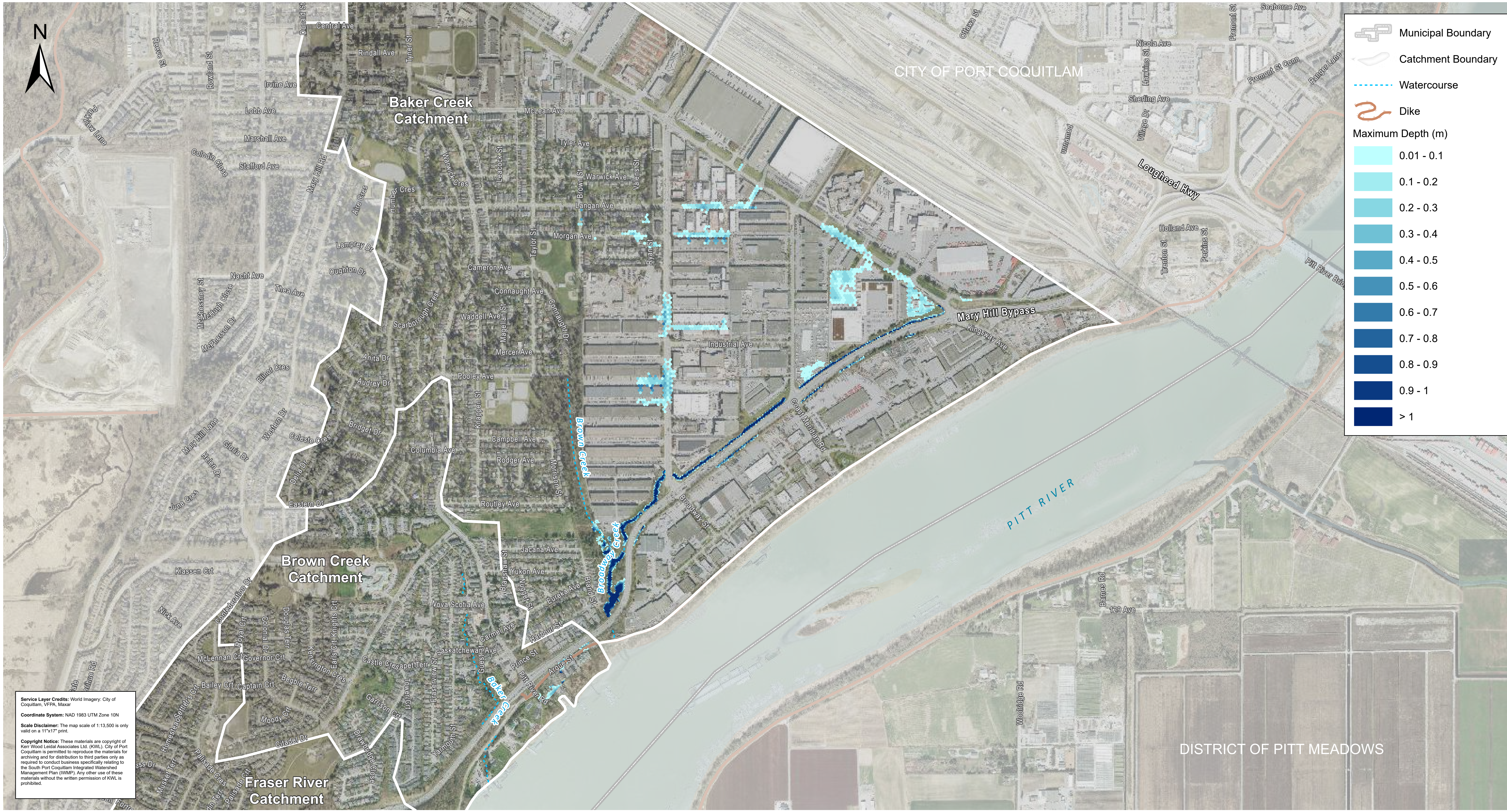
Figure C-9

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Existing Land use - 100-year 12-Hour Flooding

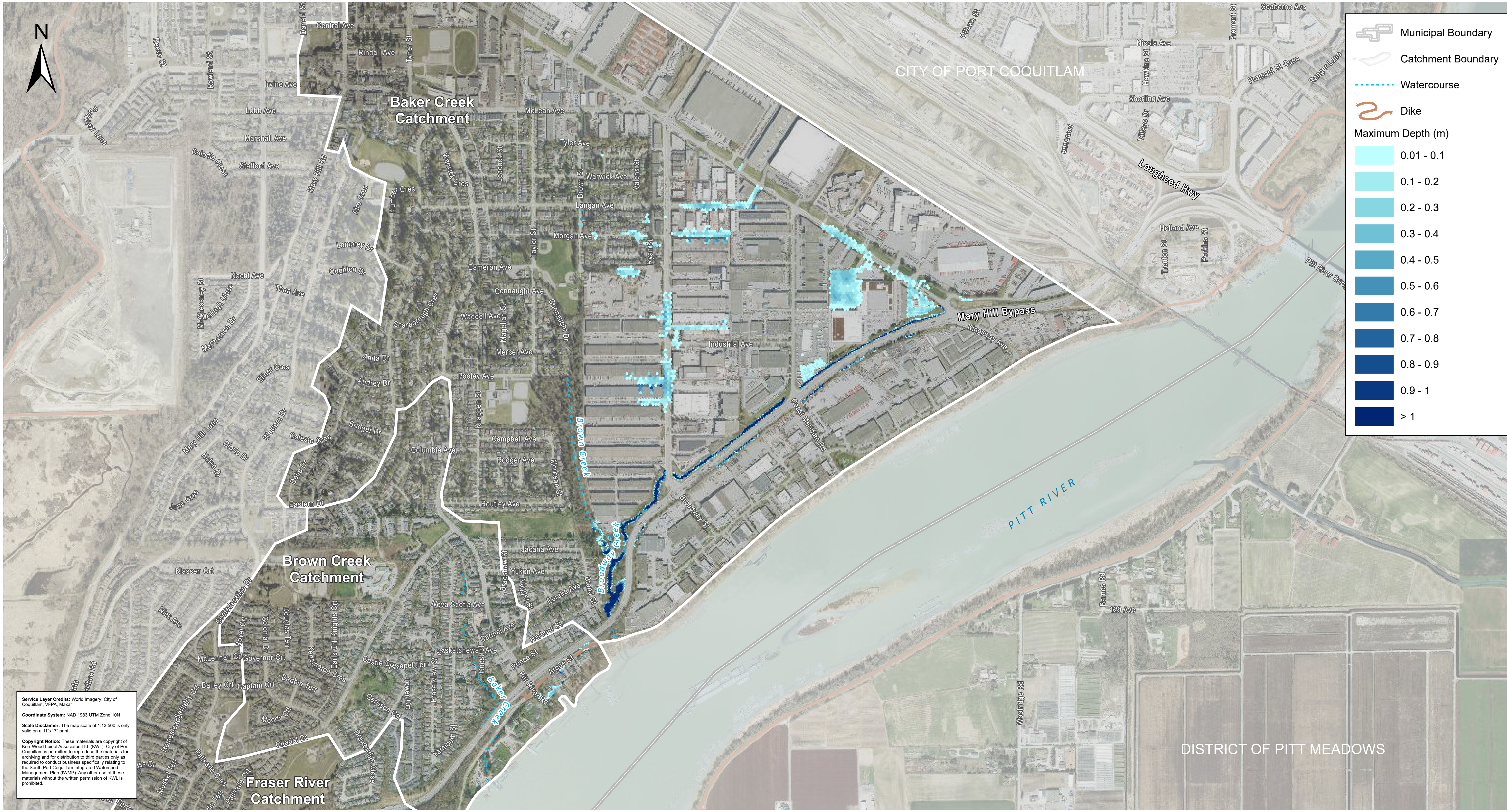
Figure C-10

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

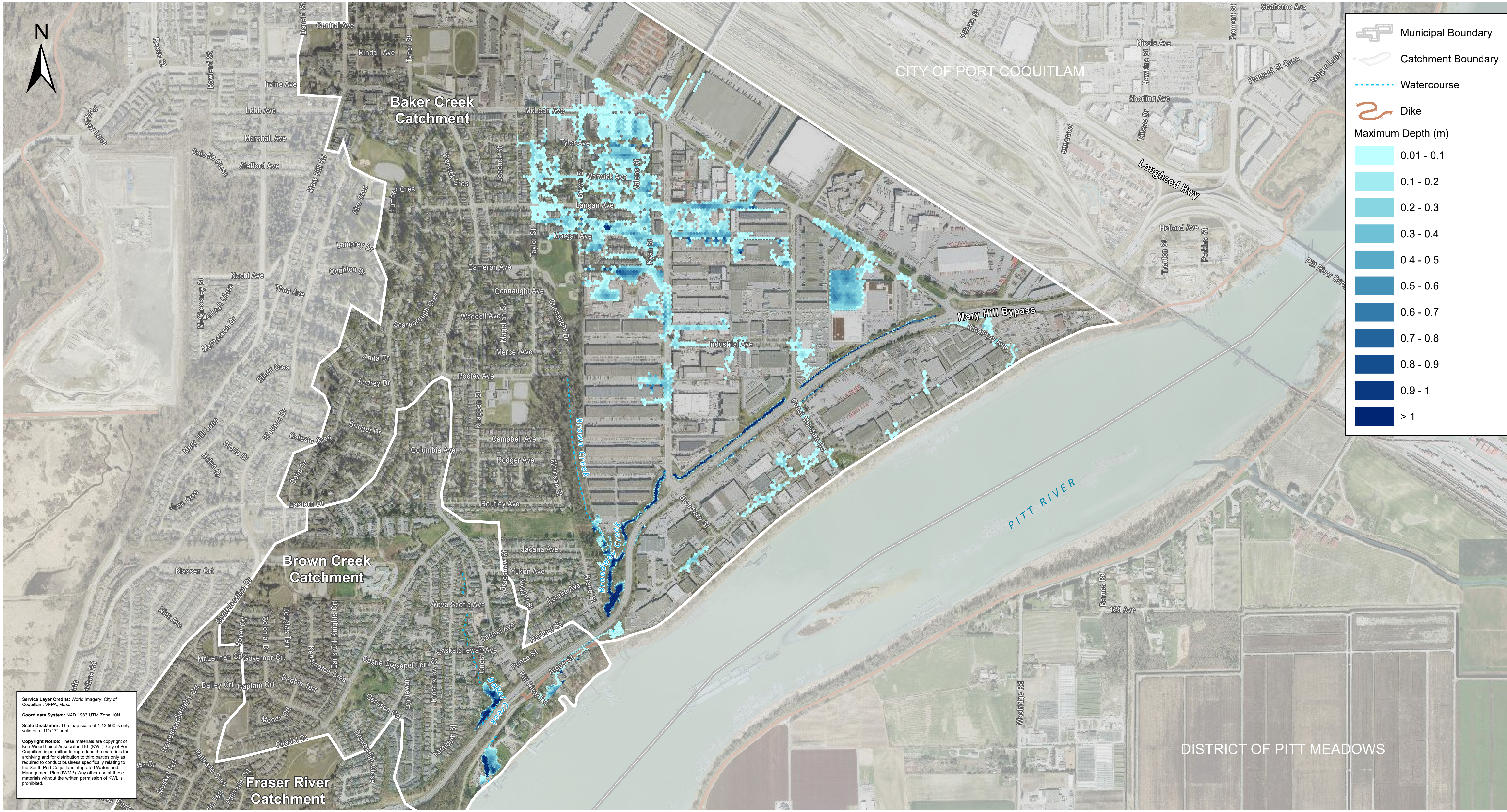
Existing Land use - 100-year 2.5 Day Flooding

Figure C-11

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

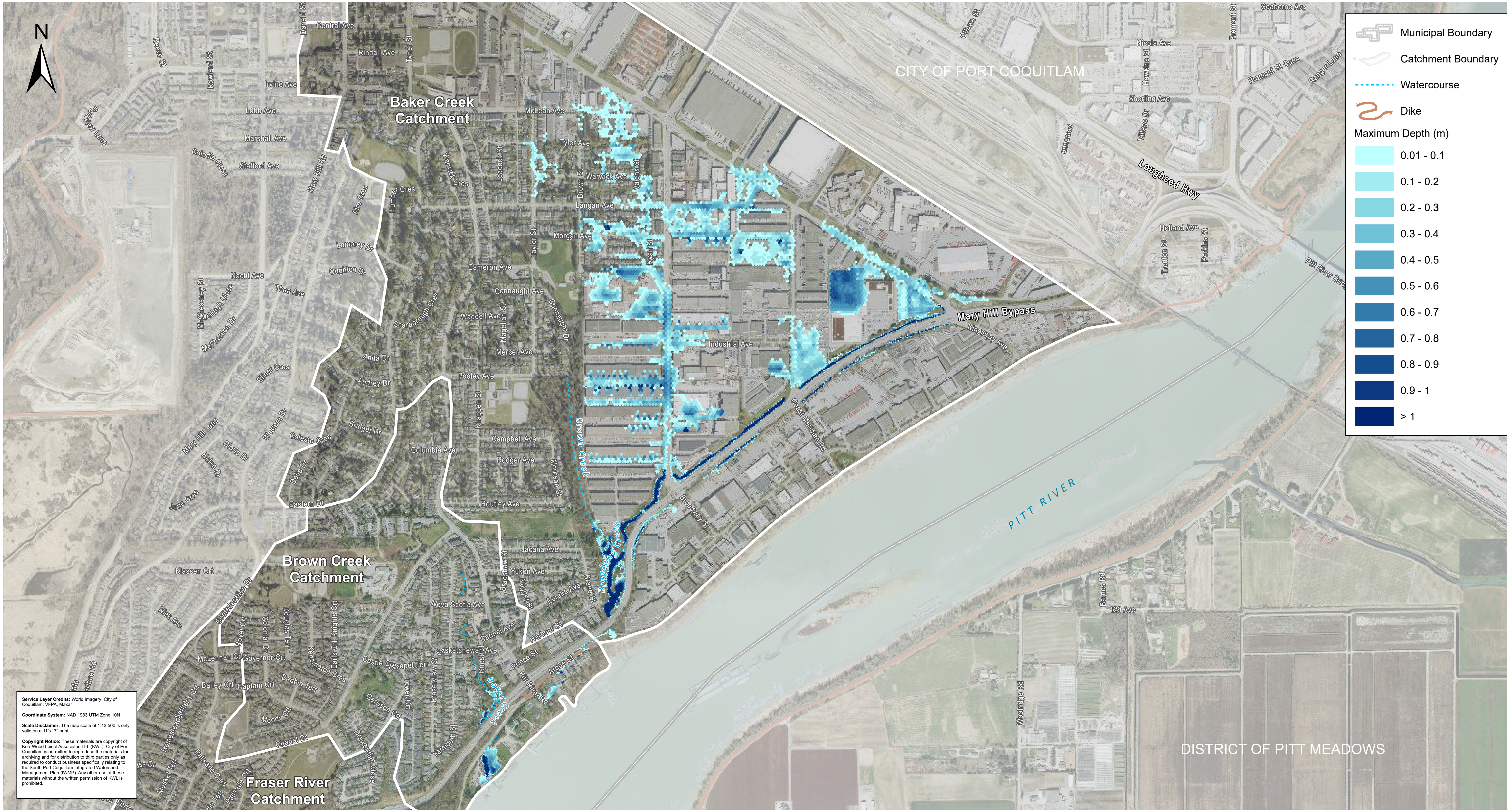
Future Land use - 100-year 1-Hour Flooding

Figure C-12

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Future Land use - 100-year 6-Hour Flooding

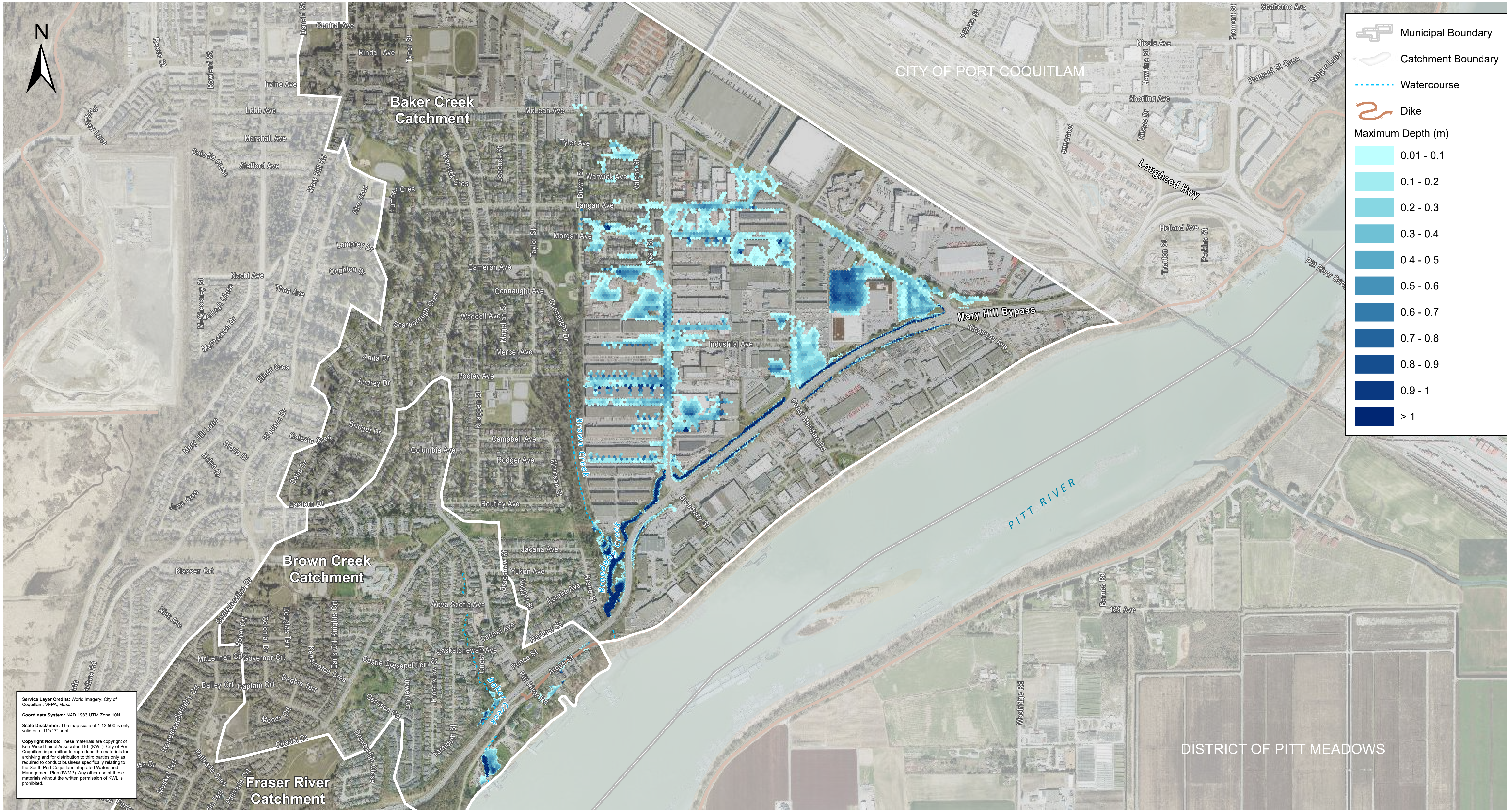
Figure C-13

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

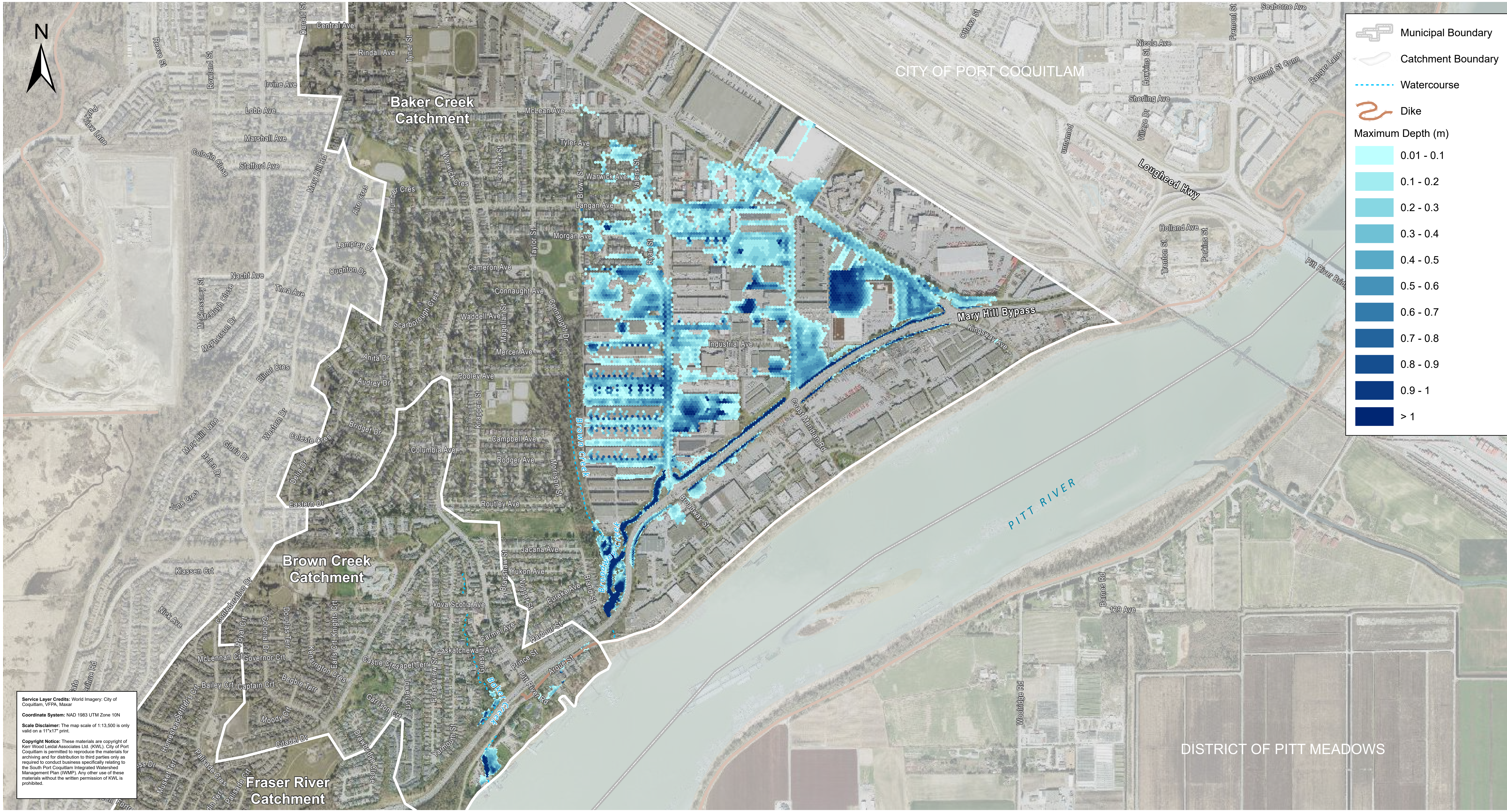
Future Land use - 100-year 12-Hour Flooding

Figure C-14

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam
South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043
Date December 2024
Scale 1:13,500
0 100 200 400 m

Future Land use - 100-year 2.5-day Flooding

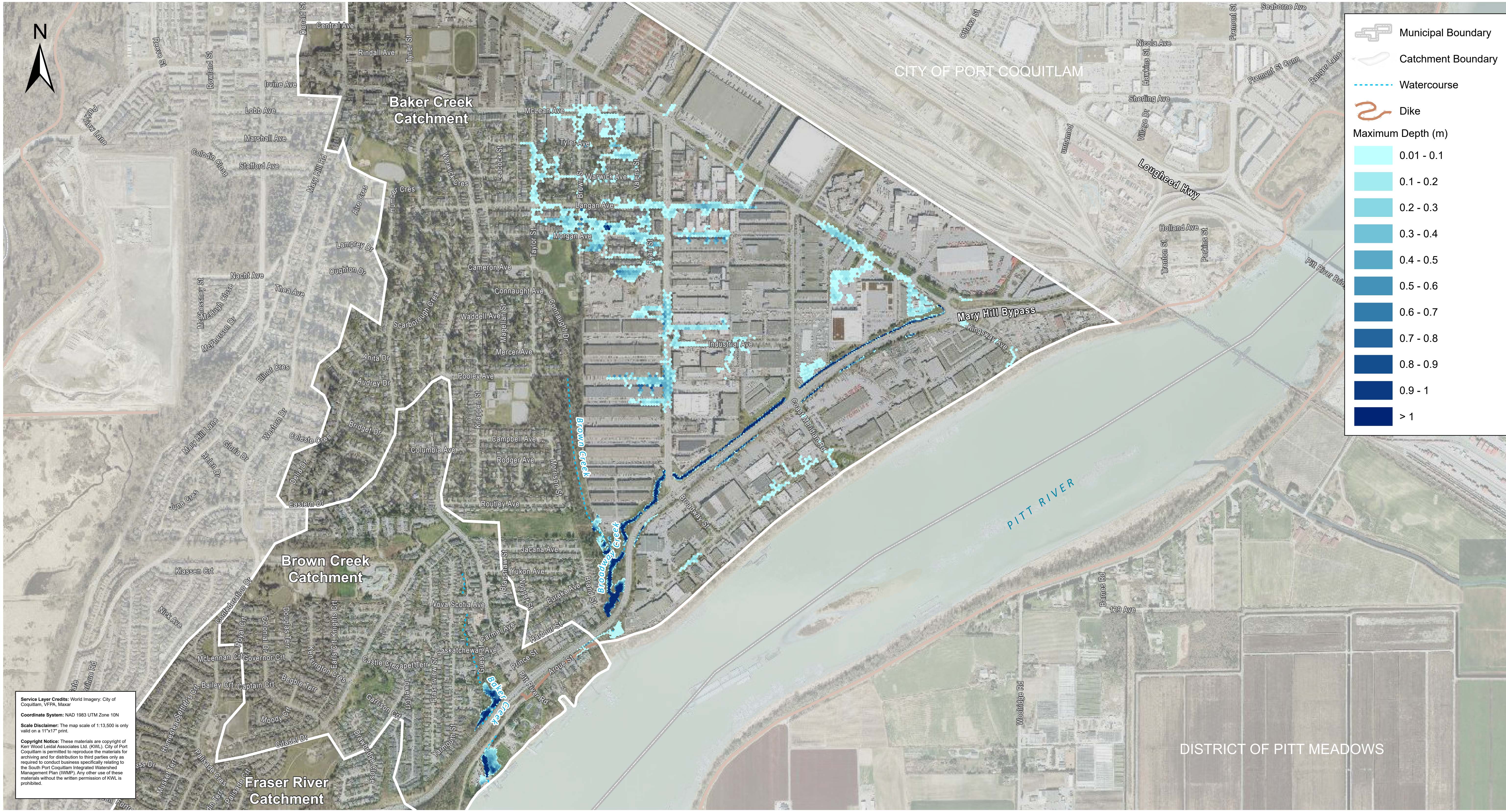
Figure C-15

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Upgraded Drainage System - Future Land use - 100-year 1-Hour Flooding

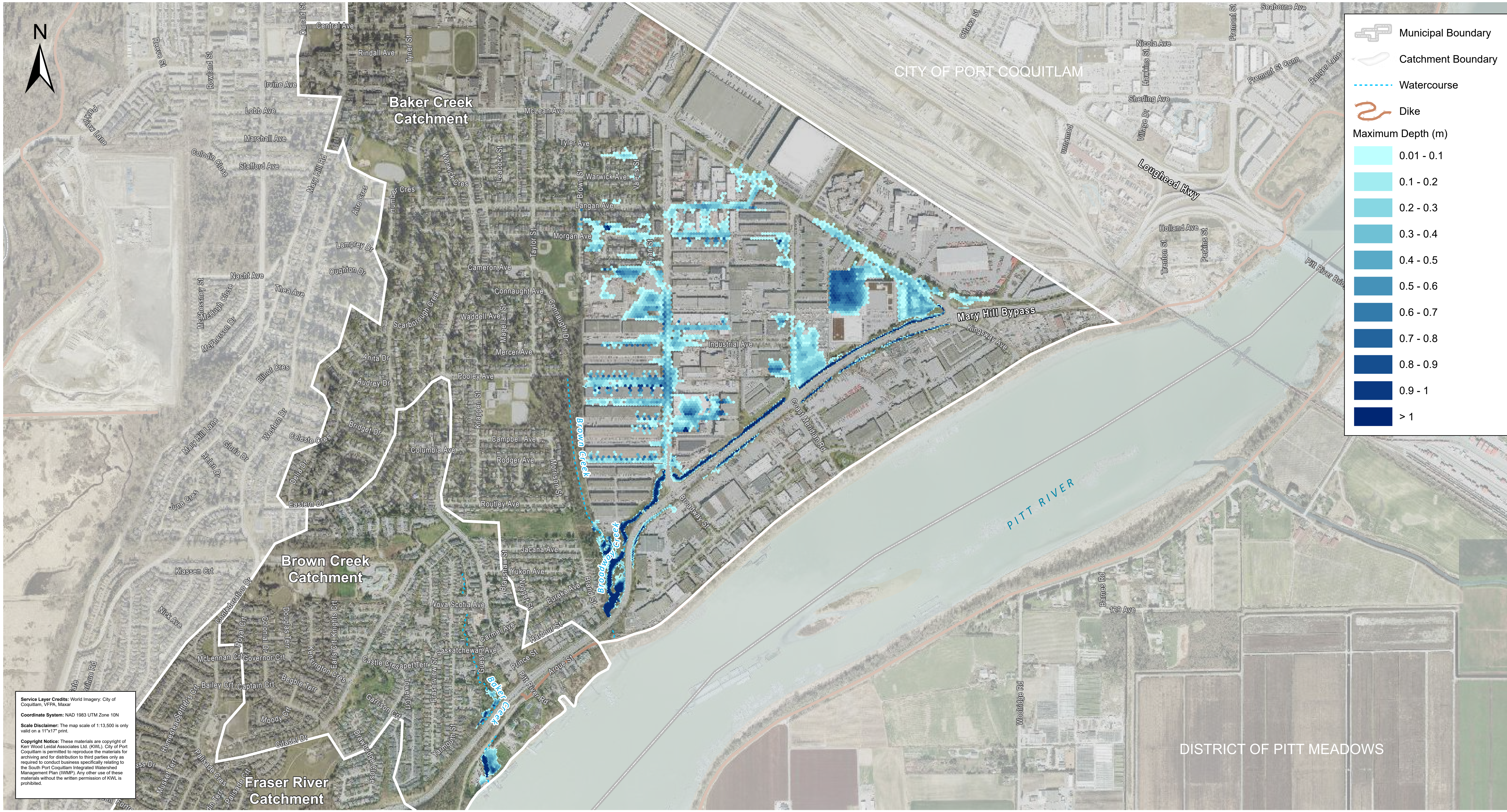
Figure C-16

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Upgraded Drainage System - Future Land use - 100-year 6-Hour Flooding

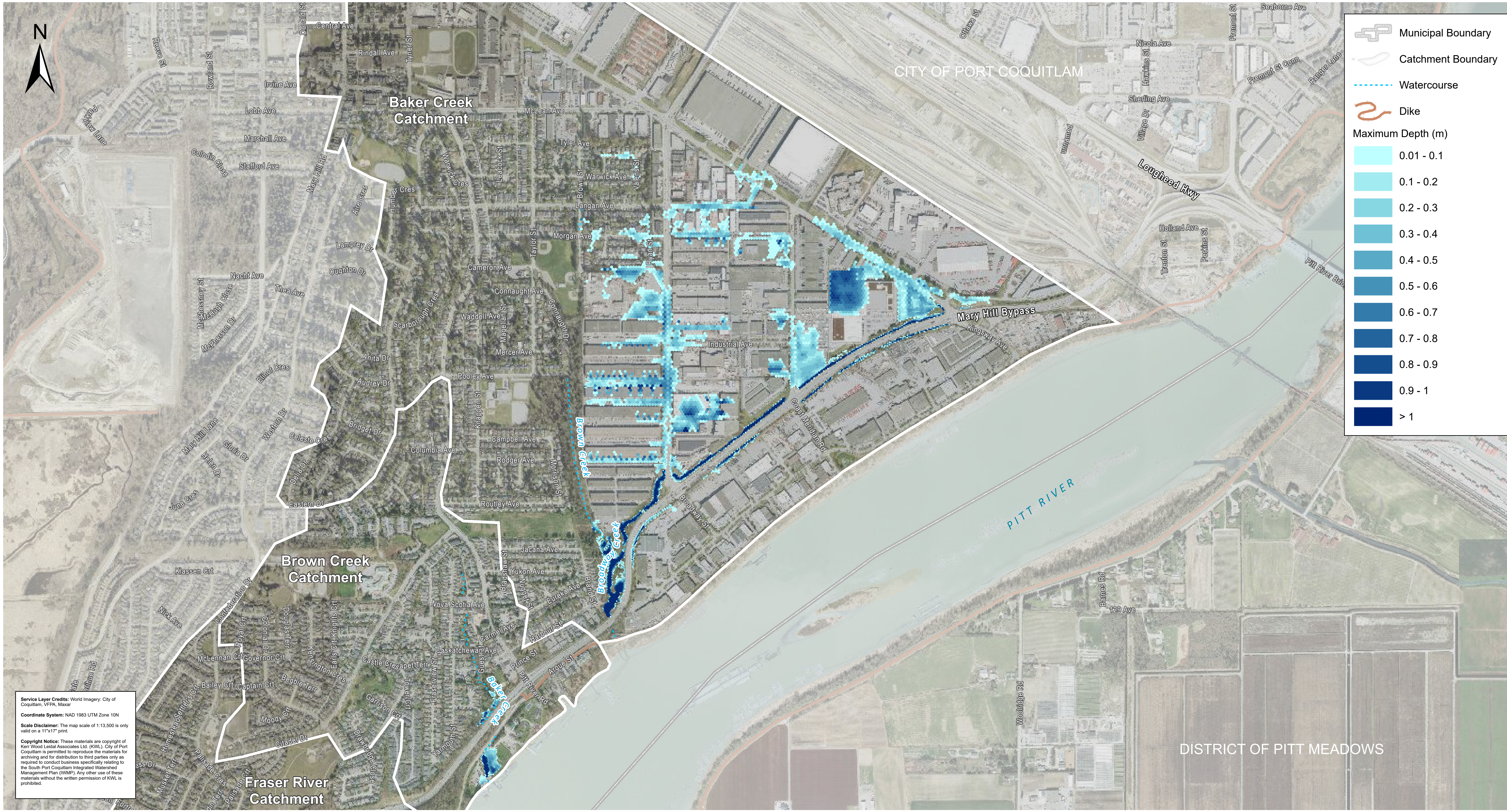
Figure C-17

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

Upgraded Drainage System - Future Land use - 100-year 12-Hour Flooding

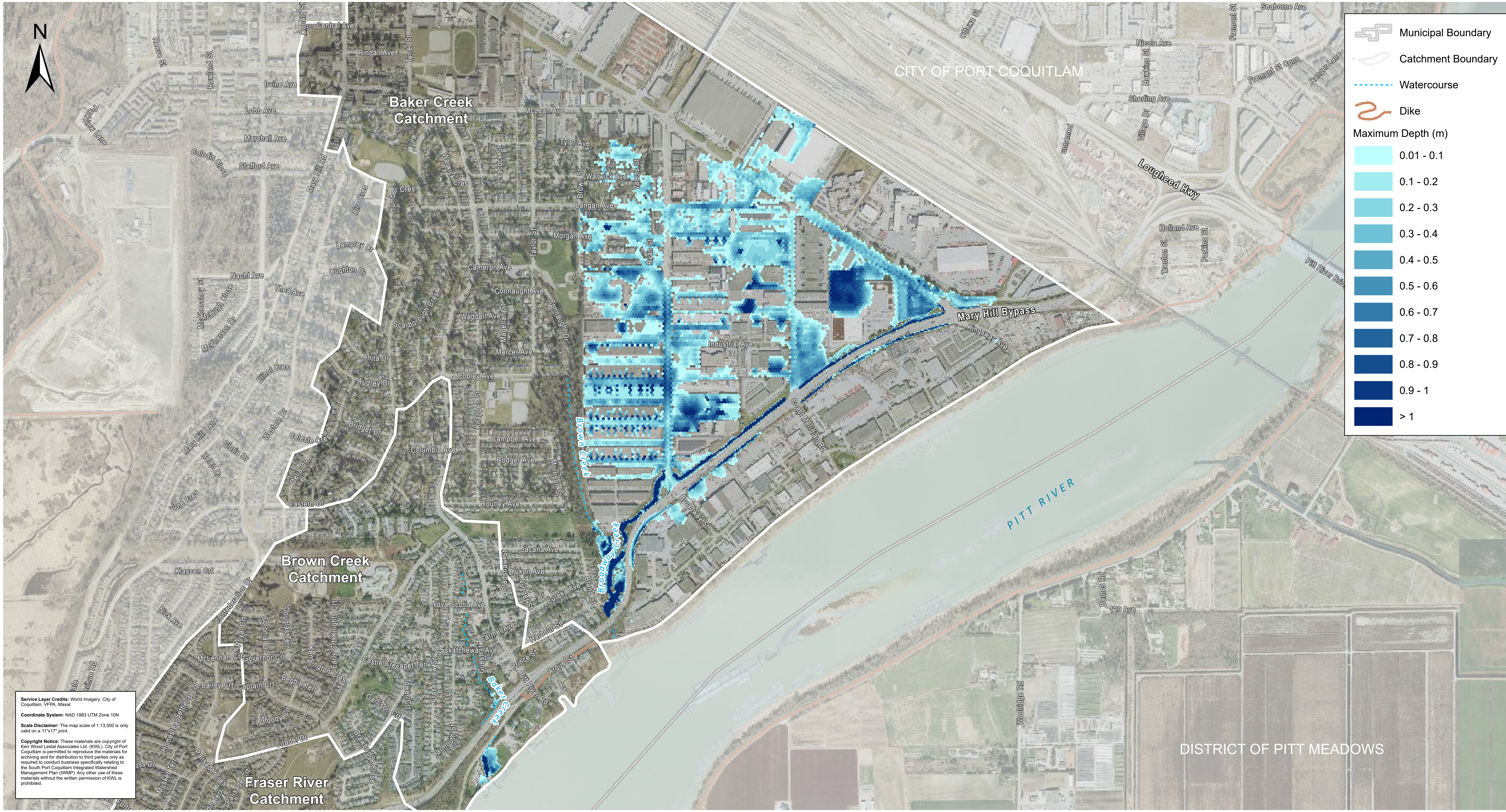
Figure C-18

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

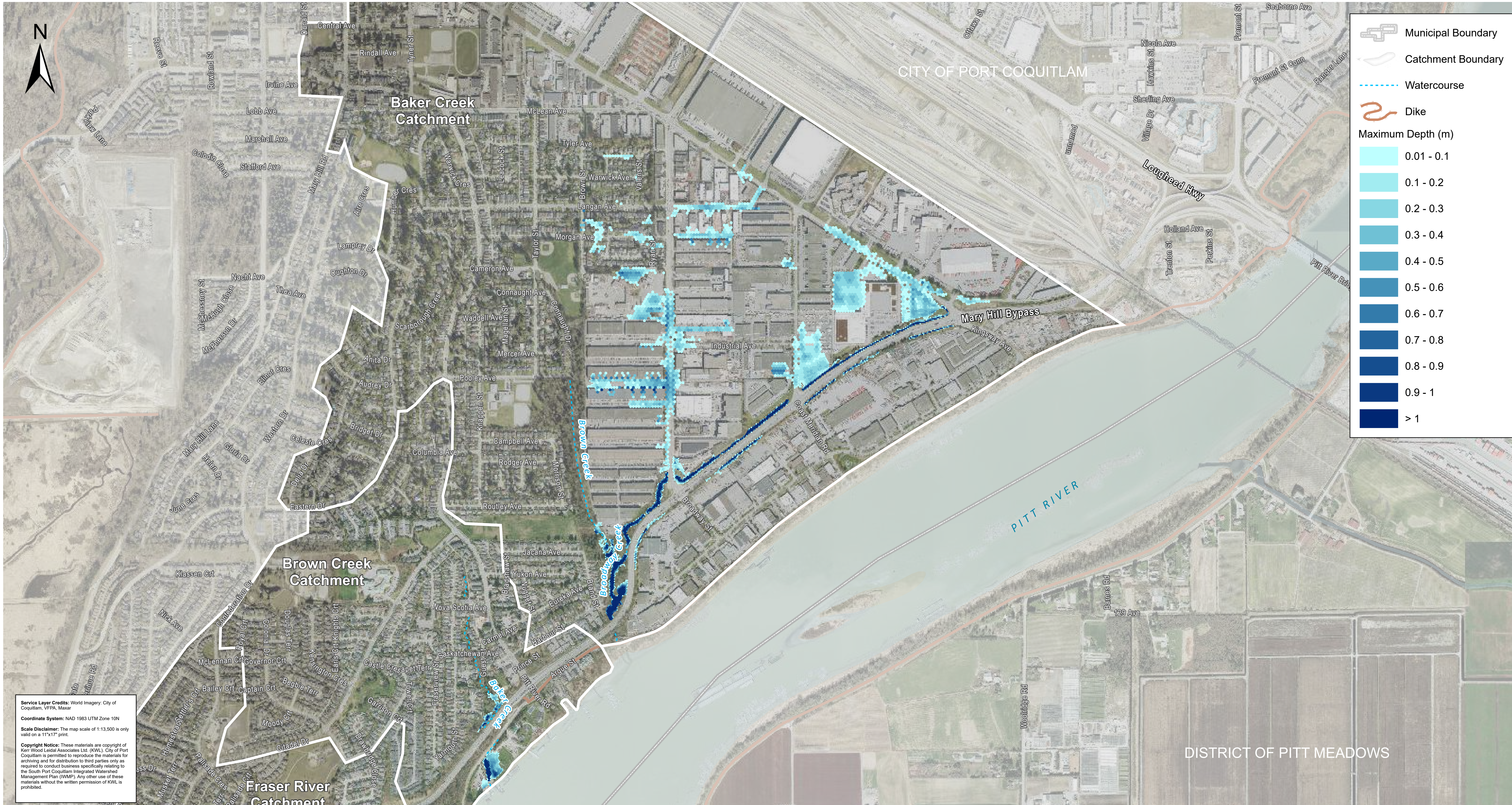
Upgraded Drainage System - Future Land use - 100-year 2.5 Days Flooding

Figure C-19

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

1.5 x Increased Pump Capacity – Future Land Use
100-year 6-Hour Flooding

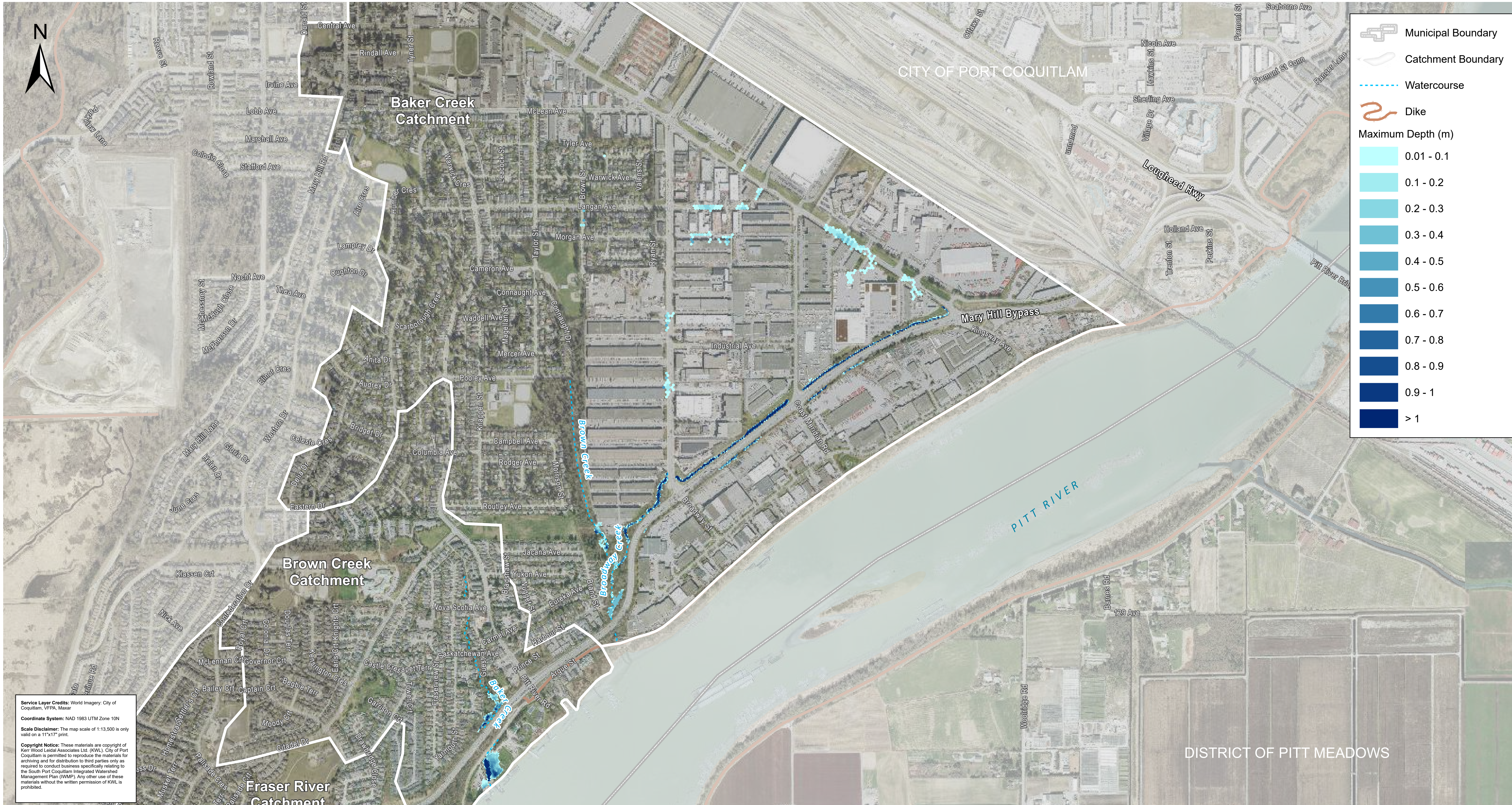
Figure C-20

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

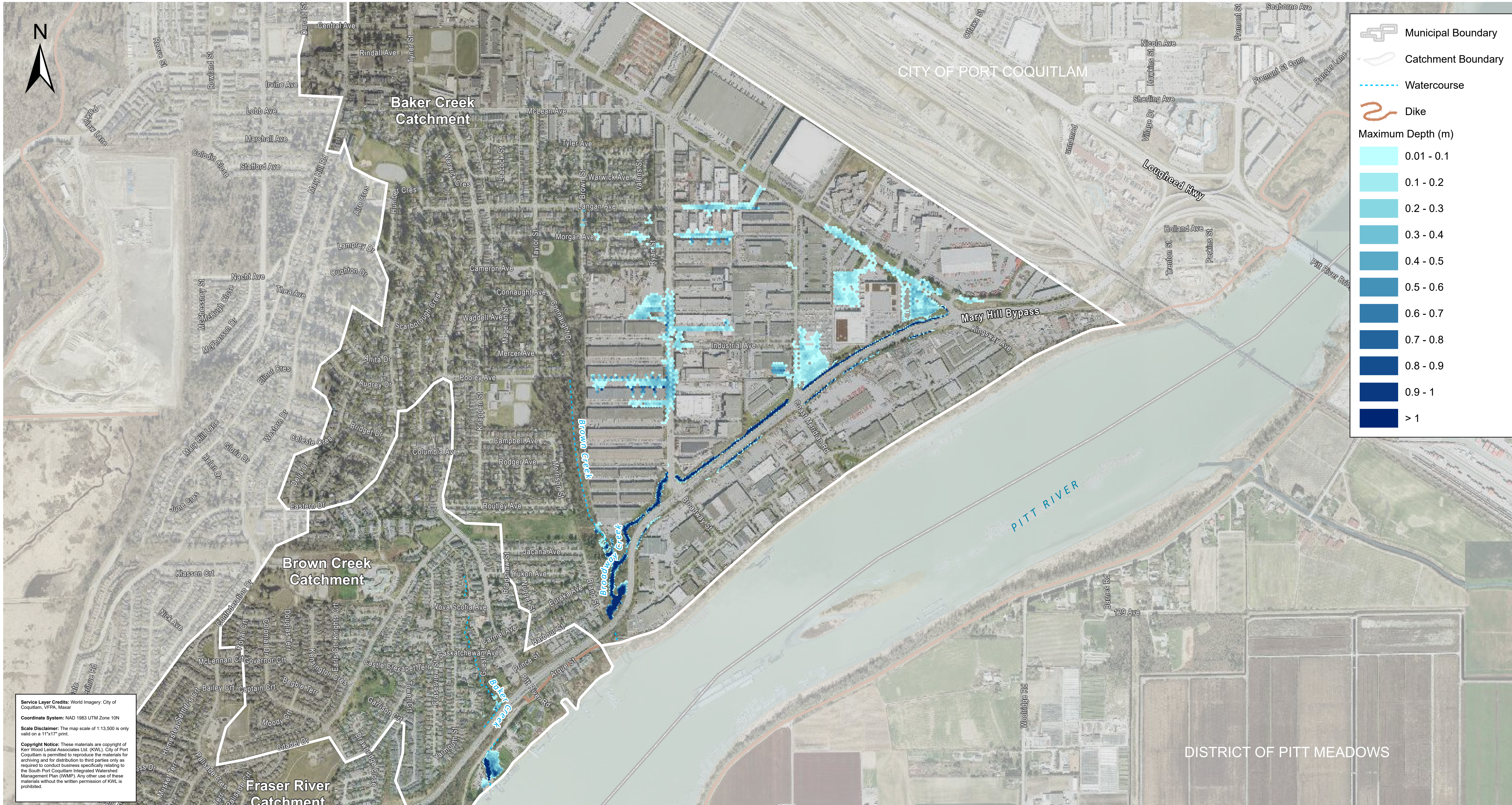
2 x Increased Pump Capacity – Future Land Use
100-year 6-Hour Flooding

Figure C-21

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No.	646.043
Date	December 2024
Scale	1:13,500

0 100 200 400 m

1.5 x Increased Pump Capacity – Future Land Use
100-year 2.5 Days Flooding

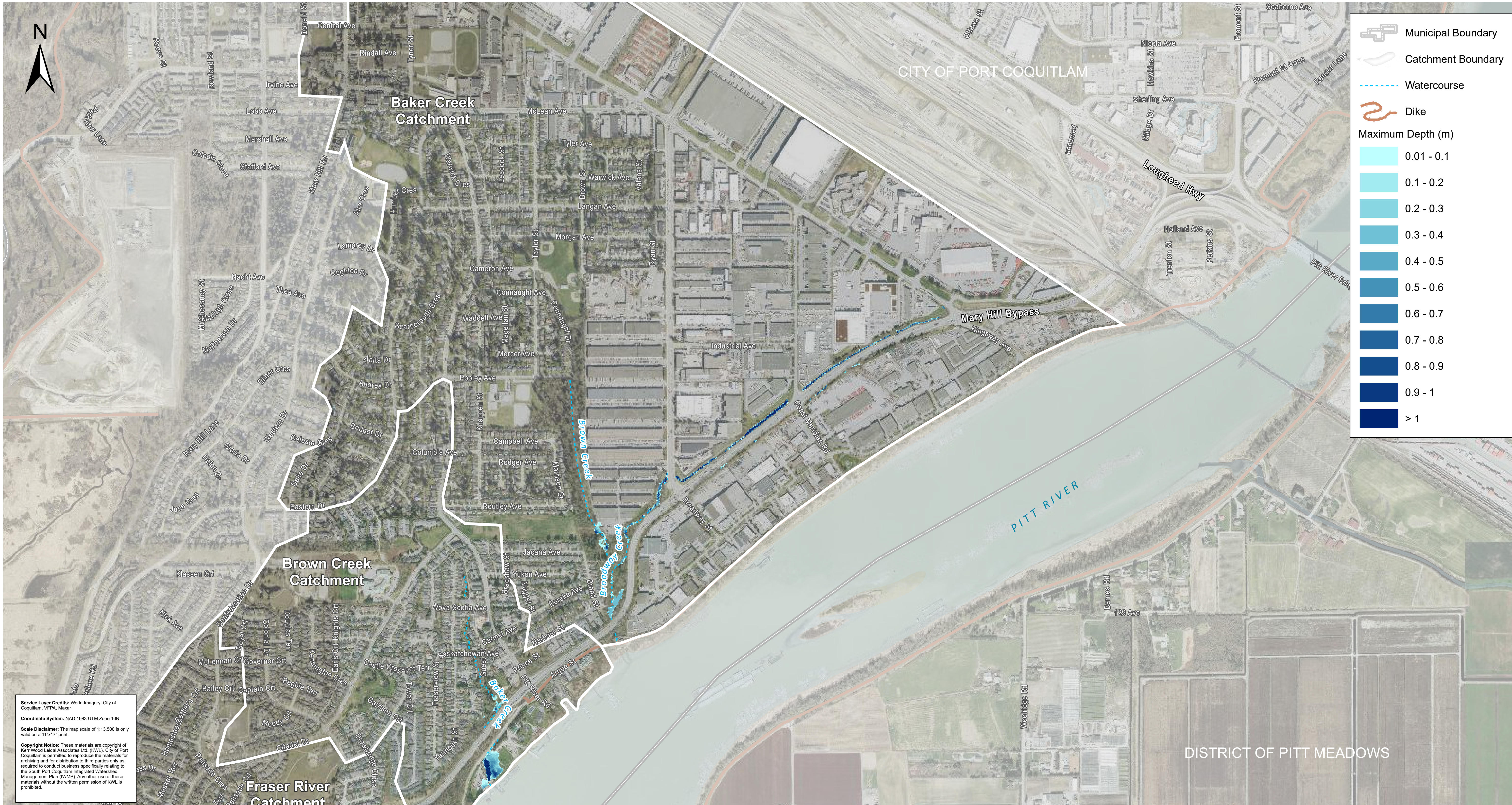
Figure C-22

Path: P:\0600-0699\646-043\430-GIS\Pro Projects\646043_SW_Figures\646043_SW_Figures.aprx Date Saved: 2024-07-15 10:23 PM | Author: JLau

City of Port Coquitlam

South Port Coquitlam Integrated Watershed Management Plan (IWMP)

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: City of Coquitlam, VFPA, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:13,500 is only valid on a 11"x17" print.

Project No. 646.043

Date December 2024

Scale 1:13,500

0 100 200 400 m

2.0 x Increased Pump Capacity – Future Land Use
100-year 2.5 Days Flooding

Figure C-23

Table C-1: Existing Minor System E & F Rated Pipes

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m³/s)	Upgraded Size (m)
CO-144	0.25	0.079	E	0.099	0.375
DM00310	0.38	0.184	E	0.234	0.675
DM00482	0.38	0.15	E	0.216	0.6
DM00662	0.3	0.106	E	0.152	0.375
DM00667	0.2	0.051	E	0.082	0.25
DM00737	0.25	0.073	E	0.106	0.375
DM00891	0.3	0.082	E	0.102	0.45
DM01339	0.3	0.129	E	0.18	0.375
DM01342	0.38	0.33	E	0.488	0.525
DM01357	0.53	0.392	E	0.579	0.675
DM04156	0.25	0.049	E	0.053	0.3
DM04667	0.3	0.139	E	0.214	0.6
DM04790	0.6	0.642	E	0.97	1.2
DM05491	0.3	0.089	E	0.151	0.6
DM05939	0.25	0.073	E	0.109	0.375
DM09245	0.25	0.063	E	0.099	0.375
DM00332	0.25	0.128	F	0.157	0.375
DM00338	0.25	0.056	F	0.068	0.375
DM00362	0.25	0.121	F	0.155	0.45
DM00364	0.25	0.077	F	0.102	0.375
DM00380	0.2	0.09	F	0.167	0.375
DM00388	0.2	0.087	F	0.161	0.375
DM00389	0.2	0.084	F	0.156	0.375
DM00391	0.2	0.081	F	0.152	0.375
DM00427	0.3	0.442	F	0.571	0.375
DM00539	0.3	0.09	F	0.127	0.375
DM00540	0.3	0.176	F	0.254	0.45
DM00541	0.3	0.199	F	0.285	0.45
DM00547	0.25	0.076	F	0.112	0.375
DM00620	0.2	0.056	F	0.081	0.3
DM00627	0.2	0.028	F	0.034	0.25
DM00640	0.25	0.155	F	0.178	0.375
DM00641	0.25	0.182	F	0.217	0.3
DM00659	0.2	0.063	F	0.095	0.3
DM00669	0.2	0.035	F	0.053	0.3
DM00673	0.25	0.071	F	0.105	0.375
DM00783	0.2	0.046	F	0.069	0.3
DM00841	1.05	1.638	F	2.48	1.35
DM00850	1.2	2.195	F	3.528	1.8
DM00865	0.3	0.091	F	0.113	0.375
DM00870	1.2	1.949	F	2.997	1.5
DM00876	0.45	0.32	F	0.398	0.75
DM00879	0.45	0.149	F	0.178	0.6
DM00888	0.25	0.079	F	0.083	0.3
DM00889	0.25	0.065	F	0.069	0.3

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m³/s)	Upgraded Size (m)
DM00903	0.6	0.431	F	0.498	0.75
DM00904	0.6	0.667	F	0.853	1.05
DM00919	0.6	0.592	F	0.814	0.75
DM00920	0.38	0.286	F	0.366	0.6
DM00921	0.38	0.476	F	0.666	0.9
DM00922	0.38	0.176	F	0.225	0.675
DM00933	0.25	0.051	F	0.063	0.3
DM00935	0.3	0.067	F	0.083	0.45
DM00964	0.45	0.366	F	0.454	0.6
DM00966	0.6	0.271	F	0.32	0.75
DM00985	0.3	0.045	F	0.071	0.375
DM00989	0.53	0.294	F	0.348	0.675
DM00990	0.6	0.379	F	0.446	0.75
DM00996	0.3	0.084	F	0.123	0.45
DM00997	0.2	0.018	F	0.026	0.3
DM00998	0.25	0.063	F	0.092	0.375
DM01004	0.3	0.125	F	0.153	0.525
DM01005	0.3	0.181	F	0.218	0.45
DM01038	0.15	0.024	F	0.026	0.25
DM01042	0.45	0.261	F	0.277	0.675
DM01043	0.45	0.503	F	0.568	0.525
DM01044	0.45	0.534	F	0.616	0.6
DM01045	0.45	0.58	F	0.678	0.675
DM01050	0.2	0.125	F	0.141	0.3
DM01056	0.6	0.969	F	1.391	1.2
DM01062	1.2	1.831	F	2.423	1.65
DM01063	1.2	2.332	F	3.05	1.8
DM01065	1.2	3.015	F	3.86	1.65
DM01066	1.2	3.058	F	3.906	1.65
DM01067	1.2	3.223	F	4.126	1.65
DM01069	0.6	0.706	F	0.901	0.9
DM01071	0.45	0.483	F	0.617	0.675
DM01072	1.2	3.256	F	4.161	1.65
DM01079	0.45	0.241	F	0.246	0.675
DM01209	0.45	0.663	F	0.687	0.75
DM01210	0.45	0.697	F	0.722	0.6
DM01215	0.25	0.063	F	0.063	0.3
DM01216	0.45	1.138	F	1.18	0.9
DM01217	0.53	1.183	F	1.227	0.9
DM01340	0.3	0.218	F	0.328	0.375
DM01343	0.38	0.442	F	0.638	0.525
DM01362	0.2	0.171	F	0.225	0.3
DM01371	0.2	0.061	F	0.077	0.25
DM01609	0.2	0.045	F	0.055	0.25
DM01610	0.3	0.192	F	0.234	0.45
DM01983	0.3	0.078	F	0.059	0.375

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m³/s)	Upgraded Size (m)
DM01989	0.3	0.162	F	0.181	0.45
DM01991	0.6	0.525	F	0.636	0.75
DM01992	0.3	0.181	F	0.169	0.45
DM01993	0.3	0.183	F	0.155	0.45
DM02015	0.3	0.166	F	0.187	0.45
DM02016	0.3	0.179	F	0.177	0.45
DM02025	0.2	0.045	F	0.061	0.375
DM02027	0.2	0.067	F	0.085	0.45
DM02028	0.2	0.103	F	0.13	0.375
DM04029	0.2	0.084	F	0.13	0.375
DM04039	0.6	0.309	F	0.376	0.675
DM04040	0.6	0.433	F	0.552	0.9
DM04058	0.3	0.049	F	0.06	0.375
DM04096	0.45	0.266	F	0.315	0.525
DM04097	0.45	0.333	F	0.398	0.75
DM04111	0.3	0.086	F	0.114	0.375
DM04162	0.2	0.075	F	0.107	0.375
DM04454	1.2	1.855	F	2.438	1.65
DM04466	0.25	0.355	F	0.377	0.525
DM04507	0.3	0.221	F	0.265	0.375
DM04539	0.3	0.161	F	0.194	0.525
DM04545	0.2	0.053	F	0.069	0.45
DM04771	1.2	2.207	F	3.563	1.65
DM04789	0.6	0.682	F	1.01	0.9
DM04792	0.3	0.067	F	0.092	0.45
DM05302	0.3	0.261	F	0.253	0.6
DM05303	0.45	0.34	F	0.344	0.525
DM05304	0.45	0.402	F	0.41	0.6
DM05305	0.45	0.645	F	0.664	0.675
DM05309	0.3	0.106	F	0.087	0.375
DM05322	0.45	0.861	F	0.909	0.9
DM05512	0.25	0.052	F	0.077	0.3
DM06049	0.2	0.071	F	0.068	0.25
DM06098	0.25	0.075	F	0.111	0.3
DM06457	1.2	2.844	F	3.644	1.8
DM06466	0.68	0.33	F	0.461	0.9
DM06473	0.6	0.381	F	0.495	0.9
DM06474	0.75	0.445	F	0.656	1.05
DM06476	0.6	0.715	F	1.059	1.2
DM06489	0.3	0.138	F	0.2	0.375
DM06545	0.25	0.121	F	0.155	0.6
DM06546	0.45	0.281	F	0.35	0.75
DM06547	0.45	0.31	F	0.385	0.9
DM06550	0.25	0.058	F	0.071	0.375
DM06551	0.25	0.063	F	0.077	0.45
DM06578	0.3	0.129	F	0.162	0.45

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m^3/s)	Upgraded Size (m)
DM06579	0.3	0.158	F	0.192	0.45
DM06625	0.6	0.565	F	0.68	0.9
DM06628	0.2	0.767	F	0.888	0.75
DM06629	0.6	1.07	F	1.521	0.75
DM06630	0.6	0.712	F	1.035	0.9
DM06631	0.6	0.778	F	1.125	1.2
DM06633	0.3	0.247	F	0.262	0.375
DM06669	0.25	0.094	F	0.114	0.3
DM06788	0.38	0.271	F	0.292	0.45
DM06889	0.25	0.104	F	0.129	0.375
DM06890	0.25	0.104	F	0.129	0.3
DM06927	0.3	0.104	F	0.129	0.525
DM06960	0.3	0.124	F	0.153	0.375
DM07129	0.15	0.023	F	0.031	0.25
DM07259	0.3	0.065	F	0.091	0.375
DM07328	0.3	0.047	F	0.074	0.45
DM07329	0.3	0.053	F	0.085	0.45
DM08235	0.25	0.054	F	0.087	0.375
DM08236	0.2	0.076	F	0.122	0.3

Table C-2: Future Minor System E & F Rated Pipes

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM00310	0.38	0.234	E	0.675
DM00428	0.45	0.587	E	0.525
DM00430	0.6	0.427	E	0.675
DM00629	0.38	0.23	E	0.45
DM00630	0.38	0.257	E	0.45
DM00653	0.25	0.046	E	0.3
DM00807	0.45	0.319	E	0.75
DM00887	0.68	0.459	E	0.9
DM01175	0.45	0.434	E	0.525
DM01190	0.53	0.804	E	0.6
DM01320	0.53	0.506	E	0.6
DM01357	0.53	0.579	E	0.675
DM04052	0.45	0.464	E	0.525
DM04156	0.25	0.053	E	0.3
DM04467	0.45	0.399	E	0.525
DM04667	0.3	0.214	E	0.6
DM06672	0.53	0.209	E	0.675
DM08926	0.375	0.26	E	0.45
CO-144	0.25	0.099	F	0.375
DM00292	0.38	0.498	F	0.45
DM00293	0.3	0.364	F	0.375
DM00295	0.3	0.229	F	0.375
DM00297	0.3	0.172	F	0.375
DM00317	0.25	0.139	F	0.3
DM00318	0.25	0.107	F	0.3
DM00332	0.25	0.157	F	0.375
DM00338	0.25	0.068	F	0.375
DM00362	0.25	0.155	F	0.45
DM00364	0.25	0.102	F	0.375
DM00378	0.3	0.303	F	0.375
DM00380	0.2	0.167	F	0.375
DM00384	0.25	0.218	F	0.3
DM00388	0.2	0.161	F	0.375
DM00389	0.2	0.156	F	0.375
DM00391	0.2	0.152	F	0.375
DM00427	0.3	0.571	F	0.375
DM00460	0.25	0.076	F	0.3
DM00474	0.53	0.506	F	0.675
DM00475	0.53	0.53	F	0.6
DM00476	0.53	0.536	F	0.75
DM00477	0.53	0.608	F	0.6
DM00481	0.45	0.264	F	0.525
DM00482	0.38	0.216	F	0.6
DM00539	0.3	0.127	F	0.375
DM00540	0.3	0.254	F	0.45

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM00541	0.3	0.285	F	0.45
DM00543	0.53	0.47	F	0.6
DM00544	0.6	0.696	F	0.675
DM00547	0.25	0.112	F	0.375
DM00620	0.2	0.081	F	0.3
DM00627	0.2	0.034	F	0.25
DM00632	0.2	0.05	F	0.25
DM00633	0.2	0.072	F	0.25
DM00638	0.2	0.053	F	0.25
DM00639	0.25	0.105	F	0.3
DM00640	0.25	0.178	F	0.375
DM00641	0.25	0.217	F	0.3
DM00654	0.25	0.046	F	0.3
DM00659	0.2	0.095	F	0.3
DM00662	0.3	0.152	F	0.375
DM00665	0.2	0.013	F	0.25
DM00667	0.2	0.082	F	0.25
DM00669	0.2	0.053	F	0.3
DM00672	0.25	0.061	F	0.3
DM00673	0.25	0.105	F	0.375
DM00688	0.2	0.041	F	0.25
DM00735	0.15	0.041	F	0.2
DM00737	0.25	0.106	F	0.375
DM00739	0.25	0.182	F	0.3
DM00741	0.3	0.312	F	0.375
DM00744	0.3	0.337	F	0.375
DM00751	0.25	0.06	F	0.3
DM00760	0.38	0.237	F	0.45
DM00762	0.2	0.032	F	0.25
DM00766	0.3	0.119	F	0.525
DM00783	0.2	0.069	F	0.3
DM00785	0.2	0.044	F	0.25
DM00789	0.2	0.079	F	0.25
DM00826	0.3	0.14	F	0.375
DM00839	0.6	0.784	F	0.75
DM00841	1.05	2.48	F	1.35
DM00846	0.3	0.262	F	0.375
DM00850	1.2	3.528	F	1.8
DM00865	0.3	0.113	F	0.375
DM00870	1.2	2.997	F	1.5
DM00876	0.45	0.398	F	0.75
DM00879	0.45	0.178	F	0.6
DM00888	0.25	0.083	F	0.3
DM00889	0.25	0.069	F	0.3
DM00891	0.3	0.102	F	0.45
DM00903	0.6	0.498	F	0.75

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM00904	0.6	0.853	F	1.05
DM00907	0.68	0.292	F	0.75
DM00919	0.6	0.814	F	0.75
DM00920	0.38	0.366	F	0.6
DM00921	0.38	0.666	F	0.9
DM00922	0.38	0.225	F	0.675
DM00928	1.05	1.467	F	1.35
DM00933	0.25	0.063	F	0.3
DM00935	0.3	0.083	F	0.45
DM00956	0.6	0.88	F	0.675
DM00964	0.45	0.454	F	0.6
DM00966	0.6	0.32	F	0.75
DM00984	0.3	0.124	F	0.375
DM00985	0.3	0.071	F	0.375
DM00986	0.3	0.057	F	0.375
DM00989	0.53	0.348	F	0.675
DM00990	0.6	0.446	F	0.75
DM00993	0.25	0.052	F	0.3
DM00996	0.3	0.123	F	0.45
DM00997	0.2	0.026	F	0.3
DM00998	0.25	0.092	F	0.375
DM00999	0.25	0.056	F	0.3
DM01004	0.3	0.153	F	0.525
DM01005	0.3	0.218	F	0.45
DM01038	0.15	0.026	F	0.25
DM01042	0.45	0.277	F	0.675
DM01043	0.45	0.568	F	0.525
DM01044	0.45	0.616	F	0.6
DM01045	0.45	0.678	F	0.675
DM01046	0.25	0.064	F	0.3
DM01048	0.45	0.302	F	0.525
DM01050	0.2	0.141	F	0.3
DM01054	0.3	0.16	F	0.375
DM01056	0.6	1.391	F	1.2
DM01062	1.2	2.423	F	1.65
DM01063	1.2	3.05	F	1.8
DM01065	1.2	3.86	F	1.65
DM01066	1.2	3.906	F	1.65
DM01067	1.2	4.126	F	1.65
DM01069	0.6	0.901	F	0.9
DM01071	0.45	0.617	F	0.675
DM01072	1.2	4.161	F	1.65
DM01079	0.45	0.246	F	0.675
DM01177	0.68	1.069	F	0.75
DM01183	0.68	1.216	F	0.9
DM01209	0.45	0.687	F	0.75

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM01210	0.45	0.722	F	0.6
DM01215	0.25	0.063	F	0.3
DM01216	0.45	1.18	F	0.9
DM01217	0.53	1.227	F	0.9
DM01319	0.53	0.765	F	0.6
DM01338	0.3	0.26	F	0.375
DM01339	0.3	0.18	F	0.375
DM01340	0.3	0.328	F	0.375
DM01341	0.3	0.364	F	0.375
DM01342	0.38	0.488	F	0.525
DM01343	0.38	0.638	F	0.525
DM01350	0.38	0.68	F	0.45
DM01351	0.53	0.978	F	0.6
DM01352	0.68	1.011	F	0.75
DM01353	0.68	1.126	F	0.75
DM01355	0.68	1.37	F	0.9
DM01358	0.53	0.513	F	0.675
DM01361	0.25	0.239	F	0.3
DM01362	0.2	0.225	F	0.3
DM01363	0.2	0.094	F	0.25
DM01366	0.68	1.417	F	0.9
DM01370	0.2	0.038	F	0.25
DM01371	0.2	0.077	F	0.25
DM01380	0.3	0.154	F	0.375
DM01386	0.25	0.079	F	0.3
DM01609	0.2	0.055	F	0.25
DM01610	0.3	0.234	F	0.45
DM01983	0.3	0.059	F	0.375
DM01989	0.3	0.181	F	0.45
DM01991	0.6	0.636	F	0.75
DM01992	0.3	0.169	F	0.45
DM01993	0.3	0.155	F	0.45
DM01994	0.6	0.33	F	0.675
DM01997	0.6	0.446	F	0.675
DM02015	0.3	0.187	F	0.45
DM02016	0.3	0.177	F	0.45
DM02025	0.2	0.061	F	0.375
DM02027	0.2	0.085	F	0.45
DM02028	0.2	0.13	F	0.375
DM04029	0.2	0.13	F	0.375
DM04030	0.2	0.142	F	0.25
DM04039	0.6	0.376	F	0.675
DM04040	0.6	0.552	F	0.9
DM04058	0.3	0.06	F	0.375
DM04096	0.45	0.315	F	0.525
DM04097	0.45	0.398	F	0.75

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM04111	0.3	0.114	F	0.375
DM04160	0.45	0.305	F	0.525
DM04161	0.2	0.074	F	0.25
DM04162	0.2	0.107	F	0.375
DM04189	0.25	0.133	F	0.3
DM04454	1.2	2.438	F	1.65
DM04466	0.25	0.377	F	0.525
DM04507	0.3	0.265	F	0.375
DM04539	0.3	0.194	F	0.525
DM04545	0.2	0.069	F	0.45
DM04654	0.3	0.359	F	0.375
DM04766	0.2	0.039	F	0.25
DM04771	1.2	3.563	F	1.65
DM04789	0.6	1.01	F	0.9
DM04790	0.6	0.97	F	1.2
DM04792	0.3	0.092	F	0.45
DM05199	0.25	0.083	F	0.3
DM05302	0.3	0.253	F	0.6
DM05303	0.45	0.344	F	0.525
DM05304	0.45	0.41	F	0.6
DM05305	0.45	0.664	F	0.675
DM05309	0.3	0.087	F	0.375
DM05322	0.45	0.909	F	0.9
DM05441	0.3	0.095	F	0.375
DM05491	0.3	0.151	F	0.6
DM05512	0.25	0.077	F	0.3
DM05679	0.3	0.233	F	0.375
DM05937	0.25	0.156	F	0.3
DM05938	0.25	0.127	F	0.3
DM05939	0.25	0.109	F	0.375
DM05949	0.15	0.017	F	0.2
DM06049	0.2	0.068	F	0.25
DM06052	0.25	0.114	F	0.3
DM06098	0.25	0.111	F	0.3
DM06457	1.2	3.644	F	1.8
DM06458	0.6	0.252	F	0.675
DM06460	0.25	0.085	F	0.3
DM06462	0.25	0.077	F	0.3
DM06466	0.68	0.461	F	0.9
DM06467	0.68	0.472	F	0.75
DM06473	0.6	0.495	F	0.9
DM06474	0.75	0.656	F	1.05
DM06476	0.6	1.059	F	1.2
DM06489	0.3	0.2	F	0.375
DM06544	0.3	0.167	F	0.6
DM06545	0.25	0.155	F	0.6

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM06546	0.45	0.35	F	0.75
DM06547	0.45	0.385	F	0.9
DM06550	0.25	0.071	F	0.375
DM06551	0.25	0.077	F	0.45
DM06578	0.3	0.162	F	0.45
DM06579	0.3	0.192	F	0.45
DM06625	0.6	0.68	F	0.9
DM06628	0.2	0.888	F	0.75
DM06629	0.6	1.521	F	0.75
DM06630	0.6	1.035	F	0.9
DM06631	0.6	1.125	F	1.2
DM06632	0.3	0.239	F	0.375
DM06633	0.3	0.262	F	0.375
DM06669	0.25	0.114	F	0.3
DM06788	0.38	0.292	F	0.45
DM06889	0.25	0.129	F	0.375
DM06890	0.25	0.129	F	0.3
DM06927	0.3	0.129	F	0.525
DM06960	0.3	0.153	F	0.375
DM07128	0.15	0.019	F	0.2
DM07129	0.15	0.031	F	0.25
DM07152	0.25	0.128	F	0.3
DM07259	0.3	0.091	F	0.375
DM07260	0.3	0.077	F	0.375
DM07328	0.3	0.074	F	0.45
DM07329	0.3	0.085	F	0.45
DM07486	0.25	0.079	F	0.375
DM07487	0.25	0.116	F	0.375
DM08235	0.25	0.087	F	0.375
DM08236	0.2	0.122	F	0.3
DM08678	0.25	0.086	F	0.375
DM08679	0.25	0.137	F	0.45
DM08925	0.375	0.265	F	0.45
DM08927	0.3	0.243	F	0.375
DM08928	0.3	0.226	F	0.375
DM09245	0.25	0.099	F	0.375

Table C-3: Existing Major System E & F Rated Pipes

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m³/s)	Upgraded Size (m)
DM00306	0.25	0.085	E	0.106	0.3
DM00347	0.75	2.744	E	3.687	0.9
DM00816	0.75	0.843	E	1.18	1.05
DM00893	0.6	0.514	E	0.666	0.9
DM00894	0.68	0.736	E	0.959	1.05
DM00895	0.9	1.25	E	1.643	1.2
DM00896	0.9	1.271	E	1.739	1.35
DM00897	0.9	1.25	E	1.674	1.35
DM00930	1.05	1.103	E	1.516	1.35
DM01198	0.68	2.622	E	3.587	0.9
DM01218	0.53	1.363	E	1.443	1.05
DM01251	0.45	0.376	E	0.624	0.75
DM03501	1.05	1.669	E	2.404	1.5
DM04184	0.45	0.791	E	0.827	0.9
DM06757	0.68	0.531	E	0.666	1.05
DM06805	0.6	0.133	E	0.173	0.6
DM07421	1.2 x 3	15.871	E	21.873	3.6
DM07530	0.75	17.605	E	4.37	1.35
DM09253	0.45	0.752	E	1.057	0.6
C11	0.9 x 1.8	4.313	F	5.456	2.1
C29	0.9 x 1.8	4.504	F	5.764	2.1
C30	0.9 x 1.8	4.503	F	5.764	1.8
C32	0.9 x 1.8	4.538	F	5.816	1.65
DM00288	0.25	0.141	F	0.179	0.375
DM00309	0.75	2.249	F	3.062	1.05
DM00320	0.25	0.091	F	0.108	0.3
DM00342	0.75	2.56	F	3.446	1.2
DM00345	0.75	2.599	F	3.497	1.35
DM00383	0.45	0.851	F	1.158	0.6
DM00386	0.25	0.083	F	0.108	0.375
DM00397	0.75	2.072	F	2.836	1.05
DM00398	0.75	1.99	F	2.728	1.05
DM00399	0.75	1.995	F	2.734	1.05
DM00406	0.75	2.108	F	2.884	1.05
DM00434	0.75	0.908	F	1.209	1.2
DM00435	0.75	0.908	F	1.215	1.05
DM00437	0.75	1.278	F	1.752	1.05
DM00439	0.38	0.768	F	1.111	0.45
DM00441	0.38	1.062	F	1.477	0.525
DM00442	0.38	0.673	F	0.996	0.6
DM00445	0.38	0.339	F	0.512	0.525
DM00446	0.3	0.422	F	0.689	0.75
DM00622	0.6	1.896	F	2.637	0.9
DM00623	0.75	1.902	F	2.645	1.05

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m³/s)	Upgraded Size (m)
DM00624	0.75	2.1	F	2.926	1.05
DM00642	0.25	0.344	F	0.438	0.375
DM00655	0.2	0.045	F	0.064	0.25
DM00790	0.25	0.124	F	0.173	0.3
DM00801	0.2	0.055	F	0.076	0.25
DM00803	0.53	0.473	F	0.653	0.675
DM00804	0.53	0.406	F	0.555	0.9
DM00809	0.53	0.482	F	0.667	1.05
DM00810	0.53	0.504	F	0.695	0.675
DM00840	0.9	2.681	F	3.917	1.65
DM00858	0.9	2.099	F	3.171	1.65
DM00859	0.9	2.202	F	3.357	1.65
DM00866	0.45	0.179	F	0.218	0.675
DM00875	0.3	0.115	F	0.171	0.6
DM00892	0.53	0.2	F	0.256	0.675
DM00900	0.38	0.3	F	0.377	0.675
DM00916	1.65	3.079	F	4.483	1.8
DM00923	0.9	1.943	F	2.424	1.65
DM00927	0.9	1.35	F	1.789	1.35
DM00971	0.9	1.639	F	2.251	1.2
DM00978	0.9	1.867	F	2.57	1.65
DM00979	0.9	1.786	F	2.457	1.35
DM00988	1.2	5.638	F	7.136	2.4
DM01039	0.2	0.036	F	0.047	0.25
DM01068	0.75	1.167	F	1.457	1.2
DM01070	0.38	0.34	F	0.42	0.9
DM01073	1.2	5.082	F	6.449	2.1
DM01078	0.45	0.163	F	0.197	0.675
DM01196	0.68	2.622	F	3.587	0.9
DM01344	0.45	0.387	F	0.477	0.525
DM01373	0.3	0.201	F	0.275	0.375
DM01384	0.25	0.141	F	0.179	0.3
DM01385	0.25	0.141	F	0.178	0.375
DM01584	0.9	2.156	F	3.271	1.65
DM01585	0.9	2.284	F	3.53	1.8
DM01984	0.75	1.153	F	1.374	1.05
DM01995	0.45	0.335	F	0.439	0.675
DM03505	0.75	0.867	F	1.341	1.05
DM03891	0.75	0.936	F	1.419	1.05
DM03979	0.3	0.303	F	0.302	0.375
DM03980	0.68	2.76	F	3.743	0.9
DM03982	0.68	3.11	F	4.232	0.9
DM04032	0.25	0.049	F	0.061	0.3
DM04033	0.25	0.119	F	0.138	0.45
DM04136	1.65	2.677	F	3.878	2.1

Conduit Name	Existing Size Diameter (m)	Existing Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m^3/s)	Upgraded Size (m)
DM04358	0.9	2.858	F	3.71	1.05
DM04393	0.9	2.662	F	3.897	1.5
DM04767	0.25	0.141	F	0.179	0.3
DM05468	1.65	3.871	F	5.569	2.4
DM05469	1.65	3.968	F	5.703	1.8
DM05932	0.25	0.052	F	0.069	0.375
DM06455	0.53	0.289	F	0.366	0.6
DM06534	1.65	3.136	F	4.582	2.1
DM06535	1.65	3.45	F	5.013	2.1
DM06538	1.5	8.782	F	12.696	2.7
DM06665	0.38	1.066	F	1.482	0.6
DM06666	0.38	0.936	F	1.283	0.6
DM06668	0.25	0.154	F	0.23	0.375
DM06779	0.9	4.651	F	6.615	2.4
DM06807	0.75	0.908	F	1.22	1.2
DM06909	0.9	0.886	F	1.135	1.2
DM06957	0.9	1.676	F	2.121	1.2
DM06958	0.9	1.715	F	2.174	1.35
DM07265	0.53	0.285	F	0.36	0.6
DM07401	0.25	0.02	F	0.03	0.3
DM07497	0.9 x 1.8	4.393	F	5.251	2.1
DM07498	0.9 x 1.8	4.624	F	5.851	1.65
DM07499	1.2 x 2.4	13.713	F	19.1	3.6
DM07500	1.2 x 3	15.682	F	21.631	3.6
DM07726	1.3 x 1.2	7.546	F	9.522	2.7
DM08030	0.75	3.439	F	3.53	1.8
DM08041	0.2	0.036	F	0.067	0.45
DM08045	0.38	0.036	F	0.067	0.45
DM08050	0.45	0.065	F	0.114	0.525
DM08066	0.53	0.442	F	0.634	0.675
DM08067	0.45	0.24	F	0.326	0.6
DM08068	0.53	0.363	F	0.5	0.675
DM08081	0.2	0.021	F	0.038	0.3
DM09044	0.3	0.183	F	0.282	0.525
DM09247	0.3	0.253	F	0.36	0.525
DM09249	0.3	0.262	F	0.364	0.45
DM09250	0.375	0.357	F	0.494	0.525
KWLDM01	1.2 x 2.4	13.79	F	19.202	3

Note: Pipes in grey have an upgraded pipe size equal to or greater than the existing pipe size due to pipe slope increasing from existing pipe slope to a minimum pipe slope of 0.01

Table C-4: Future Major System E & F Rated Pipes

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM00643	0.38	0.583	E	0.45
DM01197	0.68	3.684	E	0.9
DM01200	0.9	3.825	E	1.2
DM01218	0.53	1.443	E	1.05
DM01250	0.45	0.316	E	0.525
DM01251	0.45	0.624	E	0.75
DM04184	0.45	0.827	E	0.9
DM04442	0.3	0.203	E	0.375
DM04469	0.6	0.769	E	0.9
DM06757	0.68	0.666	E	1.05
4180	0.25	0.046	F	0.3
C11	0.9 x 1.8	5.456	F	2.1
C29	0.9 x 1.8	5.764	F	2.1
C30	0.9 x 1.8	5.764	F	1.8
C32	0.9 x 1.8	5.816	F	1.65
CO-162	0.9	2.25	F	1.65
DM00288	0.25	0.179	F	0.375
DM00290	0.25	0.197	F	0.3
DM00306	0.25	0.106	F	0.3
DM00309	0.75	3.062	F	1.05
DM00311	0.25	0.235	F	0.3
DM00320	0.25	0.108	F	0.3
DM00342	0.75	3.446	F	1.2
DM00345	0.75	3.497	F	1.35
DM00347	0.75	3.687	F	0.9
DM00348	0.75	3.708	F	0.9
DM00381	0.25	0.195	F	0.3
DM00383	0.45	1.158	F	0.6
DM00385	0.53	1.266	F	0.6
DM00386	0.25	0.108	F	0.375
DM00396	0.75	2.889	F	0.9
DM00397	0.75	2.836	F	1.05
DM00398	0.75	2.728	F	1.05
DM00399	0.75	2.734	F	1.05
DM00404	0.25	0.04	F	0.3
DM00406	0.75	2.884	F	1.05
DM00408	0.75	2.779	F	0.9
DM00433	0.75	0.883	F	0.9
DM00434	0.75	1.209	F	1.2
DM00435	0.75	1.215	F	1.05
DM00437	0.75	1.752	F	1.05
DM00439	0.38	1.111	F	0.45
DM00440	0.38	1.111	F	0.45

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM00441	0.38	1.477	F	0.525
DM00442	0.38	0.996	F	0.6
DM00445	0.38	0.512	F	0.525
DM00446	0.3	0.689	F	0.75
DM00472	0.3	0.366	F	0.375
DM00622	0.6	2.637	F	0.9
DM00623	0.75	2.645	F	1.05
DM00624	0.75	2.926	F	1.05
DM00642	0.25	0.438	F	0.375
DM00655	0.2	0.064	F	0.25
DM00787	0.3	0.234	F	0.375
DM00790	0.25	0.173	F	0.3
DM00796	0.2	0.029	F	0.25
DM00801	0.2	0.076	F	0.25
DM00802	0.53	0.567	F	0.6
DM00803	0.53	0.653	F	0.675
DM00804	0.53	0.555	F	0.9
DM00809	0.53	0.667	F	1.05
DM00810	0.53	0.695	F	0.675
DM00815	0.75	3.114	F	0.9
DM00816	0.75	1.18	F	1.05
DM00817	0.75	3.158	F	0.9
DM00840	0.9	3.917	F	1.65
DM00858	0.9	3.171	F	1.65
DM00859	0.9	3.357	F	1.65
DM00866	0.45	0.218	F	0.675
DM00875	0.3	0.171	F	0.6
DM00892	0.53	0.256	F	0.675
DM00893	0.6	0.666	F	0.9
DM00894	0.68	0.959	F	1.05
DM00895	0.9	1.643	F	1.2
DM00896	0.9	1.739	F	1.35
DM00897	0.9	1.674	F	1.35
DM00900	0.38	0.377	F	0.675
DM00916	1.65	4.483	F	1.8
DM00917	1.65	3.749	F	2.1
DM00923	0.9	2.424	F	1.65
DM00927	0.9	1.789	F	1.35
DM00930	1.05	1.516	F	1.35
DM00932	0.75	0.583	F	0.9
DM00971	0.9	2.251	F	1.2
DM00978	0.9	2.57	F	1.65
DM00979	0.9	2.457	F	1.35
DM00988	1.2	7.136	F	2.4

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m³/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM01001	0.6	0.417	F	0.675
DM01039	0.2	0.047	F	0.25
DM01068	0.75	1.457	F	1.2
DM01070	0.38	0.42	F	0.9
DM01073	1.2	6.449	F	2.1
DM01077	0.45	0.172	F	0.525
DM01078	0.45	0.197	F	0.675
DM01196	0.68	3.587	F	0.9
DM01198	0.68	3.587	F	0.9
DM01199	0.68	3.587	F	0.75
DM01344	0.45	0.477	F	0.525
DM01373	0.3	0.275	F	0.375
DM01384	0.25	0.179	F	0.3
DM01385	0.25	0.178	F	0.375
DM01584	0.9	3.271	F	1.65
DM01585	0.9	3.53	F	1.8
DM01612	0.45	0.252	F	0.525
DM01984	0.75	1.374	F	1.05
DM01995	0.45	0.439	F	0.675
DM03501	1.05	2.404	F	1.5
DM03504	0.6	1.952	F	0.75
DM03505	0.75	1.341	F	1.05
DM03891	0.75	1.419	F	1.05
DM03979	0.3	0.302	F	0.375
DM03980	0.68	3.743	F	0.9
DM03982	0.68	4.232	F	0.9
DM04032	0.25	0.061	F	0.3
DM04033	0.25	0.138	F	0.45
DM04042	1.65	6.605	F	2.4
DM04136	1.65	3.878	F	2.1
DM04356	0.2	0.246	F	0.25
DM04358	0.9	3.71	F	1.05
DM04393	0.9	3.897	F	1.5
DM04767	0.25	0.179	F	0.3
DM04770	0.3	0.091	F	0.375
DM05468	1.65	5.569	F	2.4
DM05469	1.65	5.703	F	1.8
DM05897	0.25	0.128	F	0.3
DM05931	0.25	0.03	F	0.3
DM05932	0.25	0.069	F	0.375
DM06455	0.53	0.366	F	0.6
DM06534	1.65	4.582	F	2.1
DM06535	1.65	5.013	F	2.1
DM06538	1.5	12.696	F	2.7

Conduit Name	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM06665	0.38	1.482	F	0.6
DM06666	0.38	1.283	F	0.6
DM06668	0.25	0.23	F	0.375
DM06779	0.9	6.615	F	2.4
DM06805	0.6	0.173	F	0.6
DM06807	0.75	1.22	F	1.2
DM06808	0.75	1.225	F	0.9
DM06909	0.9	1.135	F	1.2
DM06910	0.9	1.317	F	1.05
DM06957	0.9	2.121	F	1.2
DM06958	0.9	2.174	F	1.35
DM07235	0.3	0.109	F	0.375
DM07265	0.53	0.36	F	0.6
DM07401	0.25	0.03	F	0.3
DM07421	1.2 x 3	21.873	F	3.6
DM07497	0.9 x 1.8	5.457	F	2.1
DM07498	0.9 x 1.8	5.851	F	1.65
DM07499	1.2 x 2.4	19.1	F	3.6
DM07500	1.2 x 3	21.631	F	3.6
DM07530	0.75	4.37	F	1.35
DM07726	1.3 x 1.2	9.522	F	2.7
DM08030	0.75	3.53	F	1.8
DM08033	0.38	0.136	F	0.45
DM08041	0.2	0.067	F	0.45
DM08045	0.38	0.067	F	0.45
DM08050	0.45	0.114	F	0.525
DM08063	0.2	0.038	F	0.25
DM08066	0.53	0.634	F	0.675
DM08067	0.45	0.326	F	0.6
DM08068	0.53	0.5	F	0.675
DM08071	0.2	0.019	F	0.25
DM08081	0.2	0.038	F	0.3
DM09044	0.3	0.282	F	0.525
DM09247	0.3	0.36	F	0.525
DM09249	0.3	0.364	F	0.45
DM09250	0.375	0.494	F	0.525
DM09251	0.45	0.654	F	0.525
DM09253	0.45	1.057	F	0.6
DM09254	0.45	1.058	F	0.525
KWLDM01	1.2 x 2.4	19.202	F	3

Note: Pipes in grey have an upgraded pipe size equal to or greater than the existing pipe size due to pipe slope increasing from existing pipe slope to a minimum pipe slope of 0.01

Table C-5: Existing Culvert E & F Rated Pipes

Culvert ID	Existing Size Diameter (m)	Existing Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Future Peak Flow (m^3/s)	Upgraded Size (m)
DM06754	1.2	2.737	E	3.493	2.1
DM06783	0.9	0.599	E	3.507	2.1

Table C-6: Future Culvert E & F Rated Pipes

Culvert ID	Existing Size Diameter (m)	Future Peak Flow (m^3/s)	Hydraulic Level Of Service Rating	Upgraded Size (m)
DM06754	1.2	3.493	E	2.1
DM06766*	1.95	9.769	E	3.0 x 3.0
DM06767*	1.95	9.77	E	3.0 x 3.0
DM06768*	1.95	9.769	E	3.0 x 3.0
DM06771*	0.9	1.341	F	1.5
DM06775 / DM06776*	1.5	9.369	F	3.0 x 3.0

*Provincially owned culvert
Note: The culverts DM06775 and DM06776 were identified as a double culvert at the same location but only one inlet has been confirmed in the field. It is assumed that both culverts share the same inlet and was assessed as such. A single upgraded culvert was sized to replace both culverts.

KERR WOOD LEIDAL
consulting engineers

Appendix D

Engineering Drainage Inventory

Appendix D – Drainage Inventory

1. Drainage Inventory

Table D-1: Drainage Inventory

ID[1]	Location	Size	Description	Photo No.[2]	Comments
Brown Creek Catchment					
D12858	Broadway St	3.0. m x 1.2 m	Concrete with Headwall	1 & 2	Outlet submerged. Could not see condition of the culvert.
D13110	Broadway St	3.6 m x 1.8 m	Concrete with Headwall	3	Clear and unobstructed. Could not see invert
D13891	Broadway St	3.6 m x 1.8 m	Concrete with Headwall	4	Thick brush at sides. Could not see invert
D16138	Broadway St	0.2 m *Φ*	PVC Pipe with Concrete Headwall	5	Debris piling up in front of headwall.
D04553	Mary Hill Bypass	1.05 m x 2.2 m	CSP	6	Inlet to culvert could not be located due to brush
D13135	Mary Hill Bypass	1.05 m x 2.2 m	CSP	7	outlet to culvert could not be located due to brush
D13127	Mary Hill Bypass & Coast Meridian Rd	1.5 m *Φ*	CSP, Projecting	8 & 9	Plant debris at inlet and partially filled with sediment (300mm thick).
D13128	Mary Hill Bypass & Coast Meridian Rd	1.5 m *Φ*	CSP	10	Thick brush, could not see outlet.
D13133	Mary Hill Bypass & Coast Meridian Rd	0.9 m *Φ*	CSP, Mitered to slope	11	Thick layer of grass at outlet, 800 mm drop to water.
D05642	Mary Hill Bypass & Coast Meridian Rd	1.05 m *Φ*	Concrete	12	Thick brush, outlet could not be located.
D13143	Mary Hill Bypass	0.45 m *Φ*	Concrete with Headwall	13	Inlet half filled with sediment (200 mm thick). Partially obscured by brush.
D13144	Mary Hill Bypass	0.45 m *Φ*	Concrete with Headwall	14	Could not locate due to brush.
D05644	Mary Hill Bypass & Coast Meridian Rd	0.6 m *Φ*	Concrete	15	Could not locate due to brush.
D13147	Mary Hill Bypass	0.6 m *Φ*	Concrete with Headwall	16	Only top of Headwall can be seen. Rest is submerged/filled in.
D13148	Mary Hill Bypass	0.6 m *Φ*	Concrete with Headwall	17	Could not locate due to brush.
D13151	Mary Hill Bypass	0.75 m *Φ*	Concrete with Headwall	18	Partially covered with overgrown plants.
D13122	Mary Hill Bypass	0.90 m *Φ*	CSP, Mitered to slope	19	Brush partially obstructing inlet.

ID[1]	Location	Size	Description	Photo No.[2]	Comments
D12825	Brown St & Langan Ave	0.6 m Φ	Concrete with Headwall	20	Culvert highly filled with sediment and vegetation (400 mm thick)
D12830	Brown St & Langan Ave	0.6 m Φ	Concrete with Headwall	21	Clear with minor vegetation along bottom.
D05450	Brown St & Morgan Ave	1.2 m Φ	Concrete with Headwall & Grill	22	Clear and unobstructed.
D05444	Taylor St & Morgan Ave	1.2 m Φ	Concrete	23	Partially obstructed with plants
D05445	Morgan Ave	0.6 m Φ	Concrete with Headwall	24	Clear and unobstructed.
D12835	Morgan Ave	0.25 m Φ	Concrete	25	Culvert half filled with sediment (100 mm thick).
D00938	Brown St	1.2 m Φ	Concrete with Headwall & Grill	26	Culvert partially filled with sediment (300mm thick). Grill bent.
D14642	Brown Creek	0.30 m Φ	Concrete with Headwall	N/A	Could not locate due to brush.
D12843	Brown Creek	0.90 m Φ	Concrete with Headwall & Grill	27	Clear and unobstructed. Fish were seen at location.
KWL1	Brown Creek	N/A	Creek channel	28	Log over Brown creek. Potential future obstruction.
KWL2	Brown Creek	N/A	Creek channel	29	Log over Brown creek. Potential future obstruction.
D16180	Brown Creek	0.5 m Φ	Concrete	30	Partially filled with sediment (150 mm thick).
KWL3	Brown Creek	N/A	Creek channel	31	Log over Brown creek. Potential future obstruction.
D04536	Brown Creek	0.375 m Φ	Concrete	32	Old but clear of debris
KWL4	Brown Creek	N/A	Bridge	33	Bridge height 1.5 m from cord to bed. 3 m from bank to bank at cord.
KWL5	Brown Creek	N/A	Creek channel	34	Debris in creek. Potential obstruction.
D05428	Broadway Creek	0.525 m Φ	Concrete with Headwall	N/A	Could not locate due to thick brush.
D13117	Broadway Creek	Three 1.95 m Φ	CSP, Projecting	35	Clear and unobstructed. Could not see invert
D13120	Broadway Creek	Three 1.95 m Φ	CSP, Projecting	36 & 37	Minor brush extending over top of culverts.
D04521	Broadway Creek		Outfall with Flapgate & Grate	38	Clear and unobstructed.
D09021	Broadway Creek	Two 0.75 m Φ	Outfall with Flapgate	39	Clear and unobstructed.
D05426	Harbour St	0.25 m Φ	Concrete	40	Could only see top of headwall. Opening almost

ID[1]	Location	Size	Description	Photo No.[2]	Comments
					completely buried with sediment.
Baker Creek Catchment					
D05689	Nova Scotia Ave (back alley)	0.25 m Φ	Concrete with Headwall	41	Heavily brushed and obstructed.
D05690	Nova Scotia Ave (back alley)	0.45 m Φ	Concrete with Headwall	42	Clear and unobstructed.
D13104	Baker Creek	1.2 m Φ	Concrete with Headwall	43	Partially filled with sediment (300 mm thick). Higher deposits of sediment a couple feet upstream of culvert inlet.
D05433	Baker Creek	1.2 m Φ	Concrete with Headwall	44	Clear and unobstructed.
D05419	Baker Creek	1.2 m Φ	Concrete with Headwall	45	Partially filled with sediment (200 mm thick). Additonal sediment deposits just downstream. Fish seen.
D05424	Baker Creek	1.2 m Φ	Concrete with Headwall	46	Could not get to opening due to thick brush. Sediment deposits seen downstream.
D05423	Baker Creek	0.25 m Φ	Concrete with Headwall	47 & 48	Culvert mostly filled with sediment. Heavy brush at outlet.
KWL6	Baker Creek	N/A	Bridge	49	Bridge height 1.1 m from cord to bed. 2 m from bank to bank at cord.
D05422	Baker Creek	Two 1.8 m Φ	CSP, Projecting	50	Minimal sediment at inlet with some sediment deposition upstream of culvert
DM00425/ DM01580 outlet	Baker Creek	Two 1.8 m Φ	CSP, Projecting	51	Minimal sediment along bottom
D01064	Pitt River Rd	0.6 m Φ	Concrete	N/A	Could not locate due to thick brush.
D07489	Mary Hill Bypass & Pitt River Rd	0.45 m Φ	Concrete with Headwall & Flapgate	52	Clear and unobstructed.
D07490	Mary Hill Bypass & Pitt River Rd	0.45 m Φ	Concrete with Headwall	53	Thich layer of brush in front of headwall.
D07488	Argue St & Pitt River Rd	0.45 m Φ	Concrete with Headwall	54	Covered by thick brush
DM00429/ DM01581 Inlet	Argue St	Two 1.8 m Φ	CSP, Projecting	55	Clear and unobstructed.

ID[1]	Location	Size	Description	Photo No.[2]	Comments
DM00429/ DM01581 Outlet	Argue St	Two 1.8 m Φ	CSP, Projecting	56	Clear and unobstructed.
KWL7	Baker Creek	N/A	Creek channel	57	Sediment deposition downstream of culvert
Fraser River Catchment					
D12213	Argue St	Two 1.2 m Φ	CSP, Projecting	58	Minimal sediment on bottom of culvert. Some brush over inlet.
D14178	Argue St	Two 1.2 m Φ	CSP, Projecting	59	Minimal sediment on bottom of culvert
D05784	Argue St	0.3 m Φ	Concrete with Headwall & Grill	60	Bent grill across outlet.
D04567	Argue St	0.525 m Φ	Concrete with Headwall	61	highly vegetated downstream of outlet.
D04577	Mary Hill Bypass	1.2 m Φ	CSP, Projecting	62	Minimal Sedement along bottom. Downstream bed raises to 500 mm below culvert crown.
D05785	Argue St	0.45 m Φ	Concrete with Headwall & Grill	63	Heavily vegitated. Half full of sediment at outlet (200 mm thick). Downstream bed higher than culvert crown.
D05461	Argue St	0.6 m Φ	Concrete with Headwall & Grill	64 & 65	Half full of sediment (300 mm thick),Downstream channel bed rises higher than culvert crown
D05462	Argue St	0.6 m Φ	Concrete with Headwall & Grill	66 & 67	Lots of debris in front of headwall.

1. ID#s refers to the City's asset IDs as summarized in GIS

2. Brown Creek Catchment Photos

1: D12858 Submerged Headwall.

2: D 12858 Channel DS of Headwall

3: D13110 Outlet Headwall

4: D13891 Inlet Headwall.

5: D16138 Debris in front of Outlet headwall.

6: D04553 Inlet to CSP culvert hidden by brush.

7: D13135 Outlet from CSP culvert hidden by brush.

8: D13127 Partially obstructed inlet at Coast Meridian Rd

9: D13127 Upstream channel

10: D13128 Outlet obstructed by brush

11: D13133 Mary Hill Bypass culvert

12: D05642 Brush covering outlet at Kingsway Ave

13: D13143 Sediment filled concrete inlet

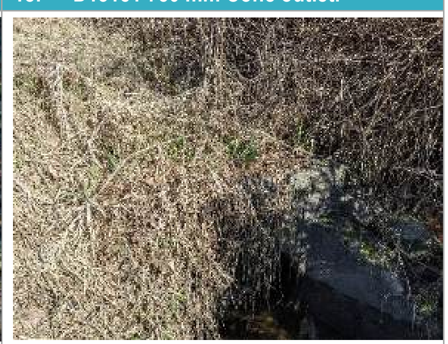
14: D13144 Obscured concrete inlet

15: D05644 Headwall obscured by brush

16: D13147 Only top of headwall seen

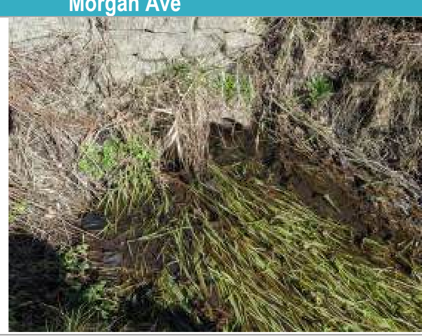
17: D13148 Headwall obscured by brush

18: D13151 750 mm Conc outlet.



19: D13122 Mitered to slope 900 mm CSP

20: D12825 Sediment filled culvert at Morgan Ave



21: D12830 600 mm conc culvert

22: D05450 Concrete headwall with Grill

23: D05444 Partially obstructed culvert

24: D05445 Concrete inlet

25: D12835 Old culvert

26: D00938 Sediment in culvert

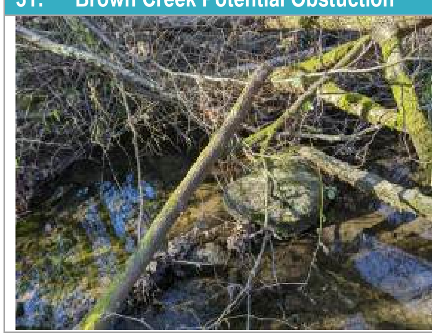
O27: D12843 Outlet into Brown Creek

28: Brown Creek Potential Obstruction

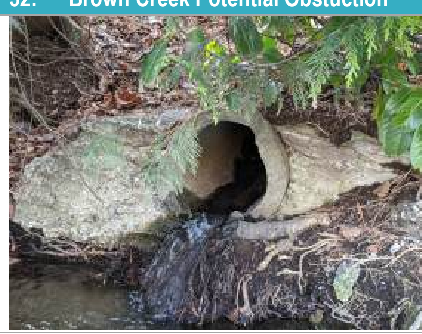
29: Brown Creek Potential Obstruction

30: D16180 Outlet into Brown Creek

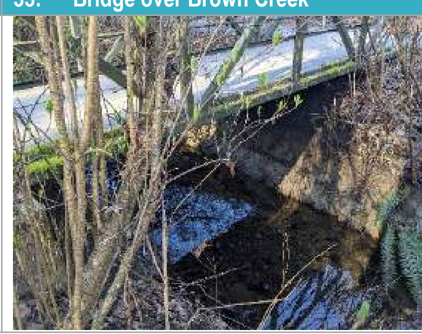
31: Brown Creek Potential Obstuction



32: Brown Creek Potential Obstuction

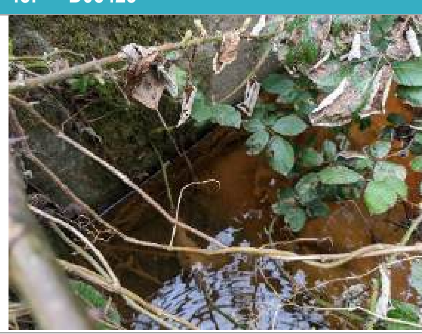


33: Bridge over Brown Creek



34: Brown Creek Obstruction	35: D13117 Brown Creek Culverts	36: D13120 Brown Creek Culverts
		
37: D13120 Brown Creek Pump inlet grill.	**38: D04521 Pump Station Outfall**	**39: D09021 Pump Station Outfall**
		
40: Headwall with covered opening.		
		

3. Baker Creek Catchment Photos

41: D05689	42: D05693	43: D13104
		
44: D05433	**45: D05419**	**46: D05424**
		
47: D05423	**48: D05423**	**49: Bridge along Baker Creek**
		

50: D05422

51: DM00425/DM01580 Outlet

52: D07489

53: D07490

54: D07488

55: DM00429/DM01581 Inlet

56: DM00429/DM01581 Outlet

57: Baker Creek Outlet

4. Fraser River Catchment Photos

58: D12213

59: D14178

60: D05784

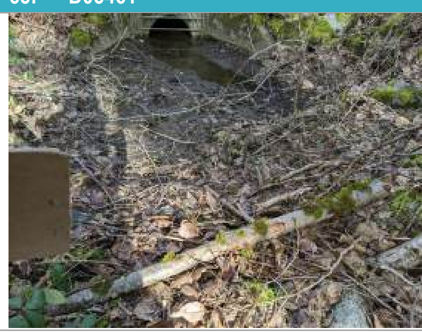
61: D04567

62: D04577

63: D05785

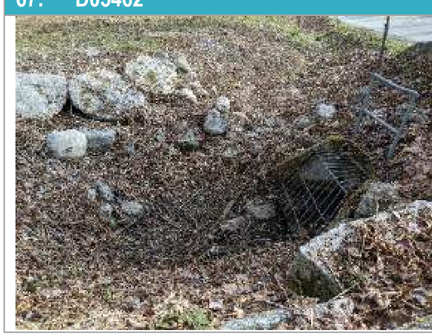
64: D05461

65: D05461



66: D05462

67: D05462



KERR WOOD LEIDAL
consulting engineers

Appendix E

Riparian Encroachment Photos

Appendix E - Riparian Encroachment Photos

Photo 1: Baker Creek – Upstream of Nova Scotia Avenue

- Little to no riparian vegetation.

Photo 2: Baker Creek – Downstream of Nova Scotia Avenue

- Retaining wall on creek bank with concrete footing.
- Retaining wall leaning towards the creek; at risk of falling.

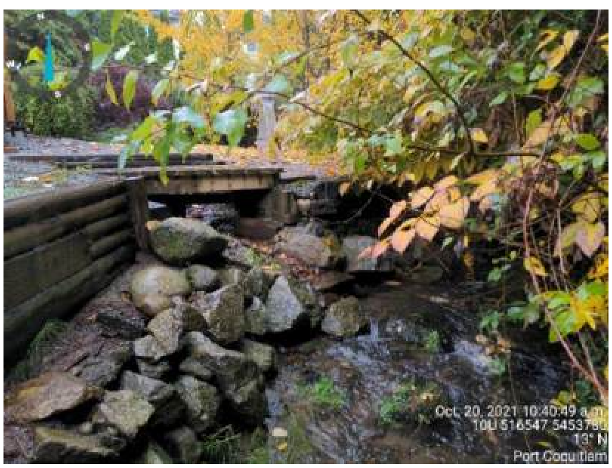


Photo 3: Baker Creek – Downstream of Nova Scotia Avenue

- No riparian vegetation on the river right bank.

Photo 4: Baker Creek – Downstream of Nova Scotia Avenue

- Deforestation on the right bank.
- Bridge over the creek.
- Three structures in riparian area.
- Retaining walls, lack of vegetation, gravel fill.
- Two drainpipes in riparian area.

Appendix E - Riparian Encroachment Photos

Photo 5: Baker Creek - Upstream of Saskatchewan Avenue

- Retaining wall in riparian area.

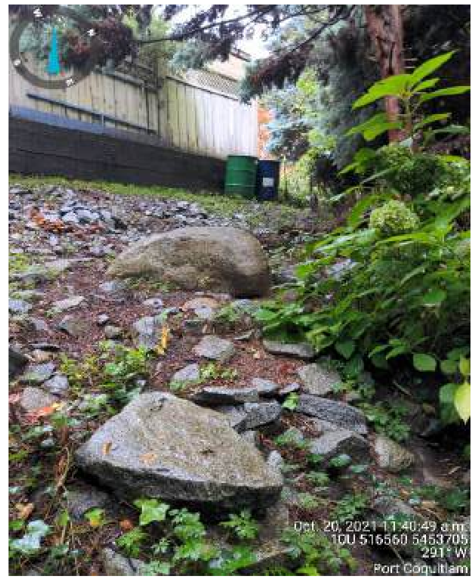


Photo 6: Baker Creek – Upstream of Saskatchewan Avenue

- Cannisters stored behind property.

Photo 7: Baker Creek - Downstream of Nova Scotia Avenue

- No riparian vegetation along the stream banks.

Photo 8: Baker Creek – Downstream of Saskatchewan Avenue

- Limited riparian vegetation on right bank.
- Water discharge pipe from adjacent property.

Appendix E - Riparian Encroachment Photos

Photo 9: Baker Creek – Upstream of Marion Kroeker Park

- No riparian vegetation.
- Structure in riparian area.
- Concrete lined creek bank.

Photo 10: Brown Creek – Downstream of Pooley Avenue

- Bare soil banks with limited riparian vegetation.
- Path runs directly beside the creek.

Photo 11: Baker Creek – Upstream of Nova Scotia Avenue

- Minimal vegetation in riparian areas.
- Creek bed and bank lined with boulders.
- Boulders in the creek backing up flow.
- Two bridges over the creek.

Photo 12: Baker Creek - Upstream of Nova Scotia Avenue

- Bridge over the creek.
- No riparian vegetation on right bank.
- In-stream weir restricting flow.

KERR WOOD LEIDAL
consulting engineers

Appendix F

Aquatic Habitat Photos

Appendix F – Aquatic Habitat Photos

Photo 1: Baker Creek – Looking upstream at the start of the creek. Upstream of Nova Scotia Avenue.

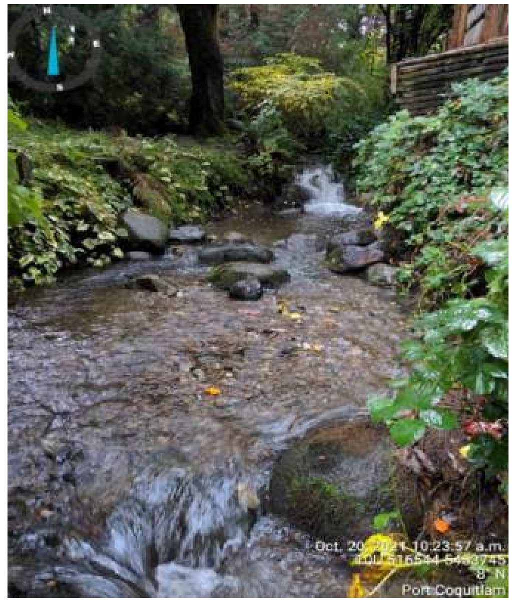


Photo 2: Baker Creek – Looking upstream at a stream reach located between Nova Scotia Avenue and Saskatchewan Avenue.

Photo 3: Baker Creek – Looking downstream at a stream reach that flows through Marian Kroeker Park.

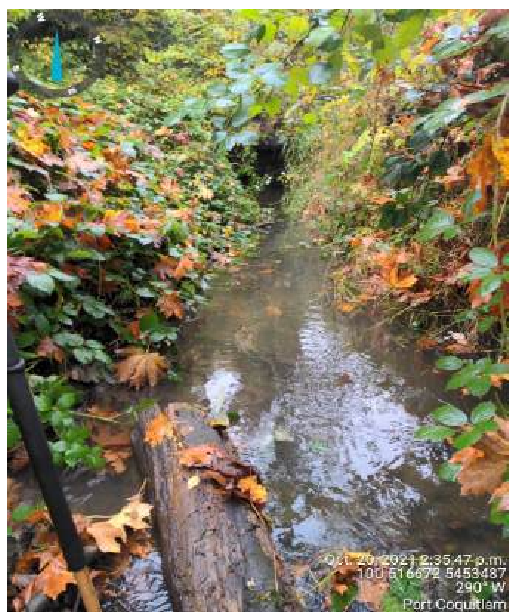


Photo 4: Baker Creek – Looking downstream at a stream reach located parallel to Mary Hill Bypass south of Marian Kroeker Park.

Appendix F – Aquatic Habitat Photos

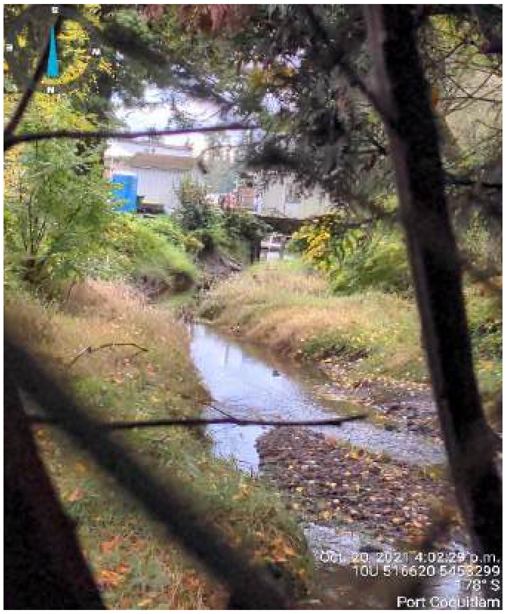


Photo 5: Baker Creek - Looking downstream at a stream reach located south of Argue Street that flows by an industrial property into the Pitt River.

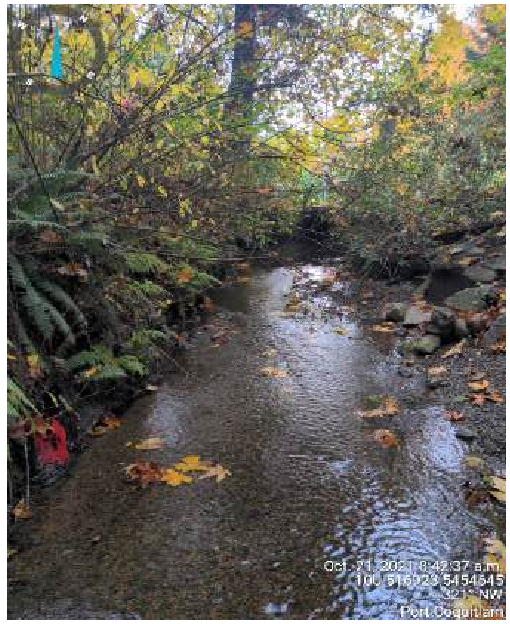


Photo 6: Brown Creek - Looking upstream at the start of the creek within Kilmer Park.

Photo 7: Brown Creek - Looking upstream at the start of the creek within Kilmer Park.

Photo 8: Brown Creek – Looking upstream at the 2003 constructed side channel habitat just upstream of the confluence at Broadway Creek.

Appendix F – Aquatic Habitat Photos

Photo 9: Broadway Creek - Looking downstream at the start of the assessed section of Broadway Creek located downstream of Broadway Street.

Photo 10: Broadway Creek – Side channel that drains into Broadway Creek located near the southern most part of the Mary Hill Bypass Business Park.

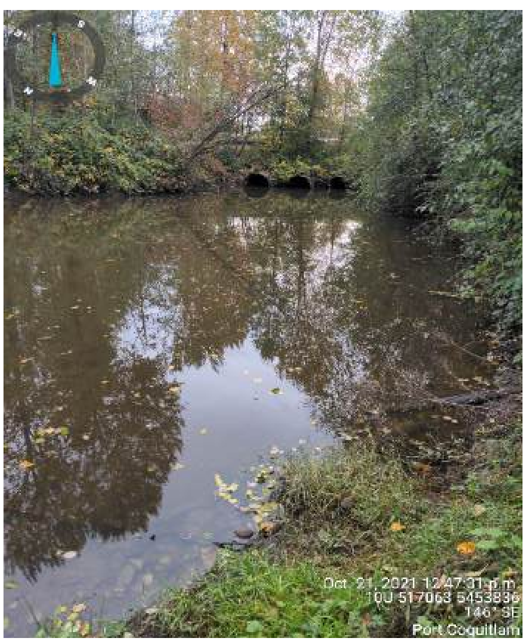


Photo 11: Broadway Creek – Looking downstream at the culverts that pass under Mary Hill Bypass.

Photo 12: Broadway Creek – Looking downstream at the Harbour Street pump station and flood boxes at the confluence of Broadway Creek and Pitt River.

KERR WOOD LEIDAL
consulting engineers

Appendix G

Invasive Plant Species Photos

Appendix G – Invasive Plant Species Photos

Photo 1: Baker Creek – Example of extensive ivy. Located near the upstream end of the culvert under Saskatchewan Avenue.

Photo 2: Baker Creek – Example of extensive Himalayan blackberry. Located along the creek immediately downstream of Marian Kroeker Park.

Photo 3: Baker Creek – Example of large Japanese knotweed patches. Located river bank right adjacent to Guest Street.

KERR WOOD LEIDAL
consulting engineers

Appendix H

Benthic Invertebrate Sampling

Appendix H – Benthic Invertebrate Sampling

Appendix H1: Benthic Invertebrate Method

Appendix H2: Benthic Invertebrate Data

Appendix H3: Benthic Invertebrate Data 02

KERR WOOD LEIDAL
consulting engineers

Appendix H1 – Benthic Invertebrate Method

Freshwater Benthic Enumeration and Identification Methods
Client: Ker Wood Leidal (KWL)
Project: South Port Coquitlam IWMP
Protocol: B-IBI (Metro Vancouver Adaptive Management Framework)

Sample Inventory

Sample arrival: 27-Sep-22
Number of samples: 6
Number of jars: 7
Screen size: 250 µm
Biologica project number: fb22-180

The chain of custody documents were checked and approved with the client. Samples were transferred from formalin into 70% ethanol and stained with Rose Bengal to aid in sorting. Each sample was provided a unique identification number and placed in the queue for analysis.

Table 1. Summary of benthic samples processed for KWL South Port Coquitlam IWMP, 2022.

Client Sample ID	Date Sampled	Biologica Sample ID	Sub-sample	Organisms Counted (raw total)
BAKER 1-3	23-Sep-22	fb22-180-001	4/24	471
BAKER 2-3	23-Sep-22	fb22-180-002	9/48	436
BAKER 3-3	23-Sep-22	fb22-180-003	4/12	472
BRW 1-3	23-Sep-22	fb22-180-004	16/48	431
BRW 2-3	23-Sep-22	fb22-180-005	5/24	552
BRW 3-3	23-Sep-22	fb22-180-006	11/48	441

Sample Processing

Sorting:

Samples were sorted using dissecting microscopes at 10–40x magnification by trained personnel. All debris in each sample was checked microscopically, including leaves, twigs, moss, elutriated gravel, and other large debris, to ensure “clinger taxa” were recovered consistently from the samples.

Split samples were subsampled using a Caton tray (Caton, 1991). All sample debris was spread evenly over a Caton grid, and equivalent quadrats were randomly selected and removed for microscopic sorting until the target count of 400 was reached.

To minimize potential sorter bias, samples were distributed among technicians such that no one person sorted all the replicates of a given sample or station.

Sorting QA/QC:

To ensure sorting efficiency was >95%, whole and/or partial sub-samples were re-sorted. Sorting efficiency was calculated using the following equation (where total count = final total number of organisms in sample):

Sorting efficiency = [1−(# of organisms in spot check or re-sort / total organisms)] x 100
*Total organisms includes the original count and the number found from the re-sort

Sorting efficiency QA/QC was performed on 33% of samples. 25%-100% of the debris was re-sorted for the selected samples. All samples checked must meet or exceed 95% sorting efficiency. Any samples falling below 95% sorting efficiency were re-sorted in their entirety, and additional checks were undertaken as necessary. For quality assurance, QA re-sorts were performed on 10% of samples. One sample was randomly selected and re-sorted in its entirety. Refer to Table 2 for sorting efficiency results.

Table 2. Summary of sorting QA/QC results for KWL South Port Coquitlam IWMP, 2022.

Client Sample ID	Biologica Sample ID	Sorting Efficiency QC: Spot check	Sorting Efficiency QA: Whole Re-sort
BAKER 1-3	fb22-180-001		
BAKER 2-3	fb22-180-002		
BAKER 3-3	fb22-180-003	99.10%	
BRW 1-3	fb22-180-004		98.59%
BRW 2-3	fb22-180-005	96.75%	
BRW 3-3	fb22-180-006		
	Average:	**97.93%**	**97.93%**

Identification:

All organisms were identified using a combination of dissecting (10–40x) and compound (100–1000x) microscopes and standard taxonomic keys (see methodological and taxonomic references) to the lowest practicable level as specified by Plotnikoff and White (1996). All specimens were archived in air-tight glass vials with glycerin and 70% ethanol for long-term storage. Taxonomic data were recorded in Biologica's custom database.

Data were compiled in an excel spreadsheet. Incidental organisms (e.g., pupae, Collembola, terrestrial insects) were reported separately and not included in the calculated indices.

The multi-metric benthic index of biological integrity (B-IBI) was calculated based on the following metrics after Karr and Chu (1999), Morely (2002) and Page et al. (2008):

- Total number of unique taxa
- Total number of unique mayfly (Ephemeroptera) taxa
- Total number of unique stonefly (Plecoptera) taxa
- Total number of unique caddisfly (Trichoptera) taxa
- Number of long-lived taxa (organisms living a minimum of 2-3 years in the immature state)
- Number of intolerant taxa
- Percent of predatory individuals
- Number of clinger taxa

- Percent dominance: the percent of individuals in the three most dominant taxa.

Long-lived, predatory, clinger, and tolerant/intolerant taxa were defined consistently with available species list attributes at pugetsoundstreambenthos.org (files constructed by R.W. Wisseman and L. Fore).

Each metric in each sample was assigned a value (1, 3 or 5) according to the thresholds reported at pugetsoundstreambenthos.org and Page et al. (2008). The sum of these values gave the sample B-IBI.

Any species new to Biologica's verified reference collections are confirmed by one of Biologica's secondary certified taxonomists.

Identification QA/QC:

For quality assurance of identification, 10% of samples were randomly selected and re-identified by a second trained taxonomist. Refer to Table 3 for QA results. A list of Biologica's taxonomists certified by the Society of Freshwater Science (SFS) are presented in Table 4.

Table 3. Summary of taxonomic QA/QC results for KWL South Port Coquitlam IWMP, 2022.

Client Sample ID	Biologica Sample ID	% Taxonomic Agreement	% Similarity in Enumeration
BRW 3-3	fb22-180-006	100%	100%

% Identification Agreement:

100-[(# of disagreements / total # of taxa identified in QA sample) x 100]

**differences in resolution are not considered disagreements*

% Enumeration Agreement:

100 – [(difference in abundance between samples/total abundance of original sample) x 100]

Table 4. Taxonomists certified by the Society of Freshwater Science (SFS).

Taxonomist	Certification	Certification Expiry*
Robynn Holma	North American Chironomidae	2022
	Western Arthropods	2022
	Western EPT	2024
	Western Chironomidae	---
	Eastern EPT	2022
	Eastern Arthropods	2024
Karen Hoban	Western EPT	2022
	Western Arthropods	2022
	Eastern EPT	2025
	Eastern Arthropods	2025
Breanna Bomback	North American Chironomidae	2025
Hiroki Tomoe	North American Oligochaeta	2020

*Certifications renewal has been delayed due to COVID-19 and certificates have been extended by SFS until such time as testing can be resumed.

Data

All data were recorded in Biologica's custom database. Results were provided to the Kerr Wood Leidal project manager in Excel spreadsheets via email.

Methodological and Taxonomic References

Barbour MT, Gerritsen J, Snyder BD, Stribling JB. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. 2nd ed. EPA 841-B-99-002. Washington (D.C.): U.S. Environmental Protection Agency; Office of Water.

Beatty JM, McDonald LE, Westcott FM, Perrin CJ. 2006. Guidelines for Sampling Benthic Invertebrates in British Columbia Streams. BC Ministry of Environment. http://www.env.gov.bc.ca/epd/regions/kootenay/wq_reports/pdf/bi-sampling-06update.pdf. Accessed December 2012.

Bousfield EL. 1958. Freshwater amphipod crustaceans of glaciated North America. The Canadian Field Naturalist. 72(2): 55–113

Clarke AH. 1981. The Freshwater Molluscs of Canada. National Museum of Natural Sciences, National Museums of Canada.

Caton LW. 1991. Improved Subsampling Methods for the EPA "Rapid Bioassessment" Benthic Protocols. Bulletin of the North American Benthological Society of America. 8(3): 317–319.

Environment Canada. 2010. Pulp and Paper Environmental Effects Monitoring (EEM) Technical Guidance Document.

Environment Canada. 2012. Metal Mining Environmental Effects Monitoring (EEM) Technical Guidance Document.

Environment Canada. 2002. Revised Guidance for Sample Sorting and Subsampling Protocols for EEM Benthic Invertebrate Community Surveys. https://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=F919D331-1. Accessed December 2012.

Epler JH. 2010. The Water Beetles of Florida - an identification manual for the families Chrysomelidae, Curculionidae, Dryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Helophoridae, Hydraenidae, Hydrochidae, Hydrophilidae, Noteridae, Psephenidae, Ptilodactylidae and Scirtidae. Tallahassee (FL): Florida Department of Environmental Protection. 399 + iv pp.

Epler JH. 2001. Identification manual for the larval Chironomidae (Diptera) of North and South Carolina. A guide to the taxonomy of the midges of the southeastern United States, including Florida. Special Publication SJ2001-SP13. Raleigh (NC) and St. John's River Water: North Carolina Department of Environmental and Natural Resources.

Essig EO. 1926. Insects of Western North America. The Macmillan Company.

Kathman RD, Brinkhurst RO. 1998. Guide to the Freshwater Oligochaetes of North America. College Grove (TN): Aquatic Resources Centre.

Karr JR, Chu EW. 1999. Restoring life in running waters: better biological monitoring. Washington (D.C.): Island Press.

McAlpine JF (ed.). Manual of Nearctic Diptera, Research Branch Agriculture. Ottawa (ON). Vol.1 (1982), Vol.2 (1987), Vol.3 (1989).

McDermott H, Paull T, Strachan S. 2012. CABIN (Canadian Aquatic Biomonitoring Network) Invertebrate Biomonitoring Field and Laboratory Manual. National Water Research Institute, Environment Canada, 30pp.

Merritt RW, Cummins KW. 1996. Aquatic Insects of North America. 3rd ed. Kendall/Hunt Publishing Company.

Morley SA, Karr JR. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. Conservation Biology. 16: 1498–1509.

Needham JG, Westfall Jr. MJ, May ML. 2014. Dragonflies of North America: the Odonata (Anisoptera) Fauna of Canada, the Continental United States, Northern Mexico and the Greater Antilles. 3rd ed. Scientific Publishers, Inc.

Northwest Biological Assessment Workgroup 9th Annual Taxonomic Workshop. 2005. Mayflies in Moscow: Northwest Ephemeroptera Nymphs. University of Idaho.

Oliver DR, Roussel ME. 1983. The Genera of Larval Midges of Canada Diptera: Chironomidae, Canada Dept. of Agriculture.

Palmer, M. A., Brooks, J., Of Biology, D., Alexander, L. C. and Lamp, W. O. (2000), Restoring Life in Running Waters: Better Biological Monitoring. Restoration Ecology, 8: 210-210. doi: 10.1046/j.1526-100x.2000.80028-2.x

Peckarsky BL, Fraissinet PR, Penton MA, Conklin Jr. DJ. 1993. Freshwater Macroinvertebrates of Northeastern North America. Cornell University Press.

Pennak RW. 2001. Freshwater Invertebrates of the United States. 4th ed. John Wiley and Sons, Inc.

Proctor H. 2006. Key to Aquatic Mites Known From Alberta. Department of Biological Sciences, University of Calgary.

Rogers DC. 2005. Identification manual to the freshwater Crustacea of the western United States and adjacent areas encountered during bioassesment. EcoAnalysts, Inc. Technical Publication #1.

Smit H, Dudok E. 1993. Biovolume as a toll in biomass determination of Oligocheata and Chironomidae. Freshwater Biology. 29: 37–46.

Stewart KW, Oswood MW. 2006. The Stoneflies (Plecoptera) of Alaska and Western Canada. The Caddis Press.

Stewart KW, Stark BP. 2002. Nymphs of North American Stonefly Genera (Plecoptera). 2nd ed. The Caddis Press.

Thorp JH, Covich AP. 1991. Ecology and Classification of Freshwater Invertebrates, Academic Press, Inc.

Webb JM. 2017. Baetidae larvae of the western United States and Canada, Version 0.1. Davis (CA): Southwest Association of Freshwater Invertebrate Taxonomists Workshop. 197 pp.

Witzel MJ, Fend SV, Coates KA, Kathman RD, Gelder SR. 2009. Taxonomy, systematics, and ecology of the aquatic Oligochaeta and Branchiobdellidae (Annelida, Clitellata) of North America. A workbook. vi + 280 pp. + color plates.

Wiggins GB. 1996. Larvae of the North American caddisfly genera (Trichoptera). 2nd ed. Toronto (ON): University of Toronto Press. 457 pp.

Appendix H2 - Benthic Invertebrate Data

biologica

Abundance data in matrix format and B-IBI calculations for KWL South Port Coquitlam IWMP, 2022. Calculations exclude copepods, ostracods, nematods, pupae and terrestrial organisms.

Station							**Baker**						**BRW**					
Client Sample ID							**BAKER 1-3**		**BAKER 2-3**		**BAKER 3-3**		**BRW 1-3**		**BRW 2-3**		**BRW 3-3**	
Biologica Sample ID							**fb22-180-001**		**fb22-180-002**		**fb22-180-003**		**fb22-180-004**		**fb22-180-005**		**fb22-180-006**	
Percent sampled							**16.67**		**18.75**		**33.33**		**33.33**		**20.83**		**22.92**	
Group Cod	**Family**	**Taxon**	**Voltinism**	**Tol/Intol**	**Clinger**	**Feeding**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**
ANOL	Lumbricidae	Eiseniella tetraedra	UV	0	no	CG	1	8	1	5	1	44	1	6	1	23	1	6
ANOL		Clitellata indet.	Uv-Sv	0	no	CG		132		81		193		88		68		114
CHAR	Ceratozetidae	Ceratozetidae indet.	Mv	0	no	SH	1	2			1	1						
CHAR	Lebertiidae	Lebertia sp.	Mv	0	no	PR	1	2	1	1	1	1	1	4	1	14	1	8
CHAR	Sperchontidae	Sperchon sp.		0	no	PR	1	1			1	1						
CHAR	Sperchontidae	Sperchonopsis sp.		0	no	PR			1	1			1	29	1	21	1	13
CHAR	Sperchontidae	Sperchontidae indet.		0	no	PR				1						3		
CHAR		Acariformes indet.	Mv	0	no	PR										1		1
CHAR		Macropylina indet.	Mv	0	no	SH	1	4			1	2						
CHAR		Oribatida indet.	Mv	0	no	SH							1	1	1	1		
CNHY	Hydridae	Hydridae indet.	Uv-Mv	0	no	PR	1	17	1	12	1	43	1	15	1	61	1	11
CRAM	Crangonyctidae	Crangonyx sp.	UV	T	no	CG	1	53	1	29	1	40	1	43	1	101	1	30
CRAM		Amphipoda indet.	UV	T	no	CG		13		36		33		55		77		36
CRIS	Asellidae	Asellidae indet.	UV	T	no	CG							1	16	1	34	1	22
CRIS		Isopoda indet.	UV	0	no	CG								1		4		8
INDI	Ceratopogonidae	Ceratopogoninae indet.	UV	0	no	PR	1	2	1	1	1	2	1	2	1	2	1	1
INDI	Chironomidae	Chironomidae indet.	Uv-Mv	0	no	CG	1	122	1	103	1	50	1	138	1	106	1	171
INDI	Dixidae	Dixa sp.	UV	0	no	CG							1	5	1	1	1	2
INDI	Dixidae	Dixella sp.	UV	T	no	CG											1	3
INDI	Empididae	Empididae indet.	UV	0	yes	PR			1	2							1	1
INDI	Empididae	Neoplasta sp.	UV	0	yes	PR					1	1						2
INDI	Simuliidae	Helodon sp.	UV	0	yes	CF	1	1										
INDI	Simuliidae	Simuliidae indet.	UV	0	yes	CF				4		2						
INDI	Simuliidae	Simulium sp.	UV	0	yes	CF			1	3	1	4						
INEP	Baetidae	Baetidae indet.	Uv-Mv	0	yes	CG		92		141		27		17		11		
INEP	Baetidae	Baetis sp.	Uv-Mv	0	yes	CG	1	1	1	5	1	18	1	8	1	8		
INEP		Ephemeroptera indet.	UN	0	no	UN				2				1		2		
INTR	Limnephilidae	Limnephilidae indet.	UV	0	no	SH	1	1										
INTR		Trichoptera indet.	UV	0	no	UN							1	1	1	1		
MOBI	Pisidiidae	Pisidiidae indet.	LL	0	no	CG	1	1	1	3	1	5						
MOBI		Bivalvia indet.	LL	0	no	CG		16		5		2					1	1
MOGA	Physidae	Physidae indet.	UV	T	no	CG									1	2		
MOGA	Planorbidae	Ferrissia sp.	UV	T	no	SC			1	1	1	1	1	1	1	1	1	6
MOGA		Gastropoda indet.	UV	0	yes	SC										1		3
NTEA		Nemertea indet.	UV	T	no	PR	1	1							1	5		
PLTY		Platyhelminthes indet.	Mv	0	no	PR	1	2			1	2			1	4	1	2
						Total		**471**		**436**		**472**		**431**		**552**		**441**

KERR WOOD LEIDAL
consulting engineers

Appendix H3 – Benthic Invertebrate Data 02

Abundance data in matrix format and B-IBI calculations for KWL South Port Coquitlam IWMP, 2022. Calculations exclude copepods, ostracods, nematods, pupae and terrestrial organisms.

Station	**Baker**						**BRW**					
Client Sample ID	**BAKER 1-3**		**BAKER 2-3**		**BAKER 3-3**		**BRW 1-3**		**BRW 2-3**		**BRW 3-3**	
Biologica Sample ID	**fb22-180-001**		**fb22-180-002**		**fb22-180-003**		**fb22-180-004**		**fb22-180-005**		**fb22-180-006**	
Percent sampled	**16.67**		**18.75**		**33.33**		**33.33**		**20.83**		**22.92**	
Group Code	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**	**Unique**	**Count**
Metrics						**Station Average**						**Station Average**
Taxon Richness	15		12		15	14	13		16		14	14
E richness	1		1		1	1	1		1		0	1
P richness	0		0		0	0	0		0		0	0
T richness	1		0		0	0	1		1		0	1
Intolerant Richness	0		0		0	0	0		0		0	0
Clinger Richness	2		3		3	3	1		1		1	1
Long-Lived Richness	1		1		1	1	0		0		1	0
% Tolerant	14.23		15.14		15.68	15.01	26.68		39.86		22.00	29.51
% Predator	5.31		4.13		10.59	6.68	11.60		20.11		8.84	13.52
%Dominance (3)	73.46		74.54		60.81	69.60	65.20		51.45		72.79	63.15
10-50 B-IBI Values (Fine Resolution)												
Taxon Richness	3		1		3	1	1		3		1	1
E richness	1		1		1	1	1		1		1	1
P richness	1		1		1	1	1		1		1	1
T richness	1		1		1	1	1		1		1	1
Intolerant Richness	1		1		1	1	1		1		1	1
Clinger Richness	1		1		1	1	1		1		1	1
Long-Lived Richness	1		1		1	1	1		1		1	1
% Tolerant	5		5		5	5	3		3		3	3
% Predator	1		1		3	1	3		5		1	3
%Dominance (3)	3		3		3	3	3		5		3	3
B-IBI Sample Score	**18**		**16**		**20**		**16**		**22**		**14**	
B-IBI Site Score						**16**						**16**
B-IBI Site Category						**Very Poor**						**Very Poor**
Community Composition												
%EPT	20.0		33.9		9.5		6.3		4.0		0.0	
%Chironomidae	25.9		23.6		10.6		32.0		19.2		38.8	
%Oligochaetes	29.7		19.7		50.2		21.8		16.5		27.2	

KERR WOOD LEIDAL
consulting engineers

Appendix I

Water Quality Sampling

Appendix I – Water Quality Sampling

Appendix I1: CARO Water Quality Data

Appendix I2 Metro Vancouver Water Quality Data

Appendix I3: Water Quality Photos

KERR WOOD LEIDAL
consulting engineers

Appendix I1 - CARO Water Quality Data

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22I3611
PO NUMBER		**RECEIVED / TEMP**	2022-09-28 09:22 / 9.3°C
PROJECT	646.043	**REPORTED**	2022-10-05 17:24
PROJECT INFO	Port Coquitlam 2022 AMF (Dry Weather)	**COC NUMBER**	No #

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
https://www.caro.ca/terms-conditions

If you have any questions or concerns, please contact me at mdeokar@caro.ca

Authorized By:

Manali Deokar
Sales Specialist

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22I3611
PROJECT	646.043	**REPORTED**	2022-10-05 17:24

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22I3611-01) | Matrix: Water | Sampled: 2022-09-27 12:22						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**816**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**770**	N/A	1	MPN/100 mL	2022-09-28	
AMF-POCO_S_BD1 (22I3611-02) | Matrix: Water | Sampled: 2022-09-27 12:51						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1090**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**594**	N/A	1	MPN/100 mL	2022-09-28	
AMF-POCO_S_BD5 (22I3611-03) | Matrix: Water | Sampled: 2022-09-27 13:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**261**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**153**	N/A	1	MPN/100 mL	2022-09-28	
AMF-POCO_S_BK3 (22I3611-04) | Matrix: Water | Sampled: 2022-09-27 13:47						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**387**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**365**	N/A	1	MPN/100 mL	2022-09-28	
AMF-POCO_S_BK7 (22I3611-05) | Matrix: Water | Sampled: 2022-09-27 11:51						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1990**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**1990**	N/A	1	MPN/100 mL	2022-09-28	
AMF-POCO_S_FR1 (22I3611-06) | Matrix: Water | Sampled: 2022-09-27 11:20						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**299**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**148**	N/A	1	MPN/100 mL	2022-09-28	
Field Blank (22I3611-07) | Matrix: Water | Sampled: 2022-09-27 12:42						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-09-28	
Replicate (22I3611-08) | Matrix: Water | Sampled: 2022-09-27 12:30						

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22I3611
PROJECT	646.043	**REPORTED**	2022-10-05 17:24

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22I3611-08) | Matrix: Water | Sampled: 2022-09-27 12:30, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1300**	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	**1200**	N/A	1	MPN/100 mL	2022-09-28	
Trip Blank (22I3611-09) | Matrix: Water | Sampled: 2022-09-27 11:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-09-28	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-09-28	

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22I3611
PROJECT	646.043	**REPORTED**	2022-10-05 17:24

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:mdeokar@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22I3611
PROJECT	646.043	**REPORTED**	2022-10-05 17:24

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2I3294										
Blank (B2I3294-BLK1)				Prepared: 2022-09-28, Analyzed: 2022-09-28						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2I3294-BLK2)				Prepared: 2022-09-28, Analyzed: 2022-09-28						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2I3294-DUP2)	**Source: 22I3611-01**			Prepared: 2022-09-28, Analyzed: 2022-09-28						
Coliforms, Fecal (Q-Tray)	921	1	MPN/100 mL		816			12	80	
E. coli (Q-Tray)	816	1	MPN/100 mL		770			6	80	

CARO ANALYTICAL SERVICES

V6V 2K9
C V1X 5C3
AB T5S 1H7

221361 1

CHAIN-OF-CUSTODY RECORD

COC#

CARO BC COC, Rev 03/13

Page 1 of 1

RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
Larissa Low	DATE: 28/09/22 TIME: 9:20am	RC WI	9/28 TIME: 9.22
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY:	DATE: TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Dry Weather)
PO #:
SAMPLED BY: Larissa Low
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1 1	☐	☑	☐	☐	1	27-09-22	12:22	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1 2	☐	☑	☐	☐	1	↓	12:51	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5 3	☐	☑	☐	☐	1	↓	13:10	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK3 4	☐	☑	☐	☐	1	↓	13:47	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7 5	☐	☑	☐	☐	1	↓	11:51	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1 6	☐	☑	☐	☐	1	↓	11:20	☐	☐	☑		☑	☑	☐
Field Blank 7	☐	☑	☐	☐	1	↓	12:42	☐	☐	☑		☑	☑	☑
Replicate 8	☐	☑	☐	☐	1	↓	12:30	☐	☐	☑		☑	☑	☑
Trip Blank 9	☐	☑	☐	☐	1	↓	11:00	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): ______
Work Order # ______
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields   Recommended Fields   SHADED AREAS: LAB USE ONLY

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22J0189
PO NUMBER		**RECEIVED / TEMP**	2022-10-03 12:50 / 12.6°C
PROJECT	646.043	**REPORTED**	2022-10-11 18:32
PROJECT INFO	Port Coquitlam 2022 AMF (Dry Weather)		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J0189
PROJECT	646.043	**REPORTED**	2022-10-11 18:32

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22J0189-01) | Matrix: Water | Sampled: 2022-10-03 11:05						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**2420**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**1300**	N/A	1	MPN/100 mL	2022-10-04	
AMF-POCO_S_BD1 (22J0189-02) | Matrix: Water | Sampled: 2022-10-03 11:18						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**6490**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**6490**	N/A	1	MPN/100 mL	2022-10-04	
AMF-POCO_S_BD5 (22J0189-03) | Matrix: Water | Sampled: 2022-10-03 10:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**393**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**241**	N/A	1	MPN/100 mL	2022-10-04	
AMF-POCO_S_BK3 (22J0189-04) | Matrix: Water | Sampled: 2022-10-03 10:52						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**261**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**261**	N/A	1	MPN/100 mL	2022-10-04	
AMF-POCO_S_BK7 (22J0189-05) | Matrix: Water | Sampled: 2022-10-03 10:16						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-10-04	
AMF-POCO_S_FR1 (22J0189-06) | Matrix: Water | Sampled: 2022-10-03 09:52						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**85**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**63**	N/A	1	MPN/100 mL	2022-10-04	
Field Blank (22J0189-07) | Matrix: Water | Sampled: 2022-10-03 10:49						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-04	
Replicate (22J0189-08) | Matrix: Water | Sampled: 2022-10-03 09:55						

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J0189
PROJECT	646.043	**REPORTED**	2022-10-11 18:32

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22J0189-08) | Matrix: Water | Sampled: 2022-10-03 09:55, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**109**	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	**63**	N/A	1	MPN/100 mL	2022-10-04	
Trip Blank (22J0189-09) | Matrix: Water | Sampled: 2022-10-03 09:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-04	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-04	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J0189
PROJECT	646.043	**REPORTED**	2022-10-11 18:32

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J0189
PROJECT	646.043	**REPORTED**	2022-10-11 18:32

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2J0299										
Blank (B2J0299-BLK2)				Prepared: 2022-10-04, Analyzed: 2022-10-04						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2J0299-DUP2)	**Source: 22J0189-05**			Prepared: 2022-10-04, Analyzed: 2022-10-04						
Coliforms, Fecal (Q-Tray)	> 2420	1	MPN/100 mL		> 2420				80	
E. coli (Q-Tray)	> 2420	1	MPN/100 mL		> 2420				80	

CARO ANALYTICAL S[...] | *22J0189*

RICHMOND, BC V6V 2K9
(604) 279-1599

ELOWNA, BC V1X 5C3
0) 765-3893

ONTON, AB T5S 1H7
9-9700

CARO BC COC, Rev 03/13

CHAIN-OF-CUSTODY RECORD

COC#

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
Larissa Low	DATE: 03/10/22 TIME: 12:05pm	NC - WI	DATE: 10/03 TIME: 12:50
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY:	DATE: TIME:

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Dry Weather)
PO #:

SAMPLED BY: Larissa Low
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

REPORT TO:
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	MATRIX: DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	SAMPLING: DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	03-10-22	11:05	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	11:18	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	10:30	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK8	☐	☑	☐	☐	1	↓	10:52	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	10:16	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	9:52	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1	↓	10:49	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1	↓	9:55	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1	↓	9:10	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.
(07→9X

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): 12.6 C
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22J1265
PO NUMBER		**RECEIVED / TEMP**	2022-10-11 13:37 / 13.3°C
PROJECT	646.043	**REPORTED**	2022-10-18 17:33
PROJECT INFO	Port Coquitlam 2022 AMF (Dry Weather)	**COC NUMBER**	No #

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
https://www.caro.ca/terms-conditions

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J1265
PROJECT	646.043	**REPORTED**	2022-10-18 17:33

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22J1265-01) | Matrix: Water | Sampled: 2022-10-11 11:52						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**1300**	N/A	1	MPN/100 mL	2022-10-12	
AMF-POCO_S_BD1 (22J1265-02) | Matrix: Water | Sampled: 2022-10-11 11:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1840**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**1030**	N/A	1	MPN/100 mL	2022-10-12	
AMF-POCO_S_BD5 (22J1265-03) | Matrix: Water | Sampled: 2022-10-11 11:05						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**190**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**152**	N/A	1	MPN/100 mL	2022-10-12	
AMF-POCO_S_BK3 (22J1265-04) | Matrix: Water | Sampled: 2022-10-11 11:40						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**167**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**142**	N/A	1	MPN/100 mL	2022-10-12	
AMF-POCO_S_BK7 (22J1265-05) | Matrix: Water | Sampled: 2022-10-11 10:48						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**2420**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**1300**	N/A	1	MPN/100 mL	2022-10-12	
AMF-POCO_S_FR1 (22J1265-06) | Matrix: Water | Sampled: 2022-10-11 10:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1120**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**365**	N/A	1	MPN/100 mL	2022-10-12	
Field Blank (22J1265-07) | Matrix: Water | Sampled: 2022-10-11 11:50						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-12	
Replicate (22J1265-08) | Matrix: Water | Sampled: 2022-10-11 10:25						

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J1265
PROJECT	646.043	**REPORTED**	2022-10-18 17:33

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22J1265-08) | Matrix: Water | Sampled: 2022-10-11 10:25, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**980**	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	**435**	N/A	1	MPN/100 mL	2022-10-12	
Trip Blank (22J1265-09) | Matrix: Water | Sampled: 2022-10-11 10:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-12	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-12	

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J1265
PROJECT	646.043	**REPORTED**	2022-10-18 17:33

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

CARO ANALYTICAL SERVICES

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J1265
PROJECT	646.043	**REPORTED**	2022-10-18 17:33

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2J1196										
Blank (B2J1196-BLK1)				Prepared: 2022-10-12, Analyzed: 2022-10-12						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2J1196-BLK2)				Prepared: 2022-10-12, Analyzed: 2022-10-12						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2J1196-DUP2)	**Source: 22J1265-03**			Prepared: 2022-10-12, Analyzed: 2022-10-12						
Coliforms, Fecal (Q-Tray)	160	1	MPN/100 mL		190			18	80	
E. coli (Q-Tray)	129	1	MPN/100 mL		152			16	80	

CARO ANALYTICAL SERVICES

☑ 110 - 4011 VIKING WAY, RICHMOND, BC V6V 2K9

22J1265

CHAIN-OF-CUSTODY RECORD COC#

CARO BC COC, Rev 03/13

Page 1 of 1

RELINQUISHED BY:	DATE: Oct 11 / 22	RECEIVED BY:	DATE: 11/10/22
Larissa Low	TIME: [illegible] pm	[illegible]	TIME: 13:37
RELINQUISHED BY:	DATE: 1:30 pm	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Dry Weather)
PO #:
SAMPLED BY: Larissa Low
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	11-10-22	11:52	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1		11:15	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1		11:05	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK3	☐	☑	☐	☐	1		11:40	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1		10:48	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1		10:30	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1		11:50	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1		10:25	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1	↓	10:00	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.
Hold field, trip, & replicate. 607-9[illegible]

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): 13.3
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CARO
ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22J2138
PO NUMBER		**RECEIVED / TEMP**	2022-10-18 08:45 / 9.5°C
PROJECT	646.043	**REPORTED**	2022-11-08 11:59
PROJECT INFO	Port Coquitlam 2022 AMF (Dry Weather)	**COC NUMBER**	No number

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
https://www.caro.ca/terms-conditions

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2138
PROJECT	646.043	**REPORTED**	2022-11-08 11:59

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22J2138-01) | Matrix: Water | Sampled: 2022-10-17 15:37						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**921**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**770**	N/A	1	MPN/100 mL	2022-10-18	
AMF-POCO_S_BD1 (22J2138-02) | Matrix: Water | Sampled: 2022-10-17 16:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**504**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**336**	N/A	1	MPN/100 mL	2022-10-18	
AMF-POCO_S_BD5 (22J2138-03) | Matrix: Water | Sampled: 2022-10-17 15:04						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1200**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**1200**	N/A	1	MPN/100 mL	2022-10-18	
AMF-POCO_S_BK7 (22J2138-05) | Matrix: Water | Sampled: 2022-10-17 14:35						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**76**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**70**	N/A	1	MPN/100 mL	2022-10-18	
AMF-POCO_S_FR1 (22J2138-06) | Matrix: Water | Sampled: 2022-10-17 13:58						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**259**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**122**	N/A	1	MPN/100 mL	2022-10-18	
Field Blank (22J2138-07) | Matrix: Water | Sampled: 2022-10-17 15:20						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-18	
Replicate (22J2138-08) | Matrix: Water | Sampled: 2022-10-17 14:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1990**	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	**1990**	N/A	1	MPN/100 mL	2022-10-18	
Trip Blank (22J2138-09) | Matrix: Water | Sampled: 2022-10-17 13:00						

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2138
PROJECT	646.043	**REPORTED**	2022-11-08 11:59

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Trip Blank (22J2138-09) | Matrix: Water | Sampled: 2022-10-17 13:00, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-18	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-10-18	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2138
PROJECT	646.043	**REPORTED**	2022-11-08 11:59

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2138
PROJECT	646.043	**REPORTED**	2022-11-08 11:59

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2J1992										
Blank (B2J1992-BLK1)				Prepared: 2022-10-18, Analyzed: 2022-10-18						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2J1992-BLK2)				Prepared: 2022-10-18, Analyzed: 2022-10-18						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2J1992-DUP2)	**Source: 22J2138-01**			Prepared: 2022-10-18, Analyzed: 2022-10-18						
Coliforms, Fecal (Q-Tray)	1200	1	MPN/100 mL		921			27	80	
E. coli (Q-Tray)	770	1	MPN/100 mL		770			< 1	80	

CARO ANALYTICAL SERVICES

* 2 2 J 2 1 3 8 *

V 2K9
1X 5C3
5S 1H7

CHAIN-OF-CUSTODY RECORD

COC#

CARO BC COC, Rev 03/13

Page 1 of 1

RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE: 10/13
Larissa Low	TIME:	Npr (ws)	TIME: 8:45
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Dry Weather)
PO #:
SAMPLED BY: Larissa Low
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	17-10-22	15:37	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	16:00	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	15:04	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK8	☐	☑	☐	☐	1	↓	15:24	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	14:35	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	13:58	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1	↓	15:20	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1	↓	14:30	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1	↓	13:00	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT
Cheque ☐
Credit ☐
Debit ☐
Cash ☐
Invoice ☐

SAMPLE RECEIPT TEMP (°C): 9, ✓
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22J2674
PO NUMBER		**RECEIVED / TEMP**	2022-10-20 15:05 / 8.6°C
PROJECT	646.043	**REPORTED**	2022-10-21 14:41
PROJECT INFO	Port Coquitlam 2022 AMF 9Dry Weather)	**COC NUMBER**	COC

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
https://www.caro.ca/terms-conditions

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2674
PROJECT	646.043	**REPORTED**	2022-10-21 14:41

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22J2674-01) | Matrix: Water | Sampled: 2022-10-20 11:45						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2419.6**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**> 2419.6**	N/A	1	MPN/100 mL	2022-10-20	
AMF-POCO_S_BD1 (22J2674-02) | Matrix: Water | Sampled: 2022-10-20 13:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**309**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**145**	N/A	1	MPN/100 mL	2022-10-20	
AMF-POCO_S_BD5 (22J2674-03) | Matrix: Water | Sampled: 2022-10-20 09:42						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**448**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**292**	N/A	1	MPN/100 mL	2022-10-20	
AMF-POCO_S_BK3 (22J2674-04) | Matrix: Water | Sampled: 2022-10-20 10:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**579**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**517**	N/A	1	MPN/100 mL	2022-10-20	
AMF-POCO_S_BK7 (22J2674-05) | Matrix: Water | Sampled: 2022-10-20 09:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**687**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**687**	N/A	1	MPN/100 mL	2022-10-20	
AMF-POCO_S_FR1 (22J2674-06) | Matrix: Water | Sampled: 2022-10-20 09:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**158**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**86**	N/A	1	MPN/100 mL	2022-10-20	
Replicate (22J2674-07) | Matrix: Water | Sampled: 2022-10-20 13:05						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**279**	N/A	1	MPN/100 mL	2022-10-20	
E. coli (Q-Tray)	**161**	N/A	1	MPN/100 mL	2022-10-20	

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2674
PROJECT	646.043	**REPORTED**	2022-10-21 14:41

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22J2674
PROJECT	646.043	**REPORTED**	2022-10-21 14:41

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2J2388										
Blank (B2J2388-BLK1)				Prepared: 2022-10-20, Analyzed: 2022-10-20						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2J2388-BLK2)				Prepared: 2022-10-20, Analyzed: 2022-10-20						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							

CARO ANALYTICAL SERVICES

2K9 5C3 1H7

22J2674

CARO BC COC, Rev 03/13

CHAIN-OF-CUSTODY RECORD

COC#

Page 1 of 1

RELINQUISHED BY:	DATE: Oct 20 2022	RECEIVED BY:	DATE: 10/20
Larissa Low	TIME: 3:00 pm		TIME: 15:05
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Dry Weather)
PO #:
SAMPLED BY: Larissa Low
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	20-10-22	11:45	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	13:10	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	9:42	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK3	☐	☑	☐	☐	1	↓	10:00	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	9:30	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	9:10	☐	☐	☑		☑	☑	☐
~~Field Blank~~	☐	☑	☐	☐	1	↓		☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1	↓	13:05	☐	☐	☑		☑	☑	☑
~~Trip Blank~~	☐	☑	☐	☐	1			☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): 8.2
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields | Recommended Fields | SHADED AREAS: LAB USE ONLY

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22K2563
PO NUMBER		**RECEIVED / TEMP**	2022-11-22 15:25 / 11.2°C
PROJECT	646.043	**REPORTED**	2022-11-29 17:30
PROJECT INFO	Port Coquitlam 2022 AMF (Wet Weather)	**COC NUMBER**	no number

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2563
PROJECT	646.043	**REPORTED**	2022-11-29 17:30

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22K2563-01) | Matrix: Water | Sampled: 2022-11-22 08:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1410**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**980**	N/A	1	MPN/100 mL	2022-11-23	
AMF-POCO_S_BD1 (22K2563-02) | Matrix: Water | Sampled: 2022-11-22 08:32						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 4840**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-23	
AMF-POCO_S_BD5 (22K2563-03) | Matrix: Water | Sampled: 2022-11-22 11:02						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 4840**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-23	
AMF-POCO_S_BK1 (22K2563-04) | Matrix: WA | Sampled: 2022-11-22 08:57						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**816**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**816**	N/A	1	MPN/100 mL	2022-11-23	
AMF-POCO_S_BK7 (22K2563-05) | Matrix: Water | Sampled: 2022-11-22 10:43						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-23	
AMF-POCO_S_FR1 (22K2563-06) | Matrix: Water | Sampled: 2022-11-22 11:17						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**2420**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**1550**	N/A	1	MPN/100 mL	2022-11-23	
Field Blank (22K2563-07) | Matrix: Water | Sampled: 2022-11-22 11:17						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-23	
Replicate (22K2563-08) | Matrix: Water | Sampled: 2022-11-22 11:17						

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2563
PROJECT	646.043	**REPORTED**	2022-11-29 17:30

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22K2563-08) | Matrix: Water | Sampled: 2022-11-22 11:17, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**980**	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	**770**	N/A	1	MPN/100 mL	2022-11-23	
Trip Blank (22K2563-09) | Matrix: Water | Sampled: 2022-11-22 13:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-23	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-23	

CARO
ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2563
PROJECT	646.043	**REPORTED**	2022-11-29 17:30

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2563
PROJECT	646.043	**REPORTED**	2022-11-29 17:30

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2K2541										
Blank (B2K2541-BLK1)				Prepared: 2022-11-23, Analyzed: 2022-11-23						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2K2541-BLK2)				Prepared: 2022-11-23, Analyzed: 2022-11-23						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2K2541-DUP1)		**Source: 22K2563-09**		Prepared: 2022-11-23, Analyzed: 2022-11-23						
E. coli (Q-Tray)	< 1	1	MPN/100 mL		< 1				80	

CARO ANALYTICAL SERVICES

☑ 11 Tl
☐ 1(Tl
☐ 17 Tl

22K2563

CARO BC COC, Rev 03/13

CHAIN-OF-CUSTODY RECORD COC#

Page 1 of 1

Jaime Dimillo

RELINQUISHED BY:	DATE: 22 NOV 22	RECEIVED BY:	DATE: NOV 22
Oskar von Wahl	TIME: 15:22	DZC WI	TIME: 15 25
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ **Please email Excel file.**
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Wet Weather)
PO #:
SAMPLED BY: Oskar von Wahl
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ *** Contact the lab to confirm, surcharges may apply**

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	MATRIX: DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	SAMPLING: DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	22-NOV-22	0800	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	0832	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	1102	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK1	☐	☑	☐	☐	1	↓	0857	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	1043	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	1117	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1	↓	1117	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1	↓	1117	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1	↓	1300	☐	☐	☑		☑	☑	☑
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT
Cheque ☐
Credit ☐
Debit ☐
Cash ☐
Invoice ☐

SAMPLE RECEIPT TEMP (°C): 11.2
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields **Recommended Fields** **SHADED AREAS:** LAB USE ONLY

CARO ANALYTICAL SERVICES

22K2559

2K9
5C3
S 1H7
TEL: (780) 489-9100 FAX: (480) 489-9700

CARO BC COC, Rev 03

CHAIN-OF-CUSTODY RECORD

COC# Page 1 of

Jaime Dimillo

RELINQUISHED BY:	DATE: 22-NOV-22	RECEIVED BY:	DATE: Nov 22
~~Oskar von Wahl~~	TIME: 15:22	DSC WT	TIME: 15 30
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Karin Bjorklund
TEL / FAX: (604) 293-3265
EMAIL PDF ☑ EDD ☐ **Please email Excel file.**
EMAIL 1: kbjorklund@kwl.ca
EMAIL 2: ovonwahl@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: kbjorklund@kwl.ca
TEL / FAX: 604 364 3344
EMAIL PDF ☐
EMAIL 1: kbjorklund@kwl.ca
EMAIL 2: mderer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 409.11
PROJECT INFO: DWV - 2022 AMF WQ Monitoring (Wet)
PO #:
SAMPLED BY: Oskar Von Wahl
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND Routine (4-7 days) ☑ Other:
TIME REQUESTED: Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ *** Contact the lab to confirm, surcharges may apply**

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	MATRIX: DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	SAMPLING: DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	Salinity	Alkalinity (Speciated)	Hardness (as CaCO3)	HOLD
AMF-DWV-P-CA_WA (Cave Watershed)	☐	☑	☐	☐	2	22-Nov-22	13:29	☐	☐	☐		☑	☑	☑	☑	☑	☐
AMF-COV-P-WE_WA (Westmount Watershed)	☐	☑	☐	☐	2	22-Nov-22	13:06	☐	☐	☐		☑	☑	☑	☑	☑	☐
Field Blank	☐	☑	☐	☐	2	↓	13:00	☐	☐	☐		☐	☐	☐	☐	☐	☑
Replicate	☐	☑	☐	☐	2	↓	13:29	☐	☐	☐		☑	☑	☑	☑	☑	☐
	☐	☐	☐	☐	4			☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	2			☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	2			☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	4			☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	4			☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐				☐	☐	☐		☐	☐	☐	☐	☐	☐

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):
OTHER INSTRUCTIONS:

PAYMENT
Cheque ☐
Credit ☐
Debit ☐
Cash ☐
Invoice ☐

SAMPLE RECEIPT TEMP (°C): 12.6
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields **Recommended Fields** **SHADED AREAS:** LAB USE ONLY

CARO
ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22K2846
PO NUMBER		**RECEIVED / TEMP**	2022-11-24 11:20 / 8.6°C
PROJECT	646.043	**REPORTED**	2022-12-01 18:06
PROJECT INFO	Port Coquitlam 2022 AMF (Wet Weather)		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2846
PROJECT	646.043	**REPORTED**	2022-12-01 18:06

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22K2846-01) | Matrix: Water | Sampled: 2022-11-24 08:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**649**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**1050**	N/A	1	MPN/100 mL	2022-11-24	
AMF-POCO_S_BD1 (22K2846-02) | Matrix: Water | Sampled: 2022-11-24 08:52						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-11-24	
AMF-POCO_S_BD5 (22K2846-03) | Matrix: Water | Sampled: 2022-11-24 09:55						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**276**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**162**	N/A	1	MPN/100 mL	2022-11-24	
AMF-POCO_S_BK1 (22K2846-04) | Matrix: Water | Sampled: 2022-11-24 09:09						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**2420**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**830**	N/A	1	MPN/100 mL	2022-11-24	
AMF-POCO_S_BK7 (22K2846-05) | Matrix: Water | Sampled: 2022-11-24 09:41						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**248**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**172**	N/A	1	MPN/100 mL	2022-11-24	
AMF-POCO_S_FR1 (22K2846-06) | Matrix: Water | Sampled: 2022-11-24 10:17						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**921**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**387**	N/A	1	MPN/100 mL	2022-11-24	
Field Blank (22K2846-07) | Matrix: Water | Sampled: 2022-11-24 08:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-24	
Replicate (22K2846-08) | Matrix: Water | Sampled: 2022-11-24 08:10						

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2846
PROJECT	646.043	**REPORTED**	2022-12-01 18:06

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22K2846-08) | Matrix: Water | Sampled: 2022-11-24 08:10, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1200**	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	**727**	N/A	1	MPN/100 mL	2022-11-24	
Trip Blank (22K2846-09) | Matrix: Water | Sampled: 2022-11-24 10:25						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-24	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-11-24	

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2846
PROJECT	646.043	**REPORTED**	2022-12-01 18:06

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22K2846
PROJECT	646.043	**REPORTED**	2022-12-01 18:06

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2K2795										
Blank (B2K2795-BLK1)				Prepared: 2022-11-24, Analyzed: 2022-11-24						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2K2795-BLK2)				Prepared: 2022-11-24, Analyzed: 2022-11-24						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							

CARO ANALYTICAL SERVI[CES]

... VIKING WAY, RICHMOND, BC V6V 2K9
...599
..., BC V1X 5C3
...893
...N, AB T5S 1H7
...700

22K2846

CHAIN-OF-CUSTODY RECORD

COC#

CARO BC COC, Rev 03/13

Page 1 of 1

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
Oskar von Wahl	DATE: 24-Nov-22 TIME: 1115	WI TL	DATE: 11/24 TIME: 1120
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY:	DATE: TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043

PROJECT INFO: Port Coquitlam 2022 AMF (Wet Weather)

PO #:

SAMPLED BY: Oskar von Wahl

SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

	CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS: (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
1	AMF-POCO_S_BR1	☐	☑	☐	☐	1	24-Nov-22	0810	☐	☐	☑		☑	☑	☐
2	AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	0852	☐	☐	☑		☑	☑	☐
3	AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	0955	☐	☐	☑		☑	☑	☐
4	AMF-POCO_S_BK1	☐	☑	☐	☐	1	↓	0909	☐	☐	☑		☑	☑	☐
5	AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	0941	☐	☐	☑		☑	☑	☐
6	AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	1017	☐	☐	☑		☑	☑	☐
7	Field Blank	☐	☑	☐	☐	1	↓	0810	☐	☐	☑		☑	☑	☑
8	Replicate	☐	☑	☐	☐	1	↓	0810	☐	☐	☑		☑	☑	☑
9	Trip Blank	☐	☑	☐	☐	1	↓	1025	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT
Cheque ☐
Credit ☐
Debit ☐
Cash ☐
Invoice ☐

SAMPLE RECEIPT TEMP (°C): 8.6
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22L0487
PO NUMBER		**RECEIVED / TEMP**	2022-12-06 12:50 / 7.5°C
PROJECT	646.043	**REPORTED**	2022-12-13 16:41
PROJECT INFO	Port Coquitlam 2022 AMF (Wet Weather)	**COC NUMBER**	No number

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0487
PROJECT	646.043	**REPORTED**	2022-12-13 16:41

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22L0487-01) | Matrix: Water | Sampled: 2022-12-06 09:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-12-06	
AMF-POCO_S_BD1 (22L0487-02) | Matrix: Water | Sampled: 2022-12-06 10:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1730**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**1550**	N/A	1	MPN/100 mL	2022-12-06	
AMF-POCO_S_BD5 (22L0487-03) | Matrix: Water | Sampled: 2022-12-06 10:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**113**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**114**	N/A	1	MPN/100 mL	2022-12-06	
AMF-POCO_S_BK1 (22L0487-04) | Matrix: Water | Sampled: 2022-12-06 10:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1990**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**345**	N/A	1	MPN/100 mL	2022-12-06	
AMF-POCO_S_BK7 (22L0487-05) | Matrix: Water | Sampled: 2022-12-06 10:51						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**411**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**326**	N/A	1	MPN/100 mL	2022-12-06	
AMF-POCO_S_FR1 (22L0487-06) | Matrix: Water | Sampled: 2022-12-06 11:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**435**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**137**	N/A	1	MPN/100 mL	2022-12-06	
Field Blank (22L0487-07) | Matrix: Water | Sampled: 2022-12-06 09:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-06	

Replicate (22L0487-08) | Matrix: Water | Sampled: 2022-12-06 09:30

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0487
PROJECT	646.043	**REPORTED**	2022-12-13 16:41

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22L0487-08) | Matrix: Water | Sampled: 2022-12-06 09:30, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	**> 2420**	N/A	1	MPN/100 mL	2022-12-06	
Trip Blank (22L0487-09) | Matrix: Water | Sampled: 2022-12-06 09:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-06	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-06	

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0487
PROJECT	646.043	**REPORTED**	2022-12-13 16:41

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline (s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0487
PROJECT	646.043	**REPORTED**	2022-12-13 16:41

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2L0576										
Blank (B2L0576-BLK1)				Prepared: 2022-12-06, Analyzed: 2022-12-06						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2L0576-BLK2)				Prepared: 2022-12-06, Analyzed: 2022-12-06						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2L0576-DUP2)		**Source: 22L0487-04**		Prepared: 2022-12-06, Analyzed: 2022-12-06						
Coliforms, Fecal (Q-Tray)	1300	1	MPN/100 mL		1990			42	80	

CARO ANALYTICAL SERVICES

V 2K9
1X 5C3
5S 1H7

* 2 2 L 0 4 8 7 *

CARO BC COC, Rev 03/13

CHAIN-OF-CUSTODY RECORD

COC#

Page 1 of 1

RELINQUISHED BY:	DATE: 06-DEC-22	RECEIVED BY:	DATE: 12/6
Oskar von Wahl	TIME: 12:30	(signature)	TIME: 12:30
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:		TIME:

REPORT TO:

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐

COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Wet Weather)
PO #:
SAMPLED BY: Oskar von Wahl
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	06-DEC-22	0930	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1	↓	1000	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1	↓	1030	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK1	☐	☑	☐	☐	1	↓	1015	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1	↓	1051	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1	↓	1115	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1	↓	0930	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1	↓	0930	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1	↓	0915	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): 7.5
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22L0888
PO NUMBER		**RECEIVED / TEMP**	2022-12-08 14:07 / 8.2°C
PROJECT	646.043	**REPORTED**	2022-12-15 11:36
PROJECT INFO	Port Coquitlam 2022 AMF (Wet Weather)	**COC NUMBER**	No#

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

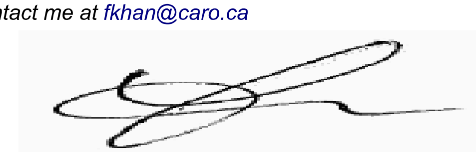
Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
https://www.caro.ca/terms-conditions

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:



Firoza Khan
CSR

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0888
PROJECT	646.043	**REPORTED**	2022-12-15 11:36

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
AMF-POCO_S_BR1 (22L0888-01) | Matrix: Water | Sampled: 2022-12-08 09:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	276	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	93	N/A	1	MPN/100 mL	2022-12-09	
AMF-POCO_S_BD1 (22L0888-02) | Matrix: Water | Sampled: 2022-12-08 09:30						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	>	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	>	N/A	1	MPN/100 mL	2022-12-09	
AMF-POCO_S_BD5 (22L0888-03) | Matrix: Water | Sampled: 2022-12-08 10:10						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	2420	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	1410	N/A	1	MPN/100 mL	2022-12-09	
AMF-POCO_S_BK1 (22L0888-04) | Matrix: Water | Sampled: 2022-12-08 09:50						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	>	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	461	N/A	1	MPN/100 mL	2022-12-09	
AMF-POCO_S_BK7 (22L0888-05) | Matrix: Water | Sampled: 2022-12-08 10:15						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	488	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	291	N/A	1	MPN/100 mL	2022-12-09	
AMF-POCO_S_FR1 (22L0888-06) | Matrix: Water | Sampled: 2022-12-08 10:50						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	488	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	172	N/A	1	MPN/100 mL	2022-12-09	
Field Blank (22L0888-07) | Matrix: Water | Sampled: 2022-12-08 09:50						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-09	
Replicate (22L0888-08) | Matrix: Water | Sampled: 2022-12-08 09:50						

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0888
PROJECT	646.043	**REPORTED**	2022-12-15 11:36

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22L0888-08) | Matrix: Water | Sampled: 2022-12-08 09:50, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**>**	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	**411**	N/A	1	MPN/100 mL	2022-12-09	
Trip Blank (22L0888-09) | Matrix: Water | Sampled: 2022-12-08 08:50						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-09	
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-09	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0888
PROJECT	646.043	**REPORTED**	2022-12-15 11:36

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L0888
PROJECT	646.043	**REPORTED**	2022-12-15 11:36

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2L1007										
Blank (B2L1007-BLK1)				Prepared: 2022-12-09, Analyzed: 2022-12-09						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2L1007-BLK2)				Prepared: 2022-12-09, Analyzed: 2022-12-09						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2L1007-DUP2)	**Source: 22L0888-01**			Prepared: 2022-12-09, Analyzed: 2022-12-09						
Coliforms, Fecal (Q-Tray)	248	1	MPN/100 mL		276			10	80	
E. coli (Q-Tray)	105	1	MPN/100 mL		93			12	80	

22L0888

ANALYTICAL SERVICES

☑ 110 - 4011 VIKING WAY, RICHMOND, BC V6V 2K9 TEL: (604) 279-1499 FAX: (604) 279-1599
☐ 102 - 3677 HIGHWAY 97N, KELOWNA, BC V1X 5C3 TEL: (250) 765-9646 FAX: (250) 765-3893
☐ 17225 - 109 AVENUE NW, EDMONTON, AB T5S 1H7 TEL: (780) 489-9100 FAX: (480) 489-9700

CHAIN-OF-CUSTODY RECORD

COC#

CARO BC COC, Rev 03/13

Page 1 of 1

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
Oskar von Wahl	DATE: 08DEC22 TIME: 1405	BTA(W1)	DATE: 12/08 TIME: 14:07
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY:	DATE: TIME:

REPORT TO:
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ Please email Excel file.
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr. Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Wet Weather)
PO #:
SAMPLED BY: Oskar von Wahl
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	✓	☐	☐	1	08-DEC-22	0915	☐	☐	✓		✓	✓	☐
AMF-POCO_S_BD1	☐	✓	☐	☐	1	↓	0930	☐	☐	✓		✓	✓	☐
AMF-POCO_S_BD5	☐	✓	☐	☐	1	↓	1010	☐	☐	✓		✓	✓	☐
AMF-POCO_S_BK1	☐	✓	☐	☐	1	↓	0950	☐	☐	✓		✓	✓	☐
AMF-POCO_S_BK7	☐	✓	☐	☐	1	↓	1015	☐	☐	✓		✓	✓	☐
AMF-POCO_S_FR1	☐	✓	☐	☐	1	↓	1050	☐	☐	✓		✓	✓	☐
Field Blank	☐	✓	☐	☐	1	↓	0950	☐	☐	✓		✓	✓	✓
Replicate	☐	✓	☐	☐	1	↓	0950	☐	☐	✓		✓	✓	✓
Trip Blank	☐	✓	☐	☐	1	↓	0850	☐	☐	✓		✓	✓	✓

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT: Cheque ☐ Credit ☐ Debit ☐ Cash ☐ Invoice ☐

SAMPLE RECEIPT TEMP (°C): 8.2
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby) 200 - 4185A Still Creek Dr Burnaby, BC V5C 6G9		
ATTENTION	Larissa Low	**WORK ORDER**	22L1200
PO NUMBER		**RECEIVED / TEMP**	2022-12-12 12:15 / 9.4°C
PROJECT	646.043	**REPORTED**	2022-12-19 17:59
PROJECT INFO	Port Coquitlam 2022 AMF (Wet Weather)	**COC NUMBER**	no number

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

Work Order Comments:

If you have any questions or concerns, please contact me at fkhan@caro.ca

Authorized By:

Firoza Khan
CSR

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L1200
PROJECT	646.043	**REPORTED**	2022-12-19 17:59

AMF-POCO_S_BR1 (22L1200-01) | Matrix: Water | Sampled: 2022-12-09 10:00

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**9700**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**5200**	N/A	1	MPN/100 mL	2022-12-13	HT3

AMF-POCO_S_BD1 (22L1200-02) | Matrix: Water | Sampled: 2022-12-12 09:30

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**2610**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**3080**	N/A	1	MPN/100 mL	2022-12-13	HT3

AMF-POCO_S_BD5 (22L1200-03) | Matrix: Water | Sampled: 2022-12-12 10:30

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**120**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**134**	N/A	1	MPN/100 mL	2022-12-13	HT3

AMF-POCO_S_BK1 (22L1200-04) | Matrix: Water | Sampled: 2022-12-12 10:15

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**4840**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**1730**	N/A	1	MPN/100 mL	2022-12-13	HT3

AMF-POCO_S_BK7 (22L1200-05) | Matrix: Water | Sampled: 2022-12-12 10:55

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**>**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**1840**	N/A	1	MPN/100 mL	2022-12-13	HT3

AMF-POCO_S_FR1 (22L1200-06) | Matrix: Water | Sampled: 2022-12-12 11:15

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**1370**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**123**	N/A	1	MPN/100 mL	2022-12-13	HT3

Field Blank (22L1200-07) | Matrix: Water | Sampled: 2022-12-12 09:30

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-13	HT3

Replicate (22L1200-08) | Matrix: Water | Sampled: 2022-12-12 09:30

TEST RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L1200
PROJECT	646.043	**REPORTED**	2022-12-19 17:59

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
Replicate (22L1200-08) | Matrix: Water | Sampled: 2022-12-12 09:30, Continued						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	**3650**	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	**2610**	N/A	1	MPN/100 mL	2022-12-13	HT3
Trip Blank (22L1200-09) | Matrix: Water | Sampled: 2022-12-12 09:00						
Microbiological Parameters						
Coliforms, Fecal (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-13	HT3
E. coli (Q-Tray)	< 1	N/A	1	MPN/100 mL	2022-12-13	HT3

Sample Qualifiers:

HT3 Microbiological analysis was initiated beyond the maximum holding time of 30 hours. Results may not be valid.

CARO ANALYTICAL SERVICES

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L1200
PROJECT	646.043	**REPORTED**	2022-12-19 17:59

Analysis Description	Method Ref.	Technique	Accredited	Location
Coliforms, Fecal in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond
E. coli in Water	NA / SM 9223 (2017)	Quanti-Tray / Enzyme Substrate Endo Agar		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>	Greater than the specified Result
MPN/100 mL	Most Probable Number per 100 millilitres
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Metro Vancouver Sewer Use Bylaw (excludes BOD)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:fkhan@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

CARO ANALYTICAL SERVICES

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Kerr Wood Leidal Associates Ltd. (Burnaby)	**WORK ORDER**	22L1200
PROJECT	646.043	**REPORTED**	2022-12-19 17:59

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Microbiological Parameters, Batch B2L1418										
Blank (B2L1418-BLK1)				Prepared: 2022-12-13, Analyzed: 2022-12-13						
E. coli (Q-Tray)	< 1	1	MPN/100 mL							
Blank (B2L1418-BLK2)				Prepared: 2022-12-13, Analyzed: 2022-12-13						
Coliforms, Fecal (Q-Tray)	< 1	1	MPN/100 mL							
Duplicate (B2L1418-DUP2)		**Source: 22L1200-01**		Prepared: 2022-12-13, Analyzed: 2022-12-13						
Coliforms, Fecal (Q-Tray)	6300	1	MPN/100 mL		9700			42	80	

CARO ANALYTICAL SERVICES

22L1200

:9
5C3
1H7

CHAIN-OF-CUSTODY RECORD

COC#

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
Oskar von Wahl	DATE: 12 DEC 22 TIME: 12:50	[signature]	DATE: Dec 12 TIME: 12:15
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY:	DATE: TIME:

REPORT TO:
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑ EDD ☐ **Please email Excel file.**
EMAIL 1: LLow@kwl.ca
EMAIL 2: PLilley@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐ FAX ☐

INVOICE TO: SAME AS REPORT TO ☐
COMPANY: Kerr Wood Leidal
ADDRESS: 200-4185A Still Creek Dr.
Burnaby, BC V5C 6G9
CONTACT: Larissa Low
TEL / FAX: 604-293-3136
EMAIL PDF ☑
EMAIL 1: LLow@kwl.ca; LMorgan@kwl.ca
EMAIL 2: MDerer@kwl.ca
MAIL HARDCOPY ☐ HOLD FOR P/U ☐

PROJECT: 646.043
PROJECT INFO: Port Coquitlam 2022 AMF (Wet Weather)
PO #:
SAMPLED BY: Oskar von Wahl
SHIPPING INSTRUCTIONS: RETURN COOLER(S) ☐
SHIP SUPPLIES (PLEASE SPECIFY IN OTHER INSTRUCTIONS SECTION) ☐

TURNAROUND TIME REQUESTED: Routine (4-7 days) ☑ Other:
Rush:* 1 Day ☐ 2 Day ☐ 3 Day ☐ * Contact the lab to confirm, surcharges may apply

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	DRINKING WATER	OTHER WATER	SOIL	OTHER	# CONTAINERS	DATE DD-MMM-YY	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	COMMENTS (i.e. flow/volume media ID/notes)	E. coli	Fecal Coliforms	HOLD
AMF-POCO_S_BR1	☐	☑	☐	☐	1	12-DEC-22	1000	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD1	☐	☑	☐	☐	1		0930	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BD5	☐	☑	☐	☐	1		1030	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK1	☐	☑	☐	☐	1		1015	☐	☐	☑		☑	☑	☐
AMF-POCO_S_BK7	☐	☑	☐	☐	1		1055	☐	☐	☑		☑	☑	☐
AMF-POCO_S_FR1	☐	☑	☐	☐	1		1115	☐	☐	☑		☑	☑	☐
Field Blank	☐	☑	☐	☐	1		0930	☐	☐	☑		☑	☑	☑
Replicate	☐	☑	☐	☐	1		0930	☐	☐	☑		☑	☑	☑
Trip Blank	☐	☑	☐	☐	1		0900	☐	☐	☑		☑	☑	☑

APPLICABLE REGULATORY LIMITS:
Canadian Drinking Water Quality Guidelines ☐
BC Drinking Water Protection Act/Reg. ☐
BC CSR: AL ☐ RL ☐ CL ☐ IL ☐ AW ☐
CCME ☐ Alberta Tier 1 ☐
OTHER:

SAMPLE RETENTION INSTRUCTIONS (Discarded 30 days after Report unless otherwise specified):
60 Days ☐ 90 Days ☐ Longer Date (Surcharges will apply):

OTHER INSTRUCTIONS:
Please include field measurements and the scanned COC with report.

PAYMENT
Cheque ☐
Credit ☐
Debit ☐
Cash ☐
Invoice ☐

SAMPLE RECEIPT TEMP (°C): 9.4
Work Order #
CUSTODY SEALS INTACT: ☐Y ☐N ☐NA

Required Fields Recommended Fields SHADED AREAS: LAB USE ONLY

KERR WOOD LEIDAL
consulting engineers

Appendix I2 – Metro Vancouver Water Quality Data

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	Port Coquitlam AMF Program Sept-27/2022
Project Number:	219015
Project Date:	28-Sep-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower. Sample bottles not from Metro Vancouver.

Analysis	Units	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK3	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB	AMF-FB
		AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK3	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF Replicate sampl	Travel Blank	Field Blank
		2022-09-27 12:22	2022-09-27 12:51	2022-09-27 13:10	2022-09-27 13:47	2022-09-27 11:51	2022-09-27 11:20	2022-09-27 12:30	2022-09-27 11:00	2022-09-27 12:42
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	6.1	2.1	2.4	1.3	1.4	2.7	3.0	<0.5	<0.5
Iron Total	µg/L	290	3170	857	79	201	2350	254	<5	<5
Lead Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	1.63	0.09	0.03	1.99	1.85	1.99	1.64	<0.01	<0.01
Zinc Total	µg/L	4	12	5	<3	<3	4	3	<3	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	Port Coquitlam AMF Program Oct-3/2022
Project Number:	219134
Project Date:	4-Oct-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower. Sample bottles not from Metro Vancouver.

Analysis	**Units**	**AMF-FB**	**AMF-PCO-S-BR1**	**AMF-PCO-S-BD1**	**AMF-PCO-S-BD5**	**AMF-PCO-S-BK3**	**AMF-PCO-S-BK7**	**AMF-PCO-S-FR1**	**AMF-REPLICATE**	**AMF-TB**
		Field Blank	Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 3	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank
		2022-10-03 10:49	2022-10-03 11:05	2022-10-03 11:18	2022-10-03 10:30	2022-10-03 10:52	2022-10-03 10:16	2022-10-03 9:52	2022-10-03 9:55	2022-10-03 9:10
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	0.13	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	<0.5	4.5	2.5	18.8	2.2	1.9	1.9	3.2	<0.5
Iron Total	µg/L	<5	401	4830	11900	101	287	2180	3880	<5
Lead Total	µg/L	<0.5	<0.5	0.5	5.4	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	<0.01	1.75	0.41	0.18	2.26	1.42	1.56	1.56	<0.01
Zinc Total	µg/L	<3	5	19	78	<3	3	<3	7	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab

1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	Port Coquitlam AMF Program Oct-11/2022
Project Number:	219372
Project Date:	12-Oct-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	Units	AMF-FB	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK3	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB
		Field Blank	Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 3	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank
		2022-10-11 11:50	2022-10-11 11:52	2022-10-11 11:15	2022-10-11 11:05	2022-10-11 11:40	2022-10-11 10:48	2022-10-11 10:30	2022-10-11 10:25	2022-10-11 10:00
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	<0.5	2.6	3.1	1.5	2.4	2.3	5.1	2.5	<0.5
Iron Total	µg/L	<5	225	3940	510	190	288	6040	2810	<5
Lead Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	<0.01	1.60	0.34	0.04	1.89	1.46	1.42	1.42	<0.01
Zinc Total	µg/L	<3	5	20	4	5	4	15	6	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Oct-17/2022
Project Number:	219490
Project Date:	18-Oct-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	Units	AMF-FB	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK3	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB
		Field Blank	Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 3	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank
		2022-10-18 15:20	2022-10-18 15:37	2022-10-18 16:00	2022-10-18 15:04	2022-10-18 15:24	2022-10-18 14:35	2022-10-18 13:58	2022-10-18 14:30	2022-10-18 13:00
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	<0.5	1.8	1.8	1.9	1.5	1.6	4.3	2.1	<0.5
Iron Total	µg/L	<5	83	2780	265	91	362	5930	257	<5
Lead Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	<0.01	1.62	0.35	1.55	1.61	0.04	1.65	1.55	<0.01
Zinc Total	µg/L	<3	4	16	5	<3	3	17	4	5

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Oct-20/2022
Project Number:	219555
Project Date:	20-Oct-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	Units	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK3	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB	AMF-FB
		Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 3	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank	Field Blank
		2022-10-20 11:45	2022-10-20 13:10	2022-10-20 9:42	2022-10-20 10:00	2022-10-20 9:30	2022-10-20 9:10	2022-10-20 13:05	2022-10-20 8:30	#############
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	2.0	2.7	3.7	2.6	2.2	4.2	2.0	<0.5	<0.5
Iron Total	µg/L	146	3190	3540	291	312	6260	2970	<5	<5
Lead Total	µg/L	<0.5	0.6	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	1.54	0.41	0.30	2.05	1.18	1.42	0.41	<0.01	<0.01
Zinc Total	µg/L	<3	18	16	3	<3	20	14	<3	5

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Nov-22/2022
Project Number:	220310
Project Date:	22-Nov-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	**Units**	**AMF-FB**	**AMF-PCO-S-BD1**	**AMF-PCO-S-BD5**	**AMF-PCO-S-BK1**	**AMF-PCO-S-BK7**	**AMF-PCO-S-BR1**	**AMF-PCO-S-FR1**	**AMF-PCO-S-FR1_REP**	**AMF-TB**
		Field Blank	Broadway Creek 1	Broadway Creek 5	Baker Creek 1	Baker Creek 7	Brown Creek 1	Fraser River Outfall 1	Fraser River Outfall 1 Replicate	Travel Blank
		2022-11-22 11:17	2022-11-22 8:32	2022-11-22 11:02	2022-11-22 8:57	2022-11-22 10:43	2022-11-22 8:00	2022-11-22 11:17	2022-11-22 11:17	2022-11-22 13:00
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	0.17	0.11	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	<0.5	24.7	15.8	7.3	6.2	9.0	8.3	8.4	0.5
Iron Total	µg/L	<5	3160	3680	652	878	609	3060	2900	<5
Lead Total	µg/L	<0.5	5.1	3.8	1.0	1.0	1.6	0.9	0.9	<0.5
Nitrogen - Nitrate as N	mg/L	<0.01	0.33	0.25	0.26	0.21	0.29	0.15	0.15	<0.01
Zinc Total	µg/L	<3	206	139	26	25	26	27	28	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Nov-24/2022
Project Number:	220354
Project Date:	24-Nov-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carie Hightower.

Analysis	**Units**	**AMF-PCO-S-BR1**	**AMF-PCO-S-BD1**	**AMF-PCO-S-BD5**	**AMF-PCO-S-BK1**	**AMF-PCO-S-BK7**	**AMF-PCO-S-FR1**	**AMF-PCO-S-BR1_REP**	**AMF-TB**	**AMF-FB**
		Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 1	Baker Creek 7	Fraser River Outfall 1	Brown Creek 1 Replicate	Travel Blank	Field Blank
		2022-11-24 8:10	2022-11-24 8:52	2022-11-24 9:55	2022-11-24 9:09	2022-11-24 9:41	2022-11-24 10:17	2022-11-24 8:10	2022-11-24 10:25	2022-11-24 8:10
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	2.0	6.9	1.9	1.3	1.3	2.3	2.1	<0.5	<0.5
Iron Total	µg/L	132	2720	618	110	285	2430	129	<5	<5
Lead Total	µg/L	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	2.00	0.75	0.17	1.74	1.43	1.61	1.99	<0.01	<0.01
Zinc Total	µg/L	4	91	9	3	5	6	<3	<3	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Dec-06/2022
Project Number:	220706
Project Date:	12-Dec-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	Units	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK1	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB	AMF-FB
		Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 1	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank	Field Blank
		2022-12-06 9:30	2022-12-06 10:00	2022-12-06 10:30	2022-12-06 10:15	2022-12-06 10:51	2022-12-06 11:15	2022-12-06 9:30	2022-12-06 9:15	############
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	2.2	3.1	2.0	1.0	0.8	1.7	2.2	0.5	0.5
Iron Total	µg/L	121	3170	890	80	334	1150	117	<5	<5
Lead Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	1.87	0.56	0.18	1.67	1.37	1.50	1.93	<0.01	<0.01
Zinc Total	µg/L	4	57	8	3	6	5	<3	<3	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Dec-08/2022
Project Number:	220643
Project Date:	8-Dec-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	Units	AMF-PCO-S-BR1	AMF-PCO-S-BD1	AMF-PCO-S-BD5	AMF-PCO-S-BK1	AMF-PCO-S-BK7	AMF-PCO-S-FR1	AMF-REPLICATE	AMF-TB	AMF-FB
		Brown Creek 1	Broadway Creek 1	Broadway Creek 5	Baker Creek 1	Baker Creek 7	Fraser River Outfall 1	AMF Replicate sample	Travel Blank	Field Blank
		2022-12-08 9:15	2022-12-08 9:30	2022-12-08 10:10	2022-12-08 9:50	2022-12-08 10:15	2022-12-08 10:50	2022-12-08 9:50	2022-12-08 8:50	############
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	0.08	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper Total	µg/L	3.1	13.4	7.3	3.3	2.9	5.3	3.3	<0.5	<0.5
Iron Total	µg/L	151	2040	1540	183	308	1200	185	<5	<5
Lead Total	µg/L	<0.5	2.9	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	1.66	0.24	0.19	1.47	1.26	1.05	1.47	<0.01	<0.01
Zinc Total	µg/L	9	88	52	15	15	21	14	<3	<3

Liquid Waste Services
Environmental Management & Quality Control
Chemistry Lab
1299 Derwent Way, Delta BC V3M 5V9
Phone: (604) 523-7173 Fax: (604) 525-0932

Customer:	**Environmental Monitoring**
Title:	POCO AMF Program Dec-12/2022
Project Number:	220717
Project Date:	12-Dec-2022
Project Status:	Authorized by RSTRACKE
Project Notes:	Results to Carrie Hightower.

Analysis	**Units**	**AMF-FB**	**AMF-PCO-S-BD1**	**AMF-PCO-S-BD5**	**AMF-PCO-S-BK1**	**AMF-PCO-S-BK7**	**AMF-PCO-S-BR1**	**AMF-PCO-S-FR1**	**AMF-REPLICATE**	**AMF-TB**
		Field Blank	Broadway Creek 1	Broadway Creek 5	Baker Creek 1	Baker Creek 7	Brown Creek 1	Fraser River Outfall 1	AMF Replicate sample	Travel Blank
		2022-12-12 9:30	2022-12-12 9:30	2022-12-12 10:30	2022-12-12 10:15	2022-12-12 10:55	2022-12-12 10:00	2022-12-12 11:15	2022-12-12 9:30	#############
		GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Cadmium Total	µg/L	<0.06	<0.06	<0.06	<0.06	<0.06	0.07	<0.06	<0.06	<0.06
Copper Total	µg/L	<0.5	3.5	1.8	1.5	1.5	10.7	2.5	3.2	0.6
Iron Total	µg/L	<5	2570	671	88	271	4330	1270	2500	<5
Lead Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	4.0	<0.5	<0.5	<0.5
Nitrogen - Nitrate as N	mg/L	<0.01	1.10	0.23	2.19	1.92	2.74	1.67	1.10	<0.01
Zinc Total	µg/L	4	46	7	6	8	24	5	45	<3

KERR WOOD LEIDAL
consulting engineers

Appendix I3 – Water Quality Photos

Appendix I3 – Baker 3

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

Photo 4: 2022/10/17

Appendix I3 – Baker 3

Photo 5: 2022/10/20

Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Baker 3

Photo 9: 2022/12/08

Photo 10: 2022/12/12

Appendix I3 – Baker 7

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

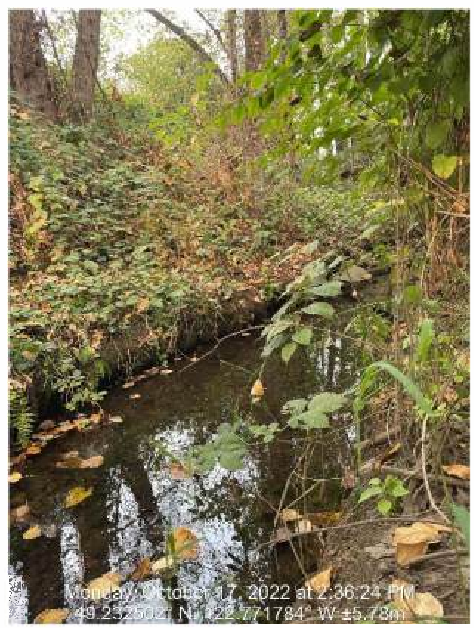


Photo 4: 2022/10/17

Appendix I3 – Baker 7

Photo 5: 2022/10/20

Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Baker 7

Photo 9: 2022/12/08

Photo 10: 2022/12/12

Appendix I3 – Broadway 1

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

Photo 4: 2022/10/17

Appendix I3 – Broadway 1

Photo 5: 2022/10/20

Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Broadway 1

Photo 9: 2022/12/08

Photo 10: 2022/12/12

Appendix I3 – Broadway 5

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

Photo 4: 2022/10/17

Appendix I3 – Broadway 5

Photo 5: 2022/10/20

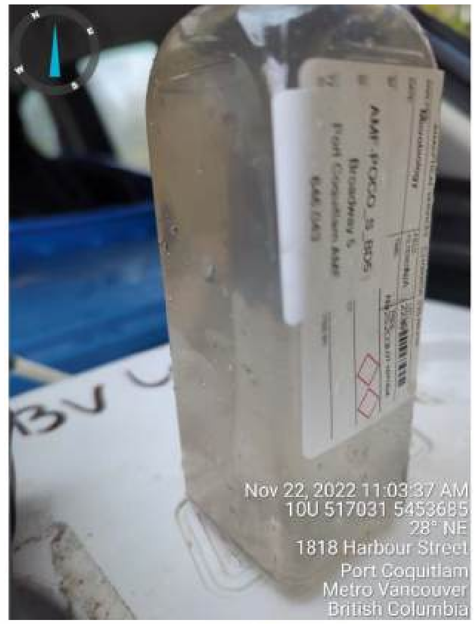


Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Broadway 5

Photo 9: 2022/12/08

Photo 10: 2022/12/12

Appendix I3 – Brown 1

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

Photo 4: 2022/10/17

Appendix I3 – Brown 1

Photo 5: 2022/10/20

Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Brown 1

Photo 9: 2022/12/08

Photo 10: 2022/12/12

Appendix I3 – Fraser 1

Photo 1: 2022/09/27

Photo 2: 2022/10/03

Photo 3: 2022/10/11

Photo 4: 2022/10/17

Appendix I3 – Fraser 1

Photo 5: 2022/10/20

Photo 6: 2022/11/22

Photo 7: 2022/11/24

Photo 8: 2022/12/06

Appendix I3 – Fraser 1

Photo 9: 2022/12/08

Photo 10: 2022/12/12

KERR WOOD LEIDAL
consulting engineers

Appendix J

Capital Cost Estimates

Table J-1: Minor Pipe Upgrades - Minor Drainage System Undersized for 10-Year Design Flow

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
Priority 1-50 years					
CO-144	250	25	375	$ 1,427	$ 37,000
DM00310	380	29	675	$ 2,158	$ 62,000
DM00482	380	84	600	$ 1,960	$ 165,000
DM00662	300	88	375	$ 1,427	$ 126,000
DM00667	200	59	250	$ 1,311	$ 78,000
DM00737	250	109	375	$ 1,427	$ 155,000
DM00891	300	67	450	$ 1,553	$ 105,000
DM01339	300	52	375	$ 1,427	$ 74,000
DM01342	380	103	525	$ 1,735	$ 179,000
DM01357	530	65	675	$ 2,158	$ 141,000
DM04156	250	51	300	$ 1,382	$ 71,000
DM04667	300	64	600	$ 1,960	$ 126,000
DM04790	600	13	1200	$ 4,150	$ 54,000
DM05491	300	79	600	$ 1,960	$ 155,000
DM05939	250	46	375	$ 1,427	$ 66,000
DM09245	250	33	375	$ 1,427	$ 48,000
DM00332	250	55	375	$ 1,427	$ 78,000
DM00338	250	118	375	$ 1,427	$ 169,000
DM00362	250	34	450	$ 1,553	$ 53,000
DM00364	250	71	375	$ 1,427	$ 102,000
DM00380	200	38	375	$ 1,427	$ 55,000
DM00388	200	17	375	$ 1,427	$ 25,000
DM00389	200	39	375	$ 1,427	$ 55,000
DM00391	200	14	375	$ 1,427	$ 21,000
DM00427	300	30	375	$ 1,427	$ 44,000
DM00539	300	79	375	$ 1,427	$ 114,000
DM00540	300	100	450	$ 1,553	$ 155,000
DM00541	300	84	450	$ 1,553	$ 131,000
DM00547	250	60	375	$ 1,427	$ 87,000
DM00620	200	114	300	$ 1,382	$ 158,000
DM00627	200	100	250	$ 1,311	$ 132,000
DM00640	250	101	375	$ 1,427	$ 144,000
DM00641	250	79	300	$ 1,382	$ 109,000
DM00659	200	73	300	$ 1,382	$ 101,000
DM00669	200	121	300	$ 1,382	$ 168,000
DM00673	250	81	375	$ 1,427	$ 116,000
DM00783	200	119	300	$ 1,382	$ 165,000
DM00841	1050	25	1350	$ 5,194	$ 128,000
DM00850	1200	114	1800	$ 6,460	$ 739,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM00865	300	77	375	$ 1,427	$ 110,000
DM00870	1200	21	1500	$ 6,152	$ 131,000
DM00876	450	26	750	$ 2,374	$ 61,000
DM00879	450	24	600	$ 1,960	$ 48,000
DM00888	250	79	300	$ 1,382	$ 110,000
DM00889	250	125	300	$ 1,382	$ 174,000
DM00903	600	69	750	$ 2,374	$ 165,000
DM00904	600	140	1050	$ 3,431	$ 481,000
DM00919	600	40	750	$ 2,374	$ 96,000
DM00920	380	30	600	$ 1,960	$ 59,000
DM00921	380	129	900	$ 2,845	$ 369,000
DM00922	380	87	675	$ 2,158	$ 188,000
DM00933	250	44	300	$ 1,382	$ 61,000
DM00935	300	22	450	$ 1,553	$ 34,000
DM00964	450	59	600	$ 1,960	$ 117,000
DM00966	600	15	750	$ 2,374	$ 37,000
DM00985	300	127	375	$ 1,427	$ 182,000
DM00989	530	79	675	$ 2,158	$ 172,000
DM00990	600	99	750	$ 2,374	$ 235,000
DM00996	300	71	450	$ 1,553	$ 111,000
DM00997	200	19	300	$ 1,382	$ 27,000
DM00998	250	112	375	$ 1,427	$ 161,000
DM01004	300	106	525	$ 1,735	$ 185,000
DM01005	300	54	450	$ 1,553	$ 84,000
DM01038	150	111	250	$ 1,311	$ 146,000
DM01042	450	80	675	$ 2,158	$ 172,000
DM01043	450	74	525	$ 1,735	$ 128,000
DM01044	450	57	600	$ 1,960	$ 113,000
DM01045	450	92	675	$ 2,158	$ 200,000
DM01050	200	36	300	$ 1,382	$ 50,000
DM01056	600	120	1200	$ 4,150	$ 498,000
DM01062	1200	80	1650	$ 5,853	$ 471,000
DM01063	1200	134	1800	$ 6,460	$ 867,000
DM01065	1200	125	1650	$ 5,853	$ 730,000
DM01066	1200	101	1650	$ 5,853	$ 591,000
DM01067	1200	124	1650	$ 5,853	$ 727,000
DM01069	600	154	900	$ 2,845	$ 439,000
DM01071	450	12	675	$ 2,158	$ 27,000
DM01072	1200	144	1650	$ 5,853	$ 843,000
DM01079	450	12	675	$ 2,158	$ 27,000
DM01209	450	28	750	$ 2,374	$ 67,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM01210	450	67	600	$ 1,960	$ 132,000
DM01215	250	81	300	$ 1,382	$ 113,000
DM01216	450	34	900	$ 2,845	$ 97,000
DM01217	530	54	900	$ 2,845	$ 155,000
DM01340	300	34	375	$ 1,427	$ 49,000
DM01343	380	44	525	$ 1,735	$ 77,000
DM01362	200	85	300	$ 1,382	$ 118,000
DM01371	200	93	250	$ 1,311	$ 122,000
DM01609	200	52	250	$ 1,311	$ 69,000
DM01610	300	42	450	$ 1,553	$ 66,000
DM01983	300	50	375	$ 1,427	$ 72,000
DM01989	300	58	450	$ 1,553	$ 90,000
DM01991	600	74	750	$ 2,374	$ 176,000
DM01992	300	138	450	$ 1,553	$ 215,000
DM01993	300	92	450	$ 1,553	$ 143,000
DM02015	300	62	450	$ 1,553	$ 96,000
DM02016	300	77	450	$ 1,553	$ 121,000
DM02025	200	44	375	$ 1,427	$ 63,000
DM02027	200	80	450	$ 1,553	$ 124,000
DM02028	200	28	375	$ 1,427	$ 41,000
DM04029	200	3	375	$ 1,427	$ 5,000
DM04039	600	129	675	$ 2,158	$ 279,000
DM04040	600	27	900	$ 2,845	$ 78,000
DM04058	300	113	375	$ 1,427	$ 161,000
DM04096	450	84	525	$ 1,735	$ 146,000
DM04097	450	53	750	$ 2,374	$ 126,000
DM04111	300	55	375	$ 1,427	$ 79,000
DM04162	200	70	375	$ 1,427	$ 100,000
DM04454	1200	10	1650	$ 5,853	$ 59,000
DM04466	250	44	525	$ 1,735	$ 76,000
DM04507	300	2	375	$ 1,427	$ 4,000
DM04539	300	12	525	$ 1,735	$ 21,000
DM04545	200	4	450	$ 1,553	$ 7,000
DM04771	1200	26	1650	$ 5,853	$ 151,000
DM04789	600	5	900	$ 2,845	$ 14,000
DM04792	300	82	450	$ 1,553	$ 128,000
DM05302	300	49	600	$ 1,960	$ 97,000
DM05303	450	18	525	$ 1,735	$ 33,000
DM05304	450	71	600	$ 1,960	$ 139,000
DM05305	450	27	675	$ 2,158	$ 59,000
DM05309	300	98	375	$ 1,427	$ 141,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM05322	450	20	900	$ 2,845	$ 56,000
DM05512	250	105	300	$ 1,382	$ 145,000
DM06049	200	82	250	$ 1,311	$ 108,000
DM06098	250	51	300	$ 1,382	$ 71,000
DM06457	1200	74	1800	$ 6,460	$ 476,000
DM06466	680	15	900	$ 2,845	$ 42,000
DM06473	600	11	900	$ 2,845	$ 31,000
DM06474	750	8	1050	$ 3,431	$ 29,000
DM06476	600	12	1200	$ 4,150	$ 50,000
DM06489	300	6	375	$ 1,427	$ 9,000
DM06545	250	13	600	$ 1,960	$ 27,000
DM06546	450	55	750	$ 2,374	$ 131,000
DM06547	450	53	900	$ 2,845	$ 150,000
DM06550	250	34	375	$ 1,427	$ 49,000
DM06551	250	16	450	$ 1,553	$ 26,000
DM06578	300	61	450	$ 1,553	$ 95,000
DM06579	300	10	450	$ 1,553	$ 16,000
DM06625	600	101	900	$ 2,845	$ 287,000
DM06628	200	10	750	$ 2,374	$ 24,000
DM06629	600	9	750	$ 2,374	$ 23,000
DM06630	600	53	900	$ 2,845	$ 152,000
DM06631	600	60	1200	$ 4,150	$ 251,000
DM06633	300	87	375	$ 1,427	$ 124,000
DM06669	250	6	300	$ 1,382	$ 8,000
DM06788	380	7	450	$ 1,553	$ 12,000
DM06889	250	13	375	$ 1,427	$ 19,000
DM06890	250	60	300	$ 1,382	$ 83,000
DM06927	300	40	525	$ 1,735	$ 70,000
DM06960	300	64	375	$ 1,427	$ 92,000
DM07129	150	44	250	$ 1,311	$ 58,000
DM07259	300	117	375	$ 1,427	$ 167,000
DM07328	300	92	450	$ 1,553	$ 143,000
DM07329	300	21	450	$ 1,553	$ 32,000
DM08235	250	94	375	$ 1,427	$ 134,000
DM08236	200	44	300	$ 1,382	$ 61,000
				Total	**$ 21,478,000**

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
Priority at redevelopment					
DM00428	450	38	525	$ 1,735	$ 66,000
DM00430	600	129	675	$ 2,158	$ 279,000
DM00629	380	46	450	$ 1,553	$ 71,000
DM00630	380	40	450	$ 1,553	$ 62,000
DM00653	250	79	300	$ 1,382	$ 110,000
DM00807	450	36	750	$ 2,374	$ 85,000
DM00887	680	107	900	$ 2,845	$ 305,000
DM01175	450	113	525	$ 1,735	$ 196,000
DM01190	530	50	600	$ 1,960	$ 99,000
DM01320	530	100	600	$ 1,960	$ 196,000
DM04052	450	112	525	$ 1,735	$ 194,000
DM04467	450	30	525	$ 1,735	$ 53,000
DM06672	530	38	675	$ 2,158	$ 82,000
DM08926	375	29	450	$ 1,553	$ 46,000
DM00292	380	52	450	$ 1,553	$ 82,000
DM00293	300	89	375	$ 1,427	$ 128,000
DM00295	300	84	375	$ 1,427	$ 121,000
DM00297	300	78	375	$ 1,427	$ 112,000
DM00317	250	38	300	$ 1,382	$ 53,000
DM00318	250	120	300	$ 1,382	$ 166,000
DM00378	300	28	375	$ 1,427	$ 41,000
DM00384	250	104	300	$ 1,382	$ 144,000
DM00460	250	74	300	$ 1,382	$ 102,000
DM00474	530	15	675	$ 2,158	$ 34,000
DM00475	530	65	600	$ 1,960	$ 129,000
DM00476	530	18	750	$ 2,374	$ 44,000
DM00477	530	106	600	$ 1,960	$ 208,000
DM00481	450	68	525	$ 1,735	$ 118,000
DM00543	530	101	600	$ 1,960	$ 199,000
DM00544	600	108	675	$ 2,158	$ 234,000
DM00632	200	47	250	$ 1,311	$ 62,000
DM00633	200	62	250	$ 1,311	$ 82,000
DM00638	200	121	250	$ 1,311	$ 159,000
DM00639	250	102	300	$ 1,382	$ 141,000
DM00654	250	79	300	$ 1,382	$ 109,000
DM00665	200	23	250	$ 1,311	$ 30,000
DM00672	250	78	300	$ 1,382	$ 109,000
DM00688	200	35	250	$ 1,311	$ 47,000
DM00735	150	43	200	$ 1,288	$ 56,000
DM00739	250	86	300	$ 1,382	$ 120,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM00741	300	94	375	$ 1,427	$ 134,000
DM00744	300	22	375	$ 1,427	$ 32,000
DM00751	250	55	300	$ 1,382	$ 77,000
DM00760	380	52	450	$ 1,553	$ 81,000
DM00762	200	28	250	$ 1,311	$ 37,000
DM00766	300	14	525	$ 1,735	$ 24,000
DM00785	200	86	250	$ 1,311	$ 114,000
DM00789	200	33	250	$ 1,311	$ 44,000
DM00826	300	92	375	$ 1,427	$ 131,000
DM00839	600	98	750	$ 2,374	$ 233,000
DM00846	300	49	375	$ 1,427	$ 71,000
DM00907	680	120	750	$ 2,374	$ 284,000
DM00928	1050	100	1350	$ 5,194	$ 521,000
DM00956	600	46	675	$ 2,158	$ 99,000
DM00984	300	39	375	$ 1,427	$ 56,000
DM00986	300	80	375	$ 1,427	$ 115,000
DM00993	250	70	300	$ 1,382	$ 97,000
DM00999	250	76	300	$ 1,382	$ 105,000
DM01046	250	69	300	$ 1,382	$ 96,000
DM01048	450	40	525	$ 1,735	$ 69,000
DM01054	300	109	375	$ 1,427	$ 156,000
DM01177	680	100	750	$ 2,374	$ 237,000
DM01183	680	126	900	$ 2,845	$ 358,000
DM01319	530	96	600	$ 1,960	$ 189,000
DM01338	300	99	375	$ 1,427	$ 142,000
DM01341	300	90	375	$ 1,427	$ 129,000
DM01350	380	72	450	$ 1,553	$ 112,000
DM01351	530	73	600	$ 1,960	$ 144,000
DM01352	680	85	750	$ 2,374	$ 201,000
DM01353	680	68	750	$ 2,374	$ 162,000
DM01355	680	87	900	$ 2,845	$ 248,000
DM01358	530	74	675	$ 2,158	$ 160,000
DM01361	250	39	300	$ 1,382	$ 55,000
DM01363	200	126	250	$ 1,311	$ 165,000
DM01366	680	80	900	$ 2,845	$ 229,000
DM01370	200	29	250	$ 1,311	$ 38,000
DM01380	300	90	375	$ 1,427	$ 129,000
DM01386	250	124	300	$ 1,382	$ 172,000
DM01994	600	41	675	$ 2,158	$ 90,000
DM01997	600	100	675	$ 2,158	$ 217,000
DM04030	200	37	250	$ 1,311	$ 49,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM04160	450	64	525	$ 1,735	$ 112,000
DM04161	200	61	250	$ 1,311	$ 80,000
DM04189	250	9	300	$ 1,382	$ 12,000
DM04654	300	32	375	$ 1,427	$ 46,000
DM04766	200	79	250	$ 1,311	$ 104,000
DM05199	250	21	300	$ 1,382	$ 30,000
DM05441	300	78	375	$ 1,427	$ 112,000
DM05679	300	80	375	$ 1,427	$ 114,000
DM05937	250	20	300	$ 1,382	$ 28,000
DM05938	250	42	300	$ 1,382	$ 58,000
DM05949	150	24	200	$ 1,288	$ 32,000
DM06052	250	37	300	$ 1,382	$ 52,000
DM06458	600	13	675	$ 2,158	$ 28,000
DM06460	250	13	300	$ 1,382	$ 18,000
DM06462	250	20	300	$ 1,382	$ 28,000
DM06467	680	8	750	$ 2,374	$ 19,000
DM06544	300	18	600	$ 1,960	$ 35,000
DM06632	300	43	375	$ 1,427	$ 62,000
DM07128	150	59	200	$ 1,288	$ 76,000
DM07152	250	12	300	$ 1,382	$ 17,000
DM07260	300	62	375	$ 1,427	$ 88,000
DM07486	250	37	375	$ 1,427	$ 53,000
DM07487	250	23	375	$ 1,427	$ 34,000
DM08678	250	78	375	$ 1,427	$ 112,000
DM08679	250	100	450	$ 1,553	$ 155,000
DM08925	375	13	450	$ 1,553	$ 21,000
DM08927	300	29	375	$ 1,427	$ 41,000
DM08928	300	44	375	$ 1,427	$ 63,000
				Total	**$ 12,106,000**

Notes:
Does not include PST or Contractor Markup/Overhead

Table J-2: Major Pipe Upgrades - Major Drainage System Undersized for 100-Year Design Flow

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
Priority 1-10 years					
C11	900 x 1800	63	2100	$ 7,849	$ 495,000
C29	900 x 1800	26	2100	$ 7,849	$ 201,000
C30	900 x 1800	27	1800	$ 6,460	$ 174,000
C32	900 x 1800	34	1650	$ 5,853	$ 201,000
DM00288	250	48	375	$ 1,427	$ 69,000
DM00309	750	67	1050	$ 3,431	$ 231,000
DM00320	250	98	300	$ 1,382	$ 137,000
DM00342	750	107	1200	$ 4,150	$ 443,000
DM00345	750	138	1350	$ 5,194	$ 718,000
DM00383	450	38	600	$ 1,960	$ 75,000
DM00386	250	129	375	$ 1,427	$ 185,000
DM00397	750	51	1050	$ 3,431	$ 175,000
DM00398	750	52	1050	$ 3,431	$ 178,000
DM00399	750	46	1050	$ 3,431	$ 159,000
DM00406	750	42	1050	$ 3,431	$ 145,000
DM00434	750	100	1200	$ 4,150	$ 416,000
DM00435	750	53	1050	$ 3,431	$ 183,000
DM00437	750	56	1050	$ 3,431	$ 193,000
DM00439	380	58	450	$ 1,553	$ 90,000
DM00441	380	69	525	$ 1,735	$ 120,000
DM00442	380	46	600	$ 1,960	$ 91,000
DM00445	380	67	525	$ 1,735	$ 117,000
DM00446	300	122	750	$ 2,374	$ 291,000
DM00622	600	49	900	$ 2,845	$ 139,000
DM00623	750	74	1050	$ 3,431	$ 256,000
DM00624	750	81	1050	$ 3,431	$ 278,000
DM00642	250	55	375	$ 1,427	$ 79,000
DM00655	200	61	250	$ 1,311	$ 80,000
DM00790	250	52	300	$ 1,382	$ 72,000
DM00801	200	23	250	$ 1,311	$ 31,000
DM00803	530	27	675	$ 2,158	$ 58,000
DM00804	530	47	900	$ 2,845	$ 133,000
DM00809	530	53	1050	$ 3,431	$ 184,000
DM00810	530	36	675	$ 2,158	$ 79,000
DM00840	900	98	1650	$ 5,853	$ 575,000
DM00858	900	63	1650	$ 5,853	$ 371,000
DM00859	900	122	1650	$ 5,853	$ 715,000
DM00866	450	107	675	$ 2,158	$ 232,000
DM00875	300	52	600	$ 1,960	$ 102,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM00892	530	106	675	$ 2,158	$ 230,000
DM00900	380	121	675	$ 2,158	$ 262,000
DM00916	1650	38	1800	$ 6,460	$ 245,000
DM00923	900	17	1650	$ 5,853	$ 103,000
DM00927	900	143	1350	$ 5,194	$ 743,000
DM00971	900	51	1200	$ 4,150	$ 211,000
DM00978	900	112	1650	$ 5,853	$ 654,000
DM00979	900	114	1350	$ 5,194	$ 595,000
DM00988	1200	120	2400	$ 8,999	$ 1,081,000
DM01039	200	54	250	$ 1,311	$ 71,000
DM01068	750	136	1200	$ 4,150	$ 567,000
DM01070	380	11	900	$ 2,845	$ 33,000
DM01073	1200	121	2100	$ 7,849	$ 947,000
DM01078	450	74	675	$ 2,158	$ 159,000
DM01196	680	55	900	$ 2,845	$ 157,000
DM01344	450	85	525	$ 1,735	$ 147,000
DM01373	300	113	375	$ 1,427	$ 161,000
DM01384	250	38	300	$ 1,382	$ 52,000
DM01385	250	45	375	$ 1,427	$ 65,000
DM01584	900	165	1650	$ 5,853	$ 966,000
DM01585	900	20	1800	$ 6,460	$ 129,000
DM01984	750	100	1050	$ 3,431	$ 342,000
DM01995	450	138	675	$ 2,158	$ 298,000
DM03505	750	35	1050	$ 3,431	$ 119,000
DM03891	750	145	1050	$ 3,431	$ 499,000
DM03979	300	95	375	$ 1,427	$ 136,000
DM03980	680	44	900	$ 2,845	$ 126,000
DM03982	680	34	900	$ 2,845	$ 98,000
DM04032	250	61	300	$ 1,382	$ 85,000
DM04033	250	10	450	$ 1,553	$ 16,000
DM04136	1650	75	2100	$ 7,849	$ 590,000
DM04358	900	26	1050	$ 3,431	$ 89,000
DM04393	900	12	1500	$ 6,152	$ 73,000
DM04767	250	48	300	$ 1,382	$ 66,000
DM05468	1650	116	2400	$ 8,999	$ 1,041,000
DM05469	1650	75	1800	$ 6,460	$ 483,000
DM05932	250	44	375	$ 1,427	$ 63,000
DM06455	530	26	600	$ 1,960	$ 52,000
DM06534	1650	78	2100	$ 7,849	$ 614,000
DM06535	1650	92	2100	$ 7,849	$ 726,000
DM06538	1500	13	2700	$ 11,008	$ 146,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM06665	380	39	600	$ 1,960	$ 76,000
DM06666	380	15	600	$ 1,960	$ 30,000
DM06668	250	52	375	$ 1,427	$ 75,000
DM06807	750	102	1200	$ 4,150	$ 426,000
DM06909	900	108	1200	$ 4,150	$ 447,000
DM06957	900	90	1200	$ 4,150	$ 374,000
DM06958	900	54	1350	$ 5,194	$ 282,000
DM07265	530	17	600	$ 1,960	$ 33,000
DM07401	250	38	300	$ 1,382	$ 53,000
DM07497	900 x 1800	324	2100	$ 7,849	$ 2,542,000
DM07498	900 x 1800	330	1650	$ 5,853	$ 1,932,000
DM07499	1200 x 2400	241	3600	$ 17,405	$ 4,195,000
DM07500	1200 x 300	434	3600	$ 17,405	$ 7,554,000
DM07726	1300 x 1200	8	2700	$ 11,008	$ 90,000
DM08030	750	19	1800	$ 6,460	$ 126,000
DM08041	200	33	450	$ 1,553	$ 52,000
DM08045	380	91	450	$ 1,553	$ 142,000
DM08050	450	128	525	$ 1,735	$ 223,000
DM08066	530	61	675	$ 2,158	$ 132,000
DM08067	450	47	600	$ 1,960	$ 93,000
DM08068	530	113	675	$ 2,158	$ 244,000
DM08081	200	19	300	$ 1,382	$ 27,000
DM09044	300	57	525	$ 1,735	$ 100,000
DM09247	300	79	525	$ 1,735	$ 138,000
DM09249	300	76	450	$ 1,553	$ 119,000
DM09250	375	76	525	$ 1,735	$ 133,000
KWLDM01	1200 x 2400	25	3000	$ 13,300	$ 327,000
				Total	**$ 41,676,000**
Priority 1-10 years (Provincial)					
DM06779*	900	51	2400	$ 8,999	$ 458,000
				Total	**$ 458,000**
Priority 10-20 years					
DM00306	250	58	300	$ 1,382	$ 81,000
DM00347	750	55	900	$ 2,845	$ 157,000
DM00816	750	82	1050	$ 3,431	$ 280,000
DM00893	600	104	900	$ 2,845	$ 297,000
DM00894	680	97	1050	$ 3,431	$ 333,000
DM00895	900	121	1200	$ 4,150	$ 502,000
DM00896	900	49	1350	$ 5,194	$ 253,000
DM00897	900	43	1350	$ 5,194	$ 226,000
DM00930	1050	72	1350	$ 5,194	$ 375,000
DM01198	680	47	900	$ 2,845	$ 133,000
DM01218	530	13	1050	$ 3,431	$ 47,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM01251	450	45	750	$ 2,374	$ 108,000
DM03501	1050	21	1500	$ 6,152	$ 128,000
DM04184	450	27	900	$ 2,845	$ 78,000
DM06757	680	139	1050	$ 3,431	$ 479,000
DM06805	600	65	600	$ 1,960	$ 128,000
DM07421	1200 x 300	26	3600	$ 17,405	$ 461,000
DM07530	750	6	1350	$ 5,194	$ 30,000
DM09253	450	34	600	$ 1,960	$ 67,000
				Total	**$ 4,163,000**
Priority At Redevelopment					
DM00643	380	44	450	$ 1,553	$ 69,000
DM01197	680	24	900	$ 2,845	$ 68,000
DM01200	900	27	1200	$ 4,150	$ 111,000
DM01250	450	155	525	$ 1,735	$ 269,000
DM04442	300	7	375	$ 1,427	$ 11,000
DM04469	600	33	900	$ 2,845	$ 95,000
4180	250	15	300	$ 1,382	$ 21,000
CO-162	900	39	1650	$ 5,853	$ 227,000
DM00290	250	35	300	$ 1,382	$ 49,000
DM00311	250	64	300	$ 1,382	$ 90,000
DM00348	750	57	900	$ 2,845	$ 164,000
DM00381	250	40	300	$ 1,382	$ 55,000
DM00385	530	27	600	$ 1,960	$ 53,000
DM00396	750	18	900	$ 2,845	$ 52,000
DM00404	250	42	300	$ 1,382	$ 58,000
DM00408	750	65	900	$ 2,845	$ 184,000
DM00433	750	81	900	$ 2,845	$ 230,000
DM00440	380	69	450	$ 1,553	$ 108,000
DM00472	300	50	375	$ 1,427	$ 72,000
DM00787	300	47	375	$ 1,427	$ 68,000
DM00796	200	38	250	$ 1,311	$ 51,000
DM00802	530	26	600	$ 1,960	$ 51,000
DM00815	750	34	900	$ 2,845	$ 96,000
DM00817	750	87	900	$ 2,845	$ 248,000
DM00917	1650	31	2100	$ 7,849	$ 240,000
DM00932	750	105	900	$ 2,845	$ 298,000
DM01001	600	102	675	$ 2,158	$ 221,000
DM01077	450	92	525	$ 1,735	$ 160,000
DM01199	680	69	750	$ 2,374	$ 164,000
DM01612	450	95	525	$ 1,735	$ 165,000
DM03504	600	19	750	$ 2,374	$ 47,000
DM04042	1650	164	2400	$ 8,999	$ 1,479,000

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
DM04356	200	11	250	$ 1,311	$ 16,000
DM04770	300	24	375	$ 1,427	$ 35,000
DM05897	250	38	300	$ 1,382	$ 53,000
DM05931	250	88	300	$ 1,382	$ 122,000
DM06808	750	27	900	$ 2,845	$ 79,000
DM06910	900	29	1050	$ 3,431	$ 102,000
DM07235	300	48	375	$ 1,427	$ 68,000
DM08033	380	96	450	$ 1,553	$ 150,000
DM08063	200	66	250	$ 1,311	$ 87,000
DM08071	200	19	250	$ 1,311	$ 25,000
DM09251	450	104	525	$ 1,735	$ 180,000
DM09254	450	4	525	$ 1,735	$ 7,000
				Total	**$ 6,198,000**

Notes:

Does not include PST or Contractor Markup/Overhead
*Provincially owned pipe

Table J-3: Culvert Upgrades - Culverts Undersized for 100-Year Design Flow

Conduit ID	Existing Diameter (mm)	Length (m)	Required Diameter (mm)	Unit Cost ($/m)	Estimate Cost ($)
Priority 1-10 years culverts under MHB (Provincial)					
DM06768*	1950	51	3000 x 3000	$ 6,590	$ 598,000
DM06767*	1950	49	3000 x 3000	$ 6,590	$ 583,000
DM06766*	1950	51	3000 x 3000	$ 6,590	$ 597,000
				Total	**$ 1,778,000**
Priority 1-10 years					
No upgrades indentified.					
				Total	**$ -**
Priority 10-20 years					
DM06754	1200	22	2100	$ 7,849	$ 213,000
DM06783	900	45	2100	$ 7,849	$ 398,000
				Total	**$ 611,000**
Priority at redevelopment (Provincial)					
DM06771*	900	37	1500	$ 6,152	$ 262,000
DM06775 / DM06776*	1500	48	3000 x 3000	$ 6,590	$ 578,000
				Total	**$ 840,000**

Notes:

Does not include PST or Contractor Markup/Overhead
DM06775 and DM06776 were sized as a single culvert
*Provincially owned culvert