City of Courtenay

Integrated Rainwater Management Plan - Phase 3 Report

July 31, 2024

Figures

Tables

Appendices

Appendix A – Rainwater BMP Review
Appendix B – Catchment Rainwater Management Performance Assessment
Appendix C – Water Quality Assessment
Appendix D – Desktop and Field Drainage Review
Appendix E - Survey
Appendix F - Modelling
Appendix G - Drainage Assessment
Appendix H - Risk Matrix
Appendix I - Capital Plan
Appendix J - Climate Change Assessment Technical Memorandum
Appendix K – IRMP Phase 3 Stakeholder Engagement
Appendix L – IRMP Phase 2 Report (Includes appended Phase 1 Report)

City of Courtenay

Executive Summary

The City of Courtenay Integrated Rainwater Management Plan (IRMP) is a community wide plan to guide changes in the way rainwater is managed. This plan was developed in response to community concerns about drought, flooding, and impacts to the aquatic environment.

Project Overview

The City initiated development of the integrated rainwater management plan and organized the work into three phases.

- Phase 1 (Jan 2019) – Development of stormwater trunks model to identify key deficiencies
- Phase 2 (Dec 2020) – Watershed analysis: hydrogeological assessment, geotechnical assessment, environmental assessment, stakeholder engagement.
- Phase 3 (Nov 2023) – Development of implementation plan, organized into three parts:
  - Complete Stormwater Modelling and Capital Plan.
  - Analyze Environmental Impacts Associated with Stormwater.
  - Develop an Integrated Rainwater Management Strategy.

This third phase presents a recommended approach to facilitate a transition from the conventional conveyance of stormwater to managing rainwater as a resource using an integrated rainwater approach.

The development of the IRMP is aligned with the provincial guidelines described in Stormwater Planning: A Guidebook for British Columbia. IRMP is a master plan informed by the City of Courtenay Official Community Plan (OCP), Bylaw No. 3070, 2022, that identifies the work needed to implement the policies described in the OCP.

Rainwater Management Key Issues & Impacts

In an undeveloped watershed, rainwater is absorbed by soils, evapotranspirated from leaves, and infiltrated into the ground, where it replenishes groundwater, aquifers, and freshwater springs. A small amount of rain runs off the landscape, travelling into streams, creeks, lakes, and rivers, as it travels toward the ocean.

As cities develop, a network of roads, and buildings are constructed. Rainwater cannot be absorbed by these impermeable surfaces, and so it is collected in underground stormwater pipes that discharge the water directly into waterways. Cities rely on stormwater conveyance systems to keep roads and buildings dry during rainfall events, but this conveyance system has a number of impacts, which include:

Flooding: Less water is absorbed by the landscape, and a larger volume of water is directed downstream.

Erosion of the creeks and rivers: The extra volume of water in waterways accelerates erosion, causing property damage, and depositing sediment in gravel beds.

Water quality issues: Stormwater washes contaminants off of developed areas and directs them into waterways.

Drought: Water has limited ability to absorb into soils and replenish groundwater resources. Groundwater is an essential source of water during dry summer months. If groundwater cannot be sufficiently recharged by rain during the wet months, it exacerbates drought conditions.

Ecosystem impacts: Poor water quality, degradation of riparian areas, and barriers to fish passage stress aquatic species, and adversely impact biodiversity.

Currently, the City of Courtenay manages most stormwater using a conventional conveyance network that discharges to receiving streams. A few site-specific rainwater source control projects, including raingardens, detention facilities and treatment devices, have been implemented and demonstrate various methods to manage stormwater.

The IRMP seeks to understand the operation of the stormwater system and the impacts associated with it, in an effort to propose changes to halt, and potentially reverse impacts over time.

IRMP Phase 3 Methodology

Part 1 – Stormwater Model & Capital Plan

To understand the operation of the stormwater system, a comprehensive InfoSWMM stormwater model was developed, and calibrated using flow data. The model was run under various rainfall events to assess the performance of the system under typical rainfall conditions, and extreme rainfall conditions.

The capacity and the condition of the pipes and culverts was analyzed. A risk matrix was developed to assess the likelihood of failure, and consequence of failure of each component. Components of the system that pose the greatest risk were included in the capital plan for upgrade in the next 2, 5, or 10 years.

Part 2 – Analysis of Environmental Impacts of Stormwater

The local environmental impacts associated with the stormwater system were analyzed by assessing the condition of the watersheds within the City of Courtenay. This involved an analysis of watershed and riparian corridor cover, benthic invertebrates, fish passage along creeks, and surface water quality.

Part 3 – Development of Rainwater Management Strategy

A rainwater management strategy was developed to identify the options and opportunities for the City to improve rainwater management going forward.

This is involved an analysis of best management practices, an analysis of rainwater management targets, a performance review of source control projects already in service, and an assessment of stormwater catchment performance. Following this analysis, an implementation strategy to shift the management of rainwater was prepared.

Implementation Plan

	Recommendation	Timeline	Cost
Capital Upgrade Plan for Storm Sewers			
1	The capital plan for the IRMP includes prioritized and costed upgrades for trunk sewer infrastructure identified for the near and medium term, 1 to 10 years in the future (Section 5 and Appendix G). Note: The allocation of funding for upgrades will impact the timing and progress of upgrade completion and the program timing may need to be reviewed or adjusted in the future. As noted above, the estimated costs for capital upgrades are based on 2022 cost data, and the level of uncertainty in the costing should be assumed to increase as time passes due to the volatility in construction and infrastructure supply markets.		
	Priority 1: Capital Upgrades	1-2 Years	$3,419,000
	Priority 2: Capital Upgrades	3-5 Years	$5,720,000
	Priority 3: Capital Upgrades	6-10 Years	$8,584,000
2	Explore additional and alternative funding sources for storm system upgrades (Section 6):		
a	Review existing funding options, including DCCs for areas where development is occurring, and combining infrastructure upgrades, such as storm pipes with road or water main upgrades, to reduce costs.	Immediate	Existing resources
b	Increase funding for storm drainage operation and capital projects for the short term to start to bridge the gap in funding and system renewals and upgrades. Consider a ramp up of increasing fees for stormwater if the full increase per property is not considered to be acceptable for a single-year increase to property taxes. Start to bring the storm system into alignment with long-term system operation and service goals.	1-3 Years	Existing staff and council resources
c	Investigate infrastructure grant opportunities to fund critical upgrades, multiple-benefit projects, and others that fit grant program parameters.	1 – 10 Years	Existing Resources
d	Review whether a formalised stormwater utility is a good fit for the long term and, if so, pursue setup.	4 – 10 Years	$200,000

	Recommendation	Timeline	Cost
Updates to Subdivision and Development Servicing Bylaw 2919 (2018)			
3	Update the 100-year return period design IDF curve to incorporate 95th percentile climate change increase in rainfall to be more conservative in the design of major system infrastructure (Section 3.1 and Appendix J).	1-2 Years	Existing Resources
4	Update the City's Supplementary Design Guidelines, Section 4, to create Section 4.3.4 Rainwater Management (Section 7.1):	1-3 Years	$100,000
a	Add requirement that all new and re-development is required to provide on-site rainwater management to capture and infiltrate 42 mm or rainfall in 24 hours.	1-2 Years	Existing Resources
b	Note infiltration exceptions. E.g., if the site is located over bedrock that does not infiltrate or if there is an identified geotechnical hazard (desktop study required, at a minimum, to identify potential hazard areas and considerations), such as an embankment, that infiltration should be separated from.	1-2 Years	Existing Resources & $50,000
c	Determine acceptable approach for infill single family residential lots (single lot development or re-development) and specify in this section. Explore the option of, disconnecting roof leaders from the storm system . If roof leader disconnection is pursued, then the City's Building bylaw would also require updating to allow disconnection.	1-4 Years	$50,000
d	Add requirement for all lots to incorporate minimum 300 mm of absorbent topsoil on all restored vegetated areas (lawns and shallow garden areas) of the lot.	Coord. w/ (4c)	Coord. w/ (4c)
e	Add a reference to a guideline or standards for rainwater management system design. Initially this should be an available guideline, such as the Metro Vancouver Stormwater Source Control Design Guidelines, but this should be updated to City-specific guidance or standards if and when they are developed (See #13, below).	1-2 Years	Existing Resources
5	Update the City's Supplementary Design Guidelines, Section 4.11.8, to be called Water Quality Treatment and add water quality requirements (Section 7.1):	1-2 Years	Existing Resources
a	Water quality treatment must be provided to treat the runoff of the rainwater capture target, i.e. 42 mm in 24 hours, to remove 80% of inflow TSS by mass from runoff from vehicle-accessible impervious surfaces such as roads, lanes, and parking areas, with rain gardens and bioswales preferred for treatment of road runoff to remove 6-PPD Quinone.	As Part of (5)	As Part of (5)

	Recommendation	Timeline	Cost
b	Note that water quality treatment and volume capture can be combined in the same facility when the target volume is routed to an infiltration rain garden (bioretention) or bioswale that both treats and infiltrates the target volume.	As Part of (5)	As Part of (5)
Protect and Enhance Environmental Values			
6	Look for opportunities to expand and revegetate riparian areas when possible, whether by negotiating additional setback, acquiring public rights-of-way, or improving publicly owned properties (Section 7.2).	1 – 10 Years, and Beyond	Dependent on Acquisition or Enhancement
7	Build on infrastructure projects, when possible, to improve environmental conditions such as fish passage (Section 7.2):		
a	Fish barriers were identified in Phase 2 IRMP (see Appendix L). Note: Fish bearing streams in the Phase 2 report have a calculated "% fish bearing", which indicates the fraction of the stream length that is accessible to fish. Streams with lower % fish bearing length and streams with high value habitat should be prioritized for improvements to fish accessibility by removal of fish barriers when there is an opportunity to do so.	1 – 10 Years, and Beyond	Incremental Increase in Cost when done as part of pipe upgrades
Programs and Operational Updates			
8	Promote green infrastructure to mitigate impacts of development and investigate methods of supporting green infrastructure implementation including (Section 8.1):		
a	Develop area-specific development cost charges dedicated to fund stormwater management, planning, and outreach activities within a specified area. This can be combined with reduced stormwater fees or charges in exchange for green infrastructure practices. External support for study likely needed to identify areas and develop costs.	4-10 Years, Coord w/ (2e)	Existing Resources and ~$85,000
b	Consider special assessment fees for new development in environmentally sensitive areas or land integral to the City's green infrastructure policy. Requires additional external consultant support to build on work completed in Phase 2 of IRMP.	4-10 Years, Coord w/ (2e)	$50,000 - $70,000
c	Allocate funds and staff time specifically to support construction of stormwater management facilities and green infrastructure. This would be in addition to funds for upgrades and maintenance of the existing system.	2-10 Years	Existing Resources; may need External Support

	Recommendation	Timeline	Cost
d	Develop design guidance and standards for green infrastructure to clarify what is allowed, efficient, and best practice (see Section 9). Develop internal processes to review, inspect, approve, and track green infrastructure installations.	2-5 Years	Existing Resources and New Staff for Internal Processes
e	Encourage bio-engineering methods for bank stabilization and erosion remediation rather than riprap and consider including in the Supplementary Design Guidelines.	2-5 Years	Existing Resources
9	Develop a plan for allowing off-site stormwater management for development on public land (Section 8.2) as a way to maximize the rainwater management mitigation for sites in constrained situations.		
a	Consult internally with staff on risks and concerns for implementation of off-site stormwater management	1-4 Years	Existing Resources
b	Identify situations and applications when off-site stormwater management would be acceptable, and limitations when it would not be acceptable. May require external consultant support on technical specifics and limitations	1-4 Years	Existing Resources; Potential Consultant
10	Consult internally and externally and develop long-term plan for maintenance of green infrastructure over time as implementation on public property increases maintenance needs and workload (Section 8.3). Plan to build City capacity over the long term.	2-5 Years (planning) Ongoing (implementation)	Existing and New Internal Resources
11	Develop communication and outreach in support of IRMP and green infrastructure programs (Section 8.3):		
a	Develop a long-term communications plan for releasing new information on stormwater and rainwater management and related City initiatives and for reminding the public about existing programs and initiatives to raise and maintain awareness of the City's work on these issues and its importance for watershed health.	1-2 Years and Ongoing	Existing Resources
b	Develop programs and funding for collaboration with streamkeepers and other environmental advocacy groups.	1-5 Years	Existing Resources and Grant Funding
c	Assess the feasibility of partnering with volunteer groups such as streamkeepers for monitoring and environmental enhancement projects.	1-5 Years	Existing Resources
d	Promote existing and new stormwater and rainwater management facilities and inform the public how they contribute to watershed health with signage to inform and engage the public with in-situ installation.	1-2 Years and Ongoing	Existing Resources

	Recommendation	Timeline	Cost
Plan and Fund Future Work Needed to Support the IRMP Goals and Desired Outcomes			
12	Develop City-specific rainwater management guidance or standards to facilitate implementation of rainwater management in accordance with recommended rainwater management targets. The guidance would support the design of functional rainwater management facilities and reduce the burden of effort for designers trying to meet the City's targets. Guidance would also streamline the City review processes for rainwater management facilities to reduce the burden of effort on the City staff. Includes internal and external consultation. (Section 9.1).	2-5 Years	$100,000+
13	Detailed assessment of detention pond capacities to better understand the level of detention performance provided by existing ponds in current conditions in comparison to the City's detention performance requirements and if there are gaps in detention capacity or controls that need to be and can be improved. Assessment may be limited to ponds with reported or suspected shortfalls in operational performance. Options for improving performance or making up for a gap in performance can be assessed for individual locations to extent needed to address concerns. (Section 9.2).	1-4 Years	$50,000- $75,000
Monitoring and Adaptive Management to Keep the IRMP On Track			
14	Implement a monitoring plan for long-term monitoring of watershed health and other key performance indicators (Section 10.1). The monitoring plan is based on the provincially approved Metro Vancouver Monitoring and Adaptive Management Framework (MAMF).		
a	Flow monitoring in priority catchments on a recurring basis every 2 to 5 years. Costs can vary widely, estimate of costs is on an annual basis for range of monitoring.	1-5 Year (Recurring)	$10,000 to 50,000
b	Water quality monitoring of receiving watercourses on a minimum 5 year cycle. Can be implemented across the City on a rotational basis to annualize the work and costs.	5 Year Cycle (Recurring)	$25,000 to $50,000
c	Development of systems for tracking spatial data on rainwater management facilities installed, soil infiltration testing locations and results, and data from stakeholder collaborations.	1-5 Years	Existing Resources
d	Additional water quality monitoring in-pipe or at end of pipe to understand stormwater discharge quality could be added to the monitoring; allocating annual operational budget for monitoring may smooth the process over the long term.	Similar to (14b)	$25,000

	Recommendation	Timeline	Cost
15	Implement adaptive management to review monitoring results and progress on IRMP tasks on a recurring basis at least once every 5 years (Section 10.2)		
a	Review tracking, data, and trends to understand changes in receiving water systems and health, and to understand progress and changes toward implementation of IRMP objectives. Likely requires external support for initial analysis, could be taken on by staff for subsequent analysis if desired.	5-10 Year (Recurring)	$10,000 to 50,000
b	If adverse trends in watershed health are observed in the monitoring data, review the mitigations and level of implementation, and assess what changes should be made to address the issue(s) and change the adverse trends.	5-10 Year (Recurring)	Existing Resources; Potential External Support

1. Introduction

The City of Courtenay experiences seasonal moisture variation, with wet winters, and dry summers. This wide variation in moisture conditions makes the region vulnerable to both flooding and drought. The City of Courtenay has developed an Integrated Rainwater Management Plan (IRMP) to manage rainwater in a way that minimizes the impacts of flooding and drought, while protecting the aquatic environment.

The development of the IRMP is aligned with the provincial guidelines described in Stormwater Planning: A Guidebook for British Columbia. A key objective of the City's IRMP is to facilitate a transition from conventional conveyance storm drainage to managing stormwater using an integrated rainwater approach.

The City initiated development of the IRMP in 2018. The work plan was organized into three phases. This third phase builds on the work completed in the first two phases and presents a plan to implement integrated rainwater management throughout the City of Courtenay.

1.1. Background for the IRMP

In an undeveloped watershed, rainwater is absorbed by soils, evapotranspired from leaves, and infiltrated into the ground, where it replenishes groundwater, aquifers, and freshwater springs. A small amount of rain runs off the landscape, travelling overland into streams, creeks, lakes, and rivers, as it travels toward the ocean.

As cities develop, a network of roads, and buildings are constructed. Rainwater cannot be absorbed by these impermeable surfaces, and so it is collected in underground stormwater pipes that discharge the water directly into waterways. Cities rely on stormwater conveyance systems to keep roads and buildings dry during rainfall events, but this conveyance system has a number of impacts, as described below.

Currently, the City of Courtenay manages most stormwater using a conventional conveyance network that discharges to receiving streams. A few site-specific rainwater source control projects, including rain gardens, detention facilities and treatment devices, have been implemented and demonstrate various methods to manage stormwater.

The IRMP seeks to understand the operation of the stormwater system and the impacts associated with it, in an effort to propose changes to halt, and potentially reverse impacts over time.

An IRMP is a tool for advancing and integrating stormwater management with environmental protection. The IRMP process preserves watershed health as a whole, while meeting community needs and allowing development and re-development to occur.

The IRMP process attempts to allow development to move forward while maintaining no-net-loss of watershed health, at a minimum. The IRMP provides a framework directing the development and upgrade of stormwater management policies and infrastructure, in conjunction with rainwater management methods, in support of mitigating the hydrologic impacts of future development and providing gains for the environmental values of the watershed existing conditions where there are opportunities for improvement.

The concept of an IRMP is described in the document *Stormwater Planning: A Guidebook for British Columbia* (Province of British Columbia, 2002). Changes to the watershed and water balance occur as an area develops, when the vegetation is reduced or removed, and impervious surfaces such as roads and roofs cover an increasing proportion of the watershed area.

Impacts of poorly managed rainwater from development include:

- Creek and property impacts:
  - Channel down cutting where a creek channel grows deeper and wider due to erosion.
  - Erosion increases bedload, fills in sediment downstream (causes loss of habitat).
  - Accumulation of nuisance water downstream of development.
- Ecological impacts on aquatic and terrestrial species:
  - Increase runoff changes the stream corridor - causing progressive degradation of the channel cross-section.
  - Declined corridor biodiversity. Few cold water fish, and a progressive transition to warm water species.
  - Eroded sediments create turbid waters that irritate fish gills and make it difficult for fish to find their food.
  - Eroded sediments also cover gravel beds used for spawning, possibly blocking areas for the next generation.
  - Decrease in infiltration reduces the slow constant groundwater supply, that keeps the stream flowing in dry weather.
- Water quality impacts include localized water pollution problems:
  - Public beach closures
  - Contaminated sediments
  - Algal blooms
  - Aquatic weed infestations
  - Fish kills
  - Shellfish harvesting closures
  - Boil-water advisories
  - Outbreaks of waterborne diseases
  - Contaminated groundwater

- Financial Impacts:
    - o Drainage costs are large for developers and municipalities.
    - o Can be a detriment to affordable housing.
    - o Installation of drainage pipes without mitigation causes erosion problems and/or flooding in downstream waters.
    - o Threatens property or public safety.
    - o Creates a risk of litigation.

The IRMP process is way to avoid the impacts described above. The outcomes of the IRMP recommend:

1. Measures and processes to slow and ideally stop the changes to hydrology that occur as a result of development.
2. Options for improving on the current state of the watershed hydrology where opportunities are available.
3. Ways to protect existing environmental values, and enhance environmental values where opportunities exist.
4. Programs to inform, engage and support progress toward improved watershed health and environmental values over time.

Municipalities have the responsibility to manage drainage, as outlined in the Local Government Act, Sections 540-549, division 6. This act gives local government direct power to manage stormwater. However, this power is also a responsibility, and local government can be held liable for nuisance flooding of downstream property owners if caused by drainage that may be the municipality's responsibility.

Solving flooding issues by piping or armoring creeks is no longer acceptable from an environmental protection perspective, and flooding and aquatic habitat concerns must be integrated with decisions on development and land use change. Integrated approaches to stormwater management acknowledge that protection of property, protection of aquatic species and protection of water quality are complimentary objectives.

Flooding concerns are expected to be exacerbated by climate change that causes increasing volume and intensity of storms into the future. The IRMP incorporates consideration of climate change and the impacts that are expected to be experienced by the drainage and rainwater management systems in the future.

1.2. Community Vision and Priorities

The IRMP guides the future of rainwater management in the City and protects the watershed health for the receiving watercourses from adverse impacts from stormwater. The IRMP is a master plan designed to implement the community vision described in the Official Community Plan (OCP).

The objective of the IRMP is to protect the aquatic environment of the receiving waters, and mitigate the impacts of flooding and drought, to the extent possible, by managing rainwater in accordance with natural hydrologic processes and patterns.

Based on the OCP guidance and community input, the desired outcomes of this work can be broadly summarized by three primary pillars:

1. **Protect** watershed health. Address water quality and water quantity concerns associated with stormwater, to improve of watershed health.
2. **Manage** the stormwater system to safely convey rainfall events of the future without property damage or flooding.
3. **Engage** the community to implement solutions to improve watershed, including restoration, monitoring, and adoption of green infrastructure.

The community, through the development of the OCP, has emphasized that rainwater management priorities cover a diverse range of categories and departments and require integration across those topics for successful outcomes. Relevant policies in the OCP come from sections on: Streets and Transportation, Buildings and Landscape, Municipal Infrastructure, Natural Environment, Parks and Recreation, and Social Infrastructure. All of these aspects are considered in the IRMP and in the development of the recommendations that are the products of the IRMP process and form the Integrated Rainwater Management Plan for the City of Courtenay.

1.3. Structure of the IRMP

The development of the IRMP was completed in phases.

Phase 1

Phase 1 of the IRMP was completed by Urban Systems in January, 2019.

The focus for Phase 1 was developing a comprehensive city-wide plan to address current and future stormwater issues through long-term capital planning and implementation programs. Phase 1 of the IRMP included development of a trunks-only storm system model to identify key deficiencies and potential upgrades that were presented as a preliminary capital plan. The Phase 1 report identified significant data gaps and uncertainties that needed to be addressed and considered before making substantial infrastructure decisions.

Phase 1 recommended storm flow monitoring, acquisition of data to resolve gaps, and additional CCTV inspection prior to Phase 2 assessment.

Phase 2

Phase 2 of the IRMP was completed by Urban Systems in December 2020. Phase 2 included:

- A hydrogeological assessment consisting of a desktop study of hydrogeological interpretation of the surficial geology and an overview of the surface soil infiltration potential within the City boundary study area. Maps were prepared to identify surface soils that have good, marginal or poor surface infiltration.
- A geotechnical assessment that included visual inspection of stormwater infrastructure to identify geotechnical hazards, such as erosion, landslides, obstructions, fill embankments, and culverts.
- An environmental assessment that identified at risk drainage catchments, and environmental impacts associated with the stormwater system. Key impacts include water high in turbidity with elevated concentrations of heavy metals, E.coli, and coliforms; unidentified storm-sanitary cross connections; and structures that present a barrier to fish passage.
- Stakeholder engagement including internal meeting where City staff provided input on issues, questions and opportunities for the IRMP process and team, as well as needs and wants for the end deliverable. Selected external stakeholders (40 groups) were invited to a session to increase awareness and understanding of the IRMP process and to gather input on existing data, challenges and successes.

The Phase 2 report recommended the following:

1. Use process flow monitoring data collected in 2019, to calibrate and expand the Phase 1 hydraulic model of the municipally-owned rainwater management infrastructure. This will solidify a capital program for the City's drainage services.
2. Complete the remaining components of the environmental assessment, including a natural hazard assessment, ecological health analysis, and assessing the unmitigated impacts of future land use.
3. Engage external stakeholders for supplemental input on issues. It is recommended that engagement focus on environmental stewardship groups and adjacent government jurisdictions.
4. Engage internal stakeholders to discuss management options, acceptable levels of service, refined criteria and standards, and implementation plan. Ongoing operations and maintenance, future asset replacement, cost implications and existing funding levels are important considerations in this process.
5. Compile a comprehensive IRMP, including a prioritized capital plan and recommendations, which may include but is not necessarily limited to additional study, ongoing monitoring, education, coordination with other authorities, and regulatory changes and enforcement.

Phase 3

Phase 3 of the IRMP builds on Phases 1 and 2 and combines that work with additional tasks to create a comprehensive City-wide IRMP for the City of Courtenay.

The analysis and development of Phase 3 is divided into the following tasks, described as:

1. Stakeholder Engagement:
    - Stakeholder survey to gather widespread input on priorities and considerations for rainwater management for the City.
    - Stakeholder meetings with six groups of selected stakeholders and the K'ómoks First Nation.
    - Development of a "What We Heard" summary to document the major themes received from stakeholders through the survey and the meetings.
2. Stormwater Modelling and Capital Plan:
    - Create city-wide all-pipes InfoSWMM model of drainage system.
    - Assess the storm system performance for level of service.
    - Create a decision matrix to prioritize capital plan upgrades.

3. Mitigate Environmental Impacts Associated with Stormwater:
    - Conduct additional water quality sampling.
    - Re-assess water quality data and identify priorities for improvement.
    - Recommend bylaw updates, policies, BMPs and monitoring programs for implementation.
4. Develop an Integrated Rainwater Management Strategy:
    - Set rainwater management targets.
    - Assess catchment rainwater management performance.
    - Review rainwater source control projects and make recommendations.
    - Develop recommendations for improving catchment rainwater management performance.

Phase 3 also combines the outcomes of these tasks with the outcomes of the previous phases to develop a full set of recommendations for the City-wide IRMP. These recommendations include capital projects, policy and bylaw updates, additional studies, monitoring, and adaptive management for the future.

2. Stakeholder Engagement

Stakeholder engagement for the IRMP has been pursued through the latter two phases of the work to engage and solicit input and feedback from internal (City staff) and external (public) stakeholders. The engagement efforts are summarised below. Further details are available in the notes and documentation from the stakeholder engagement in Appendix K.

2.1. Phase 2 Stakeholder Engagement

Phase 2 of the IRMP included engagement with internal and external stakeholders in the City, focussing on informing about the IRMP and the IRMP process, and soliciting feedback on staff concerns for stormwater and rainwater management, protection of receiving waters, and goals for what the IRMP should try to achieve. The core of the engagement was a workshop with City staff and external stakeholders held June 4, 2019.

Purpose:

The purpose of the stakeholder session was to increase awareness and understanding of the Integrated Rainwater Management Planning process and timeline, to acknowledge and build community capacity for working together and to gather input on identified successes, challenges, and what data currently exists.

Format:

The session was by invitation to those (approximately 40 groups) currently doing work within the Comox Valley around watershed stewardship and stormwater management. Courtenay has an active community of people and agencies working in this field who have local knowledge and history that can benefit the planning process. 30 people from a variety of Courtenay and Comox Valley organizations and companies attended.

The format provided an opportunity to update everyone at one time with the approach that is being taken and the associated timelines, it also provided opportunity to build relationships between City staff, the Urban Systems team and stakeholder groups early in the process. The project team hopes to benefit from the community's perspective on what is working with regard to rainwater management, where more effort is needed, and in particular what data/information is available and can support understanding the state of the watersheds within the City.

What We Heard:

1. What's working well in the Comox Valley in terms of rainwater/stormwater management?
   a. There were several mentions of the positive relationships and collaboration that is occurring within the region and the potential for partnerships and education that exists amongst groups, schools and the community.
   b. Several participants highlighted specific projects that are working well, including specific properties such Home Depot, Walmart and the hospital and areas such as Brooklyn Creek, Arden, and Kus-kus-sum.
   c. Some mentioned demonstration projects such as the new Fifth Street Rain Gardens and there were mentions of improved regulatory tools within the valley.
2. What challenges do you see related to rainwater management or the IRMP process?
   a. Participants highlighted inconsistency amongst the various jurisdictions and amongst the many roles within development and building process, including Council and staff, developers and homeowners.
   b. Many were keen to see progress occur and some felt that rainwater management efforts have typically been postponed to future initiatives and need to be addressed.
   c. Several noted there is greater education and awareness needed of the overall watershed, natural systems and the downstream impacts of individual actions. In addition, several felt that the current standards are seen as the minimum requirements that need to be met and should be strengthened.
   d. In terms of external factors, climate change, sea level rise and flooding were identified as key challenges.
3. What objectives/outcomes would you like to see from the IRMP process? e.g. policies, programs, infrastructure?
   a. Several mentioned a desire to see greater consistency amongst all agencies within the watershed in terms of standards and policies and implementation.
   b. There were specific mentions of updating the standards in the Subdivision and Servicing Bylaw and introducing Best Management Practices to guide development activities.
   c. Many felt greater education and awareness is a necessary component to both watershed education and policies and standards.

d. In terms of the IRMP itself, some felt it should be bound by the watershed boundary and that it should be adaptive over time.

e. There were singular mentions of the need for residential incentives, increased monitoring and enforcement to ensure private and public infrastructure is in compliance.

4. What excites you about the Integrated Rainwater Management Plan?

   a. There were multiple comments about the recognition and respect for watersheds/riparian areas and pleased with the possibility of a watershed approach to development and water management. Some comments also related to the potential for retaining functional wetlands and collecting and maintaining baseline data.

5. Do you have any remaining questions or comments about the Integrated Rainwater Management Plan?

   a. The importance of having representation and data from the Brooklyn Creek Watershed Group was noted, as was the need for broad community awareness about the project objectives and schedule.

   b. The need for specific involvement from private land holders including forestry and agriculture was highlighted, and a request for ongoing meetings with stream keepers after the printed data is available.

2.2. Phase 3 Stakeholder Engagement

Phase 3 of the IRMP included additional engagement with stakeholders, including the following:

Online Survey:

- A letter with a link to the online survey sent to 44 contacts, with 32 responses. It was open from Wednesday, April 20th, to Wednesday, May 25th, 2022.
- The survey included nine questions, the first seven of which were multiple choice, while the last two required written answers.

Results of the Online Survey:

- Nearly 3/4 of respondents generally ranked their knowledge of hydrology, stormwater management and ecosystems impact of stormwater as novice to advanced. Few respondents expressed having proficient or technical expert knowledge in any of the three topic areas.

- The top three considerations that are most important in the management of rainwater are, in order, health of aquatic systems, water quality of streams, and reduced risk of flooding.
- The least important considerations to respondents were ease of development and cost to taxpayers.
- Respondents noted support for all eight rainwater/stormwater management tools with the highest support for (in order) absorbent landscaping, detailed design guidelines for land developers, and updated bylaws and development requirements.
- The top two ways the City of Courtenay should focus efforts to increase adoption of rainwater management practices are to focus on new development and City property (e.g., parks, streets, and sidewalks).
- The top three priorities respondents felt the City should support are (in order): 1) Developing policies or bylaws that support best management practices, 2) educational resources and design guidelines, and 3) public workshops and demonstrations.
- Survey respondents felt that the City should make adoption of rainwater management practices mandatory for new development and on City of Courtenay property.
- Victoria, Gibsons, Nanaimo, and communities within the Pacific Northwest (Portland and Seattle, and Shoreline, Washington) were noted as the top communities leading the way in rainwater management.
- Respondents noted the need for solid baseline and modelling data, interjurisdictional coordination, and education and guidance on specific topics such as grey water, xeriscape, rain gardens and agricultural lands.

Stakeholder Meetings with Key Stakeholder Groups:

- Six stakeholder meetings occurred. City of Courtenay staff met with:
  1. Beaver Meadow Farms (2 attendees)
  2. Comox Valley Conservation Partnership (16 attendees)
  3. Millard Piercy Watershed Stewards (5 attendees)
  4. Russell Farms (1 attendee)
  5. Town of Comox staff (2 attendees)
  6. Wedler Engineering (2 attendees)
- Meeting with K'ómoks First Nation. Staff prepared a briefing note that was presented at the monthly Community 2 Community Forum. Approximately nine people attended. The objective of the vision workshop was to establish a vision for the watershed and to establish goals for mitigating the impacts of future development on watershed health.

What We Heard from the Stakeholder Meetings:

- Strong interest in groups and governments working together.
- The need for reliable data and monitoring to evaluate the operation of the traditional stormwater system, the natural function of the watershed, and the condition of the streams.
- Objective-based regulations that allow for site specific flexibility and scalable options are desirable, instead of prescriptive regulations that don't allow for flexibility.
- Climate change and planning are important considerations that must be built into the stormwater model and the stormwater system must be designed to accommodate more intense rainfall events.
- There are other communities that are further ahead, that Courtenay can look to for guidance and lessons learned.
- Importance of interjurisdictional consistency and coordination across the Comox Valley governments, and value of working with community groups and volunteers (e.g., Brooklyn Creek Watershed Society, Millard Piercy Watershed Stewards).
- The cumulative impacts of development on downstream watercourses and agricultural lands must be considered. (e.g., Mallard Creek).
- A review of DCC bylaw and development requirements may be beneficial, resulting in clear policy and requirements that can be well communicated.
- Traditional infrastructure requirements such as road widths, stormwater drainage in new development, etc. need to be reconsidered.
- Consider incentives to increase the amount of permeable surface in new and existing developments.
- Subsurface geology must be considered when designing rainwater source control systems.

3. Rainwater Management Strategy

The rainwater management strategy is developed to understand the current needs of the City's watersheds with regards to rainwater management and identify the options and opportunities for the City to improve rainwater management going forward.

The provincial guidelines Stormwater Planning: A Guidebook for British Columbia, describes objectives for protecting watershed health in the urban environment. These objectives include:

Water Balance Objectives

- Objective 1 - Preserve and protect the water absorbing capabilities of soil, vegetation and trees.
- Objective 2 - Prevent the frequently occurring small rainfall events from becoming surface runoff.

Hydrology and Water Quality Objectives

- Objective 3 – Provide runoff control so that the Mean Annual Flood (MAF) approaches that for natural conditions.
- Objective 4 – Minimize the number of times per year that the flow rate corresponding to the natural MAF is exceeded after a watershed is urbanized.
- Objective 5 – Establish a total suspended solids (TSS) loading rate (i.e., kilograms per hectare per year) that matches pre-development conditions.
- Objective 6 – Maintain a baseflow condition equal to 10% of the Mean Annual Discharge (MAD) in fisheries-sensitive systems.

Biophysical Objectives

- Objective 7 - Limit impervious area to less than 10% of total watershed area.
- Objective 8 - Retain 65% forest cover across the watershed.
- Objective 9 - Preserve a 30-metre wide intact riparian corridor along all streamside areas.
- Objective 10 - Maintain B-IBI (Benthic Index of Biological Integrity) score above 30.

For the City of Courtenay's rainwater management strategy, the water balance objectives provide the direction that the City wants to strive for, in maintaining, and where possible, improving on, the rainwater management that occurs in the catchments within the City boundary. The hydrology objectives speak to the control of rainwater to imitate natural hydrologic conditions.

The biophysical objectives seek to limit the impervious area in the watershed. The 10% impervious area target is intended to protect downstream watercourses from damage due to the hydrologic impacts of development.

A key piece of research that has driven the use of rainwater management approaches in the coastal region of BC is the paper entitled *"The Importance of Imperviousness"* (Schueler, 1994) that evaluated stream stability in developed and undeveloped watersheds and showed that when impervious cover in the watershed exceeds 10%, the stream begins to show signs of instability. In general, the relationship between impervious cover and stream quality or health can be described as shown in Table 3-1 below.

Table 3-1: Impact of Impervious Area on Streams*

Watershed Impervious Cover	Stream Quality Potential
1 – 10%	Sensitive
11 – 25%	Impacted
26 % +	Degraded (Non-Supporting)
*based on Schueler, 1994	

Additional research supports the correlation proposed by Schueler. Research from the University of Washington (Booth, 1997), (Booth D. , 2000), (Horner, 1997) that focused on watersheds and development trends in King County, Washington found that, in general, the impervious cover relates directly to stream health in a watershed, and the 25% impervious cover threshold as a distinguishing point between "impacted" and "degraded" streams appears to hold true in the Pacific Northwest region.

Studies by the Greater Vancouver Regional District (GVRD) also looked at the link between impervious coverage and stream health for watersheds with the Metro Vancouver region. This work (GVRD, 1999) categorised the stream health differently, separating it into Good, Fair and Poor categories, but the relationship between impervious coverage and stream health was again reinforced.

However, Schueler and others have noted that these stream health impacts are attributed to impervious areas that are directly connected to pipes within the storm drainage system. Impervious surfaces that are disconnected allow runoff from impervious surfaces to infiltrate into the ground do not have the same impacts on watercourses. This is where rainwater management, low impact development (LID) and similar techniques become important. By utilizing rainwater management, some or all of the impervious area becomes disconnected, and the 'total impervious area' (TIA) becomes less important than the 'effective impervious area' (EIA).

EIA is a value that represents the reduced amount of impervious area that is 'effectively' directly connected to a storm drainage system when rainwater is managed outside the stormwater system.

EIA is not the same as TIA, and strictly speaking includes only a reduction in the hydrologic effects of impervious coverage, without necessarily considering other anthropogenic effects from urbanization and urban activities. The link between EIA and stream health is not as well established as for TIA, primarily because the percent EIA in a watershed is significantly more difficult to define and thus TIA is more commonly used in studies (CWP, 2002).

3.1. Current City Bylaws & Policies

Current City bylaws and policies were reviewed to provide understanding of the current municipal requirements and expectations for stormwater and rainwater management and protections currently in place for aspects of watershed and environmental health.

Official Community Plan

The City of Courtenay Official Community Plan (OCP), Bylaw No. 3070, 2022 provides significant support and guidance for objectives, priorities, and policies supporting rainwater management in the City of Courtenay. There are many relevant clauses of the OCP that align with the IRMP; the most relevant clauses are summarized in the table below.

Table 3-2: OCP Objectives & Policies Related to Stormwater, Rainwater, or Other IRMP Components

OCP Section	OCP Clause or Statement
Streets and Transportation, Objective 4	**Excess existing road space is repurposed to support public life, active travel, and green infrastructure.**
ST12	Amend the subdivision and Development Servicing Bylaw to Incorporate wherever feasible the BC Active Transportation Design Guide Recommendations including, but not limited to: b. increased sidewalk width including opportunities for green infrastructure such as rain garden and street trees; Sub-bullets a, c-f not shown.
Buildings and Landscape, Objective 3	**Living landscape elements are incorporated for water, energy, and biodiversity purposes.**
BL 8	Utilize development permit area guidelines for the purposes of: b. Incorporating biodiversity and sensitive rainwater management practices within landscapes.

OCP Section	OCP Clause or Statement
Municipal Infrastructure, Objective 2	**Infrastructure investments are guided by a multiple bottom line decision-making approach; this means energy efficient, fiscally responsible, equitably distributed, sustainable levels of service that protect public health, safety, and the environment.**
MI 3	Utilize ecological services provided by natural systems wherever practical. This means applying and integrating natural capital in the City's Asset Management Plan to provide for their maintenance and regular support alongside traditional capital assets including reclamation and restoration of degraded natural assets.
MI 6	Support variances to development and servicing specifications to permit green infrastructure, public amenity, or active transportation infrastructure on public land where such opportunities are technically feasible, where operations and maintenance considerations have been identified and are supported, and where such infrastructure is in accordance with the vision and goals of the OCP.
MI 13	Review fees and charges to fully recover costs of utility operations and maintenance as well as capital replacement through user fees and frontage fees. Explore the feasibility of a utility approach to rain and stormwater management, including incentivizing permeable landscapes.
Municipal Infrastructure, Objective 3	**Natural and engineered forms of green infrastructure are integrated to manage rainwater resources, protect water, and air quality, maintain ecosystem function, provide flood control, and address and adapt to climate impacts.**
MI15	Evaluate opportunity for green infrastructure specifications and best management practices for incorporation into regulatory tools such as Zoning and Subdivision and Development Servicing Bylaws.
MI16	Ensure that rain and stormwater management planning and infrastructure support both watershed health and public safety objectives by: a. Minimizing and mitigating cumulative impacts, working at the watershed scale across jurisdictional boundaries, and avoiding inter-basin transfer of water via the drainage network. b. Designing new rainwater infrastructure to manage flows to pre-development rates including future climate change projections. This includes preventing frequently occurring small rainfall events from becoming surface run-off and ensuring the maintenance of minimum base flows, and in some instances augmented base flows, in water bodies. c. Returning water collected in drainage networks to the natural waterbody it belongs in as close to source as possible.

OCP Section	OCP Clause or Statement
	This includes exploring the opportunity for multiple small outfalls throughout the watershed to maintain adequate stream flow. d. Supporting the integration of rainwater detention, infiltration, and conveyance systems with community or natural amenity space where possible. Promote park and streetscape designs that serve as temporary rainwater detention. e. Mimicking natural ecosystem processes in rainwater system design and construction as much as possible. This includes minimizing runoff, maximizing infiltration, preserving, and protecting the water absorbing capabilities of soil, vegetation, and trees particularly along riparian corridors, and minimizing impervious surfaces on both private and public lands. f. Encouraging the capturing of rainwater and discharging to ground where appropriate on public and private properties, while reducing impact to downslope properties. g. Ensuring stormwater meets applicable BC surface water objectives at the time it is discharged into receiving waterbodies. h. Ensuring that pesticides, herbicides, and other chemicals with harmful water quality impacts are restricted or prohibited across all land uses where municipal authority exists to restrict such substances. i. Applying best practices to land use management to prevent erosion and sedimentation during construction.
Natural Environment, Objective 2	**The K'omoks Estuary is "kept living" and environmental, indigenous, subsistence and recreational values are protected and restored.**
Natural Environment, Objective 3	**Courtenay's air, water and soil are clean**
NE 15	Continue to regulate the use of pesticides on private land and limit the use on public land.
NE16	Limit the extent of impervious surfaces on private and public land.
NE17	Strive to maintain and/or restore the water balance. Consider options to reduce the volume of stormwater runoff through interflow, infiltration, retention, and/or detention.
NE18	Explore the use of enforcement tools to protect water quality related to development practices, such as an erosion and sediment control bylaw.
NE19	Update the Subdivision and Development Servicing Bylaw to incorporate the recommendations of the Integrated Rainwater Management Plan.

Subdivision and Development Bylaw

The City of Courtney Subdivision and Development Servicing Bylaw – Bylaw No. 2919 (May 7, 2018) describes the City's servicing requirements for provision of stormwater management.

Included in this bylaw are:

- Schedule 1 – Supplementary Design Guidelines
- Schedule 2 – Supplementary Construction Specifications
- Schedule 3 – Supplementary Standard Detail Drawings

Schedule 1 - Supplementary Design Guidelines describe the City's current design criteria as the following:

Table 3-3: Current Stormwater Management Design Criteria

Component	Stormwater Design Criteria
Level of Service	Minor Drainage System: 10-year return period design event. Major Drainage System: 100-year return period design event.
Climate Change	Design rainfall intensities have been increased by 15% as indicated in discussion below.
Discharge Rates	All stormwater detention facilities shall be designed to limit post-development peak flows to equal to the corresponding pre-development peak flows for the 1 in 2, 1 in 5, 1 in 10 and 1 in 25 year return period storm events.
Water Quality	Not covered.
Rainwater Management	To the extent possible, the total runoff generated from storms should be minimized through the application of site adaptive planning and the use of source controls.

The design criteria for rainwater management is currently not specific and does not provide a target level of mitigation for development hydrologic impacts other than rate control.

Climate Change in Intensity-Duration-Frequency (IDF) Curves

IDF curves define the rainfall intensities to be used for design of stormwater infrastructure to meet the required level of service for the system. In support of the IRMP work, KWL completed a limited climate change assessment to compare the City's existing IDF curve guidance to the most up-to-date projections available for climate change. IDF curves are created from historical rainfall data, and they represent the probability that a given average rainfall intensity will occur within a given period of time.

In the City's Subdivision and Development Servicing Bylaw 2919 (March 2018), IDF curves are provided for a single climate station, with design storms ranging from 2-year to 100-year, with storm durations that range from 15-minutes to 24-hours. These IDF curves represent the City's most recent guidance, and they include a 15% increase on historical rainfall intensities.

Climate change is an evolving science and as such projections are subject to change with time, science, and updated climate models. KWL completed an independent climate change assessment on the Courtney Puntledge BCHP Environment Canada climate station (ID#1021990), to verify that the design storms in the City's bylaw are consistent with current predictions of climate change impacts to rainfall. This assessment is provided in Appendix J.

Climate Change IDF Curves

The climate change assessment was completed for the 2020-2080 time horizon, for infrastructure intended to have a life span through at least Year 2050.

The median and 95^{th} percentile projected increases were assessed for the 2-year to 100-year design storms (across ranges from 1-hour through 24-hour durations). Based on this assessment, the IDF curves in the City's Subdivision and Development Servicing Bylaw 2919 appear to be consistent with the predicted increases in rainfall for the 2020-2080 time horizon and adequately account for expected climate change to the median level of probability.

Climate Change Risk Consideration

As the medians of the ensemble of GCMs for the SSP5.85 represent a moderate approach under status quo conditions for applying climate change, the median climate change projections represent best practices for estimating the 'most likely' future scenario. However, when there are high risks and consequences (e.g., loss of life) or when assessing the major drainage system without a safe overland flow path, it is appropriate to use the 'worst case' future scenario among the ensemble of GCMs (i.e., 95^{th} percentile).

Recommended IDF Modification for Major System Design Storm

For the City of Courtenay, it is recommended to retain the City's current IDF curves, as documented in the Subdivision and Development Servicing Bylaw, for design of the minor storm system and for all IDF curves for design storms up to 50-year return period events. These curves are consistent with the predicted median (50^{th} percentile) climate projections for the time horizon centering on the year 2050.

It is also recommended that the City adopt an increased IDF curve representing the 95th percentile prediction for climate change for design of the major system at the 100-year return period level of service. The 95th percentile curve would result in an increase of 25-34% in rainfall volume for that design storm, as opposed to the 15% increase in rainfall incorporated in the current IDF curves including the 100-year return period. As major storm infrastructure has higher risk consequences, a more conservative climate change increase is appropriate. See Appendix J for the recommended update to the 100-year return period IDF curve.

Other Bylaws and Policies

Asset Management Bylaw No. 2981, 2019

This bylaw sets out a policy of planning for maintenance and replacement of City assets including utility assets, which would include stormwater management and related systems.

The bylaw also acknowledges that natural assets have value and should be accounted for in terms of the services they provide, recommending that the City "regularly identify new opportunities for achieving Sustainable Service Delivery, including by identifying opportunities for incorporating Natural Assets into the Asset Management Program".

Placement of Fill and Removal of Soil Bylaw No. 2359

This bylaw prohibits placement of fill and soil materials except when performed in accordance with the City's Sediment Control Best Management Practices, included in "Schedule A" of the bylaw.

Tree Protection Bylaw No. 2850

This bylaw prohibits removal of trees in a variety of situations, including any area that is designated as a riparian area by the Riparian Area Regulation or any area designated as an Environmentally Sensitive Area.

3.2. Rainwater Management Targets

A key implementation piece for rainwater management is to set clear targets so that when and where rainwater management facilities are designed and implemented, the City can rely on those systems to provide a minimum level of performance for mitigation of hydrologic impacts development in the catchment.

Rainwater Management Design Criteria - Sources

Table 3-4, below, summarizes the sources of rainwater management criteria used in BC, as well as provides other municipal criteria for comparison.

Table 3-4: Rainwater Management Criteria for Reference

Source/Type	Criteria
2001 DFO Draft Guideline	
Rate Control	Reduce post-development flows to pre-development levels for the: • 6-month hydrograph • 2-year hydrograph • 5-year hydrograph
Volume Control	Retain the 6-month, 24-hour rainfall event or 90% of average annual rainfall.
Water Quality	Collect and treat the 6-month, 24-hour rainfall event or 90% of average annual rainfall.
KWL Calculation Approach	Define the 6-month, 24-hour rainfall event as 72% of the 2-year, 24-hour event.
2002 BC Stormwater Guidebook	
Rate Control	Control the runoff from events that are between 50% of MAR and MAR to pre-development flow rates.
Volume Control	Infiltrate 50% of MAR.
Water Quality	Treat 50% of MAR.
KWL Calculation Approach	Define "50% of MAR" as 50% of 2-year, 24-hour rainfall event.
Note: MAR is noted in the guidebook to be "Mean Annual Rainfall" and equivalent to a storm event with a return period of 2.33 years. As this is not a value that is typically known, various calculation approaches have been used to approximate "MAR" in the application of the guidebook.	
2015 BC Water Sustainability Partnership – Beyond the Guidebook	
Update to 2002 Criteria	50% MAR Volume Reduction criterion as prescribed in the provincial *2002 SW Guidebook* has been superseded in *Beyond the Guidebook, 2007, 2010*. Authors conceded that 50% MAR was to focus attention on 'paradigm-shift' and was not adequately defined at the time. The use of 50% of the 2-year, 24-hour rainfall event for MAR has since become common in application of the Guidebook's principles.
City of Vancouver City-Wide ISMP/Rainwater Management Bulletin	
Rate Control	Control development discharge including Year 2100 climate change to pre-development levels with 2014 rainfall for the 10-year event governing duration.
Volume Control	Capture / infiltrate 24 mm for lots (between 50% and 70% of 6-month, 24-hour rainfall). Capture / infiltrate 48 mm for public spaces including roads.
Water Quality	Treatment of Volume Control amount from all surfaces.

Source/Type	Criteria
City of Nanaimo - MOESS	
Rate Control	Reduce post-development flows to pre-development levels for the: • 6-month hydrograph • 2-year hydrograph • 5-year hydrograph
Volume Control	Retain or infiltrate 50% of 2-year, 24-hour rainfall volume.
Water Quality	Treat 50% of 2-year, 24-hour rainfall volume.
Town of Comox	
Rate Control	Impervious area limit: • 60% residential • 90% non-residential
Volume Control	Roof Leader disconnection required (only applicable for northeast woods area, not the whole of the Town of Comox). 300 mm topsoil required.
Water Quality	Not specified.

Rainwater Management Design Targets for City of Courtenay

The current City Supplementary Design Guidelines for the Stormwater Management cover the following design criteria:

Table 3-5: Current Stormwater Management Design Criteria

Component	Stormwater Design Criteria
Level of Service	Minor Drainage System: Convey 10-year return period design event. Major Drainage System: Convey 100-year return period design event.
Climate Change	Design rainfall intensities have been increased by 15% as indicated in Section 4.4.
Discharge Rates	All stormwater detention facilities shall be designed to limit post-development peak flows to equal to the corresponding pre-development peak flows for the 1 in 2, 1 in 5, 1 in 10 and 1 in 25 year return period storm events.
Water Quality	Not covered.
Rainwater Management	To the extent possible, the total runoff generated from storms should be minimized through the application of site adaptive planning and the use of source controls.

The design criteria for rainwater management is currently not specific and does not provide a target level of mitigation for development hydrologic impacts other than rate control.

For consideration, the range of potential rainwater management targets for City of Courtenay are shown below in Table 3-6, for comparison of the amounts of water required to be managed to meet the different criteria.

The target values are calculated based on the IDF information provided in the City's Subdivision and Development Servicing Bylaw.

Table 3-6: Potential Rainwater Management Targets for City of Courtenay

Target Description	Quantity (mm rain/24 hrs)
DFO Criteria	
Volume Control and Water Quality	60 mm
BC Stormwater Guidebook Criteria	
Volume Control and Water Quality	42 mm
Minimum value ("first flush") approach (US EPA origin)	
Water Quality (may be used for Volume Control)	24 mm

As the City's goals for this IRMP are intended to bring City rainwater management implementation in line with the BC Guidebook, **it is recommended that the City adopt and implement rainwater management criteria based on the Guidebook approach**.

This level of performance target is consistent with those adopted in IRMPs and ISMPs in many municipalities in BC, including the City of Nanaimo as shown in Table 3-4. This approach will provide mitigation for new development to an acceptable level to minimize impacts of new and re-development. It is often challenging to meet rainwater performance criteria on-lot in urban areas where space is constrained and a moderate target such as this provides a high level of mitigation with a moderate burden on development and development design compared to adoption of the highest target value. Additional overall benefit to the watershed health of the receiving water systems is expected to be provided by retrofit projects, public realm projects, and environmental enhancement opportunities.

3.3. Review of Rainwater Source Control Projects

As part of KWL's work on Phase 3 of the City of Courtenay IRMP, KWL reviewed as-built record drawings for five (5) installed stormwater source control projects in the City of Courtenay. These projects serve various functions, and each are assessed in the context of the goals of the IRMP, including to mitigate the effects of development on the receiving waters at the outfalls of the City's storm drainage system, and to protect the environmental values of the City's watersheds from the hydrologic impacts of development.

For each of the reviewed projects, KWL reviewed the functionality of the provided design and, where applicable, made recommendations for improving the performance of similar types of projects.

The project reviews consisted of the following locations and facilities:

- 5th Street Complete Street Rain Gardens.
- Buckstone Investments Subdivision for The Ridge Phase 1.
- Courtenay Seniors Village Retirement Centre is at the corner of Headquarters Road and Dingwall Road.
- Malahat Park Storm Pond near Marble Place Subdivision.
- North Courtenay Commercial Development.

Recommendations on Project Designs

Some of the recommendations on the project designs that were reviewed include the following:

1. Rain garden overflow outlets should be located as far as possible from runoff inlets to maximize residence time and treatment within the rain garden. The curb cut inlets should not lead directly to any storm system inlet.
2. The lawn basin outlets for rain gardens should be raised above the rain garden surface so that ponding and infiltration through the growing media occurs before overflow to the storm drain system.
3. There should be a depth of ponding available above the surface of the growing medium for water to pond in the rain garden before water backs up into the street. The surface of the rain garden area should be lower than the street to allow ponding.
4. The potential for water quality improvement for stormwater ponds would be increased if outlets are placed as far away from the inlets as possible, to lengthen the hydraulic residence time of the incoming flows.
5. Additional design features for ponds could be considered to improve treatment potential, such as incorporating a sediment forebay for ease of cleanout, or an island or berm and baffles to lengthen the flow path from the inlets to the outlets.

Recommendations to Improve Performance of Future Projects

As a result of the review, policy, and operational approaches to improve the implementation and performance of rainwater management facilities were identified. These are:

1. Clarify performance targets for rainwater management relative to goals for capture and treatment:
    a. Capture and infiltrate a given amount of rainfall in 24 hours (42 mm recommended – see section 7.1).
    b. Treat a given amount of rainfall in 24 hours (42 mm recommended – see section 7.1) for water quality improvements; treatment must obtain a minimum 80% removal of inflow sediment on a mass basis.
2. Develop guidance or standards for rainwater management system implementation to support design of systems that provide the desired level of performance, including such guidance as:
    a. State that green infrastructure/source controls for management of road runoff should provide treatment of runoff in addition to capture.
    b. State that rain gardens should be designed to provide ponding up to an acceptable limit (typically 100 to 200 mm) in order to maximize infiltration capture, with raised outlets for overflow above that ponding limit.
    c. Note that the locations of overflow outlets should be located as far as is practical from the inlets.
    d. Note that ponds and rain gardens that treat road runoff should incorporate pre-treatment for management of coarse sediment, considering ease of access and use of existing municipal equipment.
3. If not already a requirement, require that drawings be accompanied by a basis of design memorandum that describes the targets that the system is designed for, and the methods and calculations that show how the design meets those targets.

Further details of the review may be found in Appendix A.

3.4. Stormwater System Catchment Area Performance

To monitor and track changes in the stormwater system catchment areas, the City needs an understanding of the current rainwater management performance of the lands within the City boundary, This information sets an initial baseline for understanding future changes, and to prioritize areas where there is the most opportunity for improvement in rainwater management.

As noted above, the most relevant hydrology metric is effective impermeable area (EIA), but at this time there is no clear way of determining EIA for individual catchments or for the City as a whole as the EIA is itself derived from the overall existing hydrologic performance of the system. Therefore, this IRMP looks at some of the components of EIA, based on available data, to develop an initial understanding of rainwater performance in the City's catchments.

As discussed in the BC Stormwater Guidebook, the keys to sustainable management of runoff include:

***1. Rainfall Capture* (Volume Control)**

The key to runoff volume reduction and water quality improvement is capturing the small storm runoff from rooftops and paved surfaces. This captured rainfall should be infiltrated, evapotranspired, and/or re-used at the source. Rainfall capture can be provided at the source with source control facilities.

***2. Runoff Control* (Rate Control)**

The runoff resulting from the larger storm events causes the most significant peak flows in downstream watercourses. Runoff peak flow rates see significant increase along with impervious cover within the watershed.

The performance of stormwater catchments within the City of Courtenay, were analyzed with respect to both volume and rate control (see Appendix B for assessment).

These assessments are based on the methodologies and data available and evaluate different sets of catchments, therefore the results indicate the relative performance of stormwater catchments across areas of the City. The assessment of stormwater volume and rate control indicate areas of the City where there is a need for improvement in rainwater management within the catchment areas. The results of both assessments were utilized in determining which areas of the City should be prioritized for rainwater management. The priority areas for improvement in rainwater management performance are shown in Figure 3-1.

In addition to the catchment performance assessment, additional considerations in prioritization included:

- The prioritization focuses on areas where implementation of rainwater source controls would provide improvement in the volume of water that is discharged to and impacts the receiving water.
- Areas draining directly or mainly to the Courtenay River estuary were not prioritized for rainwater management as the estuary is essentially part of the ocean and is not sensitive to the volume of water that drains into it via the storm system. Note that water quality is still extremely important for these catchments.

- Areas that drain to small creeks, as opposed to rivers, and were indicated to have room for improvement in rainwater management, were prioritized as smaller creeks are typically more sensitive to changes in runoff volume than larger streams.

Areas that are prioritized for rainwater management should be prioritized for pilot and public realm projects that focus on infiltration of runoff from existing impervious areas, such as roads, parking areas, and roofs. At this time, specific capital projects for the public realm are not identified. The City should use this prioritization to develop projects when opportunities are available due to funding, utility upgrades or other projects that can be combined, or public building or facility development or upgrades. A strategy could be developed to identify areas where opportunities for green infrastructure in the public realm would provide the most benefit and are the most feasible, to create a wish-list of projects to develop when those funding and co-development opportunities arise, but at this time such as strategy has not been developed.

3.5. Rainwater Management Strategy Findings

In summary, the work toward a rainwater management strategy found the following:

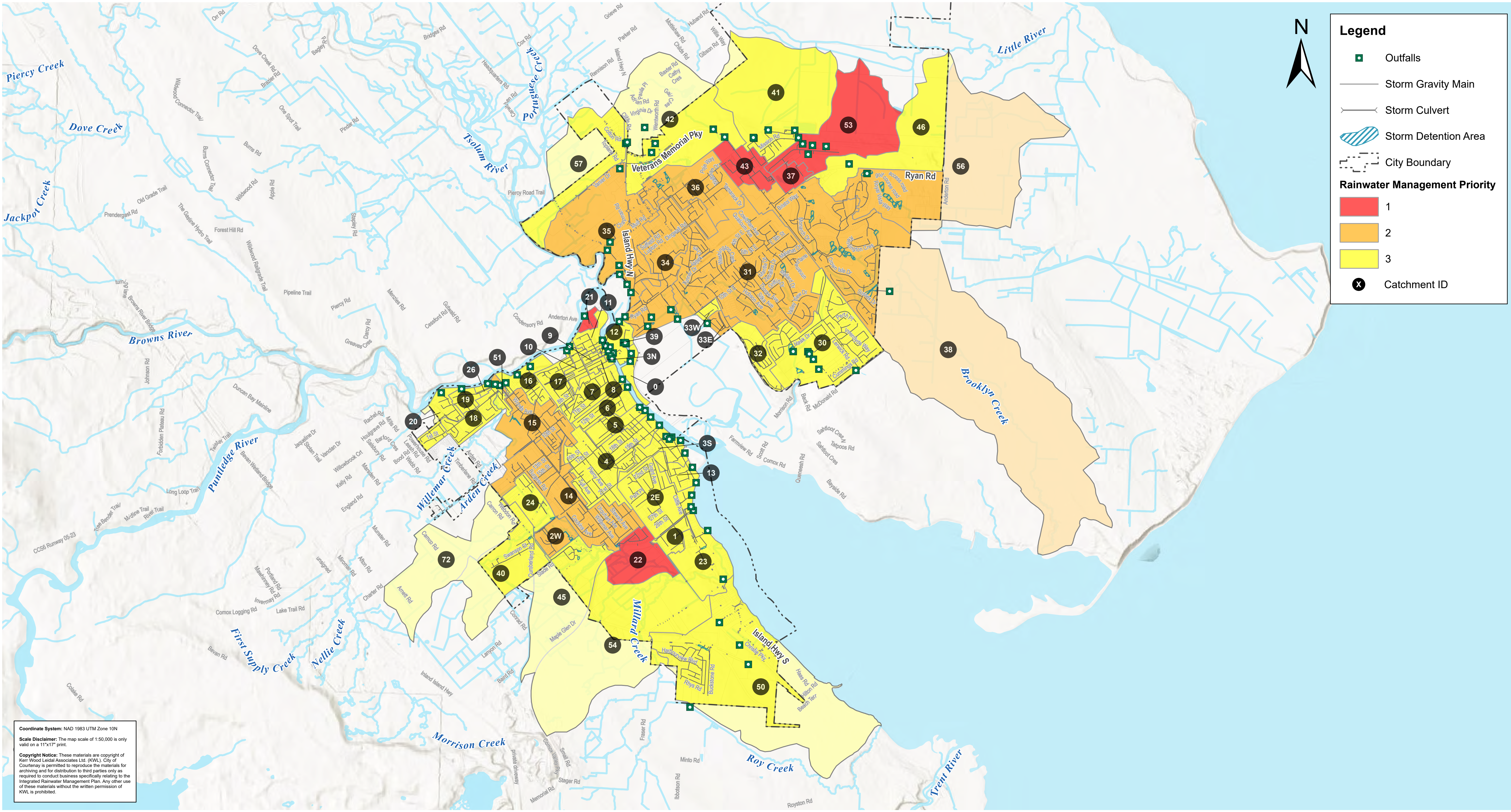
1. The City needs to adopt and implement clear rainwater management criteria for volume capture and water quality treatment.
2. The City should develop and implement guidance or standards for design of rainwater management BMPs to meet the City's criteria and provide a consistent level of performance.
3. Develop public rainwater management projects in existing developed areas to increase infiltration. Prioritize catchments identified to be a rainwater management priority as shown in Figure 3-1: Priority Catchments for Improving Rainwater Management.

The recommendations for updates to policies and bylaws that are based on the rainwater management strategy work are found in Chapter 7.

City of Courtenay

Integrated Rainwater Management Plan - Phase 3

KERR WOOD LEIDAL
consulting engineers



Project No. 2980-014

Date February 2023

Scale 1:50,000

0 0.25 0.5 1 (km)

Catchment Rainwater Performance
Priority Catchments for Improving Rainwater Management

Figure 3-1

4. Environmental Impacts of Stormwater

4.1. Impacts of Development and Changes to Hydrology

As discussed in Section 2, the provincial guideline "2002 Stormwater Planning: A Guidebook for British Columbia", describes objectives for protecting watershed health in the urban environment, including biophysical objectives in addition to the hydrologic objectives:

Biophysical Objectives

- Objective 7 - Limit impervious area to less than 10% of total watershed area.
- Objective 8 - Retain 65% forest cover across the watershed.
- Objective 9 - Preserve a 30-metre-wide intact riparian corridor along all streamside areas.
- Objective 10 - Maintain B-IBI (Benthic Index of Biological Integrity) score above 30.

These biophysical objectives are tied to the identified links (see Section 3) between development (represented by impervious area) in a watershed and the health of the receiving watercourse.

4.2. Environmental Assessment – Key Results

The Phase 2 IRMP work included environmental assessment of the receiving creeks and rivers in the City of Courtenay. Some of the key results are shown here.

Fish Accessibility

Fish presence was assessed as the percentage of each stream or river, within the City boundaries, that was considered accessible to migrating fish species. Note that this does not represent confirmed fish presence but indicates the prevalence of barriers to fish.

TABLE 10: FISH PRESENCE IN URBAN STREAMS

WATERCOURSE	TOTAL LENGTH (M) BASED ON SENSITIVE HABITAT ATLAS	CONFIRMED FISH PRESENCE LENGTH (M)	PERCENT FISH BEARING (%)
Brooklyn Creek	5,680	0	0
Courtenay River	7,222	7,222	100
Glen Urquhart Creek	7,247	4,047	56
Little River	16,593	13,705	83
Millard-Piercy Creek	24,983	22,832	91
Morrison Creek	5,533	4,825	87
Portuguese Creek	7,394	866	12
Puntledge River	3,271	3,271	100
Tsolum River	5,146	3,485	68

Excerpt 4-1: Table 10 – Fish Presence in Urban Streams (Phase 2 IRMP Report)

Watershed and Riparian Corridor Impervious Cover

The evaluation of the riparian corridor in Phase 2 of the IRMP reviewed a 30 m riparian corridor along each watercourse within the City of Courtenay to understand the level of development impact on the riparian corridors within the City. An excerpt from the Phase 2 report (Table 9, below) summarizes the findings on the riparian corridor assessment.

TABLE 9: IMPERVIOUS AREA COVER WITHIN CITY WATERSHEDS

WATERSHED	WATERSHED AREA		RIPARIAN CORRIDOR	
	Area Within City of Courtenay (ha)	Percent Total Impervious Area (%)	Area Within City of Courtenay (ha)	Percent Total Impervious (%)
Brooklyn Creek	162	51	29	52
Courtenay River	836	39	37	24
Glen Urquhart Creek	568	44	43	24
Little River	646	11	93	3
Millard-Piercy Creek	476	8	126	14
Morrison Creek	135	34	27	12
Portuguese Creek	230	26	40	13
Puntledge River	227	37	16	12
Tsolum River	353	25	26	20
City of Courtenay (overall)	3,376	30	437	16

Excerpt 4-2: Table 9 – Impervious Area Cover Within City Watersheds (Phase 2 IRMP Report)

Benthic Invertebrate Sampling and Watercourse Classification

The Phase 2 work also included sampling of stream sediments in the watercourses and lab analysis of the sediments to understand the abundance and diversity of the community of benthic invertebrate insects that live in the stream sediments. The benthic invertebrates are considered indicators of the health of the stream ecosystem, with higher abundance and diversity indicating a healthier system. The analysis of the benthic invertebrates provides a score on the benthic index of biological integrity (B-IBI), which is linked to a level of stream condition or watershed health. Six of the City's watercourses were sampled for determination of a B-IBI metric.

TABLE 11: STREAM CONDITION CLASSIFICATION BASED ON B-IBI SCORE

10 METRIC B-IBI SCORE	STREAM CONDITION
46-50	Excellent
38-44	Good
28-36	Fair
18-26	Poor
10-16	Very Poor

Excerpt 4-3: Table 11 – Stream Condition Classification Based on B-IBI Score (Phase2 IRMP)

TABLE 12: BENTHIC INDEX OF BIOTIC INTEGRITY SCORES

WATERCOURSE	B-IBI SCORE	STREAM CONDITION
Brooklyn Creek	16	Very Poor
Courtenay River	12	Very Poor
Glen Urguhart Creek	20	Poor
Little River	n/a	n/a
Millard Piercy Creek	na	n/a
Morrison Creek	18	Poor
Portuguese Creek	14	Very Poor
Puntledge River	18	Poor
Tsolum River	n/a	n/a

Excerpt 4-4: Table 12 – Benthic Index of Biotic Integrity Scores (Phase 2 IRMP Report)

As noted in the Phase 2 report, "These results generally align with the results of the impervious area analysis and water quality analysis and are reflective of typical watersheds that have experienced significant development."

4.3. Water Quality Assessment

Desktop and field studies were combined to evaluate environmental concerns associated with stormwater in the City. The desktop study involved a review of existing water quality data to identify potential water quality issues and knowledge gaps, as well as mapping of land use to investigate potential nonpoint pollutant sources. Outcomes from the desktop studies were used to develop a plan for additional sampling and monitoring to fill some of the knowledge gaps and get a better understanding of potential water quality issues in the City.

Desktop Study

Water quality monitoring was previously performed as part of Phase 2 of the City's Integrated Rainwater Management Plan (IRMP) [1]. Data was collected from stormwater flows prior to flows discharging into receiving waters. The program included:

- Summer and winter sampling to capture low and high flow conditions.
- Sampling at six stormwater discharge sites, one in each of the catchments Piercy Creek, Courtenay River, Morrison Creek, Puntledge River, Glen Urquhart Creek, and Brooklyn Creek (Figure 1 of Phase 2 report).

[1] City of Courtenay (2020). Integrated Rainwater Management Plan: Phase 2 Report and Recommendations to Guide Next Steps.

- Collection of *in situ* data from the stormwater including pH, specific conductivity, temperature, dissolved oxygen, and turbidity, and analyzed water samples in the lab for nitrate, bacteria, and the metals cadmium, copper, iron, lead, and zinc.

Baseline water quality monitoring for the Tsolum River and its tributary Portuguese Creek was performed in 2019 for the B.C. Ministry of Environment and Climate Change Strategy (ENV) [2]. Data were analyzed to determine potential impacts associated with agricultural activity. The study concluded that water quality is generally good in the lower Tsolum River and poor in Portuguese Creek, where almost 40% of the land use is for agricultural purposes.

Stormwater quality and ambient water quality is often correlated to land use. Certain activities are known to increase pollutants loads, such as metals from traffic and bacteria from agricultural land use. Land uses within City boundaries were mapped as part of the IRMP Phase 2 Report.

2021 Monitoring Program

Additional monitoring was completed as part of Phase 3 work and as follow-up on the Phase 2 sampling work. KWL recommended a limited program for supplementary monitoring of water quality in major watercourses in the City. The objective of the additional monitoring was to get a better understanding of water quality in watercourses receiving stormwater discharges from the City, and to investigate whether City discharges may negatively impact ambient water quality.

Monitored watercourses include:

- Tsolum River
- Puntledge River
- Morrison Creek
- Courtenay River
- Piercy Creek
- Glen Urquhart Creek
- Mallard Creek

[2] Montgomery-Stinson, T. and A. Furness. 2020. Summary of Baseline Water Quality Monitoring in Agricultural Areas of the Comox Valley. Environmental Quality Series. Prov. B.C., Victoria B.C. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/monitoring-water-quality/west-coast-wq-docs/comox_agricultural_area_water_quality_monitoring.pdf

Monitored water quality parameters for 2021 work include the following:

Table 4-1: Monitored Water Quality Parameters

In situ measurements	Laboratory analysis
pH	Nitrogen as Nitrate
Water temperature	*E. coli*
Conductivity	Fecal Coliforms
Dissolved oxygen (DO)	Total cadmium
Turbidity	Total copper
	Total iron
	Total lead
	Total zinc

Water Quality Assessment Guidelines

Collected water quality data have been evaluated according to the system proposed in the Metro Vancouver Monitoring and Adaptive Management Framework (MAMF), which was developed based on Provincial water quality guidelines and in consultation with the Province. The MAMF water quality assessment approach was developed to provide a simplified system to help municipalities identify where water quality conditions are good and where concerns exist. Water quality is interpreted as follows:

- **Good Priority Indicator:** Suggests that water quality for this parameter is good. No further monitoring for this parameter is required in the drainage system for 5 years and no adaptive management is required.
- **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.
- **Need Attention Priority Indicator:** Suggests that water quality is in non-attainment with Provincial Water Quality guidelines.

Priority Areas for Adaptive Management for Water Quality

Based on the water quality results, priority areas are identified where mitigations are warranted to improve watershed health. Priority is given to areas with relatively higher exceedances of water quality objectives. Based on performed water quality monitoring (see Figure 5-2), watersheds in the City were categorized into areas of higher and lower priority for adaptive management of water quality, Table 4-2 summarizes the watersheds that are considered higher priority for water quality mitigation. This information should be used in conjunction with the results of the catchment study (see Section 3.4), when considering projects to improve rainwater management in existing developed areas by implementation of projects in the public realm.

Projects such as road-side rain gardens, that can have a substantial benefit for water quality improvement, should be implemented in the areas that are highlighted for water quality mitigation. Upstream agricultural runoff is thought to play a role in water quality issues identified within the City; it is recommended that the City work with the Comox Valley Regional District and/or the province to engage with agricultural operators to improve runoff water quality.

Table 4-2: Prioritization of Watersheds for Adaptive Management Based on Observed Water Quality

Watershed	Rationale
Higher Priority	
Morrison Creek	Stormwater: • Exceedances of the AMF 'need attention' level for conductivity, turbidity, and bacteria. • Exceedances of the AMF 'satisfactory' level for several of the metals. Receiving Water: • Exceedances of the AMF 'satisfactory' level for conductivity, turbidity, bacteria, and several metals.
Piercy Creek	Stormwater: • Exceedances of the AMF 'need attention' level for zinc and fecal coliforms. • Exceedances of the AMF 'satisfactory' level for conductivity, *E. coli* and metals. Receiving Water: • Bacteria levels vary between the 'good' and 'need attention' threshold. • Exceedances of the AMF 'satisfactory' level for conductivity, turbidity, and several metals.
Courtenay River	Stormwater: • Exceedances of the AMF 'need attention' level for conductivity, bacteria, and iron. • Exceedances of the AMF 'satisfactory' level for copper and zinc. Receiving water: • Adequate water quality.
Puntledge River	Stormwater: • Exceedances of the AMF 'need attention' level for conductivity and bacteria. • Exceedances of the AMF 'satisfactory' level for copper, iron, and zinc. Receiving Water: • Adequate water quality.

Appendix C provides further details of the water quality assessment.

4.4. Water Quality Improvement Options

Contaminants in stormwater may come from a variety of sources, which are divided into the categories of “point source” and “nonpoint source” pollutants. Point source contaminant sources are those that can be attributed to specific locations, for example industrial sites, construction sites, or sewer cross-connections where sanitary sewer services are erroneously connected to the storm sewer. Nonpoint sources are those that are distributed over an area and are widespread, such as roads and roofs. Point and nonpoint source pollution can be controlled through pollution prevention actions and operational measures, as well as best management practices including both source controls and end-of-pipe facilities.

Note that many common pollutants in stormwater naturally adsorb to sediment particles, and because of this water quality targets are often focused on removal of total suspended solids (TSS) as a means of removing a wide array of pollutants.

Options for improving water quality in stormwater and therefore in the receiving watercourses are discussed below.

Pollution Prevention

Non-structural measures to prevent or reduce bacteria, metals and other common pollutants in urban stormwater include for example:

- Pet waste control.
- Bird and mammal control.
- Garden, lawn, and park maintenance to reduce nutrient and sediment discharges.
- Street sweeping.
- Storm and sanitary system maintenance.
- Conscientious vehicle washing maintenance to reduce pollutant discharges.
- Avoid construction materials, particularly galvanized metals, which may leach zinc.

Several non-structural measures to prevent stormwater pollution would need involvement from the public, including pet waste control, garden and lawn maintenance, proper vehicle maintenance, septic field maintenance, and water-wise material choices for outdoor applications. Such measures may be promoted through City-administered public education and outreach programs.

Pollution Control – Source Control and End-of-Pipe Practices

Stormwater source controls are commonly recommended for stormwater management to maintain and improve watershed health. They are designed to prevent or mitigate the impacts of stormwater at or near its source by using engineered infrastructure or natural features to reduce stormwater volumes and rates as well as improve its quality. Examples of source controls include:

- Absorbent landscape: Designed to increase infiltration, filtration, and evapotranspiration of rainfall and runoff by using leafy greens and soils with high infiltration capacity.
- Bioretention: Captures, infiltrates, and treats runoff from impervious surfaces by using the natural properties of soil and vegetation. Bioretention practices are commonly designed as shallow depressions with engineered soils and resilient vegetation that can tolerate both wet and dry conditions. Bioretention practices include rain gardens, bioswales, bioretention cells and planters, and tree trenches.
- Permeable pavement: Allows stormwater to drain through the surface and infiltrate into the subsoil, which reduces runoff volumes and improve water quality. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and grass-filled pavers made of concrete or polymer. Generally, permeable pavements are used on surfaces with low traffic volumes, such as walkways, plazas, driveways, and parking areas.
- Infiltration practices: Provide storage and infiltration of stormwater in infiltration beds of varying types. Infiltration practices reduce stormwater volumes, provide pollutant removal through soil filtration, and help recharge groundwater. Dry wells, infiltration trenches, and sumps are underground excavations with level or gently sloping bottom grade that are filled with clean stone or other void-forming structures for temporary storage of water before infiltration into the underlying soil. Infiltration chambers and perforated pipes can generally support vehicular loading and can be placed under parking or landscaped areas to maximize land use. For proper long term function of infiltration practices, pretreatment to remove sediment is required.
- Green roofs: Roofs with growing media and vegetation that enable filtration and evapotranspiration of rainwater and help reduce stormwater peak flows and volume. Intensive green roofs with thick layers of soil are more effective for water storage than extensive roofs with thinner layers of soil or fibre/felt matting.

Source controls have the potential to improve watershed health and are generally more cost-effective than end-of-pipe measures because they are more distributed and smaller-scale. Structural end-of-pipe practices, for example ponds and wetlands, may be employed to treat the residual stormwater impacts that cannot be controlled at the source.

Oil-water and oil-grit separators are structural treatment practices that may be used as source controls when installed on-lot, or as end-of-pipe practices when installed in or at the ends of the storm sewer system.

Source controls with soils and vegetation generally employ several different processes to reduce pollutant loads, for example ponding, which leads to settling of solids and particle-bound pollutants as well as volatilization petroleum hydrocarbons; filtration through soil; plant uptake; microbial degradation; and sorption to soil particles. Preferred control measures to reduce bacteria and metals in stormwater include source controls such as bioretention, sand filters, permeable pavement, infiltration basins or trenches, and tree trenches. End-of-pipe solutions based on particle settling and filtration through vegetation for pollutant removal, e.g., retention ponds and wetlands, are also efficient for reducing bacteria and total metal concentrations in stormwater but are not effective for removing dissolved pollutants.

All source control, structural and end-of-pipe practices require maintenance to perform as designed for the intended lifespan of the system. While the City can implement maintenance procedures for facilities in the public realm, the facilities that are located on private land and privately operated are also privately maintained. It has been raised that there is no way of knowing or tracking whether needed maintenance is routinely completed for privately owned facilities.

Table 4-3 summarizes how well-suited source controls and end-of-pipe practices are for various types of land use.

4.5. Environmental Impacts of Stormwater Findings

In summary, the findings of the work defining the environmental impacts of stormwater in the City of Courtenay include the following:

1. The environmental assessments show impacts of development on the health and quality of the receiving watercourses in the City.
2. Implement riparian planting and restoration, along the watercourses, with focus on those identified as having more impervious cover in the riparian corridor within the City as noted in Excerpt 5-2. This work would likely be organized or led by the City Parks Department but could incorporate work with volunteer environmental stewardship organizations as a way to connect with, educate, and involve the public.
3. In planning for infrastructure work, particularly culvert upgrades, consideration for replacement should be given to those culverts that are identified as fish barriers, which prevent use of upstream portions of the watercourse by migratory fish in particular.

4. Where opportunities arise to implement public rainwater management projects that provide water quality treatment of pollutant sources such as roads, the City should prioritize these projects in the identified watersheds of priority for water quality improvement in Table 5-3.
5. A system to locate and track all oil-grit separators across the City, including tracking of maintenance of the systems would improve understanding of the extent of implementation and the benefit of these measures for water quality improvement over time.
6. A system to locate and track rainwater management facilities across the City would improve understanding of the extent of implementation and help understand where water quality mitigations are in place relative to the areas where water quality concerns have been identified.

Table 4-3: Suitability and Potential Use of Source Control and End-of-Pipe Stormwater Management Practices for Different Land Uses

Table 4-3. Suitability and potential use of source control and end-of-pipe stormwater management practices for different land uses

Land Use Type	Absorbent Landscape	Bioretention	Permeable Pavement	Infiltration Practices	Green Roofs	End-of-Pipe Practices
Dense Urban	Limited to certain land uses, e.g., institutional and parks	Potential for bioretention practices with small footprints, e.g., tree trenches and stormwater planters along streets, greenways, and bike lanes, as well as bioswales and bioretention cells installed as parking lot islands, median strips, and traffic islands	Can be used on sidewalks and walkways, bike lanes, parking lanes and lots, laneways, plazas, etc.	Potential for underground infiltration chambers and perforated pipes to manage roof, walkway, parking lot and road runoff; can be installed underneath parking or landscaped areas such as lawns and planting beds to maximize land use	Well suited for dense urban environments, e.g., office, retail, and institutional buildings as well as multi-unit residential buildings	Limited potential
Commercial and Light Industrial	Limited potential	Potential for bioswales and bioretention cells installed as parking lot islands and medians as well as along roads; Limited potential for rain gardens to manage roof runoff	Can be used on sidewalks, parking areas and driveways; however, should not be applied at stormwater pollution "hot spots" such as recycling facilities, industrial storage and loading facilities, works yards, and vehicle service and maintenance areas	Potential for underground infiltration chambers installed underneath e.g., parking areas; should not be applied at stormwater pollution "hot spots"	Well suited for many retail, office, and light industrial buildings	Limited potential
Residential Urban	Limited potential to retrofit gutters, downspouts, driveways to discharge onto grassy areas	Potential for bioswales and bioretention cells installed in traffic calming bulges/curb extensions, along greenways, bike lanes, local streets, and parks; Limited potential for rain gardens to manage roof runoff	Can be used on sidewalks, bike lanes, parking lanes and lots, laneways, and low traffic streets	Potential for underground infiltration chambers installed underneath landscaped areas or pathways	Well suited for institutional and multi-unit residential buildings	Some potential for e.g., detention basins, ponds, and wetlands in large public spaces such as parks
Suburban	Large potential to retrofit gutters, downspouts, driveways, patios, etc. to discharge onto grassy areas and use leafy greens to enhance interception	Potential for bioswales and bioretention cells installed in traffic calming bulges/curb extensions, along greenways, bike lanes, local streets, and parks; Large potential for rain gardens to manage roof and driveway runoff	Can be used on sidewalks, bike lanes, and low traffic streets; Large potential for permeable pavement on driveways	Large potential for dry wells and other types of soakaways to manage roof and walkway runoff on individual lots; Infiltration trenches are useful in narrow strips of land between buildings or properties, or along road rights-of-way; Underground infiltration chambers and perforated pipes can be used e.g., in laneways	Absorbent landscape can replace the need for green roofs	Some potential for e.g., detention basins, ponds, and wetlands in large public spaces such as parks
Rural	Large potential to retrofit gutters, downspouts, driveways, patios, etc. to discharge onto grassy areas and use leafy greens to enhance interception	Large potential for bioswales along roads and many types of bioretention on individual lots	Can be used on driveways, sidewalks and low traffic roads	Large potential for soakaways and infiltration trenches on individual lots	Absorbent landscape can replace the need for green roofs	Large potential for ponds and wetlands

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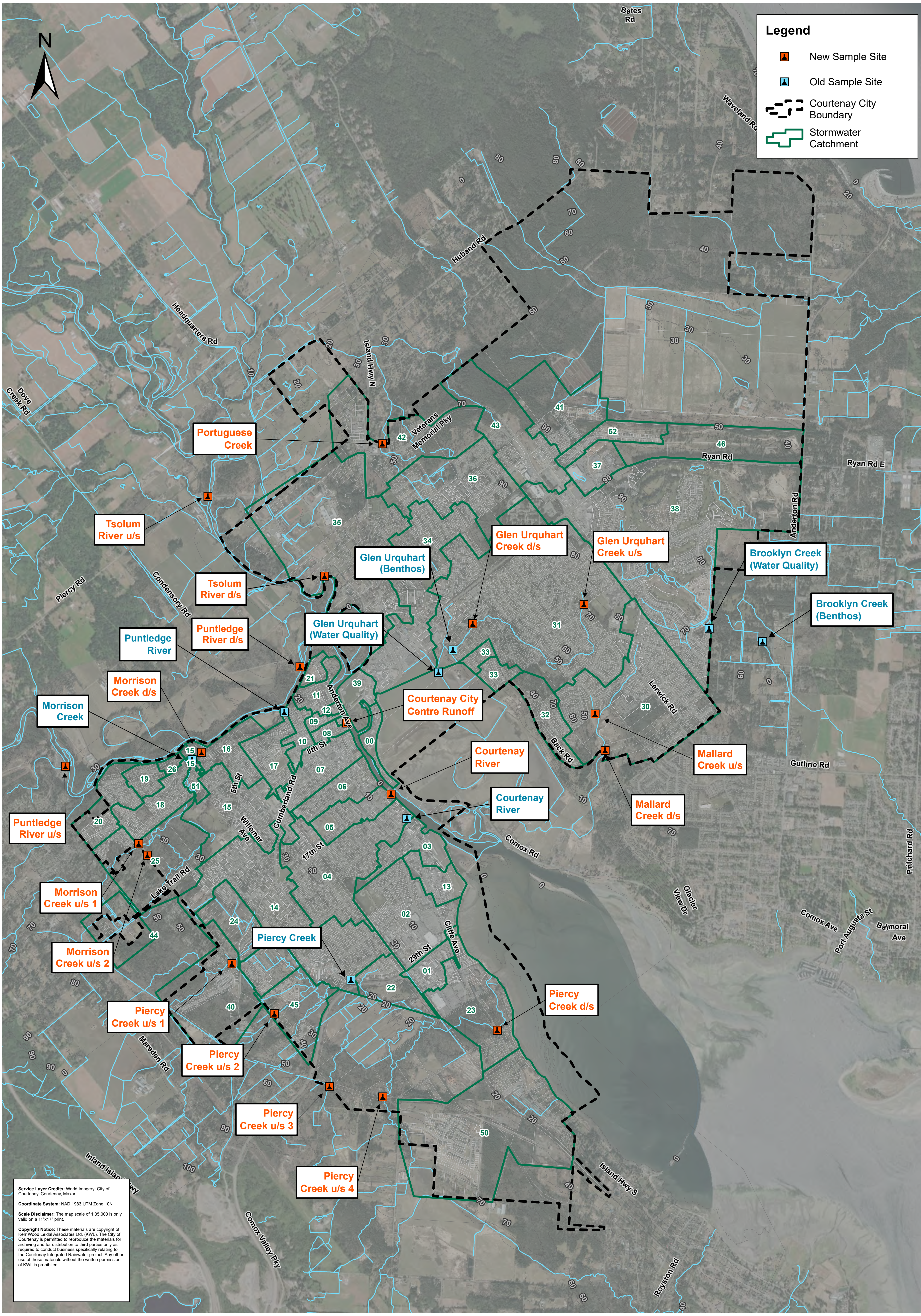
City of Courtenay

Courtenay Integrated Rainwater

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: City of Courtenay, Courtenay, Maxar

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:35,000 is only valid on a 11"x17" print.

Project No. 2980-014

Date December 2021

Scale 1:35,000

0 250 500 1,000 Metres

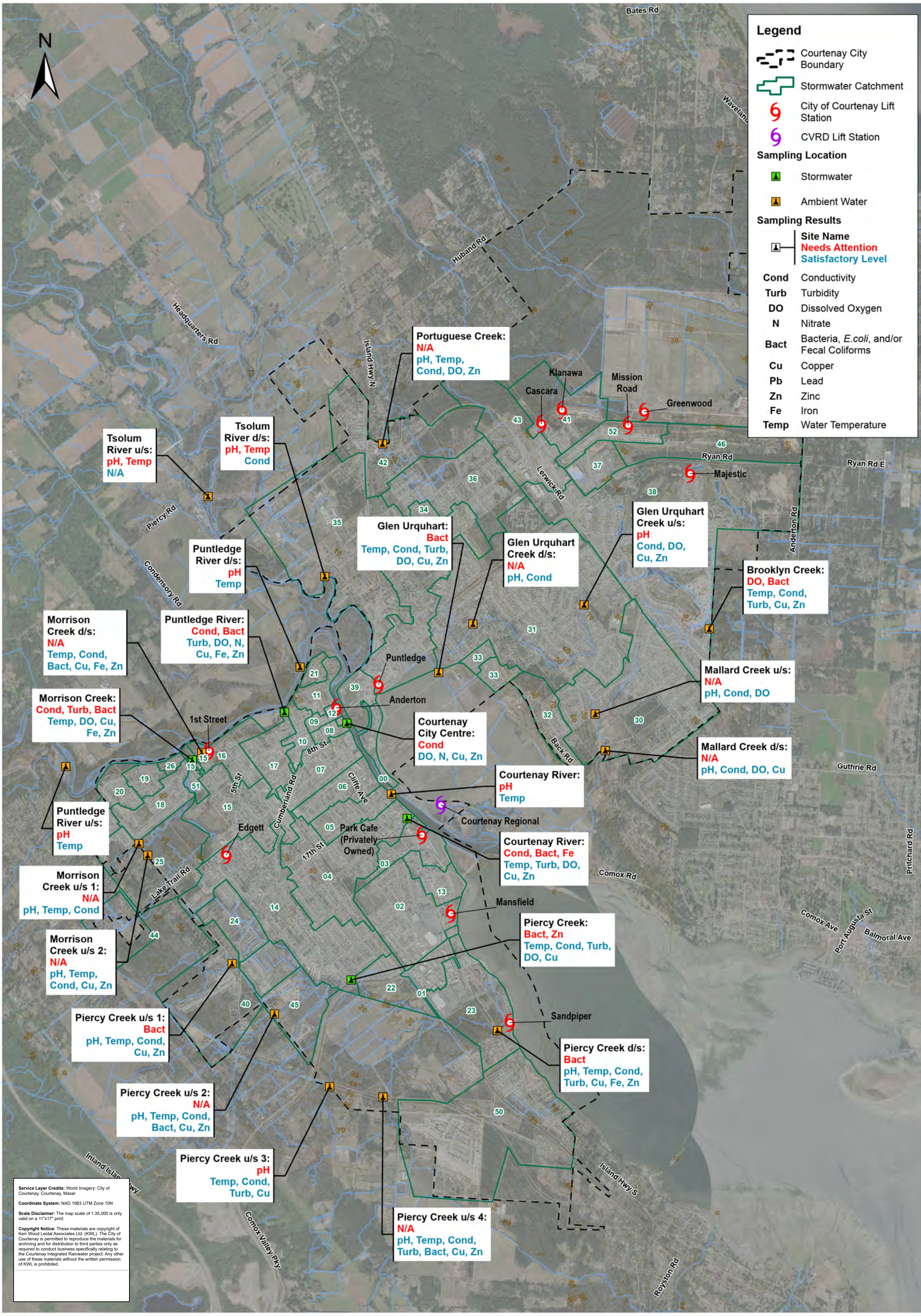
New and Old Sampling Locations

Figure 4-1

City of Courtenay

Courtenay Integrated Rainwater

KERR WOOD LEIDAL
consulting engineers



Project No.	2980-014
Date	June 2022
Scale	1:35,000

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Stormwater and Ambient Water Sampling Locations with Sanitary Lift Stations

Figure 4-2

5. Stormwater Capital Plan

5.1. Background Review

The available background data, reports and GIS layers provided by the City were reviewed and are listed in Appendix D.

The review of existing conditions and data included an initial summary of the watershed characteristics and a review of existing bylaws and criteria to manage stormwater and drainage. Key drainage issues and environmental concerns were obtained from background documents and initial stakeholder input. These pertained to undersized drainage infrastructure, impacts of recent and future development and the need for protection of fisheries and other environmental values. These issues were reviewed and considered during the work on the IRMP.

Existing Bylaws and Criteria

Criteria to manage stormwater and drainage within the City were collected from the following major sources and are summarized in Table 5-1:

- City of Courtenay Subdivision and Development Servicing Bylaw No. 2919 – 2018
- City of Courtenay Official Community Plan Bylaw No. 3070 – 2022

Table 5-1: Summary of Existing Stormwater Criteria

Application	Criteria/Methodology
Conveyance	
Minor Drainage System	Consists of pipes, gutters, catch basins, driveway culverts, open channels, watercourses, and stormwater management “best management practices” (BMPs) designed to capture, convey, treat, or modify flows up to and including the 10-year return period storm event.
Major Drainage System	Consists of surface flow paths, roadway culverts, watercourses, and stormwater management facilities designed to capture, convey, treat or modify larger flows up to and including the 100-year return period storm event. If required to accommodate low building elevations, and if approved, a piped minor system may be enlarged or supplemented to accommodate major flows.

Application	Criteria/Methodology
Stormwater Management – Rate Control	
Detention Release Rates	All stormwater detention facilities shall be designed to limit post-development peak flows to equal to the corresponding pre-development peak flows for the 2-, 5-, 10-, and 25-year return period storm events. Overland escape routes must be provided to account for greater storms up to 100-year return period in a manner which does not result in flooding of any properties. The total volume of runoff generated during storms can also have a significant impact on receiving watercourses. To the extent possible, the total runoff generated from storms should be minimized through the application of site adaptive planning and the use of source controls. Site adaptive planning focuses on limiting total imperviousness at development sites and preserving natural features such as wetlands, forests, and native soils. Source controls focus on reducing volume by retaining or enhancing opportunities for infiltration and evapotranspiration on development sites. Discharge shall be controlled such that the downstream watercourses receiving outflow from detention facilities are protected from surcharge and erosion. Where stability cannot be maintained, measures to avoid or mitigate erosion shall be proposed.

Field Drainage Inventory

The desktop review of existing data and documents was followed by a KWL field survey of data gaps in the drainage features and infrastructure information.

All surveyed storm sewers, storm manholes, culverts and storm detention ponds/facilities can be seen on Figure E-1 in Appendix E. A total of 12 individual culverts, 8 storm sewer pipes, and 6 storm manholes were surveyed. In addition, 6 stormwater ponds were surveyed within the Crown Isle Resort and Golf Community development, and 1 storm detention pond was surveyed located on the North Island College site.

Further details of the survey are found in Appendix E. The surveyed information was incorporated into the system data used to model the drainage infrastructure for the study area.

5.2. Existing Drainage Assessment

GIS Layer of Existing Drainage System

The City provided GIS databases (layers) for a wide variety of data. This includes municipal boundary, catchment boundary, zoning, topographic contours, drainage features, and roads. The GIS drainage features included watercourse locations, ditches, culverts, storm sewers, storm manholes, and storm detention facilities.

The desktop analysis of the stormwater drainage infrastructure was undertaken to assess the quality and completeness of the GIS data and identify gaps and errors in the data prior to undertaking the field inventory. The data gaps were filled as described in Appendix F. In general, the GIS data, the as-built information, and the survey information provided a complete representation of the drainage system.

Existing Land Use Assessment

The existing land use within the City was considered based on the BC Assessment GIS land use data as requested and provided by the City. Existing impervious percentage for all land parcels was assigned by applying the base impervious percentage values to the corresponding land use (see Appendix F for details).

Stormwater System Model Development and Calibration

The City's stormwater system was modelled using SWMM software and calibrated and validated to locally collected rainfall and flow data (see Appendix F for details of model build and calibration).

Design Flow Estimates

Design flows were estimated for all modelled pipes and culverts in the study watersheds. The model in this study was developed at a City scale to provide indications of drainage infrastructure performance, to allow for long range planning and capital budgeting. Prior to undertaking upgrades, refined estimates of design flows should be undertaken for each project.

Trunk Storm Sewer Capacity Assessment

The capacity of the existing trunk storm sewers was assessed for the existing land use and existing climate rainfall scenario as described in Appendix G.

Results from modelling the City trunk storm sewer network highlighted a number of areas where existing pipes are undersized and surcharging above the pipe inlet crowns and road/ground surface elevations. Figure 5-4 shows the 2-year capacity assessment and Figure 5-5 shows the 10-year capacity assessment for the existing minor trunk sewers. In summary for the 10-year event, 269 minor system trunk sewers of the 477 total minor system trunk storm sewers are identified as undersized. Table 5-2 below provides a summary of the undersized trunk storm sewers for the 10-year event. A full listing of these pipes is included in Table G-2 in Appendix G. The capacity assessment results sheets are also included in Appendix G.

Table 5-2: Trunk Storm Sewers Undersized for Existing Land Use and Climate

Pipe Size (mm)	Total Length (m)	% of Total Trunk System	10-year Minor System	
			Length Undersized (m)	% of Total Trunk System Undersized
< 200	0	0.0%	0	0.0%
200	199	0.7%	0	0.0%
250	389	1.3%	389	1.3%
300	641	2.1%	222	0.7%
375	1245	4.1%	960	3.1%
450	5198	17.0%	3376	11.0%
500	289	0.9%	113	0.4%
525	1643	5.4%	1290	4.2%
600	9838	32.1%	6234	20.3%
675	218	0.7%	199	0.6%
750	4554	14.9%	3340	10.9%
800	370	1.2%	340	1.1%
900	1650	5.4%	729	2.4%
1000	161	0.5%	132	0.4%
1050	1384	4.5%	768	2.5%
1200	1098	3.6%	482	1.6%
>1200	1779	5.8%	551	1.8%
Total	**30656**	**100.0%**	**19125**	**62.4%**

Culvert Capacity Assessment – Existing Land Use and Existing Climate

Undersized driveway (minor system) culverts were identified at multiple locations and are shown on Figure 5-5. In summary, 2 driveway (minor system) culverts of the 13 total modelled driveway culverts are identified as undersized. Undersized roadway and major watercourse (major system) culverts were identified at multiple locations and are shown on Figure 5-6. In summary, 31 roadway and major watercourse (major system) culverts of the 57 total modelled roadway and major watercourse culverts are identified as undersized.

The details of the minor and major culvert assessments are included in Appendix G. The capacity assessment results sheets are also included in Appendix G.

5.3. Future Drainage Assessment

Future Land Use Conditions

The future land use for the IRMP was developed by using the City Official Community Plan (OCP) GIS data as provided by the City. Future impervious percentage for all land parcels was assigned by applying the base impervious percentage values to the corresponding land use (see Appendix F for details).

Climate Change Assessment

KWL performed a climate change assessment to determine the IDF values to use for the Year 2050 time horizon. That work is summarized in Appendix J.

In summary, the City's current climate change IDF is proposed to be used for all return periods except the 100-year. A more conservative climate change increase of 32% is proposed for the 100-year return period because of the potential consequences in the major event.

Future Drainage System Assessment

Trunk Storm Sewer Capacity Assessment

Trunk storm sewers were evaluated using 2-year, 10-year and 100-year peak flow estimates reflecting future land use and climate change conditions as described in Appendix G. The future scenario 2-year and 10-year assessment results for the trunk storm sewers are shown on Figure 5-8 and Figure 5-9, respectively.

Minor Drainage System

The capacity of the trunk storm sewers that have a safe overland flow route was assessed using the 10-year future condition design storm as described in Appendix G. Figure 5-9 shows all trunk storm sewers considered to be undersized in the minor drainage system 10-year design storm event.

In total, 204 minor system trunk sewers of the 477 total system trunk sewers were identified as undersized. Table 4 below provides a summary of the undersized trunk storm sewers under future conditions for the minor drainage system 10-year design storm event. A full listing of these pipes is included in Table G-3 in Appendix G. The capacity assessment results sheets are also included in Appendix G.

Culvert Capacity Assessment – Future Land Use and Future Climate

Undersized driveway (minor system) culverts were identified and are shown on Figure 5-9. 2 driveway (minor system) culverts of the 13 total modelled driveway culverts are identified as undersized. Undersized roadway and major watercourse (major system) culverts were identified at multiple locations and are shown on Figure 5-10. In total, 33 roadway and major watercourse (major system) culverts of the 57 total modelled roadway and major watercourse culverts are identified as undersized.

The details of the minor and major culvert assessments are included in Appendix G. The capacity assessment results sheets are also included in Appendix G.

Major Drainage System (Future Upgrades)

Undersized trunk storm sewers that are in locations where there does not appear to be a safe overland flow route for the major (100-year) event are recommended for upgrade to future major drainage system (100-year) pipes. These are shown on Figure 5-11.

In total, 103 existing trunk storm sewers were identified as requiring upgrade to future major drainage system (100-year) pipes. Table 5-3 below provides a summary of the undersized trunk storm sewers requiring upgrade to future major drainage system (100-year) pipes. A full listing of these pipes is included in Table G-4 in Appendix G. The capacity assessment results sheets are also included in Appendix G.

Table 5-3: Trunk Storm Sewers Undersized for Future Land Use and Future Climate Conditions

Pipe Size (mm)	Total Length (m)	% of Total Trunk System	10-year Minor System		100-year Major System	
			Length Undersized (m)	% of Total Trunk System Undersized	Length Undersize d (m)	% of Total Trunk System Undersized
< 200	0	0.0%	0	0.0%	0	0.0%
200	199	0.7%	0	0.0%	0	0.0%
250	389	1.3%	389	1.3%	0	0.0%
300	641	2.1%	375	1.2%	85	0.3%
375	1245	4.1%	884	2.9%	130	0.4%
450	5198	17.0%	2379	7.8%	1239	4.0%
500	289	0.9%	149	0.5%	0	0.0%
525	1643	5.4%	889	2.9%	470	1.5%
600	9838	32.1%	4786	15.6%	1890	6.2%
675	218	0.7%	199	0.6%	0	0.0%
750	4554	14.9%	2043	6.7%	1772	5.8%
800	370	1.2%	340	1.1%	0	0.0%
900	1650	5.4%	705	2.3%	90	0.3%

Pipe Size (mm)	Total Length (m)	% of Total Trunk System	10-year Minor System		100-year Major System	
			Length Undersized (m)	% of Total Trunk System Undersized	Length Undersized (m)	% of Total Trunk System Undersized
1000	161	0.5%	0	0.0%	132	0.4%
1050	1384	4.5%	228	0.7%	534	1.7%
1200	1098	3.6%	298	1.0%	391	1.3%
>1200	1779	5.8%	502	1.6%	456	1.5%
Total	**30656**	**100.0%**	**14164**	**46.2%**	**7189**	**23.5%**

5.4. Proposed Storm System Upgrades and Capital Plan

While conveyance of flows is only a part of the overall stormwater management plan, the City has a primary duty to protect public safety and provide and maintain safe flow routes for drainage at the minor and major drainage system service levels. Potential infrastructure upgrades are proposed when the modelling results show that the existing minor drainage system or future required major drainage system is unable to provide adequate conveyance for the 10-year (Minor) or 100-year (Major) design event. These potential upgrade sizes are based on the current modelling results for the future land use (OCP) and future climate change scenarios.

The upgrades were costed (as described below) and then grouped into capital projects (as described in Appendix H).

Please note that upgrade sizes are calculated based on future flows but not verified by re-modelling (except in a few cases where culverts or pipes are twinned and cannot be sized separately). Each upgrade must be checked and verified prior to detailed design. In some cases detailed review may identify alternative solutions, rather than pipe upgrade, or may identify additional upgrade options such as doubled pipe or, in some cases, a bridge.

5.5. Capital Plan Risk Matrix and Prioritization

The capital plan risk matrix was developed to include all trunk storm sewers and culverts and rank them according to a risk calculated based on available information to inform the likelihood of failure and the consequence of failure for each pipe as described in detail in Appendix H. Individual sewer pipes to be upgraded were grouped into capital projects as described in Appendix H, and the projects were prioritized based on the risk rankings of the component upgrades. The trunk sewer capital project groups are shown on Figure 5-12. The culvert upgrades are all individual projects for each culvert. The culvert upgrade priorities are shown on Figure 5-13.

Prioritized Upgrades, Cost Estimates and Capital Plan

Trunk Storm Sewer and Culvert Upgrades Sizing

The sizing for trunk storm sewer and culvert upgrades is based on the future land use (OCP) conditions and for future Year 2050 climate change rainfall projections. The required upgrades were sized to convey their respective incoming peak flow with no surcharging above pipe/culvert inlet crowns; the future scenario 10-year design storm peak flow for minor system trunk storm sewers and the future scenario 100-year design storm peak flow for future major system trunk storm sewers and culverts.

Sizing of the trunk storm sewer upgrades in the IRMP is conceptual in nature at this phase of the project and does not include the effects of detention facilities. During preliminary design, the design flows to each pipe should be reviewed including reviewing the tributary catchment area in additional detail, which may be further refined between now and then, and using the most up-to-date design criteria including any IDF curve updates and the latest climate change projections available at that time.

Trunk Storm Sewer and Culvert Upgrades Class 'C' Cost Estimates

The Class 'C' cost estimates were completed for budgeting purposes for the trunk storm sewers and culverts that were identified as requiring upgrade. These estimates are considered to be Class 'C' because some site-specific information such as depth of excavation and surface type (road or boulevard) for restoration are considered in the costing. The summary of the upgrades Class 'C' cost estimates for the future land use (OCP) and future Year 2050 climate change rainfall scenario is provided in **Table 5-4** below. The Class 'C' cost estimates are detailed in Appendix I. The Class 'C' cost estimates are based on infrastructure costs per unit length and account for general estimated site conditions such as:

- required estimated excavation volumes;
- removal of excavated fill;
- imported fill;
- trench depth;
- supply and install costs for new trunk storm sewers and associated new storm manholes;
- culvert headwalls;
- road structure granular sub-base; and,
- paving surface areas.

Table 5-4: Capital Upgrades, Class 'C' Cost Estimates and 10-Year Capital Plan

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
Priority 1 – Immediate Term Plan (Construction Year 1 and 2)								
Construction Year 1								
DCUL0001	CA	Creek Culvert	Morrison Creek crossing Willemar, Willemar Culvert	2100	0.54	2100	Creek crossing culvert showing signs of failure. As part of the major system, it must convey highest flows to prevent flooding or road washouts. Proposed to be replaced with a bridge. Cost shown is pipe replacement, but there is inadequate depth of cover for a standard pipe.	$214,000
DCUL0240	CAO	Creek Culvert	Piercy Creek crossing culvert at Cliffe Ave	1700 x 3	1.93	2400 x 4	Undersized and requires additional barrel for upgrade.	$776,000
DMAIN-38-0710	AT5	Storm main	Lerwick Road, from Ryan road North Island Hospital Comox Valley	450	2.11	600	Model indicates inflow from adjacent lots overwhelms pipe and it should be upgraded to prevent future flooding at critical road junction near hospital.	$1,066,000
DMAIN-38-0711	AT5	Storm main		375	3.69	600		$626,000
						Construction Year 1 Subtotal		$2,468,000
DMAIN-9-0003	J1	Storm main	5th Street, from Cliffe Avenue to Courtenay River	375	1.22	450	Major flow route to river, crosses key road – 2 pipes are undersized and middle pipe (steeper slope) is included for upgrade so as to avoid reduced size pipe between larger sections.	$347,000
DMAIN-9-0002	J1	Storm main		375	0.92	450		$882,000
DMAIN-9-0001	J2	Storm main		375	1.41	450		$183,000
DCUL0024	CP	Creek Culvert	Glen Urquhart Creek at 10th Street E	1200	2.92	1800	Undersized for flow and road flooding expected. Poor condition documented.	$385,000
DCUL0002	CB	Creek Culvert	1st Street culvert crossing Morrison Creek	3000	3.61	3050x 2438	Undersized for flow and road flooding expected. Fair condition documented.	$349,000

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
						Construction Year 2 Subtotal		$2,146,000
						Priority 1 Construction Subtotal		**$4,614,000**
Priority 2 – Short Term Plan (Construction Year 3, 4 and 5)								
Construction Year 3								
DCUL0006	CD	Creek Culvert	Piercy Creek crossing culvert on Cumberland road, north of the intersection of Arden road	750	6.41	3050	Undersized for flow and road flooding expected. High consequence of failure. Fair condition documented.	$2,698,000
						Construction Year 3 Subtotal		$2,698,000
Construction Year 4								
DCUL0014	CF	Creek Culvert	Piercy creek crossing culvert on Arden road	1200 H x 1650 W Elliptical	1.92	3050	Undersized for flow and road flooding expected. High consequence of failure. Fair condition documented. Hydraulics indicate challenging location; May require a bridge rather than culvert replacement.	$817,000
DCUL0020	CL	Creek Culvert	Glen Urquhart Creek crossing culvert at Back Road	900	1.70	1200	Undersized for flow and road flooding expected. High consequence of failure. Fair condition documented. These culverts are twinned and the two should be replaced together.	$429,000
DCUL0019	CK	Creek Culvert	Glen Urquhart Creek crossing culvert at Back Road	1200	1.29	1350		$408,000
DCUL0046 & DCLU0654	CT	Creek Culvert	Culvert crossing Buckstone Road	2 x 600	2.54	2 x 1200	Twinned culverts. Undersized for flow and road flooding expected. High consequence of failure.	$296,000
DCUL0162	CY	Creek Culvert	Culvert Crossing Arden Road at 1360 Arden Rd	450	4.36	600	Undersized for flow and road flooding expected. High consequence of failure.	$91,000
DCUL0186	CAB	Creek Culvert	Piercy Creek crossing 20th Street	1800	2.42	2400	Undersized for flow and road flooding expected. High consequence of failure.	$290,000
						Construction Year 4 Subtotal		$2,331,000

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
Construction Year 5								
DCUL0237	CAM	Creek Culvert	Creek crossing culvert, along Comox Logging Road	750 H x 1250 W	5.92	1500	Undersized for flow and road flooding expected. High consequence of failure. Fair condition documented. High cost due to deep location of culvert. Should be further evaluated for remediation options.	$21,030,000
						Construction Year 5 Subtotal		$21,030,000
						Priority 2 Construction Subtotal		**$26,059,000**
Priority 3 – Long Term Plan (Construction Year 6 - 10)								
Construction Year 6								
DCUL0369	CAV	Creek Culvert	Arden Road crossing culvert, north of laketrail	500	10.56	900	Undersized for flow with flooding predicted and rated high consequence of failure.	$114,000
DCUL0618	CBM	Creek Culvert	Piercy Creek Crossing A driveway/ walking path	450	2.56	600	Undersized for flow with flooding predicted and rated high consequence of failure.	$80,000
DMAIN-38-2012	BD	Storm main	Stormwater main at the end of Sussex Dr	450	2.53	525	Undersized for flow. This location ranked high for risk of consequence if flooding occurs; this should be reviewed in detail prior to proceeding with project as adjacent pipes were not rated for flooding and risk may be reduced be other methods than upgrade.	$258,000
DCUL0003 & DCLU0007	CC	Creek Culvert	Glen Urquhart Creek crossing at Thorpe Ave.	900 mm and 750 mm	0.85	1500 x 2	Undersized for combined flow with surcharge. Both pipes require upgrade to meet flow requirements	$443,000

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
DCUL0218	CAH	Road Crossing Culvert	Culvert connecting two storm ponds, under Gatehouse Place	1000 H x 1350 W Pipe Arch	1.86	2100	Undersized for flow with flooding predicted and considered high consequence of failure.	$308,000
DCUL0235	CAK	Creek Culvert	Creek Culvert crossing Arden Road, at 2655 Arden Road	1220 H x 2438 W Box	1.44	1500 H x 3050 W Box	Modelled as a box but undersized with flooding predicted and considered high consequence of failure. Should be reviewed in detail as hydraulics indicate larger culvert or bridge may be preferred.	$416,000
DCUL0351	CAS	Road Crossing Culvert	Culvert Crossing Lake Trail, into undeveloped area	900	1.75	1200	Undersized for flow with flooding predicted and considered high consequence of failure.	$187,000
						Construction Year 6 Subtotal		1,806,000
Construction Year 7								
DMAIN-14-0005_2	Q14	Storm main	Stormwater main along Willemar Avenue between 21st and 26th Avenue	1350	2.12	1650	Undersized for flow, recommended to carry major flow	$1,416,000
						Construction Year 7 Subtotal		$1,416,000
Construction Year 8								
DMAIN-14-0010	Q13	Storm main	Stormwater main along Willemar Avenue from 1757 to 1805 Willemar Ave	1050	1.27	1350	Undersized for flow, recommended to carry major flow	$1,243,000
DMAIN-14-0007	Q13	Storm main	Stormwater main along Willemar Avenue between 20th and 21st Avenue	1200	1.99	1500	Undersized for flow, recommended to carry major flow	$2,021,000
DMAIN-14-0006	Q13	Storm main	Stormwater main along Willemar Avenue, fronting 2135 and 3155 Willemar	1200	2.24	1500	Undersized for flow, recommended to carry major flow	$200,000

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
						Construction Year 8 Subtotal		$3,464,000
Construction Year 9								
DMAIN-14-0010	Q13	Storm main	Stormwater main along Willemar Avenue from 1757 to 1805 Willemar Ave	1050	1.27	1350	Undersized for flow, recommended to carry major flow	$1,243,000
DMAIN-14-0007	Q13	Storm main	Stormwater main along Willemar Avenue between 20th and 21st Avenue	1200	1.99	1500	Undersized for flow, recommended to carry major flow	$2,021,000
DMAIN-14-0006	Q13	Storm main	Stormwater main along Willemar Avenue, fronting 2135 and 3155 Willemar	1200	2.24	1500	Undersized for flow, recommended to carry major flow	$200,000
						Construction Year 9 Subtotal		$1,559,000
Construction Year 10								
DMAIN-14-0016	Q11	Storm main	Stormwater main along Willemar Avenue from 15th Street to 1355 Willemar Ave	900	1.7	1050	Undersized for flow, recommended to carry major flow	$756,000
DMAIN-14-0014	Q11	Storm main	Stormwater main along Willemar Avenue crossing the roundabout at Cumberland Rd	1050	1.97	1200	Undersized for flow, recommended to carry major flow	$424,000
DMAIN-14-0015	Q11	Storm main	Stormwater main along Willemar Avenue North of Cumberland Rd.	1050	2.98	1200	Undersized for flow, recommended to carry major flow	$437,000
DMAIN-14-0106	Q11	Storm main	Stormwater main along Cumberland Rd from 1430 Cumberland to Willemar intersection	600	2.35	750	Undersized for flow, recommended to carry major flow.	$447,000
						Construction Year 10 Subtotal		$2,064,000
						Priority 3 Construction Subtotal		**$10,309,000**
Table Notes								

Conduit ID[1]	Project Group ID	Asset Type	Location Description	Existing Size (mm)	Existing / Future Flow q/Q	Required Size[2] (mm)	Project Rationale /Proposed Approach	Total Costs[4]
The trunk storm sewer upgrades Class 'C' Cost Estimates are available in Appendix I. See trunk storm sewer upgrades listed in Tables G-3 and G-4 of Appendix G. See trunk storm sewer Major and Minor systems on Figure 5-11. See the Capital Project Groups on Figure 5-12.								

Notes:

1. Pink shading indicates culvert upgrades and yellow shading indicates drainage system infrastructure upgrades. See digital GIS for location of conduits.
2. Infrastructure upgrades were sized to a future land use under the Y2050 climate change rainfall.
3. Pipe costs include new manholes based on 150 m maximum spacing for pipe diameters up to 450 mm, and 300 m maximum spacing for pipe diameters of 450 mm and larger (as per City of Courtenay Bylaw No. 2919 – 2018).
4. Costs with mark-ups for allowances applied (see allowances described above in Section 5.2).

The Class ‘C’ cost estimates do not account for potential relocation or shutdown of services, or traffic management. The total capital costs with mark-ups include allowances for:

- Mobilization and Demobilization (6%);
- Insurance and Bonding (2%);
- Engineering (15%);
- Contingency (30%); and,
- Market material cost fluctuations (10%).

Note that these estimates are based on available cost information in 2022, and in the volatile construction and infrastructure supply markets estimated costs may quickly become out of date. The level of uncertainty in the estimates should be considered to increase as time goes on and may be only reliable to order-of-magnitude after 1-2 years from the time the estimates are completed.

Note that the timing of main upgrade projects may be adjusted to align with water, sewer and/or roadway upgrades along the same stretch of road. The risk of adverse consequences due to undersized culverts is more significant, and the timing of culvert upgrades is independent of utility upgrades in the roadway.

5.6. Capital Plan Summary

The capital plan for the IRMP includes prioritized and costed upgrades for trunk sewer infrastructure identified for the near and medium term, 1 to 10 years in the future.

- Priority 1 upgrades, year 1 - 2: $4,614,000
- Priority 2 upgrades, year 3 - 5: $26,059,000
- Priority 3 upgrades, year 6 - 10: $10,309,000

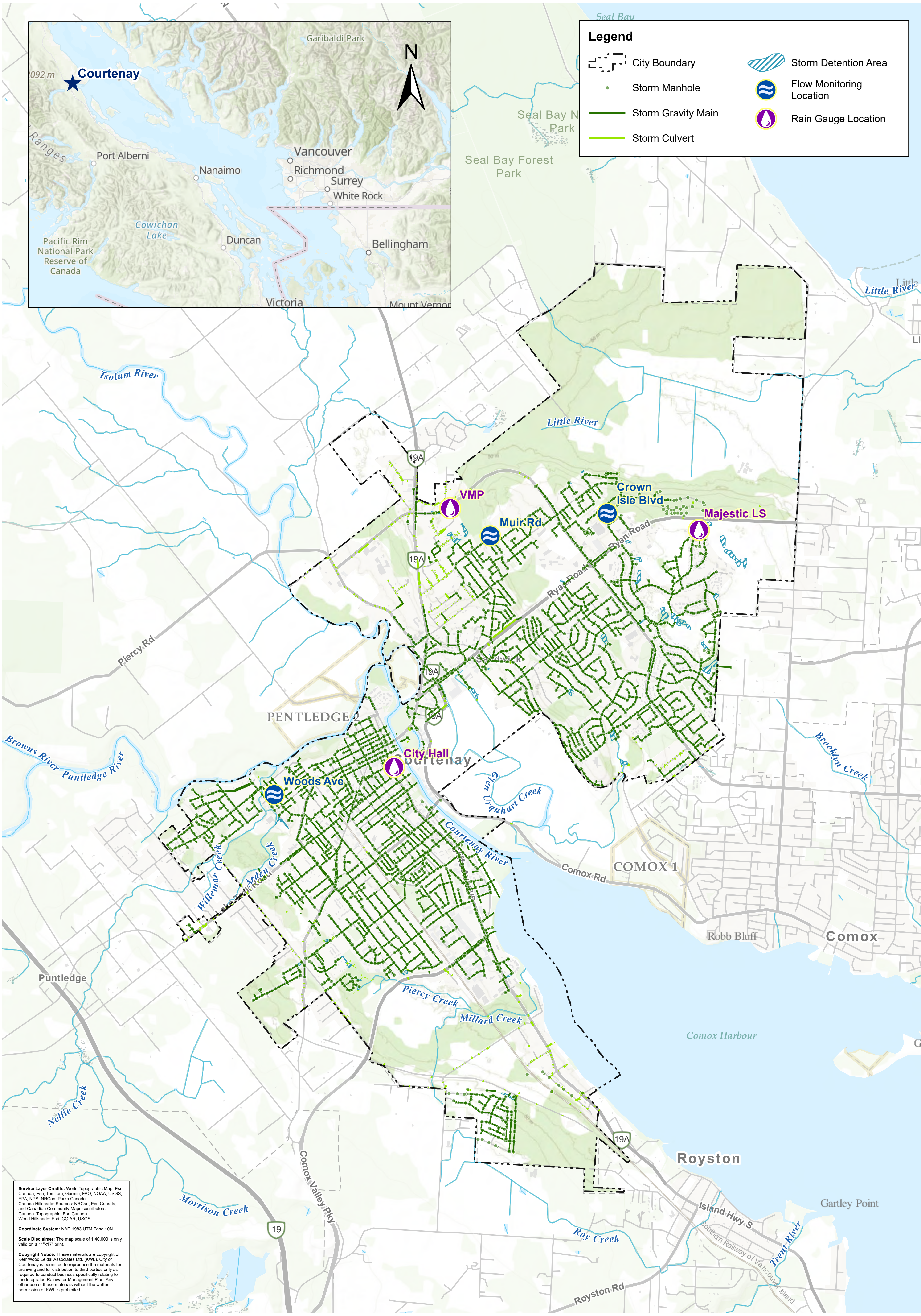
The allocation of funding for upgrades will impact the timing and progress of upgrade completion and the program timing may need to be reviewed or adjusted in the future. As noted above, the estimated costs for capital upgrades are based on 2022 cost data, and the level of uncertainty in the costing should be assumed to increase as time passes due to the volatility in construction and infrastructure supply markets. In addition, these estimates take into account only limited specific site information and the estimates may not include specific local conditions that would cause construction costs to be higher.

This capital plan as summarized was developed assuming typical annualized funding of $2M. If a sustainable annualized funding is adopted, these capital upgrades may be completed faster, allowing significant risks of flooding to be addressed. However for single upgrades that require more than $2M, addition funding would need to be allocated to allow those projects to proceed

City of Courtenay

Integrated Rainwater Management Plan - Phase 3

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Topographic Map: Esri Canada, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, NRCan, Parks Canada
Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.
Canada_Topographic: Esri Canada
World Hillshade: Esri, CGIAR, USGS

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:40,000 is only valid on a 11"x17" print.

Project No. 2980-014
Date November 2024
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Study Area

Figure 5-1

City of Courtenay

Integrated Rainwater Management Plan - Phase 3

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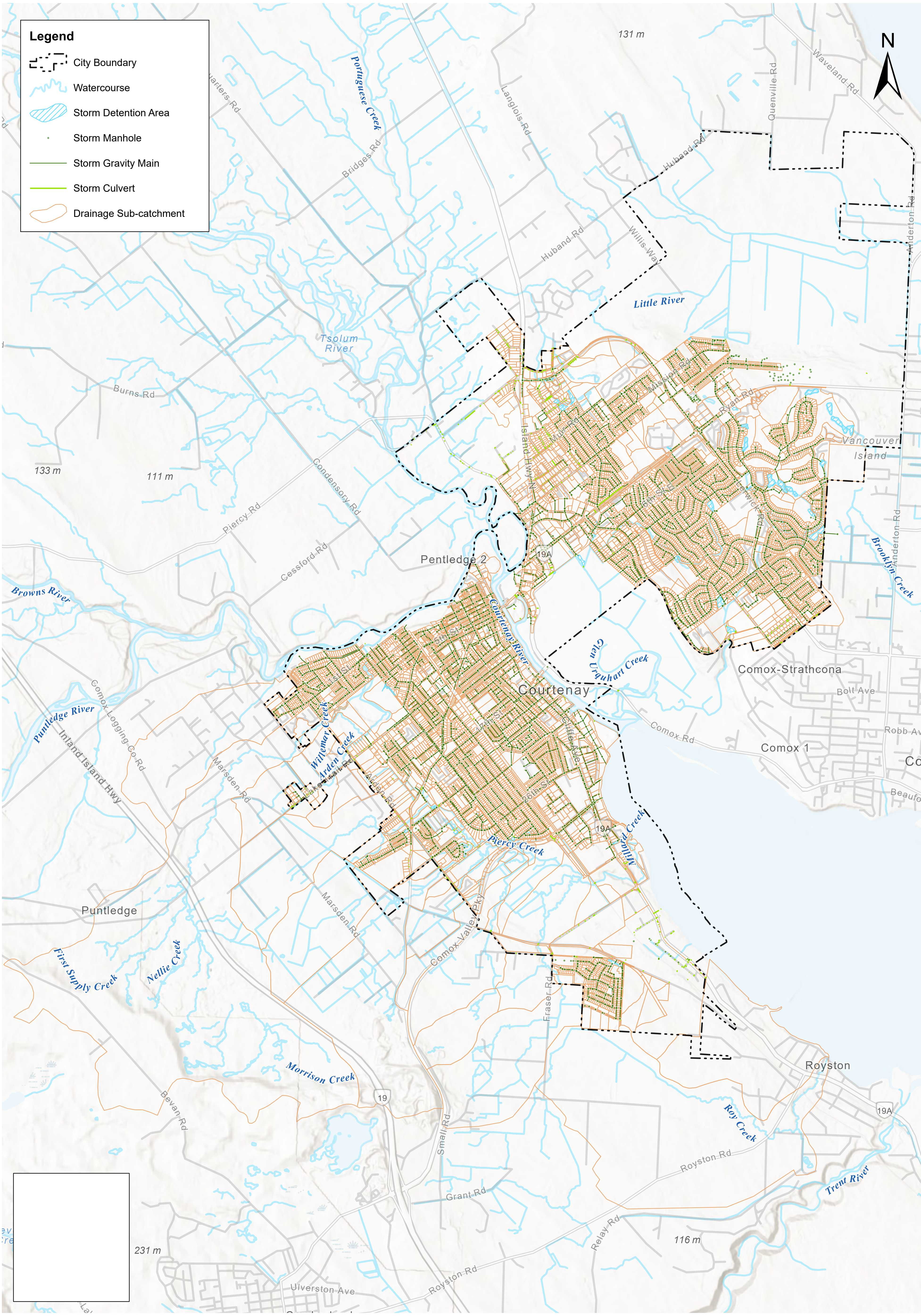

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Date	November 2024
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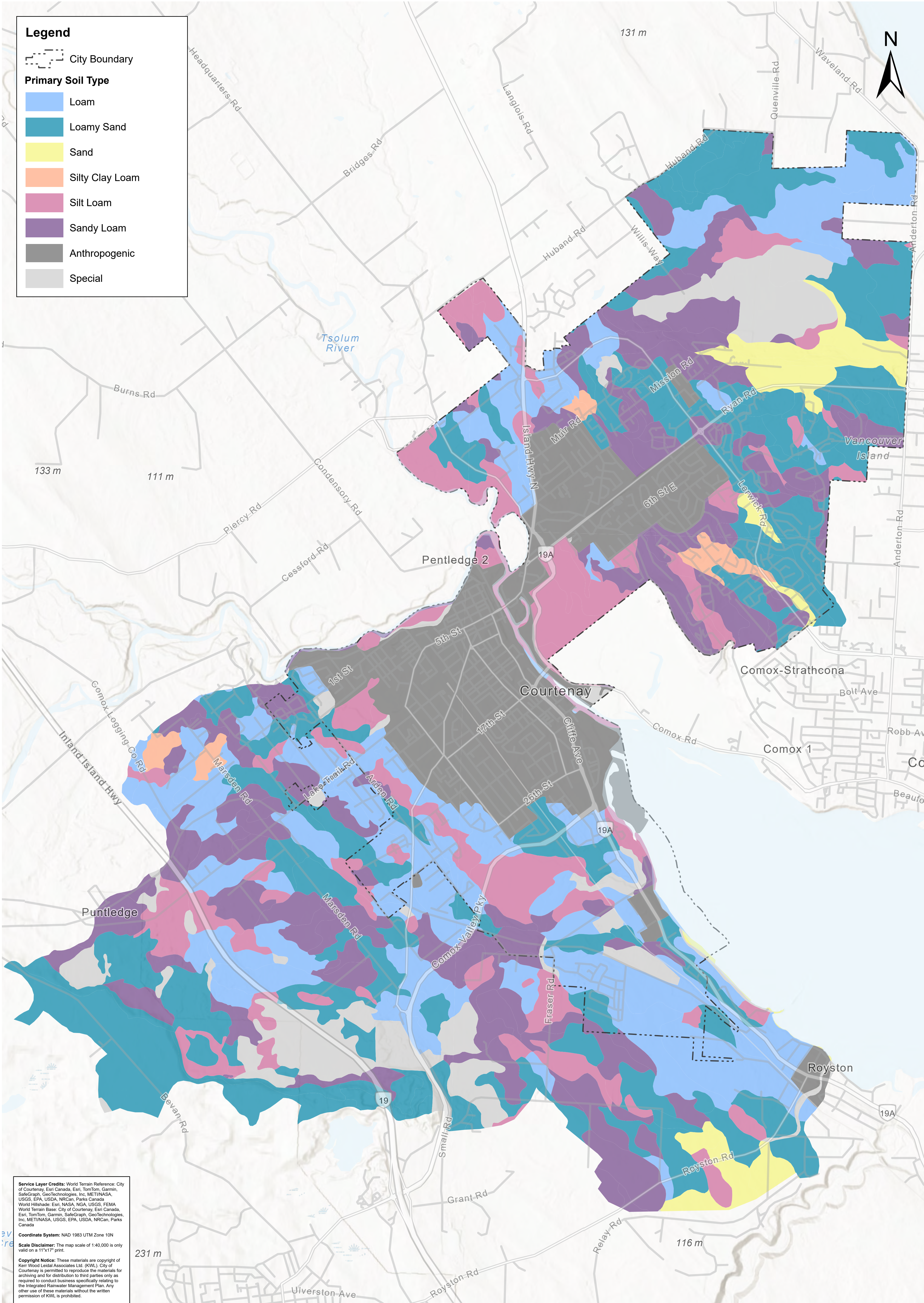
Drainage Sub-catchments

Figure 5-2



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Primary Soil Types

Figure 5-3

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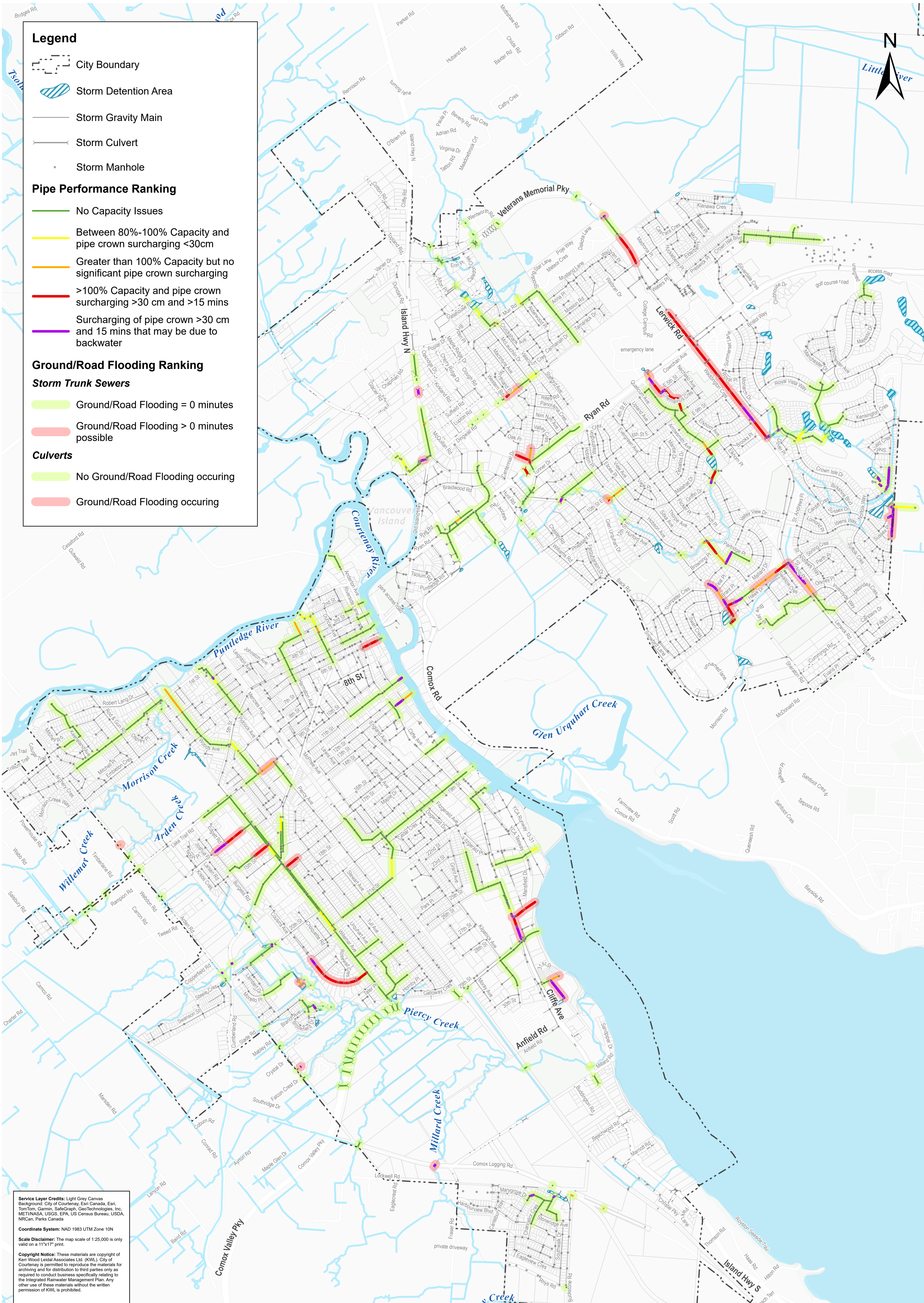

Project No. 2980-014

Date November 2024

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Storm System Performance Assessment: Existing 2-Year Design Storm (without 15% Climate Change increase) - Existing Land Use Conditions

Figure 5-4

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Integrated Rainwater Management Plan - Phase 3

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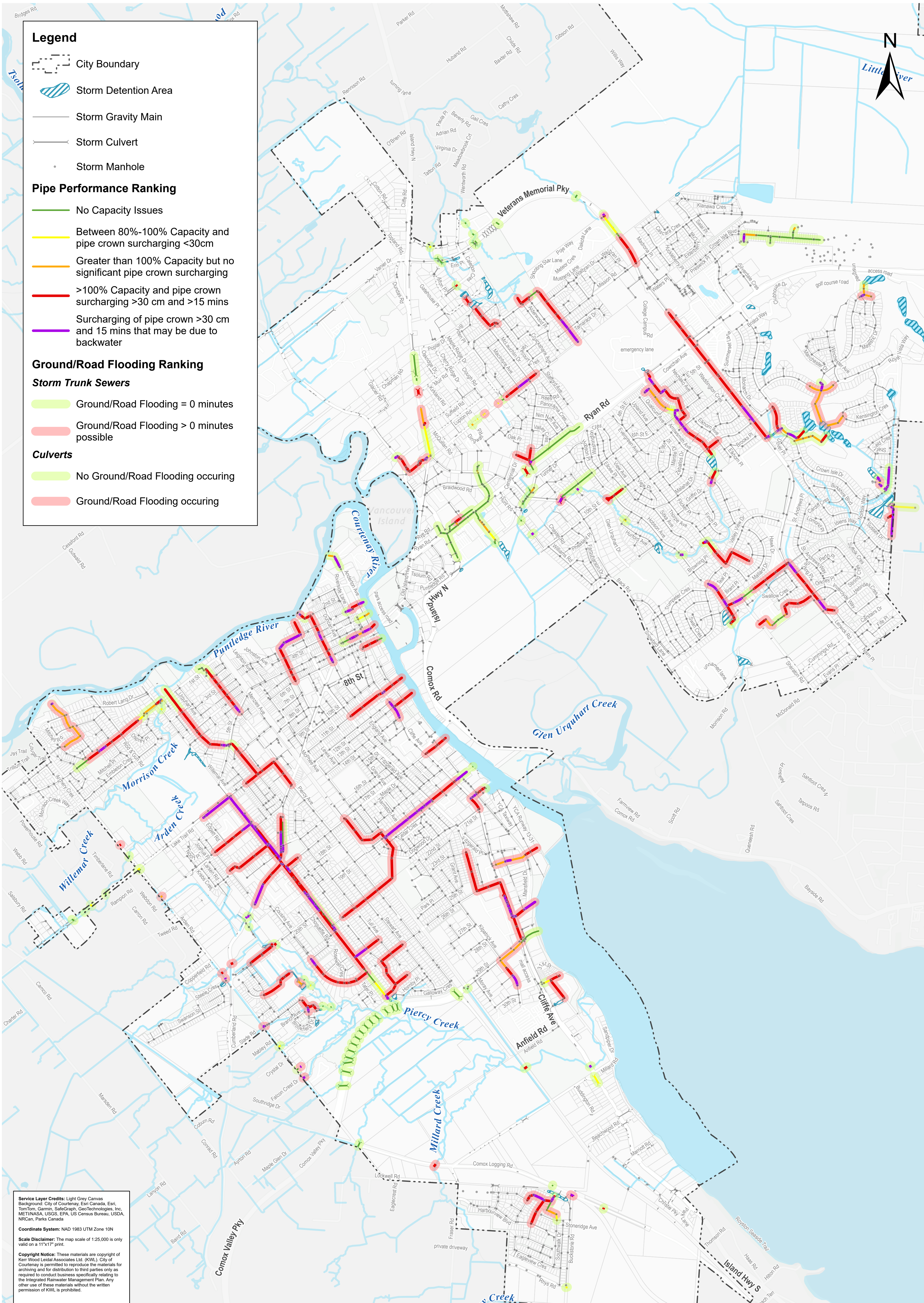

Project No.	2980-014
Date	November 2024
Scale	1:25,000

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Storm System Performance Assessment: Existing 10-Year Design Storm (without 15% Climate Change increase) - Existing Land Use Conditions

Figure 5-5

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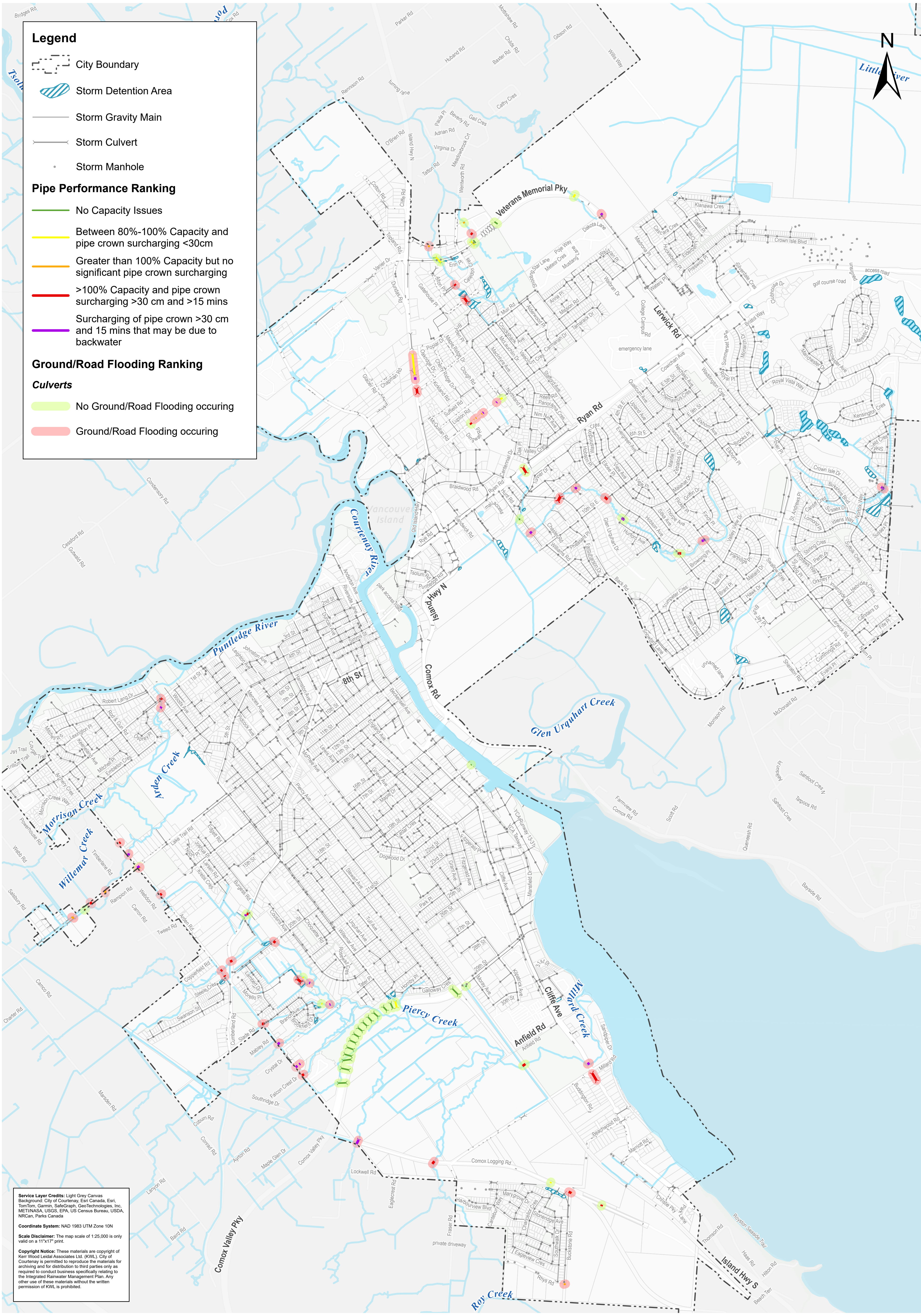

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Project No.	2980-014
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Storm System Performance Assessment: Existing 100-Year Design Storm (without 15% Climate Change increase) - Existing Land Use Conditions

Figure 5-6

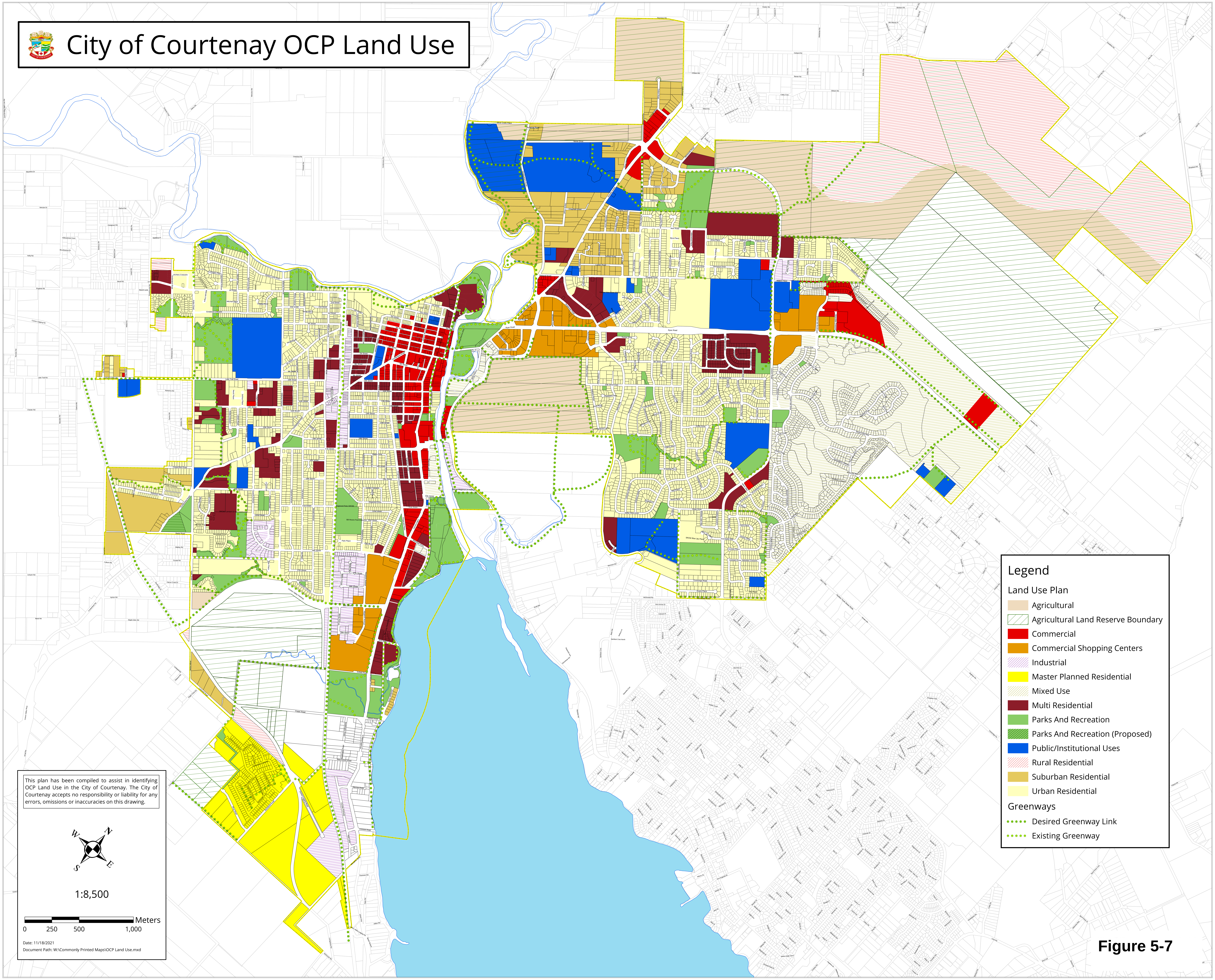
City of Courtenay OCP Land Use
Legend
Land Use Plan
Agricultural
Agricultural Land Reserve Boundary
Commercial
Commercial Shopping Centers
Industrial
Master Planned Residential
Mixed Use
Multi Residential
Parks And Recreation
Parks And Recreation (Proposed)
Public/Institutional Uses
Rural Residential
Suburban Residential
Urban Residential
Greenways
Desired Greenway Link
Existing Greenway
This plan has been compiled to assist in identifying OCP Land Use in the City of Courtenay. The City of Courtenay accepts no responsibility or liability for any errors, omissions or inaccuracies on this drawing.
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Figure 5-7

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City of Courtenay

Integrated Rainwater Management Plan - Phase 3

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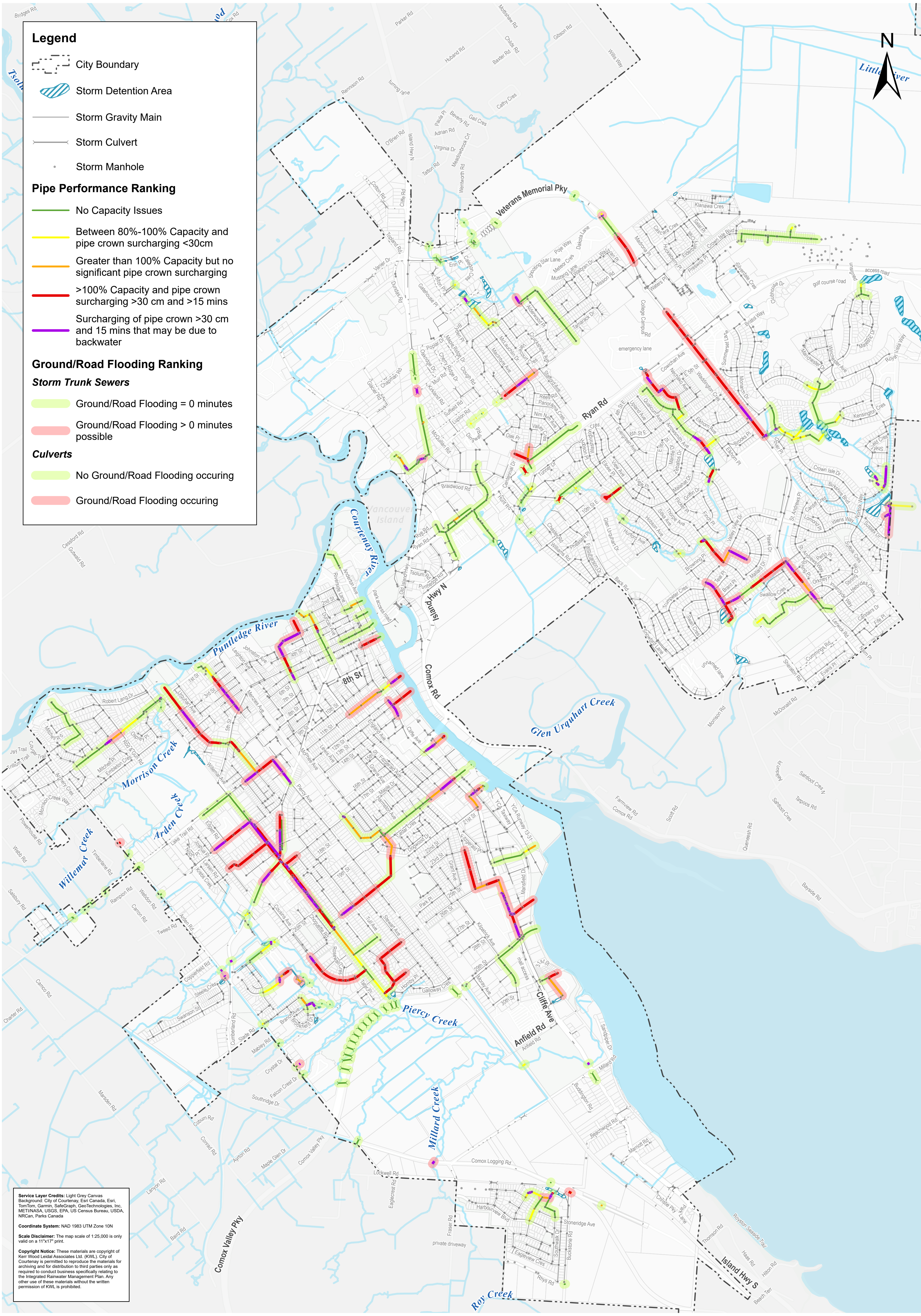

Project No. 2980-014

Date November 2024

Scale 1:25,000

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Storm System Performance Assessment: Future 2-Year Design Storm (with 15% Climate Change increase) - Future Land Use - Existing Sewers/Culverts

Figure 5-8

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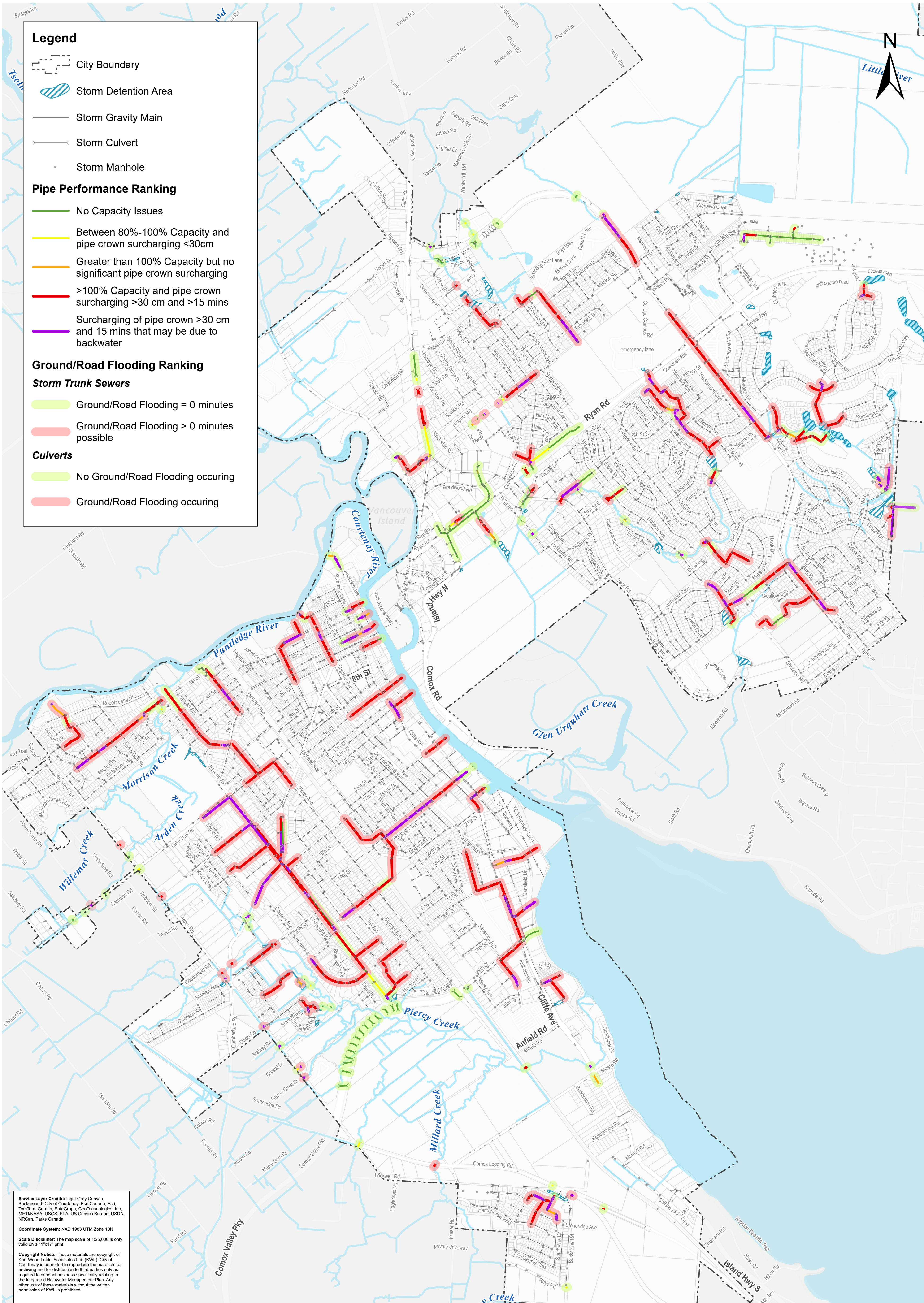

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Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:25,000 is only valid on a 11"x17" print.

Project No.	2980-014
Date	November 2024
Scale	1:25,000

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Storm System Performance Assessment: Future 10-Year Design Storm (with 15% Climate Change increase) - Future Land Use - Existing Sewers/Culverts

Figure 5-9

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City of Courtenay

Integrated Rainwater Management Plan - Phase 3

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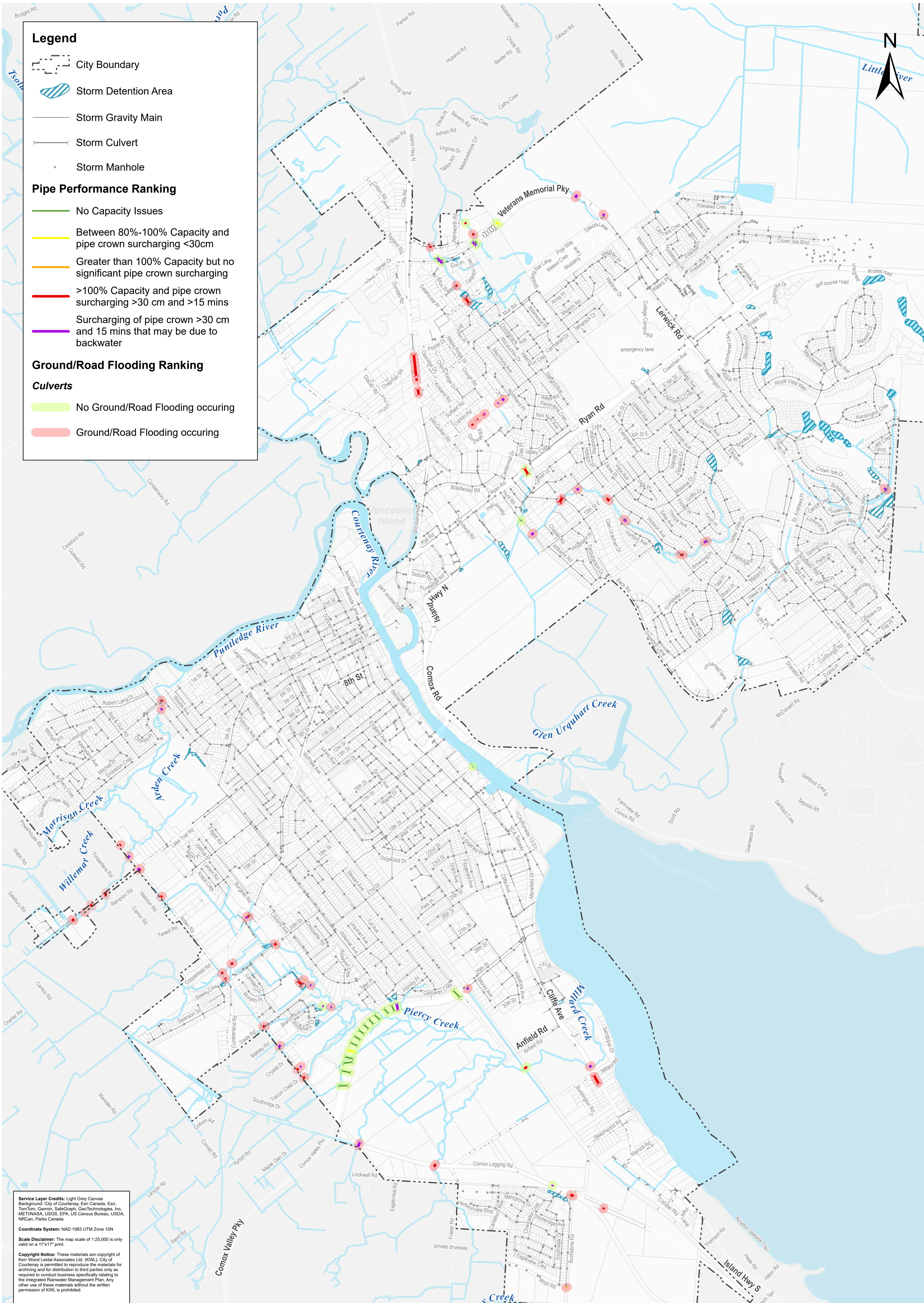

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Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:25,000 is only valid on a 11"x17" print.

Project No. 2980-014
Date November 2024
Scale 1:25,000
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Storm System Performance Assessment: Future 100-Year Design Storm (with 32% Climate Change increase) - Future Land Use - Existing Sewers/Culverts

Figure 5-10

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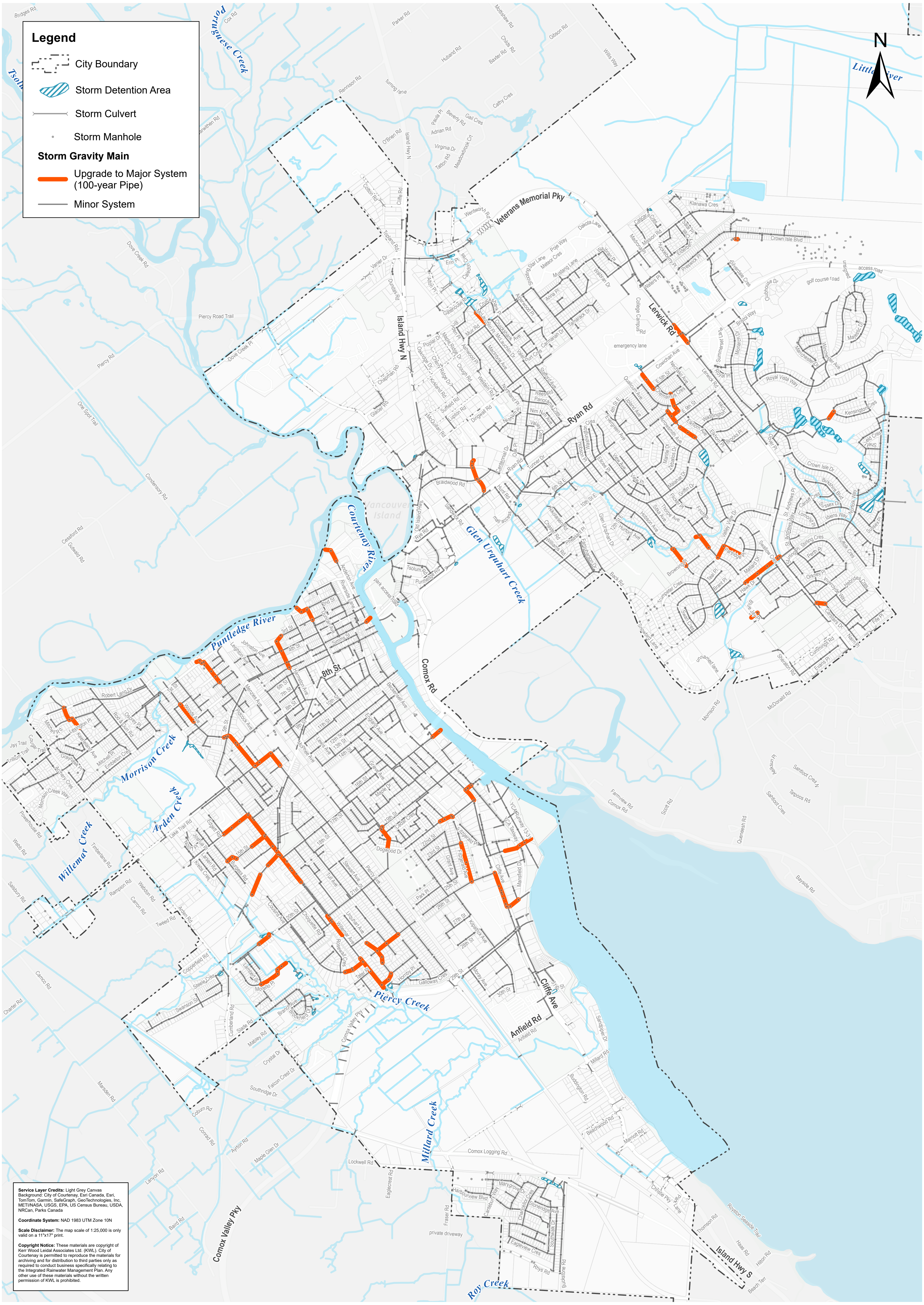
City of Courtenay

Integrated Rainwater Management Plan - Phase 3

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: Light Grey Canvas Background: City of Courtenay, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA, NRCan, Parks Canada

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:25,000 is only valid on a 11"x17" print.

Project No. 2980-014
Date November 2024
Scale 1:25,000
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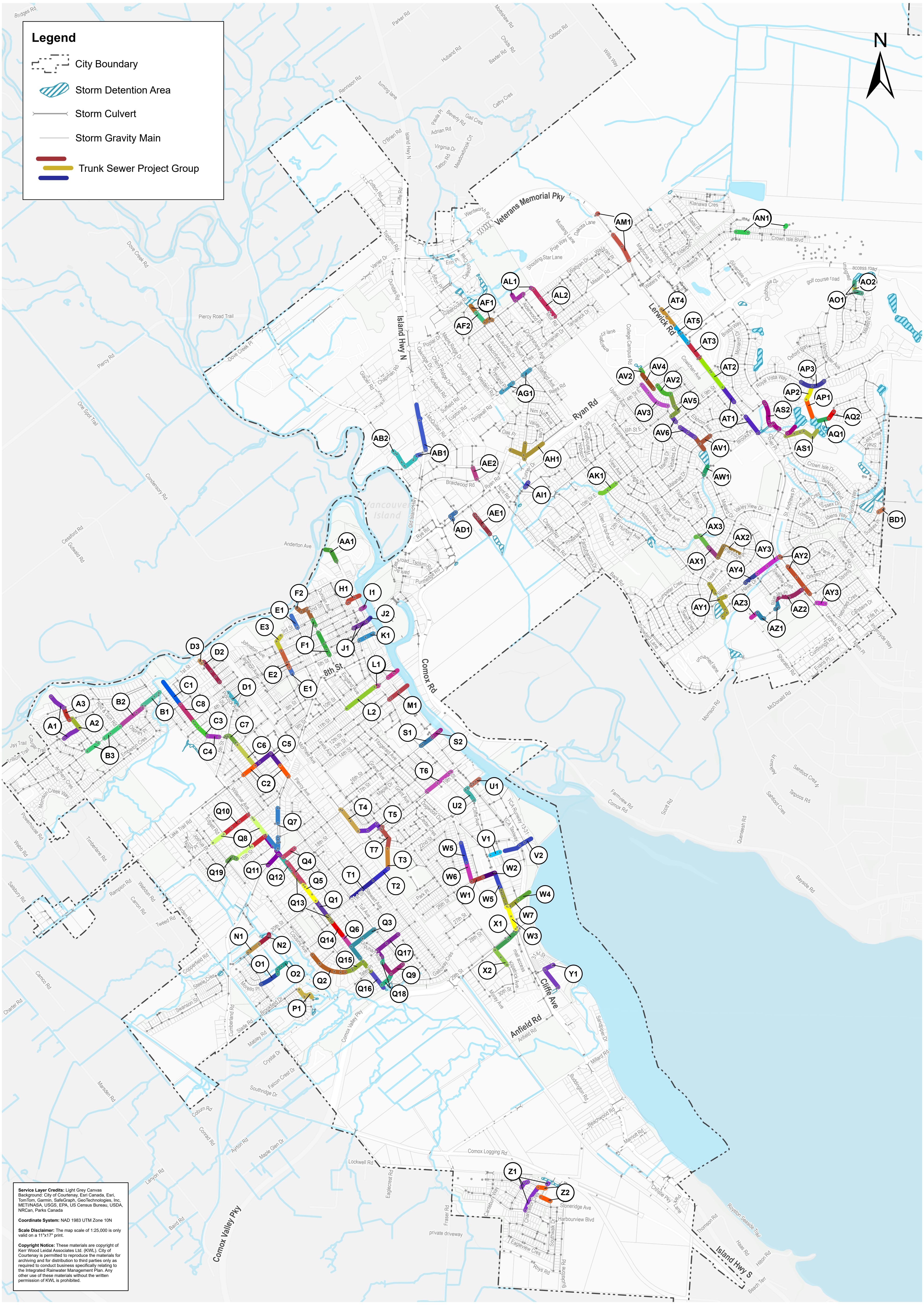
Storm System - Minor and Major Sewers

Figure 5-11

City of Courtenay

Integrated Rainwater Management Plan - Phase 3

KERR WOOD LEIDAL
consulting engineers



Project No. 2980-014
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Capital Project Groups

Figure 5-12

City of Courtenay

Integrated Rainwater Management Plan - Phase 3

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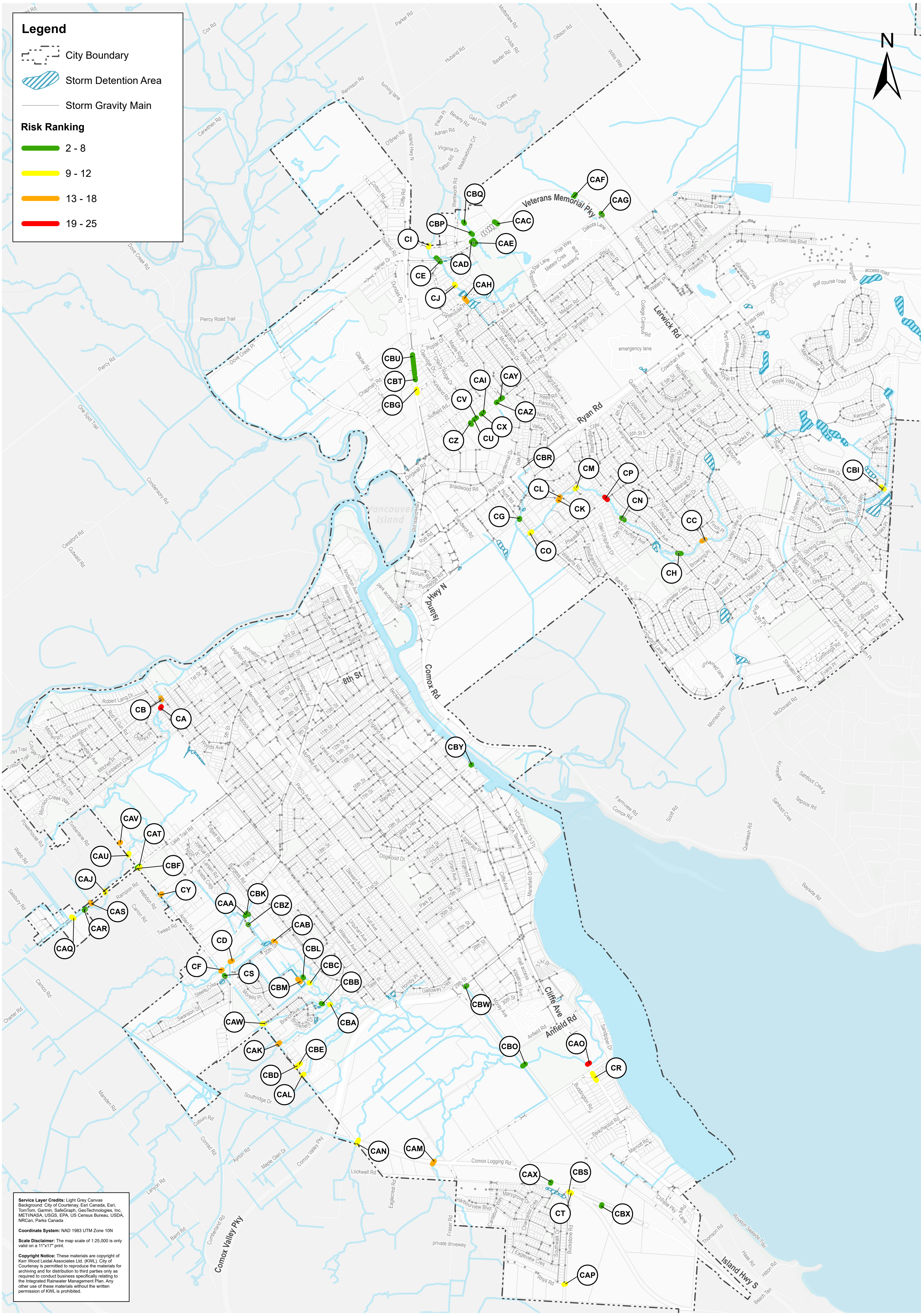

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Project No. 2980-014
Date November 2024
Scale 1:25,000
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Capital Projects - Culverts

Figure 5-13

6. Stormwater Infrastructure Funding

6.1. Historical Spending

Available financial information from the City of Courtenay has been reviewed as part of the stormwater funding review process. The last eight years' information was reported in the General Capital and Operating Financial Plans. Excerpts from the City's annual financial reports for the General Operating Fund and General Capital Revenue & Expense were provided by the City for 2015 to 2022 and include information covering stormwater related work and project items.

The Capital Revenue & Expense information includes an annual list of specific capital projects and the estimated budget and actual expenditure for the period of record available. The number of capital projects per year ranges from 4 to 11 with a total average budget of $444,850; however, the capital projects with actual expenses ranges from 2 to 7 for the same period with a total average spend of $143,566. Given this, only 35% of the capital budget was spent over the last eight years. It should be noted that the period under review includes the COVID pandemic; although the percentage of average Capital budget spent pre-COVID is very similar.

The General Operating Fund for storm sewers includes staff salaries, wages, administration, and training; and maintenance and operation of storm mains, service connections, manholes, catch basins, creek crossings, detention ponds and flood protection. As shown in Table 6-1 below, the Operation spending has historically been close to the budget, with exception of the year 2015 which appears to have a significant amount spent on dyke maintenance.

Table 6-1: Existing Drainage Spending

Year	Operation			Capital			Total	
	Budget	Actual	% Spent	Budget	Actual	% Spent	Budget	Actual
2015	$412,841	$713,762	172.9%	$911,000	$368,457	40.4%	$1,195,900	$515,739
2016	$395,100	$401,544	101.6%	$438,900	$210,797	48.0%	$1,195,900	$515,739
2017	$561,400	$415,073	73.9%	$348,100	$25,184	7.2%	$1,195,900	$515,739
2018	$547,900	$406,190	74.1%	$648,000	$109,549	16.9%	$1,195,900	$515,739
2019	$563,300	$625,889	111.1%	$344,000	$214,144	62.3%	$907,300	$840,033
2020	$567,900	$643,250	113.3%	$371,900	$1,110	0.3%	$939,800	$644,360
2021	$584,700	$476,423	81.5%	$396,900	$151,527	38.2%	$981,600	$627,950
2022	$571,700	$596,245	104.3%	$100,000	$67,759	67.8%	$671,700	$664,004
Average	**$525,605**	**$534,797**	**104.1%**	**$444,850**	**$143,566**	**35.1%**	**$1,035,500**	**$604,913**

Source: City of Courtenay

The City of Courtenay's historical average spending on Operation and Capital renewal for drainage assets from 2015 to 2022 was on average $605,000 each year. Over this period the actual spending for stormwater capital works was lower than the annual budget, while the operation spending on drainage was generally within ±25% of the budget.

6.2. Similar Communities

A review of drainage spending at ten other municipalities on Vancouver Island and the south coast with similar topography and drainage characteristics was completed to provide an indication of what typical spending levels are within similar communities.

Drainage spending information was collected for Nanaimo, Saanich, Central Saanich, Victoria, Campbell River, Comox, Powell River, Sechelt, Squamish and White Rock. Information collected from each municipality was based on publicly available annual financial reports and budget statements. The information varies in how it is reported between municipalities depending on the organization's structure and management of the assets. Most municipalities reviewed have dedicated public works departments that include separate stormwater or drainage categories or combine storm with road infrastructure. The City of Victoria is the only municipality with a Storm Utility. For municipalities where a combination of services is provided under one funding umbrella, assumptions were made to determine an appropriate percentage of stormwater related line items. For line items that included roads and drainage, 25% of the line item was considered drainage related. For the line items that including water, storm and sanitary, 30% was considered drainage related. Furthermore, the ratio between available information for each municipality was used to prorate the missing years between 2018-2022.

The annual spending was compared based on total population, total area and total length of drainage mains. Table 6-2 summarizes the range of spending among the municipalities reviewed and the City of Courtenay's spending for 2022.

Table 6-2: Typical Total Drainage Asset Spending in 2022

	Average	Range	Courtenay
Per Capita	$ 61	$ 24 - 123	$ 23
Per Square Kilometer	$ 92,237	$ 8,721 – 377,806	$ 20,481
Per Meter of Drainage Main	$ 15,195	$ 3,976 – 31,165	$ 3,976

The results show that in 2022, when compared to it's peers the City of Courtenay spent less on operation & maintenance, and capital spending for stormwater infrastructure, when compared based on total population and total length of drainage mains. When comparing based on incorporated area of the municipality, the City of Courtenay spending is less than a quarter of the average spend per square kilometer.

6.3. Sustainable Renewal Investment Needs

Asset Information

A high level review of the renewal costs for the City's linear stormwater infrastructure assets including drainage mains and culverts was conducted using information collected for the IRMP. Condition assessment data was provided for the drainage mains based on CCTV inspection scores; however, no condition data was available for culverts or other drainage assets. Given this, condition assessments for the culverts are recommended to convey the renewal investment needs more accurately and better understand the remaining service life of the system. Maintenance records and existing detailed asset level financial information were not made available.

Information for drainage assets other than culverts and drainage mains has not been included in this assessment. The additional assets may include drainage ponds, pump stations, service connections, catch basins, and flood protection structures which should be added to the overall drainage inventory and asset management program when staff resources and time permits.

Inventory and Replacement Value

The drainage asset inventory is based on information provided by the City of Courtenay for the development of the IRMP. Replacement values for each drainage main and culvert were calculated based on the existing diameter, length, and depth of the structure. This approach is similar to how the recommended capital program costs were generated; however this is a high-level Class 'D' Estimate for the entire existing storm drainage system (does not include upgrade costs). Items included in the cost estimate are excavation and disposal (assumed 50% of excavated materials not suitable for reuse), new pipe and backfill materials, manholes, and re-paving or surface restoration. It is acknowledged that variation pipe material also impacts replacement cost; however, to simplify this analysis all replacement pipe was assumed to be concrete pipe.

A summary of the City's drainage main and culvert assets and replacement value is provided in Table 6-3.

Table 6-3: Storm Sewer and Culvert Asset Inventory and Valuation Summary

	Count	Length	Replacement Value
Culvert	663	9,148 m	$ 11,146,000
Drainage Main	2,835	167,177 m	$ 202,594,000
		Total	**$ 213,740,000**

Condition and Service Life

Drainage main asset data provided by the City included a 5-point asset condition rating based on CCTV assessment and inspection results. It is not clear when the condition rating was carried out but is assumed to be relatively recent such that the data is still valid. The asset inventory also included pipe installation year and material type, so an asset service life was generated for all pipe materials based on assumed pipe lifecycle using engineering judgement.

As shown in Table 6-4 below, the condition rating scale ranges from 1 or Excellent condition to 5 or Failed. A service life deduction scale is then applied to the remaining asset life to provide a high-level estimate for asset renewal timing that is used in development of the asset renewal forecast for the drainage mains.

Table 6-4: Condition Rating

Condition	Rating	% of Life Remaining
Excellent (new or like new)	1	100 %
Good	2	75 %
Fair	3	50 %
Poor	4	25 %
Failed (replace or backlog)	5	0 %

As noted above, there is no condition information for the culvert assets and therefore these assets are assumed to fail at the expected service life based on the installation year.

Asset Renewal Forecast

Lifecycle financial needs include the one-time capital costs of acquiring and disposing of assets, and the ongoing costs of operating and maintaining the assets through the operating portion of the life cycle. This cost information is used to determine the sustainable annual cost of providing service, and all these costs are typically recovered through taxes, user chargers and/or other stable/reliable revenue sources.

Assets of different types have different life cycle lengths, deteriorate at different rates, and require different strategies for optimum life cycle performance and cost-efficiency. Intervention strategies fall into four general categories:

1. Maintenance
2. Rehabilitation, Retrofit, or Repair
3. Replacement
4. New Asset Acquisition

Figure 6-1 provides an unprioritized 35-year forecast of annual asset renewal needs and costs for the drainage infrastructure based on the infrastructure condition, service life and replacement cost information.

The estimated 35-year total renewal need for linear storm assets is $101 million with an annualized need of $2,913,000. In addition, there is also an existing backlog for renewal of linear storm assets estimated at approximately $8,066,000, which accounts for about 4% of the total asset value.

The estimated annualized renewal needs per meter of drainage main is $17,445, which is slightly above the average drainage infrastructure spending in 2022 for the peer municipality group as per Table 6-2, and significantly higher than the amount the City is currently spending. The estimated annual renewal amount is reasonable when comparing the typical drainage expenditures of similar communities but is also an indication that the City is underspending on storm sewer infrastructure renewal.

This drainage asset review only considers asset replacement for drainage mains and culverts. Additional studies are recommended to review the remaining drainage assets not included here such as City-owned and managed detention, and water quality facilities.

Maintenance of the existing systems and projection of future maintenance requirements is also not included at this time. Maintenance of the storm system is understood to be undertaken on a largely reactive basis at the current time, making it unclear what level of effort and volume of work should be accounted for in future management costs. Ideally, system maintenance plans should be developed for the desired level of ongoing maintenance so that costs of maintenance can be better understood and accounted for.

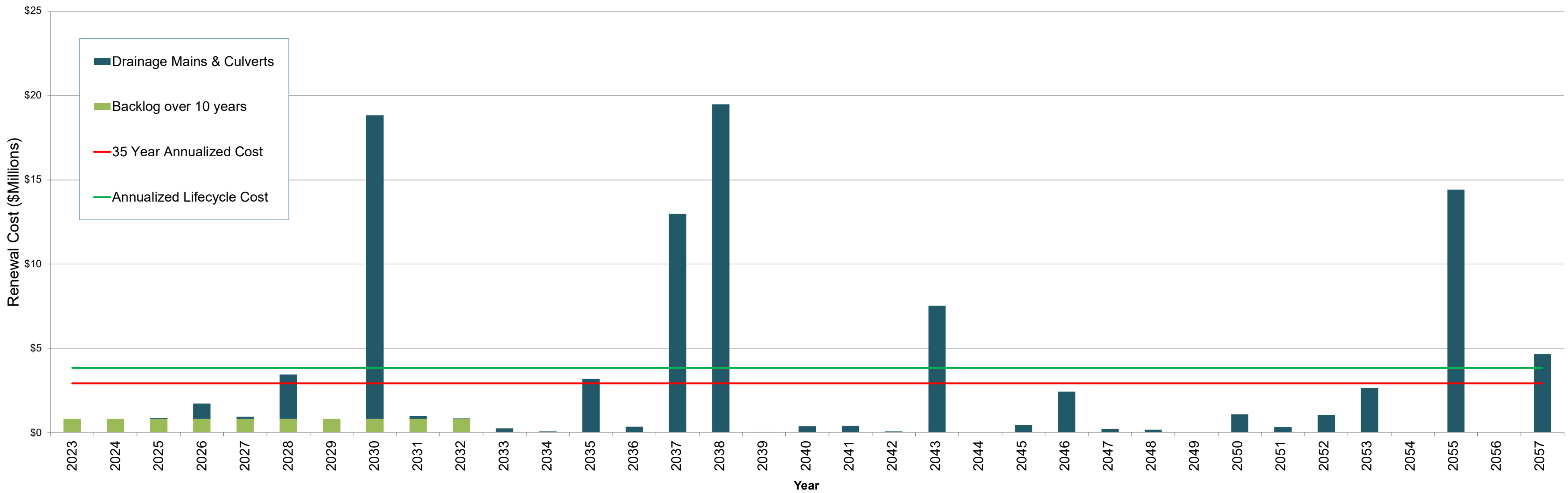

Figure 1: Uprioritized Asset Renewal

6.4. Interim Funding Approaches

Given the large gap between current available funding and identified stormwater needs, the City will need to address the gap by changing or increasing the funding sources and allocations for stormwater upgrades and system maintenance for the long term. The process for changing the funding allocations is likely to take some time. In the interim, there are some funding approaches that the City may wish to consider for moving forward with IRMP implementation:

- Environmental enhancements may be completed in conjunction with culvert or other infrastructure upgrades.
- Some environmental projects may be done with staff and volunteer time in coordination with stakeholder groups, particularly for small projects that fall below where grant funding may be applicable for eligible projects. Volunteer efforts generally require significant planning and coordination, and therefore volunteer labour should be considered supplemental to the core effort for implementation of a project.
- On-lot development mitigation would be funded by property owners/developers.
- Funding for storm sewer and culvert upgrades would come from the City's capital plan program to address existing infrastructure that is undersized or at the end of its service life. Any storm sewer upgrades needed to address development growth should come from development cost charges (DCC) to developers.
- Any internal City costs such as for development plan review, monitoring and site inspections would be incorporated into the City's operating costs. Such costs are not estimated in the IRMP as the City would be better able to understand any internal changes in operations or level of effort needed.

Note that the City is currently updating the drainage component of the development cost charge bylaw (Bylaw 2840, 2016) and the amount (or cost) of new capital infrastructure attributed to development will need to be factored into the drainage funding assessment.

For servicing upgrades required for an area of new development, the City could explore a regional DCC approach that would pool funds and upgrades for a larger area than a single development or subdivision to address wider servicing issues. As provincial regulations require that DCCs be specified in a municipal bylaw, enaction of a regional DCC program would likely be pursued as part of a regional/neighbourhood planning process that incudes infrastructure planning and would only be applicable for an area of significant expected development.

Potential Grant Funding Sources

Examples of potential grant funding sources that may be used for the IRMP implementation are described below. This list is not exhaustive and additional sources are available. Not all projects will be able to be funded under the below options; grant funding opportunities in particular have numerous constraints in their application and require significant investment staff time and upfront work to apply.

Green Municipal Fund – Federation of Canadian Municipalities

This fund finances capital projects that improve air, water and land and reduce greenhouse gas emissions. Capital projects funded involve the retrofitting, construction, replacement, or purchase and installation of fixed assets or infrastructure that will improve environmental performance in municipal, energy, transportation, waste, or water.

Additional information: https://greenmunicipalfund.ca/

EcoAction Community Funding Program – Environment and Climate Change Canada

This program provides funding for projects that will protect, rehabilitate, enhance and sustain the natural environment. The program supports projects that address clean air, clean water, climate change, and nature.

The program provides up to $100,000 per project for a maximum duration of 36 months. A minimum of 50% of the total project value must come from sources other than the Government of Canada.

The funding is available for non-government, non-profit groups and organizations. Partnerships with groups that are eligible are encouraged.

Additional information: https://www.canada.ca/en/environment-climate-change/services/environmental-funding/ecoaction-community-program.html

Clean Water and Wastewater Fund (CWWF) – Infrastructure Canada

This program targets projects that will contribute to the rehabilitation of both water treatment and distribution infrastructure as well as initiatives that improve asset management, system optimization, and planning for future upgrades. To deliver this fund, Canada has entered a Bilateral Agreement (BA) with provinces and territories, where provinces and territories are responsible for identifying projects in collaboration with municipalities.

Additional Information: https://www.infrastructure.gc.ca/plan/cwwf-fepeu-eng.html

Habitat Conservation Trust Foundation Enhancement & Restoration Grants

Each year approximately $6 million dollars in Enhancement and Restoration (E&R) Grants are awarded which focus on the following:

- Native freshwater fish, wildlife, and their habitats.
- Have the potential to achieve a significant conservation outcome.
- Align with our purposes as laid out in the Wildlife Act.

There is no upper limit on funding requests but there is a 5-year limit to project funding. Budgets typically range from $10,000 to over $100,000 annually. A priority of the foundation is to support habitat enhancement and restoration, and proposals for on-the-ground habitat enhancement and/or restoration activities are strongly encouraged.

Additional information: https://hctf.ca/grants/enhancement-grants

The British Columbia Salmon Restoration and Innovation Fund

This fund is intended to ensure the fish and seafood sector in BC is positioned for long-term environmental and economic sustainability and support the protection and restoration of wild Pacific salmon and other BC fish stocks. The fund supports:

- innovation to encourage the development of new technologies to:
  - increase productivity, and
  - help meet conservation and sustainability objectives, including the protection and restoration of wild BC stocks, including Pacific salmon,
- infrastructure to encourage capital investments in new products, processes or technologies to support the:
  - advancement of sustainable fishing practices, and
  - protection and restoration of wild BC stocks, including Pacific salmon,
- science partnerships to support collaborations with academia and other research institutions to:
  - improve our knowledge and understanding of impacts to wild stocks, and
  - develop sustainable fishing practices.

Those who are eligible to apply are British Columbia-based:

- Indigenous Groups
- Commercial Enterprises, including Fishers, Aqua Culturists and Seafood Processors
- Universities and Academics
- Industry Associations
- Other Organizations, such as Research Institutions and Stewardship Groups

Municipalities may be able to partner with stewardship and other environmental groups to pursue funding under this program. Funding is available to support project activities until March 31, 2026 and opportunities to apply may be provided throughout the year based on the availability of funding.

Additional information: https://www.dfo-mpo.gc.ca/fisheries-peches/initiatives/fish-fund-bc-fonds-peche-cb/index-eng.html

6.5. Long-Term Funding Options

Increased Allocation of General Revenue

Typical funding mechanisms are based on property value (or property taxes) which is likely the case for the City of Courtenay. General taxation revenue is then divided up into the funding areas needed to operate the municipality.

In the City, stormwater infrastructure is currently funded under the General Operating Fund under Public Works Services for operation related expenses and the General Capital Projects for new or major drainage infrastructure capital expenditures. Budget needs for expenditures from general revenue are determined on case by case basis, based on perceived need.

In 2022, the Drainage Operation and Maintenance budget was 6.4% of the total Public Works budget of $8,918,900. Similarly, in the same year the Drainage Capital budget was 0.4% of the total Engineering Capital Projects budget.

The City could work within the existing system and programs and allocate the appropriate budget to stormwater management for maintenance, renewals, and upgrades of assets. This approach would represent the minimum effort of change to the existing system of funding and budget allocation. However, given that the funding for stormwater management needs to increase substantially, it may be challenging for the City to approve large and ongoing increases in funding through the same mechanisms as are currently used. The total funding, i.e. tax revenue, would need to be increased, but there would be little clarity to the property owners on the justification for the increase when they see the bill as it would simply be a larger amount.

Stormwater Charge to Property Tax

A variation on the current funding approach for the City would be to create a specific charge for stormwater services that is part of each property's annual tax bill for City services. This would clarify the amount from tax revenue designated for stormwater management services, as well as designate the usage of funds collected from property taxes for stormwater management, preventing the funds from being easily directed to other needs.

A Stormwater Charge could be shown as a separate charge to each property, or it could be shown as a percentage of the sewer charge to each property. In either case, stormwater is frequently linked with sewer services on property taxes and calculated as a percentage of the sewer service levy.

The benefits of this approach include simplicity and clarity of the change to how stormwater would be funded moving forward. This approach provides a dedicated funding mechanism and amount for the stormwater system.

The drawback to this approach would be that it does not take into account any variation in usage of stormwater services or loading to the stormwater system, but bases the charge on the sewer levy, which is in turn typically linked with the potable water usage for each property. As generation of stormwater runoff is driven not by water usage but by impervious lot coverage, there can be a mismatch between the water-based charge and the stormwater needs or reliance of any individual property.

Stormwater Utility Approach

An alternative funding model is to establish a stormwater utility, which has been identified by the Federation of Canadian Municipalities as a best practice. In general, a stormwater utility is intended to be more transparent and equitable than general taxation and can allow for incentives to property owners for sustainable management of rainwater that reduces the burden on stormwater infrastructure. In 2015, the City of Victoria converted its stormwater funding source to a stormwater utility which has been successful in generating more public awareness and management of private stormwater particularly with single family homeowners.

The stormwater utility fees are determined by the impact each property has on the stormwater system and rates are adjusted based on the amount of existing impervious area mapped with GIS and aerial imagery, and the specific land use type (e.g. residential, multi-family, institutional, commercial or industrial). Another factor that affects the rate is the amount of street cleaning which is based on length of property frontage.

The City of Victoria has also introduced financial incentives for use of green rainwater management tools (rain gardens, cisterns, permeable pavers, etc.) to reduce the utility rates charged to customers that employ these techniques in accordance with the City's specifications.

Benefits of a Stormwater Utility Approach

A stormwater utility has the key benefits of providing a direct means of funding the ongoing maintenance and renewal of the stormwater system and linking that funding to the use or loading of the system. The utility approach creates a mechanism of allocating the costs of the system across all of the users, with the ability to increase the fee for users that more heavily use the storm drainage system.

In the case of a storm drainage system the use or loading is dependent on the impervious area that is drained, so a stormwater utility typically ties the fee structure to the area of impervious surface of a property. A property that has more impervious surface area, will be charged a larger storm utility fee.

A system of this type is more fair in the allocation of costs relative to other funding mechanisms because the fees are tied to use or loading of the system. This means the system is more sustainable, in that it can take into account better or poorer management of the runoff and loading to the storm system from a property. A stormwater utility can incentivize better stormwater practices on private property, and dis-incentivize problematic practices, by varying the fees for properties based on the stormwater management characteristics of the individual property.

Challenges of a Stormwater Utility Approach

There are three significant challenges associated with setting up a new stormwater utility.

1. Adopting the change in type of system management and governance. Typically there will be a lengthy process with staff, council and public consultation and engagement in order to understand and embrace the process of development of a new utility for a community. The process may or may not be supported by outside consultants, but the staff and council will need to put in significant effort and time to explore, understand, and navigate what the development of a utility means for the community, and the staff.
2. Developing the utility structure. There is cost and effort associated with creating a system to implement a stormwater utility for any jurisdiction. First the methods of how the fees will be determined must be developed, and then the data and systems to generate the fees and billing must be created. This requires an investment of time and cost to set up and put in place before any fees can be collected under the new utility structure.

3. Operating the utility. Once the investment has been made so there is a utility system in place, there will be an ongoing need for staff to operate the utility. This may take the form of answering questions on fees and bills, adjusting fees based on development, and making incremental revisions to the data and management of the data that make up the basis of the system. For the City of Courtenay, this likely requires at least one full-time staff member.

Overall, there is also the challenge of time for implementation of a stormwater utility. The challenges noted as 1 and 2 both require significant time, likely years, for completion, prior to a stormwater utility being ready for operation.

6.6. Recommendations

It is recommended that the City increase funding for storm drainage operation and capital projects for the short term to start to bridge the gap in funding and system renewals and upgrades. There may need to be a ramp up of increasing fees for stormwater if the full increase per property is not considered to be acceptable for a single-year increase to property taxes. There is a clear need to increase funding and start to bring the storm system into alignment with long-term system operation and service goals.

Once short-term funding has been allocated the City should consider the potential long-term funding options from a governance perspective, and review whether a formalised stormwater utility or another approach is a good fit for the long term.

7. Recommended Policy Updates

A key component of an IRMP is identification of bylaws, policies and programs that should be updated or created to support and further the City's goals for stormwater management and protection of watersheds and receiving waters.

This section of the IRMP presents recommendations for updates to:

- Bylaws, standards and other mechanisms that affect how stormwater and rainwater are managed.
- Policies and guidance documents that can be used to inform, educate, and support improvements in stormwater and rainwater management.
- Programs and operational improvements that would improve and update how the City itself manages its assets in accordance with IRMP goals.

Discussions and recommendations for these updates are detailed in the following sections of this report.

Several updates to the City's current policies and bylaws are recommended to improve stormwater and rainwater management alignment with the goals of the IRMP.

7.1. Updates to Subdivision and Development Bylaw No. 2919

Rainwater Management Target

The design criteria for rainwater management is currently not specific and does not provide a target level of mitigation for development hydrologic impacts other than rate control.

It is recommended that the City update the design criteria to require a target level of rainwater management for quantity and quality. "Stormwater Planning: A Guidebook for British Columbia" recommends that rainwater management target 50% of Mean Annual Rainfall (MAR). This value is typically approximated as 50% of the 2-year, 24-hour return period storm rainfall amount. For the City of Courtenay, the target is therefore recommended to be:

- 42 mm of rainfall in 24 hours.

The target value is calculated based on the IDF information provided in the City's Supplementary Design Guidelines, Section 4.

This target value should be incorporated into a new subsection for Rainwater Management, as Section 4.3.4, to separate the rainwater management target from the detention requirements. The Rainwater Management section should specify that the rainwater management target is required to be met for all development on a site-wide basis or should specify any exceptions. Topsoil and vegetation may be used to meet the target on pervious areas, and source control BMPs should be used to manage the target volume of rainfall on impervious surfaces on the lot by capturing and infiltrating the runoff, where possible.

In support of rainwater management performance, it is recommended that a minimum 300 mm of well-draining topsoil be required for 'typical' application on all vegetated areas (lawn and shallow garden areas) of a developed lot. Landscape areas for shrubs and trees would require deeper topsoil regardless, to support the growth of larger plants, and a landscape designer may specify different soil types where needed for specific plant and landscape applications. Well-draining topsoil is recommended to be required in any areas where runoff is directed to the landscape area from ground or roof impervious surfaces.

A reference to a guideline for rainwater management design is recommended to be included in the City' Supplementary Design Guidelines to provide a base level of information for owners, developers and designers trying to meet the City's target. The "Metro Vancouver Stormwater Source Control Design Guidelines" is a good reference, but it is a guideline rather than a standard for design and may not provide sufficient level of design detail for the City's needs for every case. The City should consider developing a City-specific guideline or standards for rainwater management in the future – see section on future work, below.

Water Quality Target

The City's design criteria currently does not include water quality as a performance requirement. The Schedule 1 – Supplementary Design Guidelines includes Section 4.11.8 requiring oil and grit separators for parking areas. It is recommended that this section be updated to be called "Water Quality Treatment" and add that alternative treatment for parking areas may be accomplished with green infrastructure BMPs such as rain gardens and bioswales.

Design of green infrastructure BMPs for water quality treatment should target the same volume as the rainwater management capture target, i.e. 42 mm rainfall in 24 hours. If that volume can be treated and infiltrated on site through infiltration BMPs, then both the rainwater capture and water quality treatment criteria may be met using the same BMP facility. In areas where infiltration is not possible, runoff may be treated and released rather than infiltrated.

At this time, research in Washington State has linked a compound derived from vehicle tires, 6-PPD Quinone, to salmonid species mortality. The primary source of 6-PPD Quinone in salmon-bearing waters is runoff from roads, with higher traffic volume roads producing higher levels of this pollutant. At this time, it has been shown that 6-PPD Quinone can be removed from runoff by treatment that filters the runoff through a soil matrix, such as a bioretention rain garden or bio-swale. Note that at this time, other treatment methods such as oil-grit separation are not known to remove the 6-PPD Quinone compound, therefore it is recommended that rain garden and bio-swale facilities be prioritised for treatment of runoff from roads and other vehicle-accessible surfaces.

Note that water quality treatment BMPs are a subset of rainwater management BMPs. The City may wish to provide guidance on what water quality treatment BMPs are preferred and how they should be designed to meet the City's desired performance and operation requirements. See recommendation under future work for development of guidance and/or standards.

100-year Climate Change IDF Update

KWL completed a limited climate change assessment on the Courtenay Puntledge BCHP station using the online IDF CC Tool. Results of this assessment were used to compare and evaluate the City's existing IDF guidance in their 2019 bylaw. The results of this comparison indicate the City's current design storms adequately capture the climate change impacts for storms up to the 50-year design storm. However, the results indicate that the City's major system IDF does not reflect the 95th percentile of the climate change projections and should be updated such that major infrastructure is designed to incorporate an additional level of conservativeness.

KWL recommends that the City continue to use their IDF curves from the bylaw (which have a 15% increase incorporated) for design storms up to the 50-year event and to increase the 100-year IDF (across all durations) by an additional factor of 15% (approximately a 32% increase on historic intensities). Table 7-1 summarizes the recommended update to the City's IDF curve in the bylaw.

Table 7-1: Recommended IDF Curve Intensity (mm/hr) – 100-Year Values Updated

Return Period						
Duration	2-year	5-year	10-year	25-year	50-year	100-year
15-minute	21.3	36.7	47.2	60.7	70.8	93.0
30-minute	16.3	26.9	34.1	43.1	49.9	65.2
1-hour	12.5	19.5	24.1	29.9	34.3	44.4
2-hour	9.5	14.7	18.2	22.6	25.9	33.5
6-hour	6.8	9.7	11.6	14	15.7	20.1
12-hour	5.1	6.7	7.8	9.1	10.1	12.8
24-hour	3.5	4.5	5.2	6.1	6.8	8.5

7.2. Protect and Enhance Environmental Values

Value of Natural Systems

It is increasingly recognized that natural systems provide a wide variety of services to society that have significant value which should be recognized.

The City of Courtenay has a wealth of natural areas that provide benefits and services to the public such as:

- Support public health with green spaces for recreation, relaxation and mental health.
- Trees and vegetation support and benefit air quality.
- Green spaces mitigate the heat island effect of development and provide natural cooling which reduces energy consumption and green house gas emissions.
- Trees and green spaces intercept rainfall and provide stormwater management services including:
    - Interception of rainfall by vegetation.
    - Infiltration or absorption of rainwater into the ground and feeding of groundwater to support other uses such as drinking water and irrigation and to provide slow exfiltration of groundwater into the creeks as baseflows through the summer months.
    - Attenuation of flows in natural ponding/storage areas.
    - Provide resiliency for increasing rainfall and runoff flows due to climate change.
    - Soil and vegetation support water quality in creeks and receiving waters through biofiltration.

Current Policies and Status

The City already has a tree protection bylaw to protect significant trees from unnecessary removal. The City also implements the provincial riparian area regulation (RAR), which protects riparian areas by designating minimum setbacks from streams and other waterways.

The minimum setback under RAR is 15 m, however a setback of 30 m is considered beneficial for protection of water quality, including summer temperature mitigation. The evaluation of the riparian corridor in Phase 2 of the IRMP was summarized in Section 5. It was noted that some watercourses have a higher percentage of impervious cover within the riparian corridor, and those watercourses represent opportunities for improvement in riparian integrity. The highest priority watercourses for riparian improvement were identified as:

- Brooklyn Creek,
- Courtenay River, and
- Glen Urquhart Creek.

Note that work within streams or redirection of creeks and streams is within the jurisdiction of the provincial and federal governments. The IRMP seeks to ensure compliance with these regulations.

Opportunities for Enhancement

The City should look for opportunities to enhance the riparian corridor for the creeks that are the most impacted by development. Brooklyn Creek has by far the highest proportion of impervious coverage in the riparian corridor, with Courtenay River and Glen Urquhart Creek being the runners up. The City should seek to restore the riparian corridor and should take advantage of any opportunities that arise to advance this work.

Where possible, fish barriers should be removed to improve fish access in the streams. The City should develop a plan to remove barriers to fish passage and increase the percentage of the waterways that are fish-bearing. The City should take advantage of any opportunities where upgrades or utility works are planned to advance this work.

8. Programs and Operational Updates

8.1. Promote Green Infrastructure to Mitigate Impacts of Development

Green infrastructure uses vegetation, soils, and engineered practices to mimic natural hydrologic and ecological functions as much as possible, with the purpose to manage wet weather impacts and create healthier urban environments by providing several environmental, economic, and health benefits. Green infrastructure can be designed to reduce negative impacts of development on runoff, for example, by providing flood protection, volume reduction, and pollution capture, as well as providing multiple other benefits such as groundwater recharge, runoff temperature reduction, heat island effect mitigation, CO_2 reduction, and biodiversity. Green infrastructure can vary in size and scope, from lot level to watershed scale, to offset impacts of development and climate change.

The important role of green infrastructure in creating a more sustainable community and improving the built environment is generally recognized. It is recommended that the City consider regulatory, funding and finance strategies and incentives to encourage developers to follow the vision of integrating green infrastructure in development and re-development areas, potentially exceeding bylaw requirements by addressing public realm runoff in addition to development impacts, including in major corridors. Strategies and incentives that could be investigated further include, but are not limited to:

- Stormwater fees or area-specific development cost charges dedicated to fund stormwater management, planning, and outreach activities within a specified area. This can be combined with reduced stormwater fees or charges in exchange for green infrastructure practices.
- Special assessment fees for new development in environmentally sensitive areas or land integral to the City's green infrastructure policy.
- Stormwater tax to support construction of stormwater management facilities and green infrastructure.
- Develop design guidance and standards for green infrastructure to clarify what is allowed, efficient, and best practice (see Future Work).
- Promote public and industry education on the benefits of green infrastructure, including benefits for treatment and removal 6-PPD Quinone and other contaminants that can harm fish.
- Encourage bio-engineering methods for bank stabilization and erosion remediation rather than riprap and consider including in the Supplementary Design Guidelines.

8.2. Allow for Off-Site Stormwater Management

In cases where full on-site stormwater management compliance is not achievable, the City may consider allowing property owners to achieve (a portion of) their obligation off-site. These off-site management facilities could be placed on adjacent private property provided by the developer, on adjacent public property (with sufficient lifecycle maintenance funding provided), on public property elsewhere, or on a third-party private property. If off-site stormwater management is used, this may reduce the developable area of the offsite property as the area of the off-site facility would be set aside and could not be developed. In all cases, it is important to ensure long-term operation and maintenance of facilities including providing the City access for long-term maintenance, and an operation and maintenance agreement is strongly recommended. The maintenance plan should lay out required maintenance activities and frequencies, documentation of maintenance and monitoring activities, assessment of facility performance and responsible parties for all maintenance activities.

Where stormwater management targets cannot be fully achieved on-lot, it must be recognized that the closest available space in which to manage the excess water is likely to be the adjacent road right-of-way. The City will need to specifically consider the use of the road right-of-way for stormwater management and whether that area may be allowed for such use, given that the roadway itself will require space for stormwater and rainwater management. This approach has been used in locations in the US. While maintenance and other concerns must also be considered, the road right-of-way provides the most immediately available space to implement off-site stormwater management.

In the cases where the off-site facility is on public land, the City would take ownership of and maintain it, through funding provided by the property owner(s). Some municipalities in BC charge a fee for properties where stormwater source control compliance is not achieved, and the funding is dedicated to stormwater management projects on public land. Off-site stormwater management on adjacent public property would use public rights-of-way such as streets or sidewalks for this purpose.

It is recommended that the City develop guidelines for allowing off-site stormwater management identifying situations and applications in which it could be allowed, as well as limitations for implementing off-site stormwater management.

8.3. Harmonize Maintenance Levels of Service for Green Infrastructure with Funding

As rainwater management BMPs are installed and the number of them increase, a discrepancy may develop between public expectations for landscaping aesthetics and the funding set aside for green infrastructure maintenance.

The City should determine and establish target levels of service for green infrastructure maintenance (both functional and aesthetic) and reconcile these service levels with maintenance funding. As time goes on, more green infrastructure systems are expected to be implemented as part of public spaces, therefore the cost of maintenance for green infrastructure will increase over time. The City will need to plan and budget for increasing funding and resources for maintenance accordingly. Going forward, it will be important to:

- Consult maintenance staff regarding preferences for the design of green infrastructure.
- Communicate with the public on the benefits of green infrastructure and how it will look in an as-maintained (not new) state.
- Allocate funding for maintenance based on service level targets.
- Ensure that increases to maintenance budgets keep pace with the implementation of green infrastructure occurring through development as well as retrofits to existing public space areas.
- Clarify that on-lot rainwater management and water quality BMPs are to be maintained by the property owner and at the owner's expense, as is already required by the City for oil-grit separators and detention facilities.
- Document and track, as part of asset management, covenants for construction and maintenance of all private on-lot stormwater facilities.

Recognizing Value of Green Stormwater Infrastructure and Best Management Practices

It is recommended the City establish maintenance service levels for green stormwater infrastructure and best management practices. Stormwater source controls are not merely an alternative form for provision of drainage services, and they should be supported and have funding and maintenance provided for the suite of services they provide to the City and the residents of Courtenay including:

- Stormwater management including conveyance.
- Water quality treatment to remove pollutants from runoff and prevent their discharge and accumulation in the receiving waters from the stream to the ocean, supporting:
  - clean water,
  - recreational water uses,
  - fisheries habitat and values, and
  - wildlife including waterfowl.
- Invasive plant species management.
- Flow and volume mitigation to reduce erosion and wear, and prevent the need for repairs, on receiving stream reaches.
- Resiliency against nuisance flooding from increased magnitude of storm events due to the changing climate.

- Temperature mitigation for runoff from pavement in the warm season to support cool water temperatures for fish habitat.
- Mitigation of the heat island effect of increasing summer air temperatures in paved urban areas by breaking up the pavement with green space and shade.
- Supporting plant, insect, and small bird biodiversity, including pollinator-friendly vegetation.
- Social and mental health benefits of green spaces for residents in the urban/suburban context.
- Reduction in CO_2 supporting the fight against climate change.
- Reducing air pollution and improving breathability in urban areas.

Public Education and Awareness

The process of developing this IRMP included consultation with City staff, stakeholder groups, and others at varying levels. Increasing the levels of communication both within the City between departments and between the City and the public would be beneficial. Increased communication and awareness of the City's efforts and programs that support watershed health would improve public confidence in the City's efforts and improve coordination between the City and stakeholder groups that have close ties to watershed health.

News Items and Notices

Education and outreach can take many forms. It is recommended that the City develop a public education program for residents. . Notice of success stories, completed projects, and issues resolved can provide positive feedback that the City is putting effort into good works and solving problems. It is recommended that the City develop a communication and education plan to support IRMP and watershed health initiatives as they are developed and put in place, and to remind the public about measures that have already been implemented. This would be a long-term, ongoing program of continued education and outreach, rather than a single campaign.

This approach could also be utilized to raise awareness when there are issues that may be of concern, but don't appear to warrant a regulatory response. For example, it has been raised in the past that mixtures of water and bleach (or other chemicals) may often be applied on the roofs of homes and businesses to kill moss. If the downspouts are directly connected to the stormwater system, the mixture of water and bleach would enter the stormwater system and be discharged directly into the stream. An informational notice or news item on the City's webpage could be used to raise awareness that this practice would harm fish and aquatic life and that non-chemical treatment of moss on roofs is preferred.

Funding and Collaborating with Stakeholder Groups

Streamkeepers and other environmental advocacy groups are very active in the City of Courtenay and have exhibited keen interest in the IRMP and its recommendations. The City can build on the relationships with these groups to develop and promote joint projects. Opportunities for joint projects include:

- Monitoring and sampling for watershed health and quality parameters – a collaborative program should be developed that links City and partner efforts and combines results to provide better and more comprehensive information in support of issues to be addressed.
- A 'citizen science' initiative to solicit public help and raise general awareness for specific issues.
- Public volunteer programs that can provide labour and cost-savings for implementation of restoration and enhancement projects, such as riparian planting, or removal of invasive or nuisance plant species.

In addition, the City may find support and collaboration with agencies, such as DFO, BC FLNRORD, BC MoE, BC MoAFF, and with other jurisdictions such as the City of Comox, and the Comox Valley Regional District, to pursue restoration and enhancement work, as well as coordinate on policies and work toward common goals and benefits.

Educational Signage

Educational signage and kiosks in public areas can raise awareness of the benefits of natural features and systems as well as highlight projects that the City has done. In particular, signage that explains the mutual benefits of natural systems and mimicking natural hydrologic benefits with flood and rainwater management can increase the public perception of the links and benefits of these types of systems. Green infrastructure systems in particular can benefit from education signage as the public may not otherwise be aware that they are highly designed systems that provide multiple benefits and require maintenance and protection to remain effective. It is recommended that the City allocate funding to install educational signage in association with significant public stormwater projects, including green infrastructure projects.

9. Recommended Future Work

9.1. Rainwater Management Guidance or Standards

To facilitate the implementation of rainwater management within the City of Courtenay, it is recommended that the City develop guidance or standards for design, construction and maintenance of rainwater management BMPs within the City. This guidance could take the form of a less formal guideline document to be provided to designers, or it could take the form of standards to be added to the supplementary schedules of the Subdivision and Servicing Bylaw.

The guidance should provide information on the City's expectations for how rainwater management facilities should be designed and should operate. This would support the design of functional rainwater management facilities and reduce the burden of effort for designers trying to meet the City's targets, as well as provide clear expectations for design that should streamline City review processes for rainwater management facilities as part of development.

Among considerations for the guidance should be:

- Preferred types of BMPs, and preferred types of water quality treatment BMPs.
- Aspects of design the City requires for each type of BMP.
- Expectation for hydrogeological or geotechnical testing to support design.
- Minimum requirements for any specific land uses, e.g., for individual development of single-family lots, the minimum requirement could be similar to that in the Town of Comox Runoff Control Bylaw:
    - Maximum 60% impervious coverage of the lot.
    - Roof leader disconnection and impervious surfaces graded to drain to landscaped areas.
    - Minimum 300 mm depth of topsoil of minimum hydraulic conductivity on all pervious areas of the lot.
- Require that drawings be accompanied by a basis of design memorandum that describes the targets that the system is designed for, and the methods and calculations that show how the design meets those targets.
- Require that an Operation and Maintenance Plan be developed and provided to the City with the design for each BMP or type of BMP.

- Design details to improve performance, such as:
  - Green infrastructure/source controls for management of road runoff should provide treatment of runoff in addition to capture.
  - Rain gardens should be designed to provide ponding up to an acceptable limit in order to maximize infiltration capture, with raised outlets for overflow above that ponding limit.
  - Note that the locations of overflow outlets should be located as far as is practical from the inlets.
  - Note that rain gardens should incorporate pre-treatment for management of coarse sediment, considering ease of access and use of existing municipal equipment.

9.2. Detailed Detention Facility Assessment

While detention ponds were included in the City-wide modelling to the extent possible at the time, further study is required to understand the performance of existing detention facilities. it is recommended that the City perform detailed assessment of individual facilities where performance may be a concern.. The information available for the City-wide modelling varied, but was often missing details such as:

- Stage-storage information for pond volume, particularly when this may have changed over time due to sediment accumulation.
- Outlet hydraulic details or design release rate flows.
- Operational details for outlets with gates or variable height weirs.
- Hydraulic details or information on erosion and susceptibility in receiving channels or creeks below ponds.
- Recorded flows or water elevations for ponds to calibrate models.

For particular ponds where downstream concerns have been identified, detailed study and assessment may be warranted to better understand the impacts of the ponds and to develop options for improvement of pond performance. With detailed study of a pond's performance, if the performance falls short of current requirements or other measures of performance, options for performance improvement can be developed and tested in the model such as:

1. **Outlet modification:** Facilities that have adequate volume but have estimated water levels that exceed their design water levels by more than 10 cm could undergo outlet modifications to drop peak water levels to a more desirable peak. Outlet modifications can also be performed to prevent water levels exceeding a facility's banks but that could entail large modifications. Before any outlet modifications take place, it is recommended that a pre-development release rate be established at every facility to determine if an outlet or weir can be enlarged to reduce peak water levels and still keep the facility within the desired pre-development release rate range.

Or, if the concern is the downstream flow rates, the outlet could be modified to provide better control of pond releases. This could be done by reducing the outlet size and flow rate, or introducing a graduated outflow, such as with a compound weir or a curved v-notch weir.

2. **Increase the detention volume:** A detailed detention facility study should be undertaken to determine if a pond may need detention volume expansion to detain the required design storms. Increasing the detention volume would preserve the current estimated release rates in the facilities, however, it may be difficult to find the space needed to add detention volume in built-out areas.
3. **Apply stricter criteria elsewhere**: If an existing detention facility is identified as underperforming compared to current design criteria, it may be possible to use stricter criteria for the design of future facilities in the same catchment area to offset the performance gap. Essentially, development upstream or nearby in the same catchment could overcompensate to release at lower rates or further reduce runoff beyond what is already established. Further modelling of the combined catchments and detention would be needed to ascertain the volumes needed at alternative locations to achieve the desired detention. Negotiation with developers may need to be considered to achieve this in future development.

10. Monitoring and Adaptive Management

10.1. Monitoring Plan

Monitoring of watersheds to understand the changes and trends in watershed health indicators is critical to ongoing management of the factors that impact watershed health. It is best practice for that all municipalities monitor stormwater to assess and report on the effectiveness of IRMP implementation. To support this need, Metro Vancouver and its member municipalities, in consultation with the province of British Columbia, have developed a Monitoring and Adaptive Management Framework for Stormwater (MAMF) (Metro Vancouver, 2014). The MAMF 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 Metro Vancouver MAMF represents the best available guidance in the province at this time for watershed health monitoring metrics and protocols.

The MAMF provides direction on the general types of monitoring to be utilized for higher gradient, lower gradient, and piped systems (see Table 10-1), the methods and parameters to be used for monitoring, and the reporting required.

Table 10-1: Standard MAMF Monitoring Program Elements Based on Stream Type

Stream Type	Water Quality	Hydrometric	Benthic Invertebrate
Lower Gradient	Yes	Yes (natural channels only)	No
Higher Gradient	Yes	Yes	Yes
Piped Systems	Yes	No	No

Based on the MAMF, all of the creeks within the City are classified as higher gradient streams (average channel slope >1%). Therefore, monitoring and performance indicators to be included in the program include those for water quality, flows and benthic invertebrates.

Monitoring Framework

The recommended monitoring framework for the IRMP includes monitoring and tracking of multiple parameters and metrics in order to be able to assess and understand changes in the watershed conditions over time.

Flow Monitoring

It is recommended that the City select specific catchments for repeat flow monitoring to periodically analyze changes in the flow regime. The priority catchments should be those, or a portion of those, that are identified as priorities for rainwater management improvement, as shown in Figure 4-1. It is likely that the extent of the monitoring will be limited by available budget, and the locations for monitoring should be selected based on priority of the catchments and the recurring available funding that is allocated. The exact locations for installing monitoring should be selected in conjunction with the monitoring provider, with the goal of establishing locations where monitoring captures a majority of the catchment flows and is in a location that can be repeatedly monitored.

The flow monitoring should be implemented on a recurring schedule of every 2 – 5 years for each selected location. Equipment may be swapped between locations to obtain flow records for different locations in different years, if desired, which reduces the amount of equipment needed, but increases the labor for installation and recovery of the equipment for each monitoring year.

The minimum length of record for each monitoring period should be 6 months from September through February, in order to capture the low flows and the high flows in that year. This period typically contains both those flow regimes, however different years do have different rainfall patterns and a longer recording period would allow for capture of flows in non-typical years.

Water Quality Monitoring

Water quality monitoring is recommended to be repeated on an ongoing basis to understand changes in water quality in the receiving streams. At a minimum, a 5-year recurring monitoring program is recommended to sample and monitor the water quality parameters based on the provincially approved Metro Vancouver MAMF sampling protocol, as noted in the 2021 sampling program. This would track changes in water quality over time for the receiving watercourses. As noted in Section 8.3, water quality monitoring may be an opportunity to collaborate with streamkeepers and other stakeholders to create a joint City and stakeholder monitoring program. Recommended watercourses for water quality monitoring include:

- Tsolum River
- Puntledge River
- Morrison Creek
- Courtenay River
- Piercy Creek
- Glen Urquhart Creek
- Mallard Creek
- Brooklyn Creek
- Little River

Water quality in Little River has not previously been monitored. Land use in the watershed is mainly agricultural and rural residential. In the IRMP Phase 2 report, it was noted that the Little River watershed has "some of the largest future development potential within the City". Before development begins, it is recommended to determine baseline water quality so that potential changes in watershed health can be tracked over time.

A combination of *in situ* measurements and water samples for laboratory analysis are recommended for monitoring at each sampling location. Water quality parameters are summarized in Table 10-2.

Table 10-2: Water Quality Parameters for Monitoring

In situ measurements	Laboratory analysis
pH	Nitrogen as Nitrate
Water temperature	*E. coli*
Conductivity	Fecal Coliforms
Dissolved oxygen (DO)	Total cadmium
Turbidity	Total copper
	Total iron
	Total lead
	Total zinc

The monitored parameters should be reviewed in comparison to the MAMF assessment levels as to whether the monitored values indicate that there are concerns for watercourse and aquatic health. Table 10-3 summarizes the MAMF assessment levels and classification.

Table 10-3: Classification of Water Quality Results (Metro Vancouver AMF Evaluation System)

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 (wet season) (°C)	7 to 12	5 to <7 or >12 to 14	<5 or >14
Conductivity (mS/cm)	<0.050	0.050-0.200	>0.200
Turbidity (NTU)	0 to 5	5 to 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 201-1000	Geomean >1000
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

Monitoring Timeline

Note that the collection of data on the catchment performance and watershed health indicators should be conducted *at a minimum* once every five years and should continue once every five years. More frequent monitoring is beneficial for understanding changes in monitored parameters. Collaboration with community groups such as streamkeepers can be beneficial for collecting and sharing data to supplement IRMP monitoring and develop a more robust dataset of monitored parameters.

It is expected the IRMP will be revisited and updated periodically; Metro Vancouver municipalities, as an example, commit to a 12 year cycle for reviewing and updating their ISMPs, though the implementation of reviews and updates appears to be occurring at a slower rate for many municipalities. A 15 year cycle may be a reasonable target for re-assessing and renewing the IRMP.

Data Collection and Tracking Opportunities

The City may also wish to consider implementing a program to track and aggregate infiltration testing results within the City's GIS system. Testing results should be provided for individual developments to support design of rainwater management BMPs, and the City could develop a system for retaining and mapping this information. This would internally support the City's understanding of the spatial variation and distribution of tested infiltration rates across the City, which would in turn support the City's implementation of rainwater management though better understanding for design and expectations of performance.

Stakeholders have indicated that they have various sampling and testing initiatives across the City's watersheds and are willing to share that information with the City. The City could consider setting up a database of this information in a spatial format in order to document and track sampling efforts. The City could also choose to coordinate with stakeholder groups to pursue sampling, in particular if there are areas of concern that stakeholders bring forward as areas that need monitoring and potential follow-up for identified or suspected concerns.

Additional Water Quality Monitoring and Improvement

The proposed monitoring plan is in accordance with goals of the IRMP and is focused on monitoring catchment performance and stream health using typical parameters. Should the City choose to do so, there are other possibilities for water quality monitoring to expand the understanding of the quality of stormwater runoff before it reaches the creeks.

In-pipe or end-of-pipe monitoring – The City could conduct in-pipe or end-of-pipe monitoring to assess the quality of stormwater runoff, as opposed to the ambient conditions in the receiving streams. Similar sampling was completed in 2018 for Phase 2 of the IRMP.

This sampling could assist with designing water quality treatment facilities, either for green infrastructure or for grey infrastructure treatment, by developing TSS loading and particle distribution curves to support design, as well as determining mass loading and concentrations. Or testing could be used to track down the locations where particular contaminants of concern are coming from in order to target those sources for treatment and water quality improvement. This testing could be implemented on an as-needed basis, or if an ongoing program is desired there may be opportunities for the City to partner with stakeholder organizations to sample and track problematic locations in order to pursue mitigation of the concerns.

Operationalization of water quality testing – While water quality testing as part of the 5-year IRMP monitoring cycle is sufficient to track long-term trends, it provides only an intermittent snapshot of the water quality in receiving waters. In order to more fully document and understand the seasonal variations and target mitigations to locations and sources where they can help, additional testing would be beneficial. The City could consider setting aside a recurring budget for testing of confirmed or suspected problem areas, with the intent of understanding seasonal issues and narrowing down areas where treatment facilities could improve water quality. The recurring budget could be used to help 'solve' individual identified problems so that beneficial mitigation can be implemented.

10.2. Adaptive Management Program

Maintaining and enhancing the ecological health of a watershed is best achieved through adaptive management. Using an adaptive management approach for IRMP implementation allows for regular feedback on the effectiveness of measures recommended in the IRMP such that informed decisions can be made about future measures based on whether watershed goals are being achieved. In cases where existing measures are not achieving results, changes can be made to improve their effectiveness, or new measures can be taken. Monitoring also allows assessment of progress towards the plan's goal and reporting to decision-makers, stakeholders, and the public. Adaptive management is also recommended to ensure mitigation of development impacts and improvements in watershed health are achieved in the most cost-effective manner.

Adaptive Management Practices (AMPs) are measures taken to mitigate the impacts of land development on watershed health. These include measures under a variety of functional categories such as rainwater source control BMPs, runoff detention, rainwater infiltration facilities, runoff pollution control, runoff treatment, outreach and education, and mitigation of construction impacts.

The iterative process of carefully collecting, analyzing, and interpreting data will allow for the effectiveness of these AMPs to be assessed, and if not achieving the desired results, to change measures, or to target different priority areas. The process requires proper planning but also flexibility, as stormwater management practices and knowledge evolve over time and new technologies become accessible.

The basis for adaptive management is long-term monitoring of the indicators listed in the proposed monitoring plan described above. If the monitoring results indicate issues or reductions in aquatic health or catchment performance, previously implemented AMPs should be re-evaluated or new, more appropriate AMPs should be implemented to mitigate the problem.

Analysis of monitoring data should occur on a regular basis. The indicators selected in the monitoring program do not all have to move in a particular direction to show improvement or degradation in watershed health; a negative trend for one indicator should be followed-up, to better understand the results, what is driving them, and whether additional testing and/or mitigation measures are needed.

The full suite of indicators should be reviewed in regular cycles to:

- note changes or trends in particular indicators,
- evaluate possible causes of those changes,
- determine if changes in the indicators represent an impact,
- evaluate if observed changes are expected or unforeseen, and
- review the goals, elements, and implementation plan of the IRMP to assess if changes should be made to the plan to remain on track and achieve the overall stormwater goals over the implementation timeline for the IRMP.

The collection of data and its full review for the catchment performance and watershed health indicators should be conducted a minimum of once every five years.

Adaptive management should prioritize issues arising from the water quality and catchment performance in all systems monitored and then schedule measures to address the highest priority issues first. Phasing adaptive management actions will also help to keep costs manageable.

Adaptive Management for the First Five Years

The primary focus for adaptive management for the first five years after completion of the IRMP will be to:

- Set up tracking systems for metrics that are not currently tracked.
- Further investigate concerns and issues identified in 2018 and 2020 monitoring and baseline analysis, such as impaired water quality and river flooding.
- Evaluate trends of metrics at the end of five years (compare to IRMP as baseline) report card information gathered) and assess whether results indicate that:
    - trends are in the desired directions'
    - issues and concerns have been mitigated or improved, and
    - revised mitigation or management approaches are needed.

The review and evaluation of trends and issues at the end of the first five years should then be used to set the priorities for the next five years of monitoring, review of data, and adaptation of programs and policies.

11. Implementation Plan for Recommendations

Multiple sections in this report include recommendations. This section summarizes the recommendations in one place, along with recommended timelines and estimated costs for implementation.

Note that most costs shown are meant to be indicative, and the only costs that have been methodically estimated are those for the capital upgrade program. Many recommendations are expected to be pursued using existing staff and resources, and no additional costs are indicated for those recommendations.

As this is meant to be a summary only, references are made to sections of the report for context and more information for the recommendations.

Table 11-1: Implementation Plan for IRMP Recommendations

	Recommendation	Timeline	Cost
Capital Upgrade Plan for Storm Sewers			
1	The capital plan for the IRMP includes prioritized and costed upgrades for trunk sewer infrastructure identified for the near and medium term, 1 to 10 years in the future (Section 5 and Appendix G). Note: The allocation of funding for upgrades will impact the timing and progress of upgrade completion and the program timing may need to be reviewed or adjusted in the future. As noted above, the estimated costs for capital upgrades are based on 2022 cost data, and the level of uncertainty in the costing should be assumed to increase as time passes due to the volatility in construction and infrastructure supply markets.		
	Priority 1: Capital Upgrades	1-2 Years	$3,419,000
	Priority 2: Capital Upgrades	3-5 Years	$5,720,000
	Priority 3: Capital Upgrades	6-10 Years	$8,584,000
2	Explore additional and alternative funding sources for storm system upgrades (Section 6):		
a	Review existing funding options, including DCCs for areas where development is occurring, and combining infrastructure upgrades, such as storm pipes with road or water main upgrades, to reduce costs.	Immediate	Existing resources
b	Increase funding for storm drainage operation and capital projects for the short term to start to bridge the gap in funding and system renewals and upgrades. Consider a ramp up of increasing fees for stormwater if the full increase per property is not considered to be acceptable for a single-year increase to property taxes. Start to bring the storm system into alignment with long-term system operation and service goals.	1-3 Years	Existing staff and council resources

	Recommendation	Timeline	Cost
c	Investigate infrastructure grant opportunities to fund critical upgrades, multiple-benefit projects, and others that fit grant program parameters.	1 – 10 Years	Existing Resources
d	Review whether a formalised stormwater utility is a good fit for the long term and, if so, pursue setup.	4 – 10 Years	$200,000
Updates to Subdivision and Development Servicing Bylaw 2919 (2018)			
3	Update the 100-year return period design IDF curve to incorporate 95th percentile climate change increase in rainfall to be more conservative in the design of major system infrastructure (Section 3.1 and Appendix J).	1-2 Years	Existing Resources
4	Update the City's Supplementary Design Guidelines, Section 4, to create Section 4.3.4 Rainwater Management (Section 7.1):	1-3 Years	$100,000
a	Add requirement that all new and re-development is required to provide on-site rainwater management to capture and infiltrate 42 mm or rainfall in 24 hours.	1-2 Years	Existing Resources
b	Note infiltration exceptions. E.g., if the site is located over bedrock that does not infiltrate or if there is an identified geotechnical hazard (desktop study required, at a minimum, to identify potential hazard areas and considerations), such as an embankment, that infiltration should be separated from.	1-2 Years	Existing Resources & $50,000
c	Determine acceptable approach for infill single family residential lots (single lot development or re-development) and specify in this section. Explore the option of, disconnecting roof leaders from the storm system. If roof leader disconnection is pursued, then the City's Building bylaw would also require updating to allow disconnection.	1-4 Years	$50,000
d	Add requirement for all lots to incorporate minimum 300 mm of absorbent topsoil on all restored vegetated areas (lawns and shallow garden areas) of the lot.	Coord. w/ (4c)	Coord. w/ (4c)
e	Add a reference to a guideline or standards for rainwater management system design. Initially this should be an available guideline, such as the Metro Vancouver Stormwater Source Control Design Guidelines, but this should be updated to City-specific guidance or standards if and when they are developed (See #13, below).	1-2 Years	Existing Resources

	Recommendation	Timeline	Cost
5	Update the City's Supplementary Design Guidelines, Section 4.11.8, to be called Water Quality Treatment and add water quality requirements (Section 7.1):	1-2 Years	Existing Resources
a	Water quality treatment must be provided to treat the runoff of the rainwater capture target, i.e. 42 mm in 24 hours, to remove 80% of inflow TSS by mass from runoff from vehicle-accessible impervious surfaces such as roads, lanes, and parking areas, with rain gardens and bioswales preferred for treatment of road runoff to remove 6-PPD Quinone.	As Part of (5)	As Part of (5)
b	Note that water quality treatment and volume capture can be combined in the same facility when the target volume is routed to an infiltration rain garden (bioretention) or bioswale that both treats and infiltrates the target volume.	As Part of (5)	As Part of (5)
	Protect and Enhance Environmental Values		
6	Look for opportunities to expand and revegetate riparian areas when possible, whether by negotiating additional setback, acquiring public rights-of-way, or improving publicly owned properties (Section 7.2).	1 – 10 Years, and Beyond	Dependent on Acquisition or Enhancement
7	Build on infrastructure projects, when possible, to improve environmental conditions such as fish passage (Section 7.2):		
a	Fish barriers were identified in Phase 2 IRMP (see Appendix L). Note: Fish bearing streams in the Phase 2 report have a calculated "% fish bearing", which indicates the fraction of the stream length that is accessible to fish. Streams with lower % fish bearing length and streams with high value habitat should be prioritized for improvements to fish accessibility by removal of fish barriers when there is an opportunity to do so.	1 – 10 Years, and Beyond	Incremental Increase in Cost when done as part of pipe upgrades
	Programs and Operational Updates		
8	Promote green infrastructure to mitigate impacts of development and investigate methods of supporting green infrastructure implementation including (Section 8.1):		
a	Develop area-specific development cost charges dedicated to fund stormwater management, planning, and outreach activities within a specified area. This can be combined with reduced stormwater fees or charges in exchange for green infrastructure practices. External support for study likely needed to identify areas and develop costs.	4-10 Years, Coord w/ (2e)	Existing Resources and ~$85,000

	Recommendation	Timeline	Cost
b	Consider special assessment fees for new development in environmentally sensitive areas or land integral to the City's green infrastructure policy. Requires additional external consultant support to build on work completed in Phase 2 of IRMP.	4-10 Years, Coord w/ (2e)	$50,000 - $70,000
c	Allocate funds and staff time specifically to support construction of stormwater management facilities and green infrastructure. This would be in addition to funds for upgrades and maintenance of the existing system.	2-10 Years	Existing Resources; may need External Support
d	Develop design guidance and standards for green infrastructure to clarify what is allowed, efficient, and best practice (see Section 9). Develop internal processes to review, inspect, approve, and track green infrastructure installations.	2-5 Years	Existing Resources and New Staff for Internal Processes
e	Encourage bio-engineering methods for bank stabilization and erosion remediation rather than riprap and consider including in the Supplementary Design Guidelines.	2-5 Years	Existing Resources
9	Develop a plan for allowing off-site stormwater management for development on public land (Section 8.2) as a way to maximize the rainwater management mitigation for sites in constrained situations.		
a	Consult internally with staff on risks and concerns for implementation of off-site stormwater management.	1-4 Years	Existing Resources
b	Identify situations and applications when off-site stormwater management would be acceptable, and limitations when it would not be acceptable. May require external consultant support on technical specifics and limitations.	1-4 Years	Existing Resources; Potential Consultant
10	Consult internally and externally and develop long-term plan for maintenance of green infrastructure over time as implementation on public property increases maintenance needs and workload (Section 8.3). Plan to build City capacity over the long term.	2-5 Years (planning) Ongoing (implementati on)	Existing and New Internal Resources
11	Develop communication and outreach in support of IRMP and green infrastructure programs (Section 8.3):		
a	Develop a long-term communications plan for releasing new information on stormwater and rainwater management and related City initiatives and for reminding the public about existing programs and initiatives to raise and maintain awareness of the City's work on these issues and its importance for watershed health.	1-2 Years and Ongoing	Existing Resources

	Recommendation	Timeline	Cost
b	Develop programs and funding for collaboration with streamkeepers and other environmental advocacy groups.	1-5 Years	Existing Resources and Grant Funding
c	Assess the feasibility of partnering with volunteer groups such as streamkeepers for monitoring and environmental enhancement projects.	1-5 Years	Existing Resources
d	Promote existing and new stormwater and rainwater management facilities and inform the public how they contribute to watershed health with signage to inform and engage the public with in-situ installation.	1-2 Years and Ongoing	Existing Resources
Plan and Fund Future Work Needed to Support the IRMP Goals and Desired Outcomes			
12	Develop City-specific rainwater management guidance or standards to facilitate implementation of rainwater management in accordance with recommended rainwater management targets. The guidance would support the design of functional rainwater management facilities and reduce the burden of effort for designers trying to meet the City's targets. Guidance would also streamline the City review processes for rainwater management facilities to reduce the burden of effort on the City staff. Includes internal and external consultation. (Section 9.1).	2-5 Years	$100,000+
13	Detailed assessment of detention pond capacities to better understand the level of detention performance provided by existing ponds in current conditions in comparison to the City's detention performance requirements and if there are gaps in detention capacity or controls that need to be and can be improved. Assessment may be limited to ponds with reported or suspected shortfalls in operational performance. Options for improving performance or making up for a gap in performance can be assessed for individual locations to extent needed to address concerns. (Section 9.2).	1-4 Years	$50,000-$75,000
Monitoring and Adaptive Management to Keep the IRMP On Track			
14	Implement a monitoring plan for long-term monitoring of watershed health and other key performance indicators (Section 10.1). The monitoring plan is based on the provincially approved Metro Vancouver Monitoring and Adaptive Management Framework (MAMF).		
a	Flow monitoring in priority catchments on a recurring basis every 2 to 5 years. Costs can vary widely, estimate of costs is on an annual basis for range of monitoring.	1-5 Year (Recurring)	$10,000 to 50,000
b	Water quality monitoring of receiving watercourses on a minimum 5 year cycle. Can be implemented across the City on a rotational basis to annualize the work and costs.	5 Year Cycle (Recurring)	$25,000 to $50,000

	Recommendation	Timeline	Cost
c	Development of systems for tracking spatial data on rainwater management facilities installed, soil infiltration testing locations and results, and data from stakeholder collaborations.	1-5 Years	Existing Resources
d	Additional water quality monitoring in-pipe or at end of pipe to understand stormwater discharge quality could be added to the monitoring; allocating annual operational budget for monitoring may smooth the process over the long term.	Similar to (14b)	$25,000
15	Implement adaptive management to review monitoring results and progress on IRMP tasks on a recurring basis at least once every 5 years (Section 10.2)		
a	Review tracking, data, and trends to understand changes in receiving water systems and health, and to understand progress and changes toward implementation of IRMP objectives. Likely requires external support for initial analysis, could be taken on by staff for subsequent analysis if desired.	5-10 Year (Recurring)	$10,000 to 50,000
b	If adverse trends in watershed health are observed in the monitoring data, review the mitigations and level of implementation, and assess what changes should be made to address the issue(s) and change the adverse trends.	5-10 Year (Recurring)	Existing Resources; Potential External Support

12. References

Booth, D. (2000). Forest Cover, Impervious Surface Area, and the Mitigation of Development Impacts in King County, Washinton.

Booth, D. B. (1997). Urbanization of Aquatic Systems-- Degredation Thresholds, Stormwater Detention and the Limits of Mitigation. *Journal of the American Water Resources Association, Vol. 22, No. 5 (October)*.

CWP, t. C. (2002). Is Impervious Cover Still Important? *Runoff Rundown*.

GVRD, G. V. (1999). *Assessment of Current & Future GVS&DD Watershed and Catchment Conditions.* Vancouver, BC: Greater Vancouver Sewerage and Drainage District.

Horner, R. B. (1997). Watershed Determinates of Ecosystem Functioning. *Effects of Watershed Development and Management on Aquatic Ecosystems, L.A. Roesner, Editor*.

Schueler. (1994). The Importance of Imperviousness. *Watershed Protection Techniques*, 100-111.

Metro Vancouver (September 2014) *Monitoring and Adaptive Management Framework for Stormwater*. Integrated Liquid Waste and Resource Management, A Liquid Waste Management Plan for the Greater Vancouver Sewerage & Drainage District and Member Municipalities.

Ministry of Land, Water and Air Protection (May, 2002). *Stormwater Planning: A Guidebook for British Columbia*.

13. Report Submission

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Revision History

Revision #	Date	Status	Revision	Author
0	July 31, 2024	Final		LM

City of
Courtenay