CITY OF KELSO

STORMWATER MANAGEMENT PLAN

Prepared for

CITY OF KELSO

PUBLIC WORKS DEPARTMENT

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ACRONYMS AND ABBREVIATIONS

ac-in	acre-inch of water (2263 gallons)
BMP	best management practices
CBD	Central Business District
CDID No.1	Consolidated Diking Improvement District No. 1 (west Kelso)
CDID No.3	Consolidated Diking Improvement District No. 3 (east and south Kelso)
cfs	cubic feet per second
CIP	Capital Improvement Plan
City	City of Kelso
City Standards	Longview/Kelso Standard Plans and Specifications
CMP	corrugated metal pipe
DID No.1	Cowlitz County Drainage Improvement District No. 1 (North Kelso)
Ecology	Washington State Department of Ecology
ft/ft	feet per foot
G&O	Gibbs & Olson, Inc.
gpm	gallons per minute
HDPE	high-density polyethylene
hp	horsepower
I-5	Interstate 5
IDDE	illicit discharge detection and elimination
JMM	JM Montgomery
KEDM	Kelso engineering design manual
KMC	Kelso Municipal Code
KSAC	Kelso Stormwater Advisory Committee
lf	lineal feet
LID	low-impact development
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
Permit	Western Washington Phase II Municipal Stormwater Permit
PS	pump station
PVC	polyvinyl chloride
SCS	Soil Conservation Service
SMMWW	Stormwater Management Manual for Western Washington
SMP	Stormwater Management Plan (this document)
SPCC	spill prevention control and countermeasure
SSA	Storm and Sanitary Analysis
SWMM	stormwater management model
SWMP	Stormwater Management Program (permit-required)
USEPA	U.S. Environmental Protection Agency
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

This summary is not intended as a stand-alone document and must be evaluated in context with the entire document.

The Stormwater Management Plan (SMP) compiles a great deal of previous work and uses a comprehensive piping system computer model to identify deficiencies in the system that may result in flooding under certain storm conditions. The City of Kelso (City) uses a 25-year, 24-hour storm event to determine if piping systems can adequately protect the surrounding ground from flooding. The use of a design storm to assess the system's performance inevitably means that under larger storm events, even a properly configured system will experience some level of flooding.

The City's stormwater system comprises many separate watersheds, many of which are behind a series of flood protection levees and served by diking or drainage districts that collect and pump stormwater over the levees and into local rivers. Because of this system configuration, many of the system's deficiencies cannot be corrected solely by the City.

The development of the SMP has several purposes, including:

- Inventorying the stormwater system characteristics such as pipe, catch basin, and manhole data
- Developing a stormwater system computer model that covers the entire City system
- Analyzing, with the help of the model, the performance of the system
- Prioritizing the system deficiencies to assist the City in preparing their six-year Capital Improvement Program

The projects identified through the use of the computer model do not always fully match the locations that are observed to have flooding issues. This can be attributed either to conditions in the piping system, such as clogging or damage that can result in flooding, or to inaccurate information on the system configuration, such as changes in pipe diameter that cannot be detected from ground surface surveys used by the City to gather data.

The SMP's Capital Improvement Plan is designed so that it can be updated in the future as system additions, revisions, or new information becomes available. The system hydraulic model and the supporting data will be reviewed every five years and updated as needed. As the model is updated, the Capital Improvement Plan ranking of projects can be reevaluated in light of the new information.

1 INTRODUCTION

1.1 Purpose and Need

This Stormwater Management Plan (SMP) provides a comprehensive review of the City of Kelso's (City) stormwater collection system, including its various structural elements and their performance and deficiencies, and suggested improvements to those elements. The computer modeling of the collection system allows identification of deficiencies and then provides an evaluation of the potential impact of problems such as inadequate pipe size or slope.

This type of system evaluation is necessary in planning for future capital improvement projects and provides needed information to assist the City in complying with the Western Washington Phase II Municipal Stormwater Permit (Permit), which addresses the quality of the stormwater being discharged from the City's system.

The City has completed two of the three phases of its SMP update process. This third and final phase, Phase III, of the SMP is intended to be the comprehensive guiding document regarding the management of stormwater (both quality and quantity) within the direct control of the City, to meet the requirements of the Permit program. Best management practices (BMPs) are identified in this SMP as guiding principles for the City's activities in the stormwater arena.

1.2 Background

Kelso is located in southwest Washington, bordering the Columbia, Cowlitz, and Coweeman rivers, and serves as the county seat for Cowlitz County. The city was incorporated in 1889 and operates under both a city charter and a council-manager form of government. It is the only Charter Code city in Washington State. The City has an annual budget of approximately $33.3 million and provides services such as police, fire, building, planning, community development, parks, library, and utilities such as water, sewer and storm drainage.

The City employs approximately 87 full-time employees, overseen by the city manager. The primary responsibility of the city manager is to carry out the City's policies, prepare the budget, direct daily operations, coordinate the various departments, and keep the city council informed.

The Public Works Department is responsible for designing, building, operating, and maintaining public utilities such as transportation, streets, stormwater, water, sewer, airports, parks, and recreation facilities. The City employs a full-time stormwater manager who oversees the City's stormwater system and compliance with current regulations.

The City has a stormwater utility with rates based on impervious area, which provide a portion of the funding for operation and maintenance of the City's stormwater system. Operation and maintenance of the stormwater system is overseen by Operations, whose "main objective is to ensure that the current drainage system operates in the most effective way possible to ensure life loss and property damage is kept to a minimum."

1.3 Previous Reports

The City previously completed studies of portions of the stormwater system in their Phase I and II plans. The City used its Global Positioning System (GPS) equipment for data collection to collect data for Phase I, which was completed in July 2006. Phase II was completed in December 2008. Maps were created in AutoCAD, and system flows and capacities were analyzed using StormCAD by Haestad Methods. SMPs for Phase I and II can be accessed on the City's Web site at http://stormwater.kelso.gov.

1.4 Regulatory Compliance

In response to the 1987 Amendments to the Clean Water Act, the U.S. Environmental Protection Agency (USEPA) developed Phase I of the National Pollutant Discharge Elimination System (NPDES) Stormwater Program in 1990. The Phase I program addressed sources of stormwater runoff that had the greatest potential to negatively impact water quality. Under Phase I, USEPA required NPDES permit coverage for stormwater discharges from medium and large municipalities (communities with populations greater than 100,000). Following the Phase I regulations, Phase II of the NPDES Stormwater Program was implemented, which required communities with populations between 1,000 and 100,000 to comply with the NPDES regulations. With a population of approximately 11,950, the city falls within these Phase II parameters and the City is now taking action to comply with the NPDES regulations.

The new Permit requirements effectively prohibit non-stormwater discharges and require jurisdictions to apply controls to reduce the discharge of pollutants to the maximum extent practicable. The City plans to reduce pollutants by implementing its Stormwater Management Program (SWMP) that addresses six minimum control measures:

- Public education and outreach on stormwater impacts
- Public involvement/participation
- Illicit discharge detection and elimination (IDDE)
- Construction site runoff control
- Post-construction stormwater management in new development and redevelopment
- Pollution prevention/good housekeeping for municipal operations

BMPs will be implemented for each minimum control measure and measurable goals developed to address specific stormwater problems in the Kelso area.

The City has prepared and made public the Phase II Municipal Stormwater Management Program (SWMP) document, which was last updated in March 2011 and outlines the City's plans and programs for compliance with the six minimum control measures under Washington State Department of Ecology (Ecology) regulations. The SWMP can be accessed on the City's Web site at: http://publicworks.kelso.gov/attachments/File/Stormwater/SWMP33110.pdf

One of the minimum performance measures of the Permit requires the City to develop a storm sewer system map. The City had already developed a map of the system but it did not fully address all of the Permit requirements, which include drainage area delineation, conveyance structures, outfall locations, and land use. The Permit mapping requirements have been satisfied by this SMP.

2 EXISTING STORMWATER PROGRAM

2.1 Stormwater Program Activities

The City has outlined its stormwater program activities in the Permit-required SWMP, updated in 2011. The Permit regulates smaller jurisdictions, construction sites equal to or greater than 1 acre, and other industrial sources. The City is now regulated as a Municipal Separate Storm Sewer System (MS4) under the Permit. The new requirements effectively prohibit non-stormwater discharges and require jurisdictions to apply controls to reduce the discharge of pollutants to the maximum extent practicable. Ecology is also using the Permit to satisfy its own Water Pollution Control Act, RCW 90.48. Requirements are specific and detailed, with numerous compliance deadlines distributed over the five-year permit cycle. The Permit program is structured around the following components:

- Public education and outreach program designed to measurably reduce stormwater pollution
- Public involvement process to guide the development of the stormwater management program
- Adoption of ordinances to control runoff from development, redevelopment, and construction activities
- An IDDE program to identify and remove improper discharges into the storm sewer system
- An operation and maintenance program that reduces pollutant runoff from municipal operations

Reporting requirements and detailed recordkeeping are included to assess compliance and allow for making changes to improve water quality.

2.2 Stormwater Policies

Stormwater policies can be found in the City's engineering design manual (KEDM) and the Kelso Municipal Code (KMC). Chapter 4 of the KEDM provides policy and guidance for stormwater design and management for development and redevelopment in the city. The City's Permit has a minimum requirement that existing local regulations be retained and that portions of the current Stormwater Management Manual for Western Washington (SMMWW) be adopted. Where portions of the KEDM and SMMWW conflict, the KEDM will apply.

Chapter 13 in the KMC pertains to stormwater management. Section 13.09.010 states:

> The purpose of this chapter is to provide for the health, safety, and general welfare of the citizens of the city through the regulation of runoff from construction, development, and redevelopment. This chapter establishes methods for controlling the introduction of runoff and pollutants into the stormwater drainage system in order to comply with requirements of the Western Washington Phase II Municipal Stormwater Permit (Permit) process.

The KMC adopted the KEDM for use in stormwater modeling, facility design, pollution and flow control, and the application of these requirements, as stated in Section 13.09.050.

2.3 Standards

There are several sets of standards that apply to stormwater system design and construction; these are discussed in the following sections.

2.3.1 City of Kelso Engineering Design Manual

Standards pertaining to conveyance, water quality, water quantity, dispersion, and infiltration can be found in the KEDM. The general local requirement states that:

Projects that disturb greater than or equal to 5,000 square feet of land or create/replace greater than or equal to 5,000 square feet of impervious surfaces are subject to the "Local" stormwater requirements described in Section 4.05 of this Chapter.

The City is also subject to the following state requirement:

> Projects that disturb one or more acres or that are part of a larger plan of development or sale, are also subject to a set of state-mandated ("State") requirements that are detailed in the SMMWW (Volume I, Section 2.5).

If state and local requirements conflict, the stricter condition is applied. Flowcharts located in the KEDM appendices are used in determining which requirements apply.

2.3.2 Longview/Kelso Standard Plans and Specifications

The cities of Kelso and Longview have adopted the Longview/Kelso Standard Plans and Specifications (City Standards) to establish standards for design and construction of public improvements. The City Standards apply for design and construction of all new and upgraded facilities that are or will become part of the City right-of-way or City-owned parcel. Qualifying facilities include but are not limited to: streets, sidewalks, and other transportation-related facilities; and storm drainage, water, and sewer facilities. They include city facilities serving customers outside city limits.

2.3.3 Stormwater Management Manual for Western Washington

The August 2012 SMMWW provides guidance on the stormwater quantity and quality control measures necessary for complying with water quality standards. The water quality standards include: Chapter 173-200 WAC, Water Quality Standards for Ground Waters of the State of Washington; Chapter 173-201A, Water Quality Standards for Surface Waters of the State of Washington; and Chapter 173-204, Sediment Management Standards. Note that federal, state, and local permitting authorities with jurisdiction can require more stringent measures deemed necessary to meet locally established goals, state water quality standards, or other established natural resource or drainage objectives.

3 STORMWATER SYSTEM CHARACTERISTICS

3.1 Watershed Characteristics

The city was divided into several watersheds based on contour data, information on the City's piping system, and previous reports and studies performed in the vicinity of the city. As the City's storm system network was inventoried and mapped, some watershed boundaries were reevaluated and modified, as appropriate. Watersheds are larger geographical areas defined by their drainage systems and the general direction of discharge. The Kelso Watershed Areas are shown on Figure A-1.

Watershed characteristics vary from undeveloped to fully developed and were further divided into basins for modeling purposes. The city has eight watersheds:

- Redpath-North Kelso
- West Kelso
- Tam O'Shanter-Northeast Kelso
- Coweeman
- South Kelso
- Baker Way
- Elks
- Southeast Kelso

For this report, the land use utilized for high-density residential development was urban density, which yields slightly higher runoff values and therefore more conservative results.

3.1.1 Redpath-North Kelso Watershed

The north Kelso drainage area is bordered on the east by steeply sloped and predominantly undeveloped forestland, which drains to the west toward residentially developed lowlands. This area is drained by a network of channels and pipes, ultimately discharging to the Cowlitz River through the Cowlitz River levee via a combination of pump stations (PSs) and gravity outfalls. This area is served by the King Creek and Redpath PSs. The currently undeveloped area is owned by the Cowlitz County Drainage Improvement District No. 1 (DID No.1). Because this area has no sanitary sewer collection system, it is not expected to undergo significant land use changes in the future, and therefore no land use change was applied for the future developed condition used to model long term development impacts on the stormwater system. See Figure A-2 for the watershed boundary.

Basin 14 is included in the Redpath-North Kelso Watershed as it is adjacent to Redpath Watershed and discharges directly to the Cowlitz River by gravity and does not contribute to the DID No.1 system.

3.1.1.1 North Kelso-King Creek Pump Station

The area draining to the King Creek PS is bounded by North Pacific Avenue to the west, Interstate 5 (I-5) to the east, Shawnee Road to the south, and DID No.1-owned property to the north. Much of the area contributing to the King Creek PS is located outside the city limits in Cowlitz County to the north and east. Contour mapping and project drawings for the North Kelso/King Creek PSs and I-5 improvements were evaluated and field investigations were performed to determine the area contributing to the King Creek PS. The King Creek PS basin is relatively flat and moderately developed, containing both urban density and some open space. Part of basin 18 in the North Kelso/King Creek PS is included in the area draining to the King Creek PS.

3.1.1.2 Redpath Pump Station

The area draining to the Redpath PS is south of Shawnee Road and the King Creek PS; see Figure A-2a. Part of this area is located in Cowlitz County, just north of the Kelso city limits. Contour mapping and inventory data were evaluated to determine the area draining to the Redpath PS.

The area to the east of I-5 is moderately steep and moderately developed, while the remaining area to the west of I-5 is relatively flat and highly developed. The Redpath PS drainage area west of I-5 is bound by North Pacific Avenue to the west, I-5 to the east, Columbia Avenue to the south, and Shawnee Road to the north. The Redpath PS drainage area east of I-5 is bounded by I-5 to the west, William Finney Road to the east, Mt. Brynion Road to the south, and a ridgeline to the north, as determined by contours. The areas to the west of I-5 are all fully developed and modeled as urban density, and therefore did not have a land use change for the developed condition. However, the basin to the east of I-5 is moderately developed, with approximately half to two-thirds of the area having an existing land use of urban density, and the rest of the land entered as 5-acre parcels. For the fully developed conditions, the 5-acre land was modeled as 1-acre parcels to represent the average future land use, based on an increase in density and accounting for portions of the land area that are not developable because of steep slopes.

The following basins are included in the area draining to the Redpath PS:

Parts of basins 17 and 18: Redpath North (RD-N)

Parts of basins 15, 16, and 17: Redpath Mid 1 (RD-M1)

Parts of basins 16 and 17: Redpath Mid 2 (RD-M2)

Part of basin 36: Redpath East (RD-E)

Part of basin 15: Redpath South 1 (RD-S1)

Part of basin 16: Redpath South 2 (RD-S2)

Basins 39 and 40, parts of basins 14 and 15: Redpath South 3 (RD-S3)

3.1.2 West Kelso Watershed

West Kelso is west of the Cowlitz River and is divided between commercial and residential land use. The area is relatively flat and is drained via a series of catch basins and pipes that drain to the south toward the Cowlitz County Fairgrounds; see Figure A-3a. This basin discharges to a large-diameter pipe at Southwest 4th Avenue and Washington Street at the border between the cities of Kelso and Longview on Washington Street. Stormwater from this outfall then flows under the fairgrounds property and ultimately discharges to Consolidated Diking Improvement District No. 1 (CDID No.1) ditch no. 4 at Peardale Lane. The following basins are included in the west Kelso area:

- Basin 34

3.1.3 Tam O'Shanter-Northeast Kelso Watershed

The northeast Kelso area is generally steeply sloped and predominantly residential land to the north, which drains south toward urban developed flatlands. This area is drained by a network of channels and pipes, ultimately discharging to the Coweeman River through the Coweeman River levee via the Tam-1 and Tam-2 PSs; see Figure A-4a. The watershed also includes a portion of the Central Business District (CBD) on the west side of I-5. This area is highly urbanized and relatively flat, with the exception of a small portion to the north between Allen Street and Cowlitz Way that is moderately steep. The CBD is drained by a network of pipes that discharge to the northeast Kelso area and ultimately to the Tam-1 and Tam-2 PSs. The following basins are included in the northeast Kelso area:

- Basins 12 and 13 (CBD)
- Part of basins 31 and 32: Highland Creek (HIL)
- Basins 29, 30 and Part of 31: Minor Road (MN)
- Part of basin 31: Swanson Road (SWN)
- Basins 32 and 33: Barr Road (BAR), Mount Brynion 1 (MB1) and Mount Brynion 3 (MB3)
- Basin 28: Kelso High School (KHS), Brookhollow (BH), Tam O'Shanter 1 (Tam-1) Tam O'Shanter 2 (Tam-2)

Contour maps, the JM Montgomery[1] (JMM), Kelso Stormwater Phase I and II SMPs, and Kelso High School Remodel Stormwater reports were used to determine the area of basins in the Tam O'Shanter-Northeast Kelso watershed; they total approximately 900 acres. The basins vary in topography from moderately steep residential land to the north, to relatively flat commercial and open areas to the south. The area draining to the Tam-1 and Tam-2 PSs is bound by North Pacific Avenue to the west, Mt. Brynion Road to the north, and the Coweeman River levee to the south and east. Kelso High School and Coweeman Middle School properties collect and drain to the intertie pipe between the Tam-1 and Tam-2 PSs.

3.1.4 South Kelso Watershed

The South Kelso watershed is flat and is bounded by the Cowlitz River to the west; Cowlitz Way, Allen Street, Grade Street, and the Three Rivers Mall to the north; the Coweeman watershed to the south; and the Coweeman River to the southeast. All drainage in this area is pumped to the Coweeman River over the Coweeman River flood protection levee via the Coweeman PS. The area draining to the Coweeman PS contains mostly commercial and urban low-density land use designations, with a small amount of urban high-density land use. The South Kelso watershed is divided into three basins listed below and shown in Figure A-5a.

- Basin 1: Chestnut Street (CHT)
- Basin 10: Grade Street (GRD)
- Basin 11: Three Rivers Mall (3RM)

[1] Lower Cowlitz River Flood Control Master Plan, October 1989, James M. Montgomery, Consulting Engineers

3.1.5 Coweeman Watershed

The Coweeman watershed is flat and is bordered on the north by relatively flat, predominantly residential land, and to the east by the Coweeman River and I-5, and generally drains to the east. All drainage in this area is pumped to the Coweeman River through or over the Coweeman River flood protection levee via the Coweeman PS. This area contains mostly industrial and urban low-density land use, with small amounts of commercial, agricultural, and open space land use. These areas are drained by a network of channels and pipes. The Coweeman area is divided into two basins listed below and as shown in Figure A-6a.

- Part of basin 2 and basin 3: Baker Way No. 1 (BK1)
- Elks: basins 7, 8, and 9

Data and contour maps were evaluated and the JMM and Kelso Stormwater Phase I and II SMP reports were reviewed to estimate the total area of the basins draining to the Coweeman and Baker Way PSs. Approximately 304 acres drain to the Coweeman PS, and 660 acres drain to the Baker Way PS.

3.1.6 Baker Way Watershed

The Baker Way watershed is bounded on the east and south by the Coweeman River, on the north by the Coweeman watershed, and on the west by the Burlington Northern Santa Fe Railroad (Figure A-7a)a. There is also a portion of the watershed south of the Coweeman River along Coweeman Park Drive. The watershed consists of industrial and commercial development. Drainage from the developed area north and west of the Coweeman River flows to the two Baker Way PSs and is pumped to the Coweeman River. The Baker Way watershed consists of four basins, listed below:

- Part of basin 2 and basins 4 and 5: Baker Way No. 2 (BK2)
- basin 6: Longview Wye

3.1.7 Elks Watershed

The Elks watershed is bounded by the Cowlitz River to the west, north, and south, and the Coweeman and Baker Way watersheds to the east (Figure A-8). No closed-system drainage information was provided for these basins and therefore this watershed has been excluded from analysis. The watershed consists partly of the Three Rivers Golf Course, with the remaining area comprising open space, single-family residential, commercial, and industrial land use. Contour maps were evaluated and the JMM reports were reviewed to determine that basins 8 and 9 drain to the Elks PS and are independent of the Coweeman and Baker Way watersheds.

The Elks watershed is divided into three basins, listed below and shown on Figure A-1b:

- Basin 7: Elks North
- Basin 8: Elks
- Basin 9: Elks

3.1.8 Southeast Kelso Watershed

The southeast Kelso watershed (Figure A-9) is a predominantly low-density residential area, bordered on the east by steeply sloped, forested land that drains to the west and north via a series of short pipes and channels that discharge to the Coweeman River at various locations. The southeast Kelso watershed is divided into six basins, listed below and shown on Figure A-9a:

- Basin 20: Grade Street
- Basin 21: Harding Road
- Basin 22: Davis Terrace
- Basin 23: Davis Terrace
- Basin 24: Davis Terrace
- Basin 25: Davis Terrace

3.2 Land Use Conditions

The Kelso watershed areas were modeled evaluating the existing land use. In most cases, the existing land use conditions were applied according to the level of development that exists today as shown in Figure 3-1: City of Kelso Land Use Map. All changes to existing land use designations are shown in Table 3-1 and Figure 3-2: Changes to Land Use Designation for Modeling Purposes.

Table 3-1
Changes to Land Use Designation for Modeling Purposes

No.	Description	City of Kelso Land Use Map	Land Use Designation used for Modeling
1	Huntington Middle High School, basin 15	ULD	50% UHD, 50% OS
2	Kelso High School, basin 28	OS	30% UHD, 70% OS
4	Parcel 244120100 North of Sunrise St/Harris Street , basin 33	ULD	OS
6	Undeveloped land between Harris Street & Allen Street, basin 33	UHD	OS
7	Undeveloped land south of Allen Street, basin 28	UHD	OS
8	Undeveloped land within city limits, basin 27	ULD	OS
9	Undeveloped land and condemned development (Banyon Dr), basin 25	ULD	OS
10	Large parcels north of Haussler Rd, basin 22	ULD	10-AC
11	Large parcels south of Haussler Rd, basin 22	ULD	10-AC
12	Large parcels near Tybren Heights Rd, basin 25	ULD	10-AC
13	Large parcels near Tybren Heights Rd, basin 21	ULD	10-AC

NOTES:
10-AC = rural residential.
OS = open space.
ULD = urban low density.
UHD = urban high density.

3.3 Projected Land Developments

The developed land use conditions were assigned to the undeveloped basins (basins 8, 21, 22, 25, 27, 28, and 33). In most cases, the most dense land use development that could possibly occur was applied based on the City of Kelso Zoning Map with consideration of areas of steep slopes. However, the Aldercrest Subdivision in basin 25 experienced landslides in the past and has since been identified as an unbuildable area. Under the assumption that this area will not be developed in the future, it was modeled as Open Space for both present and future land conditions. Other deviations from the Kelso Land Use and Zoning maps are listed below in Table 3-2 and in Figure 3-3: Changes to Zoning Designation for Modeling Purposes.

This evaluation was performed to demonstrate the developed drainage scenario for estimated fully developed future land use conditions. Because of changing stormwater requirements, the developed land use scenario is no longer considered the "worst-case" scenario and therefore has not been modeled. New stormwater regulations will require all runoff flows on future developed land to not exceed runoff flows at the existing conditions, making the current land use conditions the worst-case scenarios.

Table 3-2
Changes to Zoning Designation for Modeling Purposes

No.	Description	Equivalent City of Kelso Zoning (for developed conditions)	Developed Land Use Designation based on actual conditions
1	Huntington Jr. High School, basin 15	UHD	50% UHD, 50% OS
2	Kelso High School, basin 28	SUB	30% UHD, 70% OS
3	Parcels 240280200, 242390100, 24028, 24239 west of Kelso High School, basin 28	ULD	COM
4	Parcel 244120100 North of Sunrise St/Harris Street, basin 33	SUB	ULD
5	Undeveloped land east of Parcel 244120100, basin 33	SUB	OS
8	Undeveloped land within city limits, basin 27	OS	ULD
9	Undeveloped land and condemned development (Banyon Dr), basin 25	OS & SUB	OS
10	Large parcels north of Haussler Rd, basin 22	SUB	ULD
11	Large parcels south of Haussler Rd, basin 22	SUB	ULD
12	Large parcels near Tybren Heights Rd, basin 25	SUB	ULD
13	Large parcels near Tybren Heights Rd, basin 21	SUB	ULD
14	Parcels 24375 24376, and 24378 adjacent to the Three Rivers Golf Course	SUB	ULD

NOTES:
COM = commercial.
OS = open space.
SUB = suburban residential, which is identified as RSF-15 on the City of Kelso Zoning Map.
ULD = urban low density, which is identified as RSF-10 on the City of Kelso Zoning Map.
UHD = urban high density, which is identified as RSF-5 on the City of Kelso Zoning Map.

3.4 Delineation of Stormwater Basin

As stated previously, the City stormwater system has been divided into numbered basins. Stormwater basins are shown in Figure 3-2. More detailed maps of the basins can be found in Appendix A. Contour maps and the following documents were used to delineate the basins:

- 1989 Lower Cowlitz River Flood Control Master Plan prepared by JMM
- Kelso Stormwater Phase I and II reports, Kelso High School Remodel Stormwater reports
- Washington State Department of Transportation (WSDOT) plans for the I-5 freeway drainage
- Project drawings for the North Kelso/King Creek PS and I-5 improvements

- Drainage reports for Consolidated Diking Improvement District No. 3 (east and south Kelso) (CDID No.3) for Tam-1/Tam-2 PSs and Coweeman/Baker Way PSs
- Drainage report for DID No.1 for King Creek and Redpath PSs
- Field investigations

Basins were developed using basin information, contour and plat maps, and pipe information provided by the City. Ecology suggests that basin areas be created for pipe sizes larger than 24 inches in diameter. For this report, basins were determined based on review of the inventory data and the determination of a peripheral system connection to a trunk line. The peripheral systems had a trunk line typically 12 inches to 18 inches in diameter or greater.

The basins delineated in Phase I were reviewed against the inventory data collected by the City, and basin boundaries verified or adjusted based on the layout of the system. In some cases, basin areas were consolidated based on information from the reports listed above and from field data.

3.5 Flood Management Systems

Drainage infrastructure in the city stormwater drainage area is owned and operated by the City, CDID No.3 and DID No.1. The City has jurisdiction over most structures and some ditches within the city limits. CDID No.3 and DID No.1 own and maintain PSs, sloughs, large-diameter pipes and culverts, and portions of ditches near the PSs.

3.5.1 Consolidated Diking Improvement District No. 3

The stormwater infrastructure in the Tam O'Shanter-Northeast Kelso, Coweeman, Baker Way, and Elks watersheds consists of a collection of ditches, storm drain piping, PSs, and manmade drainage ways. Most storm drain piping and inlets, catch basins, and manholes are under City jurisdiction. CDID No.3 owns and operates the Coweeman, Baker Way, Elks, Tam-1, and Tam-2 PSs and the drainage sloughs surrounding these PSs. In some areas, large-diameter piping has replaced portions of these sloughs that have been filled in as part of upstream development. A portion of the BK1 basin is owned and operated by CDID No.3 as well.

3.5.1.1 Discharge Locations

The Tam O'Shanter-Northeast Kelso watershed transitions from City to CDID No.3 jurisdiction in two locations. The Minor Avenue system flows into the main pipeline at the downstream end of the basin. The 60-inch-diameter pipeline transitions to an arch culvert at the Tam O'Shanter PS No. 1 drainage ditch. A 30-inch-diameter pipe picks up the flow from BAR and Tam-2 basins and carries it to the slough that eventually becomes the forebay to Tam O'Shanter PS No. 2.

The South Kelso watershed contains three pipeline systems: Grade Street, Chestnut Street, and Three Rivers Mall. The Grade Street pipeline transitions from City to CDID No.3 jurisdiction at the point where the southeasterly trunk line that runs along 13th Avenue discharges into an open channel that flows into the Coweeman PS. The Chestnut Street system discharges to an open ditch, where it enters CDID No.3 jurisdiction and flows to the Coweeman PS. The Three Rivers Mall area also contributes to the open ditch, except for a few acres in the north part of the mall that drain to the Tam O'Shanter system.

The northern part of the Baker Way watershed drains to a CDID No.3 open ditch that flows directly to the Baker Way PS. The southern part of Baker Way is drained by a system of pipes, culverts and open channels as part of the City's storm drainage system that is conveyed to the CDID No.3-owned and -operated Baker Way PS.

The Elks watershed is mostly within the city limits, except for a strip of land north of the Three Rivers Golf Course that is part of Cowlitz County. The Elks PS is owned and operated by CDID No.3. Elks does not have any pipelines, but natural drainage collects in open channels that flow to the Elks PS, at which point the flow is under CDID No.3 jurisdiction.

3.5.1.2 Pump Stations

Tam-1 Pump Station: The Tam-1 PS currently has three 150-horsepower (hp) pumps and one 100-hp pump. The three 150-hp pumps have a capacity of 29,000 gallons per minute (gpm) each (65 cubic feet per second [cfs]), while the 100-hp pump has a capacity of 18,000 gpm (40 cfs). This provides a total pumping capacity of 105,000 gpm or approximately 235 cfs with all four pumps running. Each pump has a dedicated discharge pipeline, each approximately 200 feet long. The discharge pipes for the three 150-hp pumps are 36 inches in diameter and the discharge pipe for the 100-hp pump is 30 inches in diameter. In 1993, the Tam-1 PS was upgraded from three pumps with a total capacity of 78 cfs to the current 235-cfs capacity. CDID No.3 has recently (2011) upgraded the Tam-1 PS so that the rated capacity of the station, 235 cfs with all four pumps in operation, is available should the river water surface reach the top of the levee. The Tam-1 PS was modeled using the upgraded pumps and associated pump curves.

The discharge from the PS was designed to take advantage of the siphon effect that occurs as a result of the elevation of the discharge pipe (elevation

22.9 feet) in relation to what was at the time of design the 100-year flood river elevation (maximum elevation 20.9 feet). The siphon effect reduced the hp requirement for the pumps. However, there have been three or four occasions since the PS was built when the water surface elevation in the river has been higher than the elevation of the discharge pipes, thereby eliminating the siphon effect. When this occurs, pumping capacity is dramatically reduced because the total dynamic head that each pump operates against increased substantially and the pump moved up the associated pump curve. This scenario occurred during the February 1996 storm event, when water levels in the river were within 6 to 12 inches of the top of the levee, approximately elevation 28.9 feet. The high water level in the river resulted in a total dynamic head greater than the pumps could operate against for a sustained period, and the pumps had to be operated intermittently, further reducing pumping capacity. The reduced pumping capacities during this event, in combination with the school district discharge pipes being under submerged conditions because of the inverts at elevations near the bottom of the Tam-1 slough, led to a backup of water in the system upstream of the Tam-1 PS and surrounding areas.

Tam-2 Pump Station: The Tam-2 PS was constructed in the early 1980s with a single pump. A second pump and forebay improvements were added in 1987. No other improvements are known to have been performed on the Tam-2 PS. The total capacity of the Tam-2 PS is approximately 105 cfs. The total capacity available from combining the Tam-1 and Tam-2 PSs is approximately 340 cfs.

Coweeman Pump Station: The Coweeman PS was originally constructed in the 1950s with two pumps. In 2001, CDID No.3 replaced the PS, which now has three 125-hp vertical turbine pumps. Each of the three pumps has a capacity of 12,000 gpm (26.7cfs). This provides a total pumping capacity of 36,000 gpm or approximately 80.1 cfs with all three pumps in operation. Each pump has a dedicated 24-inch-diameter discharge pipe that is approximately 220 lineal feet (lf) in length that conveys the pumped stormwater through the flood protection levee and to a riprap-lined outfall on the bank of the Coweeman River.

Baker Way Pump Station: The Baker Way PS was originally constructed with a single pump in the early 1980s, with a pumping capacity of 36,000 cfs (80.1 cfs). The PS forebay and building were constructed such that two additional pumps could be incorporated into the existing PS structure. In 2008, CDID No.3 upgraded the existing PS; this included adding two 150-hp vertical turbine pumps with associated dedicated 36-inch ductile iron discharge pipelines that extend approximately 300 lf to an outfall on the bank of the Coweeman River. The two new pumps each have a capacity of 17,000 gpm (37.9 cfs), for a total capacity of 34,000 gpm (approximately 75.8 cfs). Standard operation of the Baker Way PS is for one or both of the new pumps to operate or for the original pump to operate, but not for all three pumps to operate at the same time under normal operating conditions.

The total capacity available from combining the Coweeman and Baker Way PSs under normal conditions varies from approximately 155.9 to 160.2 cfs, depending on which pump(s) are operating at the Baker Way PS.

Elks Pump Station: The Elks PS was constructed in the 1970s and consists of a single 5,000-gpm (11.2 cfs), 40-hp pump, with a single 16-inch-diameter pipeline that extends approximately 250 lf to an outfall on the bank of the Cowlitz River.

3.5.2 Drainage Improvement District No. 1

The stormwater infrastructure in the north Kelso watersheds consists of storm drain piping, box culverts and large-diameter pipelines, PSs, and manmade drainage ways. Most storm drain piping and inlets, catch basins, and manholes in the north Kelso area are under City jurisdiction. DID No.1 owns and operates the King Creek/North Kelso and Redpath PSs and large-diameter pipes and culverts near basin discharge points.

3.5.2.1 Discharge Locations

The Redpath system flow is conveyed through an open channel located just northeast of Bowmont Avenue in the southeast portion of Basin 19. The runoff drains directly into a 36-inch-diameter pipeline that flows into a 3-foot-by-4-foot box culvert to the Redpath PS. The 36-inch pipeline serves as a transition point between City and DID No.1 jurisdictions specifically located at Manhole 4209. The southern part drains into an 18-inch-diameter pipeline that drains into the DID No.1 box culvert. The stormwater is then pumped over a dike into the Cowlitz River via the Redpath PS.

The North Kelso conveyance system is interconnected to the conveyance system that drains runoff to the Redpath PS at a catch basin located at the intersection of Shawnee Road and Bowmont Avenue. The conveyance system to the north consists of approximately 1,900 lf of 36-inch pipe that traverses north and west along Shawnee Road, Maple Road, Williams Avenue, and interspersed open fields before entering DID No.1-owned property and terminating in the southwest corner of the King Creek/North Kelso PS detention basin. The system to the east consists of approximately 570 lf of 36-inch pipe that travels east and northeast to an existing ditch to the northeast. The ditch is approximately 350 lf and runs north-south, then east-west, and discharges to an existing 24-inch-diameter corrugated metal pipe (CMP) that flows to an existing manhole southeast of the mini-storage units. Stormwater collected at this manhole then flows north-northwest approximately 1,200 lf in a 36-inch-diameter concrete pipe, from which it discharges into the southeast corner of the King Creek/North Kelso PS detention basin.

3.5.2.2 Pump Stations

Redpath Pump Station: The Redpath PS has four pumps with a total pumping capacity of 91 cfs, and discharges to the Cowlitz River via 24-inch- and 22-inch-diameter steel pipes. The existing Redpath PS was upgraded in 1978. At that time, new 60-hp and 100-hp pumps were added to the PS to augment the existing 50-hp and 75-hp pumps. A new wet well was constructed, adjacent to the existing wet well and 7 feet deeper, for these two new pumps. The on/off elevations for all four pumps are set such that standing water is always present in the older and shallower portion of the PS wet well. Therefore, storage below the lowest setting for the pumps to turn off (elevation 11.5) is dead storage, which includes approximately 1.5 feet of depth in the box culvert. The four pumps cycle on and off, with pump no. 3 performing most of the pumping, based on pump hour meter data from December 18, 2000, to December 16, 2010. The exception to this was a period from May 20, 2002, to December 14, 2002, when pump no. 3 was inactivated because of a mechanical problem, and pump no. 2 was operated as the main pump.

King Creek/North Kelso Pump Station: The King Creek/North Kelso PS has three 125-hp pumps with a pumping capacity of 18 cfs each for total pumping capacity of 54 cfs with all pumps in operation. Each pump conveys runoff to an 8-foot-diameter-by-23-foot-tall stand pipe structure via a dedicated 470-foot-long, 20-inch-diameter high-density polyethylene (HDPE) pipe. Storm drainage from the standpipe is gravity discharged to a 48-inch-diameter HDPE pipe inside a 60-inch-diameter steel carrier pipe that runs beneath North Pacific Avenue, the Burlington-Northern Railroad, and the Cowlitz River Dike and into a 120-inch-diameter manhole before gravity discharging to the Cowlitz River via a 48-inch-diameter HDPE pipe. A Tideflex check valve is connected to the end of the 48-inch-diameter HDPE pipe to prevent backflow from the river from entering the pipe. To model surcharged conditions at the 48-inch-diameter outlet pipe to the Cowlitz River, the head loss and entrance/exit loss in the discharge pipe were calculated and added to the water surface elevation for the different river flood stages. Table 3-3 lists the design storm and river flood stage scenarios and the associated tailwater elevation (TWE) condition entered at the 120-inch-diameter manhole.

Table 3-3
Modeling Assumptions for Surcharge Conditions

Rainfall Event vs. River Event						
Rainfall Event (yr)	River Flood Event (yr)	River Elev. (ft)	Flow (cfs)	Headloss (ft)	Entrance/Exit Loss (ft)	Total TWE at MH (ft)
25	25	28.54	54	0.18	0.29	29.01
25	100	30.12	54	0.18	0.29	30.59
100	<1	14.24	56	0.19	0.30	14.74
100	25	28.54	56	0.19	0.30	29.04
500	<1	14.24	57	0.20	0.32	14.77
500	25	28.54	57	0.20	0.32	29.07

West Kelso/CDID No.1: Most of the west Kelso system discharges to the CDID No.1 system that crosses the Cowlitz County Fairgrounds to the south and enters ditch no. 4 south of the fairgrounds. The west Kelso runoff comingles with runoff from the City of Longview and is pumped to the Cowlitz River by the district's Third Avenue PS with 50,000-gpm capacity. The CDID No.1 drainage system is interconnected with other PSs to provide backup.

A small portion of the watershed along Fishers Lane discharges to ditch no. 6 of CDID No.1. This ditch connects to a series of ditches and PSs that eventually connects to the CDID No.1 main PS along Pacific Way in Longview.

3.5.3 Maintenance

As discussed previously, the City's system drains to a number of PSs surrounding the city that are owned and operated by independent diking and drainage districts. Since the PSs are outside the control of the City, suggested maintenance of the PSs is not practical. However, there are things the City can do to facilitate their system operating, such as keeping catch basins and piping free of debris and performing regular maintenance on ditch systems. This maintenance of the City's system will not prevent a drainage problem downstream of the City's system, but could allow for some minor storage of stormwater. It is recommended the City meet regularly, such as once per year, with the diking and drainage districts to discuss how the PSs are functioning, any issues the City has noted, and potential strategies to address ongoing problems.

3.5.4 Municipal Stormwater Permit Coordination

The City should meet with the drainage and diking districts, or other permittees, to determine the order of precedence for permitting and to develop a strategy for meeting the NPDES requirements.

3.5.5 Downstream-related Flooding

As stated previously, since much of the city drains to PSs not under the City's jurisdiction, it is recommended that the City meet with the diking districts at least once per year to discuss how the PSs are working and to address any concerns the City may have with stormwater issues. It is recommended that the City take the following actions to help identify and/or address stormwater issues:

- Keep track of the locations where flooding is observed to occur, using such methods as a database or log book, including information such as: the date flooding occurred; location limits of the flooding; affected structures such as catch basins, pipes, culverts, etc; depth of water (if possible); and any identifiable possibilities for the problems, such as debris in the system or displacement of structures.
- Check the identified location against the stormwater model to determine if this was noted in the model.
- If noted in the model, consider adding the location to the City's Capital Improvement Program for the upcoming year.
- If not noted in the model, investigate structures and pipes to determine if there have been any changes to the system or if debris is blocking the system.
- If debris is the factor, perform maintenance on the system, such as cleaning catch basins and culverts and flushing pipes.
- If the City's system has been maintained but an issue is occurring, meet with the diking and drainage districts to develop a strategy to address the identified issue.

Because the City's system is interconnected with the diking and drainage districts' system, it is important that the City develop a methodology to coordinate their system with those of the districts. The above listed items are suggested steps but they may not be all-inclusive.

4 TECHNICAL ANALYSIS

4.1 Background

Preparation of a model for the Kelso SMP watershed areas began with a review of:

- Kelso SMP Phase I and II
- Report prepared by JMM as part of the 1989 Flood Control Master Plan
- Design drawings prepared by Gibbs & Olson, Inc. (G&O) for the North Kelso PS, the Tam-1 and Tam-2 PSs, and the Coweeman and Baker Way PSs
- Design drawings prepared by others for the Elks PSs
- Previous models completed for the King Creek and Redpath basins
- I-5 design plans prepared by WSDOT

4.2 Computer Modeling Program

The Kelso basins were modeled using the AutoCAD Civil 3D 2011 Storm and Sanitary Analysis (SSA) modeling software. SSA includes several hydrology methods for determining drainage area runoff, including the Rational Method, TR-55, TR-20, HEC-1, and USEPA stormwater management model (SWMM), among others. The three methods considered for this report were the Rational Method, USEPA SWMM, and Soil Conservation Service (SCS) TR-55. These methods are reviewed in the following sections.

4.2.1 The Rationale Method

The Rational Method is often used for computing peak discharge for small areas (<200 acres), but produces exaggerated flows because of the limiting amount of information and overall assumptions used in the calculations.

4.2.2 USEPA SWMM

USEPA SWMM is a dynamic rainfall-runoff simulation model that generates runoff based on precipitation reaching subcatchment areas. This method is used primarily in urban areas, is based on a variety of input parameters, and produces a runoff value lower than that generated by the Rational Method and the TR-55 method.

4.2.3 SCS TR-55

TR-55 provides simplified procedures to calculate stormwater runoff volumes and peak rates of discharge for small, urbanized watersheds. The results from TR-55 are typically higher than those developed from USEPA SWMM, but lower than results from the Rational Method. Based on this information, the TR-55 method was determined to be the most applicable method for modeling the existing drainage system with the existing land use conditions.

4.3 Data Input

Several parameters are necessary for completing the citywide system modeling, including: basins, nodes, links, and rainfall information. The SSA modeling software models the runoff for the system by evaluating the specific input entered for each identified basin. The information needed for the analysis is discussed in the following sections.

4.3.1 Design Storms

This study uses the 25- and 100-year storm events with associated 24-hour rainfall depths of 4.37 inches and 6.17 inches, respectively, with an SCS Type 1A time distribution. A rainfall design storm is defined as the percent chance of occurrence in a given year, with the 25-year storm having a 4 percent chance and the 100-year storm a 1 percent chance of occurrence in any specific year. Because the intensity of rainfall varies during storms, depending on the geographic region, the SCS developed four synthetic distributions of rainfall over a 24-hour period, based on historical regional rainfall data. The Type IA rainfall distribution used in the model is specific to the Pacific Coast region, which is characterized by wet winters and dryer summers.

The rainfall totals for 25- and 100-year, 24-hour design storm events for the Longview/Kelso area were developed as a part of the 1989 Flood Control Master Plan. The City's Public Works uses the 25-year-frequency storm event as the standard storm for designing drainage improvements and reviewing development impacts in the city. The KEDM contains a copy of the Standard Rainfall Design Storm Events used by the City.

4.3.2 Watersheds and Basins

For this analysis, the drainage system was divided into watersheds and then into smaller basins, and composite values for each basin entered. Figures A-2a to A-9a in Appendix A show the basin delineation for each larger watershed. The input parameters for each basin needed to perform the TR-55 model include the physical properties such as area, percent impervious and pervious area, Manning's roughness coefficient, and the weighted curve number. The weighted curve number is calculated for the basin area, based on the total area entered for each particular curve number. For this analysis, the land use map was applied to the overall city map, and the area for each land use in a basin calculated. The curve number for that land use and associated area was entered into the basin, and the composite curve number for the basin calculated. Table 4-1 lists the land uses in the city and their associated curve numbers.

Table 4-1
SCS Curve Numbers for Various Land Use Conditions

Land Use Condition	% Imp.	Hydrologic Condition	SCS Curve Number for Hydrologic Soil Group			
			A	B	C	D
Forested (F)	0	Fair	50	68	78	84
Agricultural-meadow/pasture (UAM)	0	Poor	57	71	80	85
Open Space (OS)	25	*n/a*	59	74	82	87
Rural Res 10 (10-AC)	2.5	*n/a*	59	74	82	87
Rural Res 5 (5-AC)	5	*n/a*	61	75	83	87
Rural Res 2 (2-AC)	12	*n/a*	64	76	84	88
Rural Res 1 (1-AC)	25	*n/a*	65	78	85	89
Suburban Res (SUB)	38	*n/a*	72	82	88	91
Urban Low Density Res, Single Family (ULD)	65	*n/a*	84	89	92	94
Urban High Density Res, Multifamily (UHD)	75	*n/a*	88	92	94	95
Industrial (IND)	75	*n/a*	88	94	95	96
Commercial (COM)	85	*n/a*	92	94	95	96

The percent of impervious area is defined by the land use and associated curve number, and is calculated for the overall basin area, based on the composite curve number.

The time of concentration is defined as the time required for a drop of water to travel from the farthest upstream point in the basin to the point of collection (inlet). The time of concentration for each basin can be computed in SSA by entering specific information relating to sheet flow, shallow concentrated flow, and channel flow. Based on the roughness coefficient, length of flow, slope, and conveyance dimensions, a time of concentration for the basin can be computed.

4.3.3 Nodes

To perform modeling of the City's system, information from the City's inventory was reviewed and entered into the SSA model. Nodes include inlets (i.e., catch basins), junctions (i.e., manholes), flow diversions, storage facilities, and outfalls. The main nodes used for this analysis were inlets, junctions, and outfalls. The City conducted the field inventory of structures located in the city, and the data from the inventory field notes were used to enter the structures into the model. The physical properties entered included rim or grate elevation, bottom elevation, and size of structure. It is possible to enter information specific to each inlet, such as the grate length and width, roadway cross slope, Manning's coefficient, and specific gutter information. However, this level of detail for each basin was not necessary, and therefore a typical inlet "cross section" was entered for each inlet node. In addition, the program allows the determination of whether the inlet is on-grade or in sag, to provide information on bypassing flow or ponding runoff.

4.3.4 Links

The final piece of information required for analysis of the City's system is the links, or conveyance, in the city. Links include: conveyance structures such as pipes, ditches, and culverts; PSs; orifices and weirs; and outlets. For this analysis, conveyance items and outlets were incorporated. The physical properties entered for the link include the length, inlet and outlet elevations, Manning's roughness coefficient, diameter, and material. The invert elevations were entered based on the data provided by the field inventory, and the length calculated by connecting an upstream node to a downstream node. Based on the material specified by the field inventory, a Manning's roughness coefficient is automatically applied to the link.

5 RESULTS OF MODELING

5.1 Background

This section summarizes the results of the hydraulic modeling for the 25- and 100-year, 24-hour storm event for the City storm drainage system. The discussion of each watershed's basins, as well as the discussion of system deficiencies, is included in Appendix A.

The City's design criteria for storm drain systems[2] are summarized as follows:

- For closed conduits (pipe), runoff from the 25-year, 24-hour storm event shall show free-flowing conditions through the proposed and/or existing conveyance system.
- The 100-year storm may overtop the conveyance system, provided the additional flow shall not extend beyond one-half of the width of the outside lane of the traveled way and shall not exceed a 4-inch depth at the deepest point, and waters do not rise to elevations more than 1 foot below that of the lowest aboveground floor of buildings and no portions of a building will be flooded.

In order to use the modeling output to identify the most important deficiencies in the system, the above design criteria have been modified to focus on hydraulic deficiencies that result in flooding above the closed conduit system (pipes, catch basins, and manholes). The degree to which the flooding occurs can then be used to assist in the prioritization of the required improvements. The basis for comparing the degree of flooding is the volume of flood waters that occurs at the peak of the event as estimated by the model.

The City's drainage system is divided into watersheds, based on where each watershed discharges. The hydraulic modeling was conducted for each watershed. This section is organized by the watersheds shown in Figure A-1. There are six major watersheds:

- Redpath-North Kelso (basins 14, 15, 16, 17, 18, 35, 39, 40)
- West Kelso (basin 34)

[2] City of Kelso. Engineering design manual. Chapter 4, storm drainage. February 2011

- Tam O'Shanter-Northeast Kelso watershed (basins 12, 13, 28, 31, 32, 33, 36)
- Coweeman watershed (basins 1, 10, 11, 2a, 3)
- Baker Way watershed (basins 2b, 4, 5, 6)
- Southeast Kelso watershed (basins 20, 21, 22, 23, 24, 25)
- The Elks watershed, as mentioned previously, was not modeled, as there is no closed drainage system information for the area that consists primarily of the Three Rivers Golf Course.

5.2 Redpath-North Kelso Watershed

The Redpath-North Kelso watershed, located north of Cowlitz Way, is divided into eight basins, basins 14, 15, 16, 17, 18, 35, 39, and 40, and contributes drainage to the Redpath PS. Some basins are divided into two or more sections to facilitate modeling. The Redpath-North Kelso watershed is shown in Figure A-2. basin 14 (Cowlitz Way basin) is adjacent to the Redpath basin immediately to the south, and does not drain to the Redpath PS. It discharges by gravity directly to the Cowlitz River. Because of its proximity to the Redpath-North Kelso Watershed, it is included in this discussion.

The predominant land uses of the Redpath-North Kelso watershed for existing conditions are urban low density, urban high density, and commercial. The Redpath-North Kelso watershed has a total area of approximately 342 acres. Contour mapping and previous reports were evaluated in determining the area of each basin in the Redpath-North Kelso watershed. Relevant profiles of the piping system, with the peak water surface elevations, are included in Appendix C.

The basin to the east of I-5 (basin 35) is moderately steep and moderately developed, while the remaining basins, to the west of I-5, are relatively flat and highly developed. The Redpath basins west of I-5 (15 to 18, 39, 40) are bound by North Pacific Avenue to the west, I-5 to the east, Columbia Avenue to the south, and Shawnee Road to the north. The Redpath-North Kelso basin east of I-5 (35) is bound by I-5 to the west, William Finney Road to the east, Mt. Brynion Road to the south, and a ridgeline to the north, as determined by contours.

The areas to the west of I-5 are all fully developed and modeled as urban high-density residential, urban low-density residential, or commercial. However, the basin to the east of I-5 (35) is moderately developed, with approximately one-half to two-thirds of the basin area having an existing land use of urban high density, and the rest of the land as 5-acre parcels. For modeling purposes, the land use was entered as urban high-density residential.

The Redpath-North Kelso watershed contains approximately 42,565 lf of pipe, 186 catch basins, 72 manholes or junctions, and four modeled outfalls. Figure A-2a shows a schematic of the Redpath-North Kelso watershed, with the structure locations and piping layout. Profiles of the piping system, with the peak water surface elevations for the 25-year storm event, are included in Appendix C, along with the modeling output data sheets.

5.2.1 Redpath-North Kelso Watershed General System Recommendations

Twenty-five-year storm event: Although no significant flooding issues were identified along most of Redpath Street, the 4-foot-by-4-foot box culvert is the limiting factor in the ability of the Redpath-North Kelso watershed to drain properly. The lack of surcharging on Redpath Street during the 25-year storm event is likely due to the depth of the box culvert and the availability of storage in the existing manholes and catch basins farther upstream. The exception to this is at the confluence of the piping network at the intersection of Kelso Avenue and Redpath Street, where flooding was identified. In addition, the catch basins at the intersection of 3rd Avenue and Redpath Street show flooding due to the elevation of the catch basin grates with respect to the water surface elevation in the box culvert. However, the elevations of the catch basins are predicated on the elevations of the surrounding area, and raising the rim elevations likely would cause additional problems by being too high to allow drainage from the surrounding area to flow into these catch basins.

The previous modeling performed for DID No.1 suggested that adjusting (lowering) the on/off settings of the two newer pumps (pump nos. 3 and 4) at the Redpath PS during the wet season may alleviate some flooding in storm events greater than the two-year storm. However, the PS is not within the jurisdiction of the City, and any changes to the PS likely would require discussion and coordination with DID No.1 personnel.

The existing PS capacity exceeds the existing capacity of the box culvert. Flooding that has been observed by DID No.1 staff is a result of the inability of stormwater runoff to reach the PS. The capacity of the existing box culvert, assuming gravity flow, is approximately 46 cfs, while the peak system flow for this watershed is 175.88 cfs. Water backs up during the 25- and 100-year storm events and, based on ground elevations, overall flow through the entire length of the box culvert is potentially increased to 65 to 70 cfs because of the surcharging effect. The PS has four pumps with a total pumping capacity of 91 cfs, and discharges to the Cowlitz River via 24- and

22-inch-diameter steel pipes. Although the PS has additional capacity that is not being used, the flat and adverse grades of the 4-foot-by-4-foot box culvert create a reservoir for the runoff, with low velocities and flow rates. In addition, catch basin 2079 to the north acts as an overflow point for the system, allowing runoff from the 4-foot-by-4-foot box culvert to flow to the north and to the north Kelso PS. This overflow point limits the elevation of the water in the 4-foot-by-4-foot box culvert, as well as the amount of head that can develop in the box culvert, limiting the elevation of the water at the Redpath PS. This could be one explanation as to why the Redpath PS is not pumping at a higher rate during the 25- and 100-year storm events.

100-year storm event: For a 4-foot-by-4-foot box culvert to pass the 100-year, 24-hour peak flow, a slope of approximately 0.02 foot per foot (ft/ft) would be required. Because of the flat topography and the elevation constraints of this basin, a 0.02 slope cannot be obtained. The sizes required for the existing box culvert to handle the 100-year design storm, based on existing slope, range from 4 feet by 4 feet, at the upstream end near Bowmont Avenue and Lewis Street, to 4 feet by 16.5 feet at the downstream end near the Redpath PS.

Providing the flow capacity needed to pass the 100-year storm event likely would require the total rebuilding of Redpath Street, North Kelso Avenue, and Bowmont Avenue in order to accommodate a much larger drainage structure. In addition, several utilities are located within the above listed road prisms, and extensive relocation of these utilities would be needed to accommodate the larger box culvert sections. This would be extremely costly. The box culvert and Redpath PS are not within the jurisdiction of the City, and therefore opinions of cost for upsizing the box culvert or increasing the pumping capacity of the PS were not calculated.

The box culvert under Redpath Street and the Redpath PS are major components of the Redpath-North Kelso watershed. It is recommended the City consult with DID No.1 officials to determine what improvements to the box culvert and PS are feasible to construct, and consider partnering with DID No.1 for proposed improvements to these structures.

Additional Recommendations: During evaluation of the data and input into the model, several pipes were indicated to lead to a mainline pipe with no identified downstream structure connection. In these cases, a blind connection was assumed, and a junction was added to the system to allow for the connection. In most cases, the City should assume that the blind connections occur at 90 degrees to the trunk line, and the City should perform additional field investigation to determine if a structure exists below the surface, or if a blind connection actually exists. This investigation would most likely require a television analysis of the system.

In addition, it is recommended that a well-defined drainage ditch system be developed for basins 16, 17, and 18, which contain very flat slopes and large areas with no drainage system in place. It is recommended the City evaluate existing ditches located in urban areas (basins 15 and 39) and consider installing closed-system drainage to connect to the overall system and eliminate the discontinuity in the storm system.

5.3 West Kelso Watershed

The west Kelso watershed consists of basin 34, an area from 8th Avenue on the west to 1st Avenue on the east, and from Fishers Lane on the north to Washington Street to the south, and is divided into four sections: 34a, 34b, 34c, and 34d. This watershed contributes drainage to ditch No. 3 and ditch No.6, which are owned and maintained by CDID No.1. The west Kelso watershed is shown in Figure A-3.

The predominant land use of the west Kelso watershed for existing conditions is urban low density, urban high density, and commercial, with a small section of open space land use. The west Kelso watershed has a total area of approximately 155 acres. Contour mapping and previous reports were evaluated in determining the area of each basin in the West Kelso watershed. Relevant profiles of the piping system, with the peak water surface elevations, are included in Appendix C.

5.3.1 West Kelso (Basin 34)

West Kelso (basin 34) contains approximately 23,150 lf of pipe, 235 inlets, 125 manholes or junctions, one detention pond, and seven modeled outlet nodes. The main outlet node for the system (Out-34c-01) is located on the south end of 4th Avenue and Washington Street. The remaining six outlet nodes lack adequate information to connect them to the overall system, and therefore had an outlet node placed at the end of the line. Figure V-3a shows a schematic of the west Kelso watershed, with the structure locations and piping layout.

5.3.2 West Kelso (Basin 34) Watershed General System Recommendations

Basin 34 is largely built out and has little area left for development. Some of the area north of Cowlitz Way contains undeveloped or open space, less than 4 percent of the overall system area, or approximately 5 acres. Based on the results discussed above, the primary system deficiencies include adverse grades, small pipe diameters, full trunk lines, and elevation "jumps" within the system. These issues are not related to any specific locations but exist throughout basin 34. The ponding identified at some of the catch basins is considered minor (no more than 4.5 inches during the 100-year storm). Therefore, due to the limited amount of surcharging occurring in the system for both the 25- and 100-year storm events, and the relatively small duration of ponding at the inlets, there are no immediate recommendations for improvements to the piping system in basin 34.

5.4 Tam O'Shanter-Northeast Kelso Watershed

The Tam O'Shanter-Northeast Kelso watershed contains a portion of downtown Kelso (basins 12 and 13) and most of the area east of I-5 and north of the Coweeman River (basins 28, 31, 32, 33, and 38), as shown in Figure A-4.

Basin 12 was further subdivided into two sections (12a and 12b), basin 28 into six sections 28a through 28f), basin 31 into three sections (31a through 31c), and basin 32 into two sections (32a and 32b). basins 12, 13, 28a, 28d, 28e, 28f, 31, and 38 drain to the slough upstream of the Tam-1 PS. Basins 28b, 28c, 28f, 32, and 33 drain to the slough upstream of the Tam-2 PS. Basins 28a and 28b contain Kelso High and Coweeman Middle schools, and drain to a large intertie pipe that connects sloughs acting as reservoirs for the Tam-1 and Tam-2 PSs. However, since these two basins are located on private property outside the City's stormwater system, and no as-built information was provided for this area, the closed-system drainage (with the exception of the large intertie pipe and the trunk line leading to it) were not included in the model. In addition, basin 28c is a private system and therefore was not modeled as a part of this report.

The predominant land uses of the Tam O'Shanter watershed for existing conditions are residential, commercial, and open space. Contour maps and previous reports were evaluated to determine the area of the basins in the Tam O'Shanter-Northeast Kelso watershed, with a total area of approximately 1,014 acres. The total area contributing to the Tam-1 slough is approximately 654 acres, with the remaining 360 acres draining to the Tam-2 PS.

The Tam O'Shanter-Northeast Kelso watershed contains approximately 71,200 lf of pipe, 354 catch basins, 191 manholes or junctions, and 36 modeled outfalls. Figure V-4a shows a schematic of the Tam O'Shanter-Northeast Kelso watershed, with the structure locations and piping layout. Relevant profiles of the piping system with the peak water surface elevations for the 25-year storm event are included in Appendix C along with the modeling output data sheets.

5.4.1 Tam O'Shanter-Northeast Kelso Watershed General System Recommendations

All of the basins in the Tam O'Shanter-Northeast Kelso watershed are fully developed, with the exception of basins 28d, 28f, and 33a. These three basins allow for future development; however, if these basins are developed in the future, stormwater regulations will require the developed area to discharge to current flow conditions. The future condition can be no worse than current conditions and likely will improve if developed to the new stormwater regulations.

The Tam O'Shanter-Northeast Kelso watershed contains large areas where no closed-system piping information is available. This is especially common in the basins north of Allen Street that contain short pipe segments that outfall to canyons and creeks. It is recommended that basins 31a, 31b, 32a, 32b, 33a and 38 be further investigated to verify the outfall assumptions made in this model in order to better represent the Tam O'Shanter-Northeast Kelso piping system.

The basins south of Allen Street include several private and separate piping systems. Basins 28a, 28b, 28d, and 28e contain Kelso High School and Coweeman Middle School, and basin 31c contains the WSDOT I-5 right-of-way.

Basins 28a, 28b, 28d, and 28e contain large-diameter pipes with very low invert elevations. These pipes, including the 54- to 60-inch intertie pipe that connects the Tam-1 and Tam-2 PSs, are surcharged during normal flow conditions because of the water surface elevations at the Tam-1 and Tam-2 PS sloughs. This affects the Kelso drainage system upstream; however, Kelso High School and Coweeman Middle School are private systems and were not investigated; information regarding pipe elevations was added to the model, based on investigation of various plans and plat maps of the area.

The 60-inch pipe that drains basins 12b and 13 is located in basin 31c within the WSDOT I-5 right-of-way, and plat maps were used to assist with the modeling layout in this basin. The 60-inch pipe connecting the basins on the west side of I-5 (basins 12 and 13) to the rest of the Tam O'Shanter-Northeast Kelso watershed has invert elevations much lower than the water surface elevation at the Tam-1 slough, causing the pipe to remain surcharged during normal flow conditions and affecting structures upstream.

The Brookhollow neighborhood is located in basin 28c and has its own separate drainage system that outfalls to the Tam-2 slough; it is not included in this model.

5.5 Coweeman Watershed

The Coweeman watershed is located on the west side of I-5, south of Laurel Street and north of Colorado Street, and is divided into two main basins: basins 2a and 3. These basins contribute drainage to an interconnected slough that acts as storage for the Coweeman and Baker Way PSs. The Coweeman watershed is shown in Figure A-6.

The predominant land use of the Coweeman watershed for existing conditions is urban low density and industrial, with a small amount of commercial, totaling approximately 313 acres. Contour mapping and previous reports were evaluated in determining the area of each basin in the Coweeman watershed.

The Coweeman watershed is bound by South Pacific Avenue to the west, I-5 to the east, Colorado Street and Talley Way to the south, and Yew Street, 7th Avenue, Laurel Street, and a ridgeline to the north, as determined by contours. All basin areas are fully developed and modeled as urban low-density residential, commercial, or industrial.

The Coweeman watershed contains approximately 7,744 lf of pipe, 44 catch basins, 23 manholes or junctions, and five modeled outfalls. Figure A-6a shows a schematic of the Coweeman watershed, with the structure locations and piping layout. Profiles of the piping system, with the peak water surface elevations for the 25-year storm event, are included in Appendix C along with the modeling output data sheets.

5.5.1 Coweeman Watershed General System Recommendations

The Coweeman watershed is partially developed to the north and less developed to the south of the watershed. The main issues for this basin include low catch basin rim elevations, adverse grades, small pipe diameters, and surcharged trunk lines within the system. Upgrades to pipes with small diameters and adverse grades are recommended. However, catch basins with low rim elevations are affected by surcharging trunk lines as a result of the water surface elevation of the slough. The lack of free outfall conditions results in ponding at these catch basins for the 25- and 100-year storms. The City should determine if further evaluation of the Coweeman and Baker Way PSs is warranted for the 25- and 100-year, 24 hour storm events to potentially reduce surcharging at those locations.

In addition, it is recommended that a well-defined ditch drainage system be developed for the southwest portion of basin 2a, which contains very flat slopes and large areas with no drainage system in place. It is recommended that the City evaluate existing ditches located in urban areas (basin 2a) and consider installing closed-system drainage to connect to the overall system.

5.6 South Kelso Watershed

The South Kelso watershed is located south of Allen Street and is divided into three main basins: basins 1, 10, and 11. These basins contribute drainage to the Coweeman-Baker Way slough. The south Kelso watershed is shown in Figure A-5.

The predominant land use of the south Kelso watershed for existing conditions is commercial, urban low density and urban high density, with a small amount of open space, totaling approximately 223 acres. (This excludes approximately 33.5 acres that were eliminated from the model of basin 10 as the system layout could not be completed due to missing pipe information.) Contour mapping and previous reports were evaluated in determining the area of each basin in the south Kelso watershed. Modeling output data sheets from Phase I and II are shown in Appendix C, provided on a compact disk.

The south Kelso watershed is bound by the Cowlitz River to the west, I-5 to the east, Allen Street to the north, and a ridgeline to the south, as determined by contours. All basin areas are fully developed and modeled as urban low-density residential, urban high-density residential, or commercial.

The South Kelso watershed contains approximately 43,186 lf of pipe, 391 catch basins, 171 manholes or junctions, and three outfalls. Figure V-9a shows a schematic of the south Kelso watershed, with the structure locations and piping layout.

5.6.1 South Kelso Watershed General System Recommendations

The south Kelso watershed is almost fully developed and has minimal area remaining for additional development. Based on the results discussed above, the main issues for this basin include small pipe diameters, flat slopes, and surcharged trunk lines within the system. Upgrades are recommended for pipes with small diameters and adverse grades.

Basin 1: Providing positive slope for pipes identified with negative slope is the first issue to be addressed. For those pipes with positive but relatively flat slopes, increasing the pipe size will provide additional capacity for the system. An important issue is the lack of ground cover for the piping system. In some cases, providing increased slope and/or larger pipe sizes may not be feasible because of the lack of ground cover over the pipes. In these instances, it may be necessary to use a specialized pipe such as an arch pipe, or to install two or more pipes of smaller diameter to provide the capacity needed.

The modeling results for the 25-year storm indicate that the trunk line down Chestnut Street and the lines on the side streets connecting into Chestnut Street are undersized and should be upsized according to the recommendations in the individual system assessments in the City of Kelso SMP, Phase I. However, it should be noted that much of the system had hydraulic grade lines at or below the existing ground elevation and, although full, may not be creating a major flooding problem.

Basins 10 and 11: The modeling results for the 25-year storm indicate that most of the system in basins 10 and 11 (Phase II) are undersized and should be upsized. However, it should be noted that much of the system had hydraulic grade lines at or below the existing ground elevation and, although full, may not be creating a major flooding problem. Many of these lines are single pipes connecting into a trunk line and are not causing a significant problem for the system flow. However, it is recommended that any new pipe installed be a minimum of 12 inches in diameter.

5.7 Baker Way Watershed

The Baker Way watershed, located on the west side of I-5, south of Colorado Street and Talley Way, is divided into four main basins, basins 2b, 4, 5, and 6, and contributes drainage to an interconnected slough that acts as storage for the Coweeman and Baker Way PSs. The Baker Way watershed is shown in Figure A-7.

The predominant land use of the Baker Way watershed for existing conditions is industrial, with a small amount of open space, commercial, and residential, and has a total area of approximately 352 acres. Contour mapping and previous reports were evaluated in determining the area of each basin in the Baker Way watershed.

The Baker Way basins (basins 2b, 4, 5, and 6) are bounded by Colorado Street to the south, I-5 to the west, and the railroad to the east. The basins south of Colorado Street are relatively flat and 95 to 100 percent industrial, while the remaining basins, to the north of Colorado Street, are relatively flat and a combination of urban low density and commercial.

The Baker Way watershed contains approximately 4,594 lf of pipe, 22 catch basins, seven manholes or junctions (structures), and five modeled outfalls. Figure V-6a shows a schematic of the Baker Way watershed, with the structure locations and piping layout. Profiles of the piping system, with the peak water surface elevations for the 25-year storm event, are included in Appendix CB, along with the modeling output data sheets.

5.7.1 Baker Way Watershed General System Recommendations

Most of the Baker Way watershed is fully developed, but it does have some areas left for development. The main issues include low catch basin rim elevations, adverse grades, and small pipe diameters. Upgrades are recommended for pipes with small diameters and adverse grades. However, catch basins with low rim elevations should be investigated to determine an appropriate recommendation for improvement.

In addition, it is recommended that a well-defined ditch drainage system be developed for basins 2b, 4, and 5, which contain very flat slopes and large areas with no drainage system in place. It is recommended the City evaluate existing ditches located within industrial areas (basins 4 and 5) and consider installing closed system drainage to connect to the overall system.

5.8 Southeast Kelso Watershed

The southeast Kelso watershed, located to the east and south of the Coweeman River, is divided into six basins (basins 20, 21, 22, 23, 24, and 25). These basins contain very few closed-system drainage structures, most of which direct runoff across roadways into canyons and creeks, eventually draining to Coweeman River. The southeast Kelso watershed is shown in Figure A-9.

The southeast Kelso watershed is bound by the Coweeman River to the north, I-5 and the Coweeman River to the west, a ridgeline to the east, and Carroll Road to the south. The predominant land use of this watershed for existing conditions is urban low density and open space, with smaller amounts of commercial, urban high density, and residential 10-acre lots totaling approximately 1,038 acres. Contour mapping and previous reports were evaluated in determining the area of each basin in the watershed.

The Southeast Kelso watershed contains approximately 7,182 lf of pipe, 83 catch basins, 25 manholes or junctions, and 42 modeled outfalls. Figure A-9a shows a schematic of the southeast Kelso watershed, with the structure locations and piping layout. Profiles of the piping system, with the peak water surface elevations for the 25-year storm event, are included in Appendix C, along with the modeling output data sheets.

5.8.1 Southeast Kelso Watershed General System Recommendations

Southeast Kelso watershed is largely undeveloped, with a small portion identified as low-density residential, and has area remaining for additional development. The main issues for this basin include small culvert and pipe diameters, shallow ditch sections with flat slopes, and sudden changes from very steep to very flat slopes in both the ditch and the closed piping system. Upgrades are recommended for culverts and pipes with small diameters. Ditch sections should be converted to closed-system piping whenever possible. In the case of sudden slope changes, it is recommended that flat downstream slopes be improved if possible.

Additionally, large areas in the southeast Kelso watershed, especially segments of Grimm Road, Alma Drive, Crestwood Lane, Apple Way, and W Highland Park Drive, have no apparent drainage system in place. It is recommended that these roads be investigated and either closed-system drainage or a well-defined ditch system be installed along main roads that lack drainage structures.

5.9 Elks Watershed

The Elks watershed is located to the west of the Coweeman and Baker Way watersheds and is divided into three main basins, basins 7, 8, and 9. The Elks watershed is shown in Figure A-8.

The watershed consists partly of the Three Rivers Golf Course, with the remaining area comprising open space, single-family residential, commercial, and industrial land use. The Elks watershed has a total area of approximately 231 acres. The basins drain to the Elks PS and are independent of the Coweeman and Baker Way watersheds. The piping system consists mostly of private culverts in the golf course, and therefore they have been excluded from the analysis.

6 RUNOFF CONTROL STRATEGIES

6.1 Background

This section discusses the general issue of stormwater runoff control as it relates to the overall system of closed-system drainage, PSs, and reservoirs, versus localized flooding. As stated in Section 3, the area within the Kelso city limits has eight main areas where stormwater is discharged, either via gravity or PS. Much of the City's system is controlled by the various PSs that discharge to either the Cowlitz River or the Coweeman River. Limitations of the PS capacities and storage facilities can have an effect on the City's drainage system, but both CDID No.3 and DID No.1 have worked over the years to refine the pumping operations of the PSs to provide protection during rainfall events. In recent years, CDID No.3 has made upgrades to the Tam-1 PS at Tam O'Shanter Park and to the Coweeman and Baker Way PSs. In addition, Cowlitz County constructed the King Creek PS to reduce flooding in the north Kelso area. CDID No.1 has not had major issues with the performance of their system downstream of the west Kelso watershed.

6.2 Regional

In most cases, the City's stormwater pipes discharge into either CDID No.1, CDID No.3, or DID No.1 piping systems, ditches, or PS reservoirs, under tailwater conditions. This inhibits the ability of the City's stormwater conveyance system to discharge freely, causing standing water in the pipes. City piping is submerged in some cases because of pumping limitations. This does limit the capacity of the City's system, as those pipes discharging under tailwater conditions do not have a free discharge, and must develop a head condition (water level above the top of drainage pipes that rises into inlets and manholes) to force runoff to discharge in spite of the standing water at the pipe outlet. The diking and drainage districts have worked to modify the pumping operations to provide a balance between excessive running of the pumps and providing stormwater protection of the areas draining to them. For the few basins that do not discharge to a PS facility, the discharge is typically free flowing, such as in basin 14, which has a gravity discharge directly to the Cowlitz River from the high ground north of Cowlitz Way.

6.3 Localized

Areas in the City's drainage system create some localized issues due to the presence of adverse grade, small pipe sizes, and discontinuity between pipe size, material and elevations. These issues can create problems in areas near catch basin inlets, and are typically a function of sudden, heavy rainfall, but dissipate quickly after the event has passed. Although it is not feasible for the City to replace every existing pipe at adverse grade, it is worth identifying those pipes with adverse grade or diameter smaller than 12 inches, and making appropriate improvements to the system while other projects are taking place, such as water line or sewer line replacement or street paving. Review of the model should take place to determine which pipes should be considered for replacement in the area of the proposed construction at the same time as other utility work is to be conducted.

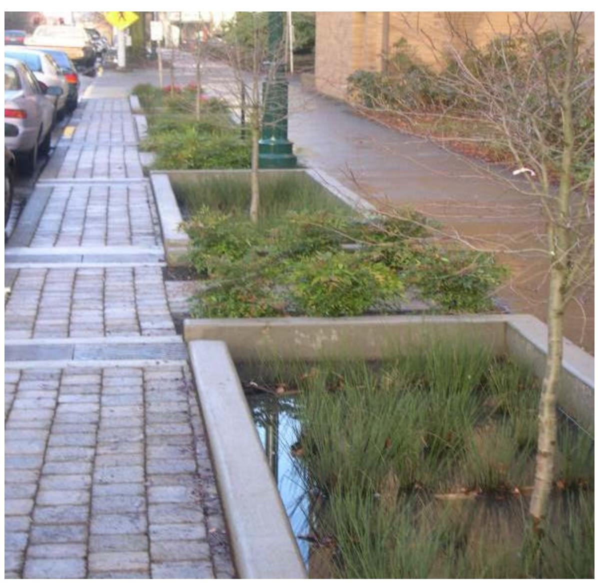
6.4 Runoff Control Strategies

The KEDM requires that stormwater from site development or redevelopment be detained or infiltrated to limit impacts to the City's storm system. Although most of the city land use is already developed, with little opportunity to implement future development requirements, there are measures the City can take, compatible with the existing land use, to help reduce runoff. Many of the measures identified in the KEDM are considered low-impact development (LID) designs. The measures most readily available for site development or redevelopment include the use of pervious pavement and dispersion in appropriate areas. For city streets, LID practices most applicable include the use of pervious pavement, bioretention planting areas, stormwater planters, or the planting of street trees to intercept stormwater.

Pervious pavement is generally applicable only to light to moderate traffic areas because of its inability to accommodate heavy loads. There are many types of porous pavement, including pervious concrete and asphalt, modular block, reinforced grass, cobblestone block and gravel. When properly installed, and in the proper setting, porous pavement can be as functional and durable as traditional surfaces for these applications.

Bioretention facilities are often incorporated into street reconstruction design by excavating below street grades outside the curb line and allowing runoff to enter through curb cuts (see photo below). These facilities require suitable soil and groundwater conditions to be successful.

A stormwater planter is a low-lying vegetated planter that receives runoff from roof drains or adjoining paved areas. A shallow surcharge zone above the vegetated surface temporarily stores stormwater. The accumulated runoff gradually infiltrates into an underlying sand/peat bed and then into a gravel layer. If the planter is a flow through stormwater planter, it has an impermeable bottom liner and an underdrain pipe to collect the treated water and discharge it to the municipal storm drain. Planters without an impermeable bottom liner (infiltration planters) will also require an underdrain when the underlying soils are less permeable than the planter's sand/peat layer.



Trees intercept stormwater and can retain a significant amount of the captured water on their leaves and branches, allowing for evaporation and dissipation of the energy of runoff. Their root structures absorb and uptake runoff and associated pollutants. The shade provided by trees keeps the ground under the trees cooler, thereby reducing the amount of heat gained in runoff as it flows over the surface and into the storm drain. In turn, this helps keep stream temperatures cool and healthy for fish and other aquatic life.[3]

As future development and street reconstruction projects take place within the city, the use of LID practices as identified in the KEDM will help minimize stormwater runoff and possibly reduce the amount of runoff contributing to the City's system.

[3] . Stormwater Quality Design Manual for the Sacramento and South Placer Regions. Chapters 5 and 6. May 2007.

7 ADMINISTRATION AND POLICIES

7.1 Stormwater Permit Administration

In February 2007, the City became a permittee under the Permit, which required the City to develop a Stormwater Management Program (SWMP). This document was last updated in 2011 and can be found on the City's Web site at http://publicworks.kelso.gov. As a followup to the City's SWMP, an inventory and mapping of the City's system was developed and is included as a part of this SMP.

Ecology issued a new Phase II stormwater permit in August 2012 which will become effective in August 2013. The new Permit includes a number of revised requirements that will result in the need to update the City's SWMP and to perform an expanded or revised role in:

- Public education on illicit discharges, LID principles and stewardship
- Revision of development-related codes, rules or standards to require LID principles and BMPs for site development by December 31, 2016
- Controlling runoff from development, redevelopment and construction sites (new permit eliminated the one-acre threshold) by developing an ordinance by June 30, 2017
- Field screening for illicit connections (at least 40% by December 31, 2017)
- Update maintenance standards by December 31, 2017. (The City has already performed the permit-required catch basin inspection and cleaning.)
- Stormwater management program effectiveness studies (or pay Ecology $4793 annually in lieu of conducting the studies locally)
- Source identification and diagnostic monitoring by paying Ecology $444 annually

The new permit also added the Kelso School District as a secondary permittee. Section S6 of the Permit defines the requirements for secondary permittees including coordination of their SWMP with the City's.

7.2 City of Kelso Administration

The City operates under a council-manager style of government in which members of the community are elected to serve on the city council. At its first meeting in January following its election to office, the city council elects from among its members officers of the city to serve as mayor and deputy mayor for a minimum of two years. The mayor is recognized as head of the city government for purposes of military law but has no administrative duties. In addition to the mayor, the city council selects an individual to act as the city manager, who works directly under the mayor. The city manager oversees City departments such as the Public Works Department and this department includes Engineering and Operations. A City Public Works Department organizational chart is shown in Figure 7-1.

Engineering includes the city engineer, staff engineers and support staff. One engineer is designated as a stormwater manager. The city engineer position is currently vacant and the Public Works Director currently assumes city engineer responsibilities. In February 2008, the City formed the Kelso Stormwater Advisory Committee (KSAC) that is composed of seven stakeholders with an interest in the quality of surface waters in and around Kelso. Stakeholder members represent the environment, recreation, development, students, citizens, business and a technical advisor. The KSAC is led by the stormwater manager, whose function is to facilitate the meetings of the KSAC and to act as a City liaison to the committee. The KSAC guides the development and implementation of the SWMP and makes recommendations to the city council.

Operations is led by the operations superintendent and include street/drainage, water/sewer, water plant, and traffic control divisions. The street/drainage division has the primary responsibility for the stormwater collection system.

7.3 Roles and Responsibilities

The Public Works Department supervises and controls the construction and maintenance of all storm sewer facilities and appurtenances, including storm sewers, drains, ditches, culverts, and streams and watercourses under jurisdiction of the City. The purpose of this section is to define the roles and responsibilities of the various City departments, staff, and operations and maintenance personnel.

7.3.1 Administration

This function provides the general and administrative activities necessary for operation of the local stormwater management program. Several subgroups of administrative functions and types of support expenses, including those associated with financial management and program development are generally included under the category of program administration activities. These include:

- General administration
- Secretarial and clerical support
- Financial management
- Program planning and development
- Capital outlay and overhead expense
- Public awareness and involvement

These activities, and occasionally the billing and collection of fees, are described as administrative functions. Overhead and logistical expenses (space, telephone, utilities, etc.), and capital outlays for office furniture and fixtures not attributable to other functions, are also identified under the administrative category. Capital outlay and overhead costs are "nonfunctional" in the sense that they are not work activities. However, they are required for general support of the program, and this category is simply the most suitable one in which to group them.

7.3.2 Engineering

Engineering is responsible for engineering services, including the design and preparation of all contract drawings and specifications for public work contracts; the preparation of cost estimates; the supervision and inspection of construction; the establishment of street, alley, and walk grades; city surveying and mapping operations; maintenance of public building, street, water, sewer and storm sewer utility records; review of subdivision plats for matters requiring engineering determination; processing of local improvement districts; and design of channelization and traffic control devices.

Engineering identifies the predetermined objectives, plans, and programs necessary to carry out the mission of the stormwater program. Engineering directly influences stormwater master plans, basin studies, and siting and sizing of the conveyance and treatment components of the stormwater management systems. These functions continue to be essential work elements as improvements are made to the program. Sub-functions included in this category are:

- Capital Improvement Programs
- Development review/approval
- Budgeting for performance
- Stormwater management master planning
- Design and field engineering

- Water quality planning and engineering
- Hazard mitigation

7.3.3 Regulation and Enforcement

Individuals, as well as developers, agricultural interests, and large companies, contribute to the need for better regulation of the stormwater systems, suggesting that another facet should be incorporated in a community's regulatory program specifically to control and mitigate the general public's actions. Homeowners dump grass clippings, brush trimmings, and other debris into drainage ditches and swales; this debris must be removed by maintenance crews or it will contribute to pollution and blockages in downstream reaches. Home mechanics dispose of crankcase oil, antifreeze, and other wastes into stormwater systems, causing water quality impacts. Public education has proven to be effective in reducing the impact that individuals have on stormwater systems, but increased regulatory enforcement is also needed. Regulation and enforcement functions included in a community's stormwater program are separated into four distinct categories:

- Code development and enforcement
- Permit administration
- Private stormwater system regulation
- Floodplain management

Experience has shown that regulatory efforts are among the most cost-effective and productive stormwater control measures. Regulations can be developed more quickly than capital projects, are less expensive than increased maintenance, tend to reduce the causes of problems quickly if vigorously pursued, and are permanent when applied consistently and repeatedly.

7.3.4 Operations and Maintenance

The active operation of the physical stormwater infrastructure of the City includes a regularly scheduled inspection and maintenance program. Maintenance operations, both routine and remedial, are necessary if the City intends to keep its stormwater infrastructure operational at or near its design capacities. The City has developed a Storm Checklist (Appendix D) that Operations uses to inspect recognized critical areas that are susceptible to flooding. The crew inspects these areas for flooding during and after major rainstorms. Although much of the flooding that occurs is the result of debris blocking the catch basin grates, some of the flooding is due to inadequate storm collection system capacity. Routine maintenance includes the normal cleaning activities required to keep the stormwater management systems in proper condition. Both routine and remedial maintenance are required to ensure that the systems work as effectively as possible when storms occur. The primary work tasks and related support activities included under the operations and maintenance category are:

- Routine maintenance
- Remedial maintenance
- Erosion and sediment control
- Emergency response operations
- Water quality operations
- Support services

7.3.5 Stormwater Utility Staffing Summary and Needs

The stormwater utility maintenance activities are the responsibility of the Street/Drainage staff which includes lead person and a maintenance technician. The utility is also supported by a senior design engineer responsible for engineering, permit compliance and program development. The new Permit has added a significant amount of work to the program development and permit compliance functions. The increased work has been estimated to result in the need for between an additional half-time and fulltime position to maintain permit compliance. The specific timing of the additional position will depend on when the City plans on beginning work on meeting the new Permit obligations.

7.4 BMPs and City Compliance

The KEDM includes design guidelines for addressing stormwater in the city. The KEDM outlines requirements for development and in general follows the SMMWW, including appropriate BMPs. A complete list of source control and runoff treatment stormwater BMPs can be found in Volumes IV and V of the SMMWW. As the City makes improvements and upgrades to the existing stormwater drainage system, adherence to the BMPs listed in the SMMWW should be followed. BMPs required by Ecology include:

- Eliminate illicit connections to storm drains. The City should examine their existing City-owned property plumbing facilities to identify illicit connections.

- Perform routine maintenance of the stormwater system. This will be discussed further in Section 10.

- Spill prevention control and countermeasure (SPCC): If City facilities meet the threshold requirements, they should maintain SPCC plans for liquid pollutants, including oils, solvents, and fuels.

8 CAPITAL IMPROVEMENT PLAN

8.1 Background

The City develops a six-year Capital Improvement Plan for all major public works infrastructure such as streets, water, sewer, and drainage. The most recent plan is the citywide 2012-2017 Capital Improvement Plan. The Capital Improvement Plan establishes the project priorities and briefly describes the projects' need, scope, cost, and schedule. The general source of funding for the projects is usually identified; however, this does not represent a commitment of funds by the City to move forward with the project. That commitment is made only by the city council in their annual budget process. The Capital Improvement Plan projects represent an acknowledgment that those projects are needed but the total cost of the projects often exceeds the known sources of funding such as the annual utility revenue. The City uses the Capital Improvement Plan to help in the budget process, qualify for grants, track the needs in the city, and provide documentation for potential funding programs that will allow the City to take full advantage of the resources that may become available.

This chapter will focus on the stormwater system projects that were identified as a result of the hydraulic modeling described in Section 5. The stormwater projects that are identified in the City's existing Capital Improvement Plan have been considered for scheduling and funding alongside the projects in this plan and are incorporated into the Capital Improvement Plan priority list.

8.2 Method

The modeling results estimate the volume of flooding (surcharging above the ground surface) at locations identified by catch basins or manholes. The flooding could be caused by a variety of conditions, not just pipe that is too small to carry the particular storm event being modeled. The flood volume information provides a sense of the magnitude of the problem but does not indicate the area or number of residences or businesses that could be impacted. Flooding could also be caused by deficiencies in system elements beyond the boundary of the City storm sewer system, e.g., a drainage district ditch, pipe, or pump station. To the extent possible, the likelihood that these external issues are the source of the flooding has also been determined.

The projects for the Capital Improvement Plan have been ranked based on the total 25-year flood volume predicted to occur in the areas of concern. The 100-year storm was also evaluated; however, the 25-year storm was selected because it is the standard storm used by the City to design drainage improvements. Intense short duration storms may result in flooding that is not identified by using the 25-year storm as the basis for selecting projects for the Capital Improvement Plan. The model input could be modified in the future to use short duration storm intensity values and then checked to see if the model correctly predicts observed transitory flooding that occurs at specific locations. If flooding from short duration storms causes interruption of traffic or other negative impacts, the City could consider adding corrective measures to the Capital Improvement Plan based on short intense storm events.

The detailed information that has been used to develop the project list is contained in Appendix A. The problem areas and the results of the flood volume rankings by basin are shown on Figures A-2b through A-9b for the 25-year storm, with the exception that the south Kelso watershed (basins 1, 10, and 11) are ranked based on the Excel spreadsheet included in Appendix C on the enclosed compact disk. The drainage basins will be discussed individually and then summarized at the end of this section.

Some of the terms used in this section are defined as follows to clarify them for the reader:

- Sag—The pipe or series of pipes has a belly or low point in the middle of a pipe run, causing poor flow conditions.
- Adverse grade—The pipe slopes uphill instead of downhill, causing the water to back up in the pipe until it can overcome the downstream elevation and start to flow. This can cause poor hydraulic capacity and flooding upstream.
- Sawtooth condition—The invert elevation of an upstream pipe was lower than the invert elevation of a downstream pipe in multiple pipe segments, causing an up-down-up-down, or sawtooth, flow condition.
- Confluence of multiple piping segments—This is where multiple pipes enter a manhole or catch basin, often at directions pointing partially upstream, which can cause turbulence and the backup of water in upstream pipe segments.
- Bubbler—This is a catch basin with an inlet pipe but without an outlet pipe that is used to discharge or "bubble" stormwater out the top of the basin so it can run across the surface, usually in a street gutter or ditch. This is an intentionally designed structure but shows up in the model output as a flooding condition. The design reduces the cost of storm drains system but provides a less than optimum operation.

- Surcharge— Surcharge is a flow condition where water within the pipe is under pressure (pressurized-conduit flow, not gravity flow). Surcharge normally occurs when the flow rate entering a pipe or catch basin exceeds the downstream pipe capacity. In a pipe, this occurs when the water level in an upstream structure, such as a catch basin, is above the pipe. Surcharging in a catch basin occurs when water is above its grate and this is seen as flooding.

8.3 Redpath-North Kelso Drainage Watershed

There are a variety of drainage issues in the Redpath-North Kelso watershed, including areas without a formal stormwater collection system. The modeling indicates areas of surcharging at approximately 40 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered as significant areas of concern. Figures V-2b and V-2c show the areas of concern for 25-year and 100-year storms, respectively. In general, surcharging tended to occur when a catch basin was in sag, or a downstream pipe had an adverse grade or a sawtooth condition. It is likely that the confluence of multiple piping segments also contributed to surcharging.

8.3.1 Basin 15-a, Area 1 (15a-1)

This basin contains two structures (1451 and 1448) in the 15a-1 area that cause the highest volume of flooding (three times higher than all the other locations in the basin) near the intersection of North Kelso Avenue and Redpath Street adjacent to Huntington Middle School. The area discharges to a 4-foot-by-4-foot box culvert that flows to DID No.1's Redpath PS. The PS has more flow capacity than the box culvert can deliver to the PS, so it is likely that the flooding is caused by lack of capacity in the box culvert. The flooding may be exacerbated by a possible accumulation of sediment in the box culvert, but this condition has not been confirmed as the box culvert has limited access for inspection. The hydraulic model showed that a properly sized box culvert would start with 4 feet by 4 feet at the upper end (see Figures V-2a and A-10a) and transition to 4 feet by 16.5 feet at the lower end. The box culvert is part of DID No.1 system but, regardless of ownership, it would be very expensive to solve the basin 15-a drainage issues by using this type of drainage structure. A second option may be to acquire property and create a detention pond that could hold runoff from a storm and release it more slowly. It would be necessary to conduct further investigation of the hydraulic requirements of this option.

The recommendation is to confer with DID No.1 about potential operational or capital improvements to DID No.1's system that would reduce the flooding impacts to this area. These options could then be compared to the feasibility of a detention pond approach. Because of the severity of flooding associated with this deficiency, this project was rated in Table 8-1 as Priority A and is listed as CIP reference number D-11 in the 2012-17 Kelso CIP.

8.3.2 Basin 15-c, Area 1 (15c-1)

The basin has several sections of 12-inch pipe (link-06 and link-470) that connect 18-inch pipe upstream and downstream of the smaller-diameter pipe, which results in a restrictions and flooding. There may also be some sharp-angled pipe connections in the same area that could contribute to the surcharging. See Appendix A, Section A.1.4.2 and Figure A-10c for more details on the problem area. It is recommended that approximately 160 lf of 18-inch pipe be installed along with new manholes along the section. This project was rated in Table 8-1 as Priority C and is listed as CIP reference number D-16 in the 2012-17 Kelso CIP.

8.3.3 Basin 17-1, Area 1 (17-1)

The basin has a mix of pipes and ditches that are inadequately draining the area near Division Street and 2nd and 3rd Avenues. There is not enough drainage system information, such as pipes and inlets, on this area to allow development of recommendations for specific improvements, so the best course of action is to include in the plan a more detailed survey and evaluation, using the hydrologic model to determine the improvements necessary to resolve the flooding issues. See Appendix A, Attachment 1 and Figure A-10f for details) This project was rated in Table 8-1 as Priority F and is listed as CIP reference number D-12 in the 2012-17 Kelso CIP.

8.4 West Kelso Watershed

The west Kelso basin has a series of small stormwater collection system deficiencies but does not have significant flooding issues. Even with the 100-year storm event, there are very few places where surcharging of the system occurs. Some of the visual reports of areas that surcharge are not validated by the model, which indicates that some of the drainage structures may be damaged or need cleaning. The areas that show limited surcharging are described in Attachment 2 of Appendix A, the modeling results discussion, but not included in the Capital Improvement Plan recommendations because of the low significance.

8.5 Tam O'Shanter-Northeast Kelso Watershed

This watershed has a number of areas with surcharging catch basins. Many of the deficient areas are on the steeper hillside in the north portion of the watershed. A number of the surcharge issues are created by the use of “bubblers” in the original design that allows runoff to flow out of the top of catch basins and then run down the street gutter to the next inlet. Four areas (31a-1, 33a-1, 32b-1, and 32b-2) have the highest volumes of flooding, which is mostly a result of the original bubbler design. Many of these locations were built over 30 years ago and have functioned in this manner since their original construction. For this reason, these areas are described in Attachment 3 of Appendix A, the modeling results discussion, and are not included in the Capital Improvement Plan recommendations.

8.5.1 Basin 32-b, Area 1(32b-1)

One of the four areas mentioned above (32b-1) has a capacity and turbulence issue in the last structure (catch basin1957) prior to its outfall. It is recommended that the catch basin structure be replaced with a larger manhole with an energy-dissipating design and that the upstream and downstream pipes be replaced with 475 and 87 lf of 18-inch-diameter pipe, respectively. (See Appendix A, Attachment 3 and Figure A-10e for details) This project was rated in Table 8-1 as Priority E and is listed as CIP reference number D-21 in the 2012-17 Kelso CIP.

8.5.2 Basin 28a, Area 1 (28a-1)

This basin is in the flat area west of Kelso High School; two of the catch basins have low top rim elevations relative to the outlet of the basin collector pipe that is submerged at the CDID No.3 Tam-1 PS slough (see Figure V-4b). This condition results in surcharging above the catch basins and some flooding. Although there are improvements that would help the flooding recede somewhat more quickly, the flooded outlet from the basin will still result in surcharging from the two catch basins. No improvements to the Kelso piping system are recommended as part of the CIP. See Figure V-4b and Appendix A, Attachment 3 for further details.

8.5.3 Basin 32a, Area 1 (32a-1)

Improvements to this area are not recommended as part of the CIP. The improvements would slightly enhance drainage but would not alleviate the surcharging and associated flood volume. See Figure V-4b and Appendix A, Attachment 3 for further details.

8.5.4 Basin 28e, Area 1 (28e-1)

Improvements to this area are not recommended as part of the capital improvement plan. Flooding issues are related to the outlet from the basin being lower than the water level in the Tam-1 PS slough. See Figure V-4b. The improvements would slightly enhance drainage but would not alleviate the surcharging and associated flood volume. See Appendix A, Attachment 3, for further details.

8.5.5 Basin 13, Area 1 (13-1)

This basin's issues are a result of the outlet of a 60-inch-diameter storm drain that crosses I-5 and discharges to Tam 1 PS slough, normally under submerged conditions. Several drainage structures are in a sag condition that causes limited flooding in the vicinity of Oak Street and Vine Street near Grade Street. The minor revisions to the drainage system (described in Attachment 3 to Appendix A are not recommended for inclusion in the CIP. See Figure V-4b.

8.6 Coweeman Watershed

Many of the surcharged conditions in this watershed are a result of the levels in the slough that connects the City system to the Coweeman and Baker Way PSs. The areas that are recommended for improvements to reduce flooding are discussed below.

8.6.1 Basin 2a, Area 1 (2a-1)

There are several pipes near the intersection of South 13th Avenue and Hazel Street that have adverse grades and other issues. It is recommended that the City replace link-4252-1591. Replacement of undersized pipes is delineated in Appendix A, Attachment 4 and in Figure A-12d. Replacement of pipe amounts to 770 lf of 12–inch pipe plus associated catch basins and manholes. This project was rated in Table 8-1 as Priority D and is listed as CIP reference number D-17 in the 2012-17 Kelso CIP.

8.6.2 Basin 2a, Area 2 (2a-2)

Pipe runs have adverse grade issues near the intersection of 9th Avenue and Yew Street. It is recommended that the City replace link-757 with 28 lf of 12-inch-diameter pipe and link-154 and link-2135 with 348 lf of 12-inch-diameter pipe (see Appendix A, Attachment 4 and Figure A-10h for details). This project was rated in Table 8-1 as Priority H and is listed as CIP reference number D-14 in the 2012-17 Kelso CIP.

8.6.3 Basin 2a, Area 3 (2a-3)

Downstream conditions in the existing slough leading to the PSs create flooding conditions; therefore, no recommendations are made for this basin.

8.6.4 Basin 3, Area 1 (3-1)

Downstream conditions in the existing slough leading to the PSs create flooding condition; therefore, no recommendations are made for this basin.

8.7 South Kelso Watershed

This watershed was analyzed in the Phase I and Phase II stormwater studies and do not have the same type of modeling output as the rest of the system. Basins 1, 10, and 11 have been included in the system hydrologic model created for the citywide stormwater system and have been considered in the Capital Improvement Plan, based on flood volume estimates. Segments of pipe along Chestnut and 8th Street drain to Pipe 239, which is shown with adverse, or negative, grade between nodes 313 and 315. This adverse grade causes back up of the system in the model results. It is recommended pipes 229, 230, 238 and 239 be upsized from 24-inch to 30-inch pipe, and pipes 240 through 246 be upsized from 30-inch to 48-inch pipe, some of which may have to be arch pipe to compensate for shallow depth of cover (see Appendix A, Attachment 4 and Figure A-10b for details). This area has significant flooding and is included in the CIP in Table 8-1 as Priority B. The project involves the replacement of 24- and 30-inch-diameter pipe with 30- and 48-inch-diameter pipe.

8.8 Baker Way Watershed

There is one deficiency in the Baker Way watershed that is ranked in the Capital Improvement Plan in basin 5 along Talley Way, south of the intersection with Parrott Way. Basin 5-3 has a pipe that is indicated to have an adverse grade; this pipe should be replaced. The project would involve replacement of 140 lf of pipe with a new 18-inch-diameter pipe (see Appendix A, Attachment 5 and Figure A-10g for details). This project was rated in Table 8-1 as Priority G and is listed as CIP reference number D-13 in the 2012-17 Kelso CIP.

8.9 Southeast Kelso Watershed

There is one deficiency in the southeast Kelso watershed that is ranked in the Capital Improvement Plan in basin 22 along North Vista Way. Basin 22-2 has a series of undersized culverts that do not have sufficient capacity to accommodate the upstream flows from larger culverts. The project would involve the replacement of approximately 53 lf of 12-inch-diameter pipe (see Appendix A, Attachment 6 and Figure A-10i for details). This project was rated in Table 8-1 as Priority I and is listed as CIP reference number D-22 in the 2012-17 Kelso CIP.

8.10 Capital Improvement Plan Summary

The importance of the impact from the deficiencies can be ranked in a variety of ways, such as flood volume, depth, or number of residences impacted. The model used for the system evaluation provides the flood volume in acre-inches of water (27,154 gallons per ac-in) at each of the problem areas, which gives an indication of how much water reaches the ground surface as a result of a particular rain event. As previously discussed, the 25-year storm event was used to develop the rating for each project. The severity of flooding will be influenced by this volume but is also dependent on the local topography and the location of roadways and structures relative to the flood elevation. For purposes of this SMP, the flood volume has been used as a good approximation of the severity of the deficiency.

The figures contained in Appendix A for the 25-year storm event show circled areas that are labeled with an area name, for example: "Area 16-1." This indicates that the primary location of the deficiency is in basin 16 and the "1" indicates the numbering system in the basin. Only those deficiencies discussed in this section were included in the plan ranking. Other projects from the City's existing CIP should be considered for addition to this list.

Cost estimates for the CIP were based on construction bids on municipal projects in southwest Washington using the average bid prices for similar municipal work in the 12 months from April 2011 through March 2012. The estimated construction costs for the projects listed in Table 8-1 should be updated based on the Engineering News Record Construction Cost Index (March 2012 ENR Construction Cost Index = 9267.57).

An expanded CIP developed by the City contains additional stormwater projects and is included in Appendix B along with individual CIP request forms provided by the City.

Table 8-1
Capital Improvement Plan
Priority Project List from Hydraulic Analysis

Priority	Project No.	Watershed	Description	Rating*	Total CIP Cost**
A	15a-1	Redpath-North Kelso	Investigate alternative solutions for major district culvert deficiency	330	$15,000
B	Basin 1, Inlet 536 – (System 16)	South Kelso	Replace undersized or poorly sloped pipe	119	$84,000
C	15c-1	Redpath-North Kelso	Undersized pipe	96	$31,000
D	2a-1	Coweeman	Undersized pipe	87	$58,000
E	32b-1	Tam O'Shanter-Northeast Kelso	Undersized pipe and turbulence	44	$76,000

F	17-1	Redpath-North Kelso	Survey and evaluate needed improvements	40	$10,000
G	5-3	Baker Way	Replace pipe at adverse grade	30	$27,000
H	2a-2	Coweeman	Undersized pipe	29	$29,000
I	22-2	Southeast Kelso	Undersized culverts	20	$5000

* Rating based on hydrologic model's predicted volume of flooding above ground surface.
** Engineering News Record Construction Cost Index (March 2012 ENR Construction Cost Index = 9267.57).

The City's 2013-2018 Capital Improvement Project Information included in Appendix B contains twenty-two projects or actions that have been identified by the City. This CIP list includes the projects identified by the SMPs hydraulic analysis in Table 8-1. It contains a variety of projects that include programmatic items such as permit compliance; maintenance issues such as failed or aging pipe replacement; operational issues such as Public Works facility improvements that impact stormwater; infrastructure improvements in areas without a storm drain system; and impacts from high water in the Cowlitz River.

Table 8-2
Combined Capital Improvement Plan

Project Identifier CIP # (Priority)	Project No.	Watershed	Description	Ranking	Total CIP Cost**
D-01	NPDES Permit Implementation	System-wide	Permit-required actions	Ongoing	$150,000
D-02	Burcham Street Canyon Upgrade	Tam O'Shanter-Northeast Kelso	Maintenance facilitation project	Non-urgent	$90,000
D-03	Chestnut Street Drainage	South Kelso	Maintain by replacement of trunk pipeline	Non-urgent	$310,000
D-04	Operations Stormwater Upgrades	South Kelso	Water quality-related work at Public Works yard	Non-urgent	$20,000
D-05	Minor Road Pipe Replacement	Tam O'Shanter-Northeast Kelso	Maintain by replacement of large drain pipe	Non-urgent	$500,000
D-06	Outfall Restoration at Grade St. Bridge	Southeast Kelso	Restore plugged outfall	Non-urgent	$18.000
D-07	S. 9th Avenue Drainage	South Kelso	Install new drain system.	Non-urgent	$100,000
D-08	304 Harris St. Stormwater System	Redpath-North Kelso	Reroute drainage due to utility conflict	Non-urgent	$40,000

D-09	Harris Street Drainage	Redpath-North Kelso	New drainage system along Harris St.	Non-urgent	$50,000
D-10	Cedar Street Drainage	South Kelso	Replace existing inadequate system	Non-urgent	$100,000
D-11 **(A)**	Redpath Investigation (15a-1)	Redpath-North Kelso	Investigate alternative solutions for major district culvert deficiency	Non-urgent	$15,000
D-12 **(F)**	Division Street Drainage System Evaluation -17-1	Redpath-North Kelso	Survey and evaluate needed improvements	Non-urgent	$10,000
D-13 **(G)**	Talley Way Drainage Pipe - 5-3	Baker Way	Replace pipe at adverse grade	Non-urgent	$27,000
D-14 **(H)**	S. 9th Ave. Drainage Pipe Upgrade – 2a-2	Coweeman	Undersized pipe	Non-urgent	$29,000
D-15 **(B)**	8th Ave. Drain Pipe Upgrade - Basin 1	South Kelso	Replace undersized or poorly sloped pipe	Non-urgent	$84,000
D-16 **(C)**	N. 4th Ave. Drainage Pipe Upgrade -15c-1	Redpath-North Kelso	Undersized pipe	Non-urgent	$31,000
D-17 **(D)**	Hazel St. Drainage Pipe Upgrade -2a-1	Coweeman	Undersized pipe	Non-urgent	$58,000
D-18	Allen Street Flood Prevention Improvements	Tam O'Shanter-Northeast Kelso	Flood protection	Non-urgent	$1,020,000
D-19	Riverside Drive Flood Prevention Improvements	Elks	Flood protection	Non-urgent	$101,000
D-20	N. 20th Ave Drainage	Tam O'Shanter-Northeast Kelso	Facilitate maintenance	Non-urgent	$100,000
D-21 **(E)**	Sunrise Street Drainage Pipe Replacement - 32b-1	Tam O'Shanter-Northeast Kelso	Undersized pipe and turbulence	Non-urgent	$76,000
D-22 **(I)**	S. Vista Way Culvert Replacement - 22-2	Southeast Kelso	Undersized culverts	Non-urgent	$5000
D-23	Update SMP	System-wide	Update plan	2018 (5-year interval)	$30,000

** Engineering News Record Construction Cost Index (March 2012 ENR Construction Cost Index = 9267.57).

9 IMPLEMENTATION

9.1 Stormwater Management Plan Implementation

The Permit requires implementation of six minimum control measures as discussed in the City's SWMP. The added requirements of the Permit that will become effective in August 2013 are discussed in Section 7.1.

As part of the current Permit, mapping of the City storm system and deficiencies that require remediation are discussed in this SMP. Some of the items that need to be expanded from the current SWMP are listed below:

- Determine the outfall of stormwater facilities from private facilities to the City's storm system.
- Regularly inspect these outfall points for illicit discharge and illegal dumping to the City's MS4 system.
- Provide training to City staff on IDDE for the City's MS4.
- Record inspections of outfalls to MS4.
- Develop a spill response program for industrial and municipal private and public sites and require notification of spills.
- Develop procedures to remove sources of illicit discharge.
- Develop public education strategies regarding illicit discharge such as mailers and radio advertisements.
- Prepare a summary of permitted stormwater facilities inspections.
- Train staff for inspection of existing stormwater facilities.
- Add a minimum half-time equivalent staff to implement the requirements of the Permit.
- Develop methods of notification regarding lack of maintenance of private stormwater construction and completed projects.

9.2 Prioritization of Implementation

The priority of implementation should be according to the most critical deficiencies in the City's stormwater system. This should coincide with the overall City Capital Improvement Program regarding the funding available to upgrade deficient storm piping.

The most efficient and cost-effective approach is to maintain the existing piping, catch basins, and manholes to prevent degradation and future replacement cost. The prioritization should also include monitoring water quality and detention facilities to reduce pollution sources and inadequate stormwater facilities. The last priority would be for replacement of stormwater structures, piping, and stormwater facilities in the CIP.

9.3 Funding Alternatives

The City has several options for funding the recommended actions in this SMP and in the City's Capital Improvement Program. One of the primary sources of funding for stormwater projects is the revenue derived from the stormwater utility operated by the City. The utility has monthly service charges based on either residential or other developed parcels. Residential parcels are charged on a monthly "base rate" of $7.33 per address. Multi-family residential developments shall be charged the base rate for each dwelling address within the parcel. Other developed parcels are charged based on impervious surface area. Monthly charges for developed parcels range from $3.50 to $48.28 per impervious acre with the rate determined by the percentage of impervious area relative to the size of the parcel.[4] The rate charge increases as the percent of impervious area increases. This funding source is used to fund capital projects, operations, and maintenance of the stormwater system. The budgeted revenue available for CIP projects for the 2013-14 period as cited in the City's final budget was approximately $82,000 per year, excluding state grants, interest, and beginning fund balance.

In addition to stormwater utility revenue, it is possible to allocate monies from the general fund toward the stormwater utility fund. This type of funding requires the City to dedicate revenue from other sources, such as tax revenue, to the stormwater utility as part of their budgeting process.

General obligation bonds are another source of funding for capital projects. General obligation bonds pledge the full faith and credit of the City that payments on the bonds will be made to the bondholders. There are two forms of general obligation bonds, non-voted and voted. The State of Washington establishes the maximum limit (debt ceiling) of general obligation debt that municipalities are allowed to have outstanding at any time. Funds generated by the stormwater utility could be used to pay the debt service along with other city revenues. In case of default, the City would ultimately be responsible to the bondholders.

Debt ceiling is not the only concern when considering issuance of general obligation bonds. The City must also consider the programmatic impacts of using its full debt capacity on one particular fund or project. For example,

[4] See City of Kelso Ordinance No. 12-3788 effective January 1, 2013

funding the recommended programs of the stormwater system with general obligation debt could expend a substantial portion of the City's debt limit, thus leaving little debt allocation for other projects. For this reason, general obligation bonds are not considered a good alternative for funding utility projects.

Revenue bonds pledge the revenues of an enterprise activity, such as a stormwater utility, against the debt service on the issued bonds. They do not require voter approval because they depend on the revenues from enterprise activity rather than the full faith and credit of the City. Because of factors such as higher interest rates, coverage requirements, and bond reserves, the cost of this type of bond is usually higher than non-voted general obligation bonds. State limitations on debt ceiling do not apply to revenue bonds. The use of revenue bond financing would place a higher priority on a guaranteed revenue base, because the collateral for these bonds would exist solely in the revenue of the stormwater utility enterprise fund.

Ecology offers grants for planning and implementation of stormwater projects. The legislature provided $30 million in appropriations for the Statewide Stormwater Grant Funding Program for FY 2011-13. Eligible applicants were Phase I and Phase II municipal NPDES permit holders such as cities and counties. There is a 25 percent cash match requirement for grant recipients. The 2012 legislative session provided an additional $37 million in funding for the program. The City applied for the FY 2012 funding allocations for their Operations Stormwater Upgrade project ($29,700) and the Burcham Canyon Upgrade project ($60,000) but the projects were not funded in that cycle. The funds were allocated to 56 permittees in 2012. Most of the funded projects had a water quality improvement element as part of the grant request. The stormwater project funding program may be funded again for future years and the state budget process should be monitored to determine if these funds will be reauthorized.

Washington State has a Public Works Trust Fund that provides low-interest loans for public works infrastructure projects. The program currently does not provide grants for capital projects. The interest rates are dependent on the term of the loan and start with 0.5% interest for 10 year term loans and go up to 30 year term loans with 2.0% interest. The program formerly had a grant program but that part of the program was discontinued. The current stormwater utility rate structure could support a 10-year loan of approximately $800,000 with an annual repayment of approximately $82,000. This approach would be far more advantageous than using municipal bonding approach discussed above as the bonds involve a significant amount of setup expense, higher interest rates, and more administration than a Public Works Trust Fund loan.

The Washington State Department of Commerce has prepared a summary of potential state grant and loan programs (updated February 1, 2013) for water-related projects including stormwater. While some of the funding sources do not include stormwater, a careful review of the eligible projects column in the summary (Appendix E) indicates that many programs do apply to stormwater.

9.4 Stormwater Utility Rate-Funded Examples

The current utility rate provides approximately $82,000 per year in capital improvement as discussed in Section 9.3. This section presents examples of how the current rate structure would be able to fund the projects included in the CIP. A detailed rate study would be necessary to examine how the rate structure could be modified to fund projects in a timelier manner.

For these examples, the projects listed in Table 8-1 will be used to demonstrate how capital project funding from the current rate structure could be applied to accomplish priority projects. Construction projects could be accomplished as soon as sufficient money has accumulated to fund the projects (Example No. 1). Projects could also be grouped into larger projects in order to minimize the City's efforts and costs in putting out projects to bid as well as the contractor's mobilization cost (Example No. 2). This would mean that the City would be holding capital funds until a reasonably-sized set of projects could be put out for construction. Projects that involve investigations or further study (examples Priority A and F in Table 8-1) have not be included in these projects groupings as they would be performed either by City staff or engineering consultants to the City with a total cost of $25,000.

<u>EXAMPLE NO. 1</u> – Complete projects as soon as sufficient funds are available. Project identification from Table 8-1.

Year 1 CIP revenue from utility rates	$82,000
Year 2 CIP revenue from utility rates	$82,000
Year 2 Project Priority "B" (funds accumulated by early Year 2 for Project "B")	$84,000
Year 2 surplus	$80,000
Year 3 CIP revenue from utility rates	$82,000
Year 3 Project Priority "C" and "D" (funds accumulated by early Year 3 for Projects "C" & "D")	$89,000
Year 3 surplus	$73,000

Year 4 CIP revenue from utility rates	$82,000
Year 4 Project Priority "E" (funds accumulated by early Year 4 for Project "E")	$76,000
Year 4 surplus	$79,000
Year 5 CIP revenue from utility rates	$82,000
Year 5 Project Priority "G", "H", "I" (funds accumulated by early Year 5 for Project "E")	$61,000
Year 5 surplus	$100,000

EXAMPLE NO. 2 – Group projects for bidding to reduce contract administration costs.

Years 1 through 3 accumulated utility rate revenue	$246,000
Year 4 Projects B, C, D, and E completed (funds accumulated by early Year 4 for projects)	$249,000
Year 4 surplus	$79,000
Year 5 Projects G, H, and I completed	$61,000
Year 5 surplus	$100,000

Both examples assume (but do not include) that the utility rates are increased annually to keep pace with inflation. In Example No. 1 there are four separate bid, award, and contract management cycles whereas Example No. 2 has only two. The costs shown do not reflect the anticipated savings from fewer construction contract cycles.

10 PROVISIONS FOR STORMWATER MANAGEMENT PLAN UPDATES

10.1 Stormwater Management Plan Update

The SMP can be updated whenever circumstances dictate. As in other utility plans, the plan should be reviewed every five years and updated if it is found to be outdated.

10.2 Capital Improvement Plan

The Capital Improvement Plan section will likely be the portion of the SMP that will require more frequent updating due to the completion of priority projects and the identification of additional system needs. The Capital Improvement Plan should be updated on an annual basis just before the City annual budget process begins so that the most up-to-date cost for a scheduled project can be used in the budget process. The estimated construction costs should be updated based on the Engineering News Record Construction Cost Index (March 2012 ENR Construction Cost Index = 9267.57).

10.3 Stormwater System Hydrologic Model

The model created for the system evaluation should be updated when changes to the system are made or new information is discovered. A regularly scheduled, quarterly review will allow the Public Works Department to make the updates while changes are still recent and the data are available. The updated model should be rerun after each update to make sure that the changes have not affected the ability of the program to produce reasonable results.

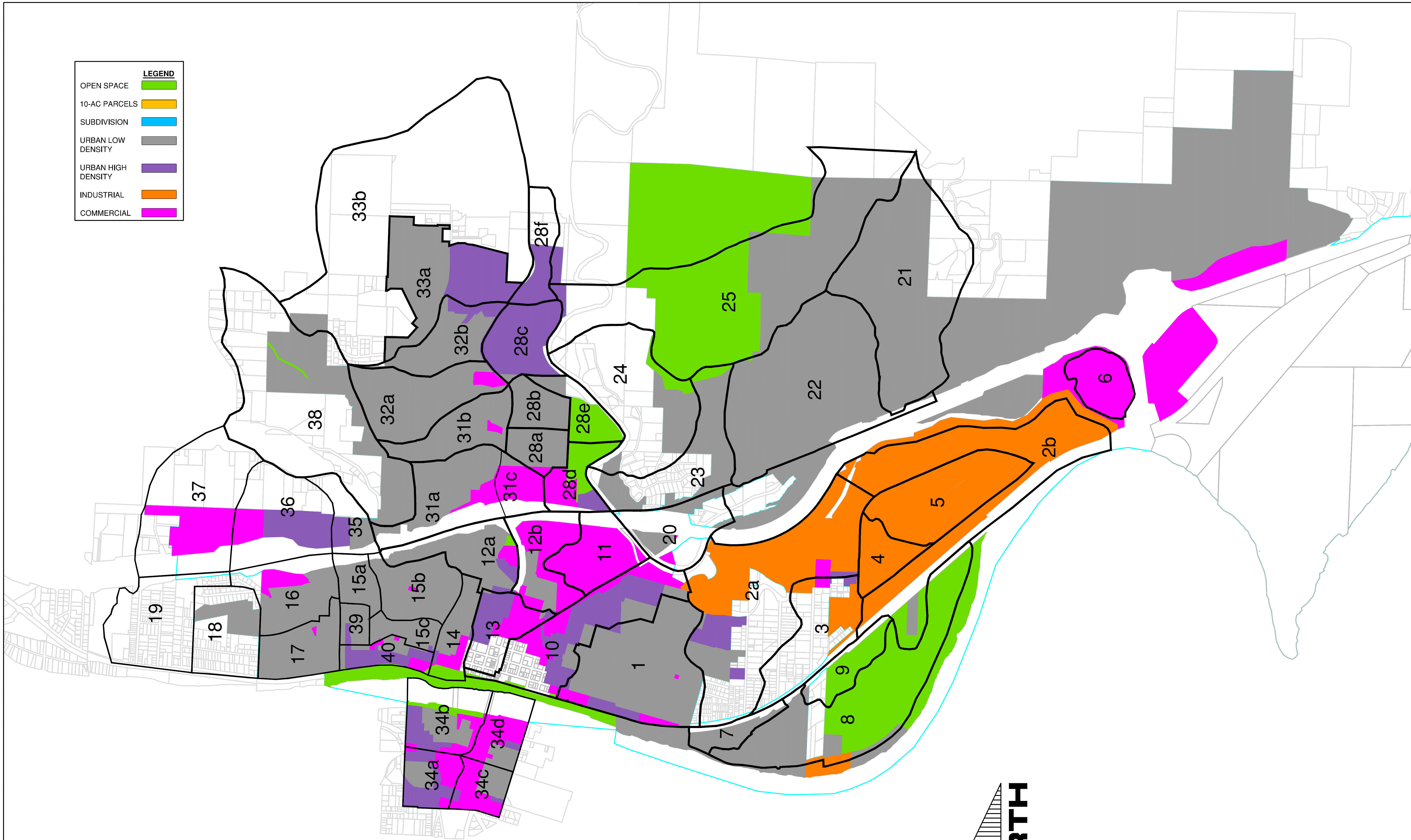
LIMITATIONS

The services undertaken in completing this plan were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This plan is solely for the use and information of our client unless otherwise noted. Any reliance on this plan by a third party is at such party's sole risk.

Opinions and recommendations contained in this plan apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this plan.

We are unable to plan on or accurately predict events that may change the site conditions after the described services are performed, whether they occur naturally or are caused by external forces. We assume no responsibility for conditions we were not authorized to evaluate, or conditions not generally recognized as predictable when services were performed.

FIGURES



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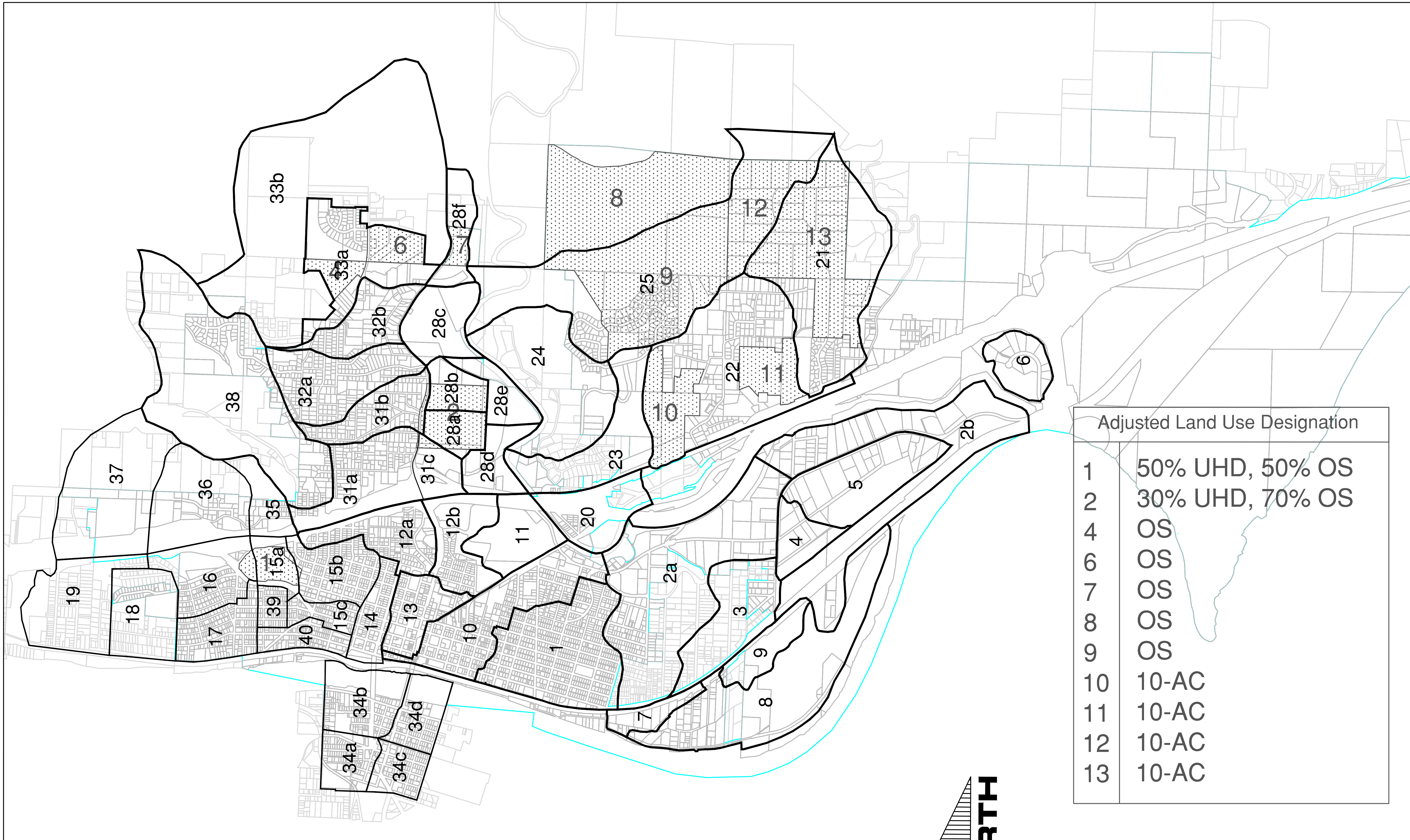
0 1000 2000 4000

Scale (in Feet)

NORTH

City of Kelso
Stormwater Management Plan, Phase III
City of Kelso Land Use Map
Figure 3-1



Adjusted Land Use Designation

1	50% UHD, 50% OS
2	30% UHD, 70% OS
4	OS
6	OS
7	OS
8	OS
9	OS
10	10-AC
11	10-AC
12	10-AC
13	10-AC

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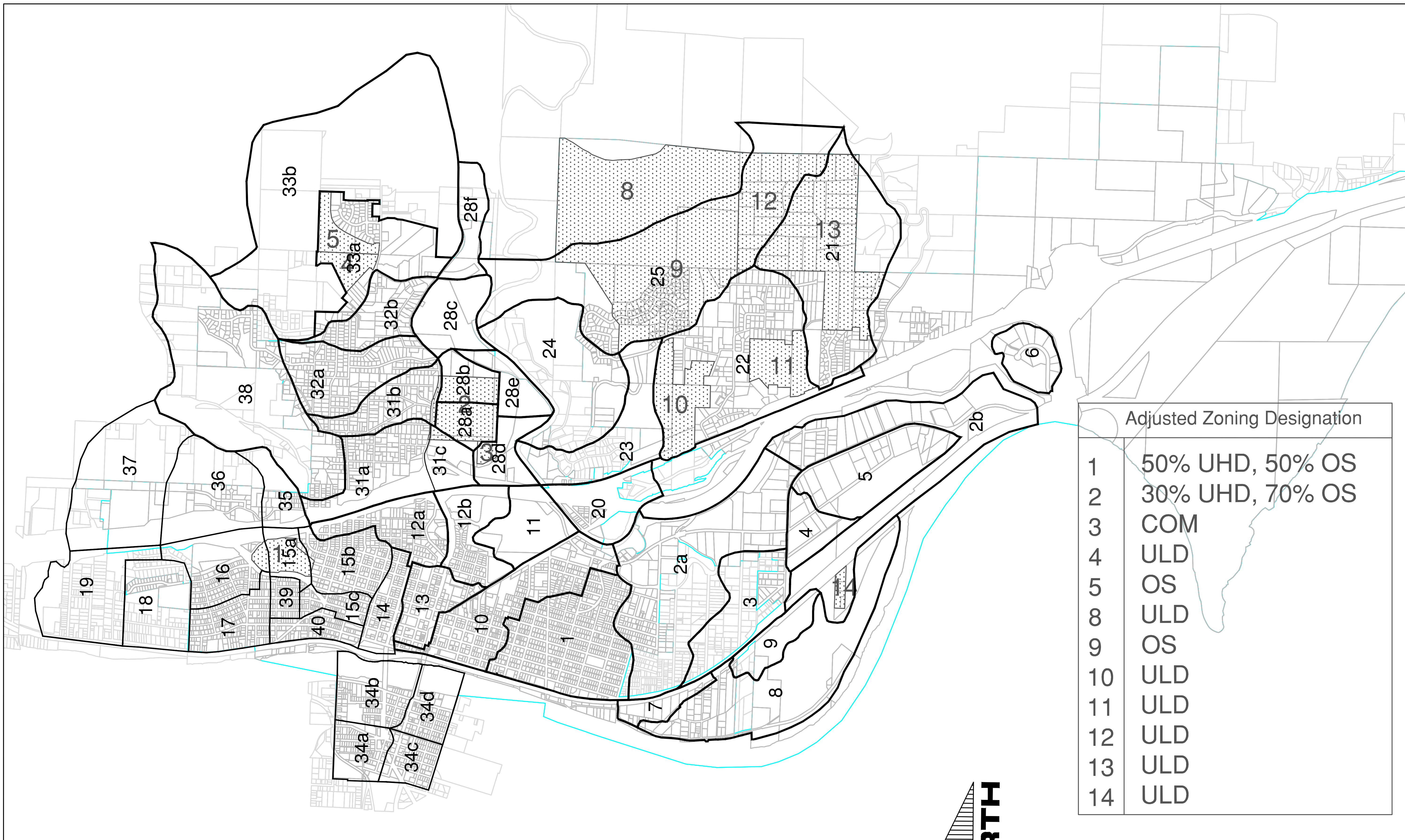
City of Kelso
Stormwater Management Plan, Phase III
Changes to Land Use Designation for Modeling Purposes
Figure 3-2



0 1000 2000 4000

Scale (in Feet)

NORTH

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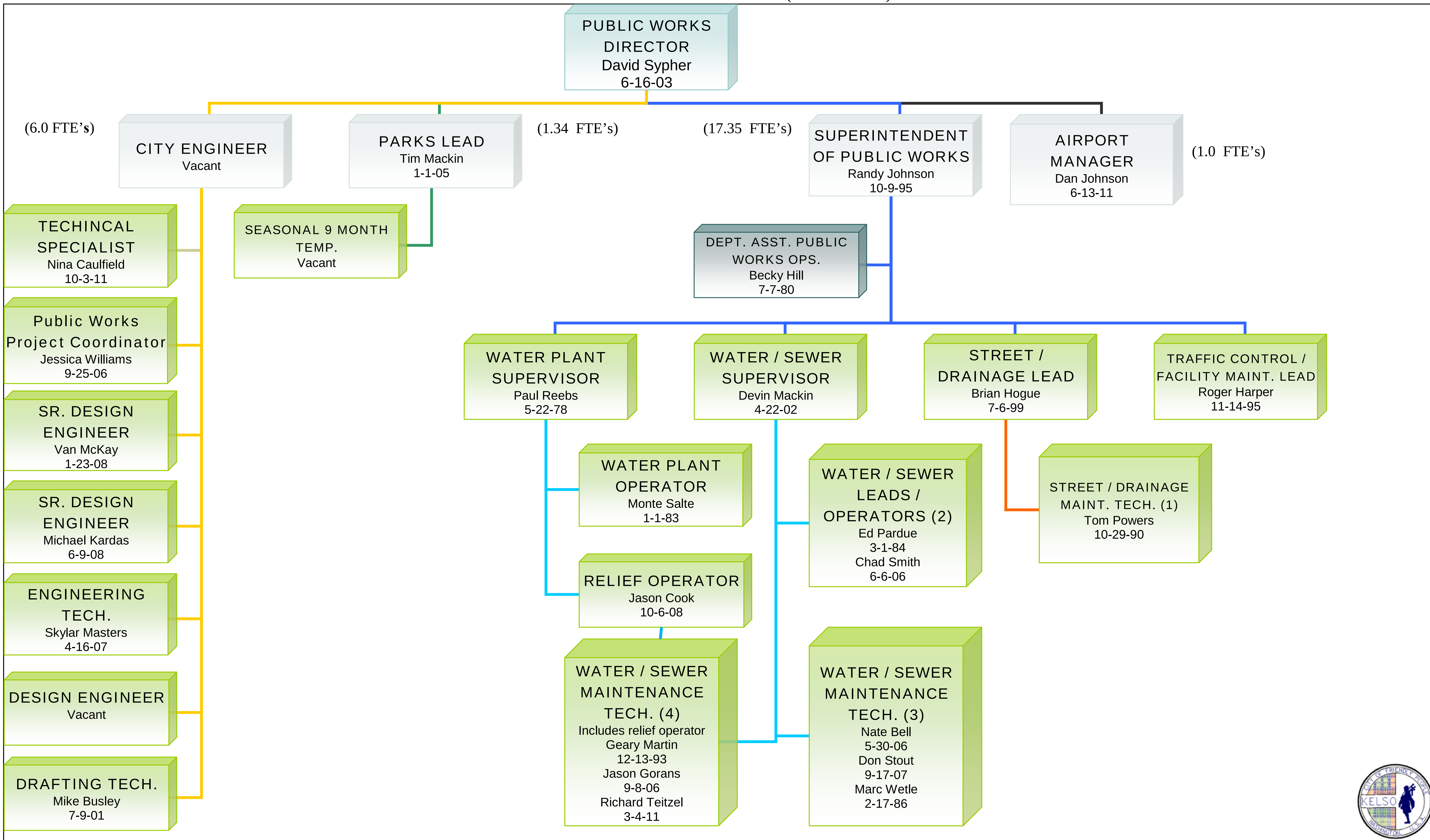
City of Kelso
Stormwater Management Plan, Phase III
Changes to Zoning Designation
Figure 3-3

FIGURE 7-1 KELSO PUBLIC WORKS DEPARTMENT
EXISTING ORGANIZATION (25.35 FTE's)



Updated November 8, 2011 G:\Projects\001100\Org Chart Updates

APPENDIX A

DETAILED HYDROLOGIC MODELING RESULTS

ATTACHMENT 1

REDPATH-NORTH KELSO WATERSHED

A.1 Redpath-North Kelso Watershed

A.1.1 Redpath-North Kelso Watershed Basin Descriptions

Basin 35 originates on the east side of I-5, and is directed under I-5 via a closed system piping network that discharges on the west side of I-5. It is our understanding, based on review of previous reports, that this area discharges to a piping network within the WSDOT right-of-way and connects to an existing catch basin located on the east side of the Huntington Middle School athletic field via an 18-inch-diameter storm pipe under I-5.

The basins west of I-5 (15 through 18, 39, 40), each discharge directly into a 3,800-foot-long box culvert that varies in size from 4 feet by 4 feet to 4 feet by 5 feet and that is located under Redpath Street, North Kelso Avenue, and Bowmont Avenue. This box culvert is under the jurisdiction of DID No.1. The average slope of the box culvert over the entire length is 0.0067 ft/ft; however, there are sections of the box culvert that have adverse grade (negative slope).

Basins 15, 39, and 40 are urban and contain a comprehensive network of catch basins and pipes. However, basins 16, 17, and 18 also consist of urbanized areas that are flat, with few to no drainage structures. In these areas, many of the residential lots and roadside ditches sit lower than the road and ponding has been observed to occur because of the inability of surface runoff to drain to the main trunk lines of the drainage system. The areas for these basins were accounted for by distributing an equivalent area to available catch basins within basins 16, 17, and 18. This approach would probably increase the peak runoff rates because it is likely that the actual conditions would increase the time of concentration for the ponded water to reach available drainage structures.

Basin 15 is further divided into three smaller basins, 15a, 15b, and 15c, with a main trunk line for each of these smaller basins. Basins 15b and 15c discharge into the main trunk line for 15a, which then discharges to the 4-foot-by-4-foot box culvert under Redpath Street. Basin 15a includes most of the area for Huntington Middle School, and includes runoff from basin 35 to the east. There are two main trunk lines within basin 15a, an 18-inch-diameter line located along the east side of Kelso Avenue from Donation Street to Redpath Street, and an 18-inch-diameter line located between the middle school building and the athletic field.

Basin 15b comprises the southeast area of the Redpath-North Kelso watershed, draining the hilltop area east of 4th Street. The system is a combination of closed-system drainage and open ditches, with the trunk lines transitioning from 8- and 10-inch-diameter pipe along 7th Avenue, to 12- and 18-inch-diameter pipe as the system moves west to 4th Avenue. There are some areas of adverse grade and sawtooth connections, and a few areas where pipe diameters are reduced for short runs. Basin 15c includes the drainage along Kelso Avenue and Harris Street, from Columbia Street to Donation Street, and a trunk line along the alley between 3rd and 4th Avenues. The main trunk line from Harris Street to the alley between 3rd and 4th Avenues to Donation Street is 12 inches in diameter, and then increases to 18 inches in diameter before connecting to manhole 4160 at the confluence of basins 15a, 15b, and 15c. There is at least one pipe in adverse grade (link-12) and one sawtooth connection, where the upstream invert elevation is lower than the downstream invert elevation, but the pipeline has a positive grade (link-418 to link-656 at manhole 4200) in this system.

Basin 16 includes the area from Division Street in the south to Barnes and Veys Streets to the north, from the alley between 3rd and 4th Avenues on the west to I-5 to the east. This basin includes several ditch systems intermixed with culverts and closed-system drainage. The main trunk line for this basin is the 4-foot-by-4-foot box culvert located under Bowmont Avenue. As previously described, the box culvert has sections of pipe in adverse grade, limiting the capacity of the culvert and potentially affecting the capacity of lateral connections.

Basin 17 includes the area just north of Redpath Street to the south to Barnes Street to the north, and North Pacific Avenue to the west to the alley between 3rd and 4th Avenues to the east. The main trunk lines in this basin include a 12-inch-diameter pipe along Home Court and Division Street that feeds into an undefined ditch system, and a 24-inch-diameter trunk line along 3rd Avenue from Division Street to Redpath Street.

Basin 18 includes the area north of Barnes Street to Shawnee Road, from North Pacific Avenue on the west to Veys Street to the east. The main trunk line in this basin is the 4-foot-by-4-foot box culvert along Bowmont Street which includes sections of the culvert in adverse grade (link-149). Another trunk line is located along Barnes Street consisting of 12-inch pipe. There is a third trunk line located along Veys Street consisting of 12-inch-diameter pipe with discontinuous catch basin connections, which may function as a bubbler system at catch basin 1526 and flow into the catch basin at the intersection of Barnes and Veys. It should be noted that at catch basin 2079, a high point occurs in the existing system, and a pipe continues to the north toward the North Kelso-King Creek PS. This pipe acts as an overflow for the Redpath-North Kelso basin, and is owned and maintained by DID No.1.

Basin 35 is located east of I-5 and consists of a combination of ditches and culverts, with some discontinuous closed-system drainage. The system outfalls into the WSDOT right-of-way on the east side of I-5. Based on previous reports, the drainage from this area is conveyed to the west side of

I-5 and flows into an 18-inch-diameter culvert connecting to the catch basin (1470) as described above for basin 15a. Since evaluation of the WSDOT system is not part of this report, the area for basin 35 was modeled as an outfall in the Huntington Middle School athletic field.

Basin 39 includes most of the Redpath box culvert and the area just north of Redpath Street to just north of Donation Street, from the alley between 1st and 2nd Avenues to Kelso Avenue. The main trunk line is the 4-foot-by-4-foot box culvert, which includes two pipes in adverse grade (link-634 and link-978) and a sawtooth connection at the structure labeled SD-Structure. Two other trunk lines are located along 3rd and 4th Avenues and connect directly to the Redpath box culvert. The 3rd Avenue line consists of 6- and 8-inch-diameter pipe, and the 4th Avenue pipe consists of 6-, 8- and 10-inch-diameter pipe.

Basin 40 is located along the southwest corner of the Redpath-North Kelso watershed and includes drainage along North Pacific Avenue and 1st Avenue. The trunk line along North Pacific Avenue, from Burcham to the intersection of 1st and North Pacific, consists of 8-, 12- and 36-inch-diameter pipe. The system transitions from a 36-inch-diameter pipe to a 12-inch-diameter pipe at manhole 4181 before connecting to the rest of the system at manhole 4178. In the as-builts provided by the City, node 4179 is listed as a CDS Technologies filter system, but the as-builts do not contain adequate information for modeling as a part of the system. The trunk line along 1st Avenue is composed of 8- and 18-inch-diameter pipe, and discharges directly to the 4-foot-by-4-foot box culvert at 4188.

The 4-foot-by-4-foot box culvert under Bowmont Avenue, Kelso Avenue, and Redpath Street discharges to the Redpath PS, which is owned and maintained by DID No.1. Based on the average slope, the calculated flow capacity of the box culvert using Manning's equations, assuming gravity conditions with the culvert flowing full, is approximately 46 cfs. Water backs up during large storm events, causing the system to operate under pressure flow conditions. Based on ground elevations, overall flow through the entire length of the box culvert is potentially increased to 65 to 70 cfs. The PS has four pumps with a total pumping capacity of 91 cfs, and discharges to the Cowlitz River via 24- and 22-inch-diameter steel pipes. The existing Redpath PS was upgraded in 1978. At that time, new 60-hp and 100-hp pumps were added to the PS to augment the existing 50-hp and 75-hp pumps. A new wet well was constructed, adjacent to the existing wet well but 7 feet deeper, for these two new pumps. The on/off elevations for all four pumps are set such that standing water is always present in the older and shallower portion of the PS wet well. Therefore, storage below the lowest setting for the pumps to turn off (elevation 11.5) is dead storage, which includes approximately 1.5 feet of depth in the box culvert. The four pumps cycle on and off, with pump no. 3 performing most of the pumping, based on pump hour meter data from December 18, 2000, to December 16, 2010. The exception to this was a period from May 20, 2002, to December 14, 2002, when pump no. 3 was inactivated because of a mechanical problem, and pump no. 2 was operated as the main pump.

A.1.2 Redpath-North Kelso Watershed Hydrologic Model

This section summarizes the modeling for the Redpath-North Kelso watershed area and the discharge to the Cowlitz River for the existing land use conditions. The piping network in the Redpath-North Kelso Watershed model was analyzed for the 25-year and 100-year, 24-hour design storms. The data output results for each design storm (Appendix C of the SMP) are provided on a compact disk.

Based on input from DID No.1 staff, portions of the Redpath-North Kelso watershed experience intermittent flooding, especially during heavy rainfall events. Previous basin modeling performed for DID No.1, using HEC-HMS, indicated that for both of the design storms analyzed, there is insufficient storage capacity at the PS and some localized flooding occurs. The City's storm drainage system discharges to DID No.1's box culvert and, based on previous modeling, would be under tailwater conditions for both the 25- and 100-year, 24-hour storm events. Based on the average slope, the calculated flow capacity of the box culvert using Manning's equations, assuming gravity conditions with the culvert flowing full, is approximately 46 cfs. Water backs up during large storm events, causing the system to operate under pressure flow conditions. Based on ground elevations, overall flow through the entire length of the box culvert is potentially increased to 65 to 70 cfs.

The closed-system modeling of the City's system indicates areas of surcharging at approximately 40 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered as areas of concern. Eliminating the small flooding areas leaves approximately eight locations for review of system issues for the 25- and 100-year storm events, as shown in Figures V-2b and V-2c.

In general, surcharging tended to occur when a catch basin was in sag, a downstream pipe had an adverse grade, or the invert elevation of an upstream pipe was lower than the invert elevation of a downstream pipe (sawtooth condition). It is likely that the confluence of multiple piping segments also contributed to surcharging.

In addition to the closed system, an open ditch drainage system consisting of short segments drains portions of basins 15, 16, 17, and 39. However, large areas in basins 16, 17, and 18 contain very flat slopes and large areas with no open ditch or piping system in place.

A.1.3 Redpath-North Kelso Watershed 25- and 100-year Storm Event

The results of the 25-year, 24-hour storm event modeling identified a number of areas of concern, which are discussed below. In these areas, there are a number of impacts noted that are often related to the same system deficiencies. Many of the inlets surcharging above ground contain a downstream connection with adverse grade and low rim elevation. Only one of the inlets showed a depth of ponding greater than 0.33 foot (4 inches). The peak runoff for the Redpath-North Kelso watershed for the 25-year storm is 175.88 cfs at 8.5 hours into the 24-hour storm event, with a peak outflow of 38.17 cfs.

The results of the 100-year, 24-hour storm event modeling amplified the areas of concern that were discussed in the paragraph above in for the 25-year storm event. Only one of the inlets showed ponding deeper than 0.57 foot (approximately 7 inches). The peak runoff for the Redpath-North Kelso watershed for the 100-year storm, based on the model, is 267.17 cfs occurring at 8.5 hours into the 24-hour storm event, with a peak outflow of 52.47 cfs.

A.1.4 Redpath-North Kelso Watershed Discussion

A.1.4.1 Basin 15a, Area 1 (15a-1)

Area 1 is the intersection of North Kelso Avenue and Redpath Street (catch basin 1451) adjacent to Huntington Middle School, and south along North Kelso Avenue adjacent to the athletic field (catch basins 1448 through 1451 and 1469 and 1470). This area is located at the confluence of several piping segments that tie to the 4-foot-by-4-foot box culvert under Redpath Street that drains to the Redpath PS, and includes drainage from the north along Bowmont Avenue, drainage from the south along Kelso Avenue, and runoff from basin 35 to the east. The following specific issues are noted in 15a-1:

- Catch basin 1451 was noted in the model as having the greatest amount of ponding water (218 ac-in at a depth of 0.18 feet with a 25-year storm event), and is influenced by the backup of water in the downstream box culvert. Catch basin 1451 is located on sag, with the surrounding elevations higher than the rim elevation of catch basin 1451, contributing to the amount of water ponding at this location. The 100-year event increases the flood depth to 0.29 foot and 317 ac-in.

- Catch basin 1448 to the south is likely influenced by the backup of water at catch basin 1451, as well as being located in sag along Kelso Avenue. Catch basins 1448 and 1451 are shown to be surcharged for most of the 24-hour storm event. Catch basin 1448 flooded to a depth of 0.38 feet with 115 ac-in of total flooded volume. The 100-year event results in a flood volume of 143 ac-in and depths above the catch basin of 0.48 foot.
- Drainage from basin 35 is understood to flow through a ditch parallel to the east side of I-5, then under I-5, and then to connect into the basin 15a system in the Huntington Middle School athletic field. The connecting pipes between basins 35 and 15a are located in the WSDOT right-of-way. Additional information is required to accurately connect basin 35 to basin 15a; therefore, basin 35 is assumed to outfall in the Huntington Middle School athletic field near catch basin 1470. The time at which the peak flow for this basin contributes to catch basin 1470 is assumed to lag behind the system peak flow with basin 15a, since the runoff from this basin has additional distance to travel before connecting into the system at 1470. During the 25-year event, basin 35 experiences a peak runoff of 15.06 cfs, with a total rainfall of 2.78 inches. During the 100-year event, the peak runoff is 24.43 cfs, with a total rainfall of 4.45 inches.

Recommendations: Area 15a-1 is the confluence of several piping segments that tie into the 4-foot-by-4-foot box culvert under Redpath Street and contains the highest surcharging in the Redpath-North Kelso watershed. Ponding in area 15a-1 is most likely caused by capacity issues in the Redpath PS and subsequently the box culvert, which has approximately 1.5 feet of standing water due to the elevation settings of the Redpath PS. However, aside from adding a storage facility in the Huntington Middle School vicinity, changes to the PS or box culvert would require coordination with DID No.1, since these structures are under DID No.1's jurisdiction.

A.1.4.2 Basin 15c, Area 1 (15c-1)

This area of surcharging is at the intersection of Donation Street, Kelso Avenue, and 3rd/4th Avenue. The following specific issues are noted in 15c-1:

- The catch basins along Donation Street and 4th Avenue (catch basins 1441 and 1442) are receiving drainage from the areas east of 4th Avenue and are just upstream of the connection to Donation Street and Kelso Avenue. The pipe connecting structures 4487 to 1441 (link-606) is an 18-inch-diameter concrete pipe, which then reduces to 12-inch-diameter concrete between structures 1441 and 1442 (link-06) and 1442 through

4158 (link-470), and then increases to 18 inches again between structures 4158 through 4160 (link-605). The drainage from the east combined with the pipe diameter restrictions likely is contributing to surcharging above the catch basins downstream (1441 and 1442).

- In addition to the restricted pipe diameters, the angle between link-606 and link-6 is 90 degrees, and between link-470 and link-605 is less than 90 degrees, also contributing to surcharging on the ground surface at catch basins 1441 and 1442. The surcharging in catch basin 1442 is minor during the 25-year event (2.22 ac-in and 0.32 feet); this increases to 5.54 ac-in at a depth of 0.38 feet during the 100-year event. Catch basin 1441 surcharges approximately 48.0 ac-in and 0.13 feet deep with the 25-year event and 83.0 ac-in and 0.19 feet deep with the 100-year event.
- The catch basins along Donation Street and 3rd Avenue (1483, 1500, 1501, and 1509) are all located in sag and are connected to the system with small-diameter pipes (6 inch) and discontinuous ditches, which contributes to minor surcharging (less than 2.6 and 5.8 ac-in during the 25- and 100-year storm events, respectively) at these catch basins.

Recommendations: One of the main 18-inch-diameter concrete trunk lines reduces to 12-inch-diameter via two pipe segments with sharp (90-degree and smaller) angles (link-6 and link-470). It is recommended that the 12-inch-diameter concrete pipe be upsized to 18-inch-diameter HDPE (37 and 124 lf, respectively) and the downstream connection be relocated to increase the angles of intersection closer to 90 degrees to reduce surcharging. It is also recommended that pipes with adverse grades (link-06 and link-12) be repaired or replaced with 12-inch-diameter concrete pipe to provide positive slope.

A.1.4.3 Basin 17, Area 1 (17-1)

This area of concern is at the intersection of Division Street and North 2nd and 3rd Avenues. The structures affected in this area include 1486, 1487, 1490, 2081, and 1554. This area is a combination of closed-system piping connected by catch basins and manholes, and discontinuous ditches. The area has very flat slopes (average slope: 0.002 ft/ft) and large areas where no drainage system appears to be in place, especially east of 2nd Avenue. Also, limited information was available at the intersection of Croy Street, 2nd Avenue, and Division Street. The following specific issues are noted in 17-1:

- Catch basin 1486, located at the intersection of Croy Street, Division Street, and North 2nd Avenue, is assumed to receive drainage from a ditch to the west. Limited information was available for this area, and it is likely that the system defined in this model is not correctly represented. Assuming that the west ditch (Junction 6279) drains to catch basin 1486, the surcharging during a 25-year storm event is 23.65 ac-in of total flooded volume at a depth of 0.26 foot. The 100-year event results in a flood volume of 27.79 ac-in and depths above the catch basin of 0.34 foot.
- The outfall from catch basin 1487 is connected to a ditch system to the east. The outfall pipe is 5.45 feet below the invert at the beginning of a ditch (Junction 6289). Limited information was available for this area, and it is likely the system defined in this area is not correctly represented.
- Catch basin 1554 is located in a low point on Home Court, leading to significant surcharging during the 25- and 100-year storm events. The total flooded volume is 16.49 and 31.68 ac-in at depths of 0.37 foot and 0.45 foot during the respective storm events.
- In addition to this increase at catch basin 1486, catch basins 1487, 1490 and 2081 experience significant surcharging during the 100-year storm event (20.64, 11.96, and 15.01 ac-in of total flooded volume at a depth of 0.45, 0.57 and 0.55 feet, respectively).

Recommendations: The main issue with area 17-1 is the lack of information surrounding the discontinuous ditch segments and the closed piping network. It is recommended that the City investigate the drainage system at Division Street, North 2nd Avenue, and North 3rd Avenue further to provide a more complete and detailed system to reflect what is occurring. It is recommended that the City eliminate the ditches along the south side of Division Street between Croy/North 2nd and 3rd, and connect the piping segments by linking catch basin 1490 to 1486 with 85 lf of 12-inch-diameter HDPE pipe, and catch basin 1487 to 2081 with 260 lf of 12-inch-diameter HDPE pipe.

A.1.4.4 Basin 39, Area 1 (39-1)

This area of concern is located near Redpath Street along 3rd and 4th Avenues. The main area affected is at the intersection of Redpath and 3rd Avenue (1503-1506), which is a low point in the surrounding area and receives bypass flow from upstream catch basins. The following specific issues are noted in 39-1:

- The pipes linking catch basins 1503-1506 with the box culvert under Redpath are all at adverse grade (links 67, 68, 986, 987, and 988), contributing to surcharging at the catch basins.
- Additionally, during the 100-year event, catch basin 1506 has a flooded volume of 13.36 ac-in at a depth of 0.40 foot.

Recommendations: The main issue in Area 39-1 is that the catch basins at the intersection of Redpath and 3rd Street are in a low point relative to the surrounding area and the connecting pipes between the catch basins and the box culvert under Redpath are all at adverse grade. It is recommended that links 67, 68, 986, 987, and 988 be replaced with the appropriate lengths of 12-inch-diameter HDPE pipe (16, 18, 13, 12, and 52 lf) with positive slopes. The positive slopes will facilitate drainage and reduce ponding.

A.1.4.5 Basin 15c, Area 2 (15c-2)

This area includes the trunk line along North Pacific Avenue and structures on North Pacific Avenue, 3rd Avenue, and 4th Avenue. The general nature of the surcharging in this area is due to the presence of sag conditions for the catch basins, and adverse grade and surcharging in pipes downstream. The catch basin with the greatest issue is 1456, which has a grate elevation lower than the downstream water surface elevation. The 25-year storm event produces minor surcharging (less than 6.5 ac-in); however, the 100-year event results in total flooded volume of 13.58 ac-in at a depth of 0.24 foot. In addition, the drainage system along 4th Avenue transitions from underground piping to a ditch system and connects with the east-west ditch along Harris Street. The existing ditch is extremely shallow and is insufficient to handle the runoff and shows surcharging in the ditch.

Recommendations: The general nature of the surcharging in this area is due to the presence of sag conditions, and adverse grade and surcharging in pipes downstream. It is recommended that pipes with adverse grade (links 12, 14, and 611) be replaced with 124, 41, and 97 lf of 12-inch-diameter HDPE pipe with positive slopes to reduce surcharging. The shallow ditch along 4th Avenue and Harris Street is identified on the City's Capital Improvement Plan as requiring attention. It is recommended the ditch system in this area be replaced with underground drainage, including two catch basins at junctions 6432 and 8084 and approximately 150 lf of 12-inch-diameter HDPE pipe that connects to the existing 12-inch-diameter pipe (link-691) at the southeast corner of 4th and Harris.

A.1.4.6 Basin 40, Area 1 (40-1)

This area includes the system located along North Pacific Avenue, 1st Avenue, and Burcham Street. Based on the presence of HDPE pipe and a water quality structure, it is assumed that this system is fairly new.

Information on the CDS Technologies filter system water quality structure was not available for the modeling, and therefore assumptions were required to complete the modeling. It is likely that this structure, which is assumed to belong to the City, is causing some backup of the system and leading to minor surcharging at catch basins 1461, 1463, 1467, and 2086 (less than 5. ac-in). Review of project drawings, if available, would provide information to more accurately model this portion of the system. Catch basins 1468 and 1474 discharge to the main 12-inch-diameter trunk line along 1st Avenue that connects to the box culvert under Redpath Street, and likely are surcharging because the box culvert is full during the peak of the storm event as well. With the exception of structure 4179, which is the water quality structure, the flooding duration at the remaining structures is relatively short, approximately one to two hours.

Recommendations: It is recommended that system connections be checked against the as-built drawings to verify where surcharging occurs, and confirm the connection of the CDS structure to the system. Surcharging in this area is minor and no other recommendations are provided at this time.

A.1.4.7 Basin 16, Area 1 (16-1)

Area 16-1 is located along Bowmont Avenue and includes structures at the intersections of Bowmont with Lewis, Croy, and Division Streets. This area is a combination of closed-system piping connected by catch basins and manholes, and discontinuous ditches. The area has very flat slopes (average slope: 0.0008 ft/ft) and large areas where no drainage system appears to be in place, particularly the southwest quadrant, south of Lewis Street and west of Ross Street. Most of the pipes are located along Bowmont Avenue. Those connecting the catch basins to the box culvert are small-diameter pipes, 6 to 8 inches in diameter. The following specific issues are noted in area 16-1:

- Catch basin 1514, which is located at the intersection of Bowmont and Division, is at a low point along Bowmont Avenue and flows into the box culvert under Bowmont. The 4-foot-by-4-foot box culvert is full during the peak of the 25- and 100-year storm events, creating a tailwater condition for the outlet pipes to discharge to, likely creating surcharging at these basins. The 25-year event results in flood volume of 12.84 ac-in and a depth above the catch basin of 0.38 foot in catch basin 1514. The 100-year event results in a flood volume of 29.49 ac-in and depth above the catch basin of 0.45 foot.
- The 100-year event results in catch basin 1515, also a low point along Bowmont Avenue, surcharging a total flooded volume of 18.86 ac-in for a depth of 0.55 foot.
- Additionally, during the 100-year storm event, catch basin 1524 drains a low point in Bowmont Avenue, and also discharges to

the box culvert under Bowmont. The duration of the surcharging ranges from two to four hours. The 100-year event results in flood volume of 11.98 ac-in and a depth above the catch basin of 0.45 foot.

Recommendations: The main area of concern is at the intersection of Bowmont and Division. Two catch basins (1514 and 1515) are located at low points along Bowmont Avenue and flow into the box culvert under Bowmont. During the peak of both the 25- and 100-year storm events, the 4-foot-by-4-foot box culvert is full, creating a tailwater condition for the outlet pipes to discharge to, likely creating surcharging at these basins. Storage for surcharging conditions may be provided by increasing the size of the pipe from catch basin 1524 from 6 to 12 inches in diameter, but no other recommendations are provided for this area. The City may want to consider eliminating the ditch system along 4th Avenue and Lewis Street and replacing it with a closed drainage system, including four catch basins and approximately 850 lf of 12-inch-diameter HDPE pipe.

A.1.4.8 Basin 15b, Area 1 (15b-1)

Area 15b-1 encompasses the southeast area of the Redpath-North Kelso watershed, and is located east of 5th Avenue, between Bloyd Street and Columbia Street. The surcharging that occurs in this area is typically due to sag conditions in the roadway and in general lasts from one to four hours. Most of the pipes leading from the catch basins to the trunk lines are 6 inches to 8 inches in diameter, and a few pipes have adverse grades (links 96 and 597) or sawtooth conditions at the downstream structures. Many of the catch basin grate elevations are at the peak water surface elevation in the trunk line and collect bypass drainage from upstream structures, leading to surcharging at the downstream catch basin. In addition, many of the pipes leading from the catch basins to the trunk lines are at flat slopes (<0.3%). The catch basins of most concern are 1399 and 1422. Catch basin 1399 is connected to the trunk line via link-96, which is shown as having a negative slope of -8.71 percent. Because this pipe is shown as having significant adverse grade, drainage from upstream pipes is filling this basin and causing surcharging. Catch basin 1422 is located in a low point and also collects bypass drainage from upstream structures that flow downstream through a 6-inch-diameter pipe (link-596). The 100-year event results in 12.14 and 12.03 ac-in of flooded volume (in catch basins 1399 and 1422) at depths of 0.33 and 0.22 feet, respectively.

Recommendations: The aboveground surcharging that occurs in this area is typically due to sag conditions and small pipe diameters. It is recommended the City further investigate link-96 and link-597 to ensure that the system is connected and functioning properly. Additionally, in their CIP the City has noted that the ditches along Harris Street and 8th Avenue are problematic because residents fill in the existing ditches, leaving no place for stormwater to flow. It is recommended that 750 feet of 12-inch-diameter storm drain pipe and five catch basins be installed on the south side of Harris Street, connecting into existing catch basin 1404, to accommodate this drainage issue.

ATTACHMENT 2

WEST KELSO WATERSHED

A.2 West Kelso Watershed

A.2.1 West Kelso Watershed Basin Descriptions

The main collection system for basin 34 discharges to manhole 4266 on Washington Street via a 42-inch-diameter concrete pipe, which continues south toward the Cowlitz County Fairgrounds and ultimately discharges to ditch No.3, owned and maintained by CDID No.1. Manhole 4266 is considered the end of the City's system, based on the information provided by the City. The infrastructure south of manhole 4266, including the 42-inch-diameter concrete pipe, is understood to be owned by CDID No.1 and therefore information concerning it was not provided for this report. Because no information on the outfall was available, a reasonable, and conservative, assumption of a tailwater elevation equal to the outfall pipe invert elevation plus one-half the pipe diameter was applied to the outfall at MH-4266 (TWE = 10.75 inches).

Basin 34a drains the area north of Grant Street and west of Long Avenue, to the west city limits (approximately Southwest 8th Avenue and the Patriot Railroad) and north to Fishers Lane. The area to the north of Royal Street is primarily residential (70%), and the area south of Royal Street mainly commercial (30%). The main trunk lines in basin 34a are located along Long Avenue and Grant Street/Cowlitz Way, and consist of 12-inch-diameter pipes that drain to the trunk line located on 4th Avenue at the intersection of 4th Avenue and Grant Street. Catch basins 1847 and 1848, and links 1146 and 156, are located along Fishers Lane to the north and discharge into a large-diameter pipe running east/west, which ultimately discharges to ditch No.6, owned and maintained by CDID No.1. The field data did not provide information on the large-diameter pipe leading to ditch No.6. In addition, a few catch basins are located at the intersection of 8th Avenue and Clark Avenue, which outfall directly to ditch No.6 (catch basins 1845, 1846, 4507, 4506, 4505, and 4504).These identified nodes and pipes do not connect with the rest of the basin 34 system. To include these identified nodes and pipes in the model, outlet nodes Out-34a-01 and Out-34a-02 were inserted at the end of the pipe runs via links 1145-6 and 1146-6. Because of the lack of information and to ensure that these connections are investigated to confirm accurate pipe routing and outfall locations in basin 34a, the elevations of the outlet node for Out-34a-02 was assumed to be equal to the rim elevations of the catch basin directly upstream of the outlet node (catch basin 1848). These outlet nodes are considered the end of the City's system. Since this part of the drainage system is very small and the information on the receiving storm drain is lacking, the results of the modeling for basin 34a will focus on the main system south of Fishers Lane to Grant Street/Cowlitz Way, between 8th Avenue and Long Avenue.

Basin 34b drains the area north of West Main Street and east of 4th and Long Avenues and east to 1st Avenue Northwest and north to Fishers Lane, and includes Catlin Elementary School. The land use for this basin is 75 percent residential, 15 percent commercial, and 10 percent open space. This basin contains three main trunk lines draining from the north and south along 1st, 2nd, and 3rd Avenues to the trunk line in Grant Street, consisting of 10-, 12- and 18-inch-diameter pipes. Catch basins 1803, 1804, and 1805, and links 449, 1143, and 1144, are located along Fishers Lane to the north, and also discharge into a large-diameter pipe running east/west that ultimately discharges to ditch No.6, owned and maintained by CDID No.1. As stated in the discussion of basin 34a, the field data did not provide information on the large-diameter pipe leading to ditch No.6. Nodes 1803 and 1804 and associated pipes do not connect with the rest of the basin 34 system. To include these identified nodes and pipes in the model, outlet nodes Out-34b-02 and Out-34b-03 were inserted at the end of the pipe runs via links 1143-6 and 1144-6. Because of the lack of information and to ensure that these connections are investigated to confirm accurate pipe routing and outfall locations in basin 34, the elevations of the outlet nodes were assumed to be equal to the rim elevations of the catch basin directly upstream of these respective outlet nodes. These outlet nodes are considered the end of the City's system. Ditch No.6 is located beyond these outfalls and is not included in the model. Since this part of the drainage system is very small and the information on the receiving storm drain is lacking, the results of the modeling for basin 34b will focus on the main system south of Fishers Lane to Grant Street, between Long Avenue and 1st Avenue.

Basin 34c comprises the area south of Cowlitz Way and Grant Street, south to Washington Street, from 8th Avenue east to 4th Avenue. This basin is approximately half commercial and half residential. The main trunk lines in this basin consist of 12-inch-diameter pipes draining from west to east along West Main and Catlin Streets, the main system trunk line on 4th Avenue, from Grant Street to Washington Street, and the basin outfall. The main trunk line along 4th Avenue consists of 24-, 36- and 42-inch-diameter concrete pipe.

Basin 34d comprises the area east of 4th Avenue and south of West Main Street, east to 1st Avenue Northwest and south to Washington Street. The area is approximately 60 percent commercial and 40 percent residential, and consists of trunk lines running east to west along West Main, Catlin, Lincoln, and Washington Streets to the main trunk line in 4th Avenue. The piping along these streets consists of pipe ranging from 10 to 24 inches in diameter. Basin 34d contains a detention pond at the southeast corner of West Main Street and West 1st Avenue. There are a few areas in the system where adverse grade is present, which may be a result of settling in the system. Relevant profiles of the main trunk lines are included in the SMP's Appendix C, showing the peak water elevation during the 25-year storm event.

A.2.2 West Kelso Watershed Hydrologic Model Results

This section summarizes the modeling results for the West Kelso Watershed area and the discharge to CDID No.1, ditch No.3 for the existing land use conditions. The piping network in the West Kelso Watershed model was analyzed for the 25- and 100-year, 24-hour design storms. Based on input from City staff, no major areas of flooding were observed during normal rainfall events.

Basin 34 does not contain any specific areas with large ponding issues. The City crew has stated that no major flooding issues have been witnessed in basin 34. However, on November 22, 2011, field observations indicated localized flooding on Royal Street at the intersections of 6th and 7th Avenues, 2nd Avenue at Grant and Washington Streets, and the southeast intersection of 4th Avenue and Catlin Street. The 24-hour rainfall for this day was approximately 2 inches. Since this total is less than the 2-year, 24-hour storm event (2.47 inches), this may be an indication that maintenance of the system is needed in these areas.

The closed-system modeling of the City's system indicates areas of aboveground surcharging at less than 10 percent of the existing catch basins. All of these surcharging catch basins had only a small volume of water aboveground, many for a short period of time, and are not considered as areas of concern. However, these areas of shallow ponding are shown in Figures V-3b and V-3c for the 25- and 100-year storm events, respectively. In general, aboveground surcharging tended to occur when a catch basin was in sag, a downstream pipe had an adverse grade, or the invert elevation of an upstream pipe was lower than the invert elevation of a downstream pipe (sawtooth condition). In addition, the presence of the confluence of multiple piping segments contributed to aboveground surcharging.

A.2.3 West Kelso Watershed 25- and 100-year Storm Event

The results of the 25-year storm event produced very few places of surcharging out of structures in basin 34. Many of the inlets identified as surcharging contain a downstream connection with adverse grade and low rim elevation, and none of the inlets showed ponding deeper than 0.33 foot (4 inches). The peak runoff for basin 34 for the 25-year storm is 97.50 cfs at 8.5 hours into the 24-hour storm event, with a peak discharge of 49.93 cfs at 8.5 hours into the 24-hour storm event.

As with the 25-year storm, there were few places of surcharging out of structures for the 100-year, 24-hour storm event. The areas with surcharging occurred at same locations as during the 25-year storm, where an inlet is on sag or the downstream pipe is at adverse grade. The peak runoff for basin 34 for the 100-year storm event is 144.75 cfs at 8.5 hours into the 24-hour storm event, and 55.47 cfs at the outfall.

A.2.4 West Kelso Basin Discussion

A.2.4.1 Basin 34a, Area 1 (34a-1)

Catch basin 1845 is located at the beginning of the piping network at the southwest corner of 8th Avenue and Clark Street, connecting to catch basin 1846 via a 6-inch-diameter concrete pipe (link-187) with a negative slope of -0.0475 and outflowing through catch basin 4504 and outfall Out-34a-01. The small pipe diameter and steep adverse grade require that water build up in catch basin 1845 and link-187 before it can flow through the rest of the system to the outfall, causing surcharging in catch basin 1845. The maximum flooded depth at catch basin 1845 for the 25-year storm is 0.17 inch and the total flooded volume is 3.76 ac-in. The 100-year storm event increases the flood depth to 0.25 inch, with a total flooded volume of 5.81 ac-in.

Recommendations: It is recommended the existing 6-inch-diameter pipe (link-187) be replaced with 33 lf of 12-inch-diameter HDPE pipe, as well as 85 lf of 12-inch-diameter HDPE pipe for links 190 and 450, to provide better flow conditions for catch basin 1845. Also, the outfall for catch basin 4504 should be located and identified. It is recommended that, if the structure outfall elevation is below the ordinary high water surface elevation of ditch No.6, a backflow prevention device, such as a Tideflex valve, be installed at the end of this pipe to prevent backflow of water from ditch No.6 into the City's system.

A.2.4.2 Basin 34c, Area 1 (34c-1)

Catch basin 1760 is in sag and is located at the southwest corner of 6th Avenue and Cowlitz Way at the end of a series of pipes with an outfall (Out-34c-02) having an assumed elevation equal to the rim elevation, causing surcharging. The total flooded volume in catch basin 1760 for the 25-year storm event is 3.46 ac-in, with a maximum flooded depth of 0.11 inch. The 100-year storm event increases the flood depth to 0.16 inch, with a total flooded volume of 5.07 ac-in.

Recommendations: Catch basin 1760 requires investigation to determine the outfall elevation and how the pipes are connected to the overall system in order to more accurately model this portion of the City's system.

A.2.4.3 Basin 34b, Area 1 (34b-1)

Catch basin 1780's rim elevation is lower than the structures surrounding it (catch basins 1778 and 1779), and is located on the west side of 2nd Avenue south of Grant Street. The low rim elevation, coupled with a small-diameter pipe (6-inch) that connects into the trunk line on Grant Street, already full with stormwater, is attributed to the surcharging at this catch basin. The total flooded volume in this catch basin is 3.44 and 8.18 ac-in, with a maximum flooded depth of 0.24 and 0.33 inch, for the 25-year and 100-year storm events, respectively.

Recommendations: The pipe connecting catch basin 1780 to its downstream node (link-1068) should be upsized to 12-inch-diameter HDPE pipe (152 lf). However, because the trunk lines are full, upgrading the pipe may not prevent all surcharging in these catch basins.

A.2.4.4 Basin 34b, Area 2 (34b-2)

Catch basins 1784 and 1787 are located on the northwest and northeast corners of Grant Street and 2nd Avenue, respectively, and have rim elevations that are lower than the other structures surrounding them. The low rim elevations, coupled with small-diameter pipes (6-inch) that connect into the trunk line in Grant Street, already full with stormwater, are attributed to the surcharging at these two catch basins. The total flooded volume in these catch basins for the 25-year storm event is 1.08 and 2.34 ac-in, respectively, with a maximum flooded depth of 0.26 and 0.31 inches. For the 100-year storm event, the total flooded volume increases to 2.68 and 5.98 ac-in, respectively, with a maximum flooded depth of 0.33 and 0.37 inches.

Recommendations: The pipe connecting this catch basin to its downstream node (link-587) should be upsized to 12-inch-diameter HDPE pipes (29 lf). However, because the trunk lines are full, upgrading the pipe may not prevent all surcharging in these catch basins.

A.2.4.5 Basin 34a, Area 2 (34a-2)

Catch basin 1818 is in a low point relative to the surrounding structures (catch basins 1823, 1824, 1825, and 1826, and manhole Jun-407) and ultimately connects to 1826 via 6- and 8-inch-diameter pipes with adverse slopes of -0.0026. The adverse grade, the low rim elevation, and the slight elevation "jump" at Jun-407 (between 1818 and 1826) contribute to the surcharging at catch basin 1818. The maximum flooded depth at catch basin 1818 is 0.28 and 0.34 inches and the total flooded volume is 2.09 and 5.08 ac-in for the 25- and 100-year storms, respectively.

Recommendations: It is recommended that link-1062 be replaced with 118 lf of 12-inch-diameter HDPE pipe with a positive slope and the elevation "jump" removed to relieve flooding at catch basin 1818.

A.2.4.6 Basin 34a, Area 3 (34a-3)

Catch basin 1843 has a rim elevation that is lower than the structures surrounding it, and is located at the intersection of Clark Street and 5th Avenue. This low rim elevation, coupled with a small-diameter pipe (8-inch) that connects into the trunk line on 5th Street, already full with stormwater, is attributed to the surcharging at this catch basin. The total flooded volume in this catch basin is 2.05 and 5.02 ac-in, with a maximum flooded depth of 0.32 and 0.37 inches, for the 25-year and 100-year storm events, respectively.

Recommendations: The pipe connecting catch basin 1843 to its downstream node (link-176) should be upsized to 12-inch-diameter HDPE pipes (60 lf). However, because the trunk lines are full, upgrading the pipe may not prevent all surcharging in this catch basin.

A.2.4.7 Basin 34c, Area 2, (34c-2)

Catch basin 1755 is located at the end of the Catlin Street pipeline and has a rim elevation lower than the adjacent structures (catch basin 1754, manhole 4500, manhole 4501, and catch basin 1708). Catch basin 1755 connects to manhole 4500 via link-1044, which has a slight adverse slope of -0.0002. Manhole 4500 connects to catch basin 1705 via link-1047 with an adverse slope of -0.0165. The invert of the pipe flowing into catch basin 1705 is lower than the invert of the pipe flowing out of catch basin 1705, and therefore water must build up in catch basin 1705 before it can flow down through link-498 and toward the main trunk line along 4th Avenue. These adverse grades, the low rim elevation, and the elevation "jump" in catch basin 1705 contribute to the surcharging at catch basin 1755. The maximum flooded depth at catch basin 1755 is 0.09 and 0.14 inches, and the total flooded volume is 1.73 and 4.08 ac-in, for the 25-year and 100-year storm events, respectively.

Recommendations: An investigation of the system drainage at the intersection of Cowlitz Way/Washington Way and Ocean Beach Highway (catch basins 1755, 1754, 1709, and 1708 and manholes 4500 and 4501) is recommended to verify that the identified structures flow to the City and basin 34 systems. Although these inlets do not drain a large area and the modeling did not show surcharging in this area except at catch basin 1755, these pipes connect to the system with adverse grade and contain elevation "jumps." It is advisable to investigate how these structures connect to the system and to verify ownership such that proper maintenance can be provided. It is recommended, should investigation identify catch basin 1755 as part of the City system, that links 1044, 1047, and 498 be replaced with 114, 61, and 156 lf of 12-inch-diameter HDPE pipe with positive slopes, and the elevation "jump" removed. However, the trunk line along 4th Avenue is full, and these improvements may not correct all surcharging at catch basin 1755.

A.2.4.8 Basin 34a, Area 4 (34a-4)

Catch basin 1835 is located on the east side of 7th Avenue, midway between Grant and West Main Streets. This catch basin is a small area drain located at the beginning of the piping network, but has a rim elevation lower than the peak water surface elevation in the pipe segment in Grant Street, and therefore shows surcharging of water at this location. The maximum flooded depth at catch basin 1835 is 0.26 and 0.33 inches, and the total flooded volume is 1.48 and 3.50 ac-in for the 25-year and 100-year storm events, respectively.

Recommendations: There are no recommendations at this time.

A.2.4.9 Basin 34a, Area 5 (34a-5) and Basin 34b, Area 4 (34b-5)

Three of the largest total flooded volumes in basin 34 occur at catch basins 1803, 1805, and 1847, which are located near Fishers Lane. The total flooded volume in these catch basins is 3.25, 6.49, and 5.71 ac-in, respectively, with a maximum flooded depth of 0.18, 0.18, and 0.16 inches. Because of the lack of information and to ensure that these connections are investigated to confirm accurate pipe routing and outfalls in basins 34a and 34b, the elevations of the outlet nodes directly downstream from 1803, 1805, and 1847 were assumed to be equal to the rim elevations of these catch basins. The outlets correlating with 1805 and 1847 are believed to empty into a large-diameter pipe running east-west to the north of Fishers Lane. More information on this pipe is needed to properly assess whether ponding would actually occur at catch basins 1803, 1805, and 1847. The as-built provided for 1803 mentions heavy flow coming from 1803 and flowing north into an east-west pipe. Further investigation is necessary to determine the characteristics of this east-west pipe on Fishers Lane.

Recommendations: Catch basins 1803, 1805, and 1847 were given an assumed outfall elevation equal to the rim elevation of the last known catch basin in the run. It is recommended that the large east-west pipe on Fishers Lane be investigated to properly assess whether ponding would actually occur at catch basins 1803, 1805, and 1847.

A.2.4.10 Basin 34b, Area 6 (34b-6)

The second largest flood volume in basin 34 occurs at catch basin 1802, located on the west side of 2nd Avenue, approximately 300 lf south of Fishers Lane. Catch basins 1801 and 1802 are connected across 2nd Avenue with a 6-inch-diameter pipe; it is unclear where the outlet for 1802 flows. Therefore, further investigation is necessary to determine where 1802 outfalls or how it connects to the system. As with catch basins 1803, 1805, and 1847, described above, the outlet nodes directly downstream from 1802 were assumed to be equal to the rim elevations of these catch basin because of the lack of information and to ensure that this connection was investigated to provide accurate pipe routing and outfalls in basin 34b.

Recommendations: Catch basin 1802 was given an assumed outfall elevation equal to the rim elevation of the last known catch basin in the run. Catch basin 1802 requires investigation to determine the outfall elevation and how this pipe is connected to the overall system in order to more accurately model this portion of the City's system.

A.2.4.11 Basin 34b, Area 6 (34b-6)

In addition to some minor ponding at catch basins, manhole 4516 is shown to be surcharging. This manhole is shown to be in sag and the trunk line it feeds is filled past the rim elevation of manhole 4516. The total flooded volume at manhole 4516 is 0.06 ac-in for the 25-year storm event. This is such a small amount of water that it is unlikely that any affects will be seen at manhole 4516. For the 100-year storm event, the total flooded volume at manhole 4516 increases to 1.31 ac-in, and it is likely that this volume of water creates a small area of ponding at the manhole.

As stated above, all of these catch basins have less than 0.33 foot (4 inches) during the 25-year storm event, and less than 0.37 foot (4.5 inches) during the 100-year storm event, of ponding water on the surface at any one time. These areas contain the largest total flooded volume in basin 34 during the 25-year and 100-year storm events.

Recommendations: There are no recommendations at this time.

ATTACHMENT 3

TAM O'SHANTER NORTHEAST KELSO WATERSHED

A.3 Tam O'Shanter Northeast Kelso

A.3.1 Tam O'Shanter-Northeast Kelso Watershed Basin Descriptions

Basins 12 and 13 originate on the west side of I-5. Basin 12b and basin 13 are directed under I-5 via a closed-system piping network that connects to the remaining Tam O'Shanter-Northeast Kelso piping system on the east side of I-5. No data were available for modeling basin 12a.

Basin 12b is bounded by Allen Street to the north; I-5 to the east; 8th Avenue to the west; and ridgelines to the south, as determined by contours. The south ridgeline runs along Grade Street and then around the north edge of the Three Rivers Mall parcel.

Basin 12a is north of basin 12b and is bounded by I-5 to the east and ridgelines to the north and west. The ridgeline starts just north of Allen Street and 8th Avenue and continues to the north, running approximately parallel to 9th Avenue to its intersection with Lord Street. The ridgeline then tracks east past 10th Avenue, continues in a northwesterly direction to Sunnyside Street, and then tracks east to I-5.

Basin 13 is west of basins 12a and 12b and east of 1st Avenue. The north boundary is just south of Cowlitz Street and the south boundary tracks just south of Allen Street to Oak and then along Grade Street until it intersects with the boundary of basin 12b.

The main trunk line in basin 13 drains along Allen Street, south on 5th Avenue, east on Oak Street, and southeast to Vine Street, and then feeds into basin 12b. The main trunk line in basin 12b continues east along Vine Street, north on 10th Avenue, and then east along Allen Street to manhole O-4355 (manhole O-4355 indicates the end of the Phase II data), which connects to the piping network east of I-5 and eventually drains to the slough upstream of Tam-1 PS.

The basins east of I-5 (28a-f, 31-33, 38) discharge into the Tam-1 and Tam-2 PSs via upstream sloughs, or to the large intertie pipe between the PSs.

Basins 28a, 28d, 28e, and 28f all drain to the slough upstream of the Tam-1 PS. The northern boundary of basin 28a is just south of Allen Street from 19th Avenue to Swanson Road. The eastern boundary tracks directly south of the intersection of Allen Street and Swanson Road. The southern boundary is created by the road just south of the northernmost baseball field. The western boundary is located approximately at Tam O'Shanter Way and intersects at 19th Avenue and Allen with the northern boundary. Basin 28a contains Kelso High School and the baseball field directly south of the high school building and drains to a large intertie pipe that connects the Tam-1 and Tam-2 sloughs. However, since this basin is located on private property outside the City's stormwater system, and no as-built information was provided for this area, the closed-system drainage (with the exception of the large intertie pipe and the trunk line leading to it) was not included in the model. Basin 28a directly connects to basins 28d and 28e via 54- and 60-inch-diameter concrete intertie pipes.

Basin 28d contains the commercial buildings south of McDonald's and the baseball fields south of basin 28a and the Tam-1 PS. The Coweeman River is the southern boundary of this basin. The basin is bounded on the west by I-5, and the eastern boundary is just east of basin 28a. The northern boundary is located just south of McDonald's and then shares a boundary with the east and south borders of basin 28a. The basin drains to the Tam-1 PS via three main pipelines: an 18-inch-diameter, 590-lf pipe line that drains the west side of the basin; a 683-lf pipe line, consisting of 18- and 30-inch-diameter segments, that drains the east side of basin 28d and part of basin 28e, and outfalls directly to the Tam-1 PS; and a third pipe line consisting of the 54-inch portion of the concrete intertie pipe that flows west 473 lf and outfalls into the slough located upstream from the Tam-1 PS.

Basin 28e is east of basin 28d and contains the Tam-2 PS, the remaining baseball fields and the strip of open space southeast of the Tam 2 slough. The north boundary is located just south of the two track and field stadiums and the slough that drains southwest from its intersection with the Brookhollow development. This development creates the eastern boundary, while the western boundary is shared with basin 28d and the southern boundary created by the Coweeman River. Basin 28e contains the 60-inch portion of the intertie pipe line, 1,014 lf of concrete pipe that outfalls in the slough located upstream from Tam-2 PS and one 36-inch pipe line that drains into basin 28d via the 18-inch-diameter pipe line downstream.

Basins 31 and 38 also drain to the slough upstream of the Tam-1 PS. Basin 31 is divided in three smaller basins (31a, 31b, and 31c). Basin 31a is located north of Allen Street and contains Highland Park. Basin 31a is bounded by I-5 to the west and Allen Street to the south. The north and east boundaries are defined by ridgelines, as determined by contours. The northern ridgeline tracks along Mt. Brynion Road from I-5 to 13th Avenue. The eastern ridgeline runs south along 13th Avenue, east along Burcham Street, and south along the east side of 18th and then crosses to the west side of 19th Avenue. Basin 31a contains one main trunk line along Minor Road. This 60-inch-diameter pipe line channels inflow from Highland Creek approximately 1800 lf and into basin 31c.

Basin 31b is located to the east of basin 31a. The north boundary is defined by a ridgeline along Jones Road, the west boundary is shared with basin 31a, and the south boundary tracks along Allen Street. The eastern boundary is defined by a ridgeline that tracks southeast from the intersection of Jones Road and Sunrise Street to the intersection of Allen Street and North 23rd Avenue. Basin 31b contains many short pipe segments, especially along North 18th Avenue/Bates Road and North 20th Avenue. Based on information provided by the City and additional research by G&O, a model has been developed linking these segments to downstream inlets to create a complete system. The main trunk line along North 18th Avenue/Bates Road consists of 950 lf of 12- and 15-inch-diameter pipe that drains south toward Allen Street.

Basin 31c shares its northern boundary with basin 31a, its southern boundary with basin 28d, and its eastern boundary with basin 28a. The western boundary is I-5. The basin contains a Denny's restaurant and other commercial buildings. Three main trunk lines converge in basin 31c; a 60-inch pipeline from basin 12b to the west, a 72-inch pipeline from basin 31a to the north and a 20- and 36-inch pipeline from basin 28a to the east. All three trunk lines drain into the upstream slough that flows south to the Tam-1 PS.

Basin 38 is the largest and northernmost basin in the Tam O'Shanter-Northeast Kelso watershed and is defined by ridgelines, as determined by contours on all sides. The southern/eastern ridgeline creates the northern boundaries of basins 31a, 31b, 32a, 32b, and 33b. The western/northern ridgeline generally follows Williams-Finney Road and connects with the eastern boundary south of North Kelso Avenue/Holcomb Road. This basin contains many short pipe lines along Travis Court, Pries Court, Tara Court, and Behshel Heights Road, which outfall into a canyon to the west and drain to Highland Creek.

Basins 28b, 28c, 28f, 32, and 33 drain to the slough upstream of the Tam-2 PS. Basin 28b is bounded by Allen Street to the north, basin 28e to the east and south, and basin 28a to the west. Basin 28b contains Coweeman Middle School and drains to the large intertie pipe that connects the Tam-1 and Tam-2 PSs. However, since this basin is located on private property outside the City's stormwater system, and no as-built information was provided for this area, the closed-system drainage (with the exception of the large intertie pipe and the trunk line leading to it) was not included in the model. In addition, basin 28c, which is located to the east of basins 28b and 28e, is a private system, and therefore was not modeled as a part of this report.

Basin 28f is located east of basin 28c and contains very few drainage structures. Allen Street defines the boundary to the north, and the southern boundary is defined by the city limits. The eastern boundary is located approximately 0.5 mile east of the intersection of Corduroy Road and Allen Street. This basin contains a short pipe line with four catch basins along Allen Street that drains to the south side of the road.

Basin 32 is divided into two smaller basins (32a and 32b) and is located east of basin 31b. Basin 32a shares its northern boundary with the ridgeline of basin 38, which follows northeast along Jones Road and ends at the southern end of Graham Drive. The eastern boundary is defined by a ridgeline that runs southeast from Graham Drive to Allen Street just east of Crescent Drive. Allen Street bounds basin 32a to the south, and basin 32a shares a boundary with basin 31b to the west. The main pipe line has been approximated using City data and other information gathered as part of this plan. The pipe line drains south along 22nd Avenue, through a creek, continues south along 23rd Avenue, and drains into basin 28c. Various pipe diameters (from 12 inches to 36 inches), ditch sections, and gutter flows make up this flow path.

Basin 32b shares its western boundary with basin 32a. It is triangular in shape and the eastern boundary starts at the northeast corner of basin 32a and tracks southeast along Sunrise Street, east on Harris Street, and south along Corduroy Road to Allen Street, with the southern border defined by Allen Street. Basin 32b contains a few short pipe segments, beginning at the intersection of Miller and Sunrise Streets that appear to act as bubblers and drain downstream via the Sunrise Street gutters until they outfall into a field at the southeast corner of Sunrise Street and Corduroy Road in basin 33a.

Basin 33 is located east of basin 32b and south of basin 38 and is divided into two basins. Basin 33a is bounded by the Kelso city limits to the north and east, by Allen Street to the south, and by basin 32b to the west. The two main pipe lines in basin 33a are located along Edinburgh Court and Harris Street and contain areas of gutter flow. A 15-inch-diameter pipe line drains south along Edinburgh Court and west along Roberts Court and outfalls to the canyon west of the cul-de-sac at the end of Roberts Court. A 12-inch-diameter pipe line drains to the west along the north side of Harris Street, converges with a ditch on the south side of Harris Street and then outfalls to a drainage.

Basin 33b contains county land south of basin 38, east of basin 33a, and north of basin 28f. While this basin does not contain any storm drainage structures, it does contribute runoff to basin 33a, which has been taken into consideration in modeling basin 33a.

The sloughs upstream of the Tam-1 and Tam-2 PSs and the PSs themselves are owned and maintained by CDID No.3. The sloughs act as additional storage for the PSs and have an average water surface elevation of 6.5 feet for both the Tam-1 and Tam-2 sloughs. The sloughs and PSs are not included in the model. The modeled outfalls are given tailwater conditions with an elevation of 9 feet, based on modeling of the PSs performed for CDID No.3.

A.3.2 Tam O'Shanter-Northeast Kelso Watershed Hydraulic Model Results

This section summarizes the modeling results for the Tam O'Shanter-Northeast Kelso watershed area and the discharge to the Tam-1 slough for the existing land use conditions. The piping network in the Tam O'Shanter-Northeast Kelso watershed model was analyzed for the 25- and 100-year, 24-hour design storms. The data output results for each design storm are included on a compact disk (Appendix C of the SMP).

The closed-system modeling of the City's system indicates areas of surcharging at approximately 23 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered areas of concern. Eliminating the small flooding areas leaves approximately 11 locations for review of system issues for the 25- and 100-year storm events, as shown in Figures V-4b and V-4c.

A.3.3 Tam O'Shanter-Northeast Kelso Watershed 25- and 100-year Storm Events

The results of the 25-year, 24-hour storm event modeling identified 11 areas of concern, which are discussed below. Within these areas, there are a number of impacts noted that are often related to the same system deficiencies. Many of the inlets surcharging aboveground contain a downstream connection with adverse grade and low rim elevation. Many of the inlets showed ponding deeper than 0.33 foot (4 inches). The peak runoff for the Tam O'Shanter-Northeast Kelso watershed for the 25-year storm is 421.34 cfs at 8.5 hours into the 24-hour storm event.

The results of the 100-year, 24-hour storm event modeling amplified the areas of concern that are discussed in the paragraph above for the 25-year storm event. Many of the inlets showed ponding deeper than 0.50 foot (6 inches). The peak runoff for the Coweeman watershed for the 100-year storm is 649.38 cfs at 8.5 hours into the 24-hour storm event.

A.3.4 Tam O'Shanter-Northeast Kelso Basin Discussion

A.3.4.1 Basin 31a, Area 1 (31a-1)

This area of concern is at the intersection of North 16th Avenue and Lord Street. The structure affected in this area is catch basin 2040. This area is a combination of closed-system piping connected by catch basins and manholes, and overland gutter flows.

- Catch basin 2040 is assumed to act as a bubbler, allowing water to build up in the catch basin, spill into the gutter, and flow downstream along North 16th Avenue to be collected by catch basin 2065 at the corner of North 16th Avenue and Crawford Street. The surcharging during a 25-year storm event is 22.48 ac-in of total flooded volume at a depth of 0.49 foot. The 100-year event results in a flood volume of 35.61 ac-in and a depth above the catch basin of 0.63 foot.

Recommendations: Water bubbles out of the inlet grate at catch basin 2040 and drains south along North 16th Avenue to catch basin 2065. It is recommended that this area be investigated further to determine how the system is draining if catch basin 2040 does indeed function as a bubbler. No other recommendations are provided at this time.

A.3.4.2 Basin 33a, Area 1 (33a-1)

This area of surcharging is located at the intersection of Edinburgh Court and Harris Street and includes catch basin 4410. The following specific issues are noted in 33a-1:

- Catch basin 4410 is a low point among the surrounding structure rim elevations. Catch basin 4410 drains to catch basin 4409 downstream; however, catch basin 4409 acts as a bubbler, allowing the water surface elevation to rise above the rim elevation of catch basin 4410. The 25-year storm event results in 24.73 ac-in of total flooded volume at a depth of 0.32 foot. The 100-year event results in a flood volume of 39.29 ac-in to a depth of 0.41 foot.

Recommendations: Catch basin 4410 has a low rim elevation and its assumed downstream connection (to catch basin 4409) acts as a bubbler. Water must rise and bubble out of catch basin 4409, and because the rim elevation of catch basin 4409 is higher than that of catch basin 4410, surcharging occurs at catch basin 4410. It is recommended that this location be investigated and all connections be verified by the City. No other recommendations are provided at this time.

A.3.4.3 Basin 32b, Area 1 (32b-1)

This area of concern is located along Sunrise Street from Miller Drive to Corduroy Road and includes catch basins 2005, 2007, 2008, and 1957. The following specific issues are noted in 32b-1:

- Catch basins 2007 and 2008 are located along Sunrise Street just south of its intersection with Bloyd Street. Both catch basins are located on a steep grade. Catch basin 2008 drains to 2007 via the west gutter along Sunrise Street. Catch basin 2007 is very shallow (1 foot from rim to invert) and both catch basins are identified as "bubblers" in the City as-builts: water builds up in the catch basin and spills out of the grate to drain downstream via gutter flow. The 25-year event results in flooded depths of 0.35 and 0.40 feet with 21.69 and 15.61 ac-in of total flooded volume for catch basin 2007 and 2008, respectively. The 100-year event results in depths above the catch basins of 0.42 and 0.50 feet and flooded volumes of 30.56 and 23.67 ac-in.

- Catch basin 2005 is located along Sunrise Street at its intersection with Burcham Street. Catch basin 2005 is a bubbler that drains 340 lf via overland flow at a steep slope (0.137 ft/ft) to catch basin 2004. The 25-year event results in a flooded depth of 0.40 foot with 6.21 ac-in of total flooded volume. The 100-year event results in a depth above the catch basin of 0.50 foot and a flood volume of 9.54 ac-in.
- Catch basin 1957 is located at the intersection of Corduroy Road and Sunrise Street. This catch basin is located at the downstream end of the Sunrise Street pipe lines. The upstream pipe (link-3143) is a 10-inch-diameter CMP with a slope of 0.126 ft/ft. Catch basin 1957 outfalls into a field at the southeast corner of the intersection (Out-33a-01). The 25-year event results in a flooded depth of 0.35 foot with 8.57 ac-in of total flooded volume. The 100-year event results in a depth above the catch basin of 0.43 foot and a flood volume of 20.67 ac-in.

Recommendations: All four catch basins in this area of concern are located along Sunrise Street on very steep grades and have assumed outfall elevations. Catch basins 2005, 2007, and 2008 have no outlet pipes and therefore water bubbles out of the catch basin grate and drains downstream along Sunrise Street. Surcharging is due to this bubbler effect. It is recommended that a closed pipe system be installed at link-2008-2007, direct-3142, and direct-3140. Replace direct-3140, link-2008-2007, and direct-3142 with 340, 212 and 31 lf of 12-inch HDPE with slopes of 0.135, 0.050, and 0.110 ft/ft. Replace catch basins 2004 and 2007 with Type 1 storm drain catch basins.

Surcharging at catch basin 1957 is likely due to the small pipe diameters and turbulence in the upstream pipes due to the steep slopes. It is recommended that the upstream (link-3143) and downstream (link-3144) pipes be replaced with 475 and 87 lf of 18-inch-diameter HDPE pipe, respectively. The 18-inch-diameter pipes will not eliminate flooding in these areas, but can help to reduce ponding during lower-intensity storms (i.e., less than 25-year). It is good engineering practice and may significantly reduce the duration of ponding at catch basin 1957.

A.3.4.4 Basin 32b, Area 2 (32b-2)

This area of concern is located at the intersection of Corduroy Road and Allen Street and includes catch basin 1958. The following specific issues are noted in 32b-2:

- Catch basin 1958 is located along the west side of Corduroy Road. The catch basin is in a sag condition and drains downstream to catch basin 1959 via link-5000. The 25-year event results in a flooded depth of 0.45 foot with 20.93 ac-in of total flooded volume. The 100-year event results in a depth above the catch basin of 0.57 foot and a flood volume of 31.71 ac-in.

Recommendations: Catch basin 1958 is in a sag condition and has an assumed 6-inch downstream connection to catch basin 1959. Catch basin 1959 also acts as a bubbler, causing water to rise up and spill out of the rim, which is higher than the rim elevation of catch basin 1958. It is recommended that the City install 139 lf of 12-inch-diameter HDPE pipe between catch basin 1959 to catch basin 1961 with a minimum ground of cover of 2 feet and a minimum slope of 0.005 ft/ft. This will require catch basin 1959 to be replaced with a Type I storm drain catch basin that is at least 3 feet deep. No other recommendations are provided at this time.

A.3.4.5 Basin 28a, Area 1 (28a-1)

This area of concern is located on the west side of Kelso High School and includes catch basins 1948 and 1949. The following specific issues are noted in 28a-1:

- Catch basin 1949 is located along Tam O'Shanter Way west of Kelso High School. It has a low rim elevation in relation to the other structures nearby. The 25-year event results in a flooded depth of 0.54 foot with 8.58 ac-in of total flooded volume. The 100-year event results in a flood volume of 28.55 ac-in and a depth above the catch basin of 0.98 foot.
- Catch basin 1948 is located along Tam O'Shanter Way west of a baseball field. This catch basin also has a low rim elevation, although the flooding experienced during the 25-year event is relatively minor. The 100-year event results in a flood volume of 5.31 ac-in and a depth above the catch basin of 0.98 foot.

Recommendations: The catch basins in this area (1948 through 1949) are in sag conditions. Additionally, 940 lf of 60-inch-diameter pipe downstream from the catch basins remains full of water in normal conditions because the outlet elevation of the 60-inch-diameter pipe (Out-31c-14) is lower than the water surface elevation at the Tam-1 slough. The pipe downstream from catch basin 1949 (link-1177) is an 8-inch-diameter CMP connection. It is recommended that link-1177 be replaced with 32 lf of 12-inch-diameter HDPE pipe at a 0.005 ft/ft slope. Additionally, replacing the inlet grate at catch basin 1949 with a 48- x 36-inch grate may allow more runoff to drain into the catch basin and therefore into the system. The 12-inch-diameter pipe and large inlet grate may facilitate drainage and reduce some ponding; however, this will not alleviate all ponding that is due to the tailwater conditions downstream. The Kelso High School drainage system and surrounding piping systems are poorly defined and it is recommended that the City investigate this area further. No other recommendations are provided at this time.

A.3.4.6 Basin 32a, Area 1 (32a-1)

This area of concern is located around the intersection of Behshel Heights Road and Sunrise Street and includes catch basins 1972 and 2017 and manhole 4467. The following specific issues are noted in 32a-1:

- Catch basin 1972 is located on the west side of Behshel Heights Road, north of the intersection with Sunrise Street. Catch basin 1972 collects runoff from a 4–inch-diameter polyvinyl chloride (PVC) yard drain and bubbles out into the street, contributing to the ponding at this location. The 25-year event results in a flooded depth of 0.32 foot with 6.29 ac-in of total flooded volume. The 100-year event results in a flood volume of 9.53 ac-in and a depth above the catch basin of 0.38 foot.
- Catch basin 2017 is located west of the intersection of Sunrise Street and North 22nd Avenue. The catch basin is located in a low spot that outfalls south to a creek. The outfall information has been entered into the model, based on City schematics and additional research by the engineer. The upstream and downstream pipes (link-1156 and link-1158) are 10-inch-diameter CMPs. The 25-year event results in a flooded depth of 0.37 foot with 7.24 ac-in of total flooded volume. The 100-year event results in a flood volume of 15.34 ac-in and a depth above the catch basin of 0.45 foot.
- Manhole 4467 is located at the intersection of Sunrise Street and North 22nd Avenue, northeast of catch basin 2017. The rim elevation of manhole 4467 is lower than the hydraulic grade line of manhole 4468 downstream, contributing to surcharging at manhole 4467. The 25-year storm event results in 7.95 ac-in of total flooded volume for four hours and 47 minutes. The 100-year event results in a flood volume of 17.09 ac-in for seven hours and 46 minutes.

Recommendations: Ponding at catch basin 1972 likely is due to the shallow invert elevation and catch basin 1972's probable function as a bubbler (no outlet pipes are identified). It is recommended that link G-1970-1972 and link-1155 be converted to a closed system with 112 and 136 lf of 12–inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft and a minimum ground cover of 2 feet.

Catch basin 2017 and manhole 4467 are low spots and the hydraulic grade lines in the systems are higher than the rim elevations of these structures. It is recommended that link-1156 and link-1158 be replaced with 27 and 11 lf of 12-inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft. Replacing link-1156 and link-1158 is good engineering practice; however, it may not eliminate all surcharging. It is recommended that this area be investigated to verify the outfall connections downstream.

A.3.4.7 Basin 28e, Area 1 (28e-1)

This area of concern is located on the west side of basin 28e and includes catch basins 1942, 1944, and 1946. The following specific issues are noted in 28e-1:

- Catch basins 1942 and 1944 are located south of the baseball field in basin 28e. The catch basins are affected by the water backing up in the pipe line because the outfall (Out-28d-TAM1-01) elevation is lower than water surface elevation of the Tam-1 PS slough located downstream. The 25-year event results in flooded depth of 0.46 foot for both catch basins with 4.72 and 1.47 ac-in of total flooded volume, respectively. The 100-year event results in a flood volume of 14.73 and 6.09 ac-in and a depth above both catch basins of 0.59 foot.
- Catch basin 1946 is located northeast of catch basins 1942 and 1944 and is in a sag condition. The downstream 36-inch-diameter pipe (link-971) was entered into the model, based on plat maps provided by the City. It has an adverse grade of -0.007 ft/ft, contributing to the surcharging at catch basin 1946. The 25-year event results in a flooded depth of 0.46 foot with 1.11 ac-in of total flooded volume. The 100-year event results in a flood volume of 5.26 ac-in and a depth above the catch basin of 0.59 foot.

Recommendations: Catch basins 1942 and 1944 are surcharging as a result of the outlet pipe (Out-28e-x) being under tailwater conditions at the Tam-1 PS slough and the turbulence created by the sharp bends in the pipe line between catch basin 1943 at the end of the line and Jun-227 where the pipe line ties into a larger trunk line. It is recommended that 163 lf of 12-inch-diameter HDPE pipe be installed from catch basin 1942 to 1941 at a minimum slope of 0.005 ft/ft and that link-315 be removed, eliminating one of the bends in the pipe line.

Ponding at catch basin 1946 likely is due to water backing up from the slough because the outfall pipe is lower than the water surface elevation of the slough. It is recommended that link-772, link-971, and link-850 be replaced with 95, 290, and 198 lf of 12-inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft. Additionally, link-971 and link-850 should be replaced with 290 and 198 lf of 18-inch-diameter HDPE pipe with a positive slope and matching the crowns of the pipes. In order to achieve a positive slope, manhole Jun-227 must have an invert elevation of at least 4.85 feet. These improvements will not eliminate surcharging in this area that is due to the rim elevation of catch basin 1946 being lower than the hydraulic grade line of the pipe line; however, it may facilitate drainage and allow for storage within the pipes during less intense storm events.

A.3.4.8 Basin 31b, Area 1 (31b-1)

This area of concern is located around the intersection of North 18th Avenue and Bloyd Street and includes catch basin 2020. The following specific issues are noted in 31b-1:

- Catch basin 2020 is located at the southeast corner of Bloyd Street and North 18th Avenue. It acts as a bubbler, allowing water to flow out of the grate and drain south along North 18th Avenue. Catch basin 2020 also contains a downstream connection (link-927) that has an inlet invert elevation located at the rim of catch basin 2020 and runs through several parcels and drains to catch basin 2026. This connection was confirmed by the City crew. The 25-year event results in a flooded depth of 0.25 foot with 8.98 ac-in of total flooded volume. The 100-year event results in a flood volume of 13.62 ac-in and a depth above the catch basin of 0.33 foot.

Recommendations: The main issue in Area 31b-1 is that water bubbles up out of catch basin 2020, contributing to ponding in that area. It is recommended that the downstream pipe (link-927) be investigated further to the invert elevations and downstream connection to catch basin 2026. No other recommendations are provided at this time.

A.3.4.9 Basin 13, Area 1 (13-1)

This area of concern is located around the intersection of Behshel Heights Road and Sunrise Street and includes catch basin 1103 and manhole J-13-2. The following specific issues are noted in 13-1:

- Catch basin 1103 is located at the east end of Oak Street and is in a sag condition. The downstream pipe (link-P-13-115) has a steep slope of 0.133 ft/ft connecting into catch basin 4022. The 25-year event results in a flooded depth of 0.11 foot with 3.89 ac-in of total flooded volume. The 100-year event results in a flood volume of 15.34 ac-in and a depth above the catch basin of 0.45 foot.
- Manhole J-13-2 is located on Vine Street, where it intersects with Grade Street. The manhole is in a sag condition and is just upstream from the 60-inch-diameter pipe that crosses under I-5 in the WSDOT right-of-way. This 60-inch-diameter pipe is surcharged during normal conditions because the invert of the outlet pipe is lower than the water surface elevation of the Tam-1 slough. This allows water to back up into the smaller pipes to the east and west. The 25-year storm event results in 5.12 ac-in of total flooded volume for two hours and six minutes. The 100-year event results in a flood volume of 12.73 ac-in for four hours and 50 minutes.

Recommendations: Catch basin 1103 is also in a sag condition. It is recommended that the downstream pipe (link-P-13-115) be replaced with 12 lf of 12-inch-diameter HDPE pipe with a minimum slope of 0.005 ft/ft. This may not alleviate all flooding but it is good engineering practice and may facilitate drainage in less intense events (less than the 25-year storm). Flooding at manhole J-13-2 is due to its sag condition; the rim elevation of manhole J-13-2 is lower than the water surface elevation because of surcharging in the downstream 60-inch-diameter pipe line that drains under I-5. Any improvements are subject to the water surface elevation in the 60-inch-diameter pipe, which remains full most of the year. No recommendations are provided for manhole J-13-2 at this time.

A.3.4.10 Basin 31b, Area 2 (31b-2)

This area of concern is located near the cul-de-sac at the end of North 20th Avenue and includes catch basin 2062. The following specific issues are noted in 31b-2:

- Catch basin 2062 is located near the cul-de-sac at the end of North 20th Avenue. City as-builts note that this catch basin has been filled with concrete, limiting the pipe opening to 3 inches. The catch basin is less than 2 feet deep from rim to bottom elevation and acts as a bubbler, allowing runoff to spill out of the inlet grate and drain south along North 20th Avenue to the downstream catch basin 2063. The 25-year event results in a flooded depth of 0.31 foot with 5.75 ac-in of total flooded volume. The 100-year event results in a flood volume of 8.71 ac-in and a depth above the catch basin of 0.36 foot.

Recommendations: The main issues to address in Area 31b-2 is the concrete in catch basin 2062, which limits pipe capacity, and that the lack of an outlet pipe forces catch basin 2062 to act as a bubbler, contributing to ponding at the structure. It is recommended that the bubbler condition be removed by installing 240 lf of 12-inch-diameter HDPE pipe (link-1166) at a minimum slope of 0.005 ft/ft. It is also recommended that further investigation of the area, and catch basin 2062, be performed to determine the exact flow path of the piping system in this area, and the reason for the presence of concrete in this catch basin.

A.3.4.11 Basin 31c, Area 1 (31c-1)

This area of concern is located along Minor Road and includes catch basin 1955 and manholes 4480, 4521, and Jun-31c-05. The following specific issues are noted in 31c-1:

- Catch basin 1955 is located at the intersection of Minor Road and Allen Street, and is less than 3 feet deep. The upstream connection (link-1331a) drains to catch basin 1955 via an adverse grade of -0.680 ft/ft, and the downstream pipe (link-1182) drains to Jun-416 at a slope of 0.599 ft/ft. The 25-year event results in a flooded depth of 0.40 foot with 0.83 ac-in of total flooded volume. The 100-year event results in a flood volume of 5.76 ac-in and a depth above the catch basin of 0.47 foot.
- Manholes 4480 and 4521 are located along Minor Road between the intersections with Burcham Street and Allen Street. Link-1216 is located downstream from manhole 4480 and has an adverse grade of -0.016 ft/ft. These manholes experience very minor surcharging that remains below the ground surface during the 25-year storm event. The invert elevations at these manholes are much lower than the hydraulic grade line during the 100-year storm event. The 100-year event results in flood volumes of 31.63 and 6.58 ac-in for one hour and eight minutes and 0 hours and 34 minutes, respectively.
- Manhole Jun-31c-05 also experienced only minor flooding during the 25-year storm event. It is located just north of Kelso High School in the parking lot near the intersection of Allen Street and North 19th Avenue. Based on the Kelso High School plans, the upstream pipe (link-1229) was entered in the model as a 12-inch-diameter concrete pipe, while the downstream pipe (1230) was entered as a 36-inch-diameter concrete pipe. This manhole is a low point in the pipe system and has a rim elevation much lower than the structures surrounding it. Additional research revealed

that manhole Jun-31c-05 is "full of water and silt." The amount of flooding during the 25-year storm event is insignificant; however, the 100-year event results in a flood volume of 7.27 ac-in for two hours and eight minutes.

Recommendations: Ponding at catch basin 1955 likely is due to the shallow catch basin invert elevation and the extreme slopes of the upstream and downstream pipes. It is recommended that catch basin 1955 be replaced with a 48-inch-deep Type I storm drain catch basin. It is also recommended that the pipe downstream of catch basin 1955 (link-1182) be replaced with 26 lf of 12-inch-diameter HDPE pipe. The slopes of both the upstream (link-1331a) and downstream (link-1182) pipes should match the slope of link-774 as closely as possible while still providing 2 feet of ground cover.

Manholes 4480 and 4521 are low points in the system located along Minor Road, just upstream from the convergence of many large-diameter pipes. Ponding at these manholes is likely due to the increased flow at the convergence of pipe lines and to the elevation of the outlet (Out-31c-14) being lower than the water surface elevation of the Tam-1 slough. Preliminary review of the pipes along Minor Road (link-1212, link-1216, link-1217, and culvert-253) suggests that eliminating the adverse slope at link-1216 and increasing pipe size will not decrease surcharging at manholes 4480 and 4521. The surcharging at these manholes is controlled by the invert elevations of the manholes and the water surface elevation at the Tam-1 slough. Continued maintenance of the pipe line is recommended to maintain full storage capacity. No other recommendations are provided at this time.

Manhole Jun-31c-05 is in a sag condition and there is a large difference in the diameters of the upstream (link-1229) and downstream (link-1230) pipes. Surcharging at this manhole is dependent on the water surface elevation at the Tam-1 slough and the standing water in the 60-inch-diameter WSDOT pipe that drains the basins on the west side of I-5 (basin 12b and basin 13). It is recommended that the upstream (link-1229) and downstream (link-320 and link-1231) pipes be replaced with 36-inch-diameter HDPE pipe. Link-1229 and link-1231 should maintain their original slopes, while link-320 should be installed with a positive slope. Upgrading these pipes allows for additional storage and facilitates drainage, reducing surcharging above the ground surface.

ATTACHMENT 4

COWEEMAN WATERSHED

A.4 Coweeman

A.4.1 Coweeman Watershed Basin Descriptions

Basin 2a includes an area north of Colorado Street and Talley Way that contains a large slough system that collects runoff from the Coweeman and Baker Way watersheds, acting as storage for the Coweeman and Baker Way PSs. This slough is interconnected with the slough section that collects stormwater from the Baker Way basins. This interconnected slough creates a loop running approximately from Elm Street to the north, 11th Avenue to the west, Hawthorne to the south, and 13th Avenue to the east. This slough is under the jurisdiction of CDID No.3. The slough has an average top of bank elevation of 11 feet and an average bottom width of 40 feet.

The basin is bounded by I-5 to the east and South Pacific Avenue to the west. The north and south boundaries are defined by ridgelines, as determined by contours. The southern border begins at I-5, north of the Baker Way PS, and continues west along Talley Way and Colorado Street.

This basin includes several ditch systems intermixed with culverts and closed-system drainage. There are three main trunk lines in basin 2a that outfall to the slough system: a 12-inch-diameter line located along the east side of 9th Avenue from Laurel Street and continuing along the south side of Yew Street to the slough (Out-02a-02); a 12-inch-diameter line located along Walnut Street from 9th Avenue to the slough outfall (Out-02a-05); and a 16-inch-diameter line located along S. 13th Avenue from Colorado Street to the intersection at Hazel Street, where basin 3 connects and a 16-inch-diameter line flows east to outfall (at Out-02a-03) to a slough segment along the west side of I-5. Basin 2a discharges directly to a slough in two other locations along S. 13th Avenue (Out-02a-01 and Out-02a-04).

Basin 3 includes the area from Colorado Street in the south and South Pacific Avenue to the west. The north and east borders are shared with basin 2a. The north border shares the ridgeline from South Pacific Avenue and Willow Street, continuing southeast to the intersections of Hawthorne Street and the slough. The east border tracks south from that intersection until it intersects with Colorado Street.

The basin contains one main trunk line located along the length of Hazel Street. Basin 3 directly connects to basin 2a at the intersection of S. 13th Avenue and Hazel Street.

A.4.2 Coweeman Watershed Hydrologic Model Results

This section summarizes the modeling results for the Coweeman watershed area and the discharge to the Coweeman-Baker Way slough for the existing land use conditions. The piping network in the Coweeman watershed model was analyzed for the 25- and 100-year, 24-hour design storms. The data output results for each design storm are included on a compact disk (Appendix C of the SMP).

Based on input from CDID No.3 staff, portions of the Coweeman basin experience intermittent flooding, especially during heavy rainfall events. Previous basin modeling performed for CDID No.3 using HEC-HMS indicated that for both of the design storms analyzed, there is sufficient storage capacity at the PS, but some minor, localized flooding occurs as the peak water surface elevation in ponds is reached. The City's storm drainage system discharges to CDID No.3's interconnected slough, and based on previous modeling and the average water elevation in the slough, outlet pipes would be under tailwater conditions for both the 25- and 100-year, 24-hour storm events.

The closed-system modeling of the City's system indicates areas of surcharging at approximately 65 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered areas of concern. Eliminating the small flooding areas leaves approximately five locations for review of system issues for the 25- and 100-year storm events, as shown in Figures V-5b and V-5c.

In addition to the closed system, an open ditch drainage system consisting of short segments drains portions of basin 2a. However, large areas in basins 2a and 3 contain very flat slopes and large areas with no open ditch or piping system in place.

A.4.3 Coweeman Watershed 25- and 100-year Storm Event

The Coweeman watershed drains to the slough, which connects the Coweeman and Baker Way PSs. The outfall pipes from Coweeman watershed are under tailwater conditions. No data were available on the water surface elevation of the slough during normal conditions. The normal water surface elevation of the slough is likely between the 25-year elevation and the lowest pump on-elevation, which occurs at the Baker Way PS. Previous studies indicate that the slough experiences a peak water surface elevation of 8.5 feet during the 25-year storm event. The on-elevation of the lowest pump is 4.5 feet. For modeling purposes, these elevations were averaged, generating a normal water surface elevation of 6.5 feet.

The results of the 25-year, 24-hour storm event modeling identified four areas of concern, which are discussed below. In these areas, there are a number of impacts noted that are often related to the same system deficiencies. Many of the inlets surcharging aboveground contain a downstream connection with adverse grade and low rim elevation. Many of the inlets showed ponding deeper than 0.4 foot (approximately 5 inches). The peak runoff for the Coweeman watershed for the 25-year storm is 84.61 cfs at 8.5 hours into the 24-hour storm event, with a peak outflow of 18.73 cfs.

The results of the 100-year, 24-hour storm event modeling amplified the areas of concern that were discussed in the paragraph above for the 25-year storm event. Many of the inlets showed ponding deeper than 0.6 foot (approximately 7 inches). The peak runoff for the Coweeman watershed for the 100-year storm is 123.94 cfs at 8.5 hours into the 24-hour storm event, with a peak outflow of 20.43 cfs.

Previous basin modeling performed for CDID No. 3 using HEC-HMS indicated that both of the design storms analyzed experienced higher peak runoffs than those found in this report, likely because the flat slopes and lack of piping in areas of basin 2a prevent some runoff from reaching the closed piping system.

A.4.4 Coweeman Basin Discussion

A.4.4.1 Basin 2a, Area 1 (2a-1)

This area of concern is the intersection of S. 13th Avenue and Hazel Street (catch basins 1591 through 1593), north along S. 13th Avenue (catch basins 1598 through 1599) and west along Hazel Street (catch basins 4250 through 4252). This area is the confluence of two piping segments that flow east to the slough, which then drains to the Coweeman PS, and includes drainage from the west along Hazel Street and drainage from the south along S. 13th Avenue. The following specific issues are noted in 2a-1:

- Catch basin 1591 is a low point just upstream from a confluence of two piping segments. Catch basin 1591 flooded to a depth of 0.28 foot with 21.43 ac-in of total flooded volume. The 100-year event results in a flood volume of 35.33 ac-in and a depth above the catch basin of 0.32 foot.
- Catch basins 1592, 1593, 1598, and 1599 have rim elevations that are at or below the water elevation of the pipe to which they drain. Catch basin 1599 flooded to a depth of 0.51 foot with 21.86 ac-in of total flooded volume. Catch basins 1592, 1593, and 1598 flooded to depths of 0.63, 0.51 and 0.41 feet with 4.44, 6.65, and 18.24 ac-in of total flooded volume, respectively. The 100-year event results in flood volumes for catch basins 1592, 1593, 1598, and 1599 of 12.41, 15.50, 24.84, and 31.57 ac-in and depths above the catch basin of 1.82, 0.64, 0.49 and 0.64 feet.

- Link-468 is upstream of catch basin 4250 and has an adverse grade of -0.004 ft/ft, contributing to flooding at the downstream catch basins. Catch basins 4250 and 4252 experience flooding of 0.57 and 0.24 feet with total flooded volumes of 9.69 and 4.55 ac-in, respectively. The 100-year event results in a flood volume of 19.36 and 8.07 ac-in and depths above the catch basins of 0.99 and 0.27 feet.
- Additionally, during the 100-year storm, catch basin 4251 floods to 0.34 foot with 6.10 ac-in total flooded volume.

Recommendations: Area 2a-1 is at the intersection of S. 13th Avenue and Hazel Street. Catch basin 1591 experiences surcharging that likely is due to a combination of issues: the confluence of two piping segments just downstream from the catch basin, the sag condition, and the water surface elevation of the downstream slough. Additionally, the upstream inlet 4252 drains to catch basin 1591 via gutter flow, contributing to surcharging at the inlet of catch basin 1591. It is recommended that this connection (Link-4252-1591) be replaced with 290 lf of 12–inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft. This improvement will not eliminate all surcharging at catch basin 1591 but it is good engineering practice and may facilitate drainage during less intense storm events.

Ponding around catch basins 1592 through 1593 and 1598 through 1599 likely is due to small pipe diameters and low rim elevations that allow water to back up in the pipe segments upstream because of the water surface elevation of the slough. It is recommended that link-2146, link-759, link-104, and link-105 be replaced with 51, 46, 18, and 17 lf of 12–inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft. This improvement may not eliminate all surcharging but it is good engineering practice and may facilitate drainage during less intense storm events.

Ponding around catch basins 4250 through 4252 likely is caused by water backing up in link-468 (because of its negative slope) before draining into 4250 and downstream toward the intersection at North 13th Avenue and Hazel Street. It is recommended that link-468 be replaced with 309 lf of 12-inch-diameter HDPE pipe with a minimum positive slope of 0.005 ft/ft. It is also recommended that link-466 be replaced with 39 lf of 12-inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft. These improvements may facilitate drainage and reduce ponding during lower-intensity storms (i.e., less than 25-year events), and are good engineering practice; however, this may not provide significant ponding reduction for the 25- and 100-year storm events because of the water surface elevation of the slough at the outfall pipes.

A.4.4.2 Basin 2a, Area 2 (2a-2)

This area is located along 9th Avenue and Yew Street and includes catch basins 1616 and 2113. The following specific issues are noted in 2a-2:

- The catch basin at the intersection of Yew Street and 9th Avenue (catch basin 1616) is receiving drainage from the areas north of Yew Street. Catch basin 1616 is in a sag condition and connects to an 8-inch-diameter pipe downstream (link-757), which then drains to the trunk line on Yew Street and outfalls to the slough downstream. Catch basin 1616 is flooded to a depth of 0.47 foot with 10.03 ac-in of total flooded volume. The 100-year event results in a flood volume of 22.30 ac-in and a depth above the catch basin of 0.59 foot.
- Catch basin 2113 is a low point in the piping segment and has a sawtooth connection where the upstream pipe has a lower inlet elevation than the downstream outlet elevation. Also, two downstream links (link-155 and link-154) have 6-inch-diameter piping, while the surrounding pipes are 10 and 12 inches in diameter. Catch basin 2113 flooded to a depth of 0.42 foot with 18.93 ac-in of total flooded volume. The 100-year event results in a flood volume of 30.38 ac-in and a depth above the catch basin of 0.51 foot.

Recommendations: Ponding at catch basin 1616 likely is due to the sag condition at the inlet, the small-diameter pipe downstream, and the water that backs up into downstream trunk line because of the water surface elevation at the slough. It is recommended that link-757 be replaced with 28 lf of 12–inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft.

It is recommended that link-154 and link-2135 be replaced with 35 lf and 313 lf of 12-inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft, removing the sawtooth connection by matching the crown elevations of the 8-inch-diameter pipe at structure 2113.

Replacing the smaller-diameter pipes in this area of concern with a 12–inch-diameter HDPE pipe is good engineering practice and may reduce surcharging during lower-intensity storms (less than 25-year events) but does not eliminate surcharging due to the water surface elevation of 6.5 feet at the slough.

A.4.4.3 Basin 2a, Area 3 (2a-3)

This area of concern is at the intersection of S. 13th Avenue and Colorado Street/Talley Way. The structure affected in this area is catch basin 1590. This area is a combination of closed-system piping connected by catch basins and manholes, and discontinuous ditches.

- Catch basin 1590, located at the intersection of S. 13th Avenue and Colorado Street/Talley Way, receives drainage from a ditch to the west and is a low point in the piping segment. The surcharging during a 25-year storm event is 3.39 ac-in of total flooded volume at a depth of 0.32 foot. The 100-year event results in a flood volume of 7.82 ac-in and a depth above the catch basin of 0.37 foot.

Recommendations: The surcharging in this area is due to the presence of a sag condition at catch basin 1590 and water elevations in the downstream pipes that exceed the rim elevation of 1590. No recommendations are provided at this time.

A.4.4.4 Basin 3, Area 1 (3-1)

This area includes the trunk line along Hazel Street. The general nature of the surcharging in this area is due to the presence of sag conditions for the catch basins, adverse grade, and surcharging in pipes downstream.

- The catch basin with the greatest issue is 4241. It has a lower rim elevation than the upstream and downstream catch basins and the diameter of the pipe upstream from catch basin 4241 is smaller than the diameter of the downstream pipes. The surcharging during a 25-year storm event that occurs at 4241 is 37.02 ac-in of total flooded volume at a depth of 0.62 foot. The 100-year event results in a flood volume of 74.18 ac-in and a depth above the catch basin of 1.22 feet.
- Additionally, during the 100-year storm, catch basin 4242 floods to a depth of 2.36 feet, with a total flooded volume of 5.68 ac-in. Catch basin 4242 drains to 4241 and has a rim elevation that is approximately 1 foot lower than the catch basins surrounding it. Water is diverted to catch basin 4241 during a storm event, allowing catch basin 4242 to drain without issue during the 25-year storm, but 4242 experiences backup during the 100-year storm when catch basin 4241 experiences larger surcharging.

Recommendations: The general nature of the surcharging in this area is due to the presence of sag conditions at catch basins 4241 and 4242 and surcharging in pipes downstream. Downstream improvements (Area 2a-1 recommendations) may help reduce surcharging and facilitate drainage at catch basins 4241 and 4242. No other recommendations are provided at this time.

ATTACHMENT 5

SOUTH KELSO WATERSHED

A.5.1 South Kelso Watershed Basin Descriptions

Basin 1 is bounded by the Cowlitz River to the west; basin 10 and the Coweeman slough to the east; and ridgelines to the north and south, as determined by contours. The basin contains one main trunk line located along Chestnut Street that outfalls into a large slough system at the intersection of 12th Avenue and Chestnut Street. This slough system collects runoff from the south Kelso, Coweeman, and Baker Way watersheds, acting as storage for the Coweeman and Baker Way PSs.

Basin 10 is located north of basin 1 and is bounded by Allen Street and Grade Street to the north, I-5 to the east, the Cowlitz River to the west, and a ridgeline to the south. The main trunk line is located along Grade Street and drains to outlet node O-4138. Runoff from this outlet flows into a 36-inch-diameter pipe that crosses Grade Street, continues south along 13th Avenue, and discharges into the Coweeman-Baker Way slough. Because of high water elevations and confined entry restrictions, field data were not obtained for this 36-inch-diameter pipe, and therefore the basin 10 model ends at outlet O-4138.

Basin 11 contains the Three Rivers Mall commercial area. Most of the structures in this basin are located outside the City right-of-way and are privately held. Basin 11 is bounded by basin 12a to the north, Manasco Drive to the south, I-5 to the east, and Grade Street to the west. The basin contains large trunk lines on the east and west sides of Three Rivers Mall Drive. The outlet node modeled is O-4358 in Grade Street. Runoff from this outlet flows into a 36-inch-diameter pipe that crosses Grade Street and continues south along 13th Avenue, parallel to the 36-inch-diameter pipe draining basin 10, and discharges into the Coweeman-Baker Way slough. Because of high water elevations and confined entry restrictions, field data were not obtained for this 36-inch-diameter pipe, and therefore the basin 11 model ends at outlet O-4358.

A.5.2 South Kelso Watershed Hydrologic Model Results

This section summarizes the modeling results for the South Kelso watershed area and the discharge to the Coweeman-Baker Way slough for the existing land use conditions. The piping network within the South Kelso watershed model was analyzed for the 25-, 24-hour design storm

Based on correspondence with CDID No. 3 staff, portions of the South Kelso basin experience intermittent flooding, especially during heavy rainfall events. Previous basin modeling performed for CDID No. 3 indicated that for the design storm analyzed, there is sufficient storage capacity in the sloughs adjacent to the Coweeman Pump Station, but some minor, localized flooding occurs as the peak water surface elevation in the sloughs are reached. The City's storm drainage system discharges into CDID No. 3's interconnected slough, and based on previous modeling and the average water elevation in the slough, the outlets of the City's pipes will be under tail water conditions for the 25-year, 24-hour design storm.

The South Kelso watershed contains basins analyzed as a part of previous phases. The closed system models indicate approximately 39% of Basin 1 pipes, 62% of Basin 10 pipes and 90% of Basin 11 pipes experience a system flow greater than the pipe capacities during the 25-year, 24-hour design storm. This results in 53% of the total piping in the South Kelso watershed experiencing flows greater than capacity. Figure A-5b shows these surcharged pipes as identified in the modeling results from previous modeling phases.

One of the modeling assumptions is that only one measure down per structure was available, and therefore a constant invert elevation was utilized for each pipe entering or exiting a given structure. This assumption may have some impacts on the model's accuracy if there are differing invert pipe elevations within structures. For specific pipes identified to be upsized, a recommended first step would be to field verify specific invert elevations and pipe slopes prior to replacing the pipe.

A.5.3 South Kelso Watershed 25-year Storm Event

The South Kelso watershed drains via three outlets to the slough, and then connects the Coweeman and Baker Way Pump Stations. The outfall pipes from the South Kelso watershed are under tail water conditions. No data was available on the water surface elevation of the slough during normal conditions. The normal water surface elevation of the slough is likely between the 25-year, 24-hour design storm elevation and the lowest pump on-elevation, which is at the Baker Way Pump Station. Previous studies indicate that the slough experiences a peak water surface elevation of 8.5-feet during the 25-year, 24-hour design storm. The on-elevation of the lowest pump is elevation 4.5 feet. For modeling purposes, the average of these elevations, elevation 6.5 feet, was used

The results of modeling the 25-year, 24-hour design storm identified three main issues: 1) the use of small diameter pipe, 2) the use of less efficient pipe material, and; 3) inadequate pipe slope.

The basins that make up the South Kelso watershed were not modeled using the 100-year, 24-hour design storm; however, it is assumed that issues created by small pipe diameter and lack of pipe slopes will be amplified during a 100-year storm event.

A.5.4 South Kelso Basin Discussion

The evaluation of the South Kelso Watershed comprised of Basins 1, 10, and 11 was completed as part of the Phase I and Phase II stormwater system studies and has been included in this system-wide stormwater management plan. The identification of deficient areas in the previous study phases was done in a slightly different method, but the areas of deficiencies identified in the previous phases are consistent with the areas of deficiencies identified utilizing the current modeling method. Over 60 percent of the storm drain pipes in basin 1 are undersized, that is, less than the standard minimum size of 12-inch-diameter. This deficiency contributes to flooding in many parts of the basin. The undersized piping is summarized in Table A.5.1. The hydrologic modeling shows the severity of the flooding to be moderate, except as noted in the specific areas described in the following section.

Table A.5.1—Basin 1 Existing Pipe Totals

Pipe Size	Concrete	CMP	PVC	Terracotta	Ductile Iron	Cast Iron	Total	Percentage
6-inch	1,753		350	20		26	**2149**	**10.11%**
8-inch	4,712		995			15	**5722**	**26.93%**
10-inch	3,458		188	1,345			**4991**	**23.49%**
12-inch	2,665		401	274	77		**3417**	**16.08%**
15-inch	262			905			**1167**	**5.49%**
18-inch	289						**289**	**1.36%**
21-inch	204						**204**	**0.96%**
24-inch	1,780		276				**2056**	**9.68%**
30-inch		1,115					**1115**	**5.25%**
36-inch	140						**140**	**0.66%**
Total	**15263**	**1115**	**2210**	**2544**	**77**	**41**	**21,250**	**100.00%**
Percentage	**71.83%**	**5.25%**	**10.40%**	**11.97%**	**0.36%**	**0.19%**	**100.00%**	

For basin 10, it is recommended at a minimum that the main pipes down 1st, South Pacific, and 5th Avenues, and Ash and Grade Streets (considered trunk line pipes) be replaced with HDPE pipe in the diameter size listed in Table A.5.2. This would allow for increased pipe capacity and act as storage for the system should downstream tailwater conditions occur.

Table A.5.2—Basin 10 Existing Pipe Totals

Pipe Size	Concrete	CMP	PVC	Clay	HDPE	Total	Percentage
4-inch	4	0	0	0	0	**4**	**0.03%**
6-inch	1,753	0	196	134	0	**2083**	**13.76%**
8-inch	2,779	0	767	961	0	**4507**	**29.77%**
10-inch	510	0	240	285	0	**1035**	**6.84%**
12-inch	2,320	14	176	0	173	**2683**	**17.72%**
16-inch	353	0	0	0	0	**353**	**2.33%**
18-inch	1,218	0	0	0	0	**1218**	**8.05%**
24-inch	477	0	0	0	0	**477**	**3.15%**
36-inch	2,777	0	0	0	0	**2777**	**18.35%**
Total	**12,191**	**14**	**1,379**	**1380**	**173**	**15,137**	**100.00%**
Percentage	**80.54%**	**0.09%**	**9.11%**	**9.12%**	**1.14%**	**100.00%**	

For basin 11, it is recommended at a minimum that the main pipes down Three Rivers Mall Drive (considered trunk line pipes) be replaced with HDPE pipe in the diameter size listed in Table A.5.3. This would allow for increased pipe capacity and act as storage for the system should downstream tailwater conditions occur.

Table A.5.3—Basin 11 Existing Pipe Totals

Pipe Size	Concrete	CMP	PVC	Clay	HDPE	Ductile Iron	Cast Iron	Total	Percentage
6-inch	0	0	353	0	0	0	0	**353**	**5.19%**
8-inch	0	0	472	0	0	0	0	**472**	**6.94%**
10-inch	0	0	307	0	0	0	0	**307**	**4.52%**
12-inch	30	0	428	0	208	235	0	**901**	**13.25%**
15-inch	0	0	959	0	0	0	0	**959**	**14.11%**
21-inch	0	0	393	0	0	0	0	**393**	**5.78%**
24-inch	0	1,077	344	0	0	0	0	**1421**	**20.90%**
32-inch	0	1,336	0	0	0	0	0	**1336**	**19.65%**

Table A.5.3—Basin 11 Existing Pipe Totals

Pipe Size	Concrete	CMP	PVC	Clay	HDPE	Ductile Iron	Cast Iron	Total	Percentage
36-inch	147	416	0	0	0	0	0	**563**	**8.28%**
48-inch	0	94	0	0	0	0	0	**94**	**1.38%**
Total	**177**	**2,923**	**3,256**	**0**	**208**	**235**	**0**	**6,799**	**100.00%**
Percentage	**2.60%**	**42.99%**	**47.89%**	**0.00%**	**3.06%**	**3.46%**	**0.00%**	**100.00%**	

All three basins in the south Kelso watershed have pipes with adverse slope.

Basin 1: The most prominent issue for the functioning of Phase I (basin 1) is the lack of pipe slope (flat and adverse). Only one measure down per structure was provided, and therefore only one invert elevation for each pipe entering or exiting a structure was calculated. This may have impacts on the system function in the form of inaccurate slope calculations. It should be noted that identified undersized pipes may be found to be adequate if additional invert information is provided that changes the existing pipe slope. For pipes identified for upsizing in basin 1, a recommended first step would be to verify invert elevations and pipe slopes before replacing the pipe.

Basin 10: Most pipes along Grade Street, Ash Street, and South Pacific Avenue (P-10-100 through P-10-127, considered the trunk line) have slopes less than 0.005 ft/ft, severely inhibiting the capacity of the system. Additionally, adverse slopes are present in multiple locations.

Basin 11: Pipes P-11-100 to P-11-108 are 32 inches to 48 inches in diameter, but have insufficient slope, and are undersized, based on the modeled amount of flow in the system. Additionally, pipes P-11-102, P-11-106, and P-11-114 have adverse slopes.

Flat or adverse slopes decrease flow capacity and overall performance in the system. Table A.5.4 contains a list of pipes with adverse slopes.

Table A.5.4
Adverse Pipe Slope

Basin Name	Pipe Name	Slope (ft/ft)
Basin 1	P-17	-0.0071
Basin 1	P-20	-0.0010
Basin 1	P-21	-0.0300
Basin 1	P-51	-0.0053
Basin 1	P-60	-0.0086
Basin 1	P-62	-0.0350
Basin 1	P-65	-0.0008
Basin 1	P-71	-0.2020
Basin 1	P-73	-0.0016
Basin 1	P-86	-0.0224
Basin 1	P-87	-0.0062
Basin 1	P-116	-0.0185
Basin 1	P-190	-0.0020
Basin 1	P-192	-0.0307
Basin 1	P-193	-0.0357
Basin 1	P-206	-0.0007
Basin 1	P-229	-0.0002
Basin 1	P239	-0.0336
Basin 1	P-246	-0.0082
Basin 10	P-10-137	-0.0222
Basin 10	P-10-142	-0.0032
Basin 10	P-10-156	-0.0023
Basin 10	P-10-203	-0.0050
Basin 10	P-10-308	-0.0150
Basin 10	P-10-402	-0.0053
Basin 10	P-10-403	-0.0054
Basin 10	P-10-510	-0.0700
Basin 10	P-10-612	-0.0011
Basin 10	P-10-613	-0.0004
Basin 10	P-10-633	-0.0061
Basin 11	P-11-102	-0.0078
Basin 11	P-11-106	-0.0045
Basin 11	P-11-114	-0.0051

Recommendations: Providing positive slope for pipes identified with negative slope is the first issue to be addressed. For those pipes with positive but relatively flat slopes, increasing the pipe size will provide additional capacity for the system. An important issue is the lack of ground cover for the piping system. In some cases, providing increased slope and/or larger pipe sizes may not be feasible because of the lack of ground cover over the pipes. In these instances, it may be necessary to use a specialized pipe such as an arch pipe, or to install two or more pipes of smaller diameter in parallel, to provide the capacity required. A detailed engineered design of specific pipe replacements will be required that takes into account ground cover, existing invert elevations of adjacent pipes, other underground utilities, and the surrounding environment.

ATTACHMENT 6

BAKER WAY WATERSHED

A.6 Baker Way Watershed

A.6.1 Baker Way Watershed Basin Descriptions

Basin 2b is U-shaped and includes the area east of Talley Way and west of the airport. It contains six catch basins along Baker Way that appear to drain to the small slough south of the Baker Way PS. Basins 4 and 5 are located within the “U” of basin 2b and share borders to the east, west, and south. No information was available to link the six catch basins in basin 2a to the rest of the Baker Way piping network, and further investigation is necessary to determine how this basin contributes to the overall Baker Way watershed.

Basin 4 is triangular in shape and contains a small northern portion of Parrot Way. Basin 4 includes the area south of Colorado Street and Talley Way, east of the airport (basin 2b) and north of basin 5. The basin contains an 8-inch-diameter pipe line located along the east side of Parrot Way that collects runoff from a ditch section along the west side of the street. It is unclear where this pipe line drains to; however, runoff from basin 4 also drains to basin 5 via this ditch on the west side of Parrot Way.

Basin 5 includes the area south of basin 4 and north of basin 2b and contains Talley Way and the rest of Parrot Way. The south and east boundaries are created by Talley Way. The airport creates the west boundary and basin 4 shares its boundary with basin 5. The basin contains two large-diameter pipe lines located at the northeast and southeast corners of the basin, as well as many ditch segments along Parrot Way and Talley Way. The northeast pipe line contains 24-, 30- and 36-inch-diameter pipes that feed a ditch that drains south along the west side of Parrot Way. This pipe line is composed of 265 lf of 24-inch-diameter pipe, followed by 617 lf of 36-inch-diameter pipe, and then constricts to 30-inch-diameter pipe until it empties into the ditch along Parrot Way, approximately 443 lf. The southeast pipe line is located along Talley Way, south of Parrot Way, on the west side of the road. The pipe line drains to the north through an 18-inch-diameter pipe line that outfalls to the east via Out-05-01. The ditch segments are located along the east and west sides of Parrot Way and Talley Way. Outfalls (Out-05-02, Out-05-03, Out-05-04, and Out-05-05) have been assumed along Parrot Way and Talley Way, based on the ditch slopes and apparent direction of drainage.

Basin 6 includes the area north of State Route 432 containing Marina Road and the Dick Hannah Toyota dealership. The basin is bounded by Talley Way to the west, the Coweeman River to the north, State Route 432 to the south, and I-5 to the east. The basin contains five catch basins that are assumed to outfall (Out-06-01 and Out-06-02) into the pond that then drains to the Coweeman River.

A.6.2 Baker Way Watershed Hydrologic Model Results

This section summarizes the modeling results for the Baker Way watershed area and the discharge to the Coweeman-Baker Way slough for the existing land use conditions. The piping network in the Baker Way watershed model was analyzed for the 25- and 100-year, 24-hour design storms. The data output results for each design storm are included on a compact disk (Appendix C of the SMP).

Based on information from previous studies, portions of the Baker Way basin experience intermittent flooding, especially during heavy rainfall events. Previous basin modeling performed for CDID No.3, using HEC-HMS, indicated that for both of the design storms analyzed, there is sufficient storage capacity at the PS, but some minor, localized flooding occurs as the peak water surface elevation in the slough is reached. The City's storm drainage system discharges to CDID No.3's interconnected slough, and based on previous modeling and the average water elevation in the slough, outlet pipes would be under tailwater conditions for both the 25- and 100-year, 24-hour storm events.

The closed-system modeling of the City's system indicates areas of surcharging at approximately 75 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered areas of concern. Eliminating the small flooding areas leaves approximately five locations for review of system issues for the 25- and 100-year storm events, as shown in Figures V-6b and V-6c.

In addition to the closed system, an open ditch drainage system consisting of short segments drains portions of basins 4 and 5. Large areas in basin 2b and basins 4 and 5 contain very flat slopes and large areas with no open ditch or piping system in place.

A.6.3 Baker Way Watershed 25- and 100-year Storm Events

The outlet pipes that drain from the Baker Way watershed to the slough are under tailwater conditions. No data were available on the water surface elevation of the slough during normal conditions. The normal water surface elevation of the slough likely is between the 25-year elevation and the lowest pump-on elevation, which occurs at the Baker Way PS. Previous studies indicate that the slough experiences a peak water surface elevation of 8.5 feet during the 25-year storm event. The on-elevation of the lowest pump is 4.5

feet. For modeling purposes, these elevations were averaged, generating a normal water surface elevation of 6.5 feet.

The results of the 25-year, 24-hour storm event modeling identified a number of areas of concern that are discussed below. In these areas, there are a number of impacts noted that are often related to the same system deficiencies. Many of the inlets surcharging aboveground contain a downstream connection with adverse grade and low rim elevation. Many of the inlets showed ponding deeper than 0.33 foot (4 inches). The peak runoff for the Baker Way watershed for the 25-year storm is 89.58 cfs at 8.5 hours into the 24-hour storm event, with a peak outflow of 19.29 cfs.

The results of the 100-year, 24-hour storm event modeling amplified the areas of concern that were discussed in the paragraph above for the 25-year storm event. Many of the inlets showed ponding deeper than 0.5 foot (6 inches). The peak runoff for the Baker Way watershed for the 100-year storm is 130.81 cfs at 8.5 hours into the 24-hour storm event, with a peak outflow of 23.27 cfs.

A.6.4 Baker Way Basin

A.6.4.1 Basin 5, Area 1 (5-1)

This area of concern is the intersection of Talley Way and Baker Way (catch basin 1574), and to the west near Parrot Way (catch basin 1605). This area contains a 24-inch-diameter pipeline that increases to 36-inch-diameter and then reduces to 30-inch-diameter before draining to the ditch on the west side of Parrot Way. The following specific issues are noted in 5-1:

- Catch basin 1574 was noted in the model as having the greatest amount of ponding water. Catch basin 1574 is located on sag, with the surrounding elevations higher than the rim elevation of catch basin 1574, contributing to surcharging at this location. Also, link-907 and link-908 are 24-inch-diameter pipes that create a sawtooth connection at manhole Jun-357 and drain to a 36-inch-diameter pipe at catch basin 1573. The 25-year event results in a flood depth of 0.64 foot and 161.54 ac-in. The 100-year event increases the flood depth to 1.25 feet and 212.50 ac-in. The predicted flooding appears to be related to the downstream condition caused by CDID No.3's slough water surface elevations.
- Catch basin 1605 drains to the 30-inch-diameter pipe line that outfalls to the ditch on the west side of Parrot Way. Based on plans and aerial views, it appears that a downspout from a nearby building may be draining to catch basin 1605. Catch basin 1605

has a rim elevation lower than the structures surrounding it (sag condition), contributing to the 0.36 foot of flooded depth and 4.69 ac-in of total flooded volume during the 25-year storm event. The 100-year event increases the flood depth to 0.42 foot and 9.05 ac-in.

Recommendations: Ponding at catch basin 1605 is most likely caused by a combination of issues: sag conditions at the catch basin and a poorly defined system downstream with no known outlet. It is recommended that the connections downstream of link-1094 be investigated to determine the points to which this pipe line drains or outfalls. No other recommendations are provided at this time.

It is recommended that the City investigate the possible downspout connection at catch basin 1605. Should the City find a downspout and decide to allow this connection to remain, it is recommended that link-1093 be replaced with 48 lf of 12-inch-diameter HDPE pipe.

A.6.4.2 Basin 4, Area 1 (4-1)

This area of concern is located on the east side of Parrot Way, just south of the intersection of Colorado Street and Parrot Way (catch basins 1576, 1577) and on the west side of Parrot Way (catch basin 1603). This area has a low point at catch basin 1577, which has no identifiable outfall. The following specific issues are noted in 4-1:

- Catch basin 1577 is located along the east side of Parrot Way and is in a sag condition, which contributes to the amount of water ponding at this location. In this case, the invert elevation at catch basin 1577 is also lower than the surrounding structures to the north, south, and west. No outfall information is known for the 8-inch-diameter pipe lines to the north and south that drain to catch basin 1577. The ditch on the west side of Parrot Way also drains to catch basin 1557. The 25-year event results in a total flooded depth of 2.16 feet and a volume of 18.90 ac-in. The 100-year event results in a depth of 4.58 feet and a total flooded volume of 38.76 ac-in.
- Catch basins 1576 and 1603 are upstream of catch basin 1577 and their rim elevations are only a few inches higher than that of catch basin 1577. These low rim elevations likely contributed to the ponding water. Catch basin 1576 and 1603 experience 1.18 and 0.58 feet of flooded depth and 20.82 and 31.55 ac-in of total flooded volume during a 25-year storm event, respectively. The 100-year event increases the flood depth to 0.55 and 0.88 feet and 32.60 and 43.64 ac-in, respectively.

Recommendations: The model's indication of surcharging at catch basins 1576, 1577, and 1603 is likely due to the lack of outfall information in this area. It is recommended that Area 4-1 be investigated to determine the outlet location for the ditch, located on the west side of Parrot Way, and the 8-inch-diameter pipe line, located on the east side of Parrot Way, in order to more accurately model this section of the City's system.

A.6.4.3 Basin 5, Area 2 (5-2)

This area of concern is the south side of Parrot Way, just east of its intersection with Talley Way (catch basin 1582). This area contains a short, 12-inch-diameter pipe segment that collects runoff from a ditch to the east and outfalls to the west (Out-05-04) of the southeast corner of Parrot Way. The following specific issues are noted in 5-2:

- Catch basin 1582 is in a sag condition and the downstream pipe (link-724) has an adverse grade of -0.003 ft/ft. The crown elevation of link-724 where it connects to catch basin 1581 is equal to the rim elevation of catch basin 1582, contributing to ponding water at the catch basin. Catch basin 1582 flooded to a depth of 0.51 foot with 6.55 ac-in of total flooded volume. The 100-year event results in a flood depth above the catch basin of 0.62 foot and volume of 14.51 ac-in.

Recommendations: Ponding in Area 5-2 likely is caused by the adverse grade in the downstream pipe, link-724, and due to the sag condition at catch basin 1582. It is recommended that link-724 be replaced with 176 lf of 12-inch-diameter HDPE pipe at a minimum slope of 0.005 ft/ft.

A.6.4.4 Basin 5, Area 3 (5-3)

This area of concern is located along the west side of Talley Way, south of the intersection with Parrot Way and just north of basin 2b (catch basins 1567, 1565, and 1570). The following specific issues are noted in 5-3:

- Catch basin 1567 is in a sag condition, contributing to ponding water, and the downstream pipe (link-386) has an adverse grade (-0.001 ft/ft) that forces water to fill the pipe before flowing through catch basin 1566 and continuing downstream. The 25-year event results in a flood depth to 0.51 foot and 6.82 ac-in. The 100-year event increases the flood depth to 0.62 foot and 16.04 ac-in.
- Catch basins 1565 and 1570 are consecutive catch basins that have rim elevations lower than those surrounding them, contributing to aboveground surcharging. Catch basins 1565 and 1570 flooded to depths of 0.34 and 1.42 feet with 15.43 and 7.45

ac-in of total flooded volume. The 100-year event results in flood depths above the catch basin of 0.36 and 3.10 feet and volumes of 32.95 and 17.80 ac-in.

Recommendations: Ponding in Area 5-3 is most likely caused by low rim elevations and the adverse grade on link-386. It is recommended that link-386 be replaced with 140 lf of 18-inch-diameter HDPE pipe with a minimum slope of 0.005 ft/ft to provide a positive slope.

A.6.4.5 Basin 6, Area 1 (6-1)

This area of concern is along the south side of Marina Road in front of Dick Hannah Toyota (catch basin 4233). The following specific issues are noted in 6-1:

- Catch basin 4233 is in a sag condition and very little piping information is known in this area. Catch basin 4233 drains to catch basin 4234; it is assumed that from there 4234 bubbles onto the street and drains to catch basin 4236. The rim elevation of catch basin 4233 is lower than catch basin 4234; therefore when water bubbles out of catch basin 4234, the water elevation is higher than the rim elevation at catch basin 4233, causing water to pond at catch basin 4233. The 25-year storm results in flooding to a depth of 0.35 foot with 16.94 ac-in of total flooded volume. The 100-year event results in a flood volume of 25.03 ac-in and depths above the catch basin of 0.42 foot.

Recommendations: The model's indication of ponding in Area 6-1 is likely due to a low rim elevation at catch basin 4233 and incorrect pipe information in the basin. It is recommended that further investigation be performed to verify that the piping network is properly connected and to identify a system outfall.

ATTACHMENT 7

SOUTHEAST KELSO WATERSHED

A.7 Southeast Kelso Watershed

A.7.1 Southeast Kelso Watershed Basin Descriptions

Basin 20 includes an area bounded by the Coweeman River to the north, east, and south and S. Kelso Drive to the west and containing I-5, Grade Street, and a small residential area north of Grade Street. The basin contains a small number of catch basins, short ditch sections, and short pipe lines that outfall to the Coweeman River.

Basin 21 includes an area bounded by the ridgeline to the east and containing Cedar Falls Drive, Tybren Heights Road, and the south ends of Haussler Road and S. Vista Way. The basin contains two short pipe lines along Cedar Falls Drive and Roley Court that outfall to the creek between the two streets, and a few ditch sections along Haussler Road and S. Vista Way that drain to the north and that are assumed to outfall into canyons to the west.

Basin 22 includes an area bounded by S. Kelso Drive to the west and ridgelines to the north, east and south. The north ridgeline creates the boundary between basins 22 and 23, the east ridgeline is shared with basin 25 and the south ridgeline is shared with basin 21. The basin contains several ditch sections and short pipe lines located along roads that outfall to various canyons and creeks. The main ditch sections are located on S. Vista Way, Haussler Road, Highland Park Drive and S. Kelso Drive. The main pipe line drains along West Vista Way from the intersection with S. Vista Way to Haussler Road and outfalls to the canyon to the west.

Basin 23 includes an area bounded by basin 20 to the west, basin 22 to the south, basin 24 to the east, and the Coweeman River to the north. This basin encompasses segments of Alma Drive, Valley View Drive, S. Kelso Drive, Crestwood Lane, and Grimm Road. The basin contains short pipe lines that drain the roadways and outfall to the surrounding canyons.

Basin 24 is bounded by the Coweeman River to the north, basin 25 to the east and southeast, and basin 23 to the west and southwest. The basin contains several short pipe lines that drain across Grimm Road and Banyon Drive and outfall to the surrounding canyons.

Basin 25 is an area located east of basins 21, 22, 23, and 24, and it shares its northern boundary with basins 28c and 28f. The east and south boundaries are created by ridgelines. The basin contains the condemned Aldercrest neighborhood, and a few catch basins that drain along Banyon Drive into basin 24. Otherwise, basin 25 is largely undeveloped open space.

A.7.2 Southeast Kelso Watershed Hydrologic Model Results

This section summarizes the modeling results for the southeast Kelso watershed area for the existing land use conditions. The piping network in the southeast Kelso watershed model was analyzed for the 25- and 100-year, 24-hour design storms. The data output results for each design storm are included on a compact disk (Appendix C of the SMP).

The closed-system modeling of the City's system indicates areas of surcharging at approximately 24 percent of the existing catch basins. Several of the catch basins showing surcharging had only a small volume of water, many for a short period of time, and are not considered areas of concern. Eliminating the small flooding areas leaves approximately two locations for review of system issues for the 25- and 100-year storm events, as shown in Figures V-7b and V-7c.

In addition to the closed system, an open ditch drainage system consisting of short segments drains portions of basins 20, 21, and 22. Basins 21, 22, 23, 24, and 25 contain very steep slopes and large areas with no open ditch or piping system in place.

A.7.3 Southeast Kelso Watershed 25- and 100-year Storm Event

The results of the 25-year, 24-hour storm event modeling identified two areas of concern, which are discussed below. The peak runoff for the southeast Kelso watershed for the 25-year storm is 94.51 cfs at 8.5 hours into the 24-hour storm event.

The results of the 100-year, 24-hour storm event modeling amplified the areas of concern that were discussed in the paragraph above for the 25-year storm event. The peak runoff for the Coweeman watershed for the 100-year storm is 149.76 cfs at 8.5 hours into the 24-hour storm event.

Previous basin modeling in the JMM report indicated that both of the design storms analyzed experienced higher peak runoffs than those found in this report; these higher runoffs likely are due to the steep slopes and lack of piping in the watershed that prevent most of the runoff from reaching the closed piping system.

A.7.4 Southeast Kelso Basin Discussion

A.7.4.1 Basin 22, Area 1 (22-1)

This area of concern is located at the intersection of Haussler Road and West Vista Way and includes catch basin 1877.

- The pipe line upstream from catch basin 1877 drains west along West Vista Way, through 1877, continues south along Haussler Road, and outfalls to a canyon to the west. The pipes upstream from 1877 (links-1131, -366, -367, and -920) have very steep slopes (between 0.15 and 0.19 ft/ft). The first two downstream pipes (link-365 and -918) are both 10-inch-diameter concrete pipes with significantly flatter slopes (0.047 ft/ft and 0.073 ft/ft). During the 25-year storm event, catch basin 1877 flooded to a depth of 0.21 foot with 3.21 ac-in of total flooded volume. The 100-year event results in a flood volume of 9.41 ac-in and a depth above the catch basin of 0.24 foot.

Recommendations: Ponding around catch basin 1877 likely is caused by the extreme change in slope between the upstream and downstream pipes. The change from steep to flat slopes creates turbulence in catch basin 1877 and downstream in link-365, contributing to ponding at the catch basin. It is recommended that link-365 and link-918 be replaced with 60 and 65 lf of 12-inch-diameter HDPE pipe to facilitate drainage and decrease turbulence.

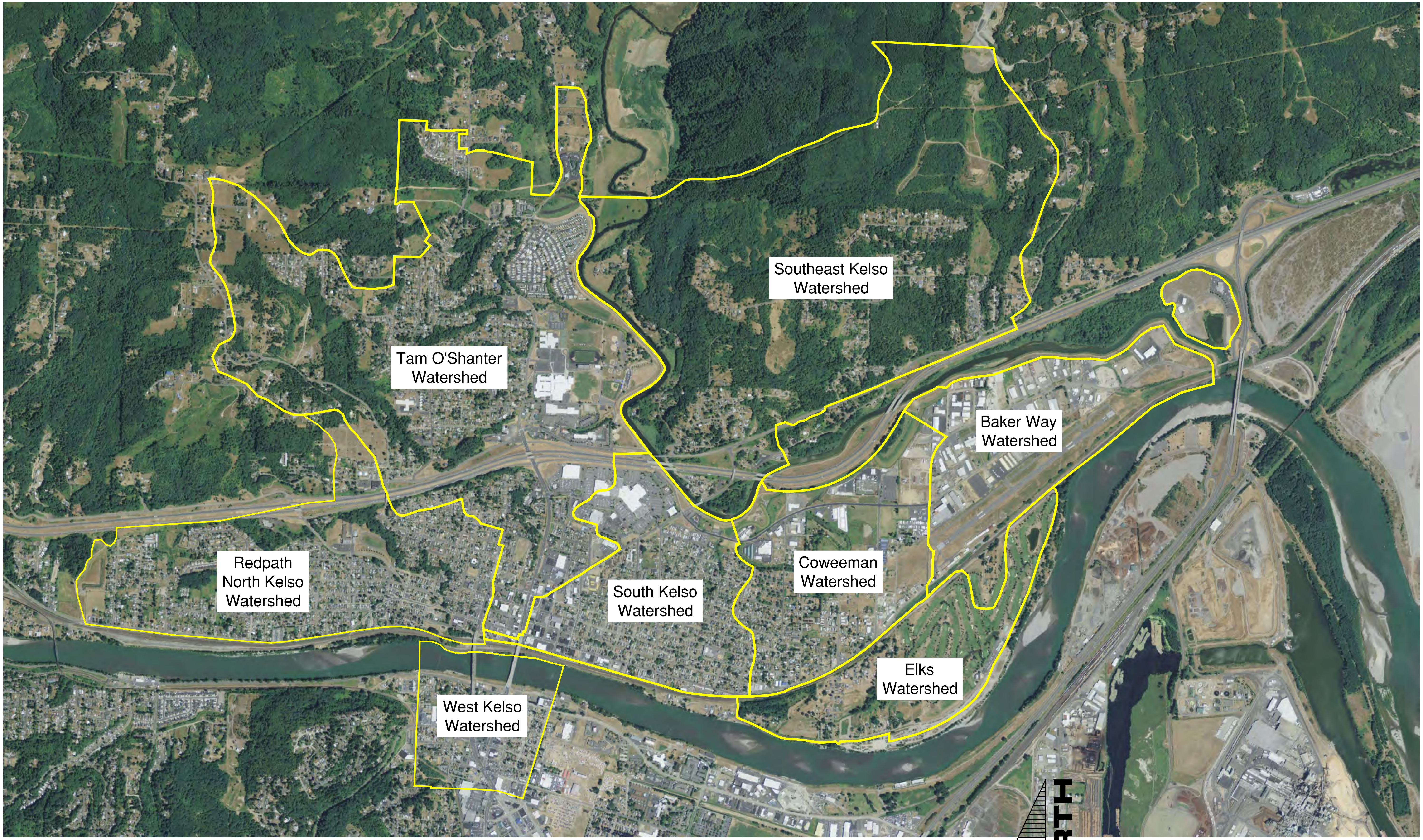
A.7.4.2 Basin 22, Area 2 (22-2)

This area of concern is located on South Vista Way and includes points of interest (8320 and 8312) along a ditch that drains south along the street.

- Two points of interest (8320 and 8312) along the South Vista Way ditch line are locations in which a larger open ditch section (ditch no. 452 and ditch no. 458) drains into two 6-inch-diameter culverts (culvert-19 and culvert-16). During the 25-year storm event, 8320 and 8312 flooded to depths of 0.63 and 0.78 feet with 13.35 and 6.01 ac-in of total flooded volume. The 100-year event results in flood volumes of 25.29 and 15.17 ac-in and a depth above the catch basin of 0.64 and 0.82 feet, respectively.

Recommendations: Ponding around 8320 and 8312 likely is due to the restriction in capacity at the downstream 6-inch-diameter culverts (culvert-19 and culvert-16). The upstream ditch sections (ditch no. 452 and ditch no. 458) that drain to these culverts have a much greater capacity than the downstream culvert, causing water to back up at the inlet end of the culverts (8320 and 8312). It is recommended that culvert-16 and culvert-19 be replaced with 30 and 23 lf of 12-inch-diameter HDPE or ductile iron culverts, depending on the depth of cover available. The increased capacity will facilitate drainage and reduce ponding.

APPENDIX A FIGURES



0 150 300 600

Scale (in Feet)

NORTH

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City of Kelso
Stormwater Management Plan, Phase III
Kelso Watershed Areas
Figure A-1

LEGEND

JUNCTIONS

INLETS

OUTFALLS

PIPE

DITCH

SURCHARGE INLET

SURCHARGE PIPE

FLOODED DITCH

UNDERSIZED PIPE

ADVERSE PIPE SLOPE

EXAMPLE OF FIGURE NAMING CONVENTION

A-(1)	WATERSHED AREA LOCATION
A-(1a)	BASIN AREA PIPING NETWORK
A-(1b)	BASIN AREAS OF CONCERN, 25-YEAR STORM
A-(1c)	BASIN AREAS OF CONCERN, 100-YEAR STORM

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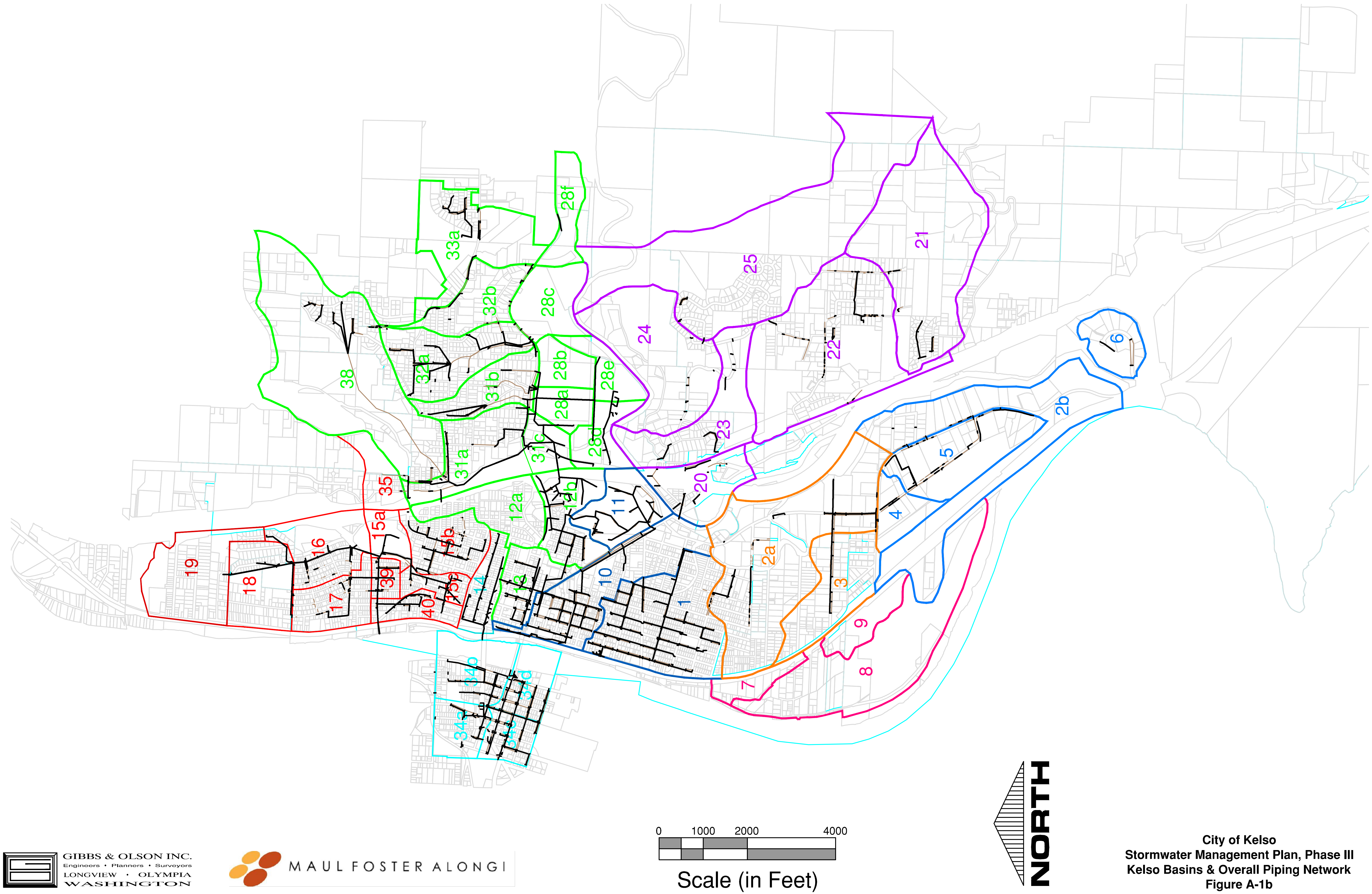
City of Kelso
Stormwater Management Plan
Linetypes and Symbol Legend
Figure A-1a



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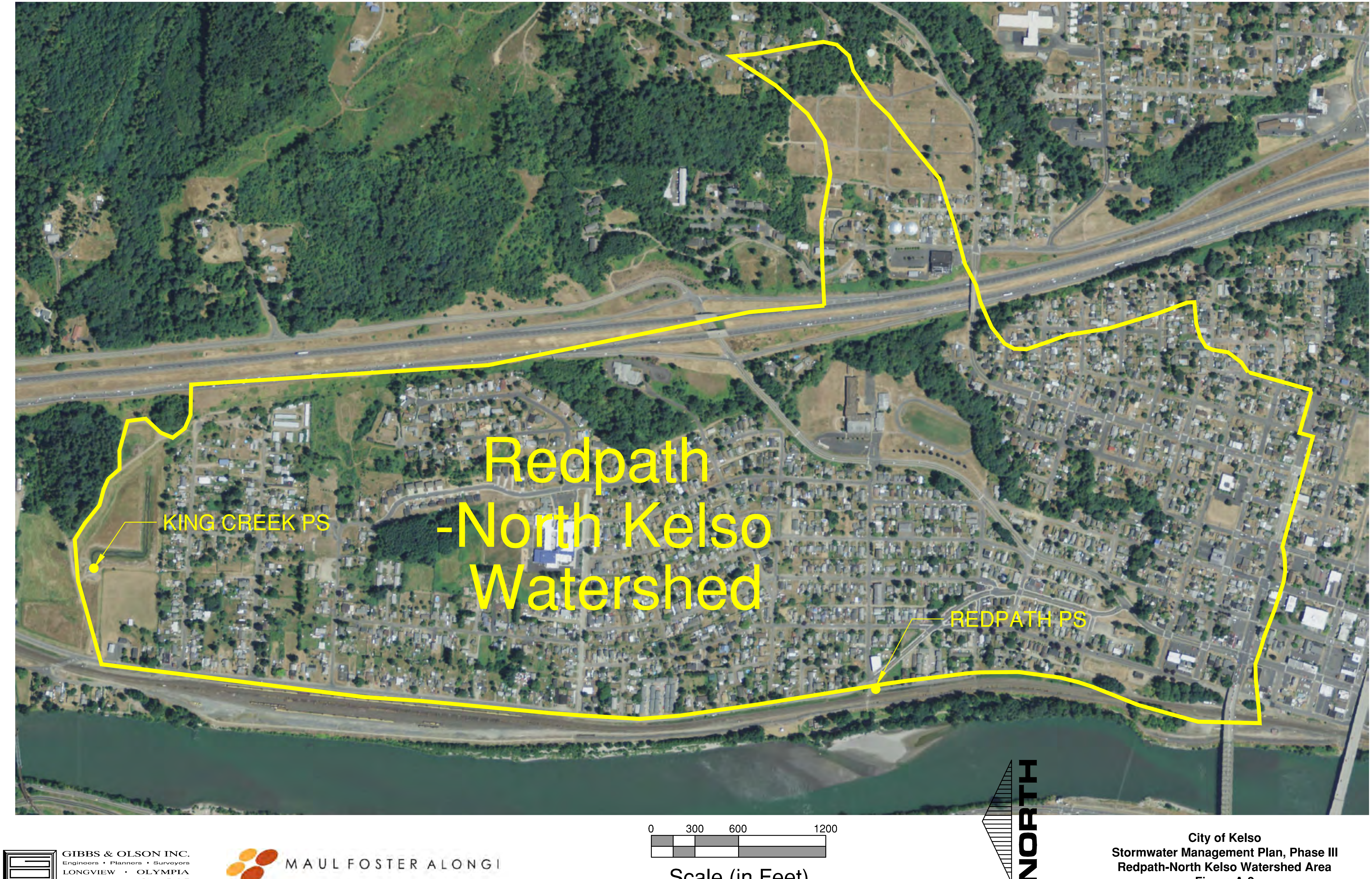
Stormwater Management Plan, Phase III
Kelso Basins & Overall Piping Network
Figure A-1b



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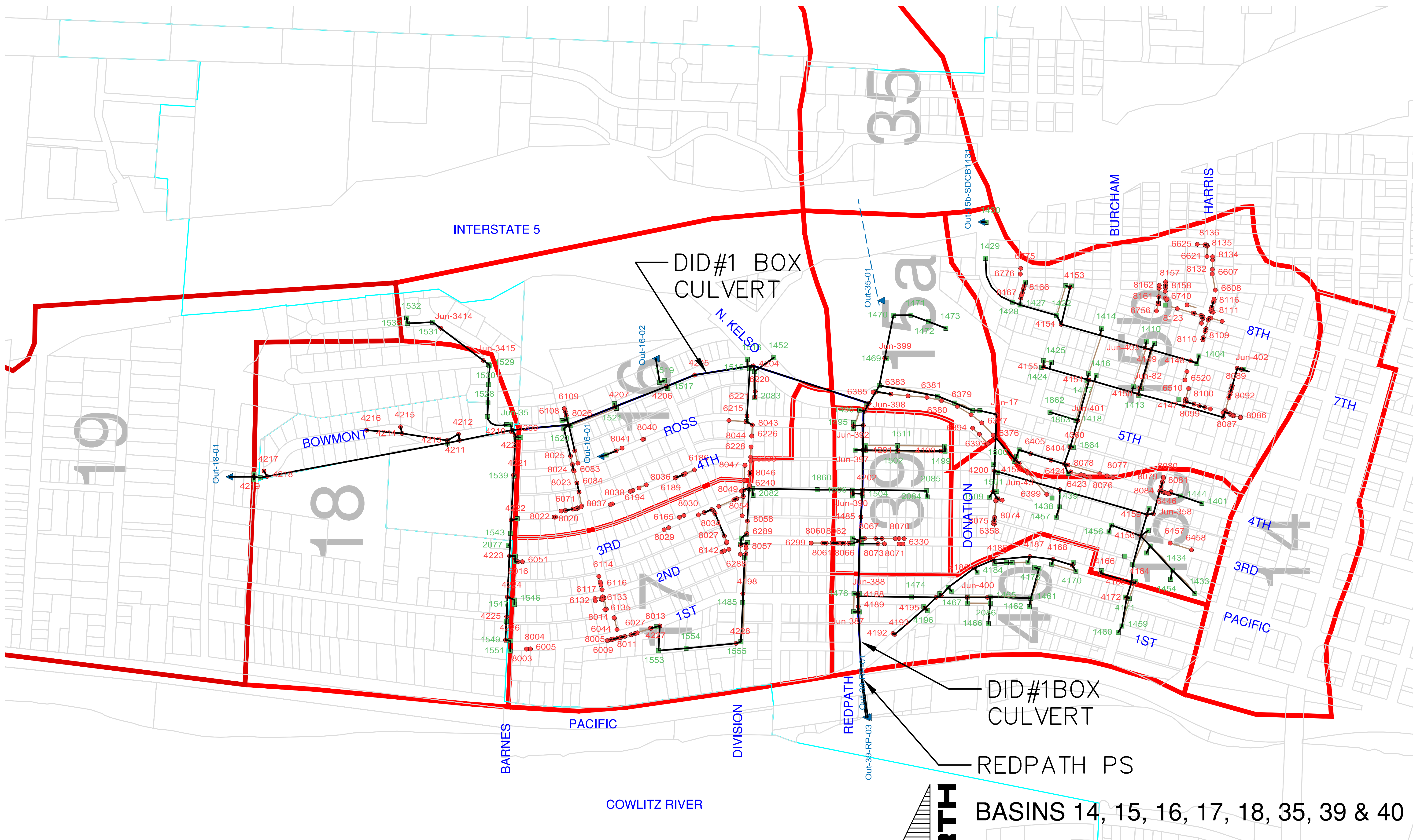
City of Kelso
Stormwater Management Plan, Phase III
Redpath-North Kelso Watershed Area
Figure A-2



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Scale (in Feet)

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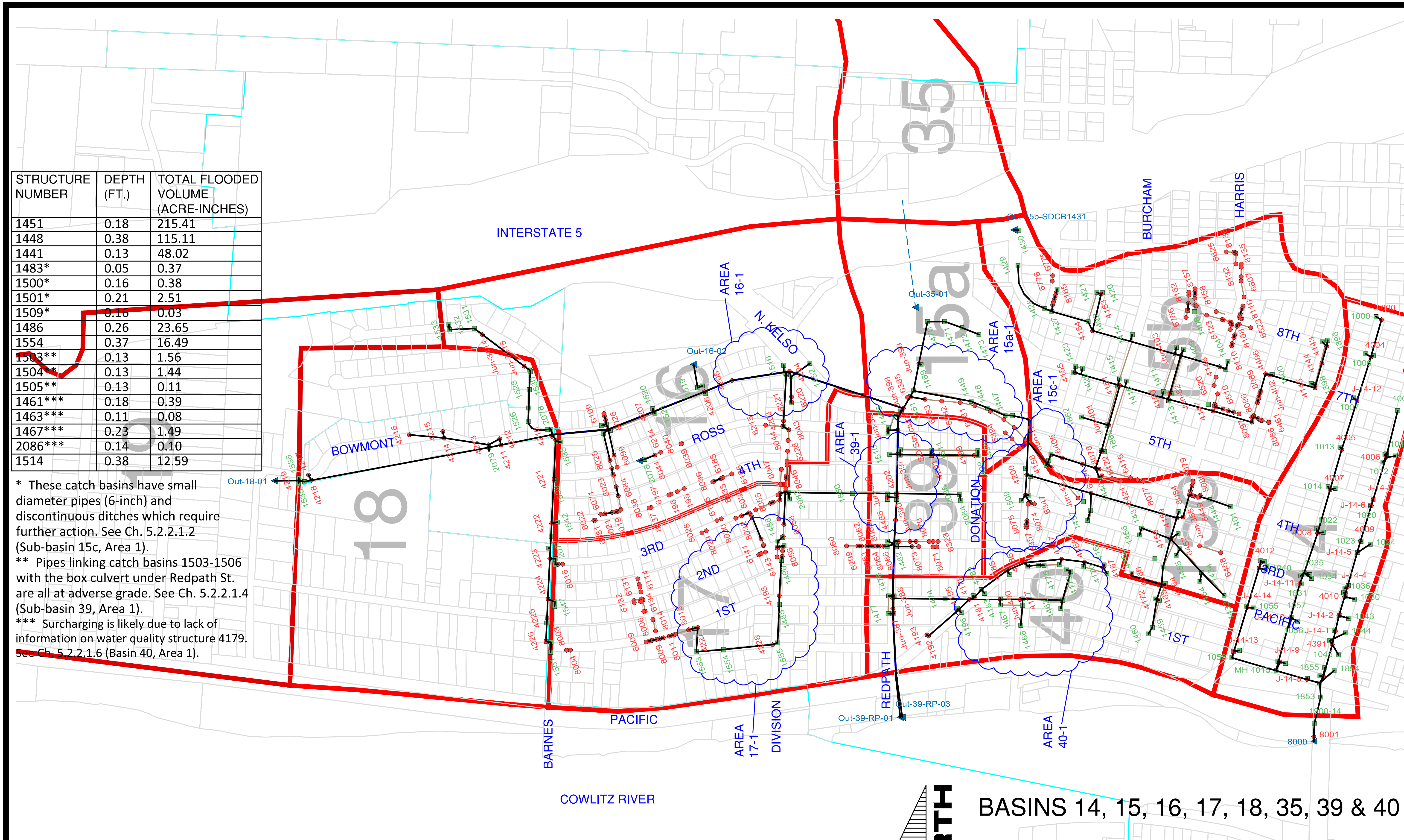
City of Kelso
Stormwater Management Plan, Phase III
Redpath-North Watershed Piping Network
Figure A-2a

STRUCTURE NUMBER	DEPTH (FT.)	TOTAL FLOODED VOLUME (ACRE-INCHES)
1451	0.18	215.41
1448	0.38	115.11
1441	0.13	48.02
1483*	0.05	0.37
1500*	0.16	0.38
1501*	0.21	2.51
1509*	0.16	0.03
1486	0.26	23.65
1554	0.37	16.49
1503**	0.13	1.56
1504**	0.13	1.44
1505**	0.13	0.11
1461***	0.18	0.39
1463***	0.11	0.08
1467***	0.23	1.49
2086***	0.14	0.10
1514	0.38	12.59

* These catch basins have small diameter pipes (6-inch) and discontinuous ditches which require further action. See Ch. 5.2.2.1.2 (Sub-basin 15c, Area 1).

** Pipes linking catch basins 1503-1506 with the box culvert under Redpath St. are all at adverse grade. See Ch. 5.2.2.1.4 (Sub-basin 39, Area 1).

*** Surcharging is likely due to lack of information on water quality structure 4179. See Ch. 5.2.2.1.6 (Basin 40, Area 1).



BASINS 14, 15, 16, 17, 18, 35, 39 & 40

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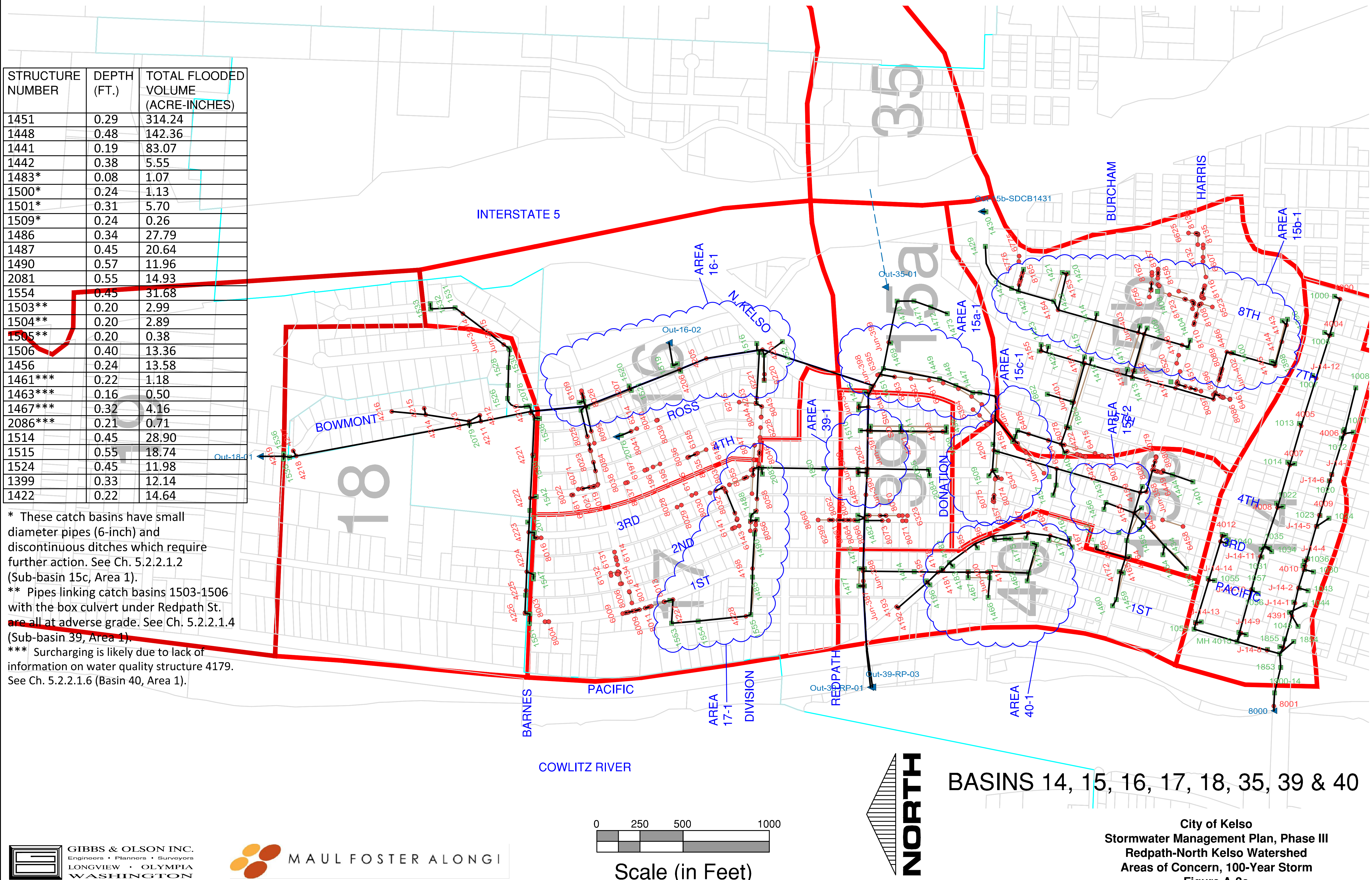
City of Kelso
Stormwater Management Plan, Phase III
Redpath-North Kelso Watershed
Areas of Concern, 25-Year Storm
Figure A-2b

STRUCTURE NUMBER	DEPTH (FT.)	TOTAL FLOODED VOLUME (ACRE-INCHES)
1451	0.29	314.24
1448	0.48	142.36
1441	0.19	83.07
1442	0.38	5.55
1483*	0.08	1.07
1500*	0.24	1.13
1501*	0.31	5.70
1509*	0.24	0.26
1486	0.34	27.79
1487	0.45	20.64
1490	0.57	11.96
2081	0.55	14.93
1554	0.45	31.68
1503**	0.20	2.99
1504**	0.20	2.89
1505**	0.20	0.38
1506	0.40	13.36
1456	0.24	13.58
1461***	0.22	1.18
1463***	0.16	0.50
1467***	0.32	4.16
2086***	0.21	0.71
1514	0.45	28.90
1515	0.55	18.74
1524	0.45	11.98
1399	0.33	12.14
1422	0.22	14.64

* These catch basins have small diameter pipes (6-inch) and discontinuous ditches which require further action. See Ch. 5.2.2.1.2 (Sub-basin 15c, Area 1).

** Pipes linking catch basins 1503-1506 with the box culvert under Redpath St. are all at adverse grade. See Ch. 5.2.2.1.4 (Sub-basin 39, Area 1).

*** Surcharging is likely due to lack of information on water quality structure 4179. See Ch. 5.2.2.1.6 (Basin 40, Area 1).



BASINS 14, 15, 16, 17, 18, 35, 39 & 40

City of Kelso
Stormwater Management Plan, Phase III
Redpath-North Kelso Watershed
Areas of Concern, 100-Year Storm
Figure A-2c

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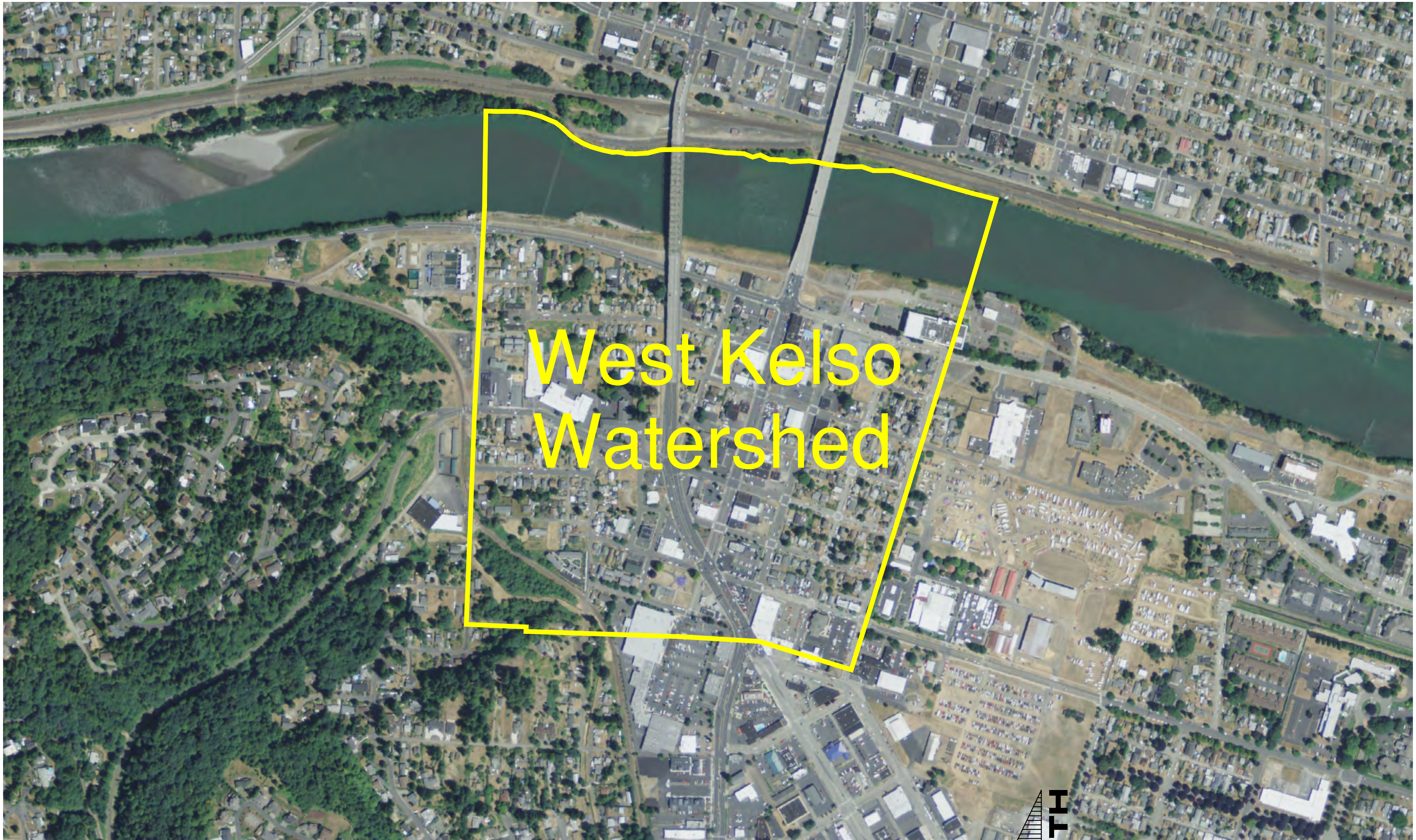

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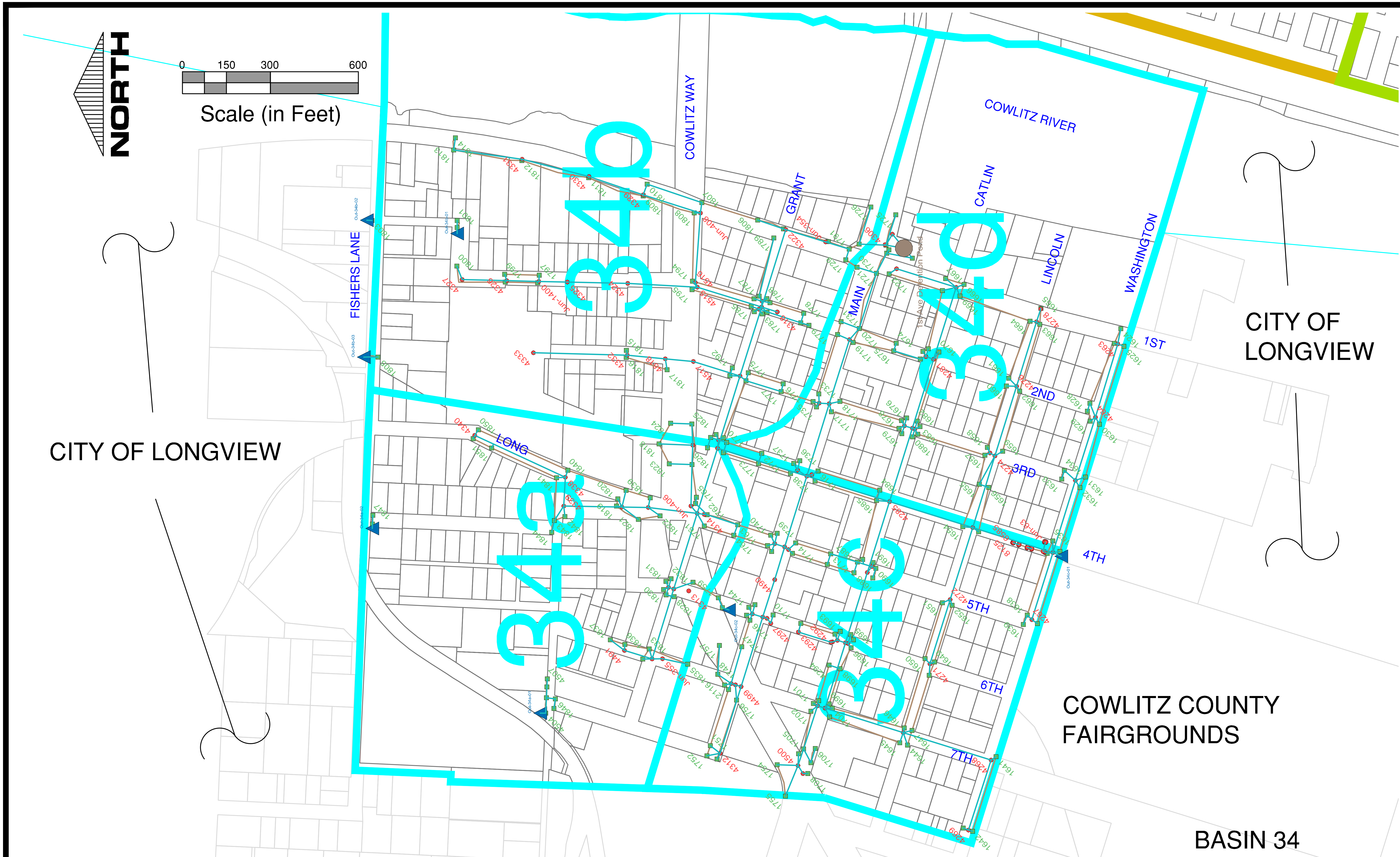
0 250 500 1000

Scale (in Feet)

NORTH

City of Kelso
Stormwater Management Plan, Phase III
West Kelso Watershed Area
Figure A-3



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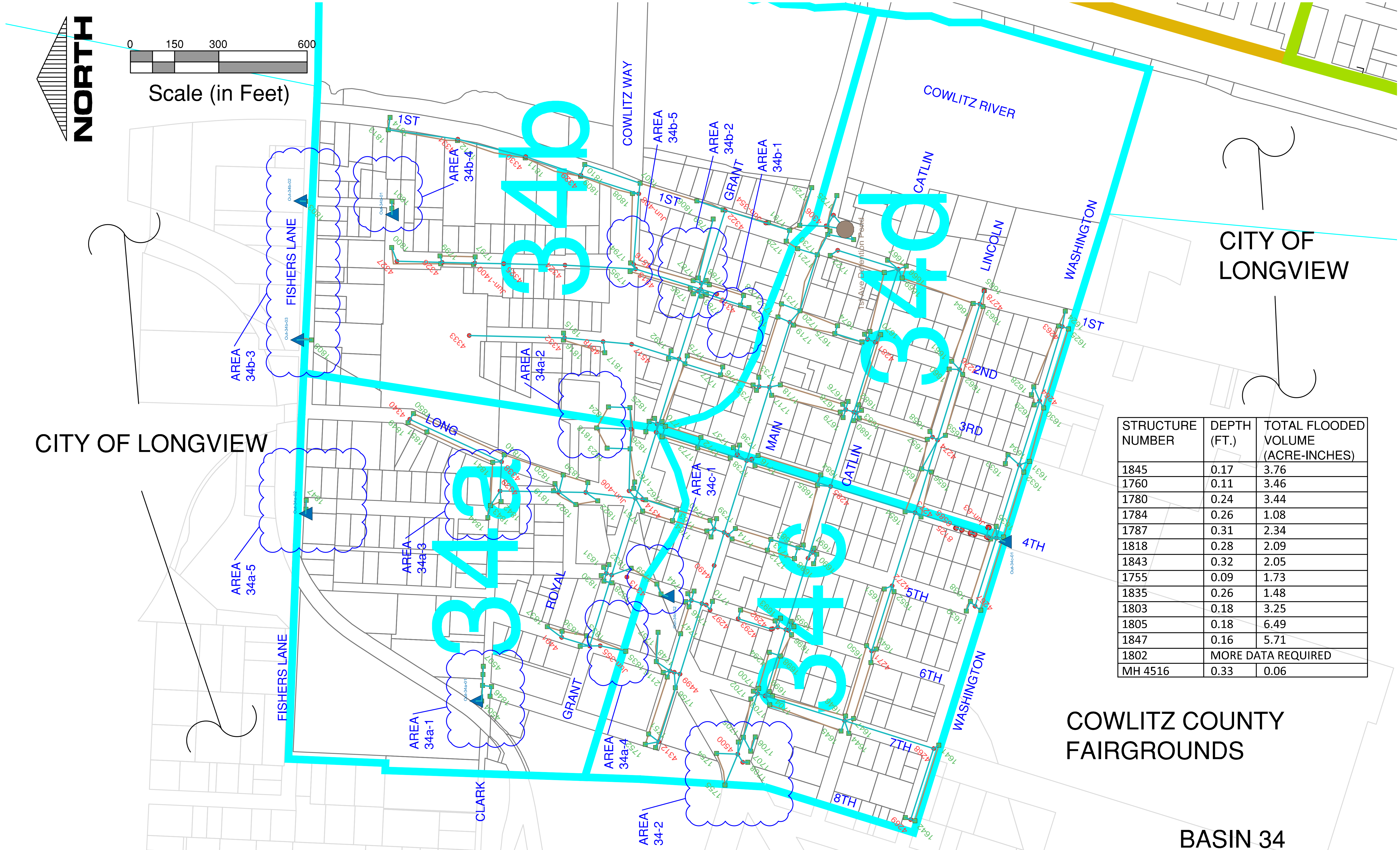
BASIN 34

City of Kelso
Stormwater Management Plan, Phase III
West Kelso Watershed Piping Network
Figure A-3a



STRUCTURE NUMBER	DEPTH (FT.)	TOTAL FLOODED VOLUME (ACRE-INCHES)
1845	0.17	3.76
1760	0.11	3.46
1780	0.24	3.44
1784	0.26	1.08
1787	0.31	2.34
1818	0.28	2.09
1843	0.32	2.05
1755	0.09	1.73
1835	0.26	1.48
1803	0.18	3.25
1805	0.18	6.49
1847	0.16	5.71
1802	MORE DATA REQUIRED	
MH 4516	0.33	0.06

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BASIN 34

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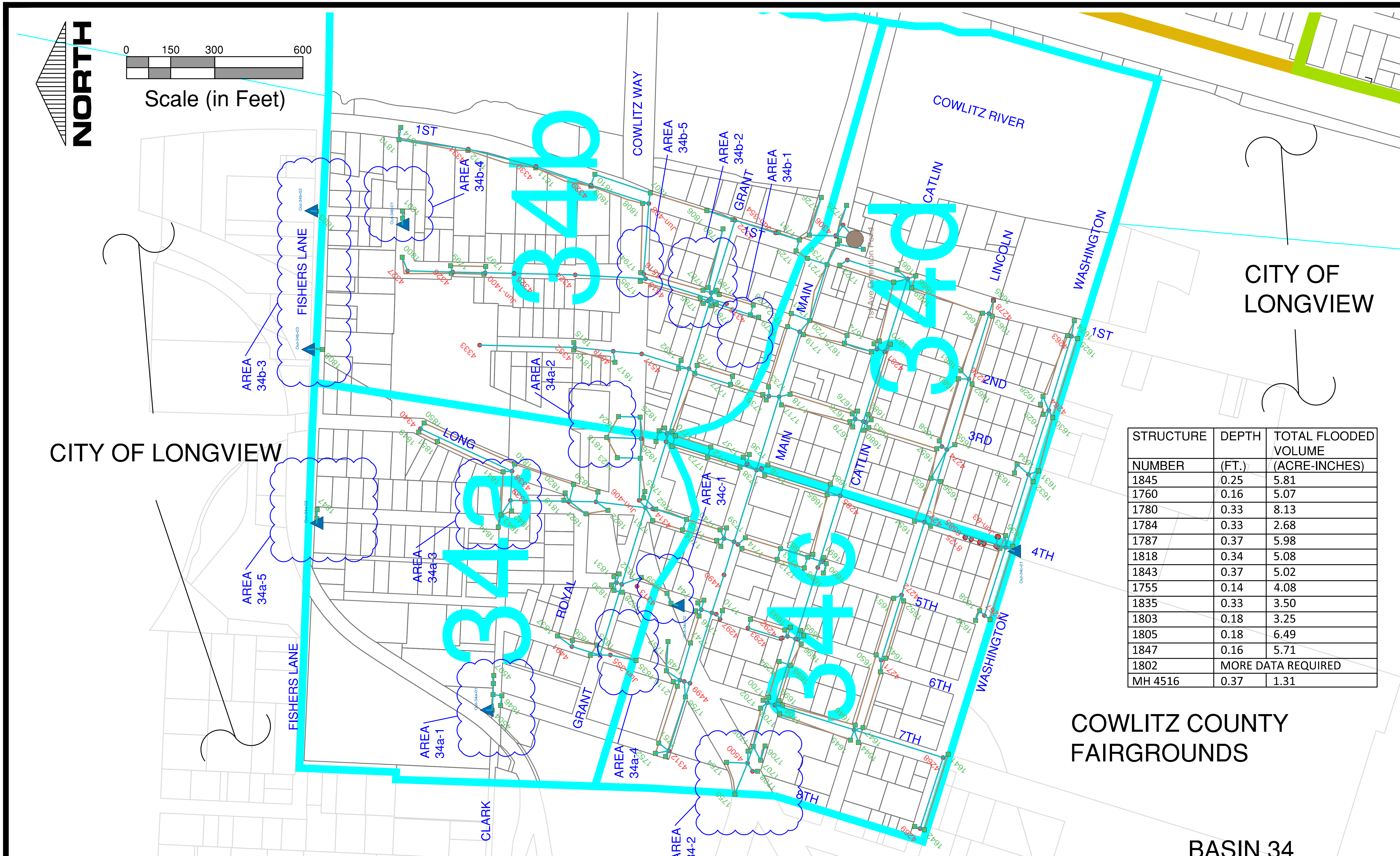
Stormwater Management Plan, Phase III
West Kelso Watershed Areas of Concern, 25-Year Storm
Figure A-3b



STRUCTURE NUMBER	DEPTH (FT.)	TOTAL FLOODED VOLUME (ACRE-INCHES)
1845	0.25	5.81
1760	0.16	5.07
1780	0.33	8.13
1784	0.33	2.68
1787	0.37	5.98
1818	0.34	5.08
1843	0.37	5.02
1755	0.14	4.08
1835	0.33	3.50
1803	0.18	3.25
1805	0.18	6.49
1847	0.16	5.71
1802	MORE DATA REQUIRED	
MH 4516	0.37	1.31

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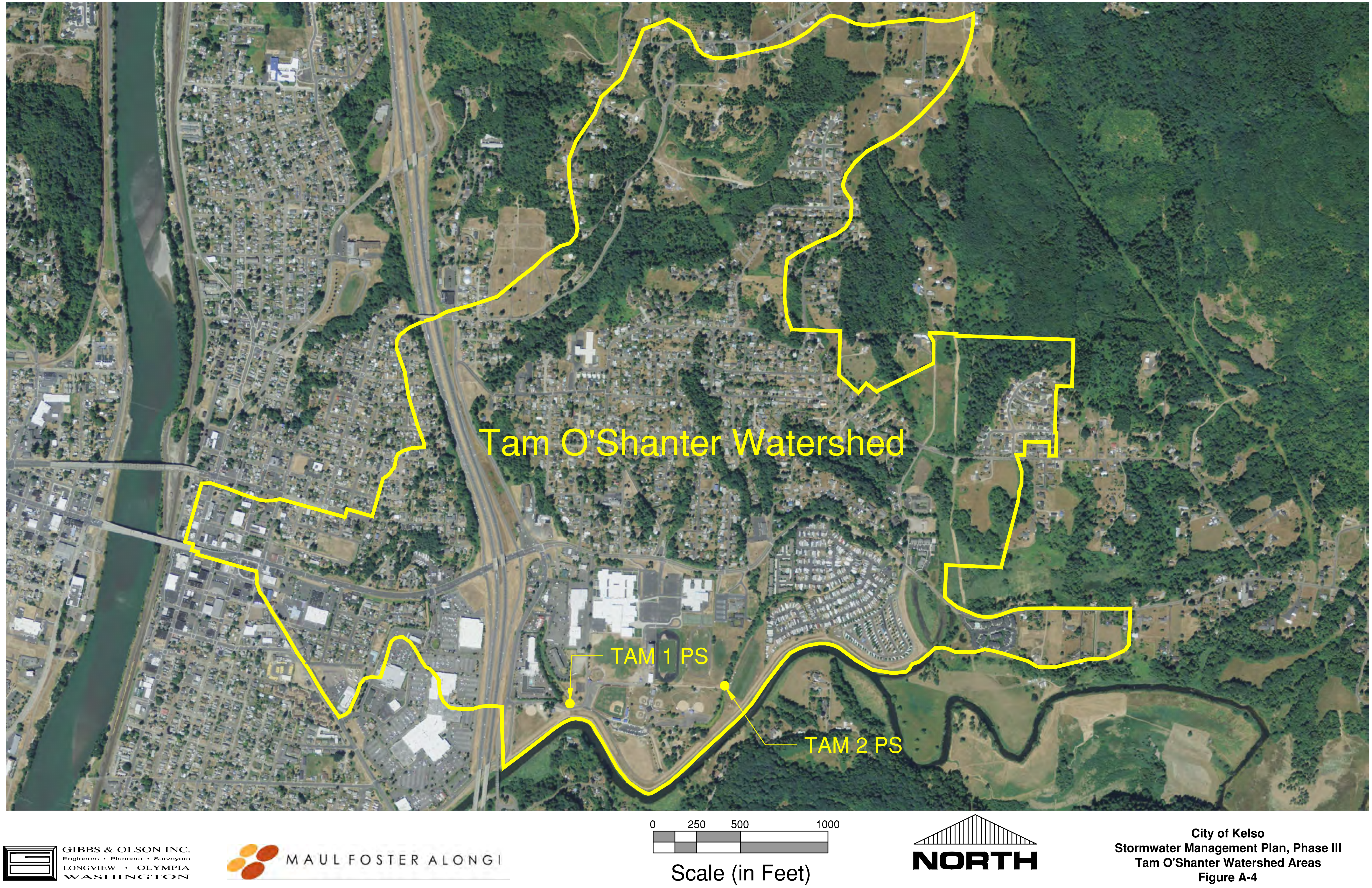
BASIN 34

City of Kelso

Stormwater Management Plan, Phase III

West Kelso Watershed Areas of Concern, 100-Year Storm

Figure A-3c



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City of Kelso
Stormwater Management Plan, Phase III
Tam O'Shanter Watershed Areas
Figure A-4