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Appendix B

Catchment Rainwater Management Performance Assessment

Appendix B – Catchment Performance

B.1 Introduction

The City of Courtenay seeks to manage stormwater more effectively by implementing an integrated rainwater management plan (IRMP) that is aligned with the best management practices described in Stormwater Planning: A Guidebook for British Columbia. Specifically, the City of Courtenay seeks to manage stormwater in a way that reduces erosion, minimizes downstream flooding, protects aquatic ecosystems, and recharges groundwater resources.

The City of Courtenay currently manages most stormwater using a conventional conveyance network with discharge to receiving streams. A few site specific rainwater source control projects have been implemented to demonstrate alternative methods to manage stormwater.

The goal of the City's IRMP is to enable a transition to managing stormwater using an integrated rainwater approach. The City initiated development of the integrated rainwater management plan in 2018. The work plan was organized into three phases, and the first two phases were completed.

This phase of the IRMP, Phase 3, builds on the work completed in the first two phases of the integrated rainwater management plan.

B.2 Rainwater Management for Watershed Health

BC Stormwater Guidebook Objectives

As part of developing an Integrated Rainwater management Strategy, the City wants to understand the current performance of the City's catchments for rainwater management.

The 2002 Stormwater Planning: A Guidebook for British Columbia, describes clear 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.

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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. And in the biophysical objectives is the target of limiting the impervious area in the water shed. 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 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 the table below:

Table 2-1: 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 directly-connected impervious area, and that areas which are disconnected and allow runoff from impervious surfaces to infiltrate into the ground do not have the same impacts. 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 management is used. EIA is not the same as TIA, and strictly

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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). However, EIA represents the best estimate available of the benefit, and reduction of the impacts of impervious coverage, of disconnecting and mitigating impervious area in a watershed.

Understanding Catchment Rainwater Management Performance

In order to monitor and track changes in the catchment rainwater management, the City needs an understanding of the current rainwater management performance of the lands within the City boundary, to set an initial baseline for understanding future changes, whether positive or negative.

As noted above, the most relevant hydrology metric is 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. While we can measure aspects of the hydrologic performance of an area, determining the EIA is problematic as there are seasonal and other factors that are difficult aggregate data on to complete the understanding of the hydrologic processes at work to produce a net effect. Therefore, this IRMP looks as 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 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 development.

For the City of Courtenay, both volume and rate control are assessed and considered using available data and tools to gain understanding of the current rainwater management performance of areas within the City.

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B.3 Runoff Volume Assessment

Monitored Flow and Rainfall Data

The City monitored and collected flow data for a period of 6.5 months from December 2018 through Mid-June 2019 at 12 in-pipe flow sites, along with 2 rainfall gauge locations. The data from this monitoring was retrieved from the vendor's website, www.flowmonitoring.net. Both flow and rain data are reported at 5 minute intervals.

The rainfall gauges were located so that one was in East Courtenay (Rain 1), and one in West Courtenay (Rain 2). According to the data record all sites were assigned to Rain 2, even if they were located in East Courtenay. It is not clear if this is due to simply an initial assignment, or if there were concerns about the Rain 1 data record. Both gauges recorded similar rainfall patterns of events, however there were differences in the amounts recorded for each gauge, and some small events were recorded at only one of the gauges. The recorded rainfall hyetographs are shown below in Figures 1 and 2.

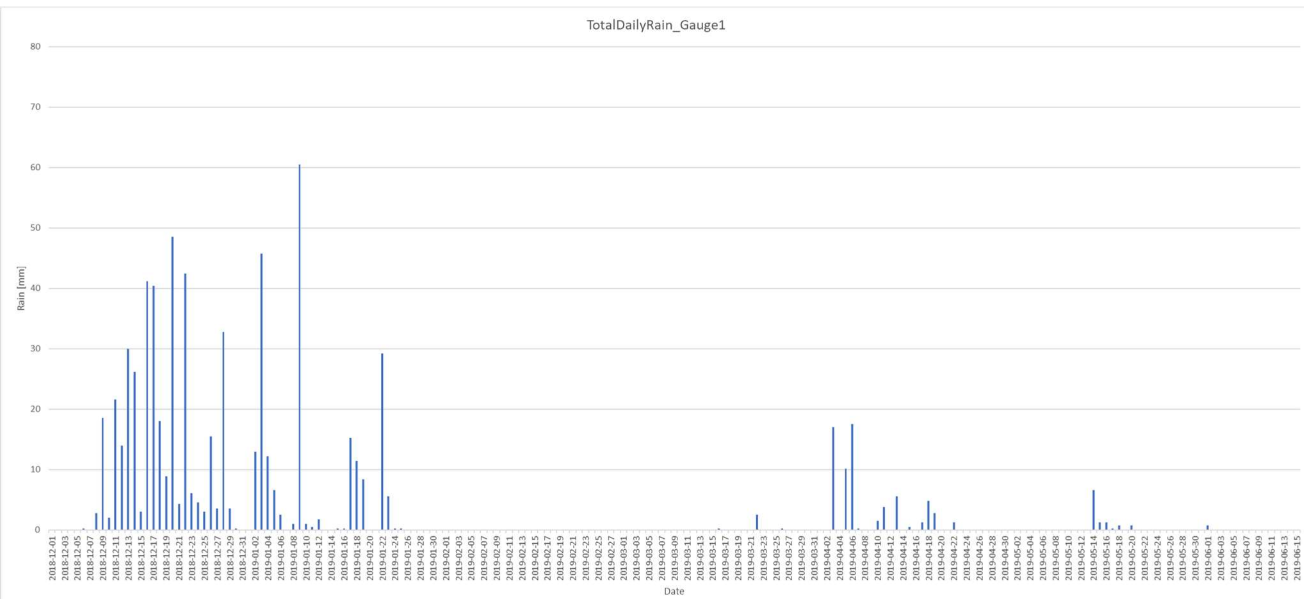

Figure 1: Recorded Rainfall Hyetograph for Rain 1 Gauge

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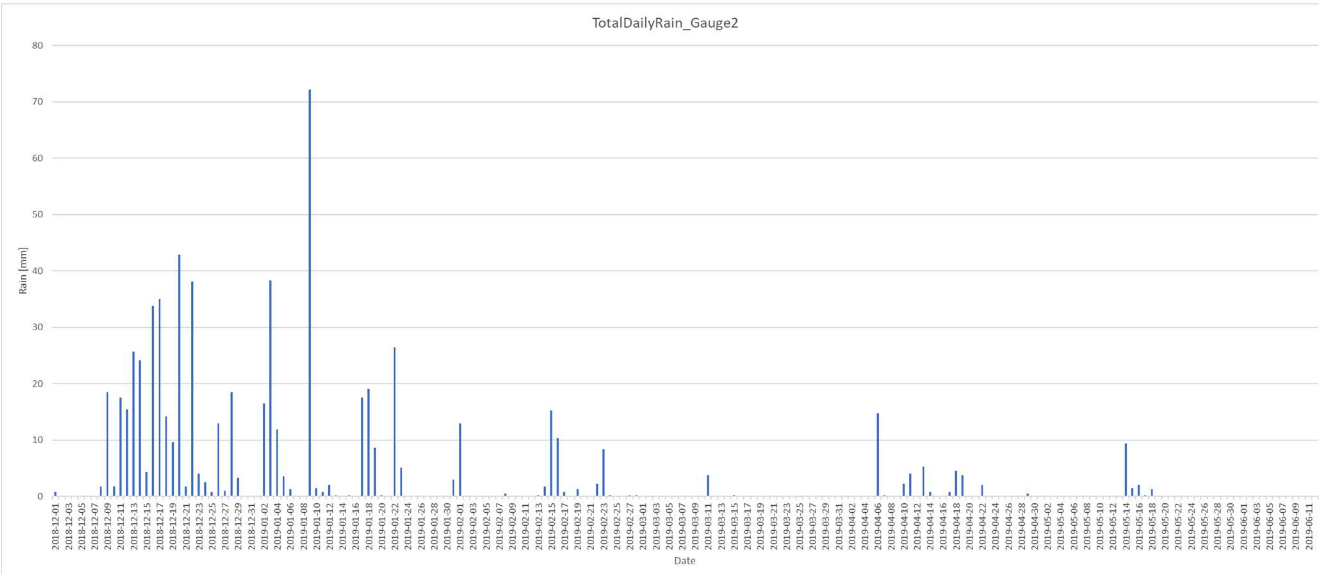

Figure 2: Recorded Rainfall Hyetograph for Rain 2 Gauge

Selection of Storm Event

The rainfall data from both gauges was analyzed to determine if a significant rainfall event could be identified in the rainfall record. Ideally, the event would be the equivalent of the 6-month storm, equating to approximately 53 mm within a 24-hour period, and occur in isolation from other events, without any rainfall for a few days before and after the 24-hour event. This separation from other rain events would allow us to see the flow resulting from the event in the flow record as a single event, rather than overlapping events. However, given that the flow monitoring occurred during winter conditions, a few days of dry weather is not enough for the flow resulting from the event to entirely isolated. Some flow during the event represents shallow groundwater flow. A catchment that is capable of capturing the 6-month 24-hour dry initial condition event is considered to also be able to capture approximately 90% of the average annual rainfall. In a forested natural landscape, this captured rainfall does not runoff to the receiving streams and instead enters as groundwater flow.

One large storm event was identified, occurring on January 9, 2019, with a duration very close to 24 hours and with a total rainfall of 60 mm at the Rain 1 gauge and 72 mm at the Rain 2 gauge. This amount exceeds the 6-month storm event, and is close to a 2-year rainfall event at the Rain 2 gauge. While two 24 hour events were identified with 40-45 mm rainfall in a 24 hour period in the data set, these occurred in close proximity to other rainfall events, making it impossible to differentiate these events from adjacent events in the flow record as the recorded flow hydrographs show that storm events have a 2-5 day ‘tail’ of receding flow as the flow returns to baseflow levels. Figure 3 shows the recorded flow hydrograph at one of the sites with the baseflow flow rate indicated. Appendix A shows the flow hydrographs at all the sites.

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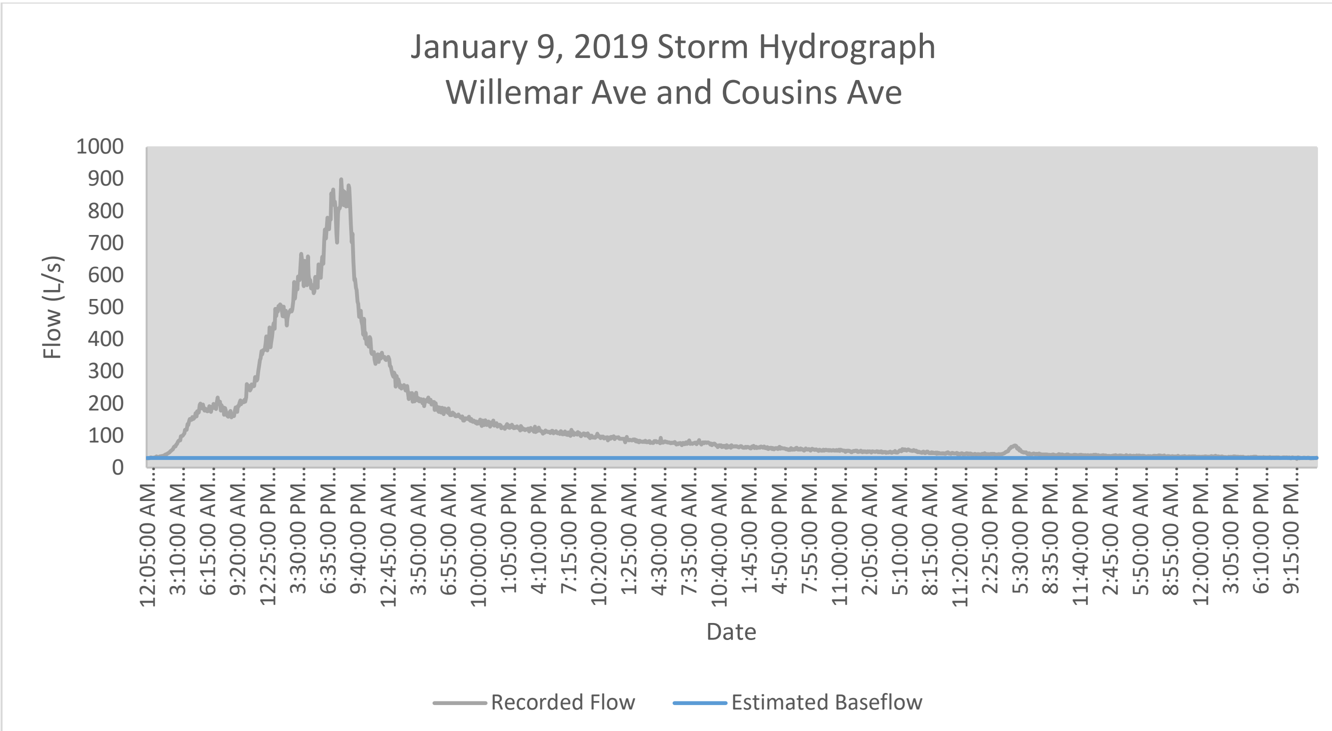

Figure 3: Example Flow Hydrograph for Target Event Showing Estimated Baseflow

As the January 9, 2019 2-year event represents an isolated event that is easily differentiable in the flow record, it was chosen for analysis even though it is larger than the desired 6-month return period event and even though it is not a dry initial condition event. Furthermore, it appears that there were some negative temperature lows in the days preceding, and the day of, the event. There may have been some snow accumulation and melt during the event. While not an ideal event for analysis, as the largest event that is separable from others in the data set it is the best available from the record.

Runoff Volume Analysis

A period beginning at midnight on the morning of January 9, 2019 and extending for 5 days, through January 14, 2019, was selected in all of the flow station records for volume analysis. For each flow station, the baseflow was established by visual assessment of the flow hydrograph. That baseflow amount was subtracted from the flow hydrograph for each location, leaving the volume under the resulting hydrograph curve representing the runoff from the storm event. The volume under the curve was calculated based on the 5-minute flow data record, which provides instantaneous flow rate measurements at 5-minute intervals. The total volume under the curve that appeared to result from the January 9 rainfall event was calculated.

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The flow volume was compared the volume of rainfall from the January 9, 2019 storm that fell on the catchment area draining to each of the flow recording locations. The city-wide model of the system was used to determine the contributing catchment area that drains to each flow recording location. That area was multiplied by the total storm rainfall to obtain the rainfall volume for that storm event.

There were several issues identified during the volume analysis, including:

- Flow Site 009 – Hawk Dr. at Drake Place – appears to have been under-reporting flow during this event. The flow value recorded drops to baseflow level multiple times throughout the event, which is not observed in any of the other flow records.
- Flow Site 008 – Cul de Sac Marble Place – the total volume of flow recorded at this location was quite low relative to the size of the catchment, such that the data appears suspect. However, the data does not appear to have quality issues such as at Sites 009 and 007. Site 008 is the closest site location to the Rain 1 rainfall gauge, which recorded 60 mm for the January 9, 2019 storm, compared to the 72 mm recorded at the Rain 2 Gauge. It is possible that this station is better represented by the Rain 1 Gauge than the Rain 2 Gauge, which may account, or partly account, for the low flow volumes recorded. Therefore, this station was assigned to the Rain 1 Gauge, rather than the Rain 2 Gauge for the analysis.
- Flow Site 007/007A – this site appears to be 2 sites, with the gauge being moved during the recording period from location 007 to location 007A. Neither location appears to have a valid flow record for the time period of the selected storm.
- Flow Site 006 – Woods Ave. at 4th St. and Flow Site 001 – Cliffe Ave. and Mansfield Drive – These sites have data that shows no obvious quality issues, but both sites recorded flow volume significantly in excess of the rainfall event over the 5 day period of the volume calculation, reporting >100% of the recorded rainfall volume as flow. This indicates there is an error, with either additional contributing area draining to the monitoring location that is not clear in the system information available or that there was additional rainfall within these catchments compared to the amount recorded at either of the two rain gauges. It is worth noting that while these catchments are both on the West side of Courtenay, Site 001 is on the south side of the Rain 2 gauge, and Site 006 is on the north side of the Rain 2 gauge, so it is unlikely that only a localized rainfall intensity is creating the extra flow volume in both catchments.

Due to these issues, the % volume of flow is not reported in Table 1 for Sites 009 and 007/7A. Results are shown for Sites 001 and 006, thought they are flagged.

The results of the volume analysis are summarized in Table 1, below, with the sites listed in order of site number. The percentage of rainfall that is measured as flow is shown calculated based on both Rain 1 and Rain 2 rainfall gauges as we don't know for any individual site, which gauge better represents the rainfall that fell in that catchment area. However, the flow recordings have all the locations noted with Rain 2 as the rainfall gauge for that location and that is assumed to be the better fit for most of the flow recording locations, with the exception of Site 008, as noted above.

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Table 2: Volume Performance Results for January 9, 2019 Storm Event

Station ID	Site No.	Catchment ID	Station Name	% Impervious	January 9, 2019 Storm Performance (% of rain measured as flow)	
					Rain 1	Rain 2
114 - 1003 - 001	Site 1	02-0014	Cliffe Ave and Mansfield Drive	59%	123%	103%
114 - 1003 - 002	Site 2	14-0004A	Willemar Ave and Cousins Ave	59%	93%	77%
114 - 1003 - 003	Site 3	04-0007	Dogwood Park	57%	79%	66%
114 - 1003 - 004	Site 4	04-0004	19th St and England Ave	61%	87%	72%
114 - 1003 - 005	Site 5	14-0271	Cumberland Rd, approx 100m SW of Willemar Ave	58%	69%	57%
114 - 1003 - 006	Site 6	15-0002	Woods Ave at 4th St	66%	134%	112%
114 - 1003 - 008	Site 8	31-0025	Cul de sac Marble Pl	69%	46%	38%
114 - 1003 - 011	Site 11	34-0428	200 Back Rd	57%	75%	63%
114 - 1003 - 012	Site 12	35-0005	Cul de sac Braidwood Rd	51%	78%	65%

* Sites shaded in blue are those that appear to be outliers relative to the other sites; sites showing more flow than rainfall on the catchment are shown with grey text.

In addition to Sites 001 and 006 which are flagged for having more runoff than rain, Site 008 is also flagged in the results as an outlier because while the catchment for the Marble Place Cul de Sac has the highest percentage impervious area of the catchments at 69% impervious, it has the lowest range of runoff volume recorded, at 38-46%. It is noted that Site 008 is the closest site to the Rain 1 gauge, making it likely that Rain 1 better indicates the rainfall in this catchment, but 46% volume of rain as runoff is still lower than all the other sites even when the others are all compared to the Rain 2 (higher rainfall) gauge. It is not known if there are other factors that would make the percentage different from other catchments.

Catchment Performance Based on Volume

The results (ignoring the outliers) are in a narrow range of impervious coverage and volume of runoff generated. The remaining group of catchments have impervious coverage in the range of 51% to 61%, and generated runoff volumes of 57% to 77% of recorded rainfall (based on the Rain 2 gauge. However,

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there is no trend or pattern observed in the results, and the impervious coverage and runoff generation do not appear to correlate within this group of data points.

Conclusion on Volume Assessment of Catchment Performance

Use of Catchment Performance Results

This work to evaluate the rainwater management performance of the City's catchments on a volume basis showed success in understanding how measured flow volumes may be used to evaluate and understand the rainwater management performance of the catchment. The method provides an approach that could be replicated in the future to assess whether changes in rainwater management have had negative or beneficial effects on the catchment performance over time.

On the basis of this single storm assessment it appears that there is room for improvement in the rainwater performance of the monitored catchments. This information may be used to prioritize rainwater management improvement in areas where the current performance appears to be poorer, i.e. where there is the most potential for improvement.

This assessment provides information only for a few monitored catchment areas within the City, and so does not provide enough information to prioritize improvements across the City. The lack of a clear relationship between impervious cover and volume capture performance means that we are unable to extrapolate performance of ungauged catchments at this time.

Future Monitoring for Volume Assessment

If this assessment were to be used as a recurring evaluation of catchment performance, the following are recommended:

1. Select a sub-set of the City's catchments for recurring monitoring and establish monitoring locations to be re-used for each round of monitoring and evaluation. The number of catchments selected may depend partly on the available budget that can be set aside for the recurring monitoring.
2. Establish a monitoring period that includes the dry summer or a full year of data, with the intent of capturing storm events that occur in dry conditions for a single storm assessment or the entire year for a full year of flows assessment. Dry initial conditions storms were not available for this analysis, but it would have been more appropriate to assess the volume performance of catchment areas under dry initial conditions. This would provide a more robust understanding of the catchment performance than is provided by a single significant wet initial condition storm event.
3. It must be acknowledged that it is possible to collect a year of data and not have a single 6-month return period or larger event occur in that monitoring period, so there is no guarantee of obtaining enough data to repeat this analysis on a single year basis. If possible, it would be recommended to monitor flows for the selected catchments on a continuous basis, or every-other-year (potentially alternating the equipment between two sets of sites). With a yearly or biennial data set, it should be possible to revisit the volume analysis at least every 2 – 4 years.

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B.4 Runoff Rate Assessment

Runoff Rate Assessment by Catchment

An assessment of the rate of runoff that is generated by each of the drainage catchments within the City was completed using the City-wide all pipes drainage model. A 2-year, 24-hour design storm event was run through the model to understand the rate of runoff generated in each catchment. In order to normalize the runoff rates, the rates were divided by catchment area to provide unit area rates of runoff in L/s/ha for each catchment.

The design storm was run both for wet and dry initial conditions, in order to understand the differences generated when disconnected areas in the catchment have more absorptive capacity available.

The resulting performance values for each catchment were compared with the results for a theorical 10% impervious catchment. The 10% impervious catchment values were generated by setting each catchment to 10% impervious coverage and running the same design storm, also with wet and dry initial conditions.

Runoff Rate Results

The results from the runoff rate assessment showed similar results for the wet and dry initial conditions in that the catchments that generate higher unit runoff rates are the same in both conditions. However the dry initial condition exacerbate the difference between the lower performing and higher performing catchments. The results are shown in Figures 4 and 5. The tables on the figures show the actual values, and the color applied to the catchments indicates the % above target performance for each catchment.

The two maps show the results using ‘dry’ and ‘wet’ initial conditions, which changes how much runoff is generated from pervious surfaces, and how much is absorbed when flow is redirected from impervious surfaces to pervious surfaces

B.5 Conclusions for Catchment Performance

Because these assessments evaluate different metrics, and are based on the methodologies and data available evaluate different sets of catchments, the results are useful as indications of relative performance across areas of the city. The specific values generated for catchment performance represent specific assumptions, climate conditions, and points in time, that may not compare to future calculations of performance. Therefore the value of the catchment performance assessment is in understanding the relative performance of the evaluated catchments when compared with other catchments. Both assessment processes provided results that 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 6. 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.

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- 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 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.

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City of Courtenay

Integrated Rainwater Management Plan - Phase 3

DRAFT

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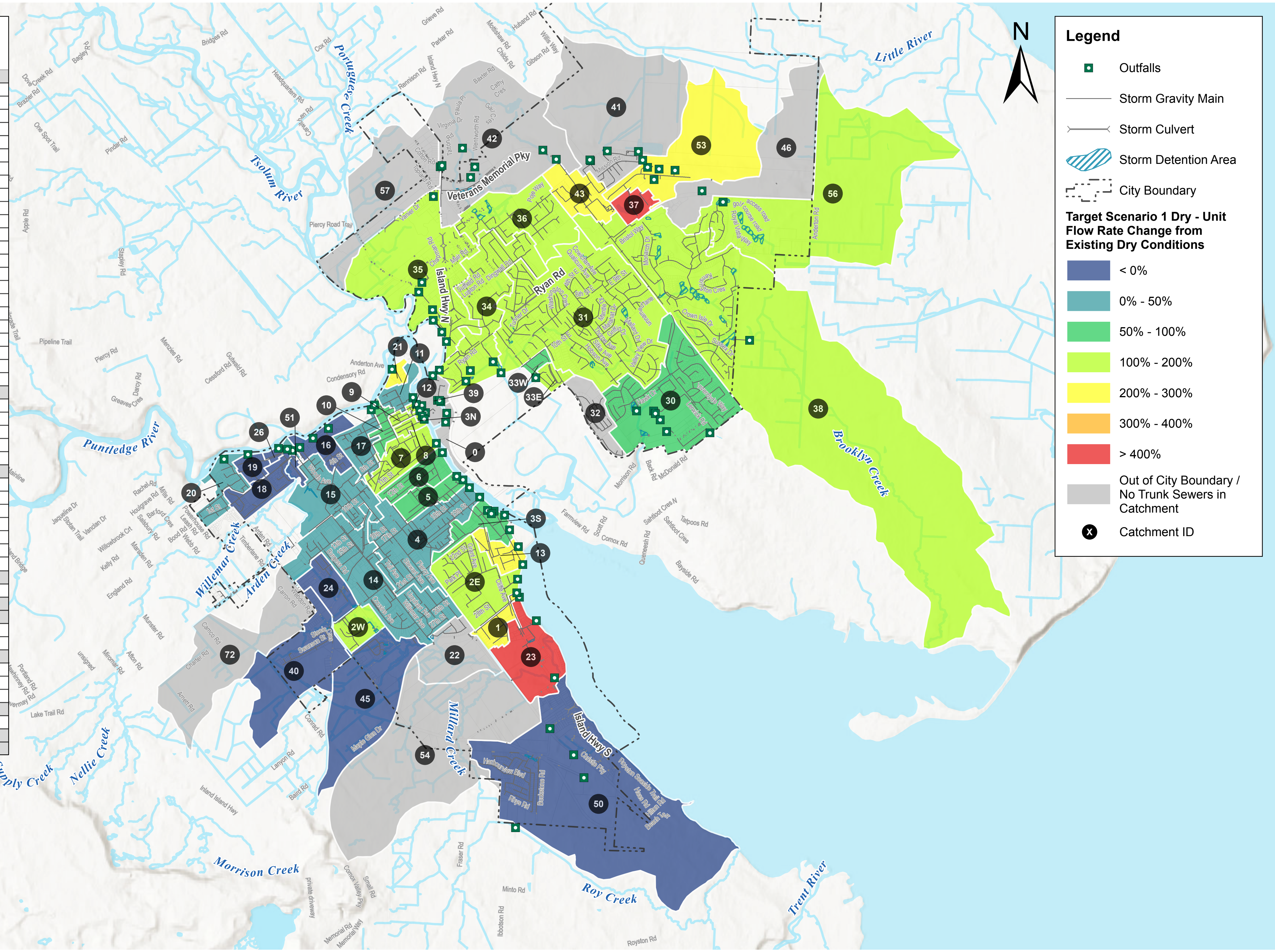
City Storm Catchment ID No.	Catchment Existing Impervious Percent (%)	Dry Initial Conditions: Catchment 2-year Unit Flow Rate (L/s/ha)	Target Scenario 1 Dry Conditions: Catchment 2-year Unit Flow Rate (L/s/ha)	Percent Change
0	N/A - No trunk sewers in this catchment			
1	91.8%	41.5	12.5	231.16%
2-East	69.7%	21.4	7.2	198.06%
2-West	58.3%	12.3	6.0	103.48%
3-North	87.1%	47.7	16.7	185.71%
3-South	63.8%	16.7	9.8	70.09%
4	57.8%	10.8	9.4	15.25%
5	72.4%	21.4	12.1	76.63%
6	65.8%	24.4	14.9	63.88%
7	77.2%	33.5	15.9	110.07%
8	81.4%	41.0	15.0	172.46%
9	85.2%	45.0	20.3	121.74%
10	68.5%	16.9	8.9	88.89%
11	62.9%	21.7	16.0	35.88%
12	78.2%	38.6	14.0	175.00%
13	81.6%	38.7	10.3	277.06%
14	59.9%	8.9	7.2	23.58%
15	55.9%	14.2	9.6	48.48%
16	66.3%	12.7	13.2	-3.61%
17	63.7%	18.7	13.3	40.70%
18	52.3%	10.0	13.1	-23.90%
19	55.6%	6.5	9.5	-31.00%
20	58.3%	14.2	11.6	22.66%
21	75.2%	40.6	10.8	275.76%
22	N/A - No trunk sewers in this catchment			
23	87.3%	52.4	8.5	516.47%
24	8.0%	0.5	0.8	-33.05%
26	58.3%	11.9	17.4	-31.48%
30	56.7%	24.8	12.6	97.61%
31	54.4%	12.1	5.3	128.36%
32	N/A - No trunk sewers in this catchment			
33-East	55.4%	32.3	15.4	109.52%
33-West	56.2%	31.1	16.8	85.57%
34	60.0%	25.9	9.7	166.23%
35	54.2%	26.4	13.0	103.51%
36	44.6%	13.8	5.2	168.22%
37	83.8%	49.9	9.4	430.95%
38	47.4%	15.7	5.6	181.07%
39	N/A - No trunk sewers in this catchment			
40	6.4%	0.6	0.9	-36.33%
41	N/A - No trunk sewers in this catchment			
42	N/A - No trunk sewers in this catchment			
43	61.0%	34.5	11.2	206.82%
45	44.0%	9.8	12.4	-20.83%
46	N/A - No trunk sewers in this catchment			
50	59.3%	2.4	3.9	-38.49%
51	55.9%	14.1	15.6	-10.00%
53	119.0%	36.0	10.0	261.13%
54	N/A - No trunk sewers in this catchment			
56	39.3%	19.4	7.8	147.17%
57	N/A - No trunk sewers in this catchment			
72	N/A - Outside city boundary			



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:50,000 is only valid on a 11"x17" print.

Project No. 2980-014

Date October 2022

Scale 1:50,000

0 0.25 0.5 1 (km)

Storm System Performance Assessment:
Storm Catchment Performance - Dry Initial Conditions to Target Scenario 1 Dry Conditions

Figure 4

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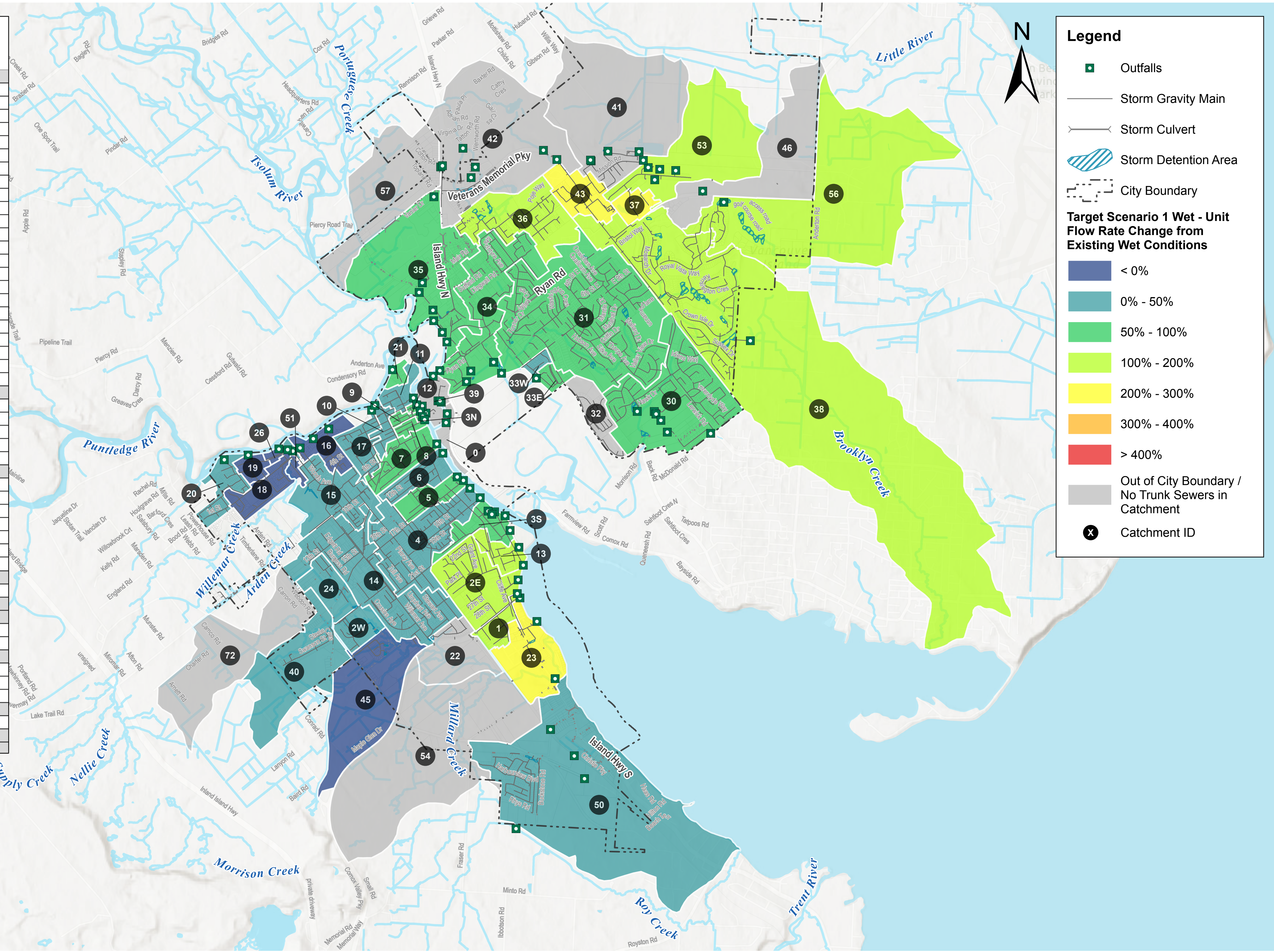
City Storm Catchment ID No.	Catchment Existing Impervious Percent (%)	Wet Initial Conditions: Catchment 2-year Unit Flow Rate (L/s/ha)	Target Scenario 1 Wet Conditions: Catchment 2-year Unit Flow Rate (L/s/ha)	Percent Change
0	N/A - No trunk sewers in this catchment			
1	91.8%	42.2	12.5	155.22%
2-East	69.7%	23.1	7.2	141.45%
2-West	58.3%	20.2	6.0	14.97%
3-North	87.1%	57.3	16.7	84.62%
3-South	63.8%	18.2	9.8	56.83%
4	57.8%	13.6	9.4	8.65%
5	72.4%	23.3	12.1	61.61%
6	65.8%	26.2	14.9	46.24%
7	77.2%	36.1	15.9	79.26%
8	81.4%	53.4	15.0	72.54%
9	85.2%	54.4	20.3	54.17%
10	68.5%	21.7	8.9	32.59%
11	62.9%	36.9	16.0	11.40%
12	78.2%	50.0	14.0	67.65%
13	81.6%	41.7	10.3	186.31%
14	59.9%	15.6	7.2	8.31%
15	55.9%	20.2	9.6	28.05%
16	66.3%	16.3	13.2	-3.76%
17	63.7%	23.9	13.3	24.46%
18	52.3%	21.2	13.1	-13.45%
19	55.6%	17.2	9.5	-20.52%
20	58.3%	18.2	11.6	16.85%
21	75.2%	52.1	10.8	60.61%
22	N/A - No trunk sewers in this catchment			
23	87.3%	54.8	8.5	277.93%
24	8.0%	9.2	0.8	0.22%
26	58.3%	28.0	17.4	-9.38%
30	56.7%	27.1	12.6	72.91%
31	54.4%	15.1	5.3	58.61%
32	N/A - No trunk sewers in this catchment			
33-East	55.4%	34.9	15.4	79.25%
33-West	56.2%	37.5	16.8	31.52%
34	60.0%	26.8	9.7	83.57%
35	54.2%	26.9	13.0	88.92%
36	44.6%	15.2	5.2	104.58%
37	83.8%	50.4	9.4	262.03%
38	47.4%	16.0	5.6	155.62%
39	N/A - No trunk sewers in this catchment			
40	6.4%	8.7	0.9	0.42%
41	N/A - No trunk sewers in this catchment			
42	N/A - No trunk sewers in this catchment			
43	61.0%	34.5	11.2	203.08%
45	44.0%	19.7	12.4	-15.56%
46	N/A - No trunk sewers in this catchment			
50	59.3%	16.3	3.9	1.67%
51	55.9%	27.8	15.6	-8.97%
53	119.0%	38.7	10.0	171.50%
54	N/A - No trunk sewers in this catchment			
56	39.3%	20.8	7.8	100.95%
57	N/A - No trunk sewers in this catchment			
72	N/A - Outside city boundary			



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:50,000 is only valid on a 11"x17" print.

Project No. 2980-014
Date October 2022
Scale 1:50,000
0 0.25 0.5 1 (km)

Storm System Performance Assessment:
Storm Catchment Performance - Wet Initial Conditions to Target Scenario 1 Wet Conditions

Figure 5

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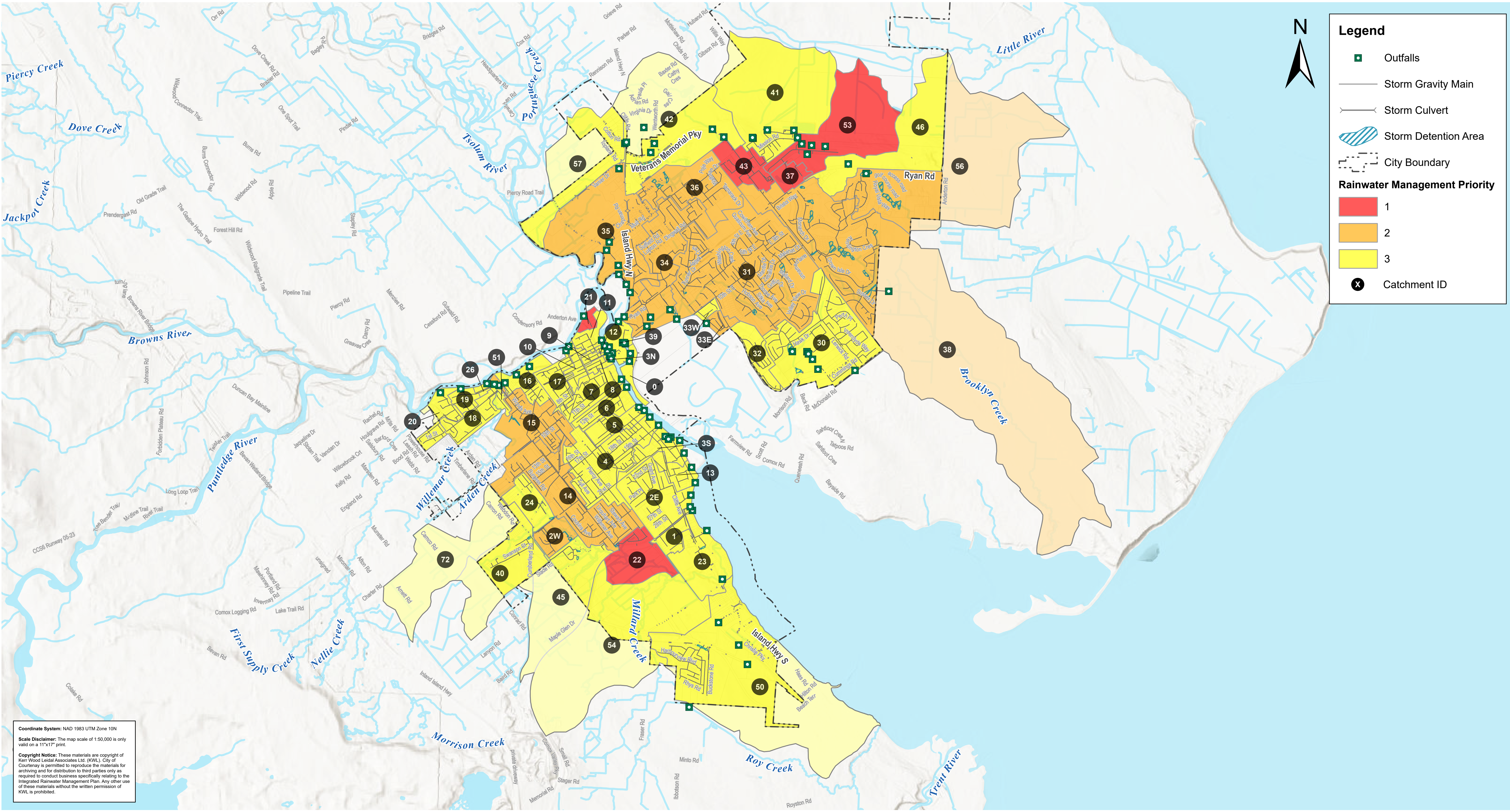
City of Courtenay

Integrated Rainwater Management Plan - Phase 3

DRAFT

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 6