Port of Kalama

CENTRAL PORT STORMWATER IMPROVEMENTS

KALAMA, WASHINGTON

PRELIMINARY STORMWATER REPORT

PREPARED BY:

CARPENTER ENGINEERING, INC.

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DATE: 10/25/2017

BOBBY R. CARPENTER
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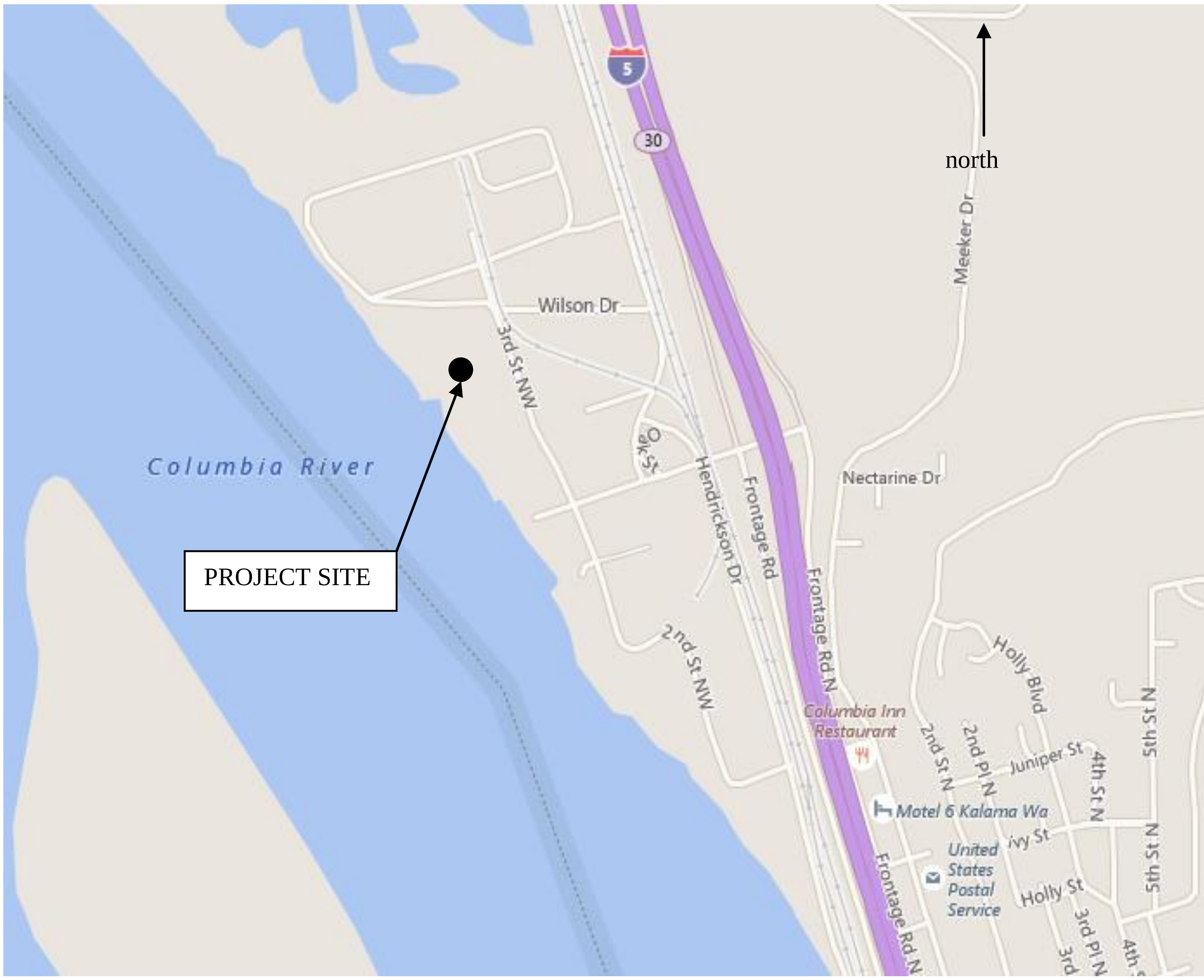
TABLE OF CONTENTS PAGE

SITE LOCATION MAP



SOILS MAP

Map Unit Legend

Cowlitz County, Washington (WA015)

Cowlitz County, Washington (WA015)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
17	Caples silty clay loam, 0 to 3 percent slopes	5.6	13.4%
160	Pilchuck loamy fine sand, 0 to 8 percent slopes	33.3	80.4%
199	Snohomish silty clay loam, 0 to 1 percent slopes	0.8	1.8%
263	Water	1.8	4.4%
Totals for Area of Interest		**41.5**	**100.0%**

I. PROJECT OVERVIEW

(1). Existing Site Conditions

The existing site has a long history of industrial use primarily related to the timber industry for mill and log operations. The site is generally flat with localized low areas for stormwater collection. Existing ground surfaces include paved roadways, building roofs, paved storage yards and log laydown yards of sand and gravel. These existing surfaces all drain to the Columbia River along the sites west boundary. A collection of ditches, catch basins, subsurface gravity pipes and pump stations deliver all surface waters to the Columbia at two locations labeled as Storm Pipe #1 and Storm Pipe #2 as shown on the Drainage Basin Plan attached in Appendix A. No designed surface water detention and or water treatment is currently provided to the existing surface area water runoff.

Please refer to the Appendix A, Drainage Basin Plan for all Basin ID labels, existing site features and proposed construction measures.

(2). Site Parameters

The site is bounded to the east by Hendrickson Drive and to the west by the Columbia River. To the North of the project area is Kalama Chemical Industrial Property and to the south is property currently occupied by RSG Wood Products.

(3). Adjacent and Existing Drainage Patterns

Contributing drainage areas have been identified and labeled as drainage basins 1 thru 9 on the attached Drainage Basin Plan. Kalama Chemical to the north of the site has its own drainage system and no surface waters have been identified to cross between the two properties. To the east of the project area and east of Hendrickson Road is Burlington Northern Rail lines and the I-5 corridor right of way. Surface waters in these areas collect into large drainage areas between the highway and the rail line. South of the project site, and south of Oak Street, is property used by RSG Forest Products. A notable feature shown on the Drainage Basin Plan is a large stormwater pond located on the east side of drainage basin # 9 constructed by RSG in 2013. This stormwater Pond is an infiltration facility receiving runoff waters from all RSG property to the south of Oak Street of approximately 42 acres. The existing pond area at one time drained into the existing ditch labeled as drainage reach # 4 on the drainage plan. Upon construction of the pond, surface waters from this area no longer discharge to the ditch but rather infiltrate. Overflow from this pond occurs to the south within a pump station facility with an outfall to the Columbia River set below the pond top of dike elevation.

Two notable drainage basins contributing to the project area include basins 2 and 3. Each of these drainage basins are cut off from normal surface water drainage patterns by the Hendrickson Drive to Oak Street onramp in the case of basin 2 and by the raised grade rail line spur on the south side of basin 3. Both basins 2 and 3 drain to existing pumps stations that discharge to the existing ditch # 4 as shown on the Drainage Basin Plan.
Drainage Basins 1 and 4 drain to a low area labeled as existing pond #1 on the drainage basin plan. This low area has a gravity pipe outfall to the Columbia River labeled as existing storm pipe # 1. An additional discharge pump station serves this low area in the event of high flows. Surface Basins 2 thru 5 and 9 all drain by gravity to an existing pimp station labeled as existing pump station # 3 on the drainage plan. This pump station discharges to the Columbia River thru storm pipe # 2 as labeled on the drainage plan. Existing drainage basins 6 thru 8 are located in a past log yard and based upon surface contours and site observations drain to surface infiltration thru localized ditches dispersed across the log yard and or sheet flow to the west directly into the river.

<u>(4). Proposed Development Details</u>

The overall project goal and proposal is to remove the stormwater outfalls to the Columbia River and to discharge to onsite storage and infiltration. Storm outfall pipes # 1 and 2, labeled on the drainage plan, will be capped and abandoned and all site stormwater will be pumped into a newly constructed three cell pond for retention and infiltration. The low area of existing pond # 1 will be filled and a new gravity pipe will be constructed to divert waters to the north and into the existing drainage system currently flowing to pump station # 3. Pump station number 3 will be upgraded with new pumps and wet-well capacity to handle the additional inflows. Rather than pump out to the Columbia a new force main will be constructed to discharge into the new infiltration pond. The proposed pond is design to store and infiltrate the 100 year rainfall event. Further description of pond design characteristics and site soils characteristics are described further later in this report.
The two tables below identify the basin size and surface characteristics of contributing basins 1 thru 9. Table 1 identifies the basin characteristics as they currently exist. Table 2 modifies some of the basins surface characteristics by increasing the amount of impervious surface to account for possible future development. The basin data in Table 2 is used in the hydrology model and pond sizing calculations for this proposal.

TABLE 1 - EXISTING CONDITION BASIN DATA TABLE

BASIN #	IMPERVIOUS AREA (Ac) CN = 98	PERVIOUS AREA (AC) CN = 85	TIME OF CONCENTRATION (Min.) (Tc)
1	1.85	0	5
2	0.8	0.2	5
3	6	0.81	7.4
4	6.23	0	6.6
5	3	1	6
6	0.41	0.41	5
7	0.36	0.36	5
8	1	1	5
9	0	6.15	40

TABLE 2 - ESTIMATED FUTURE CONDITION BASIN DATA TABLE

BASIN #	IMPERVIOUS AREA (Ac) CN = 98	PERVIOUS AREA (AC) CN = 85	TIME OF CONCENTRATION (Min.) (Tc)
1	1.85	0	5
2	0.8	0.2	5
3	6.0	0.81	7.4
4	6.23	0	6.6
5	4.0	0	6
6	0.66	0.16	5
7	0.58	0.14	5
8	2	0	5
9	4.92	1.23	15

Note that basins 1 thru 4 are considered fully developed with no changes. Basins 5 thru 9 have added impervious surface areas to account for possible future development. Basins 5 and 8 are assumed to be 100% impervious in the future and 6 and 7 are assumed to be 80% impervious in the future.

II. <u>MINIMUM REQUIREMENTS</u>

Per Section I-2.4.2 Redevelopment, of the 1992 Puget Sound Stormwater Manual, projects with redevelopment of greater than 5,000 square feet shall be required to to meet Minimim requirements 1 thru 11 for that portion of the site being redeveloped and source control BMP’s shall be applied to the entire site.

Minimum Requirement # 1 – Erosion and Sediment Control

Erosion and Sediment control measures shall be implemented thru the course of construction and maintained after construction until such time as the site is stabilized.

Existing storm inlets will receive inlet protection measures and existing paved surfaces will be protected from sediment runoff. All exposed and unworked soils shall be stabilized by suitable application of BMP's. From October 1 to April 30, no soils shall remain unstabilized for more than 2 days. From May 1 to September 30, no soils shall remain unstabilized for more than 7 days. Construction of the new pond will provide for settlement storage and prevent sediment laden waters from entering the river.

Final construction Erosion Control Plans will be prepared and submitted for review with the construction civil plans.

Minimum Requirement # 2 – Preservation of Natural Drainage Systems

In the existing condition all site stormwater drains to the Columbia River to outlet pipes 1 and 2 as described above. The goal of this project is to change this drainage pattern and discharge to an onsite retention pond for storage and infiltration. This is a change that will provide treatment and flood abatement where there was none before. Existing drainage basin 1 and 4 that outfall to storm pipe # 1 will be diverted to the north into the existing pump station in order to be pumped into the proposed pond. All other onsite drainage features such as catch basins, ditches and pipes will remain the same.

This proposal will remove the two existing outfalls to the Columbia River. No new outfalls to the Columbia River are proposed with this development. This site plan will not cause a significant adverse impact to the Columbia River, any downstream properties, or salmonids. The drainage plan will improve the existing drainage system and reduce pollution to the Columbia River.

Minimum Requirement # 3 – Source Control of Pollution

The project site will operate as it has in the past with industrial and anticipated log storage. RSG has expressed an interest in using some of the site for additional log yard storage. Applicable BMPs for Inlet Protection, Maintenance of Stormwater Drainage and Treatment Systems, Parking and Storage of Vehicles and Equipment, and Roof/ Building Drains are anticipated. The site operator will follow the BMPs for all Stormwater Drainage and Treatment Systems, Parking and

Storage of Vehicles and Equipment, and Roof/ Building Drains and Manufacturing and Commercial Buildings as necessary.

Minimum Requirement # 4 – Runoff Treatment BMP's

The proposed runoff treatment BMP utilized for this project is dead storage and settlement storage within the proposed retention pond. The proposed retention pond has been divided into three distinct cells. The easterly most cell has been designed with a 2 ft depth dead storage area for settlement of solids. This pond cell is where the proposed force main will discharge. An energy dissipation devise is anticipated to be constructed at the force main outfall. Preliminary velocity checks for a 16 inch diameter force main outfall at 5,000 gpm flow indicate an expected velocity of 8 ft/s. The central cell of the pond includes a 1 ft depth dead storage prior to overflow into the third and final cell of the pond that is reserved primarily for infiltration and volume storage.

The treatment storm is modeled as the 6 month, 24 hour rainfall event. See the HydroCAD output data for specific design input attached in Appendix D.

Minimum Requirement # 5 – Streambank Erosion Control

Streambank Erosion Control measures are not applicable to this project however the proposed retention pond will provide treatment and storm water attenuation to the overall runoff from the site.

Minimum Requirement # 6 – Wetlands

No wetlands are located or associated with this site and project.

Minimum Requirement # 7 – Water Quality Sensitive Areas

Washington State Department of Ecology Listed 303(d) Water Body. The project site is adjacent to the Columbia River, which is on the Washington State Department of Ecology 303(d) list of impaired water bodies. The parameters identified by the Washington State Department of Ecology as concerns near our project area are Temperature, Total Dissolved Gas, Dioxin, PCB, Dieldrin, 4,4'-DDE, and Bis(2- Ethylhexyl) Phthalate. The project site is not currently a source for these parameters. The proposed onsite storage and retention pond will protect the Columbia River from pollutants.

Minimum Requirement # 8 – Off-Site Analysis and Mitigation

Runoff to the site currently discharges to the Columbia River as described above. The existing outfalls will be removed and site stormwater discharged to the constructed retention/infiltration facility. No new outfalls or discharges are anticipated, off-site analysis is not required for this site.

Minimum Requirement # 9 – Basin Planning

The site is not part of an existing Basin Plan or watershed therefore this site is analyzed individually.

Minimum Requirement # 10 – Operation and Maintenance

An Operations and Maintenance Manual will be provided upon completion of final engineering plans and final drainage report preparation.

Minimum Requirement # 11 – Financial Liability

The site is owned and maintained by the Port of Kalama. The Port has the funds to construct and maintain the project site. No financial performance bonding or other guarantees are necessary

III. QUANTITY CONTROL ANALYSIS AND DESIGN

(1). Hydrologic Analysis

This stormwater design follows the standards set forth by the City of Kalama Municipal Code and the 1992 Puget Sound Stormwater Manual. Hydraulic calculations and analysis are performed using the Santa Barbara Unit Hydrograph (SBUH) single event hydrograph. HydroCAD was used to calculate the flows for the project site. The site is broken into 9 separate drainage basins culminating at the proposed re-designed and upgraded pump station and retention pond. Two storm events were modeled for the proposed facility. The water quality event and the 100 year storm. See Appendix D for HydroCAD project report printouts.

The isopluvial maps used to determine the 2, 100-year storm precipitation can be found in Appendix C.

(2). Quantity Control Design

In the existing condition no quantity control of site stormwater release exists. In the developed condition, the 100 year storm event will be retained onsite and infiltrated. See Table 3 below for the water quality and the 100 year flow Basin Data and totals.

TABLE 3 - DEVELOPED BASIN DATA TABLE W / WQ & 100 YR PEAKS

BASIN #	IMPERVIOUS AREA (Ac) CN = 98	PERVIOUS AREA (AC) CN = 85	Tc (min.)	Peak Flows (cfs) WQ	100 yr
1	1.85	0	5	0.6	2.14
2	0.8	0.2	5	0.25	1.11
3	6	0.81	7.4	1.83	7.55
4	6.23	0	6.6	2	7.16
5	3	1	6	1.29	4.59
6	0.41	0.41	5	0.21	0.91
7	0.36	0.36	5	0.18	0.8
8	1	1	5	0.47	2.32
9	0	6.15	40	1.3	5.19
			Totals	8.13	28.77

See Tables 4 below for pond water surface elevations for the water quality and 100 yr rainfall events.

TABLE 4 - RETENTION POND WATER SURFACE ELEVATIONS

RAINFALL EVENT		WATER SURFACE ELEVATION	
	East Forebay (2P)	Central Pond (3P)	West End Pond (4P)
Water Quality	25.12	23.45	23.08
100 yr	26.45	25.91	25.91

Note: The pond top of dike is at elevation 29.0 and the emergency overflow weir elevation is at elevation 28.0

(3). Quantity Control System Plan

See the attached Drainage Basin Plan in Appendix A for locations of the proposed retention/infiltration pond and location of the new gravity storm pipe that diverts waters from the current basin 1 and 4 collection low point to the proposed pump station upgrade and proposed pond.

Attached in Appendix B are civil drawings representing preliminary design plans and profiles of the proposed pond and of the proposed new gravity storm pipe.

IV. CONVEYANCE SYSTEMS ANALYSIS AND DESIGN

(1). Preliminary Stormwater Plan

Preliminary stormwater plans has been developed and attached in Appendix B. These plans depict design features of the proposed stormwater retention pond with plan and profile views.

The proposed new gravity diversion pipe is also shown in plan and profile views. Most of the existing site stormwater conveyance systems will remain the same. The existing pump station labeled as pump station # 3 of the attached drainage plan will be redesigned. The preliminary civil plans do not include final design characteristics for the pump station upgrade at this time.

The criteria used in the Hydraulic Analysis for this stormwater review include the following.

- A Type 1A storm event as per the 1992 Puget Sound Manual is used in the storm modeling.

- Soils mapped in the area by the USDA Natural Resource Conservation Service Web Soil Survey as shown on page 2 of this report consist of Pilchuck loamy fine sands. However, onsite soils investigations identify the site soils variable manmade fills of angular gravel and cobbles with sand and clay, underlain by sandier soils with depth.

- Peak rainfall storm events for the 2, and 100 year rainfall events were taken from the Washington Isopluvial Maps attached in Appendix C. The Water Quality Event was taken as 64% of the 2 yr rainfall event.

- Based upon infiltration rates tested and identified in the geotechnical report, existing site soils infiltrate at between 4 and 36 inches per hour. Infiltration rates appear to increase from east to west across the pond site location. For design purposes safety factors have been included in the design infiltration rates. For design purposes the pond has been divided into three sections. The east most corner of the pond is the fore bay where the force main will discharge and where two feet of dead storage will retain and settle out solids. No infiltration is expected to occur or design into this portion of the pond. The middle section of the pond has been designed with an infiltration rate of 2.0 inches per hour. This area of the pond is estimated to provide stormwater treatment and storage. Site sandy soils are anticipated to provide water quality treatment thru cation exchange, however if the existing soils are found unsuitable as treatment soils then some soil amendments may be tilled into the pond bottom of the central pond area to promote treatment. The 1992 Puget Sound Manual allows for existing soils with cation exchange rates of up to 5 to be suitable for water quality treatment. Although untested, it is reasonable to expect some treatment characteristics of the existing site soils and soils amendments may augment this is necessary. The west most and larges section of the proposed pond is primarily for infiltration and storage. The west pond area has been design with an infiltration rate of 7.4 inches per hour.

- Onsite test pit exploration identify water table at approximately 6 to 7 feet below ground surface. Using an average surface elevation over the site as 26.5 ft the water table would be identified at 19.5 ft elevation. The proposed bottom the retention pond is at elevation 23 or 3.5 ft above the water table elevation. The dead storage fore bay portion of the pond at the east corner has a bottom elevation of 22 or 2.5 ft above the water table elevation. It is expected that this fore bay portion of the pond will experience little if any infiltration due to site silts that will settle in this portion of the pond.

(4). Assumptions

In modeling the existing site drainage characteristics there are numerous existing pipes whose exact underground configuration is not known however it is known and understood that all site waters flow to either the existing low area labeled as existing pond #1 and to the existing pump station # 3. The Hydrologic modeling of the existing stormwater system allows for free discharge of all conveyance systems thus insuring a conservative approach to pond and pump sizing.

(5). Hydraulic Analysis

See the attached HydroCAD printout files attached in Appendix D for site and basin specific input. Basin summary tables are shown above in the prior sections.

(6). System Capacities

The existing site stormwater conveyance system does include some existing pipe sizes that are undersized and may cause surface water flows to back up. The proposed pump station upgrades and proposed retention/infiltration pond have been design as if the existing size drainage systems allow full free flow. This is a conservative design approach and will allow for the port to upsize and existing drainage pipes in the area if required. The stormwater retention/infiltration facility is designed to retain and infiltrate the 100 year storm.

V. WATER QUALITY DESIGN

(1). Preliminary Stormwater Plan

Water quality is proposed thru a combination of dead storage volume in the fore bay portion of the pond and thru treatment via infiltration thru the existing soils in the central portion of the pond if existing soils are found to be suitable. If the existing soils do not meet the criteria for cation exchange capacity then possible soils amendments could be mixed into surface soils to provide treatment.

(2). Geotechnical Information

A Geotechnical site investigation was conducted by Chinook GeoServices Inc. The report and findings are attached in Appendix F. Thirteen test holes were excavated across the proposed pond site. Test pit explorations identify site soils as variable manmade fills of angular gravel and cobbles with sand and clay, underlain by sandier soils with depth.

Infiltration testing was conducted in four locations with resultant infiltration rates of approximately 4, 7, 30 and 36 inches per hour. Groundwater was identified between 6 and 7 feet below ground surface. Groundwater elevations are heavily influenced by the Columbia River whose shoreline is located approximately 100 feet to the west of the west end of the proposed pond.

See the attached Drainage Basin Plan for site topography and existing site condition basin flows. Additionally, a copy of the Geotechnical Investigation Report prepared by Chinook GeoServices Inc. is attached in Appendix E.

(3) Identify BMP's

Typical BMP's applied to this site include, but are not limited to:

BMP C140: Dust Control
BMP C152 Sawcutting and Surface Pollution Prevention
BMP C160: Certified Erosion and Sediment Control Lead (CESCL)
BMP C220: Storm Drain Inlet Protection
Bmp C233: Silt Fence
BMP C235 Wattles

(4). Initial Site Conditions

In the existing condition no water quality is provided to surface runoff.

The site is primarily paved parking and storage yards and gravel and sand log storage yards.

(5). Design Computations

The developed condition site was broken down to individual drainage basins discharging to their respective conveyance systems. Each basin was analyzed for areas of impervious and pervious surfaces and peak flows were routed thru the individual systems.. See the HydroCAD output files for all input basin and infiltration data attached in Appendix D.

VI. SOILS EVALUATION

(1). Onsite Soil Types

A Geotechnical site investigation was conducted by Chinook GeoServices Inc. The report and findings are attached in Appendix F. Thirteen test holes were excavated across the proposed pond site. Test pit explorations identify site soils as variable manmade fills of angular gravel and cobbles with sand and clay, underlain by sandier soils with depth.

Infiltration testing was conducted in four locations with resultant infiltration rates of approximately 4, 7, 30 and 36 inches per hour. Groundwater was identified between 6 and 7 feet below ground surface. Groundwater elevations are heavily influenced by the Columbia River whose shoreline is located approximately 100 feet to the west of the west end of the proposed pond.

(2). High Water Table

Groundwater was identified between 6 and 7 feet below ground surface. Groundwater elevations are heavily influenced by the Columbia River whose shoreline is located approximately 100 feet to the west of the west end of the proposed pond.

(4). Infiltration BMP's

The proposed infiltration BMP for this project is the retention/ infiltration pond. As identified above the pond has been sized to store the site 100 yr runoff and infiltrate without overtopping. The pond design infiltration rates have been reduced by as much as a factor of 5 below the field tested rates. In the event of an overflow the pond has an emergency overflow weir designed into its berm at the northwest corner of the pond. Any overflow would flow into the existing ditch system that crisscross the pond site area where logs used to be stored where additional storage and infiltration could occur.

(5). Delineate Sub-Basins

See the Drainage Basin Plan attached in Appendix A for delineation of contributing drainage basins. The developed site has been divided into 9 individual drainage basins all routed to their perspective drainage systems and in the case of the proposal to the pump station and proposed pond.

(6). Existing and Proposed Contours

Existing contours and site surface features shown on the Drainage Basin Plan attached in Appendix A were obtainaned from Cowlitz County GIS information. Project final design plans will ultimately use current field topography to reflect current surface features and or grade changes.

VII. SPECIAL REPORTS AND STUDIES

(1). Geotechnical

A Geotechnical site investigation was conducted by Chinook GeoServices Inc. dated February 17, 2011. A copy id attached in Appendix F.

(2). Wetlands

No wetlands are present at the site.

(3). Flood Plains

The proposed stormwater pond is above the FEMA flood zone. See Appendix E for a cut sheet from the FEMA flood panel for this area.

VIII. OTHER PERMITS

The following permits are applicable to this project:

SEPA
City of Kalama Grading Permit
Washington State Department (WDOE) Stormwater Construction General Permit

IX. REFERENCES

1. United States Department of Agriculture, Natural Resources Conservation Service. " Web Soil Survey." http://websoilsurvey.nrcs.usda.gov/app/

2. Washington State Department of Ecology' s " Stormwater Management Manual for the Puget Sound Basin", February 1992.

TECHNICAL APPENDIX

A. Drainage Basin Plan

LEGEND

- △ RETENTION POND
- ☐ PIPE REACH
- ○ SUBCATCHMENT BASIN
- EXTG. CATCH BASIN
- EXTG. MANHOLE
- EXTG STORM PIPE
- SURFACE FLOW DIRECTION

FOR BASIN, REACH, AND POND DATA SEE ATTACHED HYDROCAD PRINTOUT DATA SHEETS.

NOTE: CONTOURS SHOWN ARE BASED UPON COWLITZ COUNTY GIS INFORMATION. AERIAL PHOTO PROVIDED BY GOOGLE MAPS, JUNE 2017. SHOWN AS APPROXIMATE.

TABLE 1 - EXISTING CONDITION BASIN DATA TABLE

BASIN #	IMPERVIOUS AREA (Ac) CN = 98	PERVIOUS AREA (AC) CN = 85	TIME OF CONCENTRATION (Min.) (Tc)
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6	0.41	0.41	5
7	0.36	0.36	5
8	1	1	5
9	0	6.15	40

ESTIMATED FUTURE CONDITION BASIN DATA TABLE

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4	6.23	0	6.6
5	4.0	0	6
6	0.66	0.16	5
7	0.58	0.14	5
8	2.0	0	5
9	4.92	1.23	15

PROPOSED POND AND PUMP SIZING BASED UPON ABOVE FUTURE CONDITION BASIN DATA

PREPARED FOR:
PORT OF KALAMA
110 W. MARINE DR
KALAMA, WA 98625
360-673-2325

PROJECT
CENTRAL PORT
STORMWATER IMPROVEMENTS
TAXMAP
TAXLOT
CITY, STATE KALAMA, WA

DRAWING TITLE:
DRAINAGE BASIN PLAN

REVISIONS

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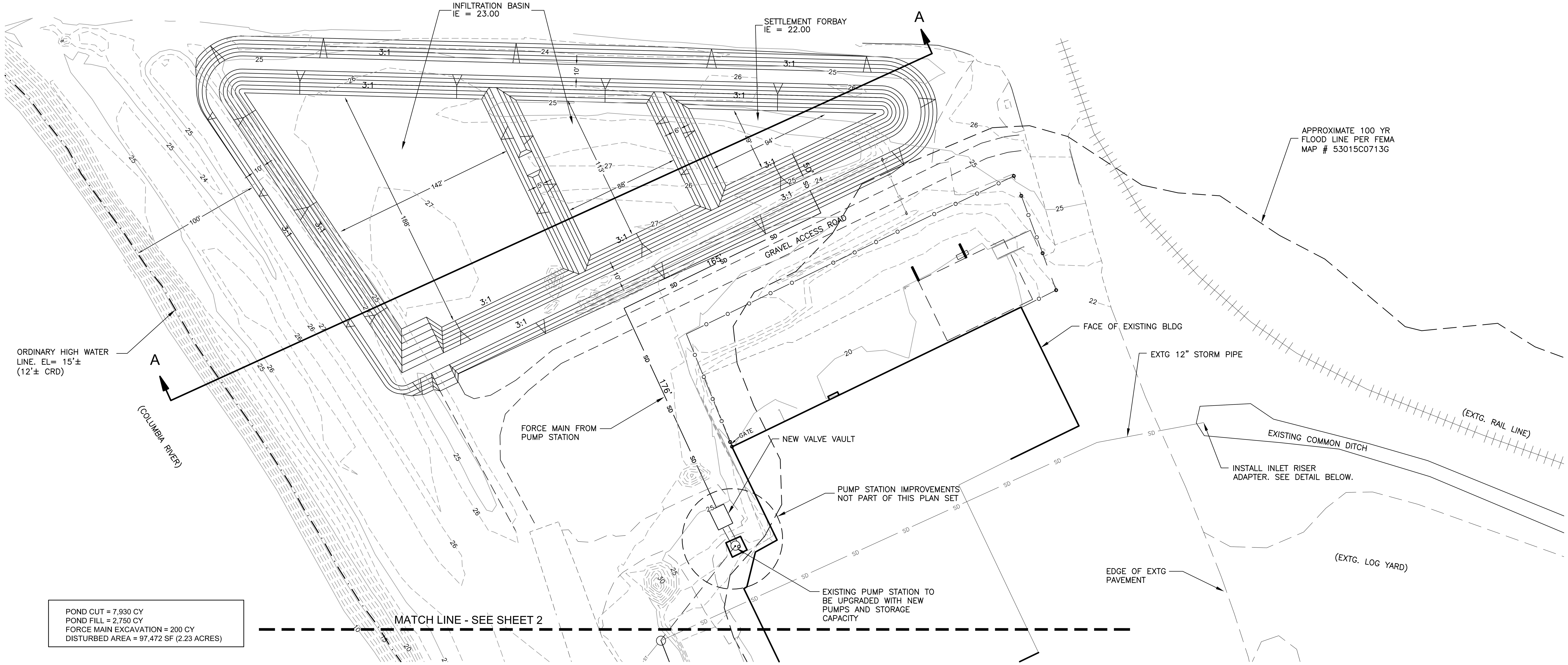
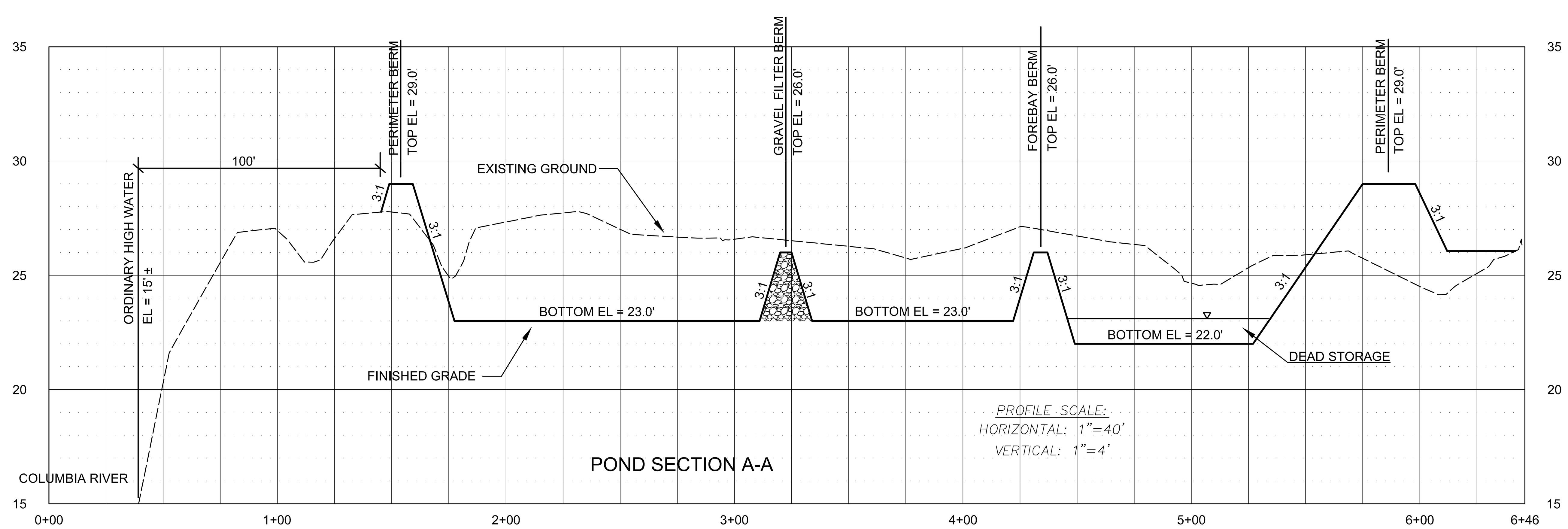
BOBBY R. CARPENTER STATE OF WASHINGTON 30032 REGISTERED PROFESSIONAL ENGINEER

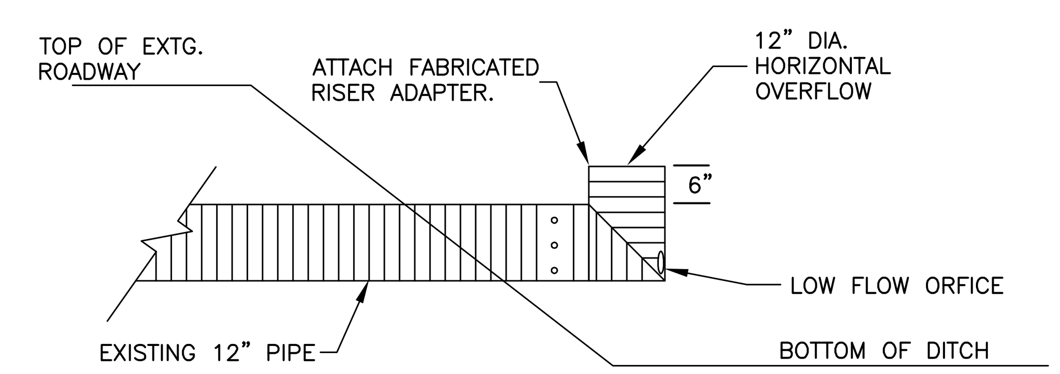
JOB NO.: 09-060
SHEET NO. 1 OF 1
BASETOPO.dwg

B. Preliminary Civil Construction Plans





POND SECTION A-A



INLET RISER ADAPTER DETAIL

NTS

SCALE 1"=40'

PREPARED FOR:
PORT OF KALAMA
110 W. MARINE DR.
KALAMA WA 98625
360-673-2337

PROJECT
PORT OF KALAMA
KALAMA, WA

DRAWING TITLE:
CENTRAL PORT STORMWATER IMPROVEMENTS
(30% PLAN SET)

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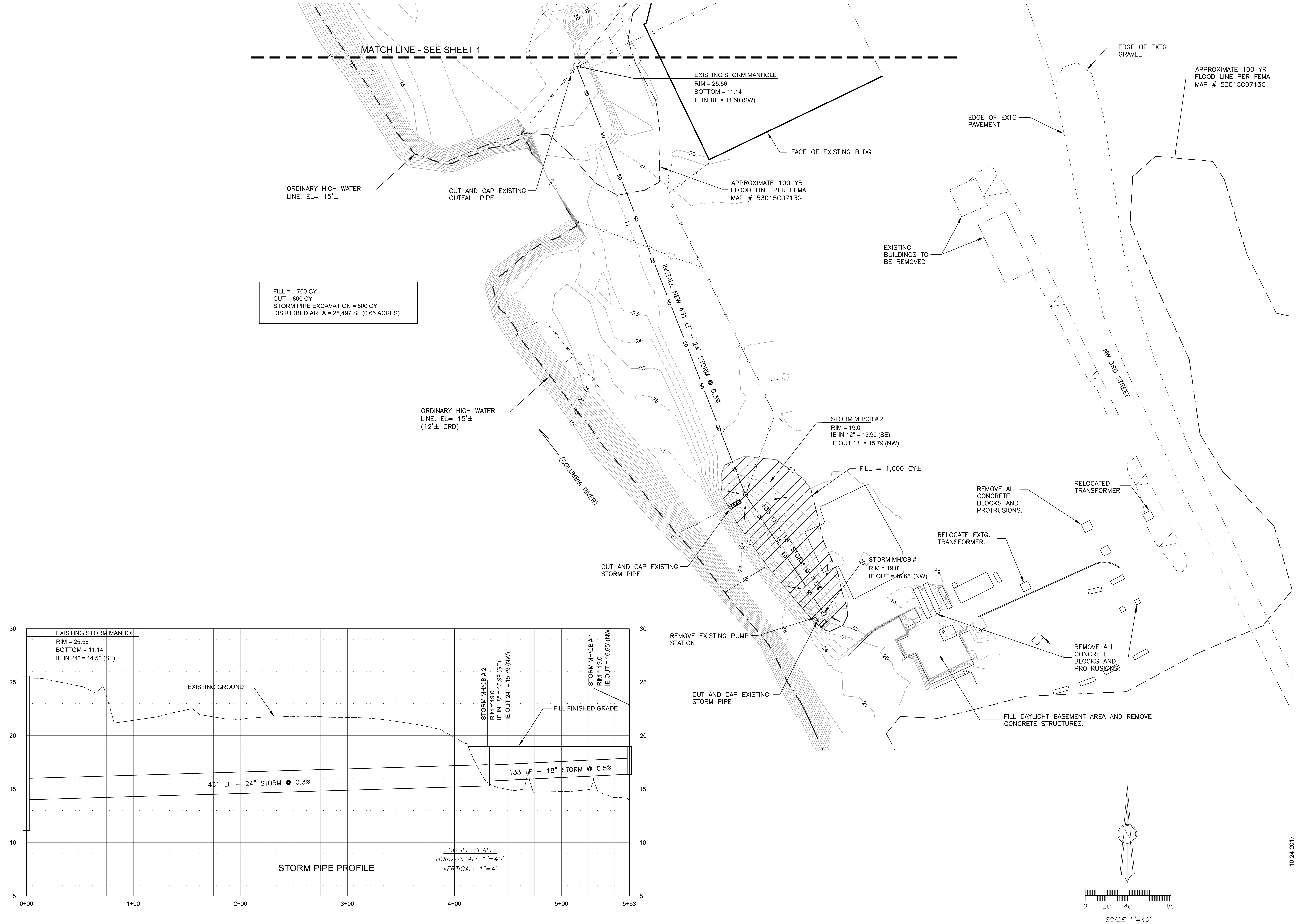
10-24-2017

JOB NO.: 09-060
SHEET NO. 1 OF 2



PREPARED FOR:
PORT OF KALAMA
110 W. MARINE DR.
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PROJECT
PORT OF KALAMA
TAXMAP
TAXLOT
CITY, STATE KALAMA, WA

DRAWING TITLE:
CENTRAL PORT STORMWATER IMPROVEMENTS
(30% PLAN SET)

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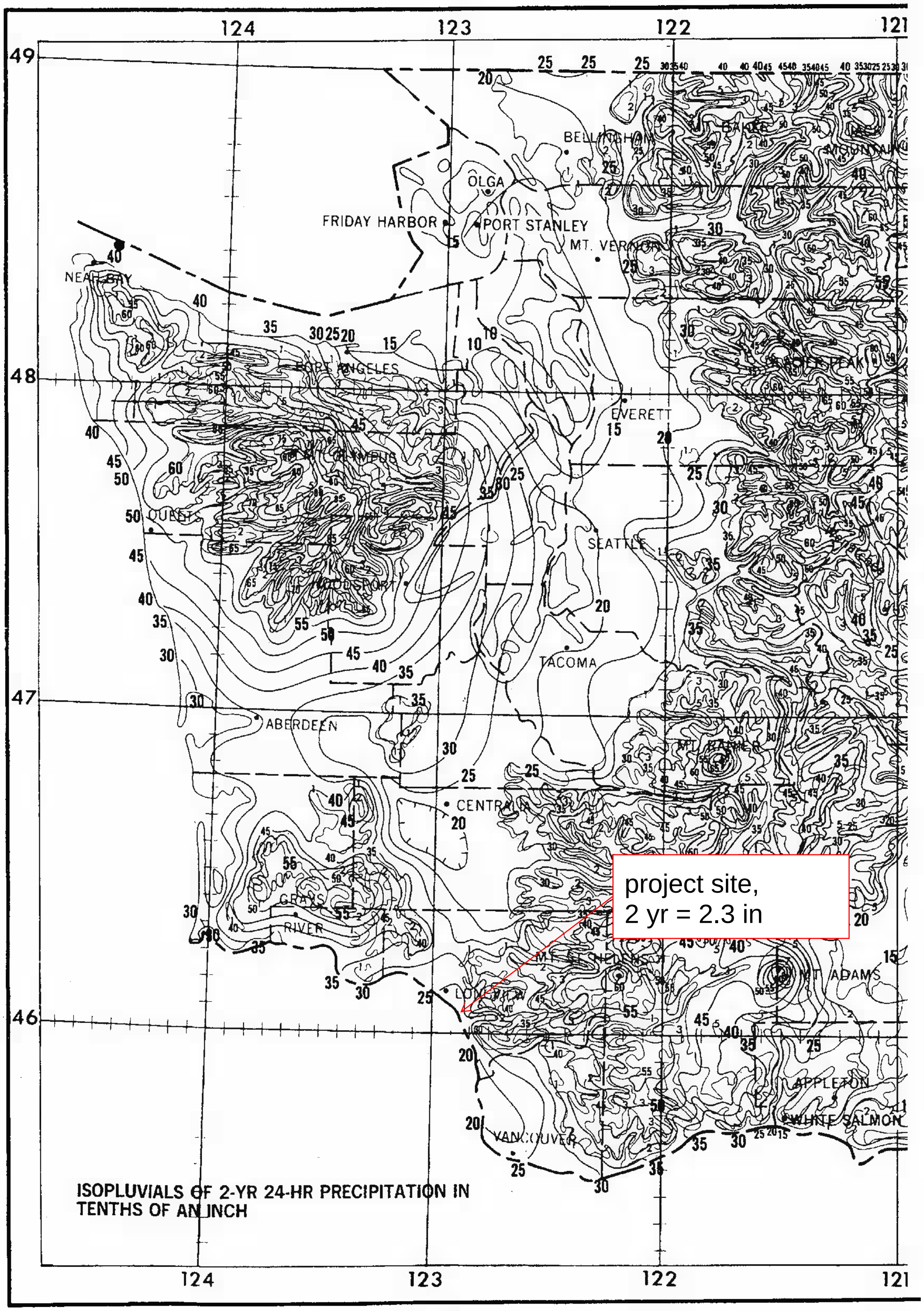
10-24-2017

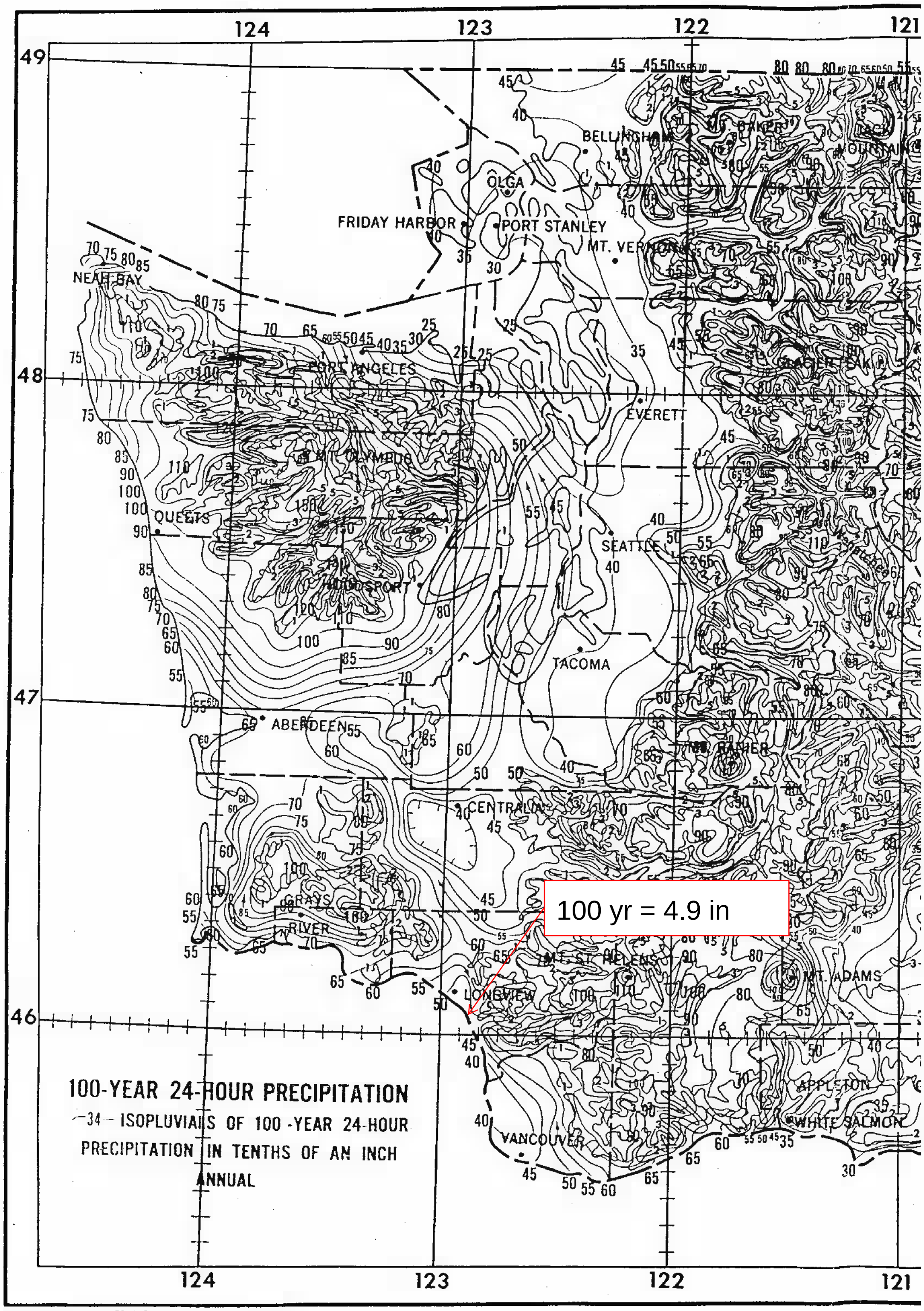
JOB NO.: 09-060
SHEET NO. 2 OF 2

C. 2 and 100 Year Isopluvial Maps

Western Washington Isopluvial 2-year, 24 hour



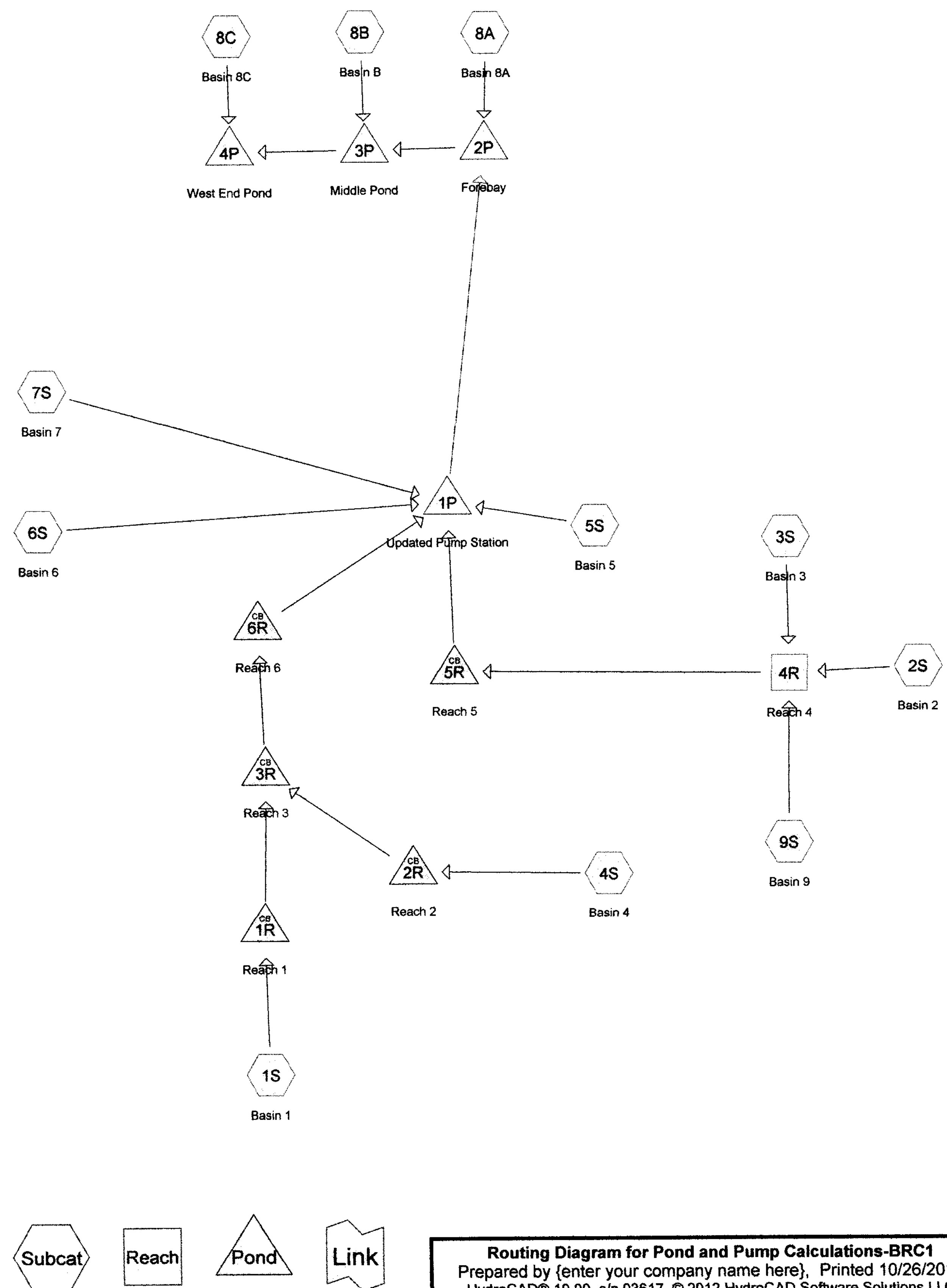
Western Washington Isopluvial 100-year, 24 hour



USDA-SCS-NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX.-1986

D. Developed 6 month (WQ)
and

100 Year HydroCad Analysis Calculations



Routing Diagram for Pond and Pump Calculations-BRC1
Prepared by {enter your company name here}, Printed 10/26/2017
HydroCAD® 10.00 s/n 03617 © 2012 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Basin 1

Runoff = 0.60 cfs @ 7.93 hrs, Volume= 0.192 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	1.850	98	Paved
	1.850		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 2S: Basin 2

Runoff = 0.25 cfs @ 7.96 hrs, Volume= 0.082 af, Depth> 0.98"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	0.800	98	Paved
*	0.200	85	Landscape
	1.000	95	Weighted Average
	0.200		20.00% Pervious Area
	0.800		80.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 3S: Basin 3

Runoff = 1.83 cfs @ 7.97 hrs, Volume= 0.603 af, Depth> 1.06"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	6.000	98	Paved and roofs
*	0.810	85	Landscape
	6.810	96	Weighted Average
	0.810		11.89% Pervious Area
	6.000		88.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	300	0.0050	0.68		**Sheet Flow, Sheet Flow** n= 0.015 P2= 2.50"

Summary for Subcatchment 4S: Basin 4

Runoff = 2.00 cfs @ 7.96 hrs, Volume= 0.648 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	6.230	98	Paved
	6.230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	300	0.0050	0.76		**Sheet Flow, Sheet Flow L1** n= 0.013 P2= 2.50"

Summary for Subcatchment 5S: Basin 5

Runoff = 1.29 cfs @ 7.95 hrs, Volume= 0.416 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	4.000	98	Paved and Roofs
	4.000		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 6S: Basin 6

Runoff = 0.21 cfs @ 7.96 hrs, Volume= 0.067 af, Depth> 0.98"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	0.660	98	Impervious
*	0.160	85	Landscape
	0.820	95	Weighted Average
	0.160		19.51% Pervious Area
	0.660		80.49% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 7S: Basin 7

Runoff = 0.18 cfs @ 7.96 hrs, Volume= 0.059 af, Depth> 0.98"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	0.580	98	Impervious
*	0.140	85	Landscape
	0.720	95	Weighted Average
	0.140		19.44% Pervious Area
	0.580		80.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 8A: Basin 8A

Runoff = 0.14 cfs @ 7.93 hrs, Volume= 0.045 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (sf)	CN	Description
*	18,954	98	water surface
	18,954		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 8B: Basin B

Runoff = 0.15 cfs @ 7.93 hrs, Volume= 0.050 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (sf)	CN	Description
*	20,731	98	water surface
	20,731		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 8C: Basin 8C

Runoff = 0.35 cfs @ 7.93 hrs, Volume= 0.114 af, Depth> 1.25"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (sf)	CN	Description
*	47,790	98	water
	47,790		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 9S: Basin 9

Runoff = 1.30 cfs @ 8.04 hrs, Volume= 0.501 af, Depth> 0.98"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr WQ Rainfall=1.47"

	Area (ac)	CN	Description
*	1.230	85	Landscape
*	4.920	98	IMPERVIOUS
	6.150	95	Weighted Average
	1.230		20.00% Pervious Area
	4.920		80.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0					**Direct Entry,**

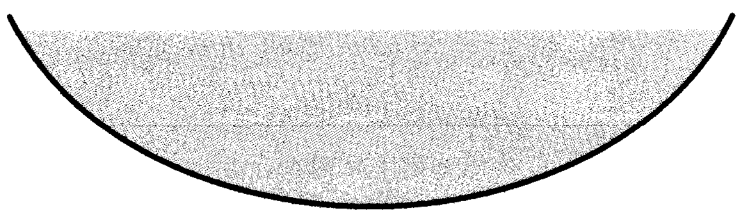
Summary for Reach 4R: Reach 4

Inflow Area = 13.960 ac, 83.95% Impervious, Inflow Depth > 1.02" for WQ event
Inflow = 3.36 cfs @ 7.99 hrs, Volume= 1.186 af
Outflow = 2.80 cfs @ 8.18 hrs, Volume= 1.167 af, Atten= 17%, Lag= 11.6 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Max. Velocity= 0.52 fps, Min. Travel Time= 20.6 min
Avg. Velocity = 0.32 fps, Avg. Travel Time= 33.7 min

Peak Storage= 3,452 cf @ 8.18 hrs
Average Depth at Peak Storage= 1.39'
Bank-Full Depth= 1.50' Flow Area= 6.0 sf, Capacity= 3.27 cfs

6.00' x 1.50' deep Parabolic Channel, n= 0.240
Length= 644.0' Slope= 0.0093 '/'
Inlet Invert= 24.00', Outlet Invert= 18.00'



Summary for Pond 1P: Updated Pump Station

Inflow Area =	27.580 ac,	90.79% Impervious,	Inflow Depth > 1.11"	for WQ event
Inflow =	6.71 cfs @	8.01 hrs, Volume=	2.549 af	
Outflow =	11.98 cfs @	8.02 hrs, Volume=	3.143 af, Atten= 0%, Lag= 0.9 min	
Primary =	11.98 cfs @	8.02 hrs, Volume=	3.143 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 13.13' @ 7.97 hrs Surf.Area= 0 sf Storage= 1,155 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 30.6 min (760.4 - 729.8)

Volume	Invert	Avail.Storage	Storage Description
#1	7.60'	2,196 cf	**Custom Stage Data** Listed below x 2

Elevation (feet)	Cum.Store (cubic-feet)
7.60	0
8.00	5
9.00	18
10.00	30
11.00	43
12.00	240
13.00	539
14.00	839
15.00	1,035
16.00	1,048
17.00	1,060
18.00	1,073
19.00	1,085
20.00	1,098

Device	Routing	Invert	Outlet Devices
#1	Primary	13.00'	**Pump** Discharges@20.35' Turns Off@11.00' 11.0" Diam. x 391.0' Long Discharge, Hazen-Williams C= 150 Flow (gpm)= 0.0 1,000.0 2,000.0 3,000.0 4,000.0 5,000.0 6,000.0 7,000.0 8,000.0 Head (feet)= 68.00 65.00 62.00 58.00 54.00 48.00 42.00 35.00 27.00 -Loss (feet)= 0.00 1.16 4.20 8.89 15.14 22.89 32.08 42.68 54.66 =Lift (feet)= 68.00 63.84 57.80 49.11 38.86 25.11 9.92 -7.68 -27.66
#2	Primary	14.00'	**Pump** Discharges@20.35' Turns Off@11.00' Flow (gpm)= 0.0 1,000.0 2,000.0 3,000.0 4,000.0 5,000.0 6,000.0 7,000.0 8,000.0 Head (feet)= 68.00 65.00 62.00 58.00 54.00 48.00 42.00 35.00 27.00

Primary OutFlow Max=30.82 cfs @ 8.02 hrs HW=12.57' TW=24.98' (Dynamic Tailwater)
1=Pump (Pump Controls 13.00 cfs)
2=Pump (Pump Controls 17.82 cfs)

Summary for Pond 1R: Reach 1

Inflow Area =	1.850 ac,100.00% Impervious,	Inflow Depth > 1.25"	for WQ event
Inflow =	0.60 cfs @ 7.93 hrs, Volume=	0.192 af	
Outflow =	0.60 cfs @ 7.93 hrs, Volume=	0.192 af, Atten= 0%, Lag= 0.0 min	
Primary =	0.60 cfs @ 7.93 hrs, Volume=	0.192 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 18.43' @ 7.95 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**12.0" Round Culvert** L= 412.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.00' / 16.00' S= 0.0049 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=0.59 cfs @ 7.93 hrs HW=18.42' TW=16.56' (Dynamic Tailwater)
1=Culvert (Outlet Controls 0.59 cfs @ 2.75 fps)

Summary for Pond 2P: Forebay

Inflow Area =	28.015 ac, 90.93% Impervious,	Inflow Depth > 1.37"	for WQ event
Inflow =	12.11 cfs @ 8.02 hrs, Volume=	3.189 af	
Outflow =	7.10 cfs @ 8.11 hrs, Volume=	2.880 af, Atten= 41%, Lag= 5.0 min	
Primary =	7.10 cfs @ 8.11 hrs, Volume=	2.880 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs

Peak Elev= 25.12' @ 8.11 hrs Surf.Area= 7,079 sf Storage= 16,646 cf

Plug-Flow detention time= 109.3 min calculated for 2.869 af (90% of inflow)
Center-of-Mass det. time= 45.1 min (804.6 - 759.5)

Volume	Invert	Avail.Storage	Storage Description
#1	22.00'	53,819 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
22.00	3,716	0	0
23.00	4,717	4,217	4,217
24.00	5,791	5,254	9,471
25.00	6,938	6,365	15,835
26.00	8,155	7,547	23,382
27.00	9,445	8,800	32,182
28.00	10,799	10,122	42,304
29.00	12,231	11,515	53,819

Device	Routing	Invert	Outlet Devices
#1	Primary	24.00'	**24.0" Round Culvert X 2.00** L= 30.0' Ke= 0.900 Inlet / Outlet Invert= 24.00' / 24.00' S= 0.0000 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf
#2	Primary	28.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=7.01 cfs @ 8.11 hrs HW=25.11' TW=23.42' (Dynamic Tailwater)
1=Culvert (Barrel Controls 7.01 cfs @ 2.84 fps)
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 2R: Reach 2

Inflow Area = 6.230 ac,100.00% Impervious, Inflow Depth > 1.25" for WQ event
Inflow = 2.00 cfs @ 7.96 hrs, Volume= 0.648 af
Outflow = 2.00 cfs @ 7.96 hrs, Volume= 0.648 af, Atten= 0%, Lag= 0.0 min
Primary = 2.00 cfs @ 7.96 hrs, Volume= 0.648 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 19.42' @ 7.96 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.50'	**12.0" Round Culvert** L= 286.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.50' / 17.50' S= 0.0035 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=1.96 cfs @ 7.96 hrs HW=19.41' TW=16.56' (Dynamic Tailwater)
1=Culvert (Barrel Controls 1.96 cfs @ 3.44 fps)

Summary for Pond 3P: Middle Pond

Inflow Area =	28.491 ac, 91.08% Impervious,	Inflow Depth > 1.23"	for WQ event	
Inflow =	7.22 cfs @	8.10 hrs, Volume=	2.930 af	
Outflow =	6.06 cfs @	8.22 hrs, Volume=	2.701 af,	Atten= 16%, Lag= 6.8 min
Discarded =	0.44 cfs @	8.22 hrs, Volume=	0.639 af	
Primary =	5.62 cfs @	8.22 hrs, Volume=	2.062 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 23.45' @ 8.22 hrs Surf.Area= 9,520 sf Storage= 12,549 cf

Plug-Flow detention time= 85.2 min calculated for 2.701 af (92% of inflow)
Center-of-Mass det. time= 36.9 min (839.6 - 802.7)

Volume	Invert	Avail.Storage	Storage Description
#1	22.00'	85,007 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
22.00	7,833	0	0
23.00	8,974	8,404	8,404
24.00	10,192	9,583	17,987
25.00	11,486	10,839	28,826
26.00	12,857	12,172	40,997
27.00	14,216	13,537	54,534
28.00	15,228	14,722	69,256
29.00	16,274	15,751	85,007

Device	Routing	Invert	Outlet Devices
#1	Discarded	22.00'	**2.000 in/hr Exfiltration over Surface area**
#2	Primary	23.00'	**24.0" Round Culvert X 10.00** L= 30.0' Ke= 0.900 Inlet / Outlet Invert= 23.00' / 23.00' S= 0.0000 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf
#3	Primary	28.00'	**50.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.44 cfs @ 8.22 hrs HW=23.45' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.44 cfs)

Primary OutFlow Max=5.55 cfs @ 8.22 hrs HW=23.45' TW=23.02' (Dynamic Tailwater)
├—**2=Culvert** (Barrel Controls 5.55 cfs @ 1.61 fps)
└—**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3R: Reach 3

Inflow Area = 8.080 ac,100.00% Impervious, Inflow Depth > 1.25" for WQ event
Inflow = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af
Outflow = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af, Atten= 0%, Lag= 0.0 min
Primary = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 16.56' @ 7.95 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	15.79'	**24.0" Round Culvert** L= 431.0' Ke= 0.500 Inlet / Outlet Invert= 15.79' / 14.50' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf

Primary OutFlow Max=2.56 cfs @ 7.95 hrs HW=16.56' TW=14.87' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 2.56 cfs @ 3.42 fps)

Summary for Pond 4P: West End Pond

Inflow Area = 29.588 ac, 91.42% Impervious, Inflow Depth > 0.88" for WQ event
Inflow = 5.84 cfs @ 8.21 hrs, Volume= 2.176 af
Outflow = 4.45 cfs @ 8.72 hrs, Volume= 2.181 af, Atten= 24%, Lag= 30.2 min
Discarded = 4.45 cfs @ 8.72 hrs, Volume= 2.181 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 23.08' @ 8.72 hrs Surf.Area= 25,978 sf Storage= 1,943 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 2.2 min (816.7 - 814.5)

Volume	Invert	Avail.Storage	Storage Description
#1	23.00'	192,737 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
23.00	25,823	0	0
24.00	27,892	26,858	26,858
25.00	30,025	28,959	55,816
26.00	32,223	31,124	86,940
27.00	34,411	33,317	120,257
28.00	36,232	35,322	155,579
29.00	38,085	37,159	192,737

Device	Routing	Invert	Outlet Devices
#1	Discarded	23.00'	**7.400 in/hr Exfiltration over Surface area**
#2	Primary	28.00'	**25.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Discarded OutFlow Max=4.45 cfs @ 8.72 hrs HW=23.07' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 4.45 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=23.00' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 5R: Reach 5

Inflow Area = 13.960 ac, 83.95% Impervious, Inflow Depth > 1.00" for WQ event
Inflow = 2.80 cfs @ 8.18 hrs, Volume= 1.167 af
Outflow = 2.80 cfs @ 8.18 hrs, Volume= 1.167 af, Atten= 0%, Lag= 0.0 min
Primary = 2.80 cfs @ 8.18 hrs, Volume= 1.167 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 19.05' @ 8.18 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**12.0" Round Culvert** L= 395.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.00' / 15.00' S= 0.0076 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=2.78 cfs @ 8.18 hrs HW=19.04' TW=12.54' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 2.78 cfs @ 3.55 fps)

Summary for Pond 6R: Reach 6

Inflow Area = 8.080 ac,100.00% Impervious, Inflow Depth > 1.25" for WQ event
Inflow = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af
Outflow = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af, Atten= 0%, Lag= 0.0 min
Primary = 2.60 cfs @ 7.95 hrs, Volume= 0.840 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 14.88' @ 7.95 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	14.15'	**48.0" Round Culvert** L= 91.0' Ke= 0.500 Inlet / Outlet Invert= 14.15' / 14.00' S= 0.0016 '/' Cc= 0.900 n= 0.013, Flow Area= 12.57 sf

Primary OutFlow Max=2.56 cfs @ 7.95 hrs HW=14.87' TW=12.80' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 2.56 cfs @ 2.50 fps)

Summary for Subcatchment 1S: Basin 1

Runoff = 2.14 cfs @ 7.92 hrs, Volume= 0.718 af, Depth> 4.66"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	1.850	98	Paved
	1.850		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 2S: Basin 2

Runoff = 1.11 cfs @ 7.93 hrs, Volume= 0.359 af, Depth> 4.31"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	0.800	98	Paved
*	0.200	85	Landscape
	1.000	95	Weighted Average
	0.200		20.00% Pervious Area
	0.800		80.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 3S: Basin 3

Runoff = 7.55 cfs @ 7.96 hrs, Volume= 2.509 af, Depth> 4.42"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	6.000	98	Paved and roofs
*	0.810	85	Landscape
	6.810	96	Weighted Average
	0.810		11.89% Pervious Area
	6.000		88.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	300	0.0050	0.68		**Sheet Flow, Sheet Flow** n= 0.015 P2= 2.50"

Summary for Subcatchment 4S: Basin 4

Runoff = 7.16 cfs @ 7.95 hrs, Volume= 2.416 af, Depth> 4.65"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	6.230	98	Paved
	6.230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	300	0.0050	0.76		**Sheet Flow, Sheet Flow L1** n= 0.013 P2= 2.50"

Summary for Subcatchment 5S: Basin 5

Runoff = 4.59 cfs @ 7.94 hrs, Volume= 1.551 af, Depth> 4.65"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	4.000	98	Paved and Roofs
	4.000		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 6S: Basin 6

Runoff = 0.91 cfs @ 7.93 hrs, Volume= 0.295 af, Depth> 4.31"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	0.660	98	Impervious
*	0.160	85	Landscape
	0.820	95	Weighted Average
	0.160		19.51% Pervious Area
	0.660		80.49% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 7S: Basin 7

Runoff = 0.80 cfs @ 7.93 hrs, Volume= 0.259 af, Depth> 4.31"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	0.580	98	Impervious
*	0.140	85	Landscape
	0.720	95	Weighted Average
	0.140		19.44% Pervious Area
	0.580		80.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 8A: Basin 8A

Runoff = 0.50 cfs @ 7.92 hrs, Volume= 0.169 af, Depth> 4.66"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (sf)	CN	Description
*	18,954	98	water surface
	18,954		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 8B: Basin B

Runoff = 0.55 cfs @ 7.92 hrs, Volume= 0.185 af, Depth> 4.66"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (sf)	CN	Description
*	20,731	98	water surface
	20,731		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Summary for Subcatchment 8C: Basin 8C

Runoff = 1.27 cfs @ 7.92 hrs, Volume= 0.426 af, Depth> 4.66"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (sf)	CN	Description
*	47,790	98	water
	47,790		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Entry**

Summary for Subcatchment 9S: Basin 9

Runoff = 5.81 cfs @ 8.02 hrs, Volume= 2.201 af, Depth> 4.29"

Runoff by SBUH method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Type IA 24-hr 100 YR Rainfall=4.90"

	Area (ac)	CN	Description
*	1.230	85	Landscape
*	4.920	98	IMPERVIOUS
	6.150	95	Weighted Average
	1.230		20.00% Pervious Area
	4.920		80.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0					**Direct Entry,**

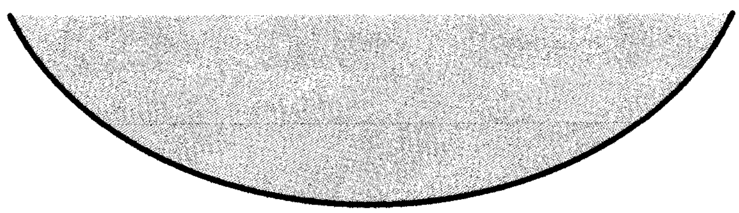
Summary for Reach 4R: Reach 4

Inflow Area = 13.960 ac, 83.95% Impervious, Inflow Depth > 4.36" for 100 YR event
Inflow = 14.39 cfs @ 7.98 hrs, Volume= 5.069 af
Outflow = 12.41 cfs @ 8.14 hrs, Volume= 5.023 af, Atten= 14%, Lag= 9.9 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Max. Velocity= 0.69 fps, Min. Travel Time= 15.6 min
Avg. Velocity = 0.48 fps, Avg. Travel Time= 22.4 min

Peak Storage= 11,635 cf @ 8.14 hrs
Average Depth at Peak Storage= 3.52'
Bank-Full Depth= 1.50' Flow Area= 6.0 sf, Capacity= 3.27 cfs

6.00' x 1.50' deep Parabolic Channel, n= 0.240
Length= 644.0' Slope= 0.0093 '/'
Inlet Invert= 24.00', Outlet Invert= 18.00'



Summary for Pond 1P: Updated Pump Station

Inflow Area =	27.580 ac, 90.79% Impervious,	Inflow Depth > 4.46"	for 100 YR event
Inflow =	26.93 cfs @ 8.00 hrs, Volume=	10.261 af	
Outflow =	30.75 cfs @ 8.09 hrs, Volume=	10.791 af, Atten= 0%, Lag= 5.7 min	
Primary =	30.75 cfs @ 8.09 hrs, Volume=	10.791 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 14.14' @ 8.03 hrs Surf.Area= 0 sf Storage= 1,732 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 13.6 min (692.0 - 678.4)

Volume	Invert	Avail.Storage	Storage Description
#1	7.60'	2,196 cf	**Custom Stage Data** Listed below x 2

Elevation (feet)	Cum.Store (cubic-feet)
7.60	0
8.00	5
9.00	18
10.00	30
11.00	43
12.00	240
13.00	539
14.00	839
15.00	1,035
16.00	1,048
17.00	1,060
18.00	1,073
19.00	1,085
20.00	1,098

Device	Routing	Invert	Outlet Devices
#1	Primary	13.00'	**Pump** Discharges@20.35' Turns Off@11.00' 11.0" Diam. x 391.0' Long Discharge, Hazen-Williams C= 150 Flow (gpm)= 0.0 1,000.0 2,000.0 3,000.0 4,000.0 5,000.0 6,000.0 7,000.0 8,000.0 Head (feet)= 68.00 65.00 62.00 58.00 54.00 48.00 42.00 35.00 27.00 -Loss (feet)= 0.00 1.16 4.20 8.89 15.14 22.89 32.08 42.68 54.66 =Lift (feet)= 68.00 63.84 57.80 49.11 38.86 25.11 9.92 -7.68 -27.66
#2	Primary	14.00'	**Pump** Discharges@20.35' Turns Off@11.00' Flow (gpm)= 0.0 1,000.0 2,000.0 3,000.0 4,000.0 5,000.0 6,000.0 7,000.0 8,000.0 Head (feet)= 68.00 65.00 62.00 58.00 54.00 48.00 42.00 35.00 27.00

Primary OutFlow Max=30.71 cfs @ 8.09 hrs HW=13.13' TW=26.36' (Dynamic Tailwater)
—**1=Pump** (Pump Controls 12.88 cfs)
—**2=Pump** (Pump Controls 17.82 cfs)

Summary for Pond 1R: Reach 1

Inflow Area =	1.850 ac,100.00% Impervious,	Inflow Depth > 4.66"	for 100 YR event
Inflow =	2.14 cfs @ 7.92 hrs,	Volume=	0.718 af
Outflow =	2.14 cfs @ 7.92 hrs,	Volume=	0.718 af, Atten= 0%, Lag= 0.0 min
Primary =	2.14 cfs @ 7.92 hrs,	Volume=	0.718 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 18.99' @ 7.95 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**12.0" Round Culvert** L= 412.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.00' / 16.00' S= 0.0049 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=2.10 cfs @ 7.92 hrs HW=18.97' TW=17.37' (Dynamic Tailwater)
—**1=Culvert** (Outlet Controls 2.10 cfs @ 3.43 fps)

Summary for Pond 2P: Forebay

Inflow Area =	28.015 ac, 90.93% Impervious,	Inflow Depth > 4.69"	for 100 YR event
Inflow =	31.17 cfs @ 8.09 hrs,	Volume=	10.960 af
Outflow =	26.18 cfs @ 8.17 hrs,	Volume=	10.609 af, Atten= 16%, Lag= 4.7 min
Primary =	26.18 cfs @ 8.17 hrs,	Volume=	10.609 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs

Peak Elev= 26.45' @ 8.17 hrs Surf.Area= 8,741 sf Storage= 27,222 cf

Plug-Flow detention time= 53.1 min calculated for 10.609 af (97% of inflow)
Center-of-Mass det. time= 29.9 min (721.4 - 691.4)

Volume	Invert	Avail.Storage	Storage Description
#1	22.00'	53,819 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
22.00	3,716	0	0
23.00	4,717	4,217	4,217
24.00	5,791	5,254	9,471
25.00	6,938	6,365	15,835
26.00	8,155	7,547	23,382
27.00	9,445	8,800	32,182
28.00	10,799	10,122	42,304
29.00	12,231	11,515	53,819

Device	Routing	Invert	Outlet Devices
#1	Primary	24.00'	**24.0" Round Culvert X 2.00** L= 30.0' Ke= 0.900 Inlet / Outlet Invert= 24.00' / 24.00' S= 0.0000 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf
#2	Primary	28.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=25.75 cfs @ 8.17 hrs HW=26.42' TW=24.51' (Dynamic Tailwater)
1=Culvert (Barrel Controls 25.75 cfs @ 4.30 fps)
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 2R: Reach 2

Inflow Area = 6.230 ac,100.00% Impervious, Inflow Depth > 4.65" for 100 YR event
Inflow = 7.16 cfs @ 7.95 hrs, Volume= 2.416 af
Outflow = 7.16 cfs @ 7.95 hrs, Volume= 2.416 af, Atten= 0%, Lag= 0.0 min
Primary = 7.16 cfs @ 7.95 hrs, Volume= 2.416 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 28.72' @ 7.95 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.50'	**12.0" Round Culvert** L= 286.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.50' / 17.50' S= 0.0035 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=7.05 cfs @ 7.95 hrs HW=28.42' TW=17.37' (Dynamic Tailwater)
1=Culvert (Barrel Controls 7.05 cfs @ 8.98 fps)

Summary for Pond 3P: Middle Pond

Inflow Area =	28.491 ac, 91.08% Impervious,	Inflow Depth > 4.55"	for 100 YR event
Inflow =	26.55 cfs @ 8.17 hrs,	Volume= 10.793 af	
Outflow =	21.48 cfs @ 8.18 hrs,	Volume= 10.195 af,	Atten= 19%, Lag= 0.4 min
Discarded =	0.59 cfs @ 11.60 hrs,	Volume= 0.943 af	
Primary =	20.98 cfs @ 8.18 hrs,	Volume= 9.253 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 25.91' @ 11.60 hrs Surf.Area= 12,731 sf Storage= 39,822 cf

Plug-Flow detention time= 78.9 min calculated for 10.153 af (94% of inflow)
Center-of-Mass det. time= 40.7 min (761.0 - 720.3)

Volume	Invert	Avail.Storage	Storage Description
#1	22.00'	85,007 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
22.00	7,833	0	0
23.00	8,974	8,404	8,404
24.00	10,192	9,583	17,987
25.00	11,486	10,839	28,826
26.00	12,857	12,172	40,997
27.00	14,216	13,537	54,534
28.00	15,228	14,722	69,256
29.00	16,274	15,751	85,007

Device	Routing	Invert	Outlet Devices
#1	Discarded	22.00'	**2.000 in/hr Exfiltration over Surface area**
#2	Primary	23.00'	**24.0" Round Culvert X 10.00** L= 30.0' Ke= 0.900 Inlet / Outlet Invert= 23.00' / 23.00' S= 0.0000 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf
#3	Primary	28.00'	**50.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.59 cfs @ 11.60 hrs HW=25.91' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.59 cfs)

Primary OutFlow Max=0.00 cfs @ 8.18 hrs HW=24.52' TW=24.67' (Dynamic Tailwater)
├─**2=Culvert** (Controls 0.00 cfs)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3R: Reach 3

Inflow Area =	8.080 ac,100.00% Impervious,	Inflow Depth > 4.65"	for 100 YR event		
Inflow =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af	
Outflow =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af,	Atten= 0%, Lag= 0.0 min
Primary =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 17.38' @ 7.94 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	15.79'	**24.0" Round Culvert** L= 431.0' Ke= 0.500 Inlet / Outlet Invert= 15.79' / 14.50' S= 0.0030 '/' Cc= 0.900 n= 0.011, Flow Area= 3.14 sf

Primary OutFlow Max=9.18 cfs @ 7.94 hrs HW=17.37' TW=15.51' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 9.18 cfs @ 4.72 fps)

Summary for Pond 4P: West End Pond

Inflow Area =	29.588 ac, 91.42% Impervious,	Inflow Depth > 3.93"	for 100 YR event		
Inflow =	21.84 cfs @	8.17 hrs,	Volume=	9.678 af	
Outflow =	5.49 cfs @	11.50 hrs,	Volume=	8.592 af,	Atten= 75%, Lag= 199.4 min
Discarded =	5.49 cfs @	11.50 hrs,	Volume=	8.592 af	
Primary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 25.91' @ 11.50 hrs Surf.Area= 32,021 sf Storage= 83,982 cf

Plug-Flow detention time= 175.0 min calculated for 8.592 af (89% of inflow)
Center-of-Mass det. time= 101.4 min (851.8 - 750.4)

Volume	Invert	Avail.Storage	Storage Description
#1	23.00'	192,737 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
23.00	25,823	0	0
24.00	27,892	26,858	26,858
25.00	30,025	28,959	55,816
26.00	32,223	31,124	86,940
27.00	34,411	33,317	120,257
28.00	36,232	35,322	155,579
29.00	38,085	37,159	192,737

Device	Routing	Invert	Outlet Devices
#1	Discarded	23.00'	**7.400 in/hr Exfiltration over Surface area**
#2	Primary	28.00'	**25.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Discarded OutFlow Max=5.48 cfs @ 11.50 hrs HW=25.91' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 5.48 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=23.00' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 5R: Reach 5

Inflow Area =	13.960 ac,	83.95% Impervious,	Inflow Depth > 4.32"	for 100 YR event	
Inflow =	12.41 cfs @	8.14 hrs,	Volume=	5.023 af	
Outflow =	12.41 cfs @	8.14 hrs,	Volume=	5.023 af,	Atten= 0%, Lag= 0.0 min
Primary =	12.41 cfs @	8.14 hrs,	Volume=	5.023 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 56.21' @ 8.14 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**12.0" Round Culvert** L= 395.0' Square-edged headwall, Ke= 0.500 Inlet / Outlet Invert= 18.00' / 15.00' S= 0.0076 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf

Primary OutFlow Max=12.31 cfs @ 8.14 hrs HW=55.57' TW=12.17' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 12.31 cfs @ 15.67 fps)

Summary for Pond 6R: Reach 6

Inflow Area =	8.080 ac,	100.00% Impervious,	Inflow Depth > 4.65"	for 100 YR event	
Inflow =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af	
Outflow =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af,	Atten= 0%, Lag= 0.0 min
Primary =	9.24 cfs @	7.94 hrs,	Volume=	3.133 af	

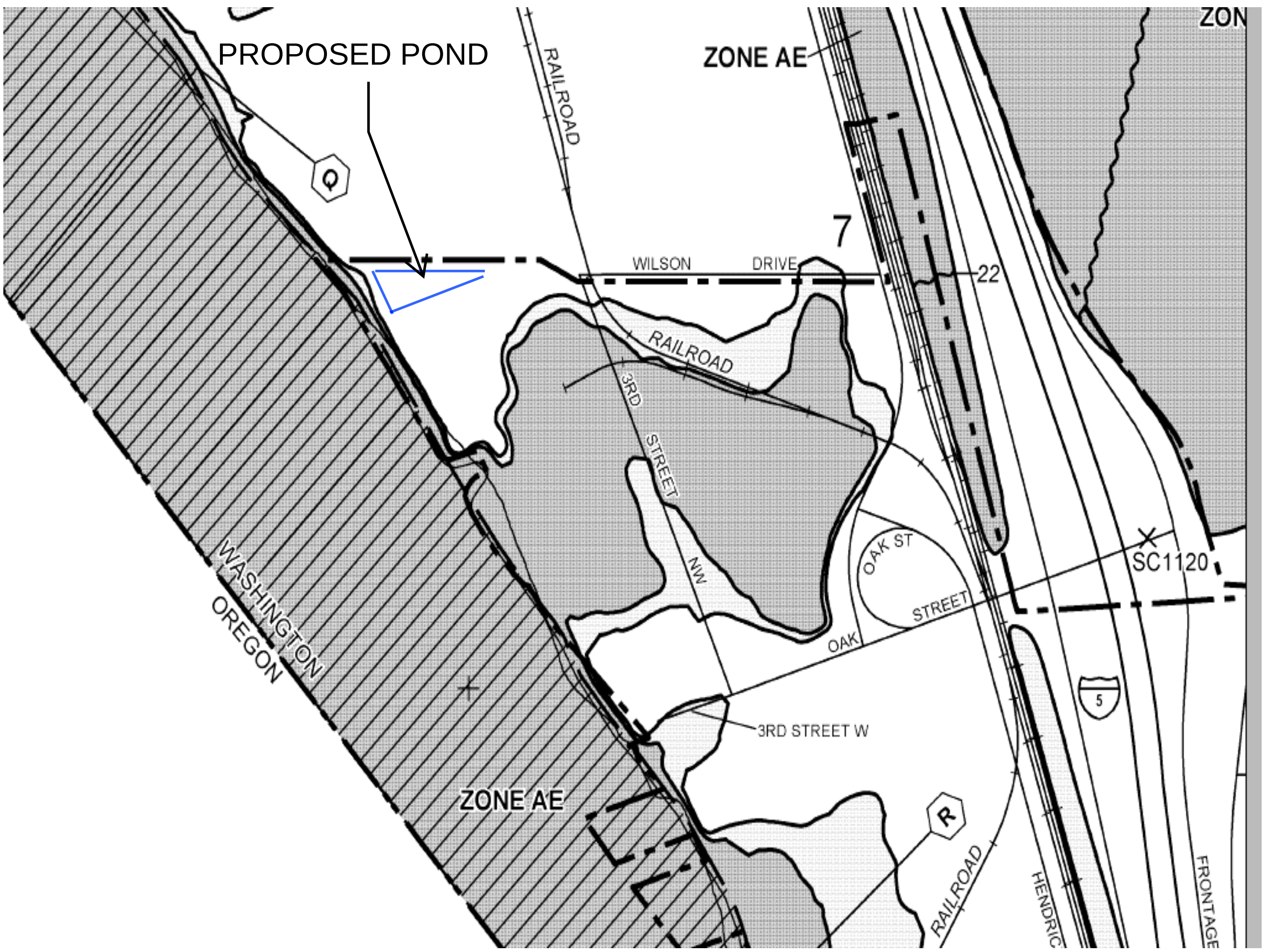
Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.10 hrs
Peak Elev= 15.52' @ 7.94 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	14.15'	**48.0" Round Culvert** L= 91.0' Ke= 0.500 Inlet / Outlet Invert= 14.15' / 14.00' S= 0.0016 '/' Cc= 0.900 n= 0.013, Flow Area= 12.57 sf

Primary OutFlow Max=9.18 cfs @ 7.94 hrs HW=15.51' TW=12.31' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 9.18 cfs @ 3.63 fps)

E. FEMA Flood Map

FEMA FLOOD PANEL # 53015C0713G



F. Geological Investigation Report

February 17, 2011

Mr. Mark Wilson
Port of Kalama
380 West Marine Drive
Kalama, Washington 98625
markwilson@portofkalama.com

Subject: **Results of Preliminary Subsurface Infiltration Testing**
Proposed Stormwater Management Improvements
Port of Kalama Property West of Northwest 3rd Street and Wilson Drive
Kalama, Washington
CGI Report No. 11-006-1

Dear Mr. Wilson:

Chinook GeoServices, Inc. (CGI) has completed infiltration testing for the Port of Kalama property located west of the intersection between Northwest 3rd Street and Wilson Drive in Kalama, Washington. Our scope of services was outlined in our proposal number 11-P005, dated January 6, 2011. Our services were authorized by you signing and returning the Proposal Acceptance Form on January 12, 2011.

PROJECT DESCRIPTION

The project site is located west of the intersection between Northwest 3rd Street and Wilson Drive in Kalama, Washington. The Columbia River borders the site on the west. North, south, and east of the site are developed industrial properties. The location of the site is shown in the attached Figure 1. The site is generally triangular in shape, but the exact property dimensions are unknown. Based on measurements of aerial photography, the dimensions of the site are roughly 750 feet (east-west) by 600 feet (southwest-northeast) by 400 feet (northwest-southeast). Based on these estimations, the approximate area of the undeveloped site is 2.5 acres to 3 acres. A general site plan is shown in the attached Figure 2.

We understand that the site has been developed multiple times in the past. The most recent use for the site was a log storage yard, which is still visible in the aerial imagery of the site dating back to 1994. The type of uses and development on the site prior to the log yard are unknown.

Site specific topographic mapping was not available. The topography across the site and in the surrounding area is relatively level. The elevation of the site is approximately 13 feet above mean sea level (MSL) according to USGS topographic mapping of the 7.5 minute Kalama quadrangle. Local variations in topography include drainage ditches, likely excavated for log yard drainage. The topography descends along the western margin of the property to the bank of the Columbia River. The elevation of the Columbia River is 7 feet above MSL according to the USGS topographic mapping. Based on interpolation of USGS mean stream gauge height, the elevation of the Columbia River adjacent to the site ranged from approximately 8 feet to 7 feet at the time of our respective site visits.

No site plans or civil engineering design were available at the time of this report. Based on our conversations with you and Bobby Carpenter of Carpenter Engineering, the project civil engineer, we understand that the site will be used for construction of a stormwater infiltration facility to serve the local Port of Kalama properties. Stormwater from roof, pavements, and other impervious surfaces will be collected and pumped to the site for treatment and infiltration entirely on the site. We understand that some of the site may be split off to create a developable industrial lot, but the dimensions or location of the partition is unknown at this time.

SCOPE OF WORK

The field work was conducted on January 24 and January 28, 2011. We explored subsurface conditions at the site by observing excavation of thirteen test pits (TP-1 through TP-13) using a medium-sized excavator provided and operated by the Port of Kalama. The locations of the test pits were selected in the field with Bob Carpenter, the project civil engineer, in the general location of potential infiltration areas. The locations of the test pits are shown on Figure 2. During test pit excavations, we observed subsurface conditions underlying the site and recorded our observations for use in this report. We also researched available water well logs, regional geologic maps, and hydrologic mapping for the area. Infiltration tests were conducted in 7 test pits at varying depths. The depth of the infiltration testing was restricted by the presence of shallow subsurface water.

SITE SOILS AND GEOLOGY

Soils mapped in the project area by the United States Department of Agriculture (USDA), Natural Resource Conservation Service Web Soil Survey (http://websoilsurvey.nrcs.usda.gov) consist of Pilchuck loamy fine sand, 0 percent to 8 percent slopes. This soil is found on flood plains and formed from alluvium. A typical 60-inch soil profile consists of loamy fine sand and fine sand in the upper 36 inches, underlain by gravelly sand to a depth of 60 inches.

According to the Geologic Map of the Mount Saint Helens Quadrangle, Washington and Oregon, Washington Division of Geology and Earth Resources, Open File Report 87-4, 1987, the subject property is mapped a Quaternary alluvium (Qal). This deposit is described as upper Pleistocene to Holocene in age (10,000 years ago to present) and consists of sand, silt, and gravel on floodplains and terraces along rivers and major creeks.

Our test pit explorations encountered variable manmade fill in all the test pits. The fill generally consisted of angular gravel and cobbles with sand and clay, underlain by sandier soil with depth. Some layers of organic debris were observed in the near surface of some test pits, and some metal and garbage was observed as well. In general, we observed cleaner sand underlying the gravel and cobble fill in the test pits closer to the river. It is our interpretation that the entire area is likely underlain by manmade fill and dredged river sand. A more detailed description of the subsurface conditions in each test pit is included in the attached test pit logs.

SUBSURFACE WATER CONDITIONS

Subsurface water seepage or saturated soil was encountered at various depths in eight of our test pit explorations. Generally, the seeping water appeared to be shallow water perched on layers of impervious fabric or above less pervious layers of fill. We extended five of our test pits to intercept the local subsurface water table, which was generally observed at depths of 6 feet to 7 feet below the ground surface.

At discussed above, we interpolated the elevation of the Columbia River adjacent to the site as ranging from approximately 8 feet to 7 feet above mean sea level at the time of our respective site visits. These stream levels are approximately 2 feet to 3 feet higher than the January monthly mean since 1998. According to USGS annual gauge height data, the month of January generally has the highest mean water level of the winter months. May and June generally represent the highest mean water level of the entire year (up to 1-foot higher than the January mean), however the precipitation would be expected to be less during this season.

It is our interpretation that the subsurface water level in the area of the site is primarily affected by the level of the Columbia River. Our investigations were conducted in January, which typically represents the highest winter water level based on USGS data. Additionally, the Columbia River was 2 feet to 3 feet higher than the January monthly mean level at the time of our investigations. Therefore, it is our opinion that the measured depth to the local subsurface water level in our test pit explorations likely represents conservative higher elevations for this site. However, flooding, storm events, seasonal variations, and climatic changes could contribute to even higher subsurface water levels. It is the responsibility of the civil engineer to design the stormwater facility to account for groundwater and design storm events.

INFILTRATION TEST METHODOLOGY

A total of eight infiltration tests were conducted in test pits TP-2, TP-4, TP-6, TP-8, TP-9, TP-10, TP-11 and TP-13 at various depths. After collecting preliminary results of testing in test pits TP-2, TP-4, TP-6, and TP-8, we estimated that infiltration rates would be less than 1/4-inch per hour and the testing was aborted. In test pits TP-8, TP-10, TP-11, and TP-13 the soil generally consisted of courser-grained clean sands, which provided better field infiltration rates.

Infiltration tests were conducted using an open pit falling head test method. An area at the base of the test pits was prepared with the excavator bucket to remove material that had fallen from the sides of the test pit. A 5-gallon bucket was placed in the bottom of the excavation and water was sprayed into the bucket from above. The bucked helped dissipate the energy of the hose and limited scouring and mixing of the soils being tested. Water was added until an approximately 6-inch to 12-inch head of water was achieved. The test pits were allowed to pre-soak prior to taking measurements. A cloth tape with a float was used to measure the water level in relation to a reference point at the top of the test pits. Measurements were taken over the course of a few hours and more water was added to the test pit when the water level dropped to below measurable levels Field infiltration rates were calculated based on the drop in water level or hydraulic head over time.

It should be noted that the open pit falling head procedure produces less conservative results than an encased falling head test due to the ability for water to spread laterally into the strata. It may be necessary to conduct performance infiltration tests at the time of construction using the encased falling head method to provide more accurate field rates.

INFILTRATION TEST RESULTS

Infiltration testing was conducted in test pits TP-8, TP10, TP-11, and TP-13 at depths of approximately 6.5 feet, 4.2 feet, 4.0 feet, and 5.0 feet, below the ground surface, respectively. At these depths the soil generally consisted of brown or gray, medium-grained sand with relatively low fines content.

Results of our infiltration testing indicate the on-site manmade fill soils exhibit highly variable infiltration rates. In general, the test pits closer to the Columbia River encountered courser-grained sands with less fines content, and the resulting infiltration rates were relatively higher than the test pits in the east, which generally encountered fine-grained sand with some fines. Table 1 presents the preliminary field infiltration rates at the test locations.

Table 1: Preliminary Field Infiltration Test Data

	TP-8	TP-10	TP-11	TP-13
Measured Infiltration Rate (inches/hour)	4	7	30	36
Depth of Test (feet)	6.5	4.2	4.0	5.0

The rates do not include a factor of safety. The stormwater management system designer is responsible for selecting an appropriate design infiltration rate and factor of safety. The subsurface water level was generally encountered at 6 feet to 7 feet below the ground surface. It is the responsibility of the stormwater management system designer to provide an adequate separation from the subsurface water level. We recommend that encased falling head infiltration tests are conducted at the time of construction to confirm field infiltration rates.

LIMITATIONS

We have prepared this report for use by Mark Wilson with the Port of Kalama and the design team for specific application to this site and project. The data and conclusions contained in this report are based on site and subsurface conditions at the time of our work. These conclusions and interpretations should not be considered as warranty of the subsurface conditions. Experience has shown that subsurface soil and groundwater conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and not be detected by this study. Infiltration rates of the as-built systems may differ from the rates measured in the field. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, CGI should be notified for review of the recommendations of this report, and revision of such if necessary. If the proposed storm water disposal system changes from that described in this report, our conclusions and recommendations should also be reviewed. Storm water systems should be designed so that overflow is directed away from structures. This report does not address environmental impacts of subsurface storm water infiltration or impacts of subsurface infiltration on regional flood events.

Please contact our office at (360) 695-8500 if you have questions concerning this report or need additional information or services.

Sincerely,
Chinook GeoServices, Inc.

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2/17/11

Marcella M. Boyer, P.E.
Principal Geotechnical Engineer

Attachments: References
Figure 1: Site Location Plan
Figure 2: Site Plan with Exploration Locations
Test Pit Logs

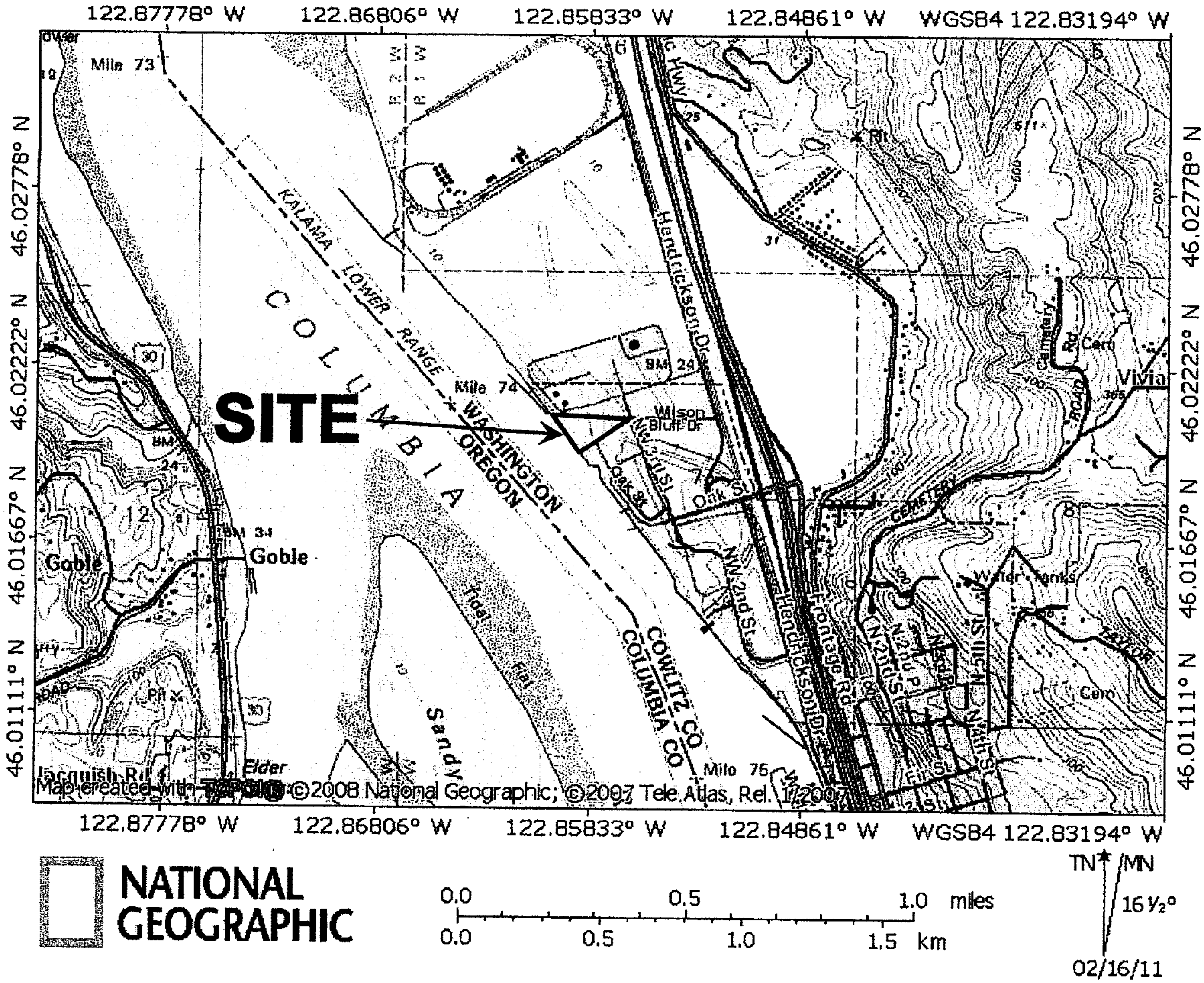
REFERENCES

Evarts, R.C., 2002, Geologic Map of the Saint Helens Quadrangle, Columbia County, Oregon and Cowlitz and Clark Counties, Washington: U.S. Geological Survey, Scientific Investigations Map 2834.

USGS Real-Time Water Data for USA, http://waterdata.usgs.gov/nwis/rt, accessed February 2011. Gauges: USGS 14246900 Columbia River at Beaver Army Terminal NR Quincy, Oregon and USGS 14144700 Columbia River at Vancouver, Washington.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/ accessed February 2011.

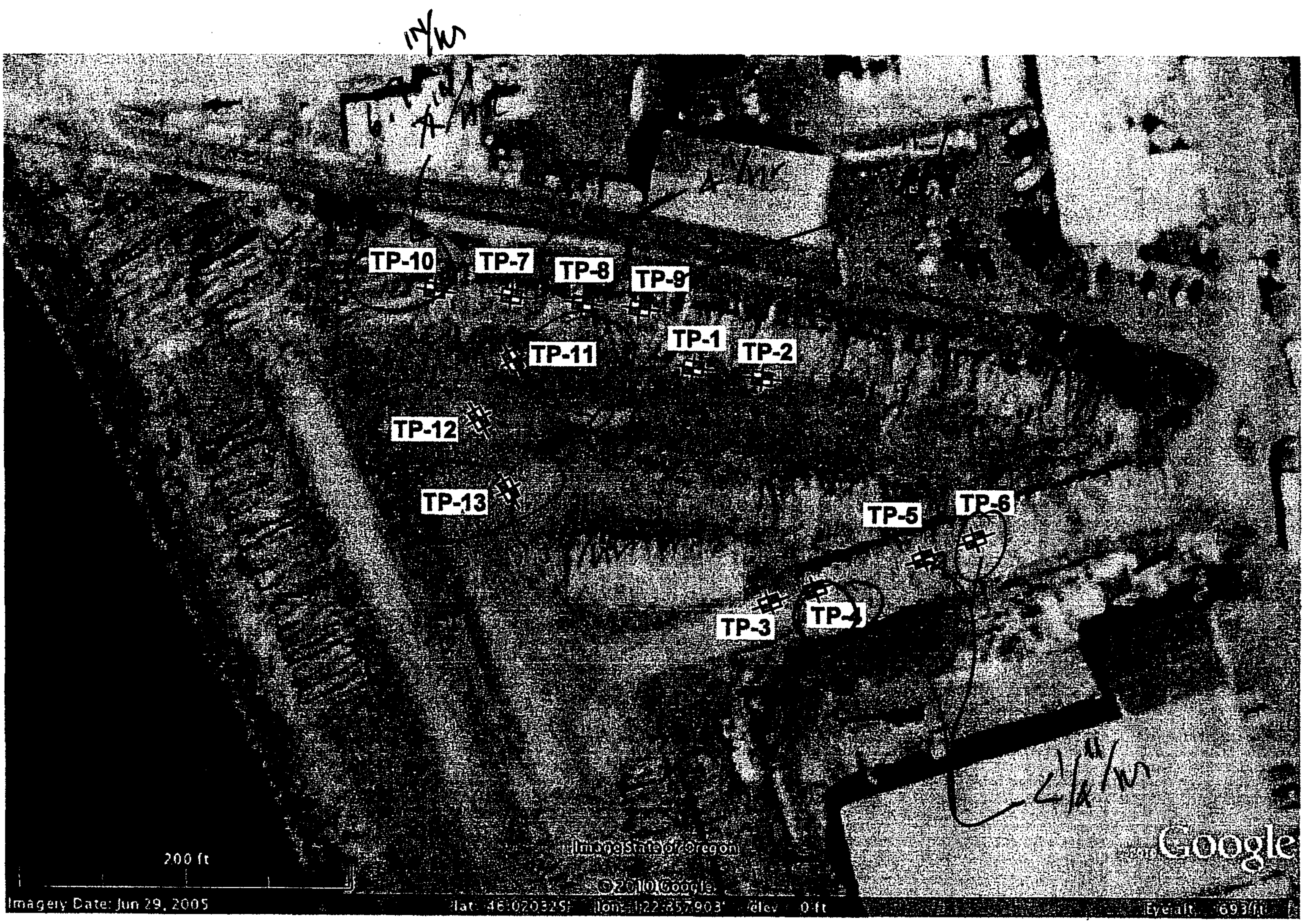
FIGURE 1: SITE LOCATION PLAN



Scale: 1 inch = 2,000 feet

Chinook GeoServices Inc.	**Proposed Stormwater Management Improvements Port of Kalama Property West of NW 3rd Street and Wilson Drive Kalama, Washington**	**Report No. 11-006-1** **Date: February 17, 2011**

FIGURE 2: SITE PLAN WITH EXPLORATION LOCATIONS



Legend

Approximate Test Pit Exploration Locations

Approximate Scale: 1 inch = 100 feet
Source: Google Earth Imagery dated June 29, 2005.

Chinook GeoServices Inc.	**Proposed Stormwater Management Improvements** **Port of Kalama Property West of NW 3rd Street and Wilson Drive** **Kalama, Washington**	**Report No. 11-006-1** **Date: February 17, 2011**

TP-1	
0 - 3.0'	Fill: Angular gravel and cobble with concrete debris and sand. Layer of fabric at 3 feet.
	▼ Subsurface water above fabric.
3.0' - 6.0'	Fill: Gray angular basalt cobbles and gravel with sand and trace metal, wires, and debris.
6.0' - 12.0'	Fill: Moist to wet gray fine-grained river sand. Severe caving of soil from sides of excavation.
	▼ Subsurface water level interpreted to be approximately 6.5' to 7' below the ground surface (BGS) based on caving soils.

TP-2	
0 - 2.5'	Fill: Angular gravel and cobble with concrete debris and sand. Layer of fabric at 2.5 feet.
	▼ Subsurface water above fabric.
2.5' - 5.5'	Fill: Gray angular basalt cobbles and gravel with sand and trace metal, wires, and debris.
5.5' - 11.5'	Fill: Gray angular basalt cobbles with gray fine-grained river sand. Becomes more sandy with depth.
	Infiltration testing at 6.5' BGS. Water level rose.
	▼ Subsurface water level approximately 6.0' to 6.5' BGS.

TP-3	
0 - 2.0'	Fill: 2 layers of crushed gravel base rock over felt fabric. No subsurface water above fabric.
2.0' - 9.0'	Fill: Gray and brown angular basalt cobbles and gravel with sand.
	▼ Subsurface water observed seeping from sides of excavation at approximately 6.5' BGS.

TP-4	
0 - 2.0'	Fill: 2 layers of crushed gravel base rock over felt fabric. No subsurface water above fabric.
2.0' - 3.0'	Fill: Gray and brown angular basalt cobbles and gravel with sand.
	Infiltration Testing at 3.0' BGS. Preliminary results indicate less than 1/4" per hour.

TP-5	
0 - 7.5'	Fill: Gray and brown angular basalt cobbles and gravel with sand. No fabric. Sheet metal debris at 7' BGS.
	▼ Subsurface water observed seeping from sides of excavation at approximately 6.5' BGS.

TP-6	
0 - 3.0'	Fill: Gray and brown angular basalt cobbles and gravel with sand. No fabric.
	▼ Subsurface water seeping from between layers at 2.5' BGS.
	Infiltration Testing at 3.0' BGS. Preliminary results indicate less than 1/4" per hour.

TP-7	
0 - 3.0'	Fill: Layers of brown gravel, woody organic material, and blue-green angular basalt gravel and cobble with clay.
3.0' - 8.0'	Fill: Brown, medium-grained sand with trace gravel.
	▼ Subsurface water level at 6 feet BGS.

TP-8	
0 - 3.0'	Fill: Layers of brown gravel, woody organic material, and green angular basalt gravel and cobble with clay.
3.0' - 6.5'	Fill: Brown, medium-grained sand with trace gravel.
	Infiltration Testing at 6.5' BGS. Approximately 4" per hour.

TP-9	
0 - 2.5'	Fill: Layers of orange crushed rock, woody organic material, and green angular basalt gravel and cobble with clay.
3.0' - 6.5'	Fill: medium dense, moist, blue-gray fine-grained sand with trace angular cobbles.
	Infiltration Testing at 3.2' BGS. Preliminary results indicated less than 1/4" per hour, testing aborted.

TP-10	
0 - 3.0'	Fill: Layers of orange crushed rock, woody organic material, and green angular basalt gravel and cobble with clay.
	▼ Subsurface water seeping from organic layer.
3.0' - 4.2'	Fill: Blue-gray medium-grained sand with trace gravel.
	Infiltration Testing at 4.2' BGS. Approximately 6.9" per hour.

TP-11	
0 - 1.5'	Fill: Layers of brown gravel and green angular basalt gravel and cobble with clay.
1.5' - 4.0'	Fill: Brown medium-grained sand.
	Infiltration Testing at 4.0' BGS. Approximately 30" per hour.

TP-12	
0 - 2.0'	Fill: Layers of brown gravel and blue-green angular basalt gravel and cobble with clay.
2.0' - 10.0'	Fill: Gray medium-grained sand.
	▼ Subsurface water seeping in at 9 feet BGS.

TP-13	
0 - 3.5'	Fill: Layers of brown gravel and blue-green angular basalt gravel and cobble with clay.
3.5' - 5.0'	Fill: Gray medium-grained sand.
	Infiltration Testing at 5' BGS. Approximately 36" per hour.