PHASE II
STORMWATER MASTER PLAN AND CAPITAL IMPROVEMENT PLAN

Prepared for

SUDDEN VALLEY COMMUNITY ASSOCIATION

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ACRONYMS AND ABBREVIATIONS

AF	Auditor's File
Board	Board of Directors
BMP	Best Management Practice
cfs	cubic feet per second
CIP	Capital Improvement Plan
CMP	corrugated metal pipe
CN	Curve Number
DEM	Digital Elevation Model
DOE	Department of Ecology (Washington State)
DU	Dwelling Unit
GIS	geographic information system
HDPE	high density polyethylene pipe
HPA	Hydraulic Project Approval
LiDAR	Light Detection and Ranging (3D mapping)
LWWSD	Lake Whatcom Water and Sewer District
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
RCP	reinforced concrete pipe
SBP	smooth black plastic
SEPA	State Environmental Protection Act
SMMWW	Stormwater Management Manual for Western Washington
SVCA	Sudden Valley Community Association
SWMM	Stormwater Management Model
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WDFW	Washington State Department of Fish and Wildlife
WDOE	Washington State Department of Ecology
WSS	Web Soil Survey
WWU	Western Washington University

GLOSSARY OF TERMS

The following is a short glossary of terms that may be useful in defining some of the engineering terms used in the report.

Antecedent Conditions
Watershed conditions prevailing prior to an event; normally used to characterize basin wetness, e.g., soil moisture. Also referred to as initial conditions or antecedent moisture conditions (AMC).

Backwater
Water backed up or retarded in its course as compared with its normal or natural condition of flow. A rise in stage produced by a temporary obstruction such as ice or weeds, permanent obstruction such as culverts or other manmade obstructions, or by the flooding of the stream below.

Baseflow
The sustained or fair weather flow in a channel due to subsurface runoff. In most streams, baseflow is composed largely of groundwater effluent. Also known as base runoff.

Calibration
Derivation of a set of model parameter values that produces the best fit to observed data.

Channel (watercourse)
An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided. Canal and floodway are terms used to describe artificial channels.

Continuous Simulation Model
A model that tracks the periods between precipitation events, as well as the actual

events. See event-based model.

Conveyance
In hydrologic and hydraulic analysis of stormwater runoff, the carrying or transporting of water from one location to another usually by way of manmade or natural courses such as pipes, ditches, streams, channels, et al.

Correlation
The process of establishing a relation between a variable and one or more related variables. Correlation is either simple if there is only one independent variable or multiple when there are two or more independent variables.

Depression Storage
The volume of water contained in natural depressions in the land surface, such as puddles. This includes pervious and impervious surface ponding, surface wetting, and interception.

Design Storm
Rainfall amount and distribution in time and space used to determine a design flood or design peak discharge.

Discharge
The volume of water that passes through a given cross-section per unit time; commonly measured in cubic feet per second (cfs) or cubic meters per second (m^3/s). Also referred to as flow.

In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean.

Drainage Area
The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide.

Event Based Model
A model that simulates some hydrologic response to a precipitation event. See continuous model.

Flood
An overflow or inundation that comes from a river or other body of water, and causes or threatens damage. Any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. A relatively high flow as measured by either gauge height or discharge quantity.

Hydrograph
A graph showing stage, flow, velocity, or other property of water with respect to time.

Hydrology
The study of water; generally focuses on the distribution of water and interaction with the land surface and underlying soils and rocks.

Hyetograph
A plot of rainfall intensity versus time; often represented by a bar graph.

Impervious
A ground surface characteristic preventing the flow of water through the surface, or not allowing runoff to infiltrate into the soil.

Infiltration
The movement of water from the land surface into the soil.

Interception
The capture of precipitation above the ground surface (e.g., by vegetation or buildings).

Isopluvial
A line on a map connecting places registering the same amount of precipitation or rainfall.

Manning's n Roughness
The Manning formula is an empirical formula estimating the average velocity of a liquid flowing in a conduit that does not completely enclose the liquid, i.e. unfilled pipe or open channel. The n roughness parameter is an empirically derived coefficient that primarily depends on surface roughness, or level of friction through its interface with flowing water. A larger n value is used for a rough surface (e.g. stream bed cobbles), a smaller n value is used for a smooth surface (e.g. plastic pipe).

Model
A physical or mathematical representation of a process that can be used to predict some aspect of the process.

Overland Flow
The shallow flow of water over the land surface before combining with additional flow to become channel flow, or before combining with a larger body of water such as a lake.

Parameter
A variable, in a general model, whose value is adjusted to make the model specific to a given situation. A numerical measure of the properties of the real-world system.

Parameter Estimation
The selection of a parameter value based on the results of analysis and/or engineering judgment. Analysis techniques include calibration, regional analysis, estimating equations, and physically based methods. Refer also to calibration.

Peak Flow
The point of the hydrograph that has the highest flow.

Pervious
A ground surface characteristic which allows water to infiltrate into the soil.

Precipitation
As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water. The term precipitation

is also commonly used to designate the quantity of water that is precipitated. Precipitation includes rainfall, snow, hail, and sleet, and is therefore a more general term than rainfall.

Rainfall
The quantity of water that falls as rain only. Not synonymous with precipitation.

Recurrence Interval (Return Period)
The average interval of time within which the given event (flood or storm) will be equaled or exceeded once. When the recurrence interval is expressed in years, it is the reciprocal of the annual exceedance probability (AEP).

Runoff
Precipitation on the ground that is not captured by evaporation, infiltration, interception, or surface storage.

NRCS Curve Number
An empirically derived relationship between location, soil-type, land use, antecedent moisture conditions, and runoff. A Natural Resources Conservation Service (NRCS) curve number is used in an event-based model to establish the initial soil moisture condition and the infiltration.

Slope
An indication of deviation from the horizontal or vertical. Measures as rise (vertical) divided by run (horizontal), usually expressed in percent. Used to indicate the relative steepness of a pipe or ground.

Storage
1. Water artificially or naturally impounded in surface or underground reservoirs. The term regulation refers to the action of this storage in modifying downstream streamflow.
2. Water naturally detained in a drainage basin, such as ground water, channel storage, and depression storage. The term drainage basin storage or simply basin storage is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin.

Storm

A disturbance of the ordinary average conditions of the atmosphere which, unless specifically qualified, may include any or all meteorological disturbances, such as wind, rain, snow, hail, or thunder.

Stream

A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural channel as distinct from a canal or ditch.

Stream flow

The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word stream flow uniquely describes the discharge in a surface stream course. The term stream flow is more general than runoff, as stream flow may be applied to discharge whether or not it is affected by diversion or regulation.

Surface Runoff

That part of the runoff that travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation.

Time of Concentration

The travel time from the hydraulically furthermost point in a watershed to the outlet. Also defined as the time from the end of rainfall excess to the inflection point on the recession curve.

Watershed

An area characterized by all direct runoff being conveyed to the same outlet. Similar terms include basin, drainage basin, catchment, and catch basin.

A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

1. EXECUTIVE SUMMARY

The foundation for the web of private roads that traverse Sudden Valley is the large network of culverts owned and maintained by the Sudden Valley Community Association (SVCA). SVCA began the process of evaluating the condition of these culverts on a strategic level in 2013 by engaging Wilson Engineering to perform an inspection and inventory of their road crossing culverts. The Stormwater Asset Inspection and Inventory report (Wilson 2013) provided a standardized grade for the condition of each inventoried culvert. It also identified priority replacements that were considered to be in critical condition. Replacement of the high priority culverts began in 2014, and the remaining culverts listed in the 2013 report are currently in the design and permitting phase.

The purpose of this report is to summarize hydrologic and hydraulic analysis and findings, and to develop a Stormwater Asset Capital Improvement Plan (CIP). This report completes the evaluation started in the Stormwater Asset Inspection and Inventory report. In addition to the physical inspection and mapping of the culverts, a hydrologic model was created for Sudden Valley and calibrated based on recorded precipitation and stream flow data. The model was used to evaluate the capacity of the culverts to accommodate a 25-year design storm and to identify potential areas of flooding. The model was also helpful in finding the location of culverts that could not be found in the prior phase and identifying driveway culverts significant to the community drainage network.

The Capital Improvement Plan prioritizes the replacement of culverts based on physical condition and hydraulic capacity. It also accounts for the risk of property damage due to flooding, location in high use areas, culvert repair or replacement cost, and grouping with similar repairs in close proximity. The plan includes 26 culverts, counting 10 that are located on potentially fish bearing streams. This translates into an average annual cost of $500,000 for the next 10 years. For the 2026-2035 CIP, there will be fewer culverts to replace on fish bearing streams, but there will still be four culverts over 60-inches in diameter with a “C” rating that will need to be monitored for replacement.

2. INTRODUCTION

2.1 Purpose and Background

The purpose of this report is to summarize hydrologic and hydraulic analysis and findings, and to develop a Stormwater Asset Capital Improvement Plan (CIP). The CIP includes a list and schedule for stormwater projects to be completed in the next 10 years, with detailed project narratives and cost estimates for the prioritized projects. The costs reflect inflation correlating to the year the projects are scheduled. The CIP is intended to be a tool for future SVCA boards to use when establishing budgets and annual property owner dues.

The CIP builds off of work performed for the Stormwater Asset Inspection and Inventory project (Wilson Engineering, 2013), in which approximately 230 individual culverts were identified and inventoried. Approximately 50 additional culverts were identified as key infrastructure during the course of the hydrologic and hydraulic analysis and subsequently inventoried. Exhibit A '2014 Culvert Condition Inventory' includes the newly inventoried culverts (this map is an update to Exhibit A included in the Asset Inspection and Inventory Report). Likewise, Appendix C 'Culvert Inventory and Hydraulic Analysis' includes the newly inventoried culverts in an update to the 2013 inspection and inventory results.

2.2 Analysis Area

The Sudden Valley hydrologic and hydraulic modeling analysis encompasses the entire watershed area which ends up draining through Sudden Valley. All of the Sudden Valley area ultimately drains to Lake Whatcom. A major tributary to Lake Whatcom which flows through Sudden Valley is Austin Creek, including its major tributary Beaver Creek. There are several other areas that drain to Lake Whatcom via smaller drainages, creeks or direct overland flow. These areas are also included in the analysis.

All Sudden Valley owned culverts crossing main roads that could be located were considered in the analysis. Private driveway culverts are not included in the original inventory; however, some critical driveway culverts were identified in the hydrologic and hydraulic analysis and subsequently inventoried. Exhibit B shows the delineated major drainage basins making up the study area watershed. Exhibit B also shows Sudden Valley culverts considered in the analysis, Whatcom County culverts, roads, streams, soils hydrologic soil group, and zoning.

2.3 Previous Studies/Reports

A report titled Drainage System Master Plan Phase 1 was prepared for the Sudden Valley Community Association circa 1982 by BELLTRAN Engineers. The objectives of the plan included quantification of stormwater runoff within the community, determining adequacy of existing facilities and recommending improvements where necessary, investigations of methods to control existing and future runoff volumes, formulation of

short range and long range drainage system improvement programs, and compilation of suggested development standards for design and review of drainage facilities within the community.

The biggest limitation to the 1982 study was the lack of reliable (if any) rainfall data and Austin Creek stream data. Without these data to establish a correlation between rainfall and runoff, it was necessary to simulate estimated conditions using typical values for parameters required for the analysis. With no data to verify, assumptions generally tend to be more conservative. The current study uses recorded rainfall data and Austin Creek stream flow data to calibrate the model runoff to real observations as discussed in more detail in Section 2.4 Hydrologic Model Calibration.

Other enhancements of the stormwater analysis provided in this report include:

- Availability of survey grade data on all culvert and infrastructure,
- Availability of LiDAR data (sub-foot accuracy) for sub-basin delineation and drainage pattern analysis (compared to lesser detailed 20-foot contour map data),
- Availability of digital GIS data files and ease of use with digital mapping analysis to more thoroughly evaluate study area and varying parameters including soils, vegetative cover, and land use/zoning (to establish development types and patterns).
- Comprehensive GIS mapping technology with ability to publish interactive ArcReader maps that can be utilized by SVCA staff and board members.

3. CAPITAL IMPROVEMENT PLAN

3.1 Prioritization Method

The culvert improvement projects considered for the Capital Improvement Plan (CIP) were identified based on two main factors; adequacy of hydraulic capacity and physical condition. A list of culverts at or near their hydraulic capacity was originally identified from the hydrologic and hydraulic analysis as described above. The culverts were then initially scored and ranked based on three criteria: physical condition, hydraulic capacity (and percent of flow over capacity), and fish passage barrier status. Once initially scored and ranked, approximately 20 culverts with the highest priority scores were re-visited in the field to further assess potential project solutions and limitations or challenges.

Projects identified for the CIP were further prioritized based on:

- field and data assessments of whether the culvert was located in a high use/high risk area,
- culvert repair/replacement cost,
- proximity to similar culvert improvements that could be combined into one construction contract,
- and flooding risk.

Final project prioritization was then performed and organized into the CIP presented in Appendix A.

3.2 CIP Projects

Almost all of the culvert repairs are clustered in the Gate 3-9-13 area between Lake Whatcom Boulevard and Lake Louise Road, with the exception of the Culvert 19.1 Louise Creek Daylighting project and a cluster of culverts at the south end of Lake Louise in Gate 2. Most of the culverts are also in the Beaver Creek drainage basin, with many located on a tributary stream. In the Appendix A map, the 2016-2025 CIP culverts are shown in black.

For the culverts that are on a potentially fish bearing stream, the costs are much higher to accommodate the larger structures necessary to meet the fish passage requirements of WDFW. The CIP list also includes two 84-inch arch culverts on Beaver Creek, culverts 23 and 54, that are showing signs of rust and deterioration and have minimal cover underneath the road. Culvert 54 is in slightly worse condition, with scour at the outlet. It is scheduled for replacement in 2023, whereas the design and permitting for culvert 23 is scheduled for 2025 but the construction would not occur until 2027 in the next 10-year CIP.

Project narratives and planning level cost estimates including permitting, design, and construction costs for the high priority projects included in the plan for the next 10

years are included as Appendix B.

3.3 CIP Budget

The 2016-2025 CIP budget includes all of the culvert repair projects recommended for the next 10 years. The annual budget for the stormwater improvements is the subtotal shown on the bottom of the first page of the spreadsheet in Appendix A. The costs listed in the 2015 column of the CIP spreadsheet are not part of the 10 year plan, but are shown for the purpose of clarifying what has already been budgeted in 2015.

Since construction must occur in the summer months and the design and permitting can often take longer than 6 months, the projects have been split into part "a" for the design and permitting phase costs and part "b" for the construction phase costs. This allows the budget to account for the design and permitting costs in the year prior to construction. For a few of the larger culvert repair projects with longer permitting timelines, the construction costs may trail the design and permitting by a couple of years.

An item has also been added for "unforeseen drainage issues". This is a contingency for addressing localized flooding and drainage issues that are identified by community members and maintenance personnel. The annual cost is based on the amount budgeted for 2015.

The average annual cost for the culvert improvements in the next 10 years is just under $500,000. Keeping with this schedule, SVCA's high priority culvert replacements will be completed by 2025. It is anticipated that the next 10 year cycle will include fewer culverts on streams. However, budget will need to be reserved for replacing the remaining Beaver Creek culverts as they near the end of their functional life.

3.4 Other CIP Considerations

The pavement overlay program is currently on-hold until some of the highest priority culvert repairs are completed. A "Road Improvements" section was added to the CIP budget with an item for a road maintenance plan in 2016 and re-starting the pavement overlay program in 2018. The road maintenance plan would coordinate pavement overlays with culvert repair locations and scheduled utility work. It would also include replacement of "C" condition culverts that are located in overlay segments.

There is one culvert in poor condition that was not included in the CIP due to its location outside of the SVCA road network. Culvert 329 is located just off of Lake Whatcom Boulevard under the access to the Floathaven Sea Plane Base. It conveys flow in a fish bearing stream and is identified as a priority fish barrier replacement in the Level A Fish Passage Culvert Assessment (GeoEngineers 2013). It appears that SVCA is responsible for maintaining this access, which would include replacing the culvert if it fails (AF 921016004).

4. HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic computer model was developed to simulate the Sudden Valley watershed runoff. The model contains only the minimum required conveyance elements to appropriately route simulated runoff to Lake Whatcom (i.e. simple representation of Beaver and Austin Creeks, and culverts and tributary streams for upper watershed drainage basins). The model was used to estimate the quantity of runoff from individual drainage basins, which was then used externally to analyze the capacity of the culverts in the drainage network. The model program used was EPA Stormwater Management Model (SWMM) Version 5.1, which can be used for event based or continuous simulation model with hydrologic and hydraulic capabilities.

The hydrologic analysis (in the model) of the Sudden Valley watershed was performed using the Curve Number infiltration method and single 24-hour design storm events. The hydraulic routing portion of the model was conducted using Dynamic Wave Routing, which can account for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flow. Culvert hydraulic capacity was calculated using Manning's Equation and capacity analysis for each culvert was performed in Microsoft Excel.

This analysis represents the current zoning density in Sudden Valley. Thus, future or ultimate development conditions are included in this analysis.

4.1 Rainfall

Design storm event rainfall quantities used in the computer model simulations were determined using the National Oceanic and Atmospheric Administration (NOAA) isopluvial maps (NOAA Atlas 2: *Precipitation-Frequency Atlas of the Western United States, Volume IX – Washington, 1973*), which is consistent with the City of Bellingham Stormwater Management Handbook and the 2012 Washington Department of Ecology (WDOE) Stormwater Management Manual for Western Washington (SMMWW), Volume III Hydrologic Analysis and Flow Control BMPs. The isopluvial maps were used to estimate the 2-year, 25-year, and 100-yr, 24-hour storm event precipitation quantities. Table 1 is a summary of the 24-hour design storms simulated in the analysis.

Table 1. 24-Hour Design Storms.

Return Period (years)	24-hour Precipitation (inches)
2	2.3
25	3.5
100	4.3

Based on the WDOE SMMWW, a Type IA 24-hour design storm hyetograph resolved to 10-minute intervals was used to simulate the rainfall distribution in the model. Average annual rainfall in Sudden Valley is approximately 38 inches.

4.2 Runoff

Sub-basins

The study area watershed is approximately 6,355 acres in size and was delineated into 21 separate sub-basins, as shown in Exhibit B.

The watershed sub-basins which comprise the Sudden Valley area of interest were determined using an iterative analysis process in ArcGIS. The sub-basin boundaries were delineated from 2013 City of Bellingham LiDAR files obtained from the Puget Sound LiDAR Consortium. The LiDAR data was converted from LAZ files (compressed) to LAS files, then into multipoint features, and finally into a Terrain dataset for visual interpretation and analysis using ArcGIS software and the Esri 3D Analyst extension. After a single Digital Elevation Model (DEM) was mosaicked from a number of DEMs with 3-ft grid spacing, the Esri extension Spatial Analyst was used to calculate the general basins for the region using the Hydrology toolset. Further refinement occurred following Engineering determination of pour points. All existing culvert inventories (both public and private) were combined and used to produce a Hydrologically Conditioned DEM that reduced the effects of "digital dams", such as roadways, which impede drainage enforcement in terrain modeling. Field Engineering verification took place and modifications to the sub-basin boundaries occurred. Python script tools were used to automate updates to watershed attributes such as average slope calculations.

Runoff from sub-basins 9, 11, and 15-21 make up the Beaver and Austin Creek drainages that flow through Sudden Valley and ultimately discharge to Lake Whatcom. Sub-basin 11 contains Lake Louise and Louise Creek. All other delineated sub-basins (1-8, 10, 12-14) drain directly to Lake Whatcom.

Soil Types

Soils data for the Sudden Valley watershed area were downloaded in GIS shapefile format from USDA NRCS Web Soil Survey (WSS). The watershed consists almost entirely of soils with medium to poor drainage characteristics (hydrologic soil groups B and C). Combination soil group classifications (i.e. B/D or C/D) were assigned the classification of the dominant soil type surrounding the combination areas. Table 3 includes the percentage of hydrologic soil groups within each sub-basin (WATER classified areas are not included in the table and make up the remainder of the sub-basin areas).

Curve Numbers

GIS data layers containing the hydrologic soil group and Whatcom County zoning were intersected and used to assign Curve Numbers to each respective portion of the sub-

basins. The Curve Numbers used in the analysis are from *Table 2.3.2 – Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas* in Volume III of the 2012 WDOE SMMWW, which are for 24-hour duration storms and typical antecedent conditions preceding 24-hour storms for western Washington. Rural Forestry zoning type was assumed to be "woods" in "good" condition. Commercial Forestry, Rural 1 Dwelling Unit (DU) per 2 acre, and Rural 1 DU per 5 acre zoning types were assumed to be "woods" in "fair" condition. Neighborhood Commercial and Resort Commercial zoning types were assumed to be "open space" in "fair" condition. All Residential Rural and Urban Residential zoning of varying density were assumed to be "open space" in "good" condition.

The Curve Number Table also provided estimated average percent impervious area for a given density of residential development, which was used to estimate percent impervious areas for the sub-basins by a weighted average method. Neighborhood Commercial, Resort Commercial, and Urban Residential Med 12/AC zoning types were relatively few in number and inherently variable in their actual impervious areas, so they were evaluated on an individual basis. Commercial Forestry logging roads were assumed to be impervious area and the average percent impervious is based on the average of a small sample subset of areas within the Sudden Valley watershed.

Table 2 summarizes the Curve Numbers and average percent impervious used in the analysis for each Zoning type.

Table 2. Curve Numbers and Percent Impervious for Zoning Types.

Zoning Description	Hydrologic Soil Group		Average % Impervious
	B	C	
Rural Forestry	55	70	0
Commercial Forestry	66	77	1
Rural 1 DU / 5 acres	66	77	4
Rural 1 DU / 2 acres	66	77	10
Residential Rural 2 / acre	80	86	25
Urban Res 3 / acre	80	86	34
Urban Res Med 6 / acre	80	86	52
Urban Res Med 12 / acre	80	86	Manual
Neighborhood Commercial	85	90	Manual
Resort Commercial	85	90	Manual

The weighted average of each sub-basin's pervious areas Curve Numbers was used as the single representative Curve Number for that sub-basin. For example, if the pervious area of a particular sub-basin with hydrologic group C soil is 75% rural forested (CN = 70) and 25% Urban Res 3/acre (CN = 86) then the Curve Number will be weighted accordingly to represent the mostly forested condition (weighted CN = [0.75 * 70] + [0.25 * 86] = 74). Table 3 includes the sub-basin percent impervious and the calculated pervious area weighted Curve Numbers.

Other Parameters

- Average slope – calculated using GIS Surface Analyst tools and LiDAR topology data.
- Width –initially approximated as average maximum overland flow lengths (measured in GIS) divided by the square feet of sub-basin area. The parameter is also commonly estimated by taking approximately twice the main drainage path length. This parameter is usually best fit to observed data and is the main parameter used for model calibration. The width parameter effects the time of concentration for runoff of pervious surfaces of a given drainage area.
- Overland Manning's n roughness – typical surface roughness ("friction") values for pervious and impervious areas, *reference: EPA SWMM User's Manual, Version 5.0, Revised July 2010, Appendix A, Table A.6*. Values used as follows:
    - Rural Forestry zoning, n = 0.8
    - Commercial Forestry, Rural 1 DU / 2 ac, and Rural 1 DU / 5 ac zoning, n = 0.4
    - All other zoning, n = 0.24
- Depression storage – typical values for pervious and impervious areas (this is the amount of rain that falls before runoff processes begin and is permanently stored subject to evaporation from the surface), *reference: EPA SWMM User's Manual, Version 5.0, Revised July 2010, Appendix A, Table A.5.* Values used as follows:
    - Rural Forestry zoning, d.s. = 0.3
    - Commercial Forestry, Rural 1 DU / 2 ac, and Rural 1 DU / 5 ac zoning, d.s. = 0.2
    - All other zoning, d.s. = 0.15
- Sub-area routing method, Percent Routed – option of Pervious, Impervious, or Outlet. The Pervious option was used for the model, in which the runoff from a certain portion of impervious areas was assumed to run onto pervious areas before being routed to the sub-basin outlet, therefore, allowing the potential for more infiltration. In general, this was assumed for roof tops and driveways and all impervious areas other than roads. Routing non-road impervious surfaces to pervious surfaces accounts for the infiltration required by Sudden Valley's long standing regulations requiring on site retention systems. Road surface areas, which are routed directly to the sub-basin outlet in the model without additional

infiltration opportunity, were estimated by summing the roads within each sub-basin and assuming a standard road width of 20 feet.

Table 3 summarizes all modeling parameters for each sub-basin, which are final values used after model calibration as discussed in Section 2.4 below.

The SWMM model input file is attached as part of Appendix D.

Table 3. Modeling Parameters for Sudden Valley Sub-Basins.

Sub-basin	Area (acres)	Average Slope (%)	Hydrologic Soil Group (% of basin) B / C	Curve Number	Percent Impervious	Width (ft)	Weighted Overland Manning's n	Weighted Depression Storage (inch)	Percent Routed (%) [Pervious method]
1	187	35.4	66 / 34	75.3	20	13,600	0.44	0.20	80
2	36	35.9	10 / 87	81.0	26	3,300	0.26	0.15	81
3	28	25.2	55 / 45	81.4	32	6,530	0.25	0.15	68
4	85	28.3	96 / 4	75.8	27	10,500	0.29	0.16	73
5	152	24.0	72 / 28	77.6	25	11,700	0.30	0.17	74
6	28	15.7	64 / 35	74.5	18	3,800	0.34	0.18	80
7	30	17.3	75 / 22	74.4	25	2,092	0.29	0.16	76
8	139	14.2	38 / 61	77.0	20	7,600	0.33	0.18	76
9	571	32.4	64 / 36	72.2	16	49,950	0.43	0.19	28
10	81	21.3	26 / 72	78.2	25	5,160	0.31	0.17	83
11	266	31.9	40 / 47	76.1	31	14,175	0.33	0.18	50
12	89	41.5	11 / 86	73.9	7	11,655	0.37	0.19	91
13	69	21.7	37 / 63	72.9	4	5,660	0.40	0.20	100
14	152	51.5	6 / 94	76.7	4	9,240	0.39	0.20	65
15	1055	23.6	72 / 28	65.9	1	73,825	0.53	0.23	67
16	143	22.6	55 / 45	70.9	21	18,116	0.51	0.22	74
17	107	25.9	57 / 43	72.6	23	14,750	0.48	0.21	77
18	124	25.4	25 / 75	84.5	34	15,580	0.24	0.15	78
19	972	39.1	38 / 62	69.9	1	74,690	0.52	0.23	85
20	379	45.4	61 / 39	68.9	1	25,025	0.45	0.21	97
21	1662	52.8	6 / 94	76.5	2	108,000	0.40	0.20	92
Total =	6355				8.2				

4.3 Conveyance

The Sudden Valley conveyance system consists primarily of ditches and culverts. There are areas of catch basins and underground piping networks, however some of those facilities are not considered in this analysis because they are only conveying localized drainage in community areas. It is assumed that future upgrades to community areas would include utilities such as enclosed stormwater systems. The hydraulic analysis for this study consists of evaluating the capacity of Sudden Valley's culverts, the majority of which were previously identified and data collected during the Stormwater Asset Inspection and Inventory project (Wilson Engineering, 2013). During the analysis for this project and further noted observations from SVCA staff, several other culverts have been identified, data collected, and included in the stormwater inventory.

There are many culverts that exist within Sudden Valley that have not been inventoried or included as part of this study. As noted previously in the inspection and inventory study, the focus is primarily on culverts that cross Sudden Valley roadways. The unidentified additional culverts consist primarily of smaller private driveway ditch culverts that are considered minor drainages for localized areas. Most of the driveway culverts that have been included convey significant drainages or quantities of stormwater. In addition, not all potentially significant culverts could be found for the inventory because they were either completely buried or inaccessible.

Conveyance Modeling

The hydrologic model contains simplified conveyance infrastructure only as required for routing runoff from sub-basins to the lake. The main arterial of Beaver/Austin Creeks are represented in the model, which roughly follows Lake Louise Road from Western Lane near River Ridge Loop to Lake Whatcom Boulevard and then through the golf course to the lake where it discharged just east of the Marina area (approximately 16,500 feet). The creek data used in the model was based on LiDAR elevation data. The culverts along this section of Beaver/Austin Creeks (Culverts 54, 4, 22, 207) were modeled based on the Inventory data. Culverts that are outlets for other sub-basins that drain to the Beaver/Austin Creeks arterial were also modeled based on Inventory data (Culverts 24, 210, 40, 217, 19). The modeled culverts were used to check/verify calculated conveyance capacities, as described below.

Sub-basins that drain directly to the lake with their own discharge point to the lake were modeled without any simulated conveyance.

Model conveyance system information can be viewed in the SWMM model input file attached as part of Appendix D.

Conveyance Capacity Calculations

Hydraulic capacity of all culverts was calculated (not included in the model) using Manning's Equation based on the Inventory data including pipe diameter, material, inlet

and outlet elevations, and length. Manning's n roughness coefficients were assumed as follows:

- Corrugated Metal Pipe (CMP), n = 0.024
- Smooth Black Plastic (SBP), n = 0.013
- Polyvinyl Chloride (PVC), n = 0.013
- Concrete, n = 0.015

Calculated maximum flow (95% full barrel) for each culvert was compared to its respective portion of the 25-yr, 24-hr design storm runoff as computed by the hydrological model for each main sub-basin. Each individual culvert's drainage area was estimated by manually delineating culvert drainage basins within GIS. The respective drainage areas were then used to proportion the runoff from the larger sub-basin in which it is contained. For example, if culvert A has a drainage area of 1 acre (and no upstream culverts) in a 10 acre sub-basin that has a peak runoff flow of 100 cfs, then the culvert is approximated to have a peak flow of 10 cfs that it must convey. The culvert drainage area analysis also considered any upstream culverts. This allowed each culvert's contributing flow to include immediate area runoff drainage as well as upstream culverts directly contributing flow. For example, if culvert A drainage area has a 10 cfs peak flow and an upstream culvert B that has a drainage area producing 10 cfs peak flow, then culvert A must convey a peak flow of 20 cfs.

4.4 Hydrologic Model Calibration

The hydrologic model was calibrated using select storm events from available Austin Creek flow data and area rainfall data. Austin Creek flow data is available online from Western Washington University (WWU) Institute for Watershed Studies (http://www.wwu.edu/iws/) for years 1998 – 2013. The Austin Creek flow monitoring location is located at the Lake Whatcom Boulevard bridge approximately 1 mile from the mouth of the creek. The flow data were perused for large (600-1400 cfs) and medium (300-600 cfs) sized peak flows. Some rainfall data is available from Lake Whatcom Water and Sewer District's (LWWSD) Division 30 water tank located near southern Sudden Valley, within the watershed, near Loganberry Lane and Repeater Road. Of the approximately 10 identified storm events targeted for calibration of the model, four (4) dates had available corresponding rainfall data. The four (4) calibration storm event peak flows (Q) and corresponding maximum 24-hr rain quantities are as follows (dates correspond to timing of peak flow):

- December 14, 2001; Q = 616 cfs, rain = 3.32 in
- January 25, 2002; Q = 443 cfs, rain = 2.79 in
- February 22, 2002; Q = 312 cfs, rain = 2.53 in
- November 19, 2003; Q = 707 cfs, rain = 3.41 in

Model simulation runoff results were compared to the above observed storm events. Model peak flows representative of the observed peak flow location were estimated

first by reducing the model node "AustinCreekOutlet" (outlet at Lake Whatcom) total inflow by the flow from the Lake Louise sub-basin 11 discharge contributions to Austin Creek (limited by the dam discharge and Lake attenuation). The observed flow data location used for comparison is at Lake Whatcom Boulevard creek crossing, which is above Lake Louise dam outlet discharge location to the creek. The estimated model peak flow at Lake Whatcom Boulevard was then increased by the approximate average winter time flow (approximate base flow) since the model simulates only storm event related runoff. The average winter time base flow was estimated to be 35 cfs for calibration purposes, which is based on available USGS monthly mean data records for the months of November – February (http://waterdata.usgs.gov/nwis). Comparing this base flow to the WWU flow data indicates a reasonable estimation.

Initially, model simulations indicated approximately 10% less runoff for the four storm events than observed. Thus, the "width" parameter for the larger, upper sub-basins (15, 19, 20, and 21) for the Beaver/Austin Creek watershed was increased. This adjustment corresponds to a shorter overland flow path and thus a quicker runoff response time and increased peak runoff. The smaller urban/residential areas of the watershed were not adjusted because the width parameter is more easily determined for developed areas and the confidence in the initial estimation is greater. Also, no adjustments were made to the sub-basins that are outside of the Beaver/Austin Creek watershed that drain directly to Lake Whatcom. These sub-basins are typically smaller and/or mostly developed, which leads to better initial parameter estimation. Additionally, there is no known observed data in these drainages for comparison. The final model comparison with observed peak flows at the Austin Creek flow site was within an average of approximately 0.6% for the four simulated events.

5. ANALYSIS RESULTS

5.1 Basin Runoff

Table 4 is a summary of the model simulation peak runoff (cubic feet per second) from each of the 21 sub-basins for the three simulated 24-hr design storms; 2-yr, 25-yr, and 100-yr. Note that summing the peak runoff of all sub-basins does not represent the peak runoff into Lake Whatcom due to differences in timing of peaks for each sub-basin.

Table 4. Model Sub-Basin Peak Runoff for 24-hr Design Storms.

Sub-basin	2-yr Peak Runoff (cfs)	25-yr Peak Runoff (cfs)	100-yr Peak Runoff (cfs)
1	25.8	65.3	92.4
2	9.9	18.6	25.5
3	9.8	18.1	24.1
4	21.4	40.9	56.2
5	31.8	64.3	88.5
6	4.7	10.7	14.9
7	4.8	10.6	14.8
8	17.0	43.42	62.5
9	57.5	186.0	278.4
10	15.9	33.0	45.5
11	59.4	118.9	162.0
12	8.6	29.8	44.2
13	3.8	14.1	23.7
14	9.8	39.2	62.5
15	35.4	92.9	175.0
16	16.7	47.3	67.2
17	17.9	40.9	56.5
18	42.7	78.2	104.5
19	42.7	128.7	251.9
20	16.2	49.3	97.0
21	104.7	425.0	681.1

The SWMM model output files for each storm are included as part of Appendix D.

5.2 Conveyance Capacity

The complete list of inventoried culverts including their diameter, material, calculated hydraulic capacity, and required hydraulic capacity is shown in Appendix C. Other relevant data entries from the Asset Inspection and Inventory (Wilson Engineering,

2013) are also shown. Many of the inventoried culverts did not have complete data required for capacity calculations. The list of culverts in Appendix C also identifies culverts that were recognized as having inadequate or near inadequate hydraulic capacity. Culverts were identified if the flow received for the 25-year design storm (q, required runoff conveyance) divided by the calculated flow capacity (Q) ratio was greater than 0.85 ($q/Q > 0.85$). The 25-year design storm is the recommended design storm for conveyance system capacity design (City of Bellingham Stormwater Management Handbook, Section 2.4.2, Table 2.2 Design Storm Criteria). As noted previously, culverts 40 and 210 were simulated in the model and their calculated limited capacity was confirmed by the model. The capacity of stormwater to enter culverts (inlet control) was also reviewed based on the size of the culvert inlet and 25-year design storm.

It is important to note that capacity calculations do not consider any hydraulic limitations introduced by the 'percent full' parameter. If a culvert is half full of sediment, its' capacity will understandably be reduced. The 'percent full' parameter is shown in the table for reference and general maintenance considerations.

5.3 Backwater Analysis

Approximately 70 culverts were identified as having inadequate hydraulic capacity for the 25-year design storm. Culverts with a 25-year design storm of over 5 cfs were further examined for potential backwater that could cause damage to private property and roads. Approximately 40 of the culverts that were considered for inclusion in the Capital Improvement Plan (CIP) list were given a preliminary check to evaluate upstream depth, road crossing depth, and proximity to homes. The risk for damage was the primary factor used to prioritize the final CIP list of culverts.

A more in-depth backwater analysis was performed for culverts 19.1, 40.1, 210, and 212 and 213. Culverts 19.1, 40.1, and 210 are the outlet culverts for sub-basins 11, 18, and 17, respectively, and were included in the hydrologic model. Culverts 212 and 213 were considered together because of their close proximity and shared flow (212 drains to 213) and both are noted as being under capacity. Maximum backwater elevations were taken from model results for the 25-year design storm and evaluated in GIS using LiDAR generated contours to establish an effected area. A summary of the analyses is as follows:

- Culvert 19.1 backwater poses low risk because of the channel depth and location. The culvert is in the pre-design stages of being day-lighted to Austin Creek.
- Culvert 40.1 backwater poses low risk because of the channel depth. Backwater would continue down the ditch to the west for approximately 100 feet before

flowing into culvert 40.2, which discharges under Honeycomb Lane and back into the main stream at the outlet of 40.1, thus 40.2 acts as a relief outlet for 40.1.

- Culvert 210 backwater poses high risk to one home and Ravenwood Court roadway. Analysis indicates the culvert is significantly undersized (approx. 122%) and the upstream topography is flat enough for significant flooding effects.
- Culverts 212 and 213 backwater pose high risk to overtopping the adjacent Polo Park Drive roadway. Culvert 213 backwater is expected to be close to, but not overtopping the roadway if the culvert barrel was at full capacity. With the existing conditions of the culvert being 33% full of sediment, it would likely overtop and end up in the same ditch/swale that 213 discharges to and should not be a threat to the adjacent down gradient home. However, culvert 212 overflow could present a threat to the down gradient home depending on the extent of flooding and the exact drainage pattern between the road and the property.

6. REFERENCES

Wilson Engineering, 2013. Stormwater Asset Inspection and Inventory, prepared for Sudden Valley Community Association, October 2013.

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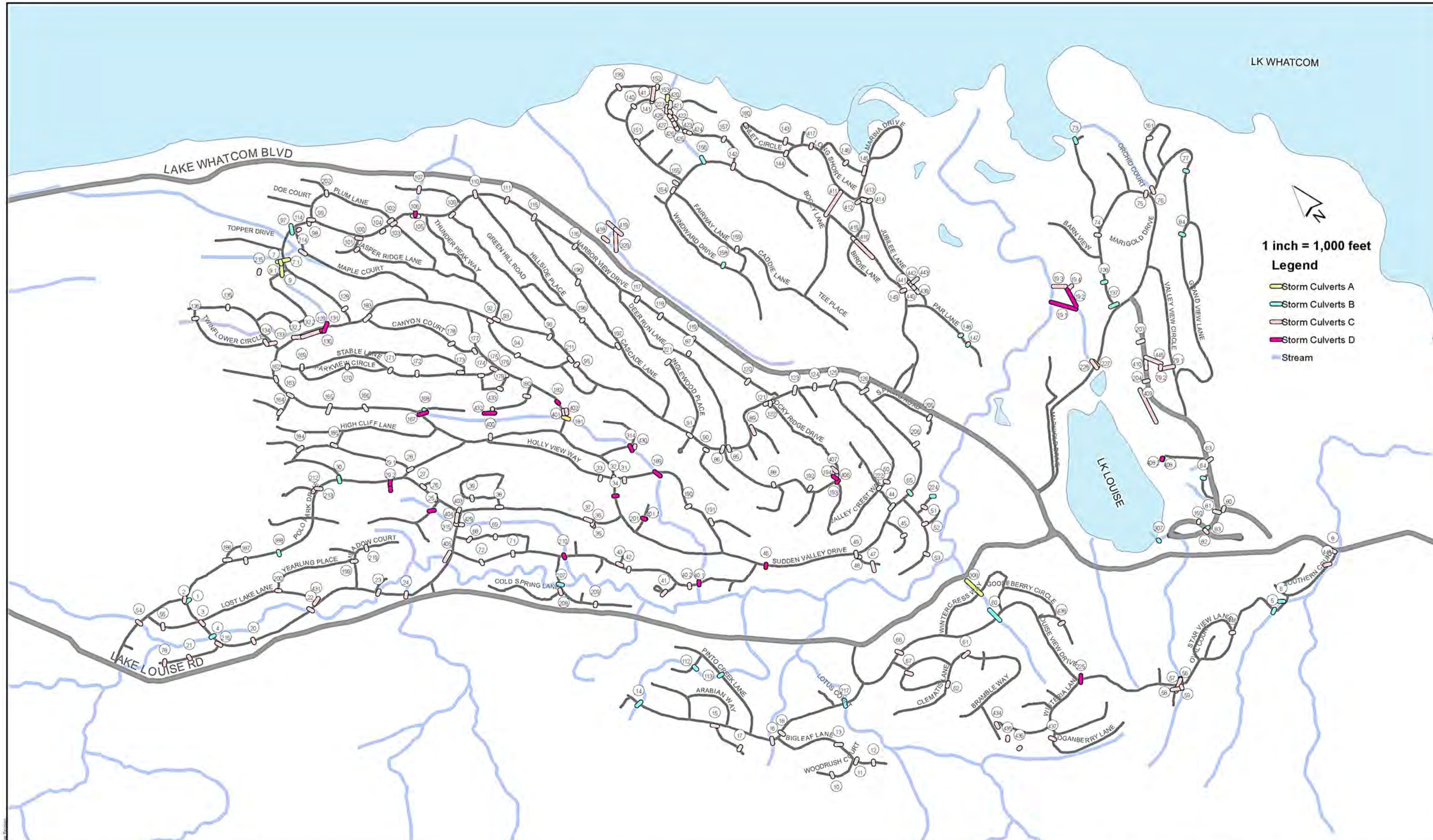

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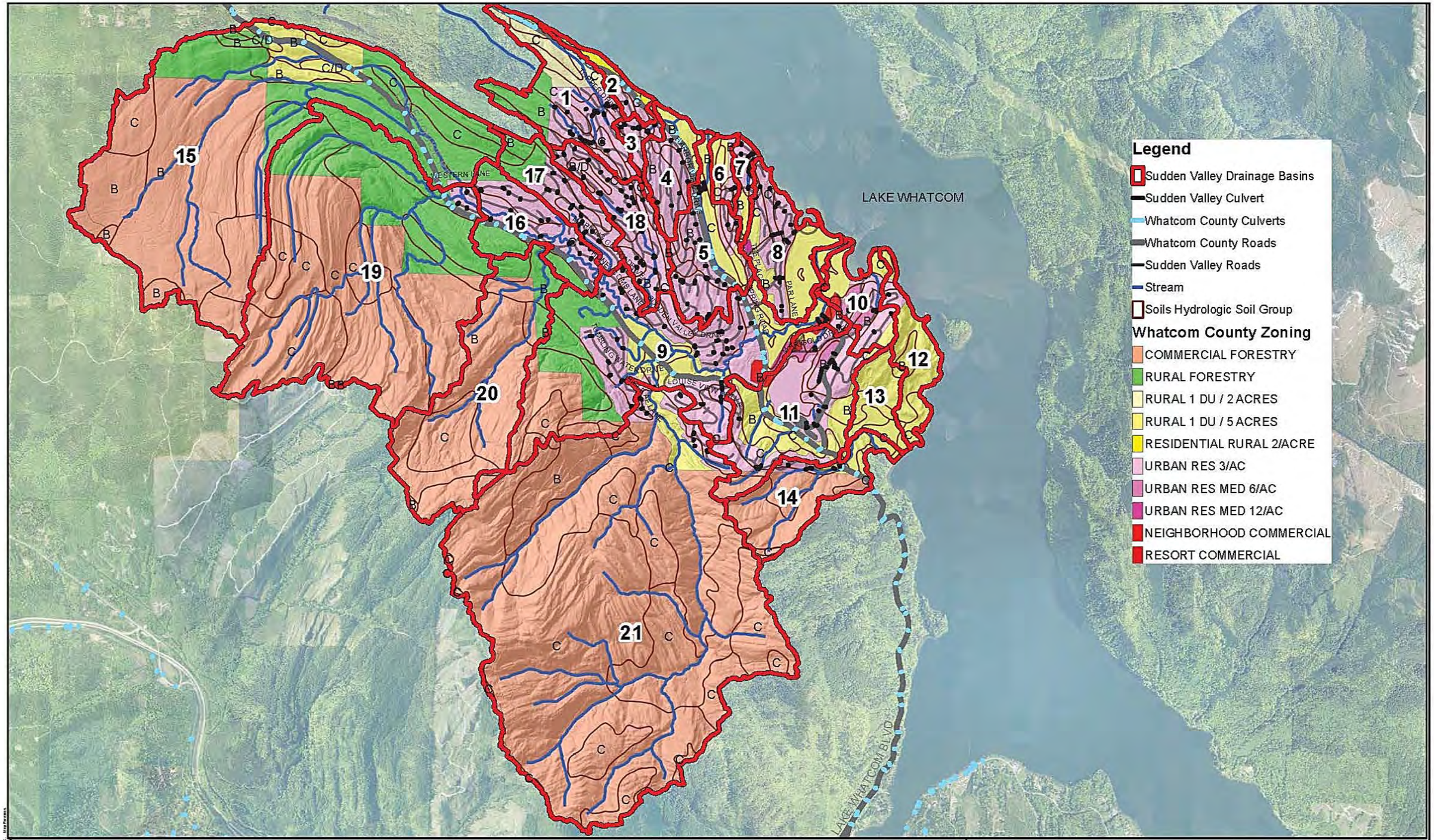
Projection:
State Plane Washington North
North American Datum 1983

Date: 12/15/2014

EXHIBIT A - 2014 Culvert Condition Inventory

Sudden Valley Community Association
Stormwater Asset Inspection & Inventory



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Projection:
State Plane Washington North
North American Datum 1983

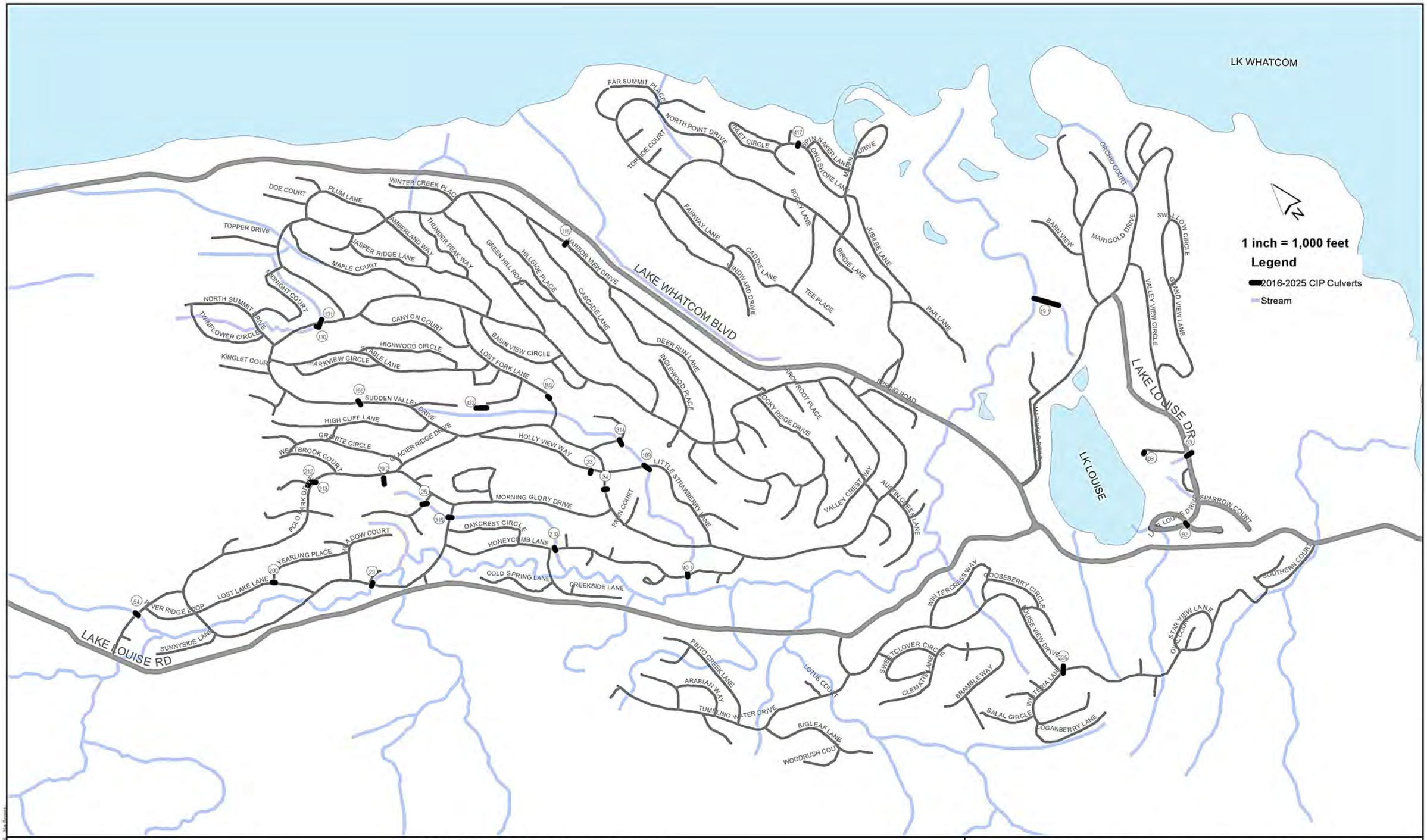
N

1 inch = 2,500 feet

Date: 12/4/2014

EXHIBIT B - Drainage Basins

Sudden Valley Community Association



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Date: 12/15/2014

APPENDIX A - 2016-2025 CIP Culverts

Sudden Valley Community Association
Stormwater Asset Inspection & Inventory

Sudden Valley Community Association
2016-2025 Culvert Capital Improvement Plan

Cost Est	Cost Est Year	Condition Rating	CIP Num	Project Name	Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	3.00%		**Stormwater Improvements**			See note 1										
$70,000	2015		-	Fast Response for Unforeseen Drainage Issues (see note 2)	$ 896,546	$ 70,000	$ 72,100	$ 74,263	$ 76,491	$ 78,786	$ 81,149	$ 83,584	$ 86,091	$ 88,674	$ 91,334	$ 94,074
$260,000	2015	D	-	CONSTRUCTION: 2015 Culvert Repairs: 46, 106, 107, 167, 193, 194, 201	$ 260,000	$ 260,000										
$60,000	2015	D	C-19a	DESIGN PHASE 2: Culvert 19.1 Daylighting and Stream Restoration	$ 60,000	$ 60,000										
$347,500	2014		C-19b	CONSTRUCTION: Culvert 19.1 Daylighting and Stream Restoration	$ 379,723			$ 379,723								
$50,000	2015	D	C-40a	DESIGN: Culvert 40.1, Remove and Replace	$ 50,000	$ 50,000										
$102,800	2014		C-40b	CONSTRUCTION: Culvert 40.1, Remove and Replace	$ 109,061		$ 109,061									
$75,000	2015	D+	C-314a	DESIGN: Culvert 314, Remove and Replace	$ 75,000	$ 75,000	.									
$185,900	2014		C-314b	CONSTRUCTION: Culvert 314, Remove and Replace	$ 197,221		$ 197,221									
$20,000	2015	D+	C-34a	DESIGN: Culvert 34, Remove and Replace	$ 20,000	$ 20,000										
$25,600	2014		C-34b	CONSTRUCTION: Culvert 34, Remove and Replace	$ 27,159		$ 27,159									
$30,000	2015	D+	C-210a	DESIGN: Culvert 210, Remove and Replace	$ 30,000	$ 30,000										
$55,800	2014		C-210b	CONSTRUCTION: Culvert 210, Remove and Replace	$ 59,198		$ 59,198									
$17,500	2014	D+	C-225a	DESIGN: Culvert 225, Slipline	$ 19,123			$ 19,123								
$37,500	2014		C-225a	CONSTRUCTION: Culvert 225, Slipline	$ 42,207				$ 42,207							
$38,900	2014	D+	C-130/131a	DESIGN: Culvert 130 Remove and Replace, Culvert 131 Slipline	$ 42,507			$ 42,507								
$101,800	2014		C-130/131b	CONSTRUCTION: Culvert 130 Remove and Replace, Culvert 131 Slipline	$ 114,577				$ 114,577							
$22,100	2014	C-	C-29a	DESIGN: Culvert 29.1 and 29.2, Remove and Replace (potential slipline)	$ 24,149			$ 24,149								
$51,200	2014		C-29b	CONSTRUCTION: Culvert 29.1 & 29.2, Remove & Replace(potential slipline)	$ 57,626				$ 57,626							
$13,400	2014	C-	C-166a	DESIGN: Culvert 166, Remove and Replace	$ 14,643			$ 14,643								
$30,100	2014		C-166b	CONSTRUCTION: Culvert 166, Remove and Replace	$ 33,878				$ 33,878							
$50,900	2014	D+	C-25a	DESIGN: Culvert 25, Remove and Replace	$ 57,288				$ 57,288							
$137,900	2014		C-25b	CONSTRUCTION: Culvert 25, Remove and Replace	$ 159,864					$ 159,864						
$52,700	2014	C-	C-315a	DESIGN: Culvert 315, Remove and Replace	$ 59,314				$ 59,314							
$143,200	2014		C-315b	CONSTRUCTION: Culvert 315, Remove and Replace	$ 170,988						$ 170,988					
$9,400	2014	C	C-200a	DESIGN: Culvert 200, Remove and Replace	$ 10,580				$ 10,580							
$19,100	2014		C-200b	CONSTRUCTION: Culvert 200, Remove and Replace	$ 22,142					$ 22,142						
$24,400	2014	C	C-212/213a	DESIGN: Culvert 200, Remove and Replace	$ 27,462				$ 27,462							
$58,200	2014		C-212/213b	CONSTRUCTION: Culvert 200, Remove and Replace	$ 67,470					$ 67,470						
$6,800	2014	D+	C-182a	DESIGN: Culvert 182, Remove and Replace	$ 8,120						$ 8,120					
$11,800	2014		C-182b	CONSTRUCTION: Culvert 182, Remove and Replace	$ 14,513							$ 14,513				
$25,500	2014	D+	C-432a	DESIGN: Culvert 432, Remove and Replace	$ 30,448						$ 30,448					
$61,500	2014		C-432b	CONSTRUCTION: Culvert 432, Remove and Replace	$ 75,637							$ 75,637				
$83,000	2014	D+	C-189a	DESIGN: Culvert 189, Remove and Replace	$ 99,106						$ 99,106					
$233,800	2014		C-189b	CONSTRUCTION: Culvert 189, Remove and Replace	$ 296,171								$ 296,171			
$9,700	2014	C	C-33a	DESIGN: Culvert 33, Remove and Replace	$ 11,930							$ 11,930				
$19,800	2014		C-33b	CONSTRUCTION: Culvert 33, Remove and Replace	$ 25,082								$ 25,082			
$221,700	2014	C-	C-54a	DESIGN: Culvert 54, Remove and Replace w/ Bridge	$ 272,663							$ 272,663				
$635,000	2014		C-54b	CONSTRUCTION: Culvert 54, Remove and Replace w/ Bridge	$ 828,531									$ 828,531		
$15,700	2014	C-	C-417a	DESIGN: Culvert 417, Remove and Replace	$ 20,485									$ 20,485		
$32,100	2014		C-417b	CONSTRUCTION: Culvert 417, Remove and Replace	$ 43,140										$ 43,140	
$10,800	2014	C-	C-116a	DESIGN: Culvert 116, Remove and Replace	$ 14,092									$ 14,092		
$22,800	2014		C-116b	CONSTRUCTION: Culvert 116, Remove and Replace	$ 30,641										$ 30,641	
$27,300	2014	D	C-408a	DESIGN: Culvert 408.1 & 408.2, Remove and Replace w/ Single	$ 35,620									$ 35,620		
$66,700	2014		C-408b	CONSTRUCTION: Culvert 408.1 & 408.2, Remove and Replace w/ Single	$ 89,639										$ 89,639	
$10,200	2014	C	C-82a	DESIGN: Culvert 82, Remove and Replace	$ 13,309									$ 13,309		
$21,100	2014		C-82b	CONSTRUCTION: Culvert 82, Remove and Replace	$ 28,357										$ 28,357	
$26,400	2014	C-	C-63a	DESIGN: Culvert 63, Remove and Replace	$ 34,446									$ 34,446		
$64,100	2014		C-63b	CONSTRUCTION: Culvert 63, Remove and Replace	$ 86,145										$ 86,145	
$221,700	2014	C-	C-23a	DESIGN: Culvert 23, Remove and Replace w/ Bridge	$ 306,885											$ 306,885
$635,000	2014		C-23b	CONSTRUCTION: Culvert 23, Remove and Replace w/ Bridge	$ -											
				SUBTOTAL	$ 5,452,684	$ 565,000	$ 464,739	$ 554,407	$ 479,423	$ 328,261	$ 389,812	$ 458,326	$ 407,344	$ 1,035,156	$ 369,256	$ 400,959

Sudden Valley Community Association
2016-2025 Culvert Capital Improvement Plan

Cost Est	Cost Est Year	Condition Rating	CIP Num	Project Name	Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
		Misc & Maintenance														
$20,000	2015			On-Call Engineering Services for CIP	$ 83,673	$ 20,000	$ 20,600	$ 21,218	$ 21,855	$ 22,510	$ 23,185	$ 23,881	$ 24,597	$ 25,335	$ 26,095	$ 26,878
$100,000	2015			Stormwater Runoff Management & Phosphorus Mitigation Plan (for County HOA Exemption to Lake Whatcom Stormwater requirements)	$ 100,000	$ 100,000										
$5,000	2015			Large Culvert or Bridge Inspection (alternating years)	$ 20,918	$ 5,000	$ 5,150	$ 5,305	$ 5,464	$ 5,628	$ 5,796	$ 5,970	$ 6,149	$ 6,334	$ 6,524	$ 6,720
$50,000	2014			Capital Improvement Plan (CIP) 2026 -2035	$ -										$ 67,196	
				SUBTOTAL	$ 204,591	$ 125,000	$ 25,750	$ 26,523	$ 27,318	$ 28,138	$ 28,982	$ 29,851	$ 30,747	$ 31,669	$ 32,619	$ 33,598
		Road Improvements														
$70,000	2014			Road Maintenance Plan (coordinated with Stormwater CIP)	$ 74,263		$ 74,263									
$100,000	2014			Pavement Overlays (see note 3)	$ 112,551	$ -	$ -	$ -	$ 112,551	$ 115,927	$ 119,405	$ 122,987	$ 126,677	$ 130,477	$ 134,392	$ 138,423
				SUBTOTAL	$ 186,814	$ -	$ 74,263	$ -	$ 112,551	$ 115,927	$ 119,405	$ 122,987	$ 126,677	$ 130,477	$ 134,392	$ 138,423
				GRAND TOTAL	$ 5,844,089	$ 690,000	$ 564,752	$ 580,930	$ 619,292	$ 472,327	$ 538,199	$ 611,165	$ 564,768	$ 1,197,303	$ 603,463	$ 572,980
		Completed														
			CIP Num													

Notes
1) Costs listed in the 2015 column are already included in the 2015 budget and are shown for clarity. They are not included in the 10-year CIP.
2) The "unforeseen drainage issues" cost is a contingency for addressing immediate needs and concerns as requested by community members and maintenance personnel.
3) Culverts classifed as "C" condition are assumed to be replaced congruent with the pavement overlays and should be included with the overlay costs.

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 19.1 Daylighting and Stream Restoration		
CIP #:	C-19.1	**Replacement Year:**	2017
Map Grid:	G11	**Drainage Basin:**	11
Pipe Diameter:	30-inch	**Pipe Length:**	300-feet
25 year flow:	17.6 cfs	**Fish Passage Req'd:**	Yes
Related Culverts with Potential for Concurrent Repair:			19.3, 19.4

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 19.1 crosses underneath the field and near the tennis courts north of Marigold Drive and the Lake Louise dam, and underneath the gravel trail from the end of Club House Circle to the Barn adjacent the golf course. Culvert 19.1 is in the Louise Creek drainage. It is a 30" CMP that is in poor condition (rated D) exhibiting extensive rust and perforations through much of the pipe length. The culvert is very flat and has been identified as having approximately half of the hydraulic capacity required for the 25-year, 24-hour design storm event. A backwater analysis was performed to determine the extent of flooding and how far Louise Creek would back up. This analysis found that Louise Creek would pond to an elevation of 329 ft at the inlet of culvert 19.1 (upstream channel elevation near outlet of Lake Louis dam elevation of 330 ft)

The culvert discharges to Austin Creek, which is a fish bearing stream. It is considered a barrier to fish passage for multiple reasons including its length of approximately 300 feet. For this reason, it cannot simply be slip-lined or even replaced. The project will remove the culvert and daylight the channel for the entire length, which would extend the open channel for Louise Creek from Lake Louise Dam to Austin Creek. A bridge will be required at the existing gravel path near Austin Creek. The bridge will be used primarily by pedestrians and for maintenance access. However, since this is the only other access point within Sudden Valley to Gate 2, the bridge will need to be designed for emergency vehicle loading. The creek alignment will also need to be designed to accommodate the field uses, including soccer and t-ball.

An adjacent 24-inch culvert that crosses directly under the tennis courts, culvert 19.2, was filled with concrete and abandoned in September of 2014. This culvert ended at a manhole on the north side of the tennis courts. Culvert 19.4 also connects to the same manhole after it collects water from the slope to the east. Culvert 19.3 takes the water from the manhole and discharges to Austin Creek. Due to the poor condition of Culvert 19.3, it will be removed from service and a new culvert will be installed to transport the slope runoff from culvert 19.4 to Austin Creek. Removing culvert 19.3 as part of this project will reduce the cost and time for permitting.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- SEPA Exemption (Whatcom County),
- Commercial Building Permit (Whatcom County),

- Shoreline Exemption (Whatcom County)

BUDGET ESTIMATE

	2014-2015	2017
Permitting:	$ 33,100	
Survey/Engineering Design Services:	$ 87,800	
Construction Engineering Services:		$ 16,600
Construction Costs:		$330,900
Total:	**$120,900**	**$347,500**
	(Cost estimate in 2014 dollars)	

PROJECT TIMELINE

Design and Permitting:	18 months
Construction:	3 months (summer only, within fish window)

Aerial photo showing culvert path through adjacent field.

Culvert inlet extensive rust through.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 19.1 - Daylighting, Louise Creek Restoration

Item	Description	Unit		Unit Price	Quantity		Total- General Const.	assumptions
	Mobilization	LS	$	23,098.70	1	$	23,099	$ 230,986.97
	Temporary Erosion Control (including access stabilization)	LS	$	5,000.00	1	$	5,000	
	Excavation incl haul	CY	$	20.00	3,618	$	72,360	assume 25 foot wide channel with 2:1 side slopes, 2-ft extra depth for new stream bed materials, plus 10% extra for meandering
	Trench Safety and Shoring	LF	$	15.00	0	$	-	
	Remove and Dispose of Existing Pipe	LS	$	10,000.00	1	$	10,000	
	Dewatering and Bypass piping	LS	$	10,000.00	1	$	10,000	
	Fish Rescue/Exclusion	LS	$	10,000.00	1	$	10,000	
	Channel bottom river cobbles	CY	$	90.00	306	$	27,500	assume half cobbles/half spawning gravel, plus 10% extra for meander
	Channel bottom spawning gravel	TON	$	45.00	306	$	13,750	assume half cobbles/half spawning gravel, plus 10% extra for meander
	Topsoil Type A	CY	$	32.00	330	$	10,560	assume 1-ft thick
	Channel side slope stabilization and restoration (grass and blanket)	SY	$	4.00	990	$	3,960	$2/SY for seeding, fertilizing, mulching (hydroseeding) + $2/SY for bionet
	Chanel side slope plants (shrubs, trees, etc.)	EA	$	30.00	248	$	7,425	assume 1 planting every 36 SF (6'x6' grid)
	Mulch for plantings	CY	$	30.00	14	$	432	assume 6-inch thick 2-ft diam circle around every planting
	Channel inlet/outlet armoring and shaping	LS	$	5,000.00	1	$	5,000	
	Bridge	LS	$	50,000.00	1	$	50,000	W.A.G.
	Pedestrian Control	LS	$	5,000.00	1	$	5,000	

ESTIMATED CONSTRUCTION COSTS	**$**	**254,086**
CONTINGENCIES (20%)	**$**	**50,817**
SALES TAX (8.5%)	**$**	**25,917**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**330,900**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**33,100**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**82,800**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**16,600**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**120,900**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**347,500**
GRAND TOTAL	**$**	**468,400**

INPUTS		
Road width =		ft
ex culvert diameter =	2.5	ft
Trench width =		ft
Cover =		ft
Culvert length =	300	ft
pipe zone ht =		ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 23 Remove and Replace w/ Bridge		
CIP #:	C-23	**Replacement Year:**	2025 (begin design)
Map Grid:	E3	**Drainage Basin:**	16
Pipe Diameter:	Rise: 6.9', Span: 9.8'	**Pipe Length:**	41-feet
25 year flow:	247 cfs	**Fish Passage Req'd:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 23 conveys Beaver Creek, which is a fish bearing stream, underneath Polo Park Dr. It is an arch CMP with a rise of 6.9 ft and span of 9.8 ft with an equivalent diameter of 84-inches. Culvert 23 is in average to poor condition (rated C-) exhibiting notable rust for the pipe length. The culvert has minimal cover, with less than 2 feet between the top of the pipe and the finished grade of the asphalt.

It is assumed that the culvert will be replaced with a bridge similar to the Beaver Creek/Polo Park Drive bridge constructed in 2013 downstream near Honeycomb Lane. However, the culvert could potentially be relined, dependent on negotiations with WDFW.

ANTICIPATED PERMITS

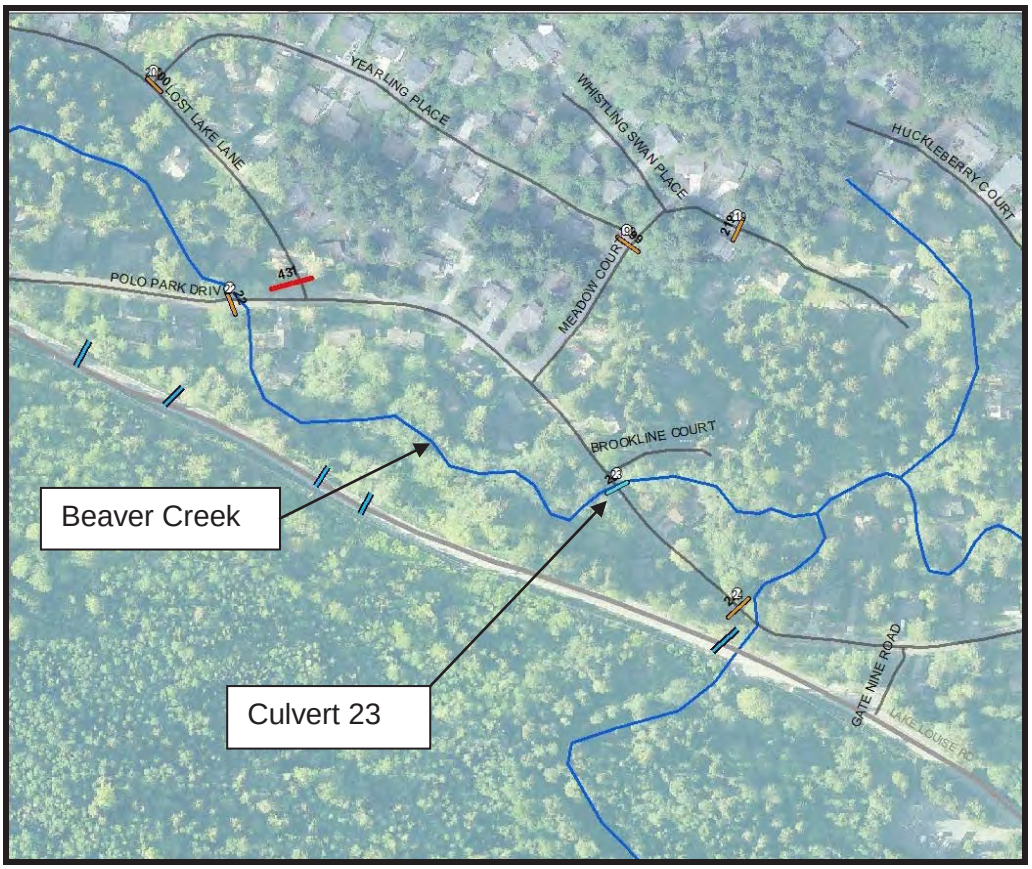
- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- SEPA Exemption (Whatcom County),
- Commercial Building Permit (Whatcom County),

BUDGET ESTIMATE

	2025	**2026**
Permitting:	$ 60,500	
Survey/Engineering Design Services:	$161,200	
Construction Engineering Services:		$ 30,300
Construction Costs:		$604,700
Total:	**$221,700**	**$635,000**
	(Cost estimate in 2014 dollars)	

PROJECT TIMELINE

Design and Permitting:	18 months
Construction:	3 months (summer only, within fish window)



Location map.

Culvert outlet – rust in bottom third of pipe

SVCA Culvert Replacements 12/2/2014

Estimate Worksheet

*reference attached breakdown for more detail

Culvert 23 - Polo Park Drive - Replace w/ Bridge

Item	Description	Unit	Unit Price	Quantity	Total- General Const.
1	**Misc.**				
	Mobilization	LS	$ 36,500	1	$ 36,500
	Bypass Pumping	LS	$ 17,600	1	$ 17,600
	Fish Rescue/Exclusion	LS	$ 8,600	1	$ 8,600
	Traffic Control	LS	$ 19,250	1	$ 19,250
	Erosion Control/SWPPP	LS	$ 18,200	1	$ 18,200
				Subtotal	**$ 100,150**
2	**Bridge Construction**				
	Demo - Road & Culvert	LS	$ 5,300	1	$ 5,300
	Abutments and Bridge	LS	$ 141,400	1	$ 141,400
	Bridge Approaches	LS	$ 9,000	1	$ 9,000
				Subtotal	**$ 155,700**
3	**Utilities / Stormwater**				
	Coordination of installation/relocation of other utilities	LS	$ 13,300	1	$ 13,300
	Stormwater	LS	$ 27,500	1	$ 27,500
				Subtotal	**$ 40,800**
4	**Creek Channelization / Restoration**				
	Earthwork	LS	$ 52,300	1	$ 52,300
	Materials in place	LS	$ 67,000	1	$ 67,000
	Logs and Plants	LS	$ 48,500	1	$ 48,500
				Subtotal	**$ 167,800**
			ESTIMATED CONSTRUCTION COSTS		**$ 464,450**
			CONTINGENCIES (20%)		**$ 92,890**
			SALES TAX (8.5%)		**$ 47,374**

TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) = $ 604,700

PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**60,500**
SURVEY MAPPING SERVICES	**$**	**10,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**151,200**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**30,300**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**221,700**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**635,000**
GRAND TOTAL	**$**	**856,700**

SUDDEN VALLEY COMMUNITY ASSOCIATION **12/2/2014**
Beaver Creek at Polo Park Drive, Culvert 23 Replacement

Prepared by: Wilson Engineering LLC CDS

CIP Level - Estimate of Probable Construction Costs

Item	Description	Quantity	Unit	Unit Price	Total Cost	
1	**MOBILIZATION, BYPASS PUMPING, & TRAFFIC CONTROL**					
a	Mobilization (10% of 2, 3, & 4)	1	LS	$ 36,404.00	$ 36,404.00	
b	Temporary Bypass Pumping - Beaver Creek (Assume 8 wks @ $2,200/wk)	1	LS	$ 17,600.00	$ 17,600.00	
c	Traffic Control	1	LS	$ 5,000.00	$ 5,000.00	
d	Flaggers - Control access to closed road	250	HR	$ 57.00	$ 14,250.00	
e	SWPPP (5% of 2, 3, & 4)	1	LS	$ 18,200.00	$ 18,200.00	
f	Fish Exclusion	1	LS	$ 8,600.00	$ 8,600.00	
	Subtotal				**$ 100,054.00**	
2	**BRIDGE CONSTRUCTION**					
a	Demolition - Road & Culvert	1	LS	$ 5,300.00	$ 5,300.00	
b	Abutments & Bridge					
	Shoring	1	LS	$ 7,500.00	$ 7,500.00	
	Excavation Dewatering	1	LS	$ 5,300.00	$ 5,300.00	
	Excavation	858	CY	$ 12.00	$ 10,296.00	
	Over-Excavation / Quarry Spall-Structural fill replacement	95	CY	$ 42.00	$ 3,990.00	
	Formwork, Rebar, & Concrete	1	LS	$ 32,600.00	$ 32,600.00	
	Piles	1	LS	$ 16,000.00	$ 16,000.00	
	Abutment Backfill					
	Gravel Base Incl. Haul	92.13	ton	$ 13.00	$ 1,197.69	
	Structural Fill Incl. Haul	61.42	ton	$ 16.00	$ 982.72	
	Drain Rock Incl. Haul	30.71	ton	$ 13.00	$ 399.23	
	Rip Rap	35	ton	$ 13.00	$ 455.00	
	Precast Concrete Bridge Deck	1	LS	$ 56,300.00	$ 56,300.00	
	Guardrail	80	LF	$ 59.00	$ 4,720.00	
	Pavement Markers, Striping, & Signing	1	LS	$ 1,600.00	$ 1,600.00	$ 141,340.64
c	Bridge Approaches (1500 SF)					
	Excavation	93	CY	$ 12.00	$ 1,116.00	
	Gravel Base In-Place (Assume 12-in)	83	ton	$ 15.00	$ 1,245.00	
	CSTC In-Place (Assume 4-in)	28	ton	$ 21.00	$ 588.00	
	Asphalt In-Place (Assume 4-in)	28	ton	$ 213.00	$ 5,964.00	$ 8,913.00
	Subtotal				**$ 155,553.64**	
3	**UTILITIES / STORMWATER**					
a	Coordinate 8-inch water line installation	1	LS	$ 5,300.00	$ 5,300.00	
b	Relocation of Existing TV Utilities - both sides	1	LS	$ 8,000.00	$ 8,000.00	
c	Stormwater					
	Type 1 CB	2	EA	$ 2,200.00	$ 4,400.00	
	Miscellaneous Stormwater Piping	1	LS	$ 10,700.00	$ 10,700.00	
	Raingarden/Swale Excavation	15	CY	$ 80.00	$ 1,200.00	
	Raingarden/Swale Construction	100	SF	$ 96.00	$ 9,600.00	
	Abandon 12-inch Drain Line	1	LS	$ 1,600.00	$ 1,600.00	$ 27,500.00
	Subtotal				**$ 40,800.00**	
4	**CREEK CHANNELIZATION**					
a	Clearing & Grubbing	0.3	acre	$ 16,000.00	$ 4,800.00	
	Excavation	1536	CY	$ 12.00	$ 18,432.00	
	Embankment	1100	CY	$ 15.00	$ 16,500.00	earthwork
	Finish Grading	1252	SY	$ 10.00	$ 12,520.00	$ 52,252.00
b	Gravel Base (incl. haul)	1400	ton	$ 13.00	$ 18,200.00	
	Streambed Sediment In-Place (6000 SF streambed)	617.0	ton	$ 27.00	$ 16,658.10	
	Streambed Boulders In-Place	50	EA	$ 53.00	$ 2,650.00	
	Topsoil In-Place	209.9	CY	$ 53.00	$ 11,122.54	
	Slope Stabilization	790	SY	$ 16.00	$ 12,640.00	materials in place
	Mulch In-Place	209.9	CY	$ 27.00	$ 5,666.20	$ 66,936.84
c	Log Features	1	LS	$ 16,500.00	$ 16,500.00	logs and plants
	Planting	1	LS	$ 32,000.00	$ 32,000.00	$ 48,500.00
	Subtotal				**$ 167,688.84**	

Assumed a 3% escalation for 2 years on all costs
Assume quantities are in line with what would be required for new bridge (same amount of stream restoration effort, etc.)

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 25, Remove and Replace		
CIP #:	C-25	**Replacement Year:**	2019
Map Tile:	E4	**Drainage Basin:**	17
Pipe Diameter:	24 or 30-inch	**Pipe Length:**	59-feet
25 year flow:	30.1 cfs	**Fish Passage:**	Likely

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 25 crosses underneath Huckleberry Court and is in poor condition (rated D+). Culvert 25 is a 24" or 30" CMP and exhibits extensive rust and perforations in the bottom of the pipe at the inlet, extensive rust through the barrel, joint separation and caving, and a crushed inlet blocked by debris. The inlet channel bottom elevation is above the culvert invert and the stream drops approximately 2 ft into the culvert at the inlet. The outlet of the pipe is also approximately 1/3 full of sediment. In addition to the poor condition, the culvert has been identified as having inadequate hydraulic capacity.

The culvert is located on a potentially fish bearing stream and will likely be required to provide fish passage when it is replaced. Since the pipe already has inadequate capacity, slip-lining is not an option. The project would replace the culvert with a RCP elliptical pipe with 83" span and 53" rise. The pipe would be installed no-slope and countersunk to provide a natural stream bed within the culvert. The pipe inlet will require a new trash rack. Both the inlet and outlet stream bed will require reshaping, stabilization, and armoring.

ANTICIPATED PERMITS

- Hydraulic Project Approval (Washington State Department of Fish and Wildlife)
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2018	2019
Permitting:	$ 13,100	
Survey/Engineering Design Services:	$ 37,800	
Construction Engineering Services:		$ 6,600
Construction Costs:		$131,300
Total:	**$50,900**	**$137,900**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	9 months
Construction:	3 months (summer only, within fish window)

Culvert inlet - debris and channel backed up to crown of pipe.

Culvert barrel at inlet (low flow) - extensive rust and joint separation/caving.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 25 - Huckleberry Court

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 9,171	1	$ 9,171	
	Sawcutting (AC&CC)	LF	$ 5	70	$ 350	$ 91,712.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	39	$ 3,900	
	Excavation of existing road subgrade incl. haul	CY	$ 20	168	$ 3,360	
	Trench Safety and Shoring	LF	$ 15	59	$ 885	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000	
	Fish Rescue/Exclusion	LS	$ 5,000	1	$ 5,000	
	83"span x 53" rise RCP elliptical pipe	LF	$ 520	59	$ 30,680	cost per Con-Cast pipe (Canada) 2014 online prices
	Pipe Installation	LS	$ 15,340	1	$ 15,340	
	Streambed cobbles	CY	$ 90	9	$ 840	assume half cobbles/gravel, plus 10 extra feet for end restoration
	Spawning gravel	TON	$ 45	17	$ 777	
	Pipe Zone Bedding and Backfill	TON	$ 50	170	$ 8,500	
	Roadway Base Gravel	TON	$ 30	41	$ 1,230	
	Roadway CSTC	TON	$ 50	7	$ 350	
	Inlet Trash Rack	LS	$ 2,500	1	$ 2,500	
	Reshaping/stabilize inlet and outlet	LS	$ 6,500	1	$ 6,500	
	Traffic Control	LS	$ 4,000	1	$ 4,000	5 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**100,883**
CONTINGENCIES (20%)	**$**	**20,177**
SALES TAX (8.5%)	**$**	**10,290**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**131,300**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**13,100**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**32,800**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**6,600**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**50,900**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**137,900**
GRAND TOTAL	**$**	**188,800**

	INPUTS	
Road width =	35	ft
Trench width =	10	ft
Depth to invert =	7	ft
Culvert length =	59	ft
prop culvert diameter =	5	ft - approximate equivalent
ex culvert diameter =	2	ft
prop pipe zone ht =	7	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culverts 29.1 and 29.2, Remove and Replace		
CIP #:	C-29	**Replacement Year:**	2018
Map Tile:	D4	**Drainage Basin:**	17
Pipe Diameter:	18-inch and 24-inch	**Pipe Length:**	133-feet
25 year flow:	6.7 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 29.1 crosses underneath Polo Park Drive. It is an 18" CMP pipe that discharges into a storm drain manhole. Culvert 29.2 is a 24" CMP pipe that coveys the stormwater from the manhole, down to the base of the slope. It appears that Culvert 29.2 and the manhole are located in the utility easement between two lots, however, this would need to be confirmed. Both pipes are in poor condition (rated D+) with extensive rust and perforations visible at the inlet and outlet and joint separation and settlement visible from the outlet.

The project will replace the culverts in kind with new 18" and 24" HDPE Corrugated Smooth Interior pipe. The 24" pipe could potentially be slip-lined if preliminary engineering investigations determine that the pipe has not had excessive settlement.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2017	2018
Permitting:	$ 4,900	
Survey/Engineering Design Services:	$ 17,200	
Construction Engineering Services:		$ 2,500
Construction Costs:		$48,700
Total:	**$22,100**	**$51,200**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert outlet - extensive rust and perforations.

Culvert barrel at outlet - extensive settlement and joint separation.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 29 - Polo Park Drive

Item	Description	Unit		Unit Price	Quantity		Total- General Const.		assumptions
	Mobilization	LS	$	3,401	1	$	3,401		
	Sawcutting (AC&CC)	LF	$	5	70	$	350	$	34,006.00
	Asphalt Concrete Removal & Restoration	SY	$	100	16	$	1,600		
	Excavation of existing road subgrade incl. haul	CY	$	20	100	$	2,000		
	Trench Safety and Shoring	LF	$	15	133	$	1,995		
	Remove and Dispose of Existing Pipe	LS	$	5,000	1	$	5,000		
	18-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$	33	64	$	2,112		
	24-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$	58	69	$	4,002		
	Pipe Installation	LS	$	3,057	1	$	3,057		
	SDMH connect outlet of 18-in and inlet of 24-in	LS	$	2,000	1	$	2,000		
	Pipe Zone Bedding and Backfill	TON	$	50	76	$	3,800		
	Roadway Base Gravel	TON	$	30	128	$	3,840		
	Roadway CSTC	TON	$	50	3	$	150		
	Reshaping/stabilization of inlet and outlet, incl restoration	LS	$	2,500	1	$	2,500		
	Traffic Control	LS	$	1,600	1	$	1,600		2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**37,407**
CONTINGENCIES (20%)	**$**	**7,481**
SALES TAX (8.5%)	**$**	**3,815**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**48,700**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**4,900**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**12,200**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**2,500**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**22,100**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**51,200**
GRAND TOTAL	**$**	**73,300**

	INPUTS	
Road width =	35	ft
ex & prop culvert diameter =	1.5	ft
Trench width =	4	ft
Depth to invert =	5	ft
Culvert length =	133	ft
prop pipe zone ht =	2.5	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 33, Remove and Replace		
CIP #:	C-33	**Replacement Year:**	2022
Map Tile:	E6	**Drainage Basin:**	18
Pipe Diameter:	10-inch	**Pipe Length:**	33-feet
25 year flow:	6.1 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 33 crosses underneath Little Strawberry Lane. The 10" CMP pipe is in average condition (rated C) exhibiting a rusty barrel. The inlet of the pipe is connected to a catch basin with two ditch pipes draining to the catch basin. The pipe has been identified as having inadequate hydraulic capacity, with less than half of the capacity necessary to pass the 25-year, 24 hour storm design event. There is a low risk of flooding to nearby homes, but road overtopping is likely in a large storm event.

The project would open cut the road and remove and replace the culvert with a 15" HDPE Corrugated Smooth Interior pipe. The existing pipe has minimal cover and the new pipe may need to be lowered.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2021	2022
Permitting:	$ 2,700	
Survey/Engineering Design Services:	$ 7,000	
Construction Engineering Services:		$ 1,800
Construction Costs:		$18,000
Total:	**$9,700**	**$19,800**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert outlet.

Culvert barrel at inlet.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 33 - Little Strawberry Lane

Item	Description	Unit		Unit Price	Quantity		Total- General Const.	assumptions
	Mobilization	LS	$	1,258	1	$	1,258	
	Sawcutting (AC&CC)	LF	$	5	40	$	200	$ 12,583.00
	Asphalt Concrete Removal & Restoration	SY	$	100	9	$	900	
	Excavation of existing road subgrade incl. haul	CY	$	20	17	$	340	
	Trench Safety and Shoring	LF	$	15	33	$	495	
	Remove and Dispose of Existing Pipe	LS	$	2,500	1	$	2,500	
	15-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$	23	33	$	759	
	Pipe Installation	LS	$	759	1	$	759	
	Connect to existing CB	LS	$	1,000	1	$	1,000	
	Pipe Zone Bedding and Backfill	TON	$	50	19	$	950	
	Roadway Base Gravel	TON	$	30	16	$	480	
	Roadway CSTC	TON	$	50	2	$	100	
	Reshaping/stabilization of outlet incl. site restoration	LS	$	2,500	1	$	2,500	
	Traffic Control	LS	$	1,600	1	$	1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**13,841**
CONTINGENCIES (20%)	**$**	**2,768**
SALES TAX (8.5%)	**$**	**1,412**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**18,000**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**2,700**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**4,500**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**1,800**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**9,700**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**19,800**
GRAND TOTAL	**$**	**29,500**

	INPUTS	
Road width =	20	ft
Trench width =	4	ft
Depth to invert =	3	ft
Culvert length =	33	ft
prop pipe zone ht =	2.25	ft
ex culvert diameter =	1	ft
prop culvert diameter =	1.25	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 34, Remove and Replace		
CIP #:	C-34	**Replacement Year:**	2016
Map Tile:	F6	**Drainage Basin:**	18
Pipe Diameter:	18-inch	**Pipe Length:**	40-feet
25 year flow:	12.0 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 34 crosses underneath Sudden Valley Drive. The 18" CMP pipe is in poor condition (rated D+) and the bottom of the pipe is rusted out for much of the length. The culvert has inadequate capacity because it is inlet controlled and the opening is not large enough to accommodate the 25-year, 24-hour design storm runoff.

The project would open cut the road and remove and replace the culvert with a 24" HDPE Corrugated Smooth Interior pipe.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2015	2016
Permitting:	$ 3,500	
Survey/Engineering Design Services:	$ 8,300	
Construction Engineering Services:		$ 2,400
Construction Costs:		$23,200
Total:	**$11,800**	**$25,600**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert inlet – bottom rusted through.

Culvert outlet.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 34 - Sudden Valley Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 1,619	1	$ 1,619	
	Sawcutting (AC&CC)	LF	$ 5	50	$ 250	$ 16,190.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	12	$ 1,200	
	Excavation of existing road subgrade incl. haul	CY	$ 20	28	$ 560	
	Trench Safety and Shoring	LF	$ 15	40	$ 600	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	24-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 58	40	$ 2,320	
	Pipe Installation	LS	$ 2,320	1	$ 2,320	
	Pipe Zone Bedding and Backfill	TON	$ 50	25	$ 1,250	
	Roadway Base Gravel	TON	$ 30	33	$ 990	
	Roadway CSTC	TON	$ 50	2	$ 100	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 1,600	1	$ 1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**17,809**
CONTINGENCIES (20%)	**$**	**3,562**
SALES TAX (8.5%)	**$**	**1,817**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**23,200**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**3,500**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**5,800**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**2,400**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**11,800**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**25,600**
GRAND TOTAL	**$**	**37,400**

	INPUTS	
Road width =	25	ft
ex & prop culvert diameter =	2	ft
Trench width =	4	ft
Depth to invert =	5	ft
Culvert length =	40	ft
prop pipe zone ht =	3	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 40.1, Remove and Replace		
CIP #:	C-40	**Replacement Year:**	2016
Map Tile:	G6	**Drainage Basin:**	18
Pipe Diameter:	36-inch	**Pipe Length:**	40-feet
25 year flow:	78.2 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 40.1 crosses underneath Honeycomb Lane and is in poor condition (rated D). Culvert 40.1 is a 36" CMP and exhibits a fully rusted out bottom. A sewer pipe passes perpendicularly through the top 1/3 of the pipe, at about center span. The culvert is identified as having limited hydraulic capacity, at about 75% of the 25-year, 24-hour design storm event.

The culvert will be required to provide fish passage when it is replaced. The project would replace the culvert with an RCP elliptical pipe with 83" span and 53" rise. The pipe would be installed no-slope and countersunk to provide a natural stream bed within the culvert. The culvert installation would accommodate the existing sewer pipe in its current location.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW)
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2015	2016
Permitting:	$ 9,800	
Survey/Engineering Design Services:	$ 29,500	
Construction Engineering Services:		$ 4,900
Construction Costs:		$97,900
Total:	**$39,300**	**$102,800**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)

Culvert barrel at inlet - no bottom and conflicting sanitary sewer pipe.

Culvert outlet – bottom completely rusted through

SVCA Culvert Replacements 11/26/2014

Estimate Worksheet

Culvert 40 - Honeycomb Lane

Item	Description	Unit	Unit Price	Quantity	Total- General Const.		
	Mobilization	LS	$ 6,834	1	$ 6,834		
	Sawcutting (AC&CC)	LF	$ 5	60	$ 300	$	68,342.92
	Asphalt Concrete Removal & Restoration	SY	$ 100	24	$ 2,400		
	Excavation of existing road subgrade incl. haul	CY	$ 20	79	$ 1,580		
	Trench Safety and Shoring	LF	$ 15	40	$ 600		
	Remove and Dispose of Existing Pipe	LS	$ 3,500	1	$ 3,500		
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000		
	Fish Rescue/Exclusion	LS	$ 5,000	1	$ 5,000		
						cost per Con-Cast pipe (Canada)	
	83"span x 53" rise RCP elliptical pipe	LF	$ 520	40	$ 20,800	2014 online prices	
	Pipe Installation	LS	$ 10,400	1	$ 10,400		
	Pipe Installation extra for sewer pipe conflict	LS	$ 2,600	1	$ 2,600	assume 25% of installation costs	
						assume half cobbles/gravel, plus	
	Streambed cobbles	CY	$ 90	6	$ 583	10 extra feet for end restoration	
	Spawning gravel	TON	$ 45	12	$ 540		
	Pipe Zone Bedding and Backfill	TON	$ 50	125	$ 6,250		
	Roadway Base Gravel	TON	$ 30	28	$ 840		
	Roadway CSTC	TON	$ 50	4	$ 200		
	Reshaping/stabilization of inlet and outlet	LS	$ 3,750	1	$ 3,750		
	Traffic Control	LS	$ 4,000	1	$ 4,000	5 days, 2 flaggers, $50/hr	

ESTIMATED CONSTRUCTION COSTS	**$**	**75,177**
CONTINGENCIES (20%)	**$**	**15,035**
SALES TAX (8.5%)	**$**	**7,668**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**97,900**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**9,800**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**24,500**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**4,900**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**39,300**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**102,800**
GRAND TOTAL	**$**	**142,100**

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 54 Remove and Replace w/ Bridge		
CIP #:	C-54	**Replacement Year:**	2023
Map Grid:	E3	**Drainage Basin:**	15
Pipe Diameter:	Rise: 6.2', Span: 7.3'	**Pipe Length:**	47-feet
25 year flow:	93 cfs	**Fish Passage Req'd:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 54 conveys Beaver Creek, a fish bearing stream, underneath Western Lane. It is an arch CMP with a rise of 6.2 feet and span of 7.3 feet. Culvert 54 is in average to poor condition (rated C-) exhibiting notable rust on the downstream end of the pipe and vegetation growing within the pipe barrel. The outlet has a 0.8 foot hydraulic drop, which is also undermining the culvert at the outlet. The culvert has minimal cover, with less than 2 feet between the top of the pipe and the finished grade of the asphalt.

In the Level A fish passage assessment conducted by GeoEngineers as part of the Phase 1 Stormwater Asset Inspection and Inventory, culvert 54 was identified as a priority replacement culvert. If the hydraulic drop is removed at the culvert outlet, potentially 2.81 miles of potential habitat could be added to the Beaver Creek stream corridor. It is assumed that the culvert will be replaced with a bridge similar to the Beaver Creek/Polo Park Drive bridge constructed in 2013 downstream near Honeycomb Lane. However, the culvert could potentially be relined with the outlet regraded, dependent on negotiations with WDFW.

ANTICIPATED PERMITS

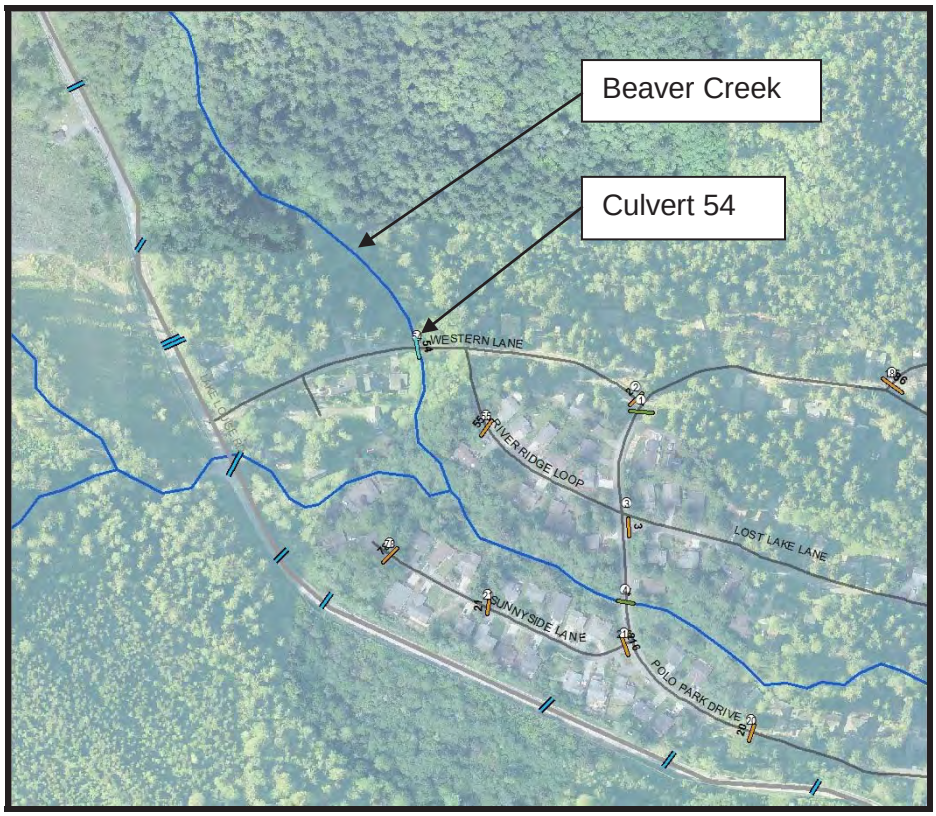
- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- SEPA Exemption (Whatcom County),
- Commercial Building Permit (Whatcom County),

BUDGET ESTIMATE

	2021-2022	2023
Permitting:	$ 60,500	
Survey/Engineering Design Services:	$161,200	
Construction Engineering Services:		$ 30,300
Construction Costs:		$604,700
Total:	**$221,700**	**$635,000**
	(Cost estimate in 2014 dollars)	

PROJECT TIMELINE

Design and Permitting:	18 months
Construction:	3 months (summer only, within fish window)



Location map.

Culvert outlet – Hydraulic drop and scour undermining outlet.

SVCA Culvert Replacements 12/2/2014

Estimate Worksheet

*reference attached breakdown for more detail

Culvert 54 - Western Ln - Replace w/ Bridge

Item	Description	Unit		Unit Price	Quantity		Total- General Const.
1	**Misc.**						
	Mobilization	LS	$	36,500	1	$	36,500
	Bypass Pumping	LS	$	17,600	1	$	17,600
	Fish Rescue/Exclusion	LS	$	8,600	1	$	8,600
	Traffic Control	LS	$	19,250	1	$	19,250
	Erosion Control/SWPPP	LS	$	18,200	1	$	18,200
					Subtotal	**$**	**100,150**
2	**Bridge Construction**						
	Demo - Road & Culvert	LS	$	5,300	1	$	5,300
	Abutments and Bridge	LS	$	141,400	1	$	141,400
	Bridge Approaches	LS	$	9,000	1	$	9,000
					Subtotal	**$**	**155,700**
3	**Utilities / Stormwater**						
	Coordination of installation/relocation of other utilities	LS	$	13,300	1	$	13,300
	Stormwater	LS	$	27,500	1	$	27,500
					Subtotal	**$**	**40,800**
4	**Creek Channelization / Restoration**						
	Earthwork	LS	$	52,300	1	$	52,300
	Materials in place	LS	$	67,000	1	$	67,000
	Logs and Plants	LS	$	48,500	1	$	48,500
					Subtotal	**$**	**167,800**
				ESTIMATED CONSTRUCTION COSTS		**$**	**464,450**
				CONTINGENCIES (20%)		**$**	**92,890**
				SALES TAX (8.5%)		**$**	**47,374**
				TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =		**$**	**604,700**
				PERMITTING INCLUDING AGENCY FEES (10%)		**$**	**60,500**
				SURVEY MAPPING SERVICES		**$**	**10,000**
				ENGINEERING DESIGN SERVICES (25%)		**$**	**151,200**
				CONSTRUCTION ENGINEERING SERVICES (5%)		**$**	**30,300**
				TOTAL ESTIMATED DESIGN AND PERMITTING COST		**$**	**221,700**
				TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST		**$**	**635,000**
				GRAND TOTAL		**$**	**856,700**

SUDDEN VALLEY COMMUNITY ASSOCIATION **12/2/2014**
Beaver Creek at Western Lane, Culvert 54 Replacement

Prepared by: Wilson Engineering LLC CDS

CIP Level - Estimate of Probable Construction Costs

Item	Description	Quantity	Unit	Unit Price	Total Cost	
1	**MOBILIZATION, BYPASS PUMPING, & TRAFFIC CONTROL**					
a	Mobilization (10% of 2, 3, & 4)	1	LS	$ 36,404.00	$ 36,404.00	
b	Temporary Bypass Pumping - Beaver Creek (Assume 8 wks @ $2,200/wk)	1	LS	$ 17,600.00	$ 17,600.00	
c	Traffic Control	1	LS	$ 5,000.00	$ 5,000.00	
d	Flaggers - Control access to closed road	250	HR	$ 57.00	$ 14,250.00	
e	SWPPP (5% of 2, 3, & 4)	1	LS	$ 18,200.00	$ 18,200.00	
f	Fish Exclusion	1	LS	$ 8,600.00	$ 8,600.00	
	Subtotal				**$ 100,054.00**	
2	**BRIDGE CONSTRUCTION**					
a	Demolition - Road & Culvert	1	LS	$ 5,300.00	$ 5,300.00	
b	Abutments & Bridge					
	Shoring	1	LS	$ 7,500.00	$ 7,500.00	
	Excavation Dewatering	1	LS	$ 5,300.00	$ 5,300.00	
	Excavation	858	CY	$ 12.00	$ 10,296.00	
	Over-Excavation / Quarry Spall-Structural fill replacement	95	CY	$ 42.00	$ 3,990.00	
	Formwork, Rebar, & Concrete	1	LS	$ 32,600.00	$ 32,600.00	
	Piles	1	LS	$ 16,000.00	$ 16,000.00	
	Abutment Backfill					
	Gravel Base Incl. Haul	92.13	ton	$ 13.00	$ 1,197.69	
	Structural Fill Incl. Haul	61.42	ton	$ 16.00	$ 982.72	
	Drain Rock Incl. Haul	30.71	ton	$ 13.00	$ 399.23	
	Rip Rap	35	ton	$ 13.00	$ 455.00	
	Precast Concrete Bridge Deck	1	LS	$ 56,300.00	$ 56,300.00	
	Guardrail	80	LF	$ 59.00	$ 4,720.00	
	Pavement Markers, Striping, & Signing	1	LS	$ 1,600.00	$ 1,600.00	$ 141,340.64
c	Bridge Approaches (1500 SF)					
	Excavation	93	CY	$ 12.00	$ 1,116.00	
	Gravel Base In-Place (Assume 12-in)	83	ton	$ 15.00	$ 1,245.00	
	CSTC In-Place (Assume 4-in)	28	ton	$ 21.00	$ 588.00	
	Asphalt In-Place (Assume 4-in)	28	ton	$ 213.00	$ 5,964.00	$ 8,913.00
	Subtotal				**$ 155,553.64**	
3	**UTILITIES / STORMWATER**					
a	Coordinate 8-inch water line installation	1	LS	$ 5,300.00	$ 5,300.00	
b	Relocation of Existing TV Utilities - both sides	1	LS	$ 8,000.00	$ 8,000.00	
c	Stormwater					
	Type 1 CB	2	EA	$ 2,200.00	$ 4,400.00	
	Miscellaneous Stormwater Piping	1	LS	$ 10,700.00	$ 10,700.00	
	Raingarden/Swale Excavation	15	CY	$ 80.00	$ 1,200.00	
	Raingarden/Swale Construction	100	SF	$ 96.00	$ 9,600.00	
	Abandon 12-inch Drain Line	1	LS	$ 1,600.00	$ 1,600.00	$ 27,500.00
	Subtotal				**$ 40,800.00**	
4	**CREEK CHANNELIZATION**					
a	Clearing & Grubbing	0.3	acre	$ 16,000.00	$ 4,800.00	
	Excavation	1536	CY	$ 12.00	$ 18,432.00	
	Embankment	1100	CY	$ 15.00	$ 16,500.00	earthwork
	Finish Grading	1252	SY	$ 10.00	$ 12,520.00	$ 52,252.00
b	Gravel Base (incl. haul)	1400	ton	$ 13.00	$ 18,200.00	
	Streambed Sediment In-Place (6000 SF streambed)	617.0	ton	$ 27.00	$ 16,658.10	
	Streambed Boulders In-Place	50	EA	$ 53.00	$ 2,650.00	
	Topsoil In-Place	209.9	CY	$ 53.00	$ 11,122.54	
	Slope Stabilization	790	SY	$ 16.00	$ 12,640.00	materials in place
	Mulch In-Place	209.9	CY	$ 27.00	$ 5,666.20	$ 66,936.84
c	Log Features	1	LS	$ 16,500.00	$ 16,500.00	logs and plants
	Planting	1	LS	$ 32,000.00	$ 32,000.00	$ 48,500.00
	Subtotal				**$ 167,688.84**	

Assumed a 3% escalation for 2 years on all costs
Assume quantities are in line with what would be required for new bridge (same amount of stream restoration effort, etc.)

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 63, Remove and Replace		
CIP #:	C-63	**Replacement Year:**	2024
Map Tile:	J11	**Drainage Basin:**	18
Pipe Diameter:	18-inch	**Pipe Length:**	70-feet
25 year flow:	15.5 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 63 crosses underneath Lake Louise Drive and is in average-to-poor condition (rated C-). Culvert 63 is an 18" CMP that exhibits fairly significant rust and debris buildup at the inlet. The culvert is identified as having inadequate hydraulic capacity. The culvert also has a catch basin and 12-in CMP outlet pipe directly above the pipe on the northwest side of the road.

The project would replace Culvert 63 with a 36" Corrugated Smooth Interior HDPE Pipe (Smooth Black Plastic, SBP). The project would also remove and replace the catch basin and connections and 12" CMP pipe (replace with 15" SBP) that are directly above the pipe.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW)
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2023	2024
Permitting:	$ 6,100	
Survey/Engineering Design Services:	$ 20,300	
Construction Engineering Services:		$ 3,100
Construction Costs:		$61,000
Total:	**$26,400**	**$64,100**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert inlet - significant bottom rust and debris and tree roots.

Culvert outlet (below) - additional pipe outlet directly above.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 63 - Lake Louise Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 4,256	1	$ 4,256	
	Sawcutting (AC&CC)	LF	$ 5	70	$ 350	$ 42,564.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	16	$ 1,600	
	Excavation of existing road subgrade incl. haul	CY	$ 20	70	$ 1,400	
	Trench Safety and Shoring	LF	$ 15	70	$ 1,050	
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000	
	Remove and Dispose of Existing Pipe and CB	LS	$ 3,500	1	$ 3,500	
	Remove and Replace Catch Basin directly above, reconnect pipes	LS	$ 2,500	1	$ 2,500	
	Replace 12" CMP directly above w/ 15" HDPE	LF	$ 23	14	$ 322	
	36-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 106	70	$ 7,420	
	Pipe Installation	LS	$ 7,742	1	$ 7,742	
	Pipe Zone Bedding and Backfill	TON	$ 50	43	$ 2,150	
	Roadway Base Gravel	TON	$ 30	96	$ 2,880	
	Roadway CSTC	TON	$ 50	3	$ 150	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 4,000	1	$ 4,000	5 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**46,820**
CONTINGENCIES (20%)	**$**	**9,364**
SALES TAX (8.5%)	**$**	**4,776**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**61,000**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**6,100**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**15,300**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**3,100**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**26,400**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**64,100**
GRAND TOTAL	**$**	**90,500**

INPUTS		
Road width =	35	ft
ex & prop culvert diameter =	3	ft
Trench width =	4	ft
Depth to invert =	8	ft
Culvert length =	70	ft
prop pipe zone ht =	4	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 82, Remove and Replace		
CIP #:	C-82	**Replacement Year:**	2024
Map Tile:	J11	**Drainage Basin:**	11
Pipe Diameter:	12-inch	**Pipe Length:**	36-feet
25 year flow:	4.2 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 82 crosses underneath Lake Louise Drive. The 12" CMP pipe is in average condition (rated C) and has a crushed inlet, possible joint separation and caving in, and is approximately 1/3 – 1/2 full of gravel. The pipe has been identified as having inadequate hydraulic capacity.

The project would replace the culvert with an 18" HDPE Corrugated Smooth Interior pipe.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2023	2024
Permitting:	$ 2,900	
Survey/Engineering Design Services:	$ 7,300	
Construction Engineering Services:		$ 2,000
Construction Costs:		$19,100
Total:	**$10,200**	**$21,100**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Crushed culvert inlet.

Looking down culvert barrel from inlet.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 82 - Lake Louise Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 1,333	1	$ 1,333	
	Sawcutting (AC&CC)	LF	$ 5	50	$ 250	$ 13,326.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	12	$ 1,200	
	Excavation of existing road subgrade incl. haul	CY	$ 20	23	$ 460	
	Trench Safety and Shoring	LF	$ 15	36	$ 540	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	18-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 33	36	$ 1,188	
	Pipe Installation	LS	$ 1,188	1	$ 1,188	
	Pipe Zone Bedding and Backfill	TON	$ 50	21	$ 1,050	
	Roadway Base Gravel	TON	$ 30	25	$ 750	
	Roadway CSTC	TON	$ 50	2	$ 100	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 1,600	1	$ 1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**14,659**
CONTINGENCIES (20%)	**$**	**2,932**
SALES TAX (8.5%)	**$**	**1,495**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**19,100**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**2,900**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**4,800**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**2,000**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**10,200**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**21,100**
GRAND TOTAL	**$**	**31,300**

	INPUTS	
Road width =	25	ft
ex culvert diameter =	1	
prop culvert diameter =	1.5	ft
Trench width =	4	ft
Depth to invert =	4	ft
Culvert length =	36	ft
prop pipe zone ht =	2.5	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 116, Remove and Replace		
CIP #:	C-116	**Replacement Year:**	2024
Map Tile:	C7	**Drainage Basin:**	4
Pipe Diameter:	18-inch	**Pipe Length:**	36-feet
25 year flow:	10.2 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 116 crosses underneath Harbor View Drive. The 18" CMP pipe is in average-to-poor condition (rated C-) exhibiting extensive rust with perforations beginning to form through the bottom. The culvert has inadequate capacity because it is inlet controlled and the opening is not large enough to accommodate the 25-year, 24-hour design storm runoff.

The project would replace the culvert with a 21" HDPE Corrugated Smooth Interior pipe.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2023	2024
Permitting:	$ 3,100	
Survey/Engineering Design Services:	$ 7,700	
Construction Engineering Services:		$ 2,100
Construction Costs:		$20,700
Total:	**$10,800**	**$22,800**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert outlet – rust and perforations forming through bottom.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 116 - Harbor View Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 1,444	1	$ 1,444	
	Sawcutting (AC&CC)	LF	$ 5	60	$ 300	$ 14,440.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	14	$ 1,400	
	Excavation of existing road subgrade incl. haul	CY	$ 20	21	$ 420	
	Trench Safety and Shoring	LF	$ 15	36	$ 540	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	21-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 45	36	$ 1,620	
	Pipe Installation	LS	$ 1,620	1	$ 1,620	
	Pipe Zone Bedding and Backfill	TON	$ 50	22	$ 1,100	
	Roadway Base Gravel	TON	$ 30	23	$ 690	
	Roadway CSTC	TON	$ 50	3	$ 150	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 1,600	1	$ 1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**15,884**
CONTINGENCIES (20%)	**$**	**3,177**
SALES TAX (8.5%)	**$**	**1,620**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**20,700**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**3,100**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**5,200**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**2,100**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**10,800**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**22,800**
GRAND TOTAL	**$**	**33,600**

	INPUTS	
Road width =	30	ft
ex & prop culvert diameter =	1.75	ft
Trench width =	4	ft
Depth to invert =	4	ft
Culvert length =	36	ft
prop pipe zone ht =	2.75	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 130 Remove and Replace, Culvert 131 Slipline		
CIP #:	C-130/131	**Replacement Year:**	2018
Map Tile:	B5	**Drainage Basin:**	1
Pipe Diameter:	36-inch	**Pipe Length:**	131-feet total
25 year flow:	23.4 cfs	**Fish Passage Req'd:**	No
Related Culverts with Potential for Concurrent Repair:			129

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 130 is located in the ditch parallel to Sudden Valley Drive. It connects to culvert 131, which crosses underneath Sudden Valley Drive. Both culverts are 36" CMP in poor condition (rated D+) with extensive rust and perforations forming along the bottom of the pipes. Culvert 129 is a 12" CMP that discharges to culvert 130 at a storm drain manhole. Culvert 129 appears to be in adequate condition, but should be evaluated at the same time that improvements are designed for culverts 130 and 131.

The project would replace all of existing Culvert 130 (32 LF), and approximately 12 feet of culvert 131 with a new 36" diameter HDPE Corrugated Smooth Interior pipe. The remaining 87 feet of culvert 131 would be slip lined with a 32" diameter Snap-Tite HDPE Corrugated Smooth Interior pipe. The culverts are located on an unnamed stream that discharges to Lake Whatcom and a Hydraulic Project Approval will be required from WDFW. However, it is not anticipated that fish passage will be a requirement since previous downstream projects were able to demonstrate that a natural fish barrier was located further downstream, after culvert 97 on Harbor View Drive.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2017	2018
Permitting:	$ 9,700	
Survey/Engineering Design Services:	$ 29,200	
Construction Engineering Services:		$ 4,900
Construction Costs:		$96,900
Total:	**$38,900**	**$101,800**

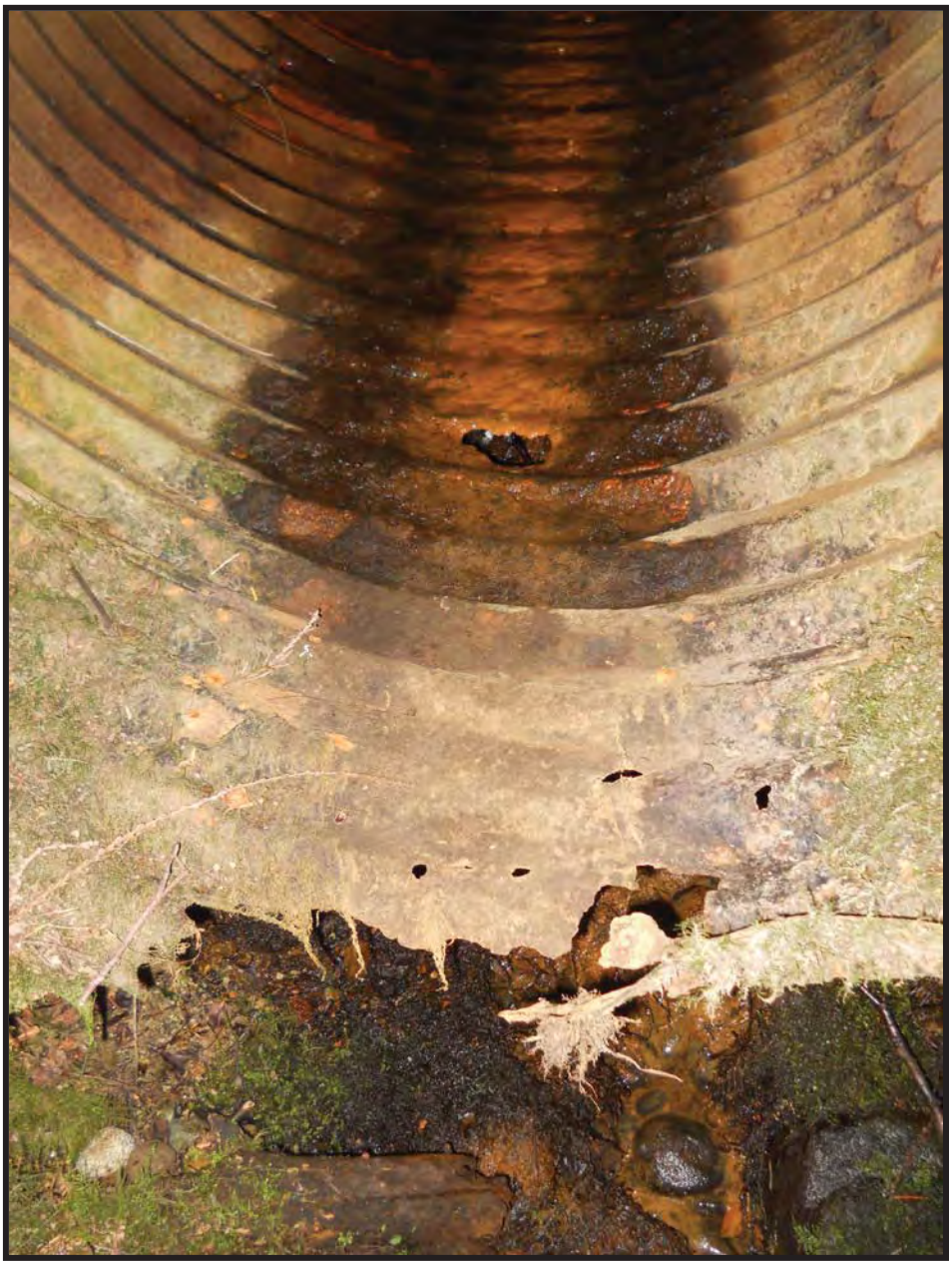
(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Inlet of Culvert 130 - pipe bottom disintegrated.

Junction of culverts 129, 130, and 131 – visible rust perforations, joint separation.



Culvert 131 outlet - rust disintegrating pipe bottom.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 129-130-131 - Sudden Valley Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	6,769	1	6,769	
	Sawcutting (AC&CC)	LF	5	0	0	$ 67,685.00
	Asphalt Concrete Removal & Restoration	SY	100	0	0	
	Excavation of existing fill around 130 and part 131	CY	20	48	960	
	Trench Safety and Shoring	LF	15	0	0	
	Remove and Dispose of Existing Pipe	LS	5,000	1	5,000	
	Dewatering and Bypass piping	LS	5,000	1	5,000	
	36-in Corrugated (smooth int.) HDPE Storm Drain Pipe to Replace 130, and 131 up to steep part to be slipline	LF	106	45	4,770	
	36-in HDPE Storm Drain Pipe Tee Fitting for 130 to 131 conn	EA	4,000	1	4,000	
	Pipe Installation	LS	4,385	1	4,385	
	32-in Snap-Tite Re-Lining (see below)	LS	25,000	1	25,000	
	SDMH connect outlet of 36-in C-130	LS	3,000	1	3,000	
	Pipe Zone Bedding and Backfill	TON	50	70	3,500	
	Re-fill around 130 and pt 131	TON	30	19	570	
	Roadway CSTC	TON	50	0	0	
	Reshaping/stabilization of inlet and outlet, incl restoration	LS	7,500	1	7,500	
	Traffic Control	LS	4,000	1	4,000	5 days, 2 flaggers, $50/hr
			ESTIMATED CONSTRUCTION COSTS		**$ 74,454**	
			CONTINGENCIES (20%)		**$ 14,891**	
			SALES TAX (8.5%)		**$ 7,594**	
			TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =		**$ 96,900**	
			PERMITTING INCLUDING AGENCY FEES (10%)		**$ 9,700**	
			SURVEY MAPPING SERVICES		**$ 5,000**	
			ENGINEERING DESIGN SERVICES (25%)		**$ 24,200**	
			CONSTRUCTION ENGINEERING SERVICES (5%)		**$ 4,900**	
			TOTAL ESTIMATED DESIGN AND PERMITTING COST		**$ 38,900**	
			TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST		**$ 101,800**	
			GRAND TOTAL		**$ 140,700**	

INPUTS			
Road width =		ft	
ex & prop culvert diameter =	3	ft	
Trench width =	6	ft	
Depth to invert =	5	ft	
Culvert length =	44	ft	only includes portions upland not sliplined
prop pipe zone ht =	5	ft	

Snaptite Relining - May 2014 costs	Quantity	Unit	Unit Price	Total Price
Moblization	6	hr	$65	$390
Laborer (2 ct)	48	hr	$75	$3,600
Concrete Pump Rental	2	day	$650	$1,300
Hotel (2 rms)	6	day	$100	$600
CDF to abandon pipe	5	CY	$125	$625
Grout	6	CY	$150	$900
2-inch schd 40 PVC pipe	100	LF	$1	$100
32-inch liner pipe	87	LF	$200	$17,400
				$24,915

Snap tite liner Pipe costs - DR 32.5 diameter (in)	Unit Price (freight included)	Lay length (ft)
14	68	21
16	80	12
18	53	21
18	86	11
20	104	12
28	156	24
30	164	24
30	198	11
30	296	4
32	196	24
36	263	11
36	400	4

hydrobell diameter (in)	Unit Price
14	1440 ea
18	2800 ea

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 166, Remove and Replace		
CIP #:	C-166	**Replacement Year:**	2018
Map Tile:	C5	**Drainage Basin:**	18
Pipe Diameter:	18-inch	**Pipe Length:**	49-feet
25 year flow:	18.7 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 166 crosses underneath Sudden Valley Drive. It is an 18" CMP pipe in average-to-poor condition (rated C-) with extensive rust, limited joint separation and partial caving in. There is also a black conduit (approx. 1" diameter) crossing through the upper ¼ of the pipe barrel. The pipe has been identified as having inadequate hydraulic capacity.

The project would replace the culvert with a new 24" HDPE Corrugated Smooth Interior pipe. The pipe alignment and slope will need to be evaluated to ensure adequate flow and prevent sedimentation.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2017	2018
Permitting:	$ 4,100	
Survey/Engineering Design Services:	$ 9,300	
Construction Engineering Services:		$ 2,800
Construction Costs:		$27,300
Total:	**$13,400**	**$30,100**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert inlet - rust, joint separation and conflicting conduit/pipe.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 166 - Sudden Valley Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 1,909	1	$ 1,909	
	Sawcutting (AC&CC)	LF	$ 5	60	$ 300	$ 19,089.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	14	$ 1,400	
	Excavation of existing road subgrade incl. haul	CY	$ 20	30	$ 600	
	Trench Safety and Shoring	LF	$ 15	49	$ 735	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	24-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 58	49	$ 2,842	
	Pipe Installation	LS	$ 2,842	1	$ 2,842	
	Coordinating working with conduit crossing over pipe	LS	$ 1,000	1	$ 1,000	
	Pipe Zone Bedding and Backfill	TON	$ 50	44	$ 2,200	
	Roadway Base Gravel	TON	$ 30	14	$ 420	
	Roadway CSTC	TON	$ 50	3	$ 150	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 1,600	1	$ 1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**20,998**
CONTINGENCIES (20%)	**$**	**4,200**
SALES TAX (8.5%)	**$**	**2,142**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**27,300**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**4,100**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**6,800**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**2,800**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**13,400**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**30,100**
GRAND TOTAL	**$**	**43,500**

	INPUTS	
Road width =	30	ft
ex culvert diamter =	1.5	ft
prop culvert diameter =	2	ft
Trench width =	4	ft
depth to invert =	4	ft
Culvert length =	49	ft
prop pipe zone ht =	4	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 182, Remove and Replace		
CIP #:	C-182	**Replacement Year:**	2021
Map Tile:	E6	**Drainage Basin:**	18
Pipe Diameter:	12-inch	**Pipe Length:**	32-feet
25 year flow:	5.2 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 182 crosses underneath a driveway just off of Lost Fork Lane. The 12" CMP pipe is in poor condition (rated D+) and the bottom of the pipe is rusted out at the inlet. The pipe has been identified as being very near its hydraulic capacity.

The project would replace the culvert with a 15" HDPE Corrugated Smooth Interior pipe. The driveway is currently surfaced with crushed gravel. Because the culvert does not cross a road and is not underneath a paved surface, it is considered a lower priority than culverts in similar condition.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2020	2021
Permitting:	$ 1,600	
Survey/Engineering Design Services:	$ 5,200	
Construction Engineering Services:		$ 1,100
Construction Costs:		$10,700
Total:	**$6,800**	**$11,800**
	(Cost estimate in 2014 dollars)	

PROJECT TIMELINE

Design and Permitting:	3 months
Construction:	3 weeks (summer only)

Culvert inlet showing rust through bottom.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 182 - Driveway at Lost Fork Lane

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 750	1	$ 750	
	Sawcutting (AC&CC)	LF	$ 5	0	$ -	$ 7,502.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	0	$ -	
	Excavation of existing driveway subgrade incl. haul	CY	$ 20	11	$ 220	
	Trench Safety and Shoring	LF	$ 15	0	$ -	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	15-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 23	32	$ 736	
	Pipe Installation	LS	$ 736	1	$ 736	
	Pipe Zone Bedding and Backfill	TON	$ 50	19	$ 950	
	Driveway Base Gravel	TON	$ 30	7	$ 210	
	Driveway CSTC	TON	$ 50	2	$ 100	
	Reshaping/stabilization of inlet and outlet	LS	$ 1,250	1	$ 1,250	
	Traffic Control	LS	$ 800	1	$ 800	1 day, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**8,252**
CONTINGENCIES (20%)	**$**	**1,650**
SALES TAX (8.5%)	**$**	**842**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**10,700**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**1,600**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**2,700**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**1,100**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**6,800**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**11,800**
GRAND TOTAL	**$**	**18,600**

	INPUTS	
Road width =	20	ft
ex culvert diameter =	1	ft
prop. Culvert diameter =	1.25	ft
Trench width =	4	ft
Depth to invert =	2	ft
Culvert length =	32	ft
prop pipe zone ht =	2.25	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 189, Remove and Replace		
CIP #:	C-189	**Replacement Year:**	2022
Map Tile:	F7	**Drainage Basin:**	18
Pipe Diameter:	36-inch	**Pipe Length:**	81-feet
25 year flow:	52.9 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 189 crosses underneath Little Strawberry Lane in a deep ravine. The 36" CMP is in poor condition (rated D+) and the bottom of the pipe is rusted out at the inlet and for much of the entire length. It is also exhibiting minor joint separation.

The culvert will be required to provide fish passage when it is replaced. Due to the steep nature of the stream channel and culvert, the project would replace the culvert with a 6' x 6' concrete box culvert with notched weirs for grade control and fish passage. The outlet of the pipe will require significant regrading and restructuring to allow for fish passage and a transitional plunge pool.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2020-2021	**2022**
Permitting:	$ 22,300	
Survey/Engineering Design Services:	$ 60,700	
Construction Engineering Services:		$ 11,200
Construction Costs:		$222,600
Total:	**$83,000**	**$233,800**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)

Culver barrel at inlet - bottom rusted through with joint separation.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 189 - Little Strawberry Lane

Item	Description	Unit		Unit Price	Quantity		Total- General Const.	assumptions
	Mobilization	LS	$	15,545	1	$	15,545	
	Sawcutting (AC&CC)	LF	$	5	66	$	330	$ 155,445.00
	Asphalt Concrete Removal & Restoration	SY	$	100	33	$	3,300	
	Excavation of existing road subgrade incl. haul	CY	$	20	330	$	6,600	
	Trench Safety and Shoring	LF	$	15	81	$	1,215	
	Remove and Dispose of Existing Pipe	LS	$	2,500	1	$	2,500	
	Dewatering and bypass piping	LS	$	5,000	1	$	5,000	
	Fish Rescue/Exclusion	LS	$	5,000	1	$	5,000	
	6'x6' concrete box with 5 weirs	LF	$	800	81	$	64,800	based on 2012-091 estimate from GPC
	Culvert Installation	LS	$	32,400	1	$	32,400	
	Concrete inlet and outlet pads	LS	$	5,000	1	$	5,000	
	Pipe Zone Bedding and Backfill	TON	$	50	200	$	10,000	
	Roadway Base Gravel	TON	$	30	250	$	7,500	
	Roadway CSTC	TON	$	50	6	$	300	
	Reshaping/stabilize inlet and outlet incl. restoration	LS	$	7,500	1	$	7,500	
	Traffic Control	LS	$	4,000	1	$	4,000	5 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS		**$**	**170,990**
CONTINGENCIES (20%)		**$**	**34,198**
SALES TAX (8.5%)		**$**	**17,441**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =		**$**	**222,600**
PERMITTING INCLUDING AGENCY FEES (10%)		**$**	**22,300**
SURVEY MAPPING SERVICES		**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)		**$**	**55,700**
CONSTRUCTION ENGINEERING SERVICES (5%)		**$**	**11,200**
TOTAL ESTIMATED DESIGN AND PERMITTING COST		**$**	**83,000**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST		**$**	**233,800**
GRAND TOTAL		**$**	**316,800**

	INPUTS	
Road width =	33	ft
Trench width =	9	ft
Depth to invert =	12	ft
Culvert length =	81	ft
prop culvert dimension =	6	ft
ex culvert diameter =	3	ft
prop pipe zone ht =	8	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 200, Remove and Replace		
CIP #:	C-200	**Replacement Year:**	2019
Map Tile:	D3	**Drainage Basin:**	16
Pipe Diameter:	12-inch	**Pipe Length:**	34-feet
25 year flow:	8.2 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 200 crosses underneath Yearling Place. The 12" CMP pipe is in average condition (rated C). Both ends are crushed and the pipe is about 1/3 full of sediment and debris. The pipe has been identified as having less than half of the required design hydraulic capacity for the 25-year, 24-hour design storm event.

The project would replace the culvert with an 18" HDPE Corrugated Smooth Interior pipe. Due to shallow cover and vulnerability to sedimentation, the pipe slope and ditches on either end will need to be adjusted.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2018	2019
Permitting:	$ 2,600	
Survey/Engineering Design Services:	$ 6,800	
Construction Engineering Services:		$ 1,800
Construction Costs:		$17,300
Total:	**$9,400**	**$19,100**
	(Cost estimate in 2014 dollars)	

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert barrel at inlet.

Crushed culvert outlet.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 200 - Yearling Place

Item	Description	Unit		Unit Price	Quantity		Total- General Const.		assumptions
	Mobilization	LS	$	1,208	1	$	1,208		
	Sawcutting (AC&CC)	LF	$	5	60	$	300	$	12,084.00
	Asphalt Concrete Removal & Restoration	SY	$	100	14	$	1,400		
	Excavation of existing road subgrade incl. haul	CY	$	20	12	$	240		
	Trench Safety and Shoring	LF	$	15	0	$	-		
	Remove and Dispose of Existing Pipe	LS	$	2,500	1	$	2,500		
	18-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$	33	34	$	1,122		
	Pipe Installation	LS	$	1,122	1	$	1,122		
	Pipe Zone Bedding and Backfill	TON	$	50	20	$	1,000		
	Roadway Base Gravel	TON	$	30	5	$	150		
	Roadway CSTC	TON	$	50	3	$	150		
	Reshaping/stabilization of inlet and outlet	LS	$	2,500	1	$	2,500		
	Traffic Control	LS	$	1,600	1	$	1,600		2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**13,292**
CONTINGENCIES (20%)	**$**	**2,658**
SALES TAX (8.5%)	**$**	**1,356**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**17,300**
PERMITTING INCLUDING AGENCY FEES (15%)	**$**	**2,600**
SURVEY MAPPING SERVICES	**$**	**2,500**
ENGINEERING DESIGN SERVICES (25%)	**$**	**4,300**
CONSTRUCTION ENGINEERING SERVICES (10%)	**$**	**1,800**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**9,400**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**19,100**
GRAND TOTAL	**$**	**28,500**

	INPUTS	
Road width =	30	ft
ex culvert diameter =	1	
prop culvert diameter =	1.5	ft
Trench width =	4	ft
depth to invert =	2	ft
Culvert length =	34	ft
prop pipe zone ht =	2.5	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 210, Remove and Replace		
CIP #:	C-210	**Replacement Year:**	2016
Map Tile:	F5	**Drainage Basin:**	17
Pipe Diameter:	24-inch	**Pipe Length:**	37-feet
25 year flow:	40.9 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 210 crosses underneath Honeycomb Lane and is in poor condition (rated D+). Culvert 210 is a 24" CMP with a partially rusted out bottom and joint failure. The culvert is identified as having less than half of the required design hydraulic capacity for the 25-year, 24-hour design storm event.

The culvert will be required to provide fish passage when it is replaced. The project would replace the culvert with a 48" HDPE Corrugated Smooth Interior pipe that would be installed no-slope and countersunk to provide a natural stream bed within the culvert.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW)
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2015	2016
Permitting:	$ 5,300	
Survey/Engineering Design Services:	$ 18,300	
Construction Engineering Services:		$ 2,700
Construction Costs:		$53,100
Total:	**$23,600**	**$55,800**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)

Culvert barrel at inlet - bottom rusted through and joint failure.

Culvert outlet - extensive rust and minor perforations forming.

SVCA Culvert Replacements 11/26/2014

Estimate Worksheet

Culvert 210 - Honeycomb Lane

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 3,707	1	$ 3,707	
	Sawcutting (AC&CC)	LF	$ 5	50	$ 250	$ 37,066.67
	Asphalt Concrete Removal & Restoration	SY	$ 100	17	$ 1,700	
	Excavation of existing road subgrade incl. haul	CY	$ 20	68	$ 1,360	
	Trench Safety and Shoring	LF	$ 15	37	$ 555	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000	
	Fish Rescue/Exclusion	LS	$ 5,000	1	$ 5,000	
	48-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 140	37	$ 5,180	cost per Wade at Fowler 8/4/2014 for ADS N-12 WTIB dual wall
	Pipe Installation	LS	$ 5,180	1	$ 5,180	
	Streambed cobbles	CY	$ 90	4	$ 333	assume half cobbles/gravel, plus 10 extra feet for end restoration
	Spawning gravel	TON	$ 45	7	$ 308	
	Pipe Zone Bedding and Backfill	TON	$ 50	81	$ 4,050	
	Roadway Base Gravel	TON	$ 30	20	$ 600	
	Roadway CSTC	TON	$ 50	3	$ 150	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 2,400	1	$ 2,400	3 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**40,773**
CONTINGENCIES (20%)	**$**	**8,155**
SALES TAX (8.5%)	**$**	**4,159**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**53,100**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**5,300**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**13,300**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**2,700**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**23,600**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**55,800**
GRAND TOTAL	**$**	**79,400**

CAPITAL PROJECT NARRATIVE

Project Name	Culverts 212 & 213, Remove and Replace		
CIP #:	C-212&213	**Replacement Year:**	2019
Map Tile:	G6	**Drainage Basin:**	17
Pipe Diameter:	12-inch & 18-inch	**Pipe Length:**	41-feet & 56-feet
25 year flow:	6.2 cfs & 15.6	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 212 crosses underneath Summer Bell Lane and is in average condition (rated C), is a 12" CMP, and is 50% full of sediment and gravel. Culvert 212 discharges to Culvert 213 approximately 10 feet downstream. Culvert 213 crosses underneath Polo Park Drive and is in average condition (rated C), is an 18" CMP, and is 33% full of sediment and large rock. Both culverts 212 & 213 are identified as being undersized for the 25-year, 24-hour design storm event. A backwater analysis was also performed on the culverts and the roadways which the culverts cross under are at high risk for overtopping. It should be noted that the hydraulic capacity and backwater analyses were performed assuming full culvert barrel passage and do not consider that the culverts are at a reduced capacity due to sediment build up.

The project would replace both culverts at the same time for cost efficiency. Culvert 212 would be replaced with a 24" HDPE Corrugated Smooth Interior pipe. Culvert 213 would be replaced with a 30" HDPE Corrugated Smooth Interior pipe.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2018	2019
Permitting:	$ 5,500	
Survey/Engineering Design Services:	$ 18,900	
Construction Engineering Services:		$ 2,800
Construction Costs:		$55,400
Total:	**$24,400**	**$58,200**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	10 weeks (summer only, within fish window)

Culvert 212 barrel at outlet.

Culvert 213 barrel at outlet.

SVCA Culvert Replacements 12/3/2014

Construction Cost - Estimate Worksheet

Culvert 212 Summer Bell Lane & Culvert 213 Polo Park Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 3,866	1	$ 3,866	$ 38,661.00
212	Sawcutting (AC&CC)	LF	$ 5	46	$ 230	
	Asphalt Concrete Removal & Restoration	SY	$ 100	11	$ 1,100	
	Excavation of existing road subgrade incl. haul	CY	$ 20	30	$ 600	
	Trench Safety and Shoring	LF	$ 15	41	$ 615	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	24-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 58	41	$ 2,378	
	Pipe Installation (including tee connection with C-433)	LS	$ 2,378	1	$ 2,378	
	Pipe Zone Bedding and Backfill	TON	$ 50	37	$ 1,850	
	Roadway Base Gravel	TON	$ 30	11	$ 330	
	Roadway CSTC	TON	$ 50	2	$ 100	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 1,500	1	$ 1,500	
213	Sawcutting (AC&CC)	LF	$ 5	58	$ 290	
	Asphalt Concrete Removal & Restoration	SY	$ 100	15	$ 1,500	
	Excavation of existing road subgrade incl. haul	CY	$ 20	62	$ 1,240	
	Trench Safety and Shoring	LF	$ 15	56	$ 840	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	30-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 70	56	$ 3,920	
	Pipe Installation (including tee connection with C-433)	LS	$ 3,920	1	$ 3,920	
	Pipe Zone Bedding and Backfill	TON	$ 50	59	$ 2,950	
	Roadway Base Gravel	TON	$ 30	9	$ 270	
	Roadway CSTC	TON	$ 50	3	$ 150	
	Reshaping/stabilization of inlet and outlet	LS	$ 2,500	1	$ 2,500	
	Traffic Control	LS	$ 2,500	1	$ 2,500	
			ESTIMATED CONSTRUCTION COSTS		**$ 42,527**	
			CONTINGENCIES (20%)		**$ 8,505**	
			SALES TAX (8.5%)		**$ 4,338**	

TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**55,400**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**5,500**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**13,900**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**2,800**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**24,400**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**58,200**
GRAND TOTAL	**$**	**82,600**

212 INPUTS			**213 INPUTS**		
Road width =	23	ft	Road width =	29	ft
ex culvert diamter =	1	ft	ex culvert diamter =	1.5	ft
prop culvert diameter =	2	ft	prop culvert diameter =	2.5	ft
Trench width =	4	ft	Trench width =	4.5	ft
depth to invert =	4.6	ft	depth to invert =	6.5	ft
Culvert length =	41	ft	Culvert length =	56	ft
prop pipe zone ht =	4	ft	prop pipe zone ht =	4.5	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 225, Slip line		
CIP #:	C-225	**Replacement Year:**	2018
Map Tile:	K9	**Drainage Basin:**	11
Pipe Diameter:	24-inch	**Pipe Length:**	79-feet
25 year flow:	5.7 cfs	**Fish Passage Req'd:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 225 crosses underneath Louise View Drive and is in poor condition (rated D+). It is a 24" CMP with extensive rust and much of the bottom completely rusted through. The channel downstream of the pipe is a steep, vegetated bank lined with an open half pipe CMP (also in poor condition). The hydraulic capacity of culvert 225 is considered more than adequate for passing the 25-year, 24-hour design storm runoff.

The project would slip line the existing culvert with a 20" diameter Snap-Tite HDPE Corrugated Smooth Interior pipe. The channel downstream of the culvert outlet would be replaced with a rip-rap stabilized channel.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County) [reshaping of inlet/outlet]

BUDGET ESTIMATE

	2017	2018
Permitting:	$ 3,600	
Survey/Engineering Design Services:	$ 13,900	
Construction Engineering Services:		$ 1,800
Construction Costs:		$35,700
Total:	**$17,500**	**$37,500**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert barrel at inlet – extensive rust, (perforations not visible in picture).

Culvert outlet - extensive rust, downstream channel de-stabilized.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 225 - Louise View Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization (10%)	LS	2490	1	2490	$ 24,900.00
	Sawcutting (AC&CC)	LF	4	0	0	
	Asphalt Concrete Removal & Restoration	SY	87	0	0	
	Excavation of existing road subgrade incl. haul	CY	7	0	0	
	Trench Safety and Shoring	LF	15	0	0	
	Remove and Dispose of Existing Pipe	LS	2500	0	0	
	20-in Snap-Tite Re-Lining (see below)	LS	14000	1	14000	
	Pipe Zone Bedding and Backfill	TON	28	0	0	
	Roadway Base Gravel	TON	10	0	0	
	Roadway CSTC	TON	24	0	0	
	Reshaping/stabilization of inlet and outlet incl restoration	LS	3500	1	3500	
	Removing half pipe channel stabilize downstream and install rip-rap lined slope	LS	5000	1	5000	
	Traffic Control	LS	2400	1	2400	3 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**27,390**
CONTINGENCIES (20%)	**$**	**5,478**
SALES TAX (8.5%)	**$**	**2,794**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**35,700**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**3,600**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**8,900**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**1,800**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**17,500**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**37,500**
GRAND TOTAL	**$**	**55,000**

INPUTS		
Road width =	0	ft
culvert diameter =	0	ft
Trench width =	0	ft
Cover =	0	ft
Culvert length =	0	ft
pipe zone ht =	2	ft

Snaptite Relining - May 2014 costs	Quantity	Unit	Unit Price	Total Price
Moblization	6	hr	$65	$390
Laborer (2 ct)	32	hr	$75	$2,400
Concrete Pump Rental	2	day	$650	$1,300
Hotel (2 rms)	4	day	$100	$400
CDF to abandon pipe	3	CY	$125	$375
Grout	4	CY	$150	$600
2-inch schd 40 PVC pipe	75	LF	$1	$75
20-inch liner pipe	79	LF	$104	$8,216
				$13,756

Snap tite liner Pipe costs - DR 32.5

diameter (in)	rice (freight included)	Lay length (ft)
14	68	21
16	80	12
18	53	21
18	86	11
20	104	12
28	156	24
30	164	24
30	198	11
30	296	4
32	196	24
36	263	11
36	400	4

hydrobell diameter (in)	Unit Price	
14	1440	ea
18	2800	ea

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 314, Remove and Replace		
CIP #:	C-314	**Replacement Year:**	2016
Map Tile:	E6	**Drainage Basin:**	18
Pipe Diameter:	36-inch	**Pipe Length:**	62-feet
25 year flow:	48.9 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 314 crosses underneath Berrywood Place in a deep ravine. The 36" CMP pipe is in poor condition (rated D+) and the bottom of the pipe is rusted out over the entire length. The hydraulic capacity of culvert 314 is considered adequate for passing the 25-year, 24-hour design storm runoff.

The culvert will be required to provide fish passage when it is replaced. Due to the steep nature of the stream channel and culvert, the project would replace the culvert with a 6' x 6' concrete box culvert with notched weirs for grade control and fish passage. The outlet of the pipe will require significant regrading and restructuring to allow for fish passage and a transitional plunge pool.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2015	2016
Permitting:	$ 17,700	
Survey/Engineering Design Services:	$ 49,300	
Construction Engineering Services:		$ 8,900
Construction Costs:		$177,000
Total:	**$67,000**	**$185,900**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)

Culvert inlet - extensive rust, bottom disintegrated.

Culvert outlet – bottom disintegrated, joint separation, pipe settlement.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 314 - Berrywood Place

Item	Description	Unit		Unit Price	Quantity		Total- General Const.	assumptions
	Mobilization	LS	$	12,361	1	$	12,361	
	Sawcutting (AC&CC)	LF	$	5	40	$	200	$ 123,610.00
	Asphalt Concrete Removal & Restoration	SY	$	100	20	$	2,000	
	Excavation of existing road subgrade incl. haul	CY	$	20	232	$	4,640	
	Trench Safety and Shoring	LF	$	15	62	$	930	
	Remove and Dispose of Existing Pipe	LS	$	2,500	1	$	2,500	
	Dewatering and bypass piping	LS	$	5,000	1	$	5,000	
	Fish Rescue/Exclusion	LS	$	5,000	1	$	5,000	
	6'x6' concrete box with 5 weirs	LF	$	800	62	$	49,600	based on 2012-091 estimate from GPC
	Culvert Installation	LS	$	24,800	1	$	24,800	
	Concrete inlet and outlet pads	LS	$	5,000	1	$	5,000	
	Pipe Zone Bedding and Backfill	TON	$	50	153	$	7,650	
	Roadway Base Gravel	TON	$	30	153	$	4,590	
	Roadway CSTC	TON	$	50	4	$	200	
	Reshaping/stabilize inlet and outlet incl. restoration	LS	$	7,500	1	$	7,500	
	Traffic Control	LS	$	4,000	1	$	4,000	5 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**135,971**
CONTINGENCIES (20%)	**$**	**27,194**
SALES TAX (8.5%)	**$**	**13,869**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**177,000**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**17,700**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**44,300**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**8,900**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**67,000**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**185,900**
GRAND TOTAL	**$**	**252,900**

	INPUTS	
Road width =	20	ft
Trench width =	9	ft
Depth to invert =	11	ft
Culvert length =	62	ft
ex culvert diameter =	3	ft
prop culvert diameter =	6	ft
prop pipe zone ht =	8	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 315, Remove and Replace		
CIP #:	C-315	**Replacement Year:**	2020
Map Tile:	E4, E5	**Drainage Basin:**	17
Pipe Diameter:	24-inch	**Pipe Length:**	79-feet
25 year flow:	37.1 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 315 crosses underneath Polo Park Drive and is in average to poor condition (rated C-). Culvert 25 is a 24" CMP and exhibits some rust and joint separation and minor caving. The culvert has been identified as having less than half of the hydraulic capacity required to pass the 25-year, 24-hour design storm runoff.

The culvert will be required to provide fish passage when it is replaced. The project would replace the culvert with a RCP elliptical pipe with 76" span and 48" rise. The pipe would be installed no-slope and countersunk to provide a natural stream bed within the culvert. Due to the extended length, the replacement culvert has a much wider span then normal in order to meet fish passage requirements.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2018-2019	2020
Permitting:	$ 13,600	
Survey/Engineering Design Services:	$ 39,100	
Construction Engineering Services:		$ 6,900
Construction Costs:		$136,300
Total:	**$52,700**	**$143,200**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)

Culvert barrel at inlet - extensive rust, joint separation, pipe settlement.

Culvert barrel at outlet – extensive rust, bottom disintegrated.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 315 - Polo Park Drive

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 9,519	1	$ 9,519	
	Sawcutting (AC&CC)	LF	$ 5	46	$ 230	$ 95,192.58
	Asphalt Concrete Removal & Restoration	SY	$ 100	26	$ 2,600	
	Excavation of existing road subgrade incl. haul	CY	$ 20	167	$ 3,340	
	Trench Safety and Shoring	LF	$ 15	79	$ 1,185	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000	
	Fish Rescue/Exclusion	LS	$ 5,000	1	$ 5,000	
	76"span x 48" rise RCP elliptical pipe	LF	$ 440	79	$ 34,760	cost per Con-Cast pipe (Canada) 2014 online prices
	Pipe Installation	LS	$ 17,380	1	$ 17,380	
	Streambed cobbles	CY	$ 90	23	$ 2,077	assume half cobbles/gravel, plus 10 extra feet for end restoration
	Spawning gravel	TON	$ 45	43	$ 1,921	
	Pipe Zone Bedding and Backfill	TON	$ 50	228	$ 11,400	
	Roadway Base Gravel	TON	$ 30	55	$ 1,650	
	Roadway CSTC	TON	$ 50	5	$ 250	
	Reshaping/stabilize inlet and outlet	LS	$ 3,500	1	$ 3,500	
	Traffic Control	LS	$ 2,400	1	$ 2,400	3 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**104,712**
CONTINGENCIES (20%)	**$**	**20,942**
SALES TAX (8.5%)	**$**	**10,681**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**136,300**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**13,600**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**34,100**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**6,900**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**52,700**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**143,200**
GRAND TOTAL	**$**	**195,900**

	INPUTS	
Road width =	23	ft
Trench width =	10	ft
Depth to invert =	5	ft
Culvert length =	79	ft
ex culvert diameter =	2	ft
prop culvert diameter =	5	ft - approximate equivalent
prop pipe zone ht =	7	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 408.1 & 408.2, Remove and Replace with Single Culvert		
CIP #:	C-408	**Replacement Year:**	2024
Map Tile:	I11	**Drainage Basin:**	11
Pipe Diameter:	10-inch & 12-inch	**Pipe Length:**	20-feet
25 year flow:	10.7 cfs	**Fish Passage:**	Yes

PURPOSE and DESCRIPTION OF THE PROJECT

Culverts 408.1 & 408.2 are two parallel culverts that are approximately 10-ft apart. Culvert 408.1 is a 10-inch CMP and culvert 408.2 is a 12-inch CMP located north of culvert 408.1. Both culverts cross underneath the gravel Lake Louise loop trail, just west of the end of Larkspur Court, and are in poor condition (rated D). Extensive rust and sedimentation is visible at the pipe inlets and outlets. The ends of culvert 408.2 are also crushed. Adjacent to the culvert outlets is a Lake Whatcom Water and Sewer District (LWWSD) sewer pump station. The culverts are identified as having less than half of the hydraulic capacity required for the 25-year, 24-hour design storm runoff. They have also been identified by SVCA maintenance staff as causing flooding and maintenance issues.

The culverts will be required to provide fish passage when they are replaced. The project would replace the two culverts with a single 54" HDPE Corrugated Smooth Interior pipe that would be installed no-slope and countersunk to provide a natural stream bed within the culvert. The gravel trail would be raised and built up over the new pipe to provide increased vertical clearance. The ditch upstream of the culverts would require reshaping and grading to combine the two micro-drainage paths into a seamless new passage. Coordination with LWWSD will be required for design and work of the passage outlet around the sewer pump station facilities.

ANTICIPATED PERMITS

- Hydraulic Project Approval (WDFW),
- Clean Water Act, Section 404 (Army Corps of Engineers)
- National Historic Preservation Act, Section 106 (Army Corps of Engineers)
- 401 Water Quality Certification (Department of Ecology)
- Land Disturbance Permit (Whatcom County)
- Shoreline Exemption (Whatcom County)

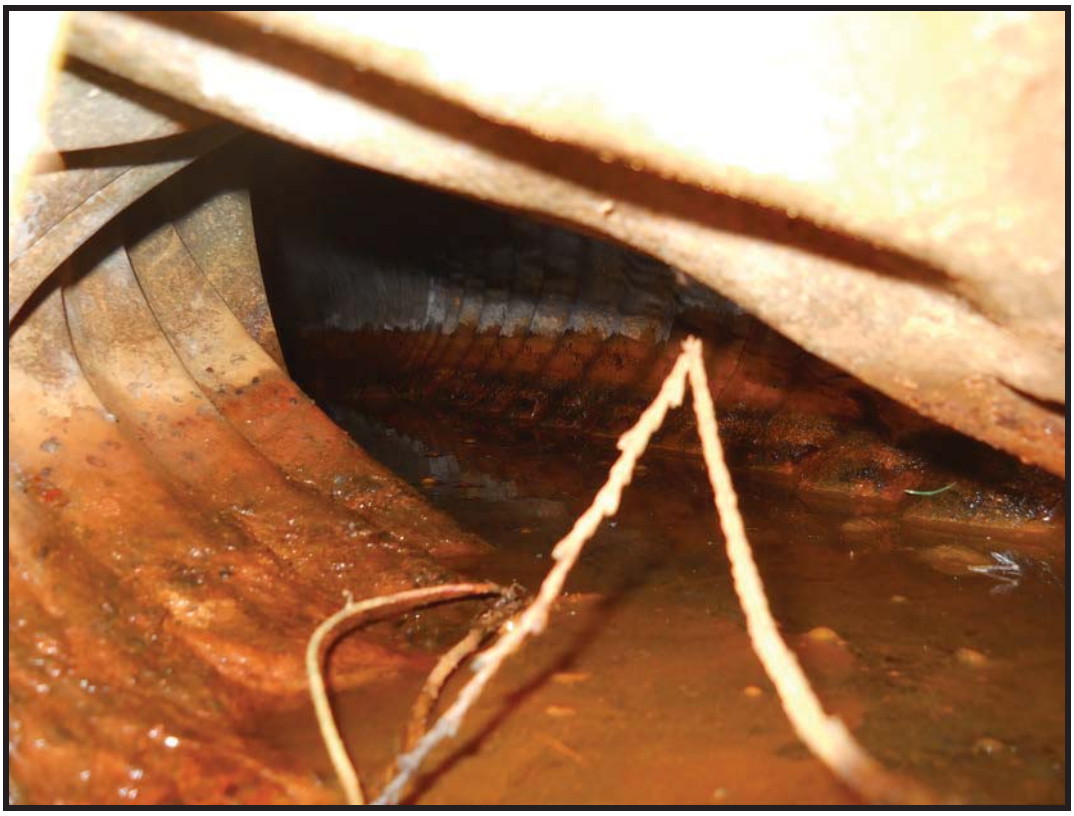
BUDGET ESTIMATE

	2023	2024
Permitting:	$ 6,400	
Survey/Engineering Design Services:	$ 20,900	
Construction Engineering Services:		$ 3,200
Construction Costs:		$63,500
Total:	**$27,300**	**$66,700**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	12 months
Construction:	3 months (summer only, within fish window)



Culvert 408.1 inlet – extensive rust.

Culvert 408.2 outlet – extensive rust and sedimentation.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culverts 408.1 & 408.2 - Larkspur Court Trail

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization (10%)	LS	$ 4,435	1	$ 4,435	
	Coordination with LWWSD regarding Pump Station very nearby	LS	$ 5,000	1	$ 5,000	$ 44,353.13
	Sawcutting (AC&CC)	LF	$ 5		$ -	
	Asphalt Concrete Removal & Restoration	SY	$ 100		$ -	
	Excavation of existing path subgrade incl. haul	CY	$ 20	11	$ 220	
	Trench Safety and Shoring	LF	$ 15		$ -	
	Remove and Dispose of Existing Pipes	LS	$ 2,500	1	$ 2,500	
	Dewatering and bypass piping	LS	$ 5,000	1	$ 5,000	
	Fish Rescue/Exclusion	LS	$ 5,000	1	$ 5,000	
	54-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 160	20	$ 3,200	cost per Fowler for ADS N-12 WT IB dual wall pipe
	Pipe Installation	LS	$ 3,200	1	$ 3,200	
	Streambed cobbles	CY	$ 90	3	$ 225	assume half cobbles/gravel, plus 10 extra feet for end restoration
	Spawning gravel	TON	$ 45	5	$ 208	
	Rebuilding trail over pipe and pipe zone bedding, crushed gravel	TON	$ 50	246	$ 12,300	
	Roadway Base Gravel	TON	$ 30		$ -	
	Roadway CSTC	TON	$ 50		$ -	
	Reshaping/stabilization of inlet and outlet, and new streambed	LS	$ 7,500	1	$ 7,500	
	Traffic Control	LS	$ 5,000		$ -	

ESTIMATED CONSTRUCTION COSTS	**$**	**48,788**
CONTINGENCIES (20%)	**$**	**9,758**
SALES TAX (8.5%)	**$**	**4,976**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**63,500**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**6,400**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**15,900**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**3,200**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**27,300**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**66,700**
GRAND TOTAL	**$**	**94,000**

INPUTS			
Road width =	12	ft	gravel path
ex culvert diameter =	1		
prop culvert diameter =	4.5	ft	
Trench width =	6	ft	
Depth to invert =	2	ft	
Culvert length =	20	ft	2 culverts, 12" and 10" CMP
prop pipe zone ht =	6.5	ft	

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 417, Remove and Replace		
CIP #:	C-417	**Replacement Year:**	2024
Map Tile:	D10	**Drainage Basin:**	8
Pipe Diameter:	12-inch	**Pipe Length:**	32-feet
25 year flow:	12.0 cfs	**Fish Passage:**	Not Likely

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 417 crosses underneath Long Shore Lane and is a 12" pipe in average-to-poor condition (rated C-). The upstream half of the pipe is PVC and the downstream half is CMP. The outlet of the pipe is almost completely buried and the entire ditch downstream is approximately 1-2 feet above the pipe. The pipe has been identified as having inadequate hydraulic capacity.

The project would replace the culvert with a 15" HDPE Corrugated Smooth Interior pipe. The ditch downstream of the pipe would require excavating, regrading, and stabilization.

It does not appear that fish passage would be required but further discussion with WDFW will need to confirm this prior to beginning the project.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	2023	2024
Permitting:	$ 3,100	
Survey/Engineering Design Services:	$ 12,600	
Construction Engineering Services:		$ 1,600
Construction Costs:		$30,500
Total:	**$15,700**	**$32,100**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert outlet.

Channel downstream of culvert outlet.

SVCA Culvert Replacements 11/26/2014

Construction Cost - Estimate Worksheet

Culvert 417 - Long Shore Lane

Item	Description	Unit	Unit Price	Quantity	Total- General Const.	assumptions
	Mobilization	LS	$ 2,132	1	$ 2,132	
	Sawcutting (AC&CC)	LF	$ 5	50	$ 250	$ 21,322.00
	Asphalt Concrete Removal & Restoration	SY	$ 100	12	$ 1,200	
	Excavation of existing road subgrade incl. haul	CY	$ 20	16	$ 320	
	Trench Safety and Shoring	LF	$ 15	0	$ -	
	Remove and Dispose of Existing Pipe	LS	$ 2,500	1	$ 2,500	
	15-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$ 23	32	$ 736	
	Pipe Installation	LS	$ 736	1	$ 736	
	Pipe Zone Bedding and Backfill	TON	$ 50	18	$ 900	
	Roadway Base Gravel	TON	$ 30	16	$ 480	
	Roadway CSTC	TON	$ 50	2	$ 100	
	Excavating, re-grading, and stabilizing downstream ditch	LS	$ 10,000	1	$ 10,000	
	Reshaping/stabilization of inlet and outlet, incl restoration	LS	$ 2,500	1	$ 2,500	significant ditch regrading downstream
	Traffic Control	LS	$ 1,600	1	$ 1,600	2 days, 2 flaggers, $50/hr

ESTIMATED CONSTRUCTION COSTS	**$**	**23,454**
CONTINGENCIES (20%)	**$**	**4,691**
SALES TAX (8.5%)	**$**	**2,392**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**30,500**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**3,100**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**7,600**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**1,600**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**15,700**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**32,100**
GRAND TOTAL	**$**	**47,800**

	INPUTS	
Road width =	25	ft
ex culvert diameter =	1	ft
prop culvert diameter =	1.25	ft
Trench width =	4	ft
depth to invert =	3	ft
Culvert length =	32	ft
prop pipe zone ht =	2.25	ft

CAPITAL PROJECT NARRATIVE

Project Name	Culvert 432, Remove and Replace		
CIP #:	C-432	**Replacement Year:**	
Map Tile:	D6	**Drainage Basin:**	18
Pipe Diameter:	24-inch	**Pipe Length:**	120-feet
25 year flow:	+/- 26 cfs	**Fish Passage:**	No

PURPOSE and DESCRIPTION OF THE PROJECT

Culvert 432 crosses underneath a residential parking and close to a house at the end of Strawberry Canyon Court. It is a 24" CMP in poor condition (rated D+). The downstream end of the pipe exhibits significant settling and joint separation as it approaches the outlet. Much of the pipe bottom near the outlet is rusted through. The culvert has inadequate capacity because it is inlet controlled and the opening is not large enough to accommodate the 25-year, 24-hour design storm runoff.

The project would replace the culvert with a 30" HDPE Corrugated Smooth Interior pipe. A new HDPE tee would be installed where culvert 433 (12" CMP) joins culvert 432 approximately 30 feet from the outlet.

ANTICIPATED PERMITS

- Land Disturbance Permit (Whatcom County)

BUDGET ESTIMATE

	Yr-1	Yr-2
Permitting:	$ 5,900	
Survey/Engineering Design Services:	$ 19,600	
Construction Engineering Services:		$ 3,000
Construction Costs:		$58,500
Total:	**$25,500**	**$61,500**

(Cost estimate in 2014 dollars)

PROJECT TIMELINE

Design and Permitting:	6 months
Construction:	6 weeks (summer only)

Culvert barrel at outlet.

SVCA Culvert Replacements 11/27/2014

Construction Cost - Estimate Worksheet

Culvert 432 - Strawberry Canyon Court

Item	Description	Unit		Unit Price	Quantity		Total- General Const.		assumptions
	Mobilization	LS	$	4,082	1	$	4,082		
	Sawcutting (AC&CC)	LF	$	5	170	$	850	$	40,820.00
	Asphalt Concrete Removal & Restoration	SY	$	100	38	$	3,800		
	Excavation of existing road subgrade incl. haul	CY	$	20	93	$	1,860		
	Trench Safety and Shoring	LF	$	15	120	$	1,800		
	Remove and Dispose of Existing Pipe	LS	$	2,500	1	$	2,500		
	30-in Corrugated (smooth int.) HDPE Storm Drain Pipe	LF	$	70	120	$	8,400		assume not replacing 433
	30"x24"x12" Tee	LS	$	2,500	1	$	2,500		
	Pipe Installation (including tee connection with C-433)	LS	$	8,400	1	$	8,400		
	Coordinating working with conduit crossing over pipe	LS	$	1,000	1	$	1,000		
	Pipe Zone Bedding and Backfill	TON	$	50	108	$	5,400		
	Roadway Base Gravel	TON	$	30	17	$	510		
	Roadway CSTC	TON	$	50	6	$	300		
	Reshaping/stabilization of inlet and outlet	LS	$	2,500	1	$	2,500		
	Traffic Control	LS	$	1,000	1	$	1,000		

ESTIMATED CONSTRUCTION COSTS	**$**	**44,902**
CONTINGENCIES (20%)	**$**	**8,980**
SALES TAX (8.5%)	**$**	**4,580**
TOTAL PROBABLE CONSTRUCTION COSTS (With Tax) =	**$**	**58,500**
PERMITTING INCLUDING AGENCY FEES (10%)	**$**	**5,900**
SURVEY MAPPING SERVICES	**$**	**5,000**
ENGINEERING DESIGN SERVICES (25%)	**$**	**14,600**
CONSTRUCTION ENGINEERING SERVICES (5%)	**$**	**3,000**
TOTAL ESTIMATED DESIGN AND PERMITTING COST	**$**	**25,500**
TOTAL ESTIMATED CONSTRUCTION AND CONSTRUCTION ENGINEERING COST	**$**	**61,500**
GRAND TOTAL	**$**	**87,000**

INPUTS		
Road width =	85	ft
ex culvert diamter =	2	ft
prop culvert diameter =	2.5	ft
Trench width =	4	ft
depth to invert =	5.5	ft
Culvert length =	120	ft
prop pipe zone ht =	4.5	ft

Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
1	D2	B	CMP	POLO PARK DR	4.0	16	56	No	50%	497.33	496.61	502.3	0.013	3.7	5.1	4.3	no	no	
2	D2	C	CMP	WESTERN LN	0.0	12	41	No	8%	500.42	0.00	0.0				4.1		YES	
3	D2	C	CMP	POLO PARK DR	0.0	10	44	No	50%	487.79	0.00	488.8				0.3		no	
4	D2	B	CMP	POLO PARK DR	4.1	84	40	Yes	0%	468.02	467.93	479.1	0.002	4.8	292	221.6	no	#N/A	actual shape is horizontal ellipse, model calculated capacity = 292 cfs
5	K11	B	SBP	LOUISE VIEW DR	2.2	30	44	No	0%	650.56	643.98	652.0	0.151	35.6	171.6	12.8	no	no	
6	K11	B	SBP	LOUISE VIEW DR	8.0	30	48	No	0%	623.27	614.95	629.6	0.173	38.1	183.6	13.0	no	no	
7	A5	A	HDPE	HARBOR VIEW DR	0.0	30	33	No	0%	508.02	506.60	532.0	0.043	19.0	91.7	39.3	no	YES	
7.1	A5	A	SBP	HARBOR VIEW DR		28	90	No	0%	506.03	500.87	532.0	0.057	21.0	88.0	39.3	no	YES	
8	K12	C	CMP	SOUTHERN CT	2.9	12	48	Yes	100%	487.16	483.69	489.3	0.072	7.3	5.6	0.2	no	no	
9	A5, B5	A	SBP	ROSE RIDGE LOOP	0.0	28	127	No	0%	528.40	517.38	537.0	0.087	25.8	108.3	26.8	no	YES	
9.1	A5	A	HDPE	ROSE RIDGE LOOP		30	28	No	0%	517.18	516.62	537.0	0.020	13.0	62.5	26.8	no	YES	
10	J6	C	CMP	WOODRUSH CT	2.9	12	40	No	50%	628.12	626.24	631.1	0.047	5.8	4.5	0.8	no	no	
11	J6	C	CMP	BIGLEAF LN	5.2	18	50	No	17%	596.92	589.22	599.8	0.155	13.9	24.1	0.4	no	no	
12	J6	C	CMP	BIGLEAF LN	4.1	24	36	No	0%	591.25	588.37	595.9	0.080	12.1	37.4	0.9	no	no	
13	I6	C	CMP	BIGLEAF LN	5.6	24	60	No	33%	567.57	566.97	574.8	0.010	4.3	13.2	0.3	no	no	
14	H5	B	SBP	TUMBLING WATER DR	8.8	18	61	No	0%	575.97	571.67	584.1	0.071	17.3	30.1	36.7	YES	YES	
15	H5	C	CMP	SHETLAND CT	2.5	12	60	No	100%	606.39	604.72	609.0	0.028	4.5	3.5	0.9	no	no	
16	I6	C	CMP	TUMBLING WATER DR	7.6	24	59	No	17%	564.52	562.91	573.3	0.027	7.0	21.7	16.9	no	YES	
17	I5	C	CMP	SHETLAND CT	3.3	18	39	No	22%	633.08	628.97	635.8	0.104	11.4	19.8	0.5	no	no	
18	I6	C	CMP	TUMBLING WATER DR	5.1	18	47	No	56%	563.00	561.49	568.8	0.032	6.3	11.0	6.9	no	no	
19.1	G11	D	CMP	TENNIS CT AT BARNS	0.0	30	283	Yes	40%	325.55	325.03	0.0	0.002	2.1	10.3	17.6	YES	no	Culvert must be daylighted for fish passage
19.2	G11		CMP	TENNIS CT AT BARNS		30	203			325.26	324.74		0.003	2.5	12.1	ABANDONED			Filled with CDF in 2014
19.3	G11	D	CONC	TENNIS CT AT BARNS		30	174			324.74	322.57		0.012	8.9	42.8	1.7	no	no	
19.4	G11	C	PVC	TENNIS CT AT BARNS		12	65			328.43	326.94		0.023	7.5	5.8	1.7	no	no	
20	D2	C	CMP	POLO PARK DR	4.4	12	41	No	83%	480.54	479.84	485.5	0.017	3.5	2.7	2.3	no	no	
21	D1	C	CMP	SUNNYSIDE LN	2.8	12	33	No	83%	485.17	482.94	487.9	0.067	7.0	5.4	0.1	no	no	
22	E3	C	CMP	POLO PARK DR	6.0	84	49	Yes	1%	457.67	457.59	470.6	0.001		239	236.3	YES	#N/A	actual shape is horizontal ellipse, model calculated capacity = 239 cfs
23	E3	C-	CMP	POLO PARK DR	1.9	84	41	Yes	1%	451.05	450.79	459.9	0.007	8.0	301.5	246.2	no	#N/A	
24	E4	C	CMP	POLO PARK DR	3.1	60	47	Yes	0%	459.40	457.39	466.5	0.042	16.2	312.5	49.3	no	#N/A	
25	E4	D+	CMP	HUCKLEBERRY CT	0.0	24	59	Yes	100%	480.17	478.80	487.0	0.023	6.5	20.2	30.1	YES	YES	INLET ELEV A BIT ABOVE TRUE INVERT - not 36" diameter, apparently 24" diameter
26	D5, E4, E5	C	CMP	POLO PARK DR	3.2	16	53	No	63%	499.22	495.35	501.8	0.073	8.9	12.1	1.0	no	no	
27	D4	C	CMP	MISTY RIDGE CT	0.0	12	40	No	50%	0.00	513.06	517.5				0.8		no	
28	D4, D5	C	CMP	GLACIER RIDGE DR	2.7	24	47	No	25%	545.74	542.42	548.7	0.071	11.4	35.3	4.4	no	no	
29.1	D4	D+	CMP	POLO PARK DR	0.0	18	63	No	67%	532.50	0.00	536.7				6.7		no	INACCESSIBLE SDMH IN MIDDLE WHERE PIPE CONVERTS FROM 18" TO 24"
29.2	D4	D+	CMP	POLO PARK DR		24	70	No		0.00	514.39	536.7				6.7		no	
30	D4	B	CMP	POLO PARK DR	2.9	16	52	No	25%	557.62	550.12	558.1	0.143	12.4	16.9	2.1	no	no	
31	F6	C	CMP	LITTLE STRAWBERRY LN	0.0	10	37	No	80%	524.87	0.00	527.8				1.2		no	
32	F6	C	CMP	HOLLY VIEW WAY	0.0	12	50	No	50%	532.46	0.00	531.3				0.2		no	
33	E6	C	CMP	HOLLY VIEW WAY	2.1	10	33	No	0%	522.67	521.07	524.8	0.049	5.3	2.8	6.1	YES	YES	low flooding risk
34	F6	D+	CMP	SUDDEN VALLEY DR	3.7	18	40	No	17%	511.49	510.26	516.1	0.031	6.2	10.7	12.0	YES	YES	deep channel, low flooding risk
35	F6	B	SBP	MORNING GLORY DR	0.0	12	20	No	50%	532.21	531.96	0.0	0.012	5.6	4.3	0.4	no	no	
36	F6	C	CMP	MORNING GLORY DR	3.2	12	35	No	83%	533.41	532.43	537.1	0.028	4.5	3.5	0.4	no	no	
37	F6	C	CMP	MORNING GLORY DR	0.0	12	68	No	100%	0.00	0.00	537.9				0.1		no	
38	E5	C	CMP	HORSESHOE CIR	0.0	12	50	No	100%	507.15	0.00	508.8				3.4		YES	
39	E5	C	CMP	HORSESHOE CIR	2.6	10	33	No	20%	501.81	500.13	504.4	0.051	5.4	2.9	0.8	no	no	
40.1	G6	D	CMP	HONEYCOMB LN	2.0	36	40	Yes	6%	420.98	420.08	425.5	0.022	8.4	58.3	78.2	YES	YES	capacity issue confirmed by model

Note: Gray Highlighted Culverts are on the 2015 CIP and Yellow Highlighted Culverts are on the 2016-2025 CIP

Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
40.2	G6	B	CMP	HONEYCOMB LN		24	34	No										no	
41	G6	C	CMP	BAYWOOD CT	2.3	16	55	No	75%	420.33	419.71	423.7	0.011	3.5	4.8	0.4	no	no	
42	F6	C	CMP	HONEYCOMB LN	3.5	18	33	No	56%	425.87	424.27	430.0	0.049	7.8	13.5	3.0	no	no	
43	F6	C	CMP	SUGARPINE PL	2.9	12	52	No	50%	428.59	427.03	431.7	0.030	4.7	3.6	1.9	no	no	
44	H8	C	CMP	RIDGE CREST WAY	2.3	12	58	No	83%	469.25	467.40	471.6	0.032	4.8	3.7	0.9	no	no	
45	H8	C	CMP	SAFFRON CT	2.2	12	33	No	0%	458.90	458.12	461.7	0.023	4.1	3.2	0.5	no	no	
46	G7	D	CMP	SUDDEN VALLEY DR	3.2	18	36	No	22%	461.82	459.22	465.2	0.072	9.5	16.4	5.1	no	no	
47	H8	C	CMP	SAGEWOOD CT	0.0	12	88	No	0%	448.81	0.00	456.0				0.4		no	
48	H8	C	CMP	SAGEWOOD CT	0.0	12	39	No	50%	465.46	0.00	465.9				1.8		no	
49	H8	C	CMP	SAGEWOOD CT	0.0	12	44	No	25%	468.02	0.00	470.9				1.8		no	
50	H8	C	CMP	VALLEY CREST WAY	0.0	12	35	No	67%	0.00	497.49	500.0				0.7		no	
51	H9	C	CMP	ACORN PL	0.0	12	34	No	0%	421.89	0.00	430.8				3.0		YES	
52	H8	C	CMP	NEWBERRY CT	0.0	12	34	No	0%	418.89	0.00	424.2				1.3		no	
53	H8	C	CMP	AUSTIN CREEK LN	0.0	12	34	No	50%	419.50	0.00	421.7				0.8		no	
54	C1	C-	CMP	WESTERN LN	1.9	84	47	Yes	7%	478.99	478.81	487.8	0.004	6.2	234.6	92.9	no	#N/A	
55	D1	C		RIVER RIDGE LOOP	0.0	12	47	No	0%	0.00	0.00	485.0				0.2		no	NOT 36", maybe 12" based on viewable portion, badly buried inlet and cannot find outlet
56	K9	C	PVC	LOUISE VIEW DR	0.0	8	86	No	0%	0.00	886.21	0.0	0.200	17.0	5.8	2.4	no	YES	
57	K9	C	CMP	LOUISE VIEW DR	0.0	24	138	No	0%	889.82	869.29	0.0	0.149	16.5	51.0	5.0	no	no	
58	K9	C	CMP	REPEATER RD	0.0	24	105	No	0%	879.04	878.24	894.6	0.008	3.7	11.5	0.4	no	no	
59	K9	C	CMP	LOUISE VIEW DR	0.0	24	109	No	0%	878.24	869.29	888.1	0.082	12.2	37.8	2.4	no	no	
60	I8	B	SBP	LOUISE VIEW DR	23.1	30	160	No	0%	601.13	569.47	610.9	0.198	40.9	196.8	8.5	no	no	
61	J8	C	CMP	BRAMBLE WAY	2.8	18	68	No	0%	659.81	656.44	662.4	0.049	7.9	13.6	3.0	no	no	
62	J7	C	CMP	CLEMATIS LN	2.1	12	40	No	0%	697.95	694.24	699.2	0.093	8.2	6.3	0.5	no	no	
63	J11	C-	CMP	LAKE LOUISE DR	6.8	18	70	No	11%	361.26	358.30	368.1	0.042	7.2	12.6	15.5	YES	YES	deep channel, low flooding risk
64	J11	B	PVC	PARTRIDGE CIR	1.2	12	25	No	33%	355.66	354.99	357.5	0.027	8.2	6.3	0.2	no	no	
65	H9	B	SBP	SUDDEN VALLEY DR	4.3	12	42	No	0%	455.56	453.17	459.6	0.057	11.9	9.2	2.7	no	YES	
66	I7	C	CMP	LOUISE VIEW DR	5.6	16	57	No	0%	559.08	555.54	564.3	0.062	8.2	11.2	1.2	no	no	
67	I7	C	CMP	SWEETCLOVER CIR	0.0	12	57	No	50%	587.37	0.00	597.3				0.9		no	
68	E4, E5	C	PVC	OAKCREST CIR	0.0	12	33	No	8%	464.01	0.00	466.6				0.2		no	
69	E5	C	CMP	OAKCREST CIR	2.6	12	24	No	17%	469.02	467.82	472.1	0.050	6.0	4.6	0.2	no	no	
71	E5, F5	C	CMP	HONEYCOMB LN	4.0	12	33	No	50%	440.43	438.78	444.6	0.049	6.0	4.6	0.5	no	no	
72	E4	C	CMP	HONEYCOMB LN	2.5	12	33	No	50%	441.99	440.93	445.0	0.032	4.8	3.7	0.7	no	no	
73	F12	B	CMP	MORNING BEACH DR	3.3	12	43	No	0%	313.43	313.09	317.5	0.008	2.4	1.8	2.9	YES	YES	
74	G12	C	CMP	MARIGOLD DR	2.7	12	38	No	0%	402.59	400.01	405.0	0.069	7.1	5.5	1.8	no	no	
75	G13	C	CMP	MARIGOLD DR	1.8	12	41	No	0%	451.77	449.91	453.6	0.046	5.8	4.5	1.4	no	no	
76	G13	C	CMP	GRAND VIEW LN	3.6	24	57	No	17%	449.69	447.95	454.5	0.031	7.5	23.1	9.8	no	no	
77	G13	B	CMP	GRAND VIEW LN	3.3	12	29	No	0%	556.41	553.40	559.2	0.104	8.7	6.7	3.3	no	YES	
78	D1	C	CMP	SUNNYSIDE LN	5.8	16	50	No	75%	480.14	479.34	486.8	0.016	4.2	5.7	2.4	no	no	
79.1	H11, I11, I12	C	CMP	VALLEY VIEW CIR	0.0	12	144	No	0%	512.51	0.00	515.2				1.6		no	
79.2	H11	C	PVC	VALLEY VIEW CIR		10	32	No		0.00	463.43					1.6		no	
80	J11	C	CMP	SPARROW CT	3.2	12	36	No	0%	349.09	347.86	352.7	0.034	5.0	3.8	3.8	YES	YES	
81	J11	C	CMP	LAKE LOUISE DR	4.6	24	58	No	25%	345.19	343.49	350.9	0.029	7.3	22.5	8.0	no	no	
82	J11	C	CMP	LAKE LOUISE DR	2.5	12	36	No	33%	350.59	350.38	354.0	0.006	4.5	3.5	4.2	YES	YES	potential flooding risk to upstream homes
83	J11	B	SBP	NIGHTHAWK CIR	2.8	12	43	No	50%	349.64	348.59	352.9	0.024	7.7	6.0	4.3	no	YES	
84	H13	B	CMP	GRAND VIEW LN	4.5	12	35	No	0%	590.03	582.18	591.6	0.221	12.7	9.8	1.3	no	no	
85	F7	C	CMP	SUDDEN VALLEY DR	0.0	12	43	No	0%	597.05	0.00	600.0				0.4		no	
86	F7	C	CMP	SUDDEN VALLEY DR	2.7	12	53	No	33%	600.82	598.77	603.5	0.039	5.3	4.1	2.1	no	no	
87	E8	C-	CMP	DEER RUN LN	2.6	12	20	No	0%	503.90	501.15	506.1	0.136	10.0	7.7	7.0	YES	YES	

Note: Gray Highlighted Culverts are on the 2015 CIP and Yellow Highlighted Culverts are on the 2016-2025 CIP

Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
88	G7	C		ROCKY RIDGE DR	0.0	18	25	No	56%	0.00	0.00	625.3				1.0		no	does not appear to be 36", inlet 95% buried, outlet completely buried
89	F8	C	CMP	INDIAN RIDGE CT	6.9	12	85	No	0%	561.00	550.72	563.8	0.121	9.4	7.2	2.9	no	YES	
90	F7	C	CMP	LOOKOUT MOUNTAIN LN	0.0	12	28	No	100%	622.87	0.00	625.2				0.6		no	
91	F7	C	CMP	INGLEWOOD PL	0.0	12	38	No	100%	656.64	0.00	657.8				0.2		no	
92	C6	C	CMP	BASIN VIEW CIR	0.0	12	30	No	50%	726.31	0.00	729.7				0.8		no	
93	C6	C	CMP	JASPER RIDGE LN	0.0	12	49	No	17%	731.62	0.00	733.0				0.2		no	
94	D6	C	CMP	BASIN VIEW CIR	0.0	12	26	No	100%	727.83	0.00	731.5				2.0		no	
95	D7	C	CMP	SUDDEN VALLEY DR	0.0	12	31	No	100%	0.00	0.00	743.6				0.2		no	
96	D7	C	CMP	SUDDEN VALLEY DR	2.8	12	35	No	25%	733.96	732.56	737.1	0.040	5.4	4.1	0.6	no	no	
97	A5	B	SBP	HARBOR VIEW DR	9.5	32	82	No	9%	486.17	485.00	497.8	0.014	11.4	62.7	44.1	no	YES	
98	A5	C	CMP	HARBOR VIEW DR	4.8	12	47	No	83%	494.09	493.48	499.5	0.013	3.1	2.4	0.8	no	no	
99	A5	C	CMP	PLUM LN	3.4	12	51	No	67%	496.00	494.04	499.4	0.038	5.3	4.1	0.5	no	no	
100	B6	C	CMP	JASPER RIDGE LN	2.8	12	50	No	33%	518.06	517.89	521.8	0.003	1.6	1.2	0.5	no	no	
101	B6	C	CMP	JASPER RIDGE LN	2.3	12	30	No	83%	529.24	526.62	531.3	0.088	8.0	6.2	0.5	no	no	
102	B6	C	CMP	PLUM LN	3.3	12	39	No	67%	487.65	486.87	491.6	0.020	3.8	2.9	1.3	no	no	
103	B6	C	CMP	AMBERLAND WAY	2.4	24	42	No	50%	488.28	486.79	491.9	0.035	8.1	24.9	10.2	no	no	
104	B6	C	CMP	HARBOR VIEW DR	0.0	24	28	No	17%	500.64	499.01	0.0	0.057	10.2	31.6	8.8	no	no	
105	B6	C	CMP	HARBOR VIEW DR	0.0	12	35	No	0%	476.28	476.00	0.0	0.008	2.4	1.9	12.1	YES	YES	105 has 2 inlets draining to 106 with an unknown outlet elev (=106 inlet elev)
106	B6	D	CMP	HARBOR VIEW DR	0.0	24	41	No	0%	476.00	472.05	478.6	0.096	13.3	41.0	12.1	no	no	inlet invert assumed, 105 pipe from south assumed at 0.5% slope to inlet of 106
107	B7	D	CMP	WINTER CREEK PL	5.9	24	47	No	0%	406.21	402.58	412.3	0.077	11.8	36.5	16.3	no	YES	
109	B7	C	SBP	GREEN HILL RD	2.3	18	40	No	0%	452.91	449.20	454.8	0.092	19.8	34.4	7.6	no	YES	
110	B7	C	CMP	HARBOR VIEW DR	6.4	18	52	No	0%	420.37	416.75	426.4	0.069	9.3	16.1	12.9	no	YES	
111	B7, C7	C	CMP	HARBOR VIEW DR	3.0	18	39	No	0%	403.91	401.86	407.4	0.053	8.1	14.1	1.3	no	no	
112	H5	B	SBP	APPALOOSA CT	0.0	18	40	No	0%	497.04	495.49	502.4	0.039	12.8	22.3	39.5	YES	YES	measured pipe ID = 18"
113	H6	B	SBP	PINTO CREEK LN	7.6	18	40	No	0%	479.44	479.51	488.6	-0.002			42.3		YES	negative-flat slope verified by re-survey
114	A5	C	CMP	MAPLE CT	0.0	12	17	No	100%	0.00	0.00	0.0							culvert location suspect
115	C7	C	CMP	HARBOR VIEW DR	0.0	18	42	No	33%	417.79	0.00	424.4				2.5		no	
116	C7	C-	CMP	HARBOR VIEW DR	2.3	18	36	No	6%	418.05	416.70	421.2	0.037	6.8	11.8	10.2	YES	YES	
117	D8	C	CMP	HARBOR VIEW DR	5.5	18	41	No	0%	422.51	418.36	427.5	0.101	11.2	19.5	1.7	no	no	
118	E8	C	CMP	HARBOR VIEW DR	0.0	18	41	No	0%	430.79	0.00	438.4				3.4		no	
119	E8	C	CMP	HARBOR VIEW DR	5.6	24	39	No	0%	449.23	445.23	454.8	0.103	13.7	42.3	7.8	no	no	
120	F8	C	CMP	HARBOR VIEW DR	4.7	18	41	No	0%	442.21	438.27	446.5	0.096	11.0	19.0	3.4	no	no	
121	F8	C	CMP	ROCKY RIDGE DR	0.7	18	91	No	0%	505.34	493.57	501.7	0.129	12.7	22.0	3.6	no	no	
122	F8	C	CMP	ROCKY RIDGE DR	0.0	18	32	No	22%	503.09	497.43	0.0	0.177	14.9	25.8	5.6	no	no	tees into 121, outlet elev estimated
123	F8	C	CMP	SUDDEN VALLEY DR	3.0	24	66	No	0%	450.47	442.64	451.6	0.119	14.8	45.5	10.9	no	no	
124	F8	C	CMP	SUDDEN VALLEY DR	0.0	12	44	No	0%	428.57	0.00	435.1	0.030	4.7	3.6	1.0	no	no	
125	F9	C	CMP	SUDDEN VALLEY DR	0.0	18	80	No	33%	431.77	0.00	431.8				2.1		no	
126	G9	C	CMP	SUDDEN VALLEY GATE 3	3.8	18	69	No	0%	411.16	406.32	414.1	0.070	9.4	16.2	1.4	no	no	
128	B5	C	CMP	HARBOR VIEW DR	0.0	12	35	No	0%	618.91	0.00	625.7				0.5		no	
129	B5	C	CMP	SUDDEN VALLEY DR	0.0	12	13		0%	634.50	0.00	0.0				23.4		YES	MID SDMH NOT ACCESSIBLE - capacity not an issue, combines with 130 to route to 131
130	B5	D+	CMP	SUDDEN VALLEY DR	0.0	36	32	No	6%	632.24	0.00	0.0				23.4		no	potentially reconfigure inlet transition
131	B5	D+	CMP	SUDDEN VALLEY DR	0.0	36	91	No	0%	632.24	619.34	638.9	0.142	21.1	146.5	23.4	no	no	slip line pipe under Sudden Valley Dr
132.1	B4, B5	C-	CMP	SUDDEN VALLEY DR	0.0	36	100	No	0%	662.68	655.90	665.7	0.068	14.6	101.3	17.3	no	no	
132.2	B4, B5	C-	CMP	SUDDEN VALLEY DR		36	218	No	0%									no	Length estimated based on other culvert locations. Outlets to 131.
133	B4	C	CMP	NORTH SUMMIT DR	6.0	24	80	No	50%	679.47	677.10	686.3	0.030	7.4	22.7	16.7	no	YES	
134	B4	C	CMP	TWINFLOWER CIR	3.5	12	46	No	33%	682.25	680.29	685.7	0.043	5.6	4.3	4.1	YES	YES	

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Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
135	A4	C	CMP	NORTH SUMMIT DR	1.9	12	30	No	0%	694.00	693.66	696.7	0.012	2.9	2.2	0	no	no	appears to have no-to-very small drainage area
136	A4	C	CMP	TWINFLOWER CIR	3.9	12	38	No	33%	688.69	687.99	693.3	0.019	3.7	2.9	2.0	no	no	culvert not at the low point, causing isolated areas of flooding
137	H11, H12	B	CMP	MARIGOLD DR	5.0	12	80	No	0%	399.67	398.51	405.1	0.014	3.2	2.5	1.0	no	no	
138	G12	B	CMP	MARIGOLD DR	3.5	12	37	No	0%	401.64	399.87	405.2	0.048	5.9	4.6	0.8	no	no	
139	B9	C	CMP	CLEAR LAKE CT	1.5	12	40	No	50%	347.43	346.77	349.6	0.017	3.5	2.7	2.0	no	no	
140	C9	C	CMP	NORTH POINT DR	0.0	12	26	No	0%	390.98	0.00	393.5				1.1		no	
141	C9	C	CMP	NORTH POINT DR	0.0	12	149	No	0%	384.57	354.42	387.3	0.202	12.1	9.4	0.5	no	no	
142	D9	C	CMP	WINDWARD DR	2.3	12	45	No	33%	462.77	461.76	465.5	0.023	4.1	3.1	0.7	no	no	
143	D10	C	CMP	INLET CIR	2.6	12	45	No	33%	337.05	335.81	340.0	0.028	4.5	3.5	1.9	no	no	
144	D10	C	CMP	INLET CIR	2.7	12	31	No	50%	356.16	354.12	358.8	0.066	6.9	5.3	1.5	no	no	
145	E10	C	CMP	SPINNAKER LN	3.4	12	71	No	83%	323.96	318.31	325.5	0.080	7.6	5.9	0.5	no	no	
146	E10	C	CMP	SPINNAKER LN	0.0	12	33	No	33%	328.87	0.00	331.3				0.4		no	
147	G10	B	CMP	PAR LN	0.0	12	20	No	0%	0.00	0.00	369.3				0.3		no	
148	G10	B	CMP	PAR LN	0.0	12	20	No	0%	0.00	0.00	354.9				0.2		no	
149	F10	C	CMP	WINDWARD DR	0.0	12	37	No	0%	369.52	368.10	373.0	0.038	5.3	4.1	5.0	YES	YES	
150	J11	C	CMP	NIGHTHAWK CIR	0.0	12	20	No	0%	346.82	0.00	349.6				0.2		no	
151	C9	C	CMP	OFFSHORE CT	2.1	12	40	No	100%	426.06	420.31	426.3	0.145	10.3	7.9	0.6	no	no	
152	C9	C	CMP	FAR SUMMIT PL	3.4	12	31	No	33%	352.37	349.02	355.1	0.107	8.8	6.8	0.8	no	no	
153	C9	A	SBP	FAR SUMMIT PL	2.7	16	46	No	0%	376.79	372.69	379.0	0.090	18.1	24.8	6.3	no	YES	
154	D9	C	CMP	WINDWARD DR	2.1	12	40	No	100%	472.64	471.05	474.9	0.040	5.4	4.2	0.8	no	no	
155	D9	C	CMP	WINDWARD DR	2.5	12	35	No	25%	469.14	467.13	471.7	0.058	6.5	5.0	1.6	no	no	
156	D9	B	CMP	WINDWARD DR	6.2	18	61	No	0%	442.30	439.40	448.5	0.048	7.7	13.4	4.5	no	no	
157	D9	C	CMP	NORTH POINT DR	4.2	12	30	No	100%	437.41	434.71	441.3	0.090	8.1	6.2	0.4	no	no	
158	E9	B	SBP	WINDWARD DR	0.9	12	30	No	17%	473.80	473.36	475.5	0.014	5.9	4.6	1.9	no	no	
159	E9	C	CMP	FAIRWAY LN	0.0	12	33	No	100%	498.56	0.00	500.8				0.3		no	
160	D10	C	PVC	INLET CIR	0.0	12	20	No	0%	347.89	0.00	349.6				1.4		no	
161	F13	C	CMP	SUNFLOWER CIR	0.0	12	28	No	17%	405.37	0.00	407.5				1.2		no	
162	B4	C	CMP	SUDDEN VALLEY DR	0.0	12	40	No	100%	0.00	0.00	734.0				1.6		no	
163	C4	C	CMP	SUDDEN VALLEY DR	0.0	12	47	No	100%	733.36	0.00	735.1				1.2		no	
164	C4	C	CMP	WHITE MOUNTAIN LN	0.0	12	43	No	83%	768.89	0.00	769.5	0.010	2.7	2.1	0.4	no	no	
165	C4	C	CMP	SUDDEN VALLEY DR	0.0	24	85	No	58%	665.63	0.00	672.5	0.015	5.2	16.2	2.2	no	no	
166	C5	C-	CMP	SUDDEN VALLEY DR	2.1	18	49	No	0%	661.87	660.88	665.0	0.020	5.0	8.7	18.7	YES	YES	Bad joint separation, no homes upstream
167	D5	D	CMP	SUDDEN VALLEY DR	7.4	36	90	No	33%	655.65	655.10	665.8	0.006	4.4	30.3	22.0	no	no	Inadequate slope, reconfigure pipe alignment
168	D5	B	PVC	BLACK BEAR CT	2.1	12	37	No	33%	661.04	660.87	664.0	0.005	3.4	2.6	1.7	no	no	
169	B4	C	CMP	STABLE LN	2.5	12	35	No	50%	689.54	688.07	692.3	0.043	5.6	4.3	1.7	no	no	
170	C5	C	CMP	PARKVIEW CIR	0.0	12	28	No	0%	0.00	0.00	672.6				3.5		YES	
171	C5	C	CMP	STABLE LN	3.0	12	32	No	83%	673.25	671.91	676.5	0.041	5.5	4.2	1.4	no	no	
172	C5	C	CMP	STABLE LN	0.0	18	33	No	89%	0.00	0.00	678.8				1.3		no	
173	D6	C	SBP	STABLE LN	0.0	12	47	No	33%	685.69	0.00	687.5				0.4		no	
174	D6	C	CMP	TAWNY CIR	1.2	12	31	No	67%	683.12	683.06	685.3	0.002	1.1	0.9	0.3	no	no	
175	D6	C	CMP	STABLE LN	2.2	12	51	No	25%	682.48	681.70	685.3	0.015	3.3	2.6	2.1	no	no	
176	D6	C	CMP	LOST FORK LN	1.4	12	49	No	25%	680.49	678.81	682.1	0.034	5.0	3.8	2.8	no	YES	
177	D6	C	CMP	CANYON CT	2.1	12	35	No	0%	692.50	691.76	695.2	0.021	3.9	3.0	0.5	no	no	
178	C6	C	CMP	CANYON CT	2.5	12	39	No	33%	697.57	697.23	700.9	0.009	2.5	1.9	0.1	no	no	
179	D6	C	CMP	LOST FORK LN	3.1	12	29	No	83%	670.47	670.06	674.3	0.014	3.2	2.4	0.4	no	no	
180	D6	C	CMP	STRAWBERRY CANYON CT	4.4	12	45	No	0%	655.42	654.74	660.5	0.015	3.3	2.6	4.5	YES	YES	
181	E6	A	SBP	LOST FORK LN	6.4	32	59	No	0%	621.04	617.10	628.5	0.066	24.6	135.0	33.7	no	YES	
182	E6	D+	CMP	LOST FORK LN	0.0	12	32	No	25%	642.98	640.80	0.0	0.069	7.1	5.5	5.2	YES	YES	Gravel Driveway
183	C5	C	CMP	CANYON CT	1.3	12	72	No	0%	660.37	654.37	659.7	0.083	7.8	6.0	2.5	no	no	

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Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
184	C4	C	CMP	QUARTZ RIDGE LN	2.8	12	56	No	67%	662.02	657.06	663.3	0.088	8.0	6.2	1.3	no	no	
185	C4	C	CMP	SHORT CIR	0.0	12	45	No	58%	0.00	665.38	672.9				0.7		no	
186	D2	C	CMP	SHOOTING STAR CT	0.0	12	60	No	25%	544.14	0.00	546.9				0.5		no	
187	D2	C	CMP	POLO PARK DR	0.0	16	40	No	75%	0.00	0.00	532.2				0.9		no	
188	D3	B	CMP	POLO PARK DR	3.5	12	39	No	83%	529.70	527.79	533.3	0.049	6.0	4.6	1.6	no	no	
189	F7	D+	CMP	LITTLE STRAWBERRY LN	9.5	36	81	Yes	0%	528.48	525.80	539.7	0.033	10.2	70.7	52.9	no	YES	Replace with fish passable box culvert
190	F7	C	CMP	LITTLE STRAWBERRY LN	0.0	12	37	No	17%	0.00	530.78	534.1				2.2		no	
191	G7	C	CMP	ALDER CT	0.0	12	47	No	100%	0.00	531.69	536.1				0.9		no	
192	G8	C	CMP	ROCKY RIDGE DR	0.0	12	31	No	8%	600.31	0.00	604.1				1.3		no	
193	G8	D	CMP	VALLEY CREST WAY	1.4	12	30	No	50%	577.82	576.98	579.8	0.028	4.5	3.5	0.4	no	no	
194	G8	D	CMP	ROCKY RIDGE DR	0.0	12	44	No	67%	579.09	575.86	579.5	0.074	7.3	5.6	0.1	no	no	
196	D7	C	CMP	HILLSIDE PL	0.0	12	19	No	25%	624.03	622.38	626.0	0.087	8.0	6.1	2.8	no	YES	
197	D7, E7	C	CMP	HILLSIDE PL	2.2	12	41	No	50%	625.89	622.34	627.3	0.086	7.9	6.1	2.4	no	no	
198	D7	C	CMP	CASCADE LN	2.8	18	37	No	0%	529.49	526.13	531.7	0.091	10.7	18.5	6.8	no	no	measured diam = 18"
199	D3	C	CMP	MEADOW CT	0.0	12	44	No	50%	0.00	467.66	476.9				4.0		YES	
200	D3	C	CMP	YEARLING PL	0.0	12	34	No	17%	489.36	488.17	491.0	0.035	5.0	3.9	8.2	YES	YES	BOTH ENDS CRUSHED AND OUTLET FULL OF SEDIMENT
201	F6	D	CMP	FAWN CT	0.0	18	43	No	22%	506.45	506.24	511.0	0.005	2.5	4.3	15.8	YES	YES	Inadequate slope, reconfigure pipe alignment
202	A6	C	CMP	PLUM LN	3.4	12	36	No	67%	482.97	481.36	486.6	0.044	5.7	4.4	1.3	no	no	
203	H11, H12	C	CMP	LAKE LOUISE DR	0.0	18	61	No	0%	0.00	406.06	409.1				2.3		no	
204	H11, I11	C	CMP	LAKE LOUISE DR	3.6	24	44	No	58%	401.71	400.23	406.6	0.034	7.9	24.3	3.9	no	no	
205	G9	C	CMP	SPRING RD	4.6	24	39	No	75%	374.87	372.16	380.1	0.069	11.2	34.6	2.0	no	no	
206	G9	C	CMP	SUDDEN VALLEY DR	4.2	12	42	No	33%	441.92	439.90	446.1	0.049	5.9	4.6	0.7	no	no	
207	F5	B	CMP	CREEKSIDE LN	0.0	96	48	Yes	0%	0.00	0.00	433.6				318.2		#N/A	
208	F5	C	CMP	COLD SPRING LN	0.0	12	45	No	33%	0.00	430.36	432.9				3.8		YES	
209	F5, G5	C	CMP	CREEKSIDE LN	1.6	12	28	No	67%	436.29	436.02	438.8	0.010	2.6	2.0	2.1	YES	no	
210	F5	D+	CMP	HONEYCOMB LN	4.2	24	37	Yes	0%	434.18	433.46	440.0	0.019	6.0	18.4	40.9	YES	YES	capacity issue confirmed by model
211	D7	C	CMP	BASIN VIEW CIR	1.6	12	41	No	92%	743.25	742.37	745.4	0.021	4.0	3.0	0.0	no	no	
212	D4	C	CMP	SUMMER BELL LN	2.6	12	41	No	50%	560.81	559.02	563.6	0.044	5.7	4.4	6.2	YES	YES	risk of flooding to road and homes upstream
213	D4	C	CMP	POLO PARK DR	3.7	18	56	No	33%	557.77	555.11	561.6	0.048	7.7	13.4	15.6	YES	YES	risk of flooding to road and homes upstream
214	A5, B5	C	CMP	MAPLE CT	0.0	18	65	No	11%	501.03	498.18	0.0	0.044	7.4	12.8	3.6	no	no	
215	A5	C	CMP		0.0	12	32	No	0%	0.00	0.00	0.0	0.010	2.7	2.1	1.2	no	no	
216	D2	C	CMP	SUNNYSIDE LN	0.0	12	50	No	100%	479.56	0.00	482.7				0.6		no	
217	I6, I7	B	CMP	TUMBLING WATER DR	0.0	156	68	Yes	0%	0.00	0.00	473.3	0.020	21.1	2747.5	425.0	no	#N/A	
219	D4	C	CMP	MEADOW CT	0.0	18	39	No	17%	0.00	0.00	0.0				1.5		no	
221	E7	C	CMP	INGLEWOOD PLACE	0.0	12	36	No	25%	0.00	0.00	0.0	0.030	4.7	3.6	1.7	no	no	
222	H8	C	CMP	RIDGE CREST WAY	0.0	12	22	No	67%	0.00	0.00	0.0	0.010	2.7	2.1	1.9	YES	no	
223	C9	C	CMP	NORTH POINT DR	0.0	18	61	No	0%	396.67	392.70	0.0	0.065	9.0	15.6	6.3	no	no	survey diam. = 18" not original inventory 24"
224	H9	B	CONC	ACORN PLACE	0.0	18	31	No	0%	0.00	0.00	0.0				0.3		no	
225	K9	D+	CMP	LOUISE VIEW DR	0.0	24	79	No	0%	796.73	786.42	0.0	0.131	15.5	47.7	5.7	no	no	Potential slipline with energy dissipation
227	H11	A	SBP	MARIGOLD DR	0.0	36	71		0%	339.93	337.68	347	0.032	18.4	127.9	13.1	no	no	Lake Louise emergency overflow culvert
228	H11	C	SBP	MARIGOLD DR	0.0	18	95		0%	336.40	334.57	346.5	0.019	9.1	15.7	13.1	no	YES	Lake Louise primary discharge culvert
307	J10	B	SBP	LAKE LOUISE DRIVE - DRIVEWAY	0.0	24	20		0%	346.20	345.10	0.0	0.055	18.5	57.0	16.9	no	YES	
308	I8	A	SBP	Wintercress Way	0.0	18	218	No	0%	0.00	0.00	0.0	0.030	11.3	19.6	10.3	no	YES	
314	E6	D+	CMP	BERRY WOOD PLACE	0.0	36	62	Yes	0%	552.49	547.87	0.0	0.075	15.3	106.3	47.5	no	YES	SURVEY DATA UPDATED - field inspection: measure diam = 36"
315	E4, E5	C-	CMP	POLO PARK DR	0.0	24	45	Yes	0%	473.11	471.88	0.0	0.027	7.1	21.8	37.1	YES	YES	measure diam. 24"
329	C8, D8	C-	CMP	Floathaven Sea Plane Base Access	0.0	36	340	Yes	0%	368.28	358.08	0.0	0.030	9.7	67.4	50.3	no	YES	
400	D5	C	CMP	SUDDEN VALLEY DRIVE	2.2	12	38	No	75%	636.61	635.77	639.4	0.022	4.0	3.1	1.7	no	no	cuvert partially crushed at inlet, culver end is 1' beneath natural ground
401	E6	B	SBP	LOST FORK LANE - DRIVEWAY	1.3	12	40	No		633.68	627.82	633.0	0.146	19.1	14.7	5.7	no	YES	

Note: Gray Highlighted Culverts are on the 2015 CIP and Yellow Highlighted Culverts are on the 2016-2025 CIP

Culvert Inventory and Hydraulic Analysis

ID #	Map Tile	Rating	Material	Crossing Street	Average Culvert Cover (ft)	Diameter (in)	Length (ft)	Fish Bearing?	PERCENT FULL	UPELEV	DOWNELEV	CROWN	Slope (ft/ft)	V (ft/s)	Max Capacity, Q (ft3/s)	25-yr, 24-hr design storm Runoff Flow to culvert (cfs)	potential capacity issues	Flow greater than min. recommended culvert size based on inlet control?	Notes
402	E6	C	CMP	LOST FORK LANE - DRIVEWAY	1.1	24	41	No		632.28	628.29	633.4	0.097	13.4	41.2	7.4	no	no	
403	E5	C	CMP	MORNING GLORY DRIVE		18	60	No		480.61	478.59		0.034	6.5	11.2	6.5	no	no	culvert corroded at inlet
404	E5	C	CMP	POLO PARK DRIVE - DRIVEWAY	1.5	18	79	No		478.40	474.46	479.5	0.050	7.9	13.7	6.5	no	no	
405	E4	B	SBP	POLO PARK DRIVE - DRIVEWAY	5.5	12	108	No		451.75	441.49	453.1	0.095	15.4	11.8	0.7	no	no	
406	G8	C	CMP	ROCKY RIDGE DRIVE - DRIVEWAY		12	49	No		576.45	575.62		0.017	3.5	2.7	0.8	no	no	
407	G8	C	CMP	ROCKY RIDGE DRIVE		12	65	No		575.81	572.78		0.047	5.8	4.5	1.0	no	no	
408.1	I11	D	CMP	LARKSPUR COURT TRAIL		10	20	Yes								10.7		YES	Pump station flooding issues, possibly located on
408.2	I11	D	CMP	LARKSPUR COURT TRAIL	1.3	12	20	Yes		344.43	343.72	346.4	0.035	5.1	3.9	10.7	YES	YES	private property, in shoreline
409	I11	C	CMP	LAKE LOUISE DRIVE - DRIVEWAYS	11.5	24	396			397.01	390.21	407.1	0.017	5.6	17.3	7.3	no	no	
410	H11	C	CMP	LAKE LOUISE DRIVE - DRIVEWAYS	0.8	12	122	No	50%	404.30	403.24	405.6	0.009	2.5	1.9	2.1	YES	no	
411	E10	C	CMP	WINDWARD DRIVE	28.5	18	296	No		419.62	367.50	423.6	0.176	14.8	25.7	4.3	no	no	
412	E10	C	CMP	MARINA DRIVE	2.5	12	67	No		357.30	350.47	357.3	0.102	8.6	6.6	0.8	no	no	outlet to CB
413	E10	C	CMP	JUBILEE LANE - DRIVEWAY		12	71	No		350.47	340.61		0.139	10.1	7.7	0.8	no	no	CB inlet and outlet
414	E10	C	CMP	JUBILEE LANE	3.9	12	21	No		340.46	338.90	344.5	0.074	7.4	5.7	1.6	no	no	CB inlet and outlet
415	E10	C	CMP	BIRDIE LANE	2.4	12	48	No		402.15	400.90	404.9	0.026	4.4	3.4	1.7	no	no	CB inlet and outlet
416	E10, F10	C	CMP	WINDWARD DRIVE - DRIVEWAYS		12	242	No		400.85	391.53		0.039	5.3	4.1	1.8	no	no	CB inlet and outlet
417	D10	C-	CMP	LONGSHORE LANE	1.7	12	32	No	50%	338.61	337.05	340.6	0.049	6.0	4.6	5.9	YES	YES	upstream half is PVC, downstream half is CMP
418	C8, D8	C	CONC	Floathaven Sea Plane Base Access	4.2	36	60			378.31	378.09	385.4	0.004	5.4	37.7	0.1	no	no	
419	D8	C	CMP	Floathaven Sea Plane Base Access	18.7	12	85			366.08	358.08	381.8	0.094	8.3	6.4	8.9	YES	YES	joins culvert 329 buried somewhere mid-span
420	C9	C	CONC	SANWICK POINT COURT		12	71	No		397.03	387.35	392.1	0.136	15.9	12.3	0.4	no	no	
421	C9	C	CONC	NORTH POINT DRIVE - DRIVEWAY	0.7	12	25	No	50%	402.59	401.04	403.5	0.062	10.7	8.3	0.4	no	no	
422	C9	C	CONC	NORTH POINT DRIVE - DRIVEWAY	1.0	12	35	No		408.73	406.67	409.8	0.059	10.5	8.1	0.3	no	no	
423	C9	C	CMP	NORTH POINT DRIVE - DRIVEWAY	1.5	12	20	No		425.62	423.19	426.9	0.122	9.4	7.2	0.1	no	no	
424	C9	C	CMP	NORTH POINT DRIVE - DRIVEWAY	0.9	12	21	No		432.03	430.19	433.0	0.088	8.0	6.2	0.1	no	no	outlet invert partially covered with large river rock
425	C9	C	CMP	NORTH POINT DRIVE - DRIVEWAY	2.4	24	42	No		411.58	410.68	415.5	0.021	6.3	19.3	5.9	no	no	
426	C9	B	SBP	NORTH POINT DRIVE - DRIVEWAY	2.6	12	31	No		410.23	409.15	413.3	0.035	9.3	7.2	6.0	no	YES	
427	C9	C	CONC	NORTH POINT DRIVE - DRIVEWAY	1.2	12	22	No		407.62	406.58	409.3	0.047	9.4	7.2	6.1	no	YES	
428	C9	C	CMP	NORTH POINT DRIVE - DRIVEWAY	1.7	12	21	No		405.39	404.13	407.5	0.060	6.6	5.1	6.2	YES	YES	
429	E5	C	CMP	POLO PARK DR	1.1	30	26	Yes		471.69	471.88	475.4	-0.007			37.1		YES	
430	E7	C	CMP	BERRY WOOD PLACE - DRIVEWAY	1.8	12	26	No		566.91	562.80	567.6	0.158	10.7	8.3	1.4	no	no	
431	E3	C	CMP	LOST LAKE LANE	4.5	18	74	No	50%	463.54	462.34	468.9	0.016	4.5	7.8	8.9	YES	YES	
432	D6	D+	CMP	STRAWBERRY CANYON CT	5.4	24	119	No		649.73	644.08	654.3	0.047	9.3	28.8	25.8	YES	YES	sinkholes are developing around the intersection of culverts.
433	D6	C	CMP	STRAWBERRY CANYON CT	5.8	12	47	No		651.85	645.36	655.4	0.138	10.0	7.7	0.5	no	no	sinkholes are developing around the intersection of culverts and threatened by dirt and debris inundation. Downstream elevation estimated.
434	J8	C	CMP	SALAL CIRCLE	3.7	12	49	No		771.77	770.12	775.6	0.034	5.0	3.8	1.0	no	no	
435	K8	C	CMP	PINEDROP PLACE	3.2	18	31	No		753.94	751.72	757.6	0.072	9.5	16.4	1.2	no	no	
436	K8	C	CMP	PINEDROP PLACE	3.2	12	21	No		742.19	740.27	745.5	0.091	8.2	6.3	1.6	no	no	
437	K8	C	CMP	LOGANBERRY LANE	3.4	24	50	No		866.97	864.62	871.2	0.047	9.3	28.6	1.0	no	no	
438	J9	C	CMP	OVERLAKE COURT	4.9	20	41	No		645.63	637.98	648.4	0.187	16.4	35.1	7.4	no	no	
439	F10	C	CMP	JUBILEE LANE - DRIVEWAY		12	62	No		357.25	355.09		0.035	5.0	3.9	0.3	no	no	
440	F10	C	CMP	JUBILEE LANE - DRIVEWAY		12	60	No		355.59						0.3		no	
441	F10	C	CPP	JUBILEE LANE - DRIVEWAY		18	27	No								0.5		no	
442	F10	C	CMP	JUBILEE LANE		20	31	No			350.20					5.8		no	
443	F10	C	CMP	JUBILEE LANE		20	62	No		350.15	322.04		0.453	25.5	54.7	5.8	no	no	
444	K11, K12	C	CMP	SOUTHERN CT	5.1	24	60	No		505.13	497.58	508.5	0.126	15.2	46.8	0.4	no	no	
445	H11, H12	C	CMP	LAKE LOUISE ROAD		12	182	No	75%	460.13	404.88		0.304	14.9	11.5	1.6	no	no	
446	K10	C	CMP	STARVIEW LANE	3.3	18	28	No		802.26	800.29	806.1	0.070	9.4	16.3	0.6	no	no	

Note: Gray Highlighted Culverts are on the 2015 CIP and Yellow Highlighted Culverts are on the 2016-2025 CIP

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  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.001)
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  2013-058B - Sudden Valley Community Association, Stormwater Inventory, Phase II - Hydrologic and Hydraulic
Analysis

  ***********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  ***********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CFS
  Process Models:
    Rainfall/Runoff ........ YES
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ YES
    Water Quality .......... NO
  Infiltration Method ...... CURVE_NUMBER
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ APR-03-2014 00:00:00
  Ending Date .............. APR-05-2014 00:00:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:10:00
  Wet Time Step ............ 00:10:00
  Dry Time Step ............ 01:00:00
  Routing Time Step ........ 1.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Head Tolerance ........... 0.005000 ft


  *************
  Element Count
  *************
  Number of rain gages ...... 1
  Number of subcatchments ... 21
  Number of nodes ........... 24
  Number of links ........... 23
  Number of pollutants ...... 0
  Number of land uses ....... 0
```

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
1	2-yr_24-hr	CUMULATIVE	10 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
Basin1	187.20	13600.00	20.00	35.4000	1	LakeWhatcom
Basin2	35.90	3300.00	26.00	35.9000	1	LakeWhatcom
Basin3	27.60	6530.00	32.00	25.2000	1	LakeWhatcom
Basin4	85.00	10500.00	28.30	26.7000	1	LakeWhatcom
Basin5	151.60	11700.00	25.00	24.0000	1	LakeWhatcom
Basin6	28.40	3800.00	18.00	15.7000	1	LakeWhatcom
Basin7	29.60	2092.00	25.00	17.3000	1	LakeWhatcom
Basin8	138.50	7600.00	20.00	14.2000	1	LakeWhatcom
Basin9	571.10	49950.00	16.00	32.4000	1	AustinCreekOutlet
Basin10	81.30	5160.00	25.00	21.3000	1	LakeWhatcom
Basin11	265.60	14175.00	31.00	31.9000	1	LakeLouiseDam
Basin12	88.60	11655.00	7.00	41.5000	1	LakeWhatcom
Basin13	68.50	5660.00	4.00	21.7000	1	LakeWhatcom
Basin14	152.30	9240.00	3.00	51.5000	1	LakeWhatcom
Basin15	1054.50	73825.00	1.00	23.6000	1	C-54_US
Basin16	143.00	18116.00	21.00	22.6000	1	C-207_US
Basin17	107.20	14750.00	23.00	25.9000	1	C-210_US
Basin18	124.10	15580.00	34.00	25.4000	1	C-40_US
Basin19	971.90	74690.00	1.10	39.1000	1	C-4_US
Basin20	379.20	25025.00	0.90	45.4000	1	C-24_US
Basin21	1661.60	108000.00	1.90	52.8000	1	C-217_US

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Node Summary
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Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
C-54_US	JUNCTION	478.99	8.78	1600.0	
C-54_DS	JUNCTION	478.81	8.96	1600.0	
C-4_US	JUNCTION	468.02	11.05	1600.0	

C-4_DS	JUNCTION	467.93	11.14	1600.0
C-22_US	JUNCTION	457.67	12.93	1600.0
C-22_DS	JUNCTION	457.59	13.01	1600.0
C-24_US	JUNCTION	459.40	7.13	1600.0
C-24_DS	JUNCTION	457.39	9.14	1600.0
20-16	JUNCTION	452.05	6.00	1600.0
C-207_US	JUNCTION	425.92	8.00	1600.0
C-207_DS	JUNCTION	425.50	8.07	1600.0
C-210_US	JUNCTION	434.18	5.80	1600.0
C-210_DS	JUNCTION	433.46	6.52	1600.0
17-9	JUNCTION	423.75	6.00	1600.0
C-40_US	JUNCTION	420.98	4.53	1600.0
C-40_DS	JUNCTION	420.08	6.00	1600.0
18-9	JUNCTION	410.94	6.00	1600.0
C-217_US	JUNCTION	455.11	18.18	1600.0
C-217_DS	JUNCTION	454.14	19.15	1600.0
21-9	JUNCTION	400.11	6.00	1600.0
C-19_DS	JUNCTION	324.66	6.00	1600.0
AustinCreekOutlet	JUNCTION	313.20	6.00	43560.0
LakeWhatcom	OUTFALL	313.00	6.00	0.0
LakeLouiseDam	STORAGE	336.40	7.60	1585584.0

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Link Summary
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Name	From Node	To Node	Type	Length	%Slope	Roughness
C-54	C-54_US	C-54_DS	CONDUIT	47.0	0.3830	0.0240
Reach54-4	C-54_DS	C-4_US	CONDUIT	900.0	1.1990	0.0400
C-4	C-4_US	C-4_DS	CONDUIT	40.0	0.2250	0.0240
Reach4-22	C-4_DS	C-22_US	CONDUIT	1200.0	0.8550	0.0400
C-22	C-22_US	C-22_DS	CONDUIT	49.0	0.1633	0.0240
Reach22-24	C-22_DS	20-16	CONDUIT	1260.0	0.4397	0.0400
C-24	C-24_US	C-24_DS	CONDUIT	48.0	4.1912	0.0240
Reach24-Basin16	C-24_DS	20-16	CONDUIT	220.0	2.4280	0.0400
Reach24-207	20-16	C-207_US	CONDUIT	2350.0	1.1120	0.0400
C-207	C-207_US	C-207_DS	CONDUIT	48.0	0.8750	0.0240
C-210	C-210_US	C-210_DS	CONDUIT	37.0	1.9463	0.0240
Reach210-Basin9	C-210_DS	17-9	CONDUIT	280.0	3.4699	0.0400
Reach207-Basin9	C-207_DS	17-9	CONDUIT	240.0	0.7292	0.0400
C-40	C-40_US	C-40_DS	CONDUIT	40.0	2.2506	0.0240
Reach40-Basin9	C-40_DS	18-9	CONDUIT	400.0	2.2856	0.0400
Reach-upperB9	17-9	18-9	CONDUIT	1750.0	0.7320	0.0400
C-217	C-217_US	C-217_DS	CONDUIT	68.0	1.4266	0.0240
DamDischarge	LakeLouiseDam	C-19_DS	CONDUIT	920.0	1.0838	0.0350
Reach217-Basin9	C-217_DS	21-9	CONDUIT	1600.0	3.3788	0.0400
Reach-upperMidB9	18-9	21-9	CONDUIT	1500.0	0.7220	0.0400

Reach-lowerMidB9	21-9	C-19_DS	CONDUIT	5600.0	1.3474	0.0400
Reach-lowerB9	C-19_DS	AustinCreekOutlet	CONDUIT	3300.0	0.3473	0.0400
Austin-Lake	AustinCreekOutlet	LakeWhatcom	CONDUIT	30.0	0.6667	0.0400

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Cross Section Summary
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Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C-54	HORIZ_ELLIPSE	6.20	48.79	1.90	7.30	1	286.56
Reach54-4	PARABOLIC	4.00	160.00	2.64	60.00	1	1241.90
C-4	HORIZ_ELLIPSE	6.90	60.43	2.11	9.60	1	292.15
Reach4-22	PARABOLIC	6.00	160.00	3.78	40.00	1	1334.63
C-22	HORIZ_ELLIPSE	6.80	58.69	2.08	9.80	1	239.36
Reach22-24	PARABOLIC	6.00	160.00	3.78	40.00	1	957.07
C-24	HORIZ_ELLIPSE	5.20	34.32	1.59	6.40	1	593.05
Reach24-Basin16	PARABOLIC	6.00	160.00	3.78	40.00	1	2249.02
Reach24-207	PARABOLIC	6.00	160.00	3.78	40.00	1	1522.02
C-207	ARCH	8.00	75.64	2.39	12.00	1	783.73
C-210	CIRCULAR	2.00	3.14	0.50	2.00	1	17.10
Reach210-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2688.63
Reach207-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	1232.51
C-40	CIRCULAR	3.00	7.07	0.75	3.00	1	54.20
Reach40-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2182.08
Reach-upperB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1234.90
C-217	ARCH	13.00	179.25	3.89	17.50	1	3277.83
DamDischarge	CIRCULAR	2.50	4.91	0.63	2.50	1	15.86
Reach217-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2653.09
Reach-upperMidB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1226.44
Reach-lowerMidB9	PARABOLIC	6.00	320.00	3.94	80.00	1	3443.36
Reach-lowerB9	PARABOLIC	6.00	320.00	3.94	80.00	1	1748.09
Austin-Lake	PARABOLIC	6.00	160.00	3.78	40.00	1	1178.50

****
Control Actions Taken
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********** Runoff Quantity Continuity **********	Volume acre-feet	Depth inches
Total Precipitation	1218.453	2.302
Evaporation Loss	0.000	0.000
Infiltration Loss	793.530	1.499

Surface Runoff	398.945	0.754
Final Surface Storage	26.439	0.050
Continuity Error (%)	-0.038	

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	398.945	130.002
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	425.562	138.676
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Seepage Loss	0.000	0.000
Initial Stored Volume	76.828	25.036
Final Stored Volume	50.334	16.402
Continuity Error (%)	-0.026	

Time-Step Critical Elements

None

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step	:	1.00 sec
Average Time Step	:	1.00 sec
Maximum Time Step	:	1.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00

Analysis begun on: Mon Dec 08 15:38:31 2014
Analysis ended on: Mon Dec 08 15:38:38 2014

Total elapsed time: 00:00:07

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.001)
  --------------------------------------------------------------

  2013-058B - Sudden Valley Community Association, Stormwater Inventory, Phase II - Hydrologic and Hydraulic
Analysis

  ***********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  ***********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CFS
  Process Models:
    Rainfall/Runoff ........ YES
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ YES
    Water Quality .......... NO
  Infiltration Method ...... CURVE_NUMBER
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ APR-03-2014 00:00:00
  Ending Date .............. APR-05-2014 00:00:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:10:00
  Wet Time Step ............ 00:10:00
  Dry Time Step ............ 01:00:00
  Routing Time Step ........ 1.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Head Tolerance ........... 0.005000 ft


  *************
  Element Count
  *************
  Number of rain gages ...... 1
  Number of subcatchments ... 21
  Number of nodes ........... 24
```

Number of links 23
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
1	2-yr_24-hr	CUMULATIVE	10 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
Basin1	187.20	13600.00	20.00	35.4000	1	LakeWhatcom
Basin2	35.90	3300.00	26.00	35.9000	1	LakeWhatcom
Basin3	27.60	6530.00	32.00	25.2000	1	LakeWhatcom
Basin4	85.00	10500.00	28.30	26.7000	1	LakeWhatcom
Basin5	151.60	11700.00	25.00	24.0000	1	LakeWhatcom
Basin6	28.40	3800.00	18.00	15.7000	1	LakeWhatcom
Basin7	29.60	2092.00	25.00	17.3000	1	LakeWhatcom
Basin8	138.50	7600.00	20.00	14.2000	1	LakeWhatcom
Basin9	571.10	49950.00	16.00	32.4000	1	AustinCreekOutlet
Basin10	81.30	5160.00	25.00	21.3000	1	LakeWhatcom
Basin11	265.60	14175.00	31.00	31.9000	1	LakeLouiseDam
Basin12	88.60	11655.00	7.00	41.5000	1	LakeWhatcom
Basin13	68.50	5660.00	4.00	21.7000	1	LakeWhatcom
Basin14	152.30	9240.00	3.00	51.5000	1	LakeWhatcom
Basin15	1054.50	73825.00	1.00	23.6000	1	C-54_US
Basin16	143.00	18116.00	21.00	22.6000	1	C-207_US
Basin17	107.20	14750.00	23.00	25.9000	1	C-210_US
Basin18	124.10	15580.00	34.00	25.4000	1	C-40_US
Basin19	971.90	74690.00	1.10	39.1000	1	C-4_US
Basin20	379.20	25025.00	0.90	45.4000	1	C-24_US
Basin21	1661.60	108000.00	1.90	52.8000	1	C-217_US

****
Node Summary

****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
C-54_US	JUNCTION	478.99	8.78	1600.0	
C-54_DS	JUNCTION	478.81	8.96	1600.0	
C-4_US	JUNCTION	468.02	11.05	1600.0	
C-4_DS	JUNCTION	467.93	11.14	1600.0	
C-22_US	JUNCTION	457.67	12.93	1600.0	
C-22_DS	JUNCTION	457.59	13.01	1600.0	
C-24_US	JUNCTION	459.40	7.13	1600.0	
C-24_DS	JUNCTION	457.39	9.14	1600.0	
20-16	JUNCTION	452.05	6.00	1600.0	
C-207_US	JUNCTION	425.92	8.00	1600.0	
C-207_DS	JUNCTION	425.50	8.07	1600.0	
C-210_US	JUNCTION	434.18	5.80	1600.0	
C-210_DS	JUNCTION	433.46	6.52	1600.0	
17-9	JUNCTION	423.75	6.00	1600.0	
C-40_US	JUNCTION	420.98	4.53	1600.0	
C-40_DS	JUNCTION	420.08	6.00	1600.0	
18-9	JUNCTION	410.94	6.00	1600.0	
C-217_US	JUNCTION	455.11	18.18	1600.0	
C-217_DS	JUNCTION	454.14	19.15	1600.0	
21-9	JUNCTION	400.11	6.00	1600.0	
C-19_DS	JUNCTION	324.66	6.00	1600.0	
AustinCreekOutlet	JUNCTION	313.20	6.00	43560.0	
LakeWhatcom	OUTFALL	313.00	6.00	0.0	
LakeLouiseDam	STORAGE	336.40	7.60	1585584.0	

****
Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
C-54	C-54_US	C-54_DS	CONDUIT	47.0	0.3830	0.0240
Reach54-4	C-54_DS	C-4_US	CONDUIT	900.0	1.1990	0.0400
C-4	C-4_US	C-4_DS	CONDUIT	40.0	0.2250	0.0240
Reach4-22	C-4_DS	C-22_US	CONDUIT	1200.0	0.8550	0.0400
C-22	C-22_US	C-22_DS	CONDUIT	49.0	0.1633	0.0240
Reach22-24	C-22_DS	20-16	CONDUIT	1260.0	0.4397	0.0400
C-24	C-24_US	C-24_DS	CONDUIT	48.0	4.1912	0.0240
Reach24-Basin16	C-24_DS	20-16	CONDUIT	220.0	2.4280	0.0400
Reach24-207	20-16	C-207_US	CONDUIT	2350.0	1.1120	0.0400

C-207	C-207_US	C-207_DS	CONDUIT	48.0	0.8750	0.0240
C-210	C-210_US	C-210_DS	CONDUIT	37.0	1.9463	0.0240
Reach210-Basin9	C-210_DS	17-9	CONDUIT	280.0	3.4699	0.0400
Reach207-Basin9	C-207_DS	17-9	CONDUIT	240.0	0.7292	0.0400
C-40	C-40_US	C-40_DS	CONDUIT	40.0	2.2506	0.0240
Reach40-Basin9	C-40_DS	18-9	CONDUIT	400.0	2.2856	0.0400
Reach-upperB9	17-9	18-9	CONDUIT	1750.0	0.7320	0.0400
C-217	C-217_US	C-217_DS	CONDUIT	68.0	1.4266	0.0240
DamDischarge	LakeLouiseDam	C-19_DS	CONDUIT	920.0	1.0838	0.0350
Reach217-Basin9	C-217_DS	21-9	CONDUIT	1600.0	3.3788	0.0400
Reach-upperMidB9	18-9	21-9	CONDUIT	1500.0	0.7220	0.0400
Reach-lowerMidB9	21-9	C-19_DS	CONDUIT	5600.0	1.3474	0.0400
Reach-lowerB9	C-19_DS	AustinCreekOutlet	CONDUIT	3300.0	0.3473	0.0400
Austin-Lake	AustinCreekOutlet	LakeWhatcom	CONDUIT	30.0	0.6667	0.0400

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C-54	HORIZ_ELLIPSE	6.20	48.79	1.90	7.30	1	286.56
Reach54-4	PARABOLIC	4.00	160.00	2.64	60.00	1	1241.90
C-4	HORIZ_ELLIPSE	6.90	60.43	2.11	9.60	1	292.15
Reach4-22	PARABOLIC	6.00	160.00	3.78	40.00	1	1334.63
C-22	HORIZ_ELLIPSE	6.80	58.69	2.08	9.80	1	239.36
Reach22-24	PARABOLIC	6.00	160.00	3.78	40.00	1	957.07
C-24	HORIZ_ELLIPSE	5.20	34.32	1.59	6.40	1	593.05
Reach24-Basin16	PARABOLIC	6.00	160.00	3.78	40.00	1	2249.02
Reach24-207	PARABOLIC	6.00	160.00	3.78	40.00	1	1522.02
C-207	ARCH	8.00	75.64	2.39	12.00	1	783.73
C-210	CIRCULAR	2.00	3.14	0.50	2.00	1	17.10
Reach210-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2688.63
Reach207-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	1232.51
C-40	CIRCULAR	3.00	7.07	0.75	3.00	1	54.20
Reach40-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2182.08
Reach-upperB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1234.90
C-217	ARCH	13.00	179.25	3.89	17.50	1	3277.83
DamDischarge	CIRCULAR	2.50	4.91	0.63	2.50	1	15.86
Reach217-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2653.09
Reach-upperMidB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1226.44
Reach-lowerMidB9	PARABOLIC	6.00	320.00	3.94	80.00	1	3443.36
Reach-lowerB9	PARABOLIC	6.00	320.00	3.94	80.00	1	1748.09

Austin-Lake	PARABOLIC	6.00	160.00	3.78	40.00	1	1178.50

****
Control Actions Taken
****

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	1218.453	2.302
Evaporation Loss	0.000	0.000
Infiltration Loss	793.530	1.499
Surface Runoff	398.945	0.754
Final Surface Storage	26.439	0.050
Continuity Error (%)	-0.038	

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	398.945	130.002
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	425.562	138.676
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Seepage Loss	0.000	0.000
Initial Stored Volume	76.828	25.036
Final Stored Volume	50.334	16.402
Continuity Error (%)	-0.026	

****
Time-Step Critical Elements
****
None

****

Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	1.00 sec
Average Time Step	:	1.00 sec
Maximum Time Step	:	1.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin1	2.30	0.00	0.00	1.24	1.00	5.11	25.82	0.437
Basin2	2.30	0.00	0.00	0.96	1.29	1.26	9.91	0.561
Basin3	2.30	0.00	0.00	0.86	1.39	1.04	9.77	0.602
Basin4	2.30	0.00	0.00	1.06	1.19	2.74	21.37	0.516
Basin5	2.30	0.00	0.00	1.08	1.16	4.80	31.81	0.506
Basin6	2.30	0.00	0.00	1.27	0.98	0.76	4.65	0.426
Basin7	2.30	0.00	0.00	1.17	1.08	0.87	4.80	0.468
Basin8	2.30	0.00	0.00	1.20	1.05	3.95	17.03	0.457
Basin9	2.30	0.00	0.00	1.37	0.88	13.69	57.46	0.384
Basin10	2.30	0.00	0.00	1.07	1.17	2.59	15.91	0.510
Basin11	2.30	0.00	0.00	1.04	1.21	8.76	59.43	0.528
Basin12	2.30	0.00	0.00	1.46	0.79	1.91	8.55	0.345
Basin13	2.30	0.00	0.00	1.56	0.69	1.28	3.82	0.300
Basin14	2.30	0.00	0.00	1.46	0.79	3.26	9.75	0.343
Basin15	2.30	0.00	0.00	1.83	0.43	12.26	35.43	0.186
Basin16	2.30	0.00	0.00	1.34	0.91	3.54	16.66	0.396
Basin17	2.30	0.00	0.00	1.26	0.99	2.89	17.90	0.431
Basin18	2.30	0.00	0.00	0.76	1.49	5.02	42.68	0.648
Basin19	2.30	0.00	0.00	1.72	0.54	14.19	42.69	0.234

Basin20	2.30	0.00	0.00	1.72	0.53	5.45	16.20	0.230
Basin21	2.30	0.00	0.00	1.49	0.77	34.62	104.73	0.333

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	hr:min
C-54_US	JUNCTION	0.51	1.50	480.49	0	15:00
C-54_DS	JUNCTION	0.26	0.77	479.58	0	15:01
C-4_US	JUNCTION	0.79	2.33	470.35	0	12:58
C-4_DS	JUNCTION	0.53	1.57	469.50	0	12:59
C-22_US	JUNCTION	0.89	2.65	460.32	0	13:06
C-22_DS	JUNCTION	0.68	2.01	459.60	0	15:08
C-24_US	JUNCTION	0.23	0.73	460.13	0	12:50
C-24_DS	JUNCTION	0.20	0.61	458.00	0	12:50
20-16	JUNCTION	0.56	1.61	453.66	0	13:13
C-207_US	JUNCTION	0.72	2.16	428.08	0	13:16
C-207_DS	JUNCTION	0.66	1.86	427.36	0	13:16
C-210_US	JUNCTION	0.39	2.51	436.69	0	08:10
C-210_DS	JUNCTION	0.14	0.58	434.04	0	08:10
17-9	JUNCTION	0.69	1.89	425.64	0	13:18
C-40_US	JUNCTION	0.42	2.51	423.49	0	08:10
C-40_DS	JUNCTION	0.20	0.96	421.04	0	08:10
18-9	JUNCTION	0.86	2.21	413.15	0	13:26
C-217_US	JUNCTION	0.48	1.58	456.69	0	10:50
C-217_DS	JUNCTION	0.43	1.33	455.47	0	10:50
21-9	JUNCTION	0.61	1.62	401.73	0	13:00
C-19_DS	JUNCTION	1.18	2.29	326.95	0	13:18
AustinCreekOutlet	JUNCTION	1.47	2.85	316.05	0	13:18
LakeWhatcom	OUTFALL	1.08	2.21	315.21	0	13:18
LakeLouiseDam	STORAGE	2.28	2.60	339.00	0	00:00

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
C-54_US	JUNCTION	35.43	35.43	0	15:00	12.3	12.3	-0.000
C-54_DS	JUNCTION	0.00	35.43	0	15:00	0	12.3	0.006
C-4_US	JUNCTION	42.69	75.13	0	12:50	14.2	26.5	-0.003
C-4_DS	JUNCTION	0.00	74.76	0	12:57	0	26.5	-0.012
C-22_US	JUNCTION	0.00	74.73	0	12:59	0	26.5	0.012
C-22_DS	JUNCTION	0.00	74.59	0	13:06	0	26.5	-0.003
C-24_US	JUNCTION	16.20	16.20	0	12:50	5.45	5.45	-0.000
C-24_DS	JUNCTION	0.00	16.20	0	12:50	0	5.45	-0.015
20-16	JUNCTION	0.00	90.27	0	13:06	0	31.9	0.018
C-207_US	JUNCTION	16.66	97.97	0	13:10	3.54	35.4	-0.011
C-207_DS	JUNCTION	0.00	97.84	0	13:16	0	35.4	0.000
C-210_US	JUNCTION	17.90	17.90	0	08:10	2.89	2.89	-0.000
C-210_DS	JUNCTION	0.00	17.90	0	08:10	0	2.89	-0.056
17-9	JUNCTION	0.00	103.88	0	13:14	0	38.3	0.013
C-40_US	JUNCTION	42.68	42.68	0	08:10	5.02	5.02	-0.000
C-40_DS	JUNCTION	0.00	42.68	0	08:10	0	5.02	-0.063
18-9	JUNCTION	0.00	112.64	0	13:13	0	43.4	-0.015
C-217_US	JUNCTION	104.73	104.73	0	10:50	34.6	34.6	-0.000
C-217_DS	JUNCTION	0.00	104.73	0	10:50	0	34.6	-0.020
21-9	JUNCTION	0.00	204.92	0	12:52	0	78	-0.027
C-19_DS	JUNCTION	0.00	219.27	0	13:00	0	95.9	0.307
AustinCreekOutlet	JUNCTION	57.45	247.63	0	13:11	13.7	109	0.149
LakeWhatcom	OUTFALL	154.73	314.49	0	12:50	29.6	139	0.000
LakeLouiseDam	STORAGE	59.43	59.43	0	08:00	8.76	33.8	-0.037

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
C-210_US	JUNCTION	0.43	0.513	3.287
LakeLouiseDam	STORAGE	13.99	0.100	5.000

****
Node Flooding Summary
****

No nodes were flooded.

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Evap Pcnt Loss	Infil Pcnt Loss	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
LakeLouiseDam	2917.591	28	0	0	3344.506	32	0 00:00	15.43

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CFS	Max Flow CFS	Total Volume 10^6 gal
LakeWhatcom	99.57	107.75	314.49	138.666
System	99.57	107.75	314.49	138.666

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
C-54	CONDUIT	35.43	0 15:00	6.30	0.12	0.18

Reach54-4	CONDUIT	35.40	0	15:01	0.92	0.03	0.39
C-4	CONDUIT	74.76	0	12:57	5.96	0.26	0.28
Reach4-22	CONDUIT	74.73	0	12:59	2.25	0.06	0.35
C-22	CONDUIT	74.59	0	13:06	4.58	0.31	0.34
Reach22-24	CONDUIT	74.60	0	13:10	2.82	0.08	0.30
C-24	CONDUIT	16.20	0	12:50	6.62	0.03	0.13
Reach24-Basin16	CONDUIT	16.20	0	12:50	1.99	0.01	0.18
Reach24-207	CONDUIT	90.14	0	13:13	3.20	0.06	0.31
C-207	CONDUIT	97.84	0	13:16	5.09	0.12	0.25
C-210	CONDUIT	17.90	0	08:10	8.34	1.05	0.65
Reach210-Basin9	CONDUIT	17.85	0	08:10	2.37	0.01	0.19
Reach207-Basin9	CONDUIT	97.84	0	13:17	3.50	0.08	0.31
C-40	CONDUIT	42.68	0	08:10	10.08	0.79	0.58
Reach40-Basin9	CONDUIT	42.65	0	08:10	2.61	0.02	0.24
Reach-upperB9	CONDUIT	103.84	0	13:18	3.25	0.08	0.34
C-217	CONDUIT	104.73	0	10:50	6.36	0.03	0.11
DamDischarge	CONDUIT	15.43	0	00:01	3.83	0.97	0.76
Reach217-Basin9	CONDUIT	104.63	0	10:50	5.91	0.04	0.24
Reach-upperMidB9	CONDUIT	112.28	0	13:20	3.90	0.09	0.32
Reach-lowerMidB9	CONDUIT	203.88	0	13:00	3.65	0.06	0.33
Reach-lowerB9	CONDUIT	217.70	0	13:18	2.43	0.12	0.43
Austin-Lake	CONDUIT	247.44	0	13:18	5.65	0.21	0.42

****
Flow Classification Summary
****

	Adjusted	Fraction of Time in Flow Class								
	/Actual		Up	Down	Sub	Sup	Up	Down	Norm	Inlet
Conduit	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl
C-54	1.00	0.03	0.43	0.00	0.24	0.29	0.00	0.00	0.46	0.00
Reach54-4	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.60	0.00
C-4	1.00	0.03	0.15	0.00	0.81	0.00	0.00	0.00	0.42	0.00
Reach4-22	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.60	0.00
C-22	1.00	0.04	0.02	0.00	0.94	0.00	0.00	0.00	0.39	0.00
Reach22-24	1.00	0.03	0.01	0.00	0.96	0.00	0.00	0.00	0.46	0.00
C-24	1.00	0.03	0.45	0.00	0.13	0.39	0.00	0.00	0.57	0.00
Reach24-Basin16	1.00	0.03	0.00	0.00	0.96	0.01	0.00	0.00	0.95	0.00
Reach24-207	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.54	0.00
C-207	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.56	0.00
C-210	1.00	0.03	0.00	0.00	0.47	0.50	0.00	0.00	0.24	0.00

Reach210-Basin9	1.00	0.03	0.00	0.00	0.96	0.01	0.00	0.00	0.96	0.00
Reach207-Basin9	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.67	0.00
C-40	1.00	0.03	0.10	0.00	0.37	0.50	0.00	0.00	0.46	0.00
Reach40-Basin9	1.00	0.03	0.00	0.00	0.96	0.01	0.00	0.00	0.95	0.00
Reach-upperB9	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.96	0.00
C-217	1.00	0.03	0.44	0.00	0.15	0.38	0.00	0.00	0.58	0.00
DamDischarge	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Reach217-Basin9	1.00	0.03	0.00	0.00	0.88	0.09	0.00	0.00	0.92	0.00
Reach-upperMidB9	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.40	0.00
Reach-lowerMidB9	1.00	0.00	0.03	0.00	0.97	0.00	0.00	0.00	0.97	0.00
Reach-lowerB9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.97	0.00
Austin-Lake	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C-210	0.01	0.01	0.01	0.22	0.01

Analysis begun on: Mon Dec 08 15:38:31 2014
Analysis ended on: Mon Dec 08 15:38:38 2014
Total elapsed time: 00:00:07

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.001)
  --------------------------------------------------------------

  2013-058B - Sudden Valley Community Association, Stormwater Inventory, Phase II - Hydrologic and Hydraulic
Analysis

  ***********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  ***********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CFS
  Process Models:
    Rainfall/Runoff ........ YES
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ YES
    Water Quality .......... NO
  Infiltration Method ...... CURVE_NUMBER
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ APR-03-2014 00:00:00
  Ending Date .............. APR-05-2014 00:00:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:10:00
  Wet Time Step ............ 00:10:00
  Dry Time Step ............ 01:00:00
  Routing Time Step ........ 1.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Head Tolerance ........... 0.005000 ft


  *************
  Element Count
  *************
  Number of rain gages ...... 1
  Number of subcatchments ... 21
  Number of nodes ........... 24
  Number of links ........... 23
  Number of pollutants ...... 0
  Number of land uses ....... 0
```

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
1	25-yr_24-hr	CUMULATIVE	10 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
Basin1	187.20	13600.00	20.00	35.4000	1	LakeWhatcom
Basin2	35.90	3300.00	26.00	35.9000	1	LakeWhatcom
Basin3	27.60	6530.00	32.00	25.2000	1	LakeWhatcom
Basin4	85.00	10500.00	28.30	26.7000	1	LakeWhatcom
Basin5	151.60	11700.00	25.00	24.0000	1	LakeWhatcom
Basin6	28.40	3800.00	18.00	15.7000	1	LakeWhatcom
Basin7	29.60	2092.00	25.00	17.3000	1	LakeWhatcom
Basin8	138.50	7600.00	20.00	14.2000	1	LakeWhatcom
Basin9	571.10	49950.00	16.00	32.4000	1	AustinCreekOutlet
Basin10	81.30	5160.00	25.00	21.3000	1	LakeWhatcom
Basin11	265.60	14175.00	31.00	31.9000	1	LakeLouiseDam
Basin12	88.60	11655.00	7.00	41.5000	1	LakeWhatcom
Basin13	68.50	5660.00	4.00	21.7000	1	LakeWhatcom
Basin14	152.30	9240.00	3.00	51.5000	1	LakeWhatcom
Basin15	1054.50	73825.00	1.00	23.6000	1	C-54_US
Basin16	143.00	18116.00	21.00	22.6000	1	C-207_US
Basin17	107.20	14750.00	23.00	25.9000	1	C-210_US
Basin18	124.10	15580.00	34.00	25.4000	1	C-40_US
Basin19	971.90	74690.00	1.10	39.1000	1	C-4_US
Basin20	379.20	25025.00	0.90	45.4000	1	C-24_US
Basin21	1661.60	108000.00	1.90	52.8000	1	C-217_US

****
Node Summary
****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
C-54_US	JUNCTION	478.99	8.78	1600.0	
C-54_DS	JUNCTION	478.81	8.96	1600.0	
C-4_US	JUNCTION	468.02	11.05	1600.0	

C-4_DS	JUNCTION	467.93	11.14	1600.0	
C-22_US	JUNCTION	457.67	12.93	1600.0	
C-22_DS	JUNCTION	457.59	13.01	1600.0	
C-24_US	JUNCTION	459.40	7.13	1600.0	
C-24_DS	JUNCTION	457.39	9.14	1600.0	
20-16	JUNCTION	452.05	6.00	1600.0	
C-207_US	JUNCTION	425.92	8.00	1600.0	
C-207_DS	JUNCTION	425.50	8.07	1600.0	
C-210_US	JUNCTION	434.18	5.80	1600.0	
C-210_DS	JUNCTION	433.46	6.52	1600.0	
17-9	JUNCTION	423.75	6.00	1600.0	
C-40_US	JUNCTION	420.98	4.53	1600.0	
C-40_DS	JUNCTION	420.08	6.00	1600.0	
18-9	JUNCTION	410.94	6.00	1600.0	
C-217_US	JUNCTION	455.11	18.18	1600.0	
C-217_DS	JUNCTION	454.14	19.15	1600.0	
21-9	JUNCTION	400.11	6.00	1600.0	
C-19_DS	JUNCTION	324.66	6.00	1600.0	
AustinCreekOutlet	JUNCTION	313.20	6.00	43560.0	
LakeWhatcom	OUTFALL	313.00	6.00	0.0	
LakeLouiseDam	STORAGE	336.40	7.60	1585584.0	

****
Link Summary
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Name	From Node	To Node	Type	Length	%Slope	Roughness
C-54	C-54_US	C-54_DS	CONDUIT	47.0	0.3830	0.0240
Reach54-4	C-54_DS	C-4_US	CONDUIT	900.0	1.1990	0.0400
C-4	C-4_US	C-4_DS	CONDUIT	40.0	0.2250	0.0240
Reach4-22	C-4_DS	C-22_US	CONDUIT	1200.0	0.8550	0.0400
C-22	C-22_US	C-22_DS	CONDUIT	49.0	0.1633	0.0240
Reach22-24	C-22_DS	20-16	CONDUIT	1260.0	0.4397	0.0400
C-24	C-24_US	C-24_DS	CONDUIT	48.0	4.1912	0.0240
Reach24-Basin16	C-24_DS	20-16	CONDUIT	220.0	2.4280	0.0400
Reach24-207	20-16	C-207_US	CONDUIT	2350.0	1.1120	0.0400
C-207	C-207_US	C-207_DS	CONDUIT	48.0	0.8750	0.0240
C-210	C-210_US	C-210_DS	CONDUIT	37.0	1.9463	0.0240
Reach210-Basin9	C-210_DS	17-9	CONDUIT	280.0	3.4699	0.0400
Reach207-Basin9	C-207_DS	17-9	CONDUIT	240.0	0.7292	0.0400
C-40	C-40_US	C-40_DS	CONDUIT	40.0	2.2506	0.0240
Reach40-Basin9	C-40_DS	18-9	CONDUIT	400.0	2.2856	0.0400
Reach-upperB9	17-9	18-9	CONDUIT	1750.0	0.7320	0.0400
C-217	C-217_US	C-217_DS	CONDUIT	68.0	1.4266	0.0240
DamDischarge	LakeLouiseDam	C-19_DS	CONDUIT	920.0	1.0838	0.0350
Reach217-Basin9	C-217_DS	21-9	CONDUIT	1600.0	3.3788	0.0400
Reach-upperMidB9	18-9	21-9	CONDUIT	1500.0	0.7220	0.0400

Reach-lowerMidB9	21-9	C-19_DS	CONDUIT	5600.0	1.3474	0.0400
Reach-lowerB9	C-19_DS	AustinCreekOutlet	CONDUIT	3300.0	0.3473	0.0400
Austin-Lake	AustinCreekOutlet	LakeWhatcom	CONDUIT	30.0	0.6667	0.0400

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Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C-54	HORIZ_ELLIPSE	6.20	48.79	1.90	7.30	1	286.56
Reach54-4	PARABOLIC	4.00	160.00	2.64	60.00	1	1241.90
C-4	HORIZ_ELLIPSE	6.90	60.43	2.11	9.60	1	292.15
Reach4-22	PARABOLIC	6.00	160.00	3.78	40.00	1	1334.63
C-22	HORIZ_ELLIPSE	6.80	58.69	2.08	9.80	1	239.36
Reach22-24	PARABOLIC	6.00	160.00	3.78	40.00	1	957.07
C-24	HORIZ_ELLIPSE	5.20	34.32	1.59	6.40	1	593.05
Reach24-Basin16	PARABOLIC	6.00	160.00	3.78	40.00	1	2249.02
Reach24-207	PARABOLIC	6.00	160.00	3.78	40.00	1	1522.02
C-207	ARCH	8.00	75.64	2.39	12.00	1	783.73
C-210	CIRCULAR	2.00	3.14	0.50	2.00	1	17.10
Reach210-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2688.63
Reach207-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	1232.51
C-40	CIRCULAR	3.00	7.07	0.75	3.00	1	54.20
Reach40-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2182.08
Reach-upperB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1234.90
C-217	ARCH	13.00	179.25	3.89	17.50	1	3277.83
DamDischarge	CIRCULAR	2.50	4.91	0.63	2.50	1	15.86
Reach217-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2653.09
Reach-upperMidB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1226.44
Reach-lowerMidB9	PARABOLIC	6.00	320.00	3.94	80.00	1	3443.36
Reach-lowerB9	PARABOLIC	6.00	320.00	3.94	80.00	1	1748.09
Austin-Lake	PARABOLIC	6.00	160.00	3.78	40.00	1	1178.50

****
Control Actions Taken
****

********** Runoff Quantity Continuity **********	Volume acre-feet	Depth inches
Total Precipitation	1854.168	3.502
Evaporation Loss	0.000	0.000
Infiltration Loss	986.716	1.864

Surface Runoff	841.740	1.590
Final Surface Storage	26.548	0.050
Continuity Error (%)	-0.045	

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	841.740	274.294
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	853.131	278.005
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Seepage Loss	0.000	0.000
Initial Stored Volume	76.828	25.036
Final Stored Volume	65.579	21.370
Continuity Error (%)	-0.015	

Time-Step Critical Elements

None

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step	:	1.00 sec
Average Time Step	:	1.00 sec
Maximum Time Step	:	1.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00

Subcatchment Runoff Summary

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin1	3.50	0.00	0.00	1.53	1.93	9.80	65.33	0.550
Basin2	3.50	0.00	0.00	1.14	2.31	2.25	18.56	0.660
Basin3	3.50	0.00	0.00	1.02	2.43	1.82	18.05	0.693
Basin4	3.50	0.00	0.00	1.30	2.15	4.96	40.88	0.613
Basin5	3.50	0.00	0.00	1.31	2.14	8.79	64.31	0.610
Basin6	3.50	0.00	0.00	1.57	1.89	1.45	10.68	0.539
Basin7	3.50	0.00	0.00	1.44	2.01	1.61	10.64	0.573
Basin8	3.50	0.00	0.00	1.46	2.00	7.51	43.42	0.570
Basin9	3.50	0.00	0.00	1.71	1.75	27.07	186.00	0.498
Basin10	3.50	0.00	0.00	1.30	2.15	4.75	33.00	0.615
Basin11	3.50	0.00	0.00	1.27	2.19	15.76	118.94	0.624
Basin12	3.50	0.00	0.00	1.80	1.65	3.97	29.75	0.471
Basin13	3.50	0.00	0.00	1.94	1.51	2.82	14.09	0.432
Basin14	3.50	0.00	0.00	1.78	1.67	6.92	39.16	0.478
Basin15	3.50	0.00	0.00	2.33	1.12	32.04	92.88	0.319
Basin16	3.50	0.00	0.00	1.67	1.78	6.90	47.31	0.508
Basin17	3.50	0.00	0.00	1.56	1.89	5.50	40.86	0.540
Basin18	3.50	0.00	0.00	0.88	2.57	8.67	78.22	0.734
Basin19	3.50	0.00	0.00	2.15	1.30	34.32	128.69	0.371
Basin20	3.50	0.00	0.00	2.18	1.27	13.11	49.27	0.363
Basin21	3.50	0.00	0.00	1.81	1.65	74.25	424.97	0.470

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min
C-54_US	JUNCTION	0.81	2.39	481.38	0 10:50
C-54_DS	JUNCTION	0.41	1.20	480.01	0 10:50
C-4_US	JUNCTION	1.25	4.03	472.05	0 08:55
C-4_DS	JUNCTION	0.82	2.53	470.46	0 08:56
C-22_US	JUNCTION	1.40	4.35	462.02	0 08:59
C-22_DS	JUNCTION	1.06	3.21	460.80	0 09:01
C-24_US	JUNCTION	0.37	1.36	460.76	0 08:50
C-24_DS	JUNCTION	0.30	1.01	458.40	0 08:50
20-16	JUNCTION	0.86	2.60	454.65	0 09:03
C-207_US	JUNCTION	1.22	4.09	430.01	0 09:05

C-207_DS	JUNCTION	1.01	3.07	428.57	0	09:05
C-210_US	JUNCTION	0.68	9.61	443.79	0	08:16
C-210_DS	JUNCTION	0.19	0.82	434.28	0	08:16
17-9	JUNCTION	1.03	3.09	426.84	0	09:04
C-40_US	JUNCTION	0.60	6.16	427.14	0	08:07
C-40_DS	JUNCTION	0.26	1.25	421.33	0	08:07
18-9	JUNCTION	1.25	3.50	414.44	0	09:08
C-217_US	JUNCTION	0.75	3.59	458.70	0	08:10
C-217_DS	JUNCTION	0.62	2.59	456.73	0	08:10
21-9	JUNCTION	0.88	2.77	402.88	0	08:52
C-19_DS	JUNCTION	1.55	3.79	328.45	0	09:04
AustinCreekOutlet	JUNCTION	1.93	4.83	318.03	0	09:05
LakeWhatcom	OUTFALL	1.47	3.84	316.84	0	09:05
LakeLouiseDam	STORAGE	2.74	3.11	339.51	1	00:15

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
C-54_US	JUNCTION	92.88	92.88	0	10:50	32	32	-0.000
C-54_DS	JUNCTION	0.00	92.88	0	10:50	0	32	-0.002
C-4_US	JUNCTION	128.69	212.46	0	08:50	34.3	66.4	0.001
C-4_DS	JUNCTION	0.00	210.17	0	08:54	0	66.4	-0.016
C-22_US	JUNCTION	0.00	209.98	0	08:56	0	66.4	0.016
C-22_DS	JUNCTION	0.00	209.18	0	08:59	0	66.4	-0.003
C-24_US	JUNCTION	49.27	49.27	0	08:50	13.1	13.1	-0.000
C-24_DS	JUNCTION	0.00	49.27	0	08:50	0	13.1	-0.015
20-16	JUNCTION	0.00	255.26	0	08:59	0	79.5	0.014
C-207_US	JUNCTION	47.31	280.80	0	08:58	6.9	86.4	-0.008
C-207_DS	JUNCTION	0.00	279.67	0	09:05	0	86.4	0.000
C-210_US	JUNCTION	40.86	40.86	0	08:10	5.5	5.5	0.000
C-210_DS	JUNCTION	0.00	37.66	0	08:16	0	5.5	-0.057
17-9	JUNCTION	0.00	299.38	0	09:02	0	91.9	0.006
C-40_US	JUNCTION	78.22	78.22	0	08:00	8.67	8.67	0.000
C-40_DS	JUNCTION	0.00	75.66	0	08:07	0	8.67	-0.068
18-9	JUNCTION	0.00	326.24	0	08:56	0	101	0.006
C-217_US	JUNCTION	424.96	424.96	0	08:10	74.2	74.2	-0.000
C-217_DS	JUNCTION	0.00	425.00	0	08:10	0	74.2	-0.023
21-9	JUNCTION	0.00	654.40	0	08:48	0	175	-0.043
C-19_DS	JUNCTION	0.00	667.47	0	08:52	0	195	0.218
AustinCreekOutlet	JUNCTION	185.98	745.83	0	08:56	27.1	222	0.084

LakeWhatcom	OUTFALL	384.30	963.39	0	08:52	56.7	278	0.000
LakeLouiseDam	STORAGE	118.93	118.93	0	08:00	15.8	40.8	-0.017

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
C-210_US	JUNCTION	1.84	7.611	0.000
C-40_US	JUNCTION	0.55	3.157	0.000
LakeLouiseDam	STORAGE	34.71	0.614	4.486

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CFS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 gal	Maximum Ponded Depth Feet
C-210_US	0.88	8.12	0 08:00	0.046	3.811
C-40_US	0.40	8.31	0 08:00	0.020	1.627

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Evap Pcnt Loss	Infil Pcnt Loss	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
LakeLouiseDam	3528.557	33	0	0	4035.915	38	1 00:15	17.37

****
Outfall Loading Summary

****

Outfall Node	Flow Freq Pcnt	Avg Flow CFS	Max Flow CFS	Total Volume 10^6 gal
LakeWhatcom	99.57	216.00	963.39	277.985
System	99.57	216.00	963.39	277.985

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
C-54	CONDUIT	92.88	0	10:50	8.80	0.32	0.29
Reach54-4	CONDUIT	92.76	0	10:50	1.16	0.07	0.64
C-4	CONDUIT	210.17	0	08:54	7.45	0.72	0.48
Reach4-22	CONDUIT	209.98	0	08:56	3.16	0.16	0.57
C-22	CONDUIT	209.18	0	08:59	6.17	0.87	0.56
Reach22-24	CONDUIT	209.01	0	09:02	3.88	0.22	0.48
C-24	CONDUIT	49.27	0	08:50	9.26	0.08	0.23
Reach24-Basin16	CONDUIT	49.25	0	08:50	3.84	0.02	0.30
Reach24-207	CONDUIT	254.54	0	09:03	3.82	0.17	0.56
C-207	CONDUIT	279.67	0	09:05	7.40	0.36	0.45
C-210	CONDUIT	37.66	0	08:16	15.88	2.20	0.71
Reach210-Basin9	CONDUIT	37.66	0	08:16	2.45	0.01	0.31
Reach207-Basin9	CONDUIT	279.66	0	09:05	4.74	0.23	0.51
C-40	CONDUIT	75.66	0	08:07	14.12	1.40	0.71
Reach40-Basin9	CONDUIT	75.65	0	08:07	3.15	0.03	0.36
Reach-upperB9	CONDUIT	299.20	0	09:04	4.60	0.24	0.55
C-217	CONDUIT	425.00	0	08:10	10.01	0.13	0.24
DamDischarge	CONDUIT	17.37	0	09:08	3.92	1.10	0.90
Reach217-Basin9	CONDUIT	424.83	0	08:11	10.04	0.16	0.43
Reach-upperMidB9	CONDUIT	323.70	0	09:01	5.42	0.26	0.52
Reach-lowerMidB9	CONDUIT	650.15	0	08:52	5.64	0.19	0.55
Reach-lowerB9	CONDUIT	649.52	0	09:04	3.33	0.37	0.72
Austin-Lake	CONDUIT	742.14	0	09:05	7.56	0.63	0.72

****
Flow Classification Summary

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Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class: Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
C-54	1.00	0.02	0.43	0.00	0.19	0.36	0.00	0.00	0.45	0.00
Reach54-4	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.00
C-4	1.00	0.02	0.15	0.00	0.83	0.00	0.00	0.00	0.41	0.00
Reach4-22	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.00
C-22	1.00	0.02	0.02	0.00	0.96	0.00	0.00	0.00	0.39	0.00
Reach22-24	1.00	0.02	0.01	0.00	0.97	0.00	0.00	0.00	0.46	0.00
C-24	1.00	0.02	0.45	0.00	0.13	0.41	0.00	0.00	0.53	0.00
Reach24-Basin16	1.00	0.02	0.00	0.00	0.97	0.01	0.00	0.00	0.95	0.00
Reach24-207	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.55	0.00
C-207	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.53	0.00
C-210	1.00	0.02	0.01	0.00	0.46	0.52	0.00	0.00	0.24	0.00
Reach210-Basin9	1.00	0.02	0.00	0.00	0.97	0.01	0.00	0.00	0.97	0.00
Reach207-Basin9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.61	0.00
C-40	1.00	0.02	0.10	0.00	0.36	0.52	0.00	0.00	0.46	0.00
Reach40-Basin9	1.00	0.02	0.00	0.00	0.97	0.01	0.00	0.00	0.97	0.00
Reach-upperB9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.97	0.00
C-217	1.00	0.02	0.43	0.00	0.14	0.41	0.00	0.00	0.56	0.00
DamDischarge	1.00	0.00	0.00	0.00	0.11	0.00	0.00	0.89	0.00	0.00
Reach217-Basin9	1.00	0.02	0.00	0.00	0.91	0.07	0.00	0.00	0.92	0.00
Reach-upperMidB9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.37	0.00
Reach-lowerMidB9	1.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.98	0.00
Reach-lowerB9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.97	0.00
Austin-Lake	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C-210	0.01	0.01	0.01	1.61	0.01
C-40	0.01	0.01	0.01	0.48	0.01
DamDischarge	0.01	0.01	0.01	5.07	0.01

Analysis begun on: Mon Dec 08 15:44:49 2014
Analysis ended on: Mon Dec 08 15:44:56 2014

Total elapsed time: 00:00:07

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.001)
  ---------------------------------------------------------------

  2013-058B - Sudden Valley Community Association, Stormwater Inventory, Phase II - Hydrologic and Hydraulic
Analysis

  ***********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  ***********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CFS
  Process Models:
    Rainfall/Runoff ........ YES
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ YES
    Water Quality .......... NO
  Infiltration Method ...... CURVE_NUMBER
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ APR-03-2014 00:00:00
  Ending Date .............. APR-05-2014 00:00:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:10:00
  Wet Time Step ............ 00:10:00
  Dry Time Step ............ 01:00:00
  Routing Time Step ........ 1.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Head Tolerance ........... 0.005000 ft


  *************
  Element Count
  *************
  Number of rain gages ...... 1
  Number of subcatchments ... 21
  Number of nodes ........... 24
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Number of links 23
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
1	100-yr_24-hr	CUMULATIVE	10 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
Basin1	187.20	13600.00	20.00	35.4000	1	LakeWhatcom
Basin2	35.90	3300.00	26.00	35.9000	1	LakeWhatcom
Basin3	27.60	6530.00	32.00	25.2000	1	LakeWhatcom
Basin4	85.00	10500.00	28.30	26.7000	1	LakeWhatcom
Basin5	151.60	11700.00	25.00	24.0000	1	LakeWhatcom
Basin6	28.40	3800.00	18.00	15.7000	1	LakeWhatcom
Basin7	29.60	2092.00	25.00	17.3000	1	LakeWhatcom
Basin8	138.50	7600.00	20.00	14.2000	1	LakeWhatcom
Basin9	571.10	49950.00	16.00	32.4000	1	AustinCreekOutlet
Basin10	81.30	5160.00	25.00	21.3000	1	LakeWhatcom
Basin11	265.60	14175.00	31.00	31.9000	1	LakeLouiseDam
Basin12	88.60	11655.00	7.00	41.5000	1	LakeWhatcom
Basin13	68.50	5660.00	4.00	21.7000	1	LakeWhatcom
Basin14	152.30	9240.00	3.00	51.5000	1	LakeWhatcom
Basin15	1054.50	73825.00	1.00	23.6000	1	C-54_US
Basin16	143.00	18116.00	21.00	22.6000	1	C-207_US
Basin17	107.20	14750.00	23.00	25.9000	1	C-210_US
Basin18	124.10	15580.00	34.00	25.4000	1	C-40_US
Basin19	971.90	74690.00	1.10	39.1000	1	C-4_US
Basin20	379.20	25025.00	0.90	45.4000	1	C-24_US
Basin21	1661.60	108000.00	1.90	52.8000	1	C-217_US

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Node Summary

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Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
C-54_US	JUNCTION	478.99	8.78	1600.0	
C-54_DS	JUNCTION	478.81	8.96	1600.0	
C-4_US	JUNCTION	468.02	11.05	1600.0	
C-4_DS	JUNCTION	467.93	11.14	1600.0	
C-22_US	JUNCTION	457.67	12.93	1600.0	
C-22_DS	JUNCTION	457.59	13.01	1600.0	
C-24_US	JUNCTION	459.40	7.13	1600.0	
C-24_DS	JUNCTION	457.39	9.14	1600.0	
20-16	JUNCTION	452.05	6.00	1600.0	
C-207_US	JUNCTION	425.92	8.00	1600.0	
C-207_DS	JUNCTION	425.50	8.07	1600.0	
C-210_US	JUNCTION	434.18	5.80	1600.0	
C-210_DS	JUNCTION	433.46	6.52	1600.0	
17-9	JUNCTION	423.75	6.00	1600.0	
C-40_US	JUNCTION	420.98	4.53	1600.0	
C-40_DS	JUNCTION	420.08	6.00	1600.0	
18-9	JUNCTION	410.94	6.00	1600.0	
C-217_US	JUNCTION	455.11	18.18	1600.0	
C-217_DS	JUNCTION	454.14	19.15	1600.0	
21-9	JUNCTION	400.11	6.00	1600.0	
C-19_DS	JUNCTION	324.66	6.00	1600.0	
AustinCreekOutlet	JUNCTION	313.20	6.00	43560.0	
LakeWhatcom	OUTFALL	313.00	6.00	0.0	
LakeLouiseDam	STORAGE	336.40	7.60	1585584.0	

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Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
C-54	C-54_US	C-54_DS	CONDUIT	47.0	0.3830	0.0240
Reach54-4	C-54_DS	C-4_US	CONDUIT	900.0	1.1990	0.0400
C-4	C-4_US	C-4_DS	CONDUIT	40.0	0.2250	0.0240
Reach4-22	C-4_DS	C-22_US	CONDUIT	1200.0	0.8550	0.0400
C-22	C-22_US	C-22_DS	CONDUIT	49.0	0.1633	0.0240
Reach22-24	C-22_DS	20-16	CONDUIT	1260.0	0.4397	0.0400
C-24	C-24_US	C-24_DS	CONDUIT	48.0	4.1912	0.0240
Reach24-Basin16	C-24_DS	20-16	CONDUIT	220.0	2.4280	0.0400
Reach24-207	20-16	C-207_US	CONDUIT	2350.0	1.1120	0.0400

C-207	C-207_US	C-207_DS	CONDUIT	48.0	0.8750	0.0240
C-210	C-210_US	C-210_DS	CONDUIT	37.0	1.9463	0.0240
Reach210-Basin9	C-210_DS	17-9	CONDUIT	280.0	3.4699	0.0400
Reach207-Basin9	C-207_DS	17-9	CONDUIT	240.0	0.7292	0.0400
C-40	C-40_US	C-40_DS	CONDUIT	40.0	2.2506	0.0240
Reach40-Basin9	C-40_DS	18-9	CONDUIT	400.0	2.2856	0.0400
Reach-upperB9	17-9	18-9	CONDUIT	1750.0	0.7320	0.0400
C-217	C-217_US	C-217_DS	CONDUIT	68.0	1.4266	0.0240
DamDischarge	LakeLouiseDam	C-19_DS	CONDUIT	920.0	1.0838	0.0350
Reach217-Basin9	C-217_DS	21-9	CONDUIT	1600.0	3.3788	0.0400
Reach-upperMidB9	18-9	21-9	CONDUIT	1500.0	0.7220	0.0400
Reach-lowerMidB9	21-9	C-19_DS	CONDUIT	5600.0	1.3474	0.0400
Reach-lowerB9	C-19_DS	AustinCreekOutlet	CONDUIT	3300.0	0.3473	0.0400
Austin-Lake	AustinCreekOutlet	LakeWhatcom	CONDUIT	30.0	0.6667	0.0400

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Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C-54	HORIZ_ELLIPSE	6.20	48.79	1.90	7.30	1	286.56
Reach54-4	PARABOLIC	4.00	160.00	2.64	60.00	1	1241.90
C-4	HORIZ_ELLIPSE	6.90	60.43	2.11	9.60	1	292.15
Reach4-22	PARABOLIC	6.00	160.00	3.78	40.00	1	1334.63
C-22	HORIZ_ELLIPSE	6.80	58.69	2.08	9.80	1	239.36
Reach22-24	PARABOLIC	6.00	160.00	3.78	40.00	1	957.07
C-24	HORIZ_ELLIPSE	5.20	34.32	1.59	6.40	1	593.05
Reach24-Basin16	PARABOLIC	6.00	160.00	3.78	40.00	1	2249.02
Reach24-207	PARABOLIC	6.00	160.00	3.78	40.00	1	1522.02
C-207	ARCH	8.00	75.64	2.39	12.00	1	783.73
C-210	CIRCULAR	2.00	3.14	0.50	2.00	1	17.10
Reach210-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2688.63
Reach207-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	1232.51
C-40	CIRCULAR	3.00	7.07	0.75	3.00	1	54.20
Reach40-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2182.08
Reach-upperB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1234.90
C-217	ARCH	13.00	179.25	3.89	17.50	1	3277.83
DamDischarge	CIRCULAR	2.50	4.91	0.63	2.50	1	15.86
Reach217-Basin9	PARABOLIC	6.00	160.00	3.78	40.00	1	2653.09
Reach-upperMidB9	PARABOLIC	6.00	160.00	3.78	40.00	1	1226.44
Reach-lowerMidB9	PARABOLIC	6.00	320.00	3.94	80.00	1	3443.36
Reach-lowerB9	PARABOLIC	6.00	320.00	3.94	80.00	1	1748.09

Austin-Lake	PARABOLIC	6.00	160.00	3.78	40.00	1	1178.50

****
Control Actions Taken
****

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	2277.978	4.303
Evaporation Loss	0.000	0.000
Infiltration Loss	1083.728	2.047
Surface Runoff	1168.861	2.208
Final Surface Storage	26.438	0.050
Continuity Error (%)	-0.046	

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	1168.861	380.891
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	1167.023	380.292
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Seepage Loss	0.000	0.000
Initial Stored Volume	76.828	25.036
Final Stored Volume	78.816	25.683
Continuity Error (%)	-0.012	

****
Time-Step Critical Elements
****
None

****

Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	0.96 sec
Average Time Step	:	1.00 sec
Maximum Time Step	:	1.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00
Percent Not Converging	:	0.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin1	4.30	0.00	0.00	1.66	2.59	13.17	92.44	0.602
Basin2	4.30	0.00	0.00	1.22	3.03	2.95	25.45	0.704
Basin3	4.30	0.00	0.00	1.10	3.15	2.36	24.12	0.733
Basin4	4.30	0.00	0.00	1.42	2.83	6.53	56.15	0.658
Basin5	4.30	0.00	0.00	1.42	2.83	11.64	88.45	0.657
Basin6	4.30	0.00	0.00	1.71	2.54	1.96	14.87	0.591
Basin7	4.30	0.00	0.00	1.58	2.67	2.15	14.84	0.621
Basin8	4.30	0.00	0.00	1.58	2.67	10.05	62.50	0.621
Basin9	4.30	0.00	0.00	1.87	2.38	36.86	278.41	0.552
Basin10	4.30	0.00	0.00	1.40	2.85	6.29	45.45	0.662
Basin11	4.30	0.00	0.00	1.38	2.87	20.73	161.95	0.668
Basin12	4.30	0.00	0.00	1.97	2.28	5.49	44.17	0.530
Basin13	4.30	0.00	0.00	2.13	2.13	3.96	23.74	0.494
Basin14	4.30	0.00	0.00	1.93	2.32	9.60	62.52	0.540
Basin15	4.30	0.00	0.00	2.61	1.65	47.32	174.99	0.384
Basin16	4.30	0.00	0.00	1.84	2.41	9.35	67.24	0.560
Basin17	4.30	0.00	0.00	1.71	2.54	7.39	56.52	0.590
Basin18	4.30	0.00	0.00	0.93	3.32	11.19	104.50	0.772
Basin19	4.30	0.00	0.00	2.38	1.88	49.56	251.88	0.436

Basin20	4.30	0.00	0.00	2.42	1.84	18.94	96.98	0.427
Basin21	4.30	0.00	0.00	1.96	2.29	103.35	681.08	0.532

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	hr:min
C-54_US	JUNCTION	0.98	3.28	482.27	0	08:50
C-54_DS	JUNCTION	0.49	1.61	480.42	0	08:50
C-4_US	JUNCTION	1.53	5.90	473.92	0	08:23
C-4_DS	JUNCTION	0.98	3.47	471.40	0	08:24
C-22_US	JUNCTION	1.69	6.30	463.97	0	08:29
C-22_DS	JUNCTION	1.26	4.37	461.96	0	08:29
C-24_US	JUNCTION	0.46	1.99	461.39	0	08:10
C-24_DS	JUNCTION	0.36	1.39	458.78	0	08:10
20-16	JUNCTION	1.02	3.56	455.61	0	08:32
C-207_US	JUNCTION	1.53	6.29	432.21	0	08:38
C-207_DS	JUNCTION	1.20	4.23	429.73	0	08:38
C-210_US	JUNCTION	0.96	15.89	450.07	0	08:17
C-210_DS	JUNCTION	0.22	0.94	434.40	0	08:17
17-9	JUNCTION	1.22	4.22	427.97	0	08:39
C-40_US	JUNCTION	0.72	9.68	430.66	0	08:07
C-40_DS	JUNCTION	0.30	1.42	421.50	0	08:07
18-9	JUNCTION	1.46	4.74	415.68	0	08:42
C-217_US	JUNCTION	0.92	4.76	459.87	0	08:10
C-217_DS	JUNCTION	0.73	3.23	457.37	0	08:02
21-9	JUNCTION	1.03	3.61	403.72	0	08:36
C-19_DS	JUNCTION	1.75	4.89	329.55	0	08:50
AustinCreekOutlet	JUNCTION	2.20	6.31	319.51	0	08:55
LakeWhatcom	OUTFALL	1.68	5.00	318.00	0	08:55
LakeLouiseDam	STORAGE	3.08	3.57	339.97	1	00:21

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	Flow Balance Error Percent
C-54_US	JUNCTION	174.99	174.99	0	08:49	47.3	47.3	-0.000
C-54_DS	JUNCTION	0.00	174.98	0	08:50	0	47.3	0.000
C-4_US	JUNCTION	251.88	418.57	0	08:20	49.6	96.9	-0.001
C-4_DS	JUNCTION	0.00	414.52	0	08:23	0	96.9	-0.012
C-22_US	JUNCTION	0.00	414.23	0	08:24	0	96.9	0.012
C-22_DS	JUNCTION	0.00	412.02	0	08:29	0	96.9	-0.003
C-24_US	JUNCTION	96.97	96.97	0	08:10	18.9	18.9	-0.000
C-24_DS	JUNCTION	0.00	96.98	0	08:10	0	18.9	-0.013
20-16	JUNCTION	0.00	501.69	0	08:28	0	116	0.005
C-207_US	JUNCTION	67.24	548.54	0	08:30	9.35	125	0.000
C-207_DS	JUNCTION	0.00	541.22	0	08:38	0	125	0.000
C-210_US	JUNCTION	56.52	56.52	0	08:10	7.39	7.39	0.000
C-210_DS	JUNCTION	0.00	50.08	0	08:17	0	7.39	-0.050
17-9	JUNCTION	0.00	583.77	0	08:37	0	133	0.002
C-40_US	JUNCTION	104.49	104.49	0	08:00	11.2	11.2	-0.000
C-40_DS	JUNCTION	0.00	98.74	0	08:07	0	11.2	-0.075
18-9	JUNCTION	0.00	628.78	0	08:37	0	144	0.013
C-217_US	JUNCTION	681.07	681.07	0	08:10	103	103	-0.000
C-217_DS	JUNCTION	0.00	681.06	0	08:10	0	103	-0.021
21-9	JUNCTION	0.00	1158.55	0	08:28	0	247	-0.039
C-19_DS	JUNCTION	0.00	1162.29	0	08:36	0	268	0.178
AustinCreekOutlet	JUNCTION	278.38	1281.07	0	08:48	36.9	304	0.066
LakeWhatcom	OUTFALL	544.99	1579.83	0	08:49	76.2	380	0.000
LakeLouiseDam	STORAGE	161.94	161.94	0	08:00	20.7	45.8	-0.011

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
C-210_US	JUNCTION	4.18	13.885	0.000
C-40_US	JUNCTION	0.81	6.679	0.000
AustinCreekOutlet	JUNCTION	0.79	0.313	0.000

LakeLouiseDam	STORAGE	44.43	1.068	4.032

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CFS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 gal	Maximum Ponded Depth Feet
C-210_US	1.38	16.60	0 08:00	0.122	10.085
C-40_US	0.62	15.46	0 08:00	0.063	5.149
AustinCreekOutlet	0.79	67.74	0 08:34	0.406	0.313

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Evap Pcnt Loss	Infil Pcnt Loss	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
LakeLouiseDam	3990.611	38	0	0	4655.624	44	1 00:21	17.74

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CFS	Max Flow CFS	Total Volume 10^6 gal
LakeWhatcom	99.57	295.74	1579.83	380.264
System	99.57	295.74	1579.83	380.264

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
C-54	CONDUIT	174.98	0	08:50	10.33	0.61	0.39
Reach54-4	CONDUIT	174.74	0	08:50	1.86	0.14	0.70
C-4	CONDUIT	414.52	0	08:23	9.16	1.42	0.68
Reach4-22	CONDUIT	414.23	0	08:24	3.69	0.31	0.79
C-22	CONDUIT	412.02	0	08:29	8.20	1.72	0.78
Reach22-24	CONDUIT	412.16	0	08:30	4.80	0.43	0.66
C-24	CONDUIT	96.98	0	08:10	11.04	0.16	0.32
Reach24-Basin16	CONDUIT	96.89	0	08:10	3.39	0.04	0.41
Reach24-207	CONDUIT	499.59	0	08:32	4.46	0.33	0.80
C-207	CONDUIT	541.22	0	08:38	9.48	0.69	0.66
C-210	CONDUIT	50.08	0	08:17	20.23	2.93	0.74
Reach210-Basin9	CONDUIT	50.08	0	08:17	2.22	0.02	0.42
Reach207-Basin9	CONDUIT	541.22	0	08:39	5.72	0.44	0.70
C-40	CONDUIT	98.74	0	08:07	17.70	1.82	0.74
Reach40-Basin9	CONDUIT	98.72	0	08:08	2.88	0.05	0.48
Reach-upperB9	CONDUIT	582.95	0	08:39	5.66	0.47	0.75
C-217	CONDUIT	681.06	0	08:10	11.76	0.21	0.31
DamDischarge	CONDUIT	17.74	0	11:19	3.99	1.12	1.00
Reach217-Basin9	CONDUIT	682.09	0	08:10	11.52	0.26	0.55
Reach-upperMidB9	CONDUIT	624.84	0	08:41	6.76	0.51	0.69
Reach-lowerMidB9	CONDUIT	1146.64	0	08:36	6.46	0.33	0.71
Reach-lowerB9	CONDUIT	1125.66	0	08:50	4.07	0.64	0.91
Austin-Lake	CONDUIT	1263.01	0	08:55	8.99	1.07	0.92

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class: Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl

C-54	1.00	0.02	0.42	0.00	0.18	0.38	0.00	0.00	0.45	0.00
Reach54-4	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.63	0.00
C-4	1.00	0.02	0.15	0.00	0.84	0.00	0.00	0.00	0.40	0.00
Reach4-22	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.63	0.00
C-22	1.00	0.02	0.02	0.00	0.96	0.00	0.00	0.00	0.38	0.00
Reach22-24	1.00	0.02	0.01	0.00	0.98	0.00	0.00	0.00	0.45	0.00
C-24	1.00	0.02	0.44	0.00	0.11	0.43	0.00	0.00	0.51	0.00
Reach24-Basin16	1.00	0.02	0.00	0.00	0.98	0.01	0.00	0.00	0.96	0.00
Reach24-207	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.56	0.00
C-207	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.51	0.00
C-210	1.00	0.02	0.01	0.00	0.45	0.52	0.00	0.00	0.24	0.00
Reach210-Basin9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.98	0.00
Reach207-Basin9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.60	0.00
C-40	1.00	0.02	0.10	0.00	0.36	0.52	0.00	0.00	0.45	0.00
Reach40-Basin9	1.00	0.02	0.00	0.00	0.98	0.01	0.00	0.00	0.97	0.00
Reach-upperB9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.97	0.00
C-217	1.00	0.02	0.43	0.00	0.12	0.43	0.00	0.00	0.54	0.00
DamDischarge	1.00	0.00	0.00	0.00	0.20	0.00	0.00	0.80	0.00	0.00
Reach217-Basin9	1.00	0.02	0.00	0.00	0.91	0.07	0.00	0.00	0.92	0.00
Reach-upperMidB9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.38	0.00
Reach-lowerMidB9	1.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.98	0.00
Reach-lowerB9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.97	0.00
Austin-Lake	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C-4	0.01	0.01	0.01	1.99	0.01
C-22	0.01	0.01	0.01	4.84	0.01
C-210	0.01	0.01	0.01	3.71	0.01
C-40	0.01	0.01	0.01	0.71	0.01
DamDischarge	1.50	1.50	1.50	26.81	0.77
Austin-Lake	0.01	0.01	0.01	0.69	0.01

Analysis begun on: Mon Dec 08 15:45:50 2014
Analysis ended on: Mon Dec 08 15:45:57 2014

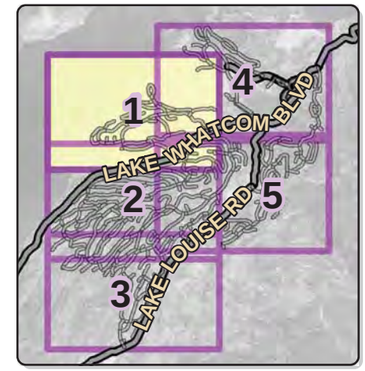
Total elapsed time: 00:00:07

Sudden Valley Community Association

Stormwater Inventory Map 1

Storm Culverts

- < 15"
- 15" - 24"
- 30" - 36"
- > 36"
- Ditch Flow Directions
- Major Roads



1 inch = 600 feet

0 300 600 1,200 1,800 Feet

Wilson ENGINEERING, LLC
805 DUPONT STREET
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(360) 733-6100 FAX (360) 647-9061
SURVEY/ENGINEERING www.wilsonengineering.com

Coordinate System:
State Plane Washington North
North American Datum 1983

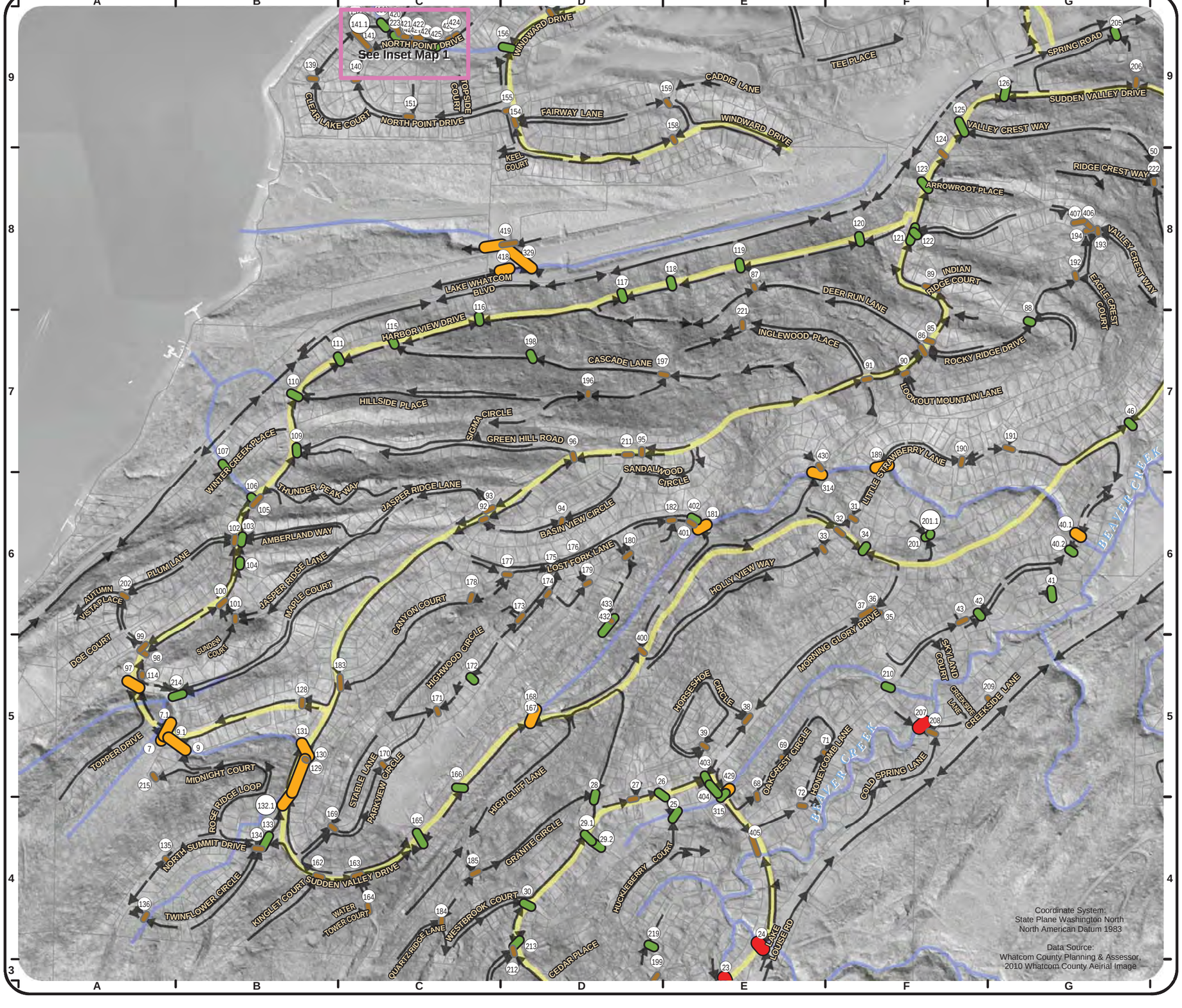
Data Source:
Whatcom County Planning & Assessor,
2010 Whatcom County Aerial Image

Date: 12/2/2014

Inset map scale: 0 50 100 200 300 Feet

Sudden Valley Community Association

Stormwater Inventory Map 2

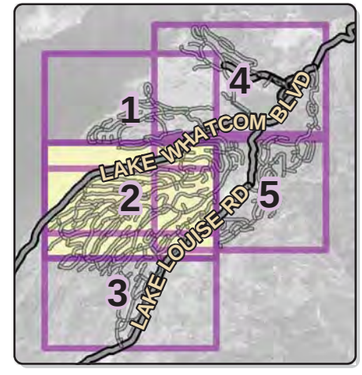


Coordinate System:
State Plane Washington North
North American Datum 1983

Data Source:
Whatcom County Planning & Assessor,
2010 Whatcom County Aeirial Image

Storm Culverts

- < 15"
- 15" - 24"
- 30" - 36"
- > 36"
- Ditch Flow Directions
- Major Roads



1 inch = 600 feet

0 300 600 1,200 1,800 Feet

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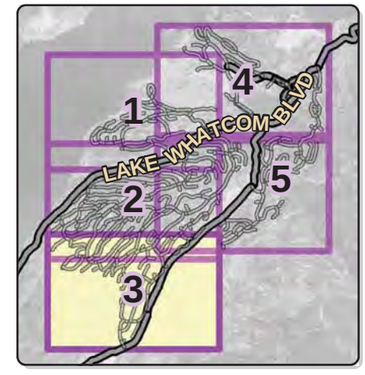
Date: 12/2/2014

Sudden Valley Community Association

Stormwater Inventory Map 3

Storm Culverts

- < 15"
- 15" - 24"
- 30" - 36"
- > 36"
- Ditch Flow Directions
- Major Roads



1 inch = 600 feet

0 300 600 1,200 1,800 Feet

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Date: 12/2/2014

Coordinate System:
State Plane Washington North
North American Datum 1983

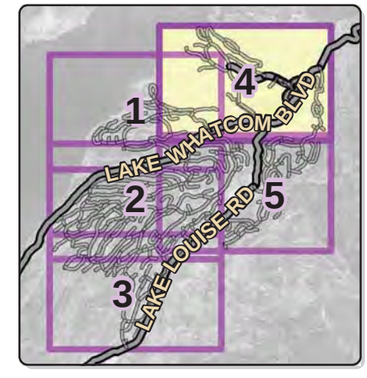
Data Source:
Whatcom County Planning & Assessor,
2010 Whatcom County Aeirial Image

Sudden Valley Community Association

Stormwater Inventory Map 4

Storm Culverts

- < 15"
- 15" - 24"
- 30" - 36"
- > 36"
- Ditch Flow Directions
- Major Roads



1 inch = 600 feet

0 300 600 1,200 1,800 Feet

Coordinate System:
State Plane Washington North
North American Datum 1983

Data Source:
Whatcom County Planning & Assessor,
2010 Whatcom County Aeirial Image

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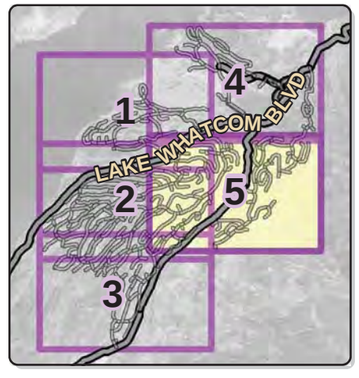
Date: 12/2/2014

Sudden Valley Community Association

Stormwater Inventory Map 5

Storm Culverts

- < 15"
- 15" - 24"
- 30" - 36"
- > 36"
- Ditch Flow Directions
- Major Roads



1 inch = 600 feet

0 300 600 1,200 1,800 Feet

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Date: 12/2/2014

Coordinate System:
State Plane Washington North
North American Datum 1983

Data Source:
Whatcom County Planning & Assessor,
2010 Whatcom County Aerial Image

SVCA Primary Culverts

	Grid Location
1	D2
2	D2
3	D2
4	D2
5	K11
6	K11
7	A5
7.1	A5
8	K12
9	A5, B5
9.1	A5
10	J6
11	J6
12	J6
13	I6
14	H5
15	H5
16	I6
17	I5
18	I6
19.1	G11
19.2	G11
19.3	G11
19.4	G11
20	D2
21	D1
22	E3
23	E3
24	E4
25	E4
26	D5, E4, E5
27	D4
28	D4, D5
29.1	D4
29.2	D4
30	D4
31	F6
32	F6
33	E6
34	F6
35	F6
36	F6
37	F6
38	E5
39	E5
40.1	G6
40.2	G6
41	G6
42	F6
43	F6
44	H8
45	H8
46	G7
47	H8
48	H8
49	H8
50	H8
51	H9
52	H8
53	H8
54	C1
55	D1
56	K9
57	K9
58	K9
59	K9
60	I8
61	J8
62	J7
63	J11
64	J11
65	H9
66	I7
67	I7
68	E4, E5
69	E5
71	E5, F5
72	E4
73	F12
74	G12
75	G13
76	G13
77	G13
78	D1
79.1	H11, I11, I12
79.2	H11
80	J11
81	J11
82	J11
83	J11
84	H13
85	F7
86	F7
87	E8
88	G7
89	F8
90	F7
91	F7
92	C6
93	C6
94	D6
95	D7

Culvert Index

	Grid Location		Grid Location		Grid Location
96	D7	137	H11, H12	176	D6
97	A5	138	G12	177	D6
98	A5	139	B9	178	C6
99	A5	140	C9	179	D6
100	B6	141	C9	180	D6
101	B6	141.1	C9	181	E6
102	B6	142	D9	182	E6
103	B6	143	D10	183	C5
104	B6	144	D10	184	C4
105	B6	145	E10	185	C4
106	B6	146	E10	186	D2
107	B7	147	G10	187	D2
109	B7	148	G10	188	D3
110	B7	149	F10	189	F7
111	B7, C7	150	J11	190	F7
112	H5	151	C9	191	G7
113	H6	152	C9	192	G8
114	A5	153	C9	193	G8
115	C7	154	D9	194	G8
116	C7	155	D9	196	D7
117	D8	156	D9	197	D7, E7
118	E8	157	D9	198	D7
119	E8	158	E9	199	D3
120	F8	159	E9	200	D3
121	F8	160	D10	201	F6
122	F8	161	F13	201.1	F6
123	F8	162	B4	202	A6
124	F8	163	C4	203	H11, H12
125	F9	164	C4	204	H11, I11
126	G9	165	C4	205	G9
128	B5	166	C5	206	G9
129	B5	167	D5	207	F5
130	B5	168	D5	208	F5
131	B5	169	B4	209	F5, G5
132.1	B4, B5	170	C5	210	F5
132.2	B5	171	C5	211	D7
133	B4	172	C5	212	D4
134	B4	173	D6	213	D4
135	A4	174	D6	214	A5, B5
136	A4	175	D6	215	A5

Culvert Index

	Grid Location
216	D2
217	I6, I7
219	D4
221	E7
222	H8
223	C9
224	H9
225	K9
227	H11
228	H11
307	J10
308	I8
314	E6
315	E4, E5
329	C8, D8
400	D5
401	E6
402	E6
403	E5
404	E5
405	E4
406	G8
407	G8
408.1	I11
408.2	I11
409	I11
410	H11
411	E10
412	E10
413	E10
414	E10
415	E10
416	E10, F10
417	D10
418	C8, D8
419	D8
420	C9
421	C9
422	C9
423	C9

	Grid Location
424	C9
425	C9
426	C9
427	C9
428	C9
429	E5
430	E7
431	E3
432	D6
433	D6
434	J8
435	K8
436	K8
437	K8
438	J9
439	F10
440	F10
441	F10
442	F10
443	F10
444	K11, K12
445	H11, H12
446	K10

Grid Location

SVCA Area Roads