CARNOUSTIE - SEMIAHMOO
BLAINE, WASHINGTON

REVISED STORMWATER SITE PLAN

SUBMISSION 3

Prepared for:

Trillium Corporation
4350 Cordata Parkway
Bellingham, Washington 98226

7/18/07

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EXPIRES 12-04-07

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TRLX0107

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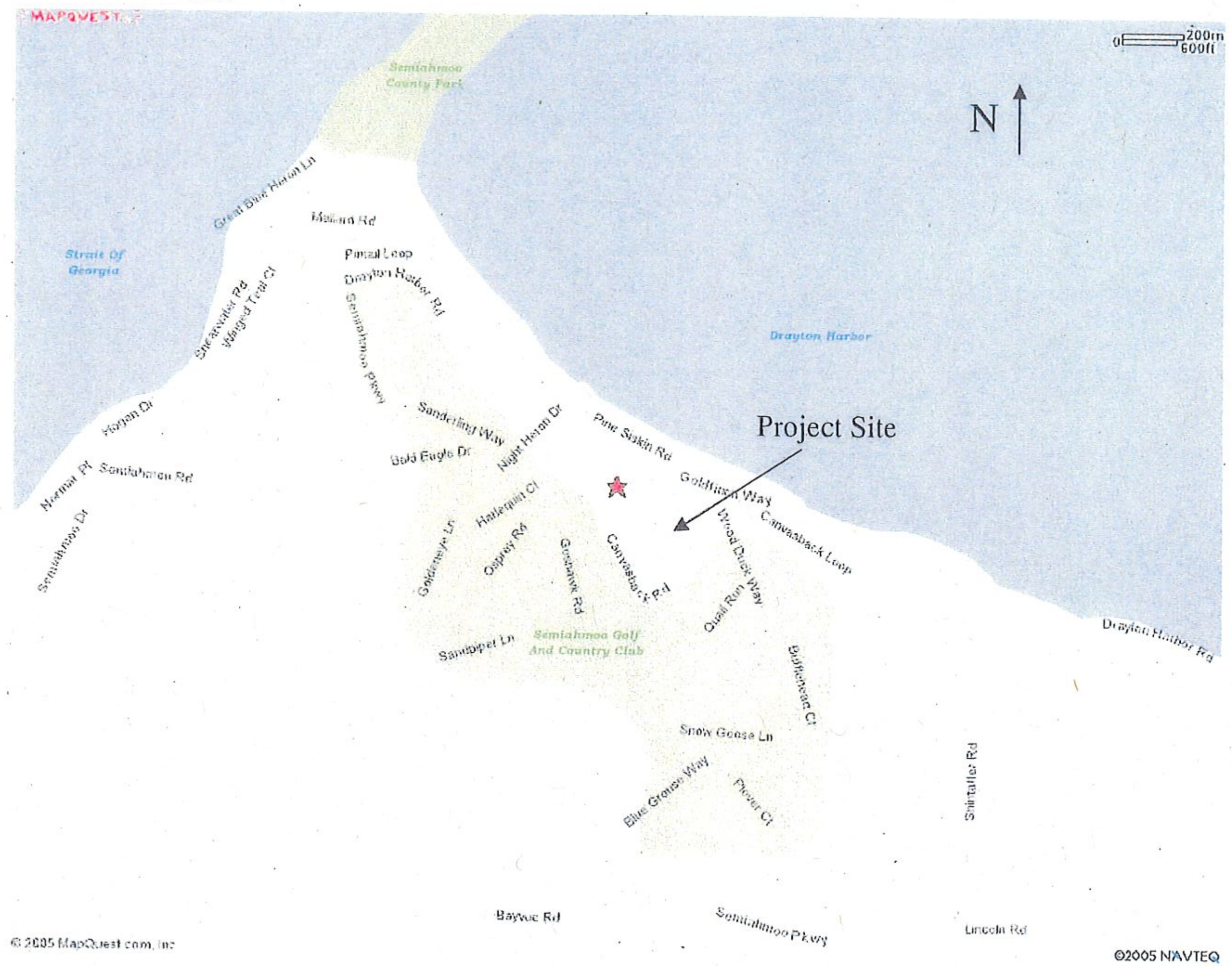
1.0 Vicinity Map



Not to scale

2.0 Project Description

This Stormwater Site Plan is for the development of Carnoustie-Semiahmoo, a 16.25-acre Planned Unit Development in Blaine, Washington. The study area lies within Section 14, Township 40 North, Range 1 West, W.M. The project area is located to the east of Bald Eagle Drive, north and west of Canvasback Road, and south of Drayton Harbor Road. There are existing developments located along the south, east and west borders. The site is presently forested and slopes towards the northeast. The project includes the construction of single-family homes, multi-residential buildings, asphalt pavement access roads, associated infrastructure, a stormwater collection and conveyance system, and a stormwater treatment facility. The stormwater system is conveyed to an existing Drayton Harbor stormwater outfall structure located east of the project site.

Due to the proximity of the project to Drayton Harbor, stormwater detention is not being proposed for this project. However an offline stormwater biofiltration swale is being proposed for stormwater treatment. This Plan does addresses the proposed improvements by examining the post-developed stormwater runoff characteristics of the site, and providing mitigating treatment measures to compensate for potential impacts resulting from the development.

3.0 DESIGN CRITERIA AND ASSUMPTIONS

3.1 Governing Guidelines

The City of Blaine has implemented the *City of Blaine Municipal Code* for identifying stormwater management requirements for development inside the city limits. These regulations require the implementation of the latest Washington State Department of Ecology stormwater management manual for water quality treatment of stormwater runoff. This manual, the 2005 *Stormwater Management Manual for the Western Washington* (WDOE Manual), is used to design the construction-phase and permanent water quality treatment facilities for this project.

Since this project contains land-disturbing activities greater than 10,000 square feet, the requirements for large development apply. These requirements include compliance with Minimum Requirements #1 through #10 outlined in the ordinance and the preparation of a stormwater site plan. These requirements are listed in Section 5, Summary of Minimum Development Requirements, of this Stormwater Site Plan along with a response of how these requirements shall be met.

Both single-family and multi-family residences are proposed for this development. Since more than 50% of the site area consists of single family residences, only basic treatment is required as defined in Volume 5, Sections 3.5 of the 2005 WDOE Manual.

3.2 Design Criteria

In accordance with the 2005 WDOE Manual, the site's hydrologic analysis was performed using the Western Washington Hydrologic Model (WWHM2), a continuous simulation hydrologic model developed by the WDOE.

3.3 Design Assumptions

Site topography used for this analysis is based on a topographic survey prepared by David Evans and Associates, Inc. in June 2005.

The developed site is divided into two basins, Basin 1 (building roofs) and Basin 2 (remaining areas). Basin 1 is collected in a separate stormwater drainage system that only drains all non-pollution generating roof runoff from the proposed buildings. Therefore Basin 1 does not require stormwater treatment.

Basin 1 (2.30 acres) is assumed to consist of the following:

- 18 single family lots with a 2,500 square foot roof.
- 3 small duplex buildings with a 2,000 square foot roof.
- 5 large duplex buildings with a 3,800 square foot roof.
- 2 triplex buildings with a 3,000 square foot roof.

- 4 four-plex buildings with a 4,000 square foot roof.

Basin 2 (13.96 acres) collects stormwater runoff from proposed landscape area, driveways, roads, and the remaining forested areas. Since the roadway surfaces and driveways are located in Basin 2, this basin requires stormwater treatment. Since the site contains more than 50-percent single-family homes, only basic treatment is required per the 2005 WDOE. Basin 2 consists of the following:

- 18 single family lots with a 500 square foot driveway surface per lot.
- 3 small duplex buildings with a 1,000 square foot driveway surface per building
- 5 large duplex buildings with a 1,000 square foot driveway surface per building.
- 2 triplex buildings with a 2,000 square foot driveway surface per building.
- 4 four-plex buildings with a 2,000 driveway surface per building.
- 87,566 square feet of roadway area, including curb, gutter and sidewalk.
- 438,608 square feet of landscape area.
- Assumed 10% of Basin 2's pervious area (area remaining after you subtract the roads and driveways) would remain forested, 48,734 square feet.

Stormwater runoff from Basin 2 is collected and routed to a bypass manhole that diverts flows up to the six-month design storm to a water quality treatment facility. Runoff flows greater than the six-month storm, and the discharge from the water-quality treatment facility will be tight-lined to the ditch on the south side of Drayton Harbor Road. The ditch discharges into an existing catch basin with a culvert that conveys runoff under Drayton Harbor Road to the north side of the road. Runoff overland flows approximately 150 ft. to Drayton Harbor. Due to the site's proximity to Drayton Harbor and the downstream system's capacity, no stormwater detention will be provided.

4.0 BASIN ANALYSIS

4.1 Site Soil Information

Soil information at the project site was obtained from the Web Soil Survey website (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) published by United States Department of Agriculture Natural Resources Conservation Service (NRCS). The soil underlying the tributary area is comprised of the Everett (#48, #49 and #51) soil series, a very gravelly sandy loam. The soil is classified as a Hydrologic Group A/B soil. Appendix A of this plan contains copies of the soils map and properties.

As noted in the geotechnical report, the sand and gravel surface soils are only a few feet thick and are underlain with till soil. This condition allows for rainfall to infiltrate quickly to the till layer and then to interflow down gradient along the top of the till layer. Since deep infiltration can not occur here, these soils are not true Group A/B Outreach soils as designated in the WWHM2 model. For this analysis the site soils are assumed to be Group C/D Till soils. This is a very conservative assumption resulting in greater runoff flow rates. Water quality and conveyance systems are therefore designed to larger runoff rates than site conditions will likely generate.

4.2 Pre-Development Conditions

Figure 1: Pre Developed Layout provides a topographical map of the present site. The project site is currently forested. Most of the topography of the project site slopes to the northeast varying between 5% and 30%, with a small portion of the site along the southeast property line sloping to the southwest at approximately 3.5%. On-site runoff generally sheet flows across the site to the existing ditch along Drayton Harbor Road. The ditch eventually conveys the stormwater to an existing outlet structure that discharges into Drayton Harbor.

Offsite stormwater runoff generated by adjacent parcels does not enter the site.

4.3 Post-Development Conditions

Figure 2: Post-Developed Layout shows the proposed site layout. The site's proposed development is for the construction of 18 single-family homes, 16 multi-residential buildings (totaling 45 units), and associated access roads. The site is modeled as two basins; Basin 1 and Basin 2. Basin 1 consists of all the proposed building roofs. Stormwater from this basin is collected and conveyed to a catch basin located along the northeast property line, where it is combined with the stormwater from Basin 2. Basin 2 includes all of the building lots, tracks, driveways, and roadways. Stormwater from Basin 2 is collected in a catch basin system and routed to a flow splitter catch basin. The treatment flow (off-line water quality flow from WWHM) from Basin 2 is split from the basin's total flow and routed through a biofiltration swale. The remaining stormwater is conveyed to a catch basin where it is recombined with the treated stormwater and the stormwater from Basin 1. The total site's stormwater runoff is then conveyed to a new closed stormwater system along Drayton Harbor Road and routed to the existing stormwater outfall located to the east of the site.

Due to the projects close proximity to Drayton Harbor and the downstream system having adequate capacity, detention is not required.

More detailed information is included in Appendix A, *"Hydrologic and Hydraulic Analysis"*, attached at the end of this report.

4.4 Summary of Basin Information

Table 1: Basin Area Summary provides information on the pervious, impervious and total area for the site's stormwater basins.

Table 1: Basin Area Summary

Basin ID	Pervious Area - Forest (ac)	Pervious Area Landscaped Area (ac)	Impervious Area (ac)	Total Area (ac)	% Impervious
Post-Developed Basin 1	0.00	0.00	2.30	2.30	100 %
Post-Developed Basin 2	1.12	10.07	2.77	13.96	20 %

4.5 Summary of Stormwater Model Analysis

Table 2: Summary of Peak Runoff Flow Rates provides the results of the WWHM2 analysis including the pre-developed, and the post-development undetained flow rates. See Section 5.7 of this plan for a discussion of the stormwater treatment system. More detailed information is included in Appendix A attached at the end of this report.

Table 2: Summary of Peak Runoff Flow Rates

	2-Year Storm (cfs)	10-Year Storm (cfs)	25-Year Storm (cfs)	100-Year Storm (cfs)
Basin 1				
Pre-Developed	0.06	0.12	0.16	0.23
Post-Developed (unmitigated)	0.67	1.06	1.26	1.59
Basin 2				
Pre-Developed	0.36	0.74	0.97	1.37
Post-Developed (unmitigated)	1.54	3.05	3.97	5.56

Note: Due to round-off errors some numbers may not appear to match.

5.0 SUMMARY OF MINIMUM DEVELOPMENT REQUIREMENTS

5.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

This report is the Stormwater Site Plan and it is prepared in accordance with Chapter 3 of Volume I of the 2005 WDOE Manual.

5.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention

A Stormwater Pollution Prevention Plan is provided as part of the design drawings for the site improvements. This Plan provides erosion and sediment control information, locations where Best Management Practices (BMPs) shall be implemented, and requirements that the contractor must follow throughout construction. These BMPs include the use of a C233: Silt Fence, C208: Triangular Silt Dike, C241: Temporary Sediment Pond (calculations are in Appendix B), and C105: Stabilized Construction Entrance and catch basin inserts, with specific details for their construction. The stabilized construction entrance will help to reduce the amount of sediment transported onto paved roads by vehicles and construction equipment. The silt fence will trap sediment in the surface runoff prior to it leaving the construction area and discharging off site. The triangular silt dike will be used as a check dam in the existing drainage ditch along Drayton Harbor Road to capture silt and decrease the stormwater flows.

The following BMPs may also be utilized at the contractor's discretion to minimize the impact of stormwater runoff:

- BMP C101: Preserving Natural Vegetation
- BMP C107: Construction Road/Parking Area Stabilization
- BMP C120: Temporary and Permanent Seeding
- BMP C121: Mulching

The SWPP Plan, which includes Temporary Erosion and Sediment Control (TESC) measures, is part of the contract documents for construction of the project. Additional erosion control measures may be applied on an as needed basis as directed by the design engineer or City of Blaine. At the completion of the project exposed soils will be planted, seeded or mulched. The establishment of vegetation on all earth surfaces will provide permanent erosion control.

5.3 Minimum Requirement #3: Source Control of Pollution

Other than the presences of the asphalt road and driveways, no improvements are proposed which will require additional source control BMPs. The buildings will incorporate asphalt shingle or enamel coated roofing and therefore will not require source control BMPs. During the construction phase of the project, source controls measures will be implemented. These measures are discussed in Minimum Requirement #2.

As required in the SWPPP, the contractor is required to develop a plan to control spills of oil, fuel, hydraulic fluids and other pollutants during the construction phase of the project. This plan shall incorporate the name of the designated contact person and emergency contact numbers, with the appropriate notification and cleanup procedures. A spill kit with absorbent materials should also be located on site to address small spills.

5.4 Minimum Requirement #4: Preservation of Natural Drainage Systems & Outfalls

The existing drainage pattern of the site will be modified only in that, in areas of development, existing sheet flow will be changed to pipe networks that discharge into the existing roadside drainage ditch along Drayton Harbor Road. The discharge location remains the same as the existing condition. The stormwater will be routed to the existing 36 inch culvert that crosses under Drayton Harbor Road. The existing culvert is inlet controlled due to the steepness of the pipe. Since the existing outfall pipe has an inlet control condition the stormwater will backup in the existing outfall manhole. The culvert's current inlet elevation is 75.97-feet, but because of the inlet control condition the stormwater will backup to elevation 83.63-feet. The manhole rim elevation is set at 84.87-feet; therefore the manhole will maintain 1.55-feet of freeboard.

The existing culvert under Drayton Harbor Road and its contributing drainage basin were evaluated to estimate the basin runoff rates and the capability of the pipe to convey the runoff. Figure 3: Contributing Outfall Basins shows the extent of the contributing basin. The basin boundary was determined based on the topography and the existing stormwater pipe layout. The amount of impervious area was found by examining an aerial photograph of the area, sampling seven typical lots to find the average amount of impervious and pervious area per lot. The typical lot size was estimated at 15,700 square feet with an average 5,800 square feet of impervious area (37%) and 9,900 square feet of pervious area (63%). The pervious area was estimated to be approximately 43% landscape area (grass) and 20% forested area.

The Offsite Drainage Basin was estimated at 126 acres and is assumed to consist of the following:

- 138 lots with 6,000 square feet of impervious surface per lot.
- 1 multi-family area with 87,000 square feet of impervious surface.
- Local access roadway is assumed to be 32 feet wide with curbs and a sidewalk on one side and 10,320 feet long.
- Drayton Harbor Road is assumed to be 40 feet wide and 2,605 feet long.
- The total impervious area is assumed 31 acres (25% of the basin).
- The total pervious area is assumed 95 acres (75% of the basin).
- The forested pervious area is assumed 6 acres (7% of the pervious area) with the remaining 88 acres of previous area (93%) as grass.

The Offsite Drainage Basin was combined with the undetained Onsite Drainage Basin and modeled using WWHMv2.5f. The total 100 year undetained runoff draining to the outfall pipe was found to be 59 cfs. The existing 36-inch diameter outfall pipe, with its slope of 14.9%, has an estimated capacity of 279-cfs. Based on this estimated flow and pipe capacity, the existing 36-inch diameter pipe will operate at 31% of its capacity and appears to be adequately sized to convey the entire drainage basin.

5.5 Minimum Requirement #5: On-site Stormwater Management

Various on-site stormwater management options were evaluated for use at this site. As discussed in Section 4.1, the site's sandy loam surface soils are only a few feet thick and are underlain with till soil. This condition allows for rainfall to infiltrate quickly to the till layer and then interflow down gradient long the top of the till layer. This condition can result in a severe erosion problem should the sandy and gravel layer daylight on top of a steep bluff, resulting in bluff erosion. Since this condition exists north of the site along the harbor, stormwater infiltration is not recommended or proposed.

5.6 Minimum Requirement #6: Runoff Treatment

This project is a mixed land use development with more than 50% of the runoff coming from the single-family residential development. As such, the WDOE Manual requires basic water quality treatment (WDOE Volume 5, Section 3.5) for the collected stormwater runoff. Of the treatment options outlined in this manual, a biofiltration swale is the most desirable approved BMP for this site.

Water quality treatment for site runoff is provided in accordance with BMP T9.10 Basic Biofiltration Swale. The stormwater from Basin 2 (treatment basin) is routed through a flow splitter designed to split the water quality treatment flow (treatment flow) from the high flows. The treatment flows are routed to the biofiltration swale. The swale is designed using the 2005 WDOE manual and the WWHM2 off-line 15 minute flow (0.31 cfs). From Figure 9.6b of Volume V of the DOE Manual, using 72% (1.5 inches) of the 2 year design storm precipitation rate of 2.1 inches, a peaking ratio of 3.75 is used to estimate the swale design flow rate at 1.18 cfs. The swale's required length is 210 feet long by 8.5 feet wide and 0.3 feet deep (treatment flow) with a 2.0 percent slope. It has a minimum 1.0-foot of freeboard and 3 (horizontal): 1 (vertical) side slopes. The swale is lined with an impermeable liner to prevent the stormwater from infiltrating into the existing soils. The treated stormwater is routed back to the high flow conveyance system and roof collection system (Basin 1) and to the existing outfall, located to the east of the project site.

The biofiltration swale shall have a top soils mix that is 12-inches deep. The soil mix consists of 60-90% sandy loam, 0-10% clay, and 10-30% composted organic mater, excluding animal waste and toxics. Refer to the contract drawings or page 9-18, Volume V of the WDOE for the recommended grass mixes suitable for treatment biofiltration swales. The biofiltration swale provides treatment with the use of amended soils and vegetation.

To ensure that the stormwater facility serves its intended function, an operation and maintenance manual will be provided with the final Stormwater Site Plan.

5.7 Minimum Requirement #7: Flow Control

Flow control (stormwater detention), is not being provided due to the site's proximity to Drayton Harbor and the downstream system's adequate capacity to handle the developed flows.

5.8 Minimum Requirement #8: Wetlands Protection

There are no existing wetlands in the project area. This project location does not alter any stormwater that discharges into wetlands directly.

5.9 Minimum Requirement #9: Basin/Watershed Planning

This project is located within the California Creek Subbasin area according to the Surface Water Drainage Boundaries in WRIA1, Version 1. However, in order to ensure that downstream water quality is not jeopardized, utilization of onsite treatment facilities are proposed for this project.

5.10 Minimum Requirement #10: Operation And Maintenance

The owner of the property will perform all necessary maintenance of the stormwater treatment and detention facilities and the on-site conveyance systems. A Stormwater Facilities Operation and Maintenance Manual is provided in Appendix C.

FIGURES

- Pre-Developed Layout
- Post-Developed Layout
- Contributing Outfall Basins

PRELIMINARY

NO. REVISIONS: APPD.

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CARNOUSTE-SEMIAHMOO

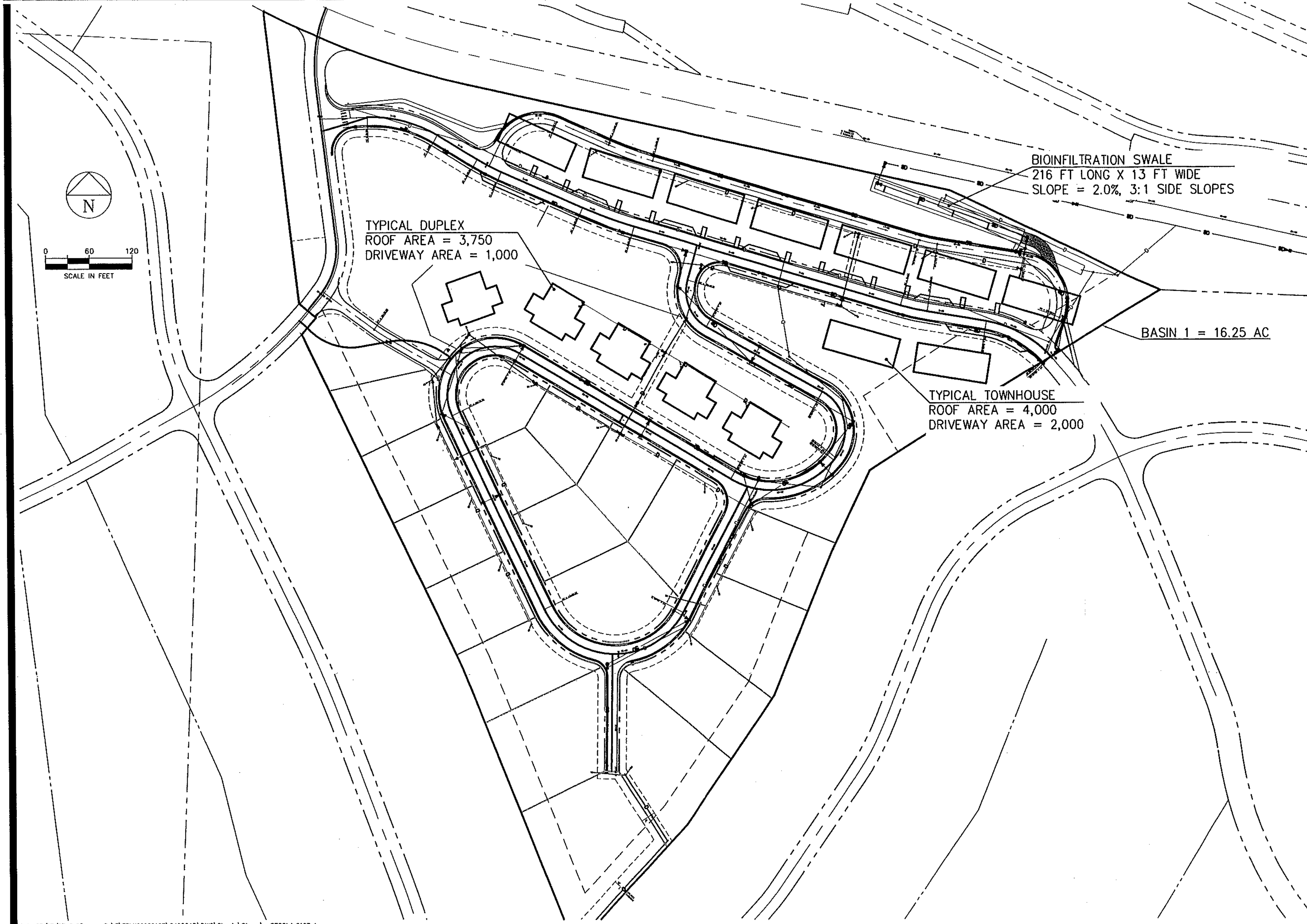
PRE DEVELOPED LAYOUT
STORMWATER EXHIBIT

PROJECT NUMBER:
TRLX0107

DATE: 1-10-06
DESIGN: MJO
DRAWN: JSB
CHECKED:

SCALE: 1"= 60'

SHEET NO.
1
OF 3



NO. REVISIONS: APPD.

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TRILLIUM CORPORATION
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CARNOUSTIE-SEMIAHMOO

POST DEVELOPED LAYOUT
STORMWATER EXHIBIT

PROJECT NUMBER:
TRLX0107

DATE: 1-10-06
DESIGN: MJD
DRAWN: JSB
CHECKED:

SCALE: 1"= 120'

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OF 3

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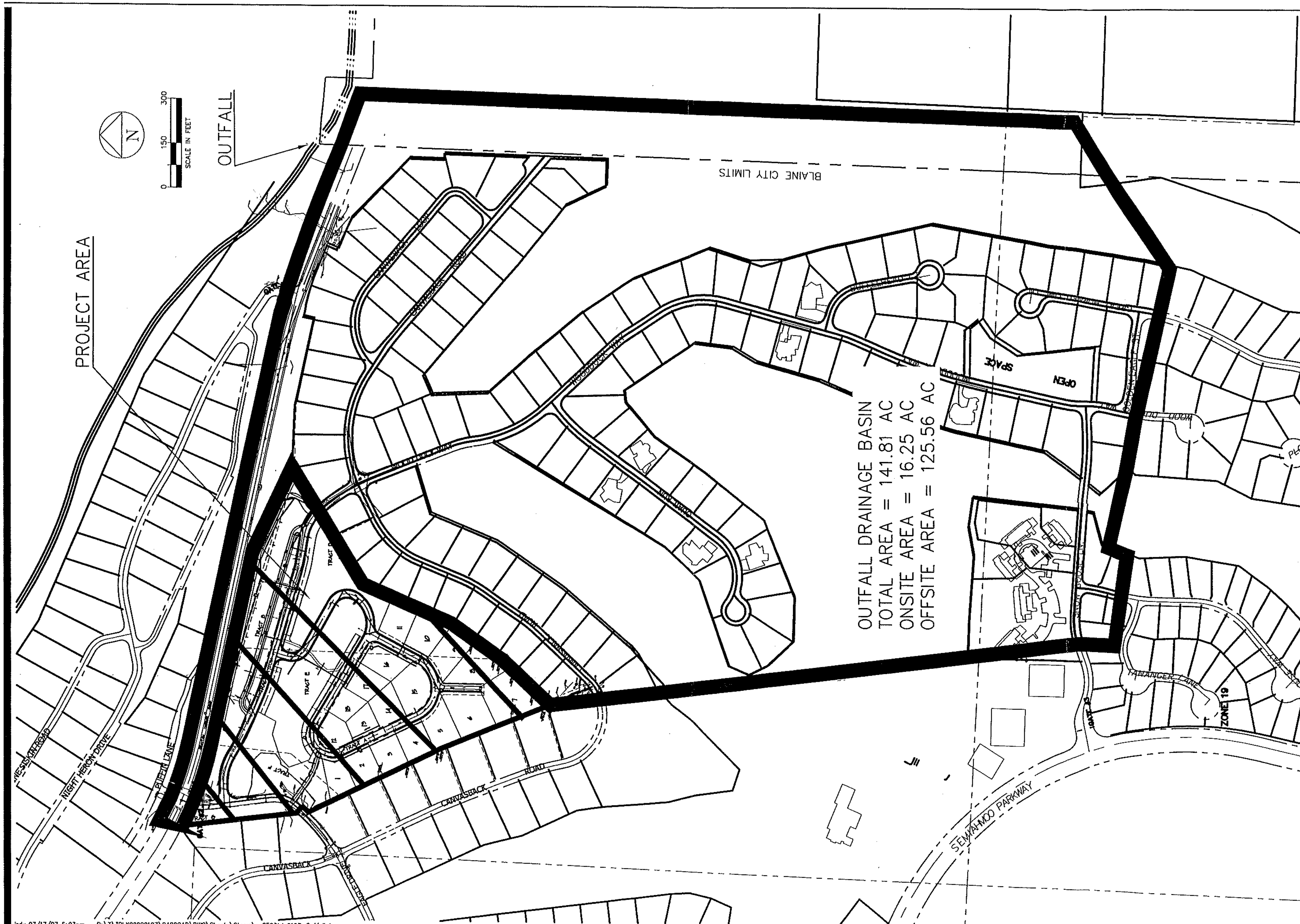

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CARNOUSTIE-SEMIAHMOO

CONTRIBUTING OUTFALL BASINS STORMWATER EXHIBIT

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Phone: 360.647.7151
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NO. REVISIONS: APPD.

PROJECT NUMBER: TRLX0107
DATE: 04-12-2007
DESIGN: GDCR
DRAWN: JSDY
CHECKED:
SCALE: 1"= 150'
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APPENDIX A

SOILS INFORMATION

- NRCS Soil number and Hydrologic Group

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 500, 1,000, 2,000, 3,000

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features

Municipalities
- Cities
- Urban Areas

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails

Roads
- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 10N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 4, Nov 21, 2006

Date(s) aerial images were photographed: 7/21/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Whatcom County Area, Washington (WA673)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
14	Birchbay silt loam, 8 to 15 percent slopes	5.3	1.3%
48	Everett gravelly sandy loam, hard substratum, 2 to 8 percent slopes	80.7	20.2%
49	Everett very gravelly sandy loam, 8 to 15 percent slopes	63.6	15.9%
51	Everett complex, 2 to 8 percent slopes	141.3	35.4%
75	Hydraquents, tidal, 0 to 1 percent slopes	5.6	1.4%
142	Sehome gravelly loam, 30 to 60 percent slopes	33.3	8.3%
Totals for Area of Interest (AOI)		399.6	100.0%

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Report—Water Features

Water Features– Whatcom County Area, Washington										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
14—Birchbay silt loam, 8 to 15 percent slopes										
Birchbay	C	—	January	2.0-4.0	3.0-5.0	—	—	None	—	None
			February	2.0-4.0	3.0-5.0	—	—	None	—	None
			March	2.0-4.0	3.0-5.0	—	—	None	—	None
			April	2.0-4.0	3.0-5.0	—	—	None	—	None
			December	2.0-4.0	3.0-5.0	—	—	None	—	None
48—Everett gravelly sandy loam, hard substratum, 2 to 8 percent slopes										
Everett	B	—	January	3.5-5.0	3.0-5.0	—	—	None	—	None
			February	3.5-5.0	3.0-5.0	—	—	None	—	None
			March	3.5-5.0	3.0-5.0	—	—	None	—	None
			April	3.5-5.0	3.0-5.0	—	—	None	—	None
			December	3.5-5.0	3.0-5.0	—	—	None	—	None
49—Everett very gravelly sandy loam, 8 to 15 percent slopes										
Everett	A	—	Jan-Dec	—	—	—	—	None	—	—

Water Features– Whatcom County Area, Washington										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
51—Everett complex, 2 to 8 percent slopes										
Everett	A	—	Jan-Dec	—	—	—	—	None	—	—
Everett	B	—	January	3.5-5.0	3.0-5.0	—	—	None	—	None
			February	3.5-5.0	3.0-5.0	—	—	None	—	None
			March	3.5-5.0	3.0-5.0	—	—	None	—	None
			April	3.5-5.0	3.0-5.0	—	—	None	—	None
			December	3.5-5.0	3.0-5.0	—	—	None	—	None
75—Hydraquents, tidal, 0 to 1 percent slopes										
Hydraquents	D	—	January	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			February	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			March	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			April	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			May	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			June	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			July	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			August	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			September	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			October	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			November	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent
			December	0.0	>6.0	0.0-1.0	Very long	Frequent	Brief	Frequent

Water Features– Whatcom County Area, Washington										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
142—Sehome gravelly loam, 30 to 60 percent slopes										
Sehome	C	—	January	2,0-3.0	2.0-3.0	—	—	None	—	None
			February	2.0-3.0	2.0-3.0	—	—	None	—	None
			March	2.0-3.0	2.0-3.0	—	—	None	—	None
			April	2.0-3.0	2.0-3.0	—	—	None	—	None
			December	2.0-3.0	2.0-3.0	—	—	None	—	None

Data Source Information

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 4, Nov 21, 2006

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

- Stormwater Calculations
- WWHMv2.5f Results
- Biofiltration Swale Calculations
- Temporary Sediment Pond Calculations

- WWHM2 Outfall Basin Results
- Manning Pipe Calculations for Outfall Pipe

Carnoustie (TRLX0107)
Onsite Storm Calculations
6:04 PM, 7/17/2007

Total Site Area = 707,908.32 16.25

Basin 1

Roof Area	# of Buildings	Imperv. Area Ea (sf)	Total Imperv. Area (sf)	Total Imperv. Area (ac)
Single Family Lots	18	2,500	45,000	1.03
Large Duplexes	5	3,800	19,000	0.44
Small Duplexes	3	2,000	6,000	0.14
Tri-Plexes	2	3,000	6,000	0.14
4 Plexes	6	4,000	24,000	0.55
Total			100,000	2.30

Basin 2 Total Area = 607,908.32 13.96

Basin 2

Treatment Area	# of Buildings	Length (ft)	Width (ft)	Imperv. Area Ea (sf)	Total Imperv. Area (sf)	Total Imperv. Area (ac)
Wood Duck Way	1	1,065	26	-	27,686	0.64
1-Way Road	1	723	15		10,847	0.25
Wood Duck Loop	1	1,795	26		46,663	1.07
Wood Duck Place	1	158	15		2,369	0.05
Single Family DW	18			500	9,000	0.21
Duplexes DW	8			1,000	8,000	0.18
Townhomes DW	8			2,000	16,000	0.37
Landscape Area					438,608.10	10.07
Forested Area					48734.233	1.12
Total					559,174	13.96

P:\T\TRLX00000107\0600INFO\Storm\Final\[07-02-26 TRLX107 Storm Calcs.xls]Biofiltration Swale

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: TRLX0107-Basin 1
Site Address: Basin 1 - Building Roofs
City : jsdy, 4/11/2007
Report Date : 4/11/2007
Gage : Blaine
Data Start : 1948
Data End : 1999
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Basin 1
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	2.3

DEVELOPED LAND USE
Basin : Basin 1
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
IMPERVIOUS:	2.3

RCHRES (POND) INFORMATION

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.059978
5 year	0.094824
10 year	0.121705
25 year	0.160054
50 year	0.191861
100 year	0.226494

Flow Frequency Return Periods for Developed Unmitigated

Carnoustie (TRLX0107)
Basin 1 – Building Roofs
6:05:24 PM, 7/17/2007

Return Period	Flow(cfs)
2 year	0.672934
5 year	0.898667
10 year	1.055407
25 year	1.262069
50 year	1.422446
100 year	1.588452

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.672934
5 year	0.898667
10 year	1.055407
25 year	1.262069
50 year	1.422446
100 year	1.588452

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.072	0.644
1950	0.066	1.117
1951	0.090	0.550
1952	0.023	0.476
1953	0.031	0.477
1954	0.055	0.974
1955	0.042	0.501
1956	0.056	0.666
1957	0.066	0.639
1958	0.029	0.867
1959	0.040	0.547
1960	0.056	0.660
1961	0.044	0.410
1962	0.040	0.815
1963	0.045	0.695
1964	0.081	0.850
1965	0.187	1.159
1966	0.067	0.692
1967	0.072	0.697
1968	0.076	0.629
1969	0.044	0.602
1970	0.018	0.373
1971	0.079	0.441
1972	0.068	0.825
1973	0.052	0.475
1974	0.053	0.399
1975	0.045	0.681
1976	0.086	0.824
1977	0.045	1.198
1978	0.065	0.753
1979	0.085	0.887
1980	0.087	0.722
1981	0.040	0.833
1982	0.095	0.586
1983	0.048	0.556
1984	0.217	1.132

1985	0.128	0.869
1986	0.196	1.178
1987	0.063	0.711
1988	0.049	0.586
1989	0.061	1.763
1990	0.081	0.763
1991	0.056	0.604
1992	0.063	0.511
1993	0.058	0.540
1994	0.024	0.438
1995	0.061	0.523
1996	0.074	0.910
1997	0.120	0.694
1998	0.023	0.444
1999	0.174	1.021

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	0.2168	1.7630
2	0.1960	1.1981
3	0.1867	1.1779
4	0.1740	1.1586
5	0.1285	1.1318
6	0.1196	1.1173
7	0.0946	1.0209
8	0.0896	0.9745
9	0.0873	0.9104
10	0.0860	0.8870
11	0.0852	0.8691
12	0.0812	0.8675
13	0.0810	0.8501
14	0.0786	0.8335
15	0.0761	0.8253
16	0.0743	0.8245
17	0.0723	0.8150
18	0.0720	0.7625
19	0.0682	0.7528
20	0.0671	0.7215
21	0.0664	0.7114
22	0.0661	0.6968
23	0.0655	0.6952
24	0.0626	0.6939
25	0.0625	0.6919
26	0.0609	0.6807
27	0.0608	0.6665
28	0.0583	0.6599
29	0.0563	0.6441
30	0.0561	0.6386
31	0.0556	0.6286
32	0.0550	0.6035
33	0.0532	0.6021
34	0.0517	0.5859
35	0.0486	0.5857
36	0.0479	0.5563
37	0.0454	0.5495

38	0.0453	0.5467
39	0.0445	0.5396
40	0.0441	0.5234
41	0.0435	0.5107
42	0.0417	0.5010
43	0.0403	0.4770
44	0.0401	0.4761
45	0.0396	0.4753
46	0.0312	0.4443
47	0.0290	0.4410
48	0.0239	0.4378
49	0.0233	0.4100
50	0.0231	0.3994
51	0.0179	0.3728

1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.0300	0	0	.0	Pass
0.0316	0	0	.0	Pass
0.0333	0	0	.0	Pass
0.0349	0	0	.0	Pass
0.0365	0	0	.0	Pass
0.0382	0	0	.0	Pass
0.0398	0	0	.0	Pass
0.0414	0	0	.0	Pass
0.0431	0	0	.0	Pass
0.0447	0	0	.0	Pass
0.0463	0	0	.0	Pass
0.0480	0	0	.0	Pass
0.0496	0	0	.0	Pass
0.0512	0	0	.0	Pass
0.0529	0	0	.0	Pass
0.0545	0	0	.0	Pass
0.0562	0	0	.0	Pass
0.0578	0	0	.0	Pass
0.0594	0	0	.0	Pass
0.0611	0	0	.0	Pass
0.0627	0	0	.0	Pass
0.0643	0	0	.0	Pass
0.0660	0	0	.0	Pass
0.0676	0	0	.0	Pass
0.0692	0	0	.0	Pass
0.0709	0	0	.0	Pass
0.0725	0	0	.0	Pass
0.0741	0	0	.0	Pass
0.0758	0	0	.0	Pass
0.0774	0	0	.0	Pass
0.0790	0	0	.0	Pass
0.0807	0	0	.0	Pass
0.0823	0	0	.0	Pass
0.0839	0	0	.0	Pass
0.0856	0	0	.0	Pass
0.0872	0	0	.0	Pass
0.0889	0	0	.0	Pass
0.0905	0	0	.0	Pass

0.0921	0	0	.0	Pass
0.0938	0	0	.0	Pass
0.0954	0	0	.0	Pass
0.0970	0	0	.0	Pass
0.0987	0	0	.0	Pass
0.1003	0	0	.0	Pass
0.1019	0	0	.0	Pass
0.1036	0	0	.0	Pass
0.1052	0	0	.0	Pass
0.1068	0	0	.0	Pass
0.1085	0	0	.0	Pass
0.1101	0	0	.0	Pass
0.1117	0	0	.0	Pass
0.1134	0	0	.0	Pass
0.1150	0	0	.0	Pass
0.1166	0	0	.0	Pass
0.1183	0	0	.0	Pass
0.1199	0	0	.0	Pass
0.1216	0	0	.0	Pass
0.1232	0	0	.0	Pass
0.1248	0	0	.0	Pass
0.1265	0	0	.0	Pass
0.1281	0	0	.0	Pass
0.1297	0	0	.0	Pass
0.1314	0	0	.0	Pass
0.1330	0	0	.0	Pass
0.1346	0	0	.0	Pass
0.1363	0	0	.0	Pass
0.1379	0	0	.0	Pass
0.1395	0	0	.0	Pass
0.1412	0	0	.0	Pass
0.1428	0	0	.0	Pass
0.1444	0	0	.0	Pass
0.1461	0	0	.0	Pass
0.1477	0	0	.0	Pass
0.1493	0	0	.0	Pass
0.1510	0	0	.0	Pass
0.1526	0	0	.0	Pass
0.1543	0	0	.0	Pass
0.1559	0	0	.0	Pass
0.1575	0	0	.0	Pass
0.1592	0	0	.0	Pass
0.1608	0	0	.0	Pass
0.1624	0	0	.0	Pass
0.1641	0	0	.0	Pass
0.1657	0	0	.0	Pass
0.1673	0	0	.0	Pass
0.1690	0	0	.0	Pass
0.1706	0	0	.0	Pass
0.1722	0	0	.0	Pass
0.1739	0	0	.0	Pass
0.1755	0	0	.0	Pass
0.1771	0	0	.0	Pass
0.1788	0	0	.0	Pass
0.1804	0	0	.0	Pass
0.1821	0	0	.0	Pass

0.1837	0	0	.0	Pass
0.1853	0	0	.0	Pass
0.1870	0	0	.0	Pass
0.1886	0	0	.0	Pass
0.1902	0	0	.0	Pass
0.1919	0	0	.0	Pass

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: TRLX0107-Treatment
Site Address: Basin 2 Stormwater Treatment
City : jsdy, 4/11/2007
Report Date : 4/11/2007
Gage : Blaine
Data Start : 1948
Data End : 1999
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Basin 2
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	13.96

DEVELOPED LAND USE
Basin : Basin 2
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	1.12
TILL GRASS:	10.07
IMPERVIOUS:	2.77

RCHRES (POND) INFORMATION

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.364043
5 year	0.57554
10 year	0.738694
25 year	0.971461
50 year	1.164515
100 year	1.374717

Flow Frequency Return Periods for Developed Unmitigated

Return Period	Flow(cfs)
2 year	1.536213
5 year	2.393259
10 year	3.047197
25 year	3.972315
50 year	4.734098
100 year	5.55895

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	1.536213
5 year	2.393259
10 year	3.047197
25 year	3.972315
50 year	4.734098
100 year	5.55895

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	0.439	1.580
1950	0.403	2.282
1951	0.544	1.371
1952	0.140	0.693
1953	0.189	0.824
1954	0.334	2.965
1955	0.253	1.161
1956	0.337	1.567
1957	0.401	1.873
1958	0.176	1.869
1959	0.243	1.179
1960	0.342	1.118
1961	0.264	0.703
1962	0.245	1.323
1963	0.276	1.110
1964	0.493	2.586
1965	1.133	4.562
1966	0.407	2.158
1967	0.437	1.981
1968	0.462	1.329
1969	0.268	1.476
1970	0.109	0.649
1971	0.477	1.030
1972	0.414	2.292
1973	0.314	1.002
1974	0.323	0.815
1975	0.270	1.090
1976	0.522	2.323
1977	0.275	1.992
1978	0.397	1.647
1979	0.517	2.514
1980	0.530	1.550
1981	0.240	1.929
1982	0.574	1.815

1983	0.291	1.238
1984	1.316	4.134
1985	0.780	2.830
1986	1.189	4.225
1987	0.380	1.448
1988	0.295	0.935
1989	0.370	4.795
1990	0.491	1.995
1991	0.341	1.267
1992	0.380	1.183
1993	0.354	1.198
1994	0.145	0.532
1995	0.369	0.947
1996	0.451	2.172
1997	0.726	1.869
1998	0.141	0.862
1999	1.056	3.014

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	1.3157	4.7949
2	1.1895	4.5621
3	1.1334	4.2251
4	1.0560	4.1338
5	0.7797	3.0138
6	0.7262	2.9648
7	0.5745	2.8298
8	0.5439	2.5861
9	0.5298	2.5137
10	0.5220	2.3233
11	0.5172	2.2921
12	0.4926	2.2817
13	0.4915	2.1722
14	0.4769	2.1579
15	0.4618	1.9951
16	0.4507	1.9915
17	0.4389	1.9809
18	0.4368	1.9291
19	0.4142	1.8731
20	0.4070	1.8692
21	0.4030	1.8686
22	0.4011	1.8153
23	0.3974	1.6475
24	0.3799	1.5804
25	0.3795	1.5673
26	0.3699	1.5502
27	0.3688	1.4762
28	0.3540	1.4483
29	0.3416	1.3710
30	0.3407	1.3294
31	0.3374	1.3227
32	0.3341	1.2674
33	0.3228	1.2382
34	0.3139	1.1983
35	0.2948	1.1833

1.0950	0	0	.0	Pass
1.1050	0	0	.0	Pass
1.1149	0	0	.0	Pass
1.1248	0	0	.0	Pass
1.1347	0	0	.0	Pass
1.1447	0	0	.0	Pass
1.1546	0	0	.0	Pass
1.1645	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0.7847 acre-feet
On-line facility target flow: 0.5541 **cfs.**
Adjusted for 15 min: 0.5684 **cfs.**
Off-line facility target flow: 0.3061 **cfs.**
Adjusted for 15 min: 0.314 **cfs.**

Zone 26

Date 4/10/2007
Project # TRLX0107

Offline Biofiltration Swale Sizing per the 2005 Washington State Department of Ecology
Stormwater Management Manual for the Puget Sound Basin (WDOE Manual) and
Biofiltration Swale Performance, Recommendations and Design Considerations

<u>Biofiltration Swale Sizing for 6 Month Storm</u>

Design Procedure from Chapter 9 of Volume V, 2005 WDOE Manual
(see WDOE Manual for detailed explanations)

Preliminary Steps:

P-1 Q = 0.31 CFS - Off-Line Adjusted for 15-min WWHM2 flow

k = 3.75 ratio determined from Figure 9.6, pg 9-10, Vol 5, 2005 WDOE

Q' = 1.18 Q * k

P-2 S = 0.02 Recommended slope: 0.015 - 0.025

P-3 Select a vegetation cover, refer to Tables 9.2, 9.3, and 9.4, Vol V 2005 WDOE

Design Steps

D-1 y = 0.33 design depth of flow (ft), maximum water depth 4" if mowed infrequently

D-2 n = 0.24 Recommended n = 0.24 for swales that are mowed infrequently

D-3 Assume trapezoidal shape

D-5 Compute A:

y = swale depth (ft) - depth of treatment area
b = swale bottom width (ft) - 2' min
Z = side slope (H/V) - 3 minimum

y = 0.33
b = 8.50
Z = 3 => Area = by + zy^2

A = 3.1 ft^2 treatment capacity

$$\text{Hydraulic Radius (R)} = \frac{(by + Zy^2)}{(b + 2y\,(Z^2 + 1)^{0.5})}$$

R = 0.30 ft treatment capacity

Water Quality Design flow rate, $Q = \frac{1.49AR^{0.67}s^{0.5}}{n}$

Q = 1.22 (cfs) swale treatment capacity per Manning's "n"

Actual 6 Month Treatment Flow & Area:

	side		Trapezoidal section			Type	Slope	V_F	Q_F
	slope	b	depth	area	wp	n	(ft/ft)	(ft/sec)	(ft^3/sec)
	3	8.50	0.32	3.06	10.54	0.24	0.020	0.38	1.178

(manually adjust depth to match design Q)

D-6 Compute treatment capacity flow velocity (V = Q'/A): V = 0.38 ft/sec
Actual treatment flow velocity

If V > 1.0 ft/sec, repeat steps D-1 to D-6 until condition is met

D-7 Compute the swale length
L = Vt * (60 sec/min)

If swale is less than 100' long, increase it to 100, the minimum allowed
Per Performance Considerations residence time = 9 minutes

Residence Time: T= 9.00 minutes

Required Swale Length, L =	203	ft
Swale Width =	8.5	ft

Temporary Sediment Pond Sizing Calculations

Carnoustie Sediment Pond

Q_2	1.54 cfs	Input	2 Year Storm Flowrate for Impervious Surface
$SA_{Required}$	**3,203 sf**	**Found**	**Surface Area Required**
A_s	3,205 sf	Input	Surface Area Provided
$L_{Required}$	**98.02857**	**Found**	**Pond Length**
$W_{Required}$	**32.67619**	**Found**	**Pond Width**
A_o	**0.029 sf**	**Found**	**Orifice Area**
D	**2.298 in**	**Found**	**Orifice Diameter**
h	3.50 ft	Input	Pond Depth
T	24 hrs	Input	Pond Drawdown Time
g	32.2 ft/s*s	Input	Gravity

Required Dewatering Orifice Diameter = 2.75"
Required Riser Pipe Diameter = 8"

Carnoustie (TRLX107)
Outfall Sizing Calculations
6:06 PM, 7/17/2007

Onsite - Basin 1

Total Site Area = 707,908.32 16.25

Treatment Area	# of Buildings	Length (ft)	Width (ft)	Area Ea (sf)	Total Imperv. Area (sf)	Total Imperv. Area (ac)
Single Family Lots	18	-	-	2,500.00	45,000.00	1.03
Large Duplex	5	-	-	3,800.00	19,000.00	0.44
Small Duples	3	-	-	2,000.00	6,000.00	0.14
Tri-Ples	2	-	-	3,000.00	6,000.00	0.14
Four-Plex	6	-	-	4,000.00	24,000.00	0.55
Wood Duck Way	1	1,064.85	26.00	-	27,686.10	0.64
1-Way Road	1	723.15	15.00	-	10,847.25	0.25
Wood Duck Loop	1	1,794.74	26.00	-	46,663.24	1.07
Wood Duck Place	1	157.96	15.00	-	2,369.40	0.05
Single Family DW	18	-	-	500.00	9,000.00	0.21
Duplexes DW	8	-	-	1,000.00	8,000.00	0.18
Four-Plex DW	8	-	-	2,000.00	16,000.00	0.37
Landscape Area					438,608	10.07
Forested Area					48,734	1.12
					707,908	16.25

Pervious	11.19	69%
Impervious	5.06	31%
Total Area	16.25	

Offsite - Basin 2

Total Site Area = 5,469,344.41 125.56

Treatment Area	# of Buildings	Length (ft)	Width (ft)	Imperv. Area Ea (sf)	Total Area (sf)	Total Area (ac)
Lots	138			6,000	828,000	19.01
Roadway	1	10,320	32	-	330,255	7.58
Multi-Family Area				87,000	87,000	2.00
Drayton Harbor Rd	1	2,605	40		104,202	2.39
Forested Area					276,125	6.34
Landscape Area					3,843,762	88.24
Total					**4,641,344**	**125.56**

Pervious	94.58	75%	LOT AREA	2,208,625	50.70
Impervious	30.98	25%	Imperv Area	828,000	19.01
Total Area	125.56		Perv Area	1,380,625	31.69

Total Area **141.81**

P:\T\TRLX00000107\0600INFO\Storm\Final\[2007-5-25 Sediment Pond Calcs.xls]Sheet1

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

```
Project Name:  TRLX107OutfallCD
Site Address:  Outfall Sizing, C/D Soils
City        :  jsdy, 04/11/2007
Report Date :  4/11/2007
Gage        :  Blaine
Data Start  :  1948
Data End    :  1999
Precip Scale:  1.00
```

PREDEVELOPED LAND USE

```
Basin      :  Basin  1 - Onsite Developed
Flows To   :  Point of Compliance
GroundWater:  No
```

Land Use	Acres
TILL FOREST:	16.25

```
Basin      :  Basin  2 - Offsite Developed
Flows To   :  Point of Compliance
GroundWater:  No
```

Land Use	Acres
TILL FOREST:	6.34
TILL GRASS:	88.24
IMPERVIOUS:	30.98

DEVELOPED LAND USE

```
Basin      :  Basin  1 - Onsite Developed
Flows To   :  Point of Compliance
GroundWater:  No
```

Land Use	Acres
TILL FOREST:	1.12
TILL GRASS:	10.06
IMPERVIOUS:	5.07

```
Basin      :  Basin  2 - Offsite Developed
Flows To   :  Point of Compliance
GroundWater:  No
```

Land Use	Acres
TILL FOREST:	6.34
TILL GRASS:	88.24
IMPERVIOUS:	30.98

RCHRES (POND) INFORMATION

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	15.635865
5 year	23.935146
10 year	30.185104
25 year	38.938243
50 year	46.084285
100 year	53.770765

Flow Frequency Return Periods for Developed Unmitigated

Return Period	Flow(cfs)
2 year	17.534772
5 year	26.708733
10 year	33.59173
25 year	43.203975
50 year	51.032286
100 year	59.436805

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	17.534772
5 year	26.708733
10 year	33.59173
25 year	43.203975
50 year	51.032286
100 year	59.436805

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	16.129	17.841
1950	23.255	26.650
1951	13.958	15.298
1952	7.185	8.211
1953	8.599	9.674
1954	28.872	32.745
1955	11.849	13.242
1956	15.831	17.851
1957	18.639	20.687
1958	18.908	21.637
1959	12.077	13.614
1960	11.476	12.694

1961	7.332	8.205
1962	13.688	15.724
1963	11.753	13.555
1964	25.348	28.519
1965	44.392	48.791
1966	21.299	23.674
1967	19.790	21.958
1968	13.687	15.384
1969	14.937	16.702
1970	6.764	7.772
1971	10.587	11.526
1972	22.815	25.519
1973	10.254	11.436
1974	8.317	9.352
1975	11.536	13.305
1976	23.240	25.779
1977	20.946	24.134
1978	16.709	19.010
1979	25.086	27.884
1980	15.803	17.442
1981	19.345	22.093
1982	18.066	19.847
1983	12.674	14.211
1984	40.728	44.459
1985	28.045	30.835
1986	41.547	45.562
1987	14.776	16.922
1988	9.632	10.842
1989	47.162	53.712
1990	20.137	22.345
1991	13.078	14.678
1992	12.123	13.472
1993	12.321	13.744
1994	5.911	6.877
1995	9.868	10.977
1996	22.020	24.681
1997	18.866	20.726
1998	8.946	10.126
1999	30.050	32.750

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	47.1616	53.7118
2	44.3924	48.7908
3	41.5466	45.5623
4	40.7275	44.4589
5	30.0498	32.7497
6	28.8721	32.7450
7	28.0451	30.8347
8	25.3482	28.5186
9	25.0864	27.8836
10	23.2548	26.6497
11	23.2402	25.7790
12	22.8150	25.5193
13	22.0197	24.6813

14	21.2990	24.1342
15	20.9456	23.6737
16	20.1371	22.3451
17	19.7902	22.0934
18	19.3448	21.9584
19	18.9076	21.6373
20	18.8657	20.7262
21	18.6392	20.6873
22	18.0656	19.8467
23	16.7088	19.0102
24	16.1286	17.8510
25	15.8306	17.8414
26	15.8033	17.4419
27	14.9365	16.9215
28	14.7760	16.7023
29	13.9576	15.7241
30	13.6880	15.3839
31	13.6872	15.2979
32	13.0776	14.6780
33	12.6735	14.2114
34	12.3214	13.7444
35	12.1231	13.6135
36	12.0772	13.5552
37	11.8493	13.4723
38	11.7526	13.3053
39	11.5358	13.2419
40	11.4763	12.6942
41	10.5874	11.5264
42	10.2543	11.4357
43	9.8678	10.9770
44	9.6324	10.8421
45	8.9458	10.1264
46	8.5991	9.6744
47	8.3173	9.3522
48	7.3316	8.2105
49	7.1846	8.2051
50	6.7641	7.7718
51	5.9108	6.8774

1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
7.8179	0	0	.0	Pass
8.2045	0	0	.0	Pass
8.5910	0	0	.0	Pass
8.9775	0	0	.0	Pass
9.3640	0	0	.0	Pass
9.7506	0	0	.0	Pass
10.1371	0	0	.0	Pass
10.5236	0	0	.0	Pass
10.9102	0	0	.0	Pass
11.2967	0	0	.0	Pass
11.6832	0	0	.0	Pass
12.0697	0	0	.0	Pass
12.4563	0	0	.0	Pass
12.8428	0	0	.0	Pass

13.2293	0	0	.0	Pass
13.6159	0	0	.0	Pass
14.0024	0	0	.0	Pass
14.3889	0	0	.0	Pass
14.7755	0	0	.0	Pass
15.1620	0	0	.0	Pass
15.5485	0	0	.0	Pass
15.9350	0	0	.0	Pass
16.3216	0	0	.0	Pass
16.7081	0	0	.0	Pass
17.0946	0	0	.0	Pass
17.4812	0	0	.0	Pass
17.8677	0	0	.0	Pass
18.2542	0	0	.0	Pass
18.6407	0	0	.0	Pass
19.0273	0	0	.0	Pass
19.4138	0	0	.0	Pass
19.8003	0	0	.0	Pass
20.1869	0	0	.0	Pass
20.5734	0	0	.0	Pass
20.9599	0	0	.0	Pass
21.3464	0	0	.0	Pass
21.7330	0	0	.0	Pass
22.1195	0	0	.0	Pass
22.5060	0	0	.0	Pass
22.8926	0	0	.0	Pass
23.2791	0	0	.0	Pass
23.6656	0	0	.0	Pass
24.0521	0	0	.0	Pass
24.4387	0	0	.0	Pass
24.8252	0	0	.0	Pass
25.2117	0	0	.0	Pass
25.5983	0	0	.0	Pass
25.9848	0	0	.0	Pass
26.3713	0	0	.0	Pass
26.7578	0	0	.0	Pass
27.1444	0	0	.0	Pass
27.5309	0	0	.0	Pass
27.9174	0	0	.0	Pass
28.3040	0	0	.0	Pass
28.6905	0	0	.0	Pass
29.0770	0	0	.0	Pass
29.4635	0	0	.0	Pass
29.8501	0	0	.0	Pass
30.2366	0	0	.0	Pass
30.6231	0	0	.0	Pass
31.0097	0	0	.0	Pass
31.3962	0	0	.0	Pass
31.7827	0	0	.0	Pass
32.1692	0	0	.0	Pass
32.5558	0	0	.0	Pass
32.9423	0	0	.0	Pass
33.3288	0	0	.0	Pass
33.7154	0	0	.0	Pass
34.1019	0	0	.0	Pass
34.4884	0	0	.0	Pass

34.8749	0	0	.0	Pass
35.2615	0	0	.0	Pass
35.6480	0	0	.0	Pass
36.0345	0	0	.0	Pass
36.4211	0	0	.0	Pass
36.8076	0	0	.0	Pass
37.1941	0	0	.0	Pass
37.5807	0	0	.0	Pass
37.9672	0	0	.0	Pass
38.3537	0	0	.0	Pass
38.7402	0	0	.0	Pass
39.1268	0	0	.0	Pass
39.5133	0	0	.0	Pass
39.8998	0	0	.0	Pass
40.2864	0	0	.0	Pass
40.6729	0	0	.0	Pass
41.0594	0	0	.0	Pass
41.4459	0	0	.0	Pass
41.8325	0	0	.0	Pass
42.2190	0	0	.0	Pass
42.6055	0	0	.0	Pass
42.9921	0	0	.0	Pass
43.3786	0	0	.0	Pass
43.7651	0	0	.0	Pass
44.1516	0	0	.0	Pass
44.5382	0	0	.0	Pass
44.9247	0	0	.0	Pass
45.3112	0	0	.0	Pass
45.6978	0	0	.0	Pass
46.0843	0	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.
Off-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.

18" DIA From Treatment Swale to Road
Culvert Calculator

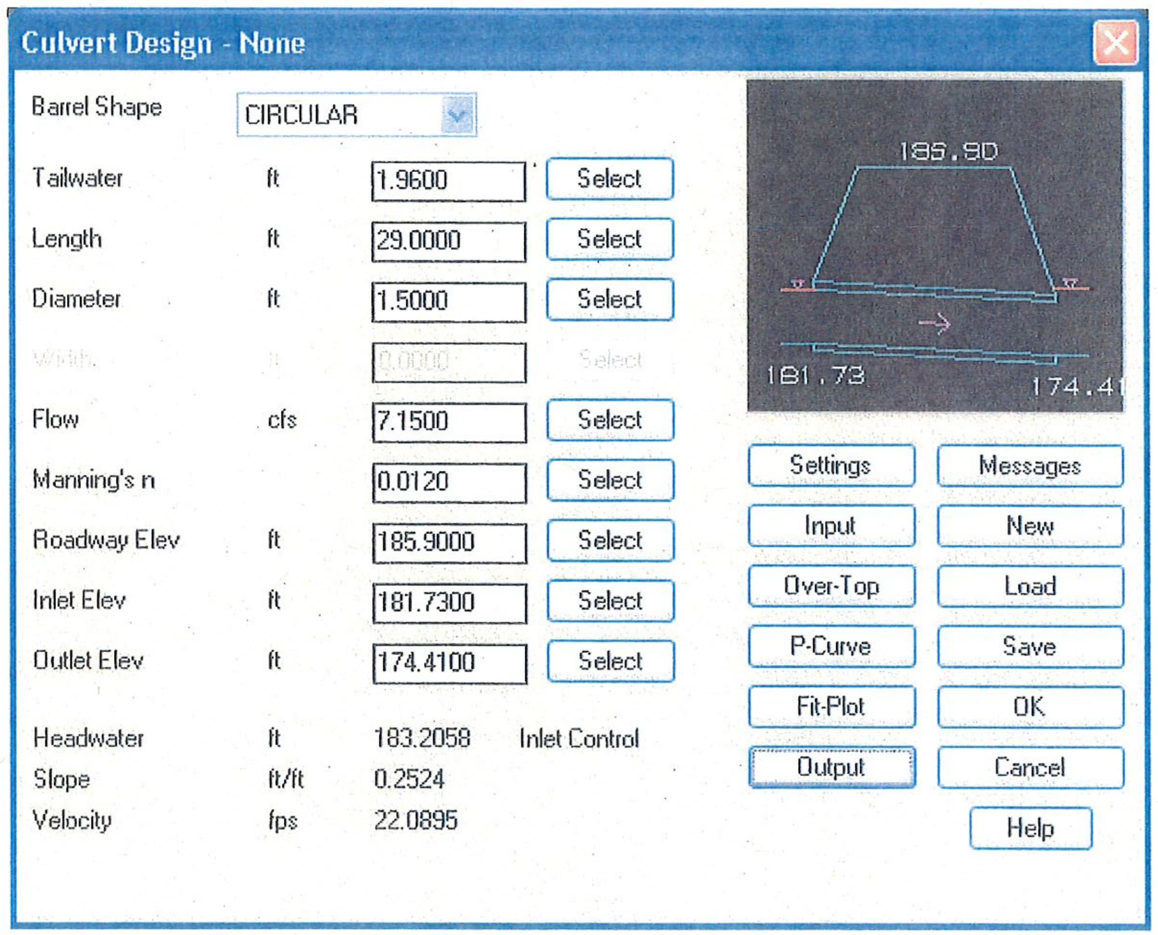
All calculator output should be verified prior to design use

```
Entered Data:
      Shape .............................. Circular
      Number of Barrels .................. 1
      Solving for ........................ Headwater
      Chart Number ....................... 1
      Scale Number ....................... 1
      Chart Description .................. CONCRETE PIPE CULVERT; NO BEVELED RING
ENTRANCE
      Scale Decsription .................. SQUARE EDGE ENTRANCE WITH HEADWALL
      Overtopping ........................ Off
      Flowrate ........................... 7.1500 cfs
      Manning's n ........................ 0.0120
      Roadway Elevation .................. 185.9000 ft
      Inlet Elevation .................... 181.7300 ft
      Outlet Elevation ................... 174.4100 ft
      Diameter ........................... 1.5000 ft
      Length ............................. 29.0000 ft
      Entrance Loss ...................... 0.0000
      Tailwater .......................... 1.9600 ft

Computed Results:
      Headwater .......................... 183.2058 ft Inlet Control
      Slope .............................. 0.2524 ft/ft
      Velocity ........................... 22.0895 fps

Messages:
      Inlet head > Outlet head.
      Computing Inlet Control headwater.
      Solving Inlet Equation 26.
      Solving Inlet Equation 28.
      Headwater: 183.2058 ft
```

Performance table - for single barrel only:

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH ft	CRITICAL DEPTH ft	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
1.43	181.78	0.00	0.05	NA	0.16	1.04	0.81	0.36	0.00	1.96
2.86	181.78	0.00	0.05	NA	0.23	1.04	1.62	0.36	0.00	1.96
4.29	181.78	0.00	0.05	NA	0.28	1.04	2.43	0.36	0.00	1.96
5.72	181.78	0.00	0.05	NA	0.32	1.04	3.24	0.36	0.00	1.96
7.15	181.78	0.00	0.05	NA	0.36	1.04	4.05	0.36	0.00	1.96
8.58	181.78	0.00	0.05	NA	0.39	1.04	4.86	0.36	0.00	1.96
10.01	181.78	0.00	0.05	NA	0.42	1.04	5.66	0.36	0.00	1.96
11.44	181.78	0.00	0.05	NA	0.45	1.04	6.47	0.36	0.00	1.96
12.87	181.78	0.00	0.05	NA	0.48	1.04	7.28	0.36	0.00	1.96
14.30	181.78	0.00	0.05	NA	0.51	1.04	8.09	0.36	0.00	1.96
15.73	181.78	0.00	0.05	NA	0.54	1.04	8.90	0.36	0.00	1.96
17.16	181.79	0.06	0.05	NA	0.56	1.44	28.30	0.56	0.00	1.96

18.59	182.44	0.71	0.05	NA	0.59	1.46	28.92	0.59	0.00	1.96
20.02	183.14	1.41	0.05	NA	0.61	1.47	29.50	0.61	0.00	1.96
21.45	183.90	2.17	0.05	NA	0.64	1.50	30.05	0.64	0.00	1.96
22.88	184.71	2.98	0.05	NA	0.66	1.50	30.57	0.66	0.00	1.96
24.31	185.57	3.84	0.05	NA	0.68	1.50	31.06	0.68	0.00	1.96
25.74	181.78	0.00	0.05	NA	0.71	1.50	14.57	0.68	0.00	1.96
27.17	181.78	0.00	0.05	NA	0.73	1.50	15.38	0.68	0.00	1.96
28.60	181.78	0.00	0.05	NA	0.75	1.50	16.18	0.68	0.00	1.96
30.03	181.78	0.00	0.05	NA	0.77	1.50	16.99	0.68	0.00	1.96
31.46	181.78	0.00	0.05	NA	0.79	1.50	17.80	0.68	0.00	1.96
32.89	181.78	0.00	0.05	NA	0.82	1.50	18.61	0.68	0.00	1.96
34.32	181.78	0.00	0.05	NA	0.84	1.50	19.42	0.68	0.00	1.96
35.75	181.78	0.00	0.05	NA	0.86	1.50	20.23	0.68	0.00	1.96

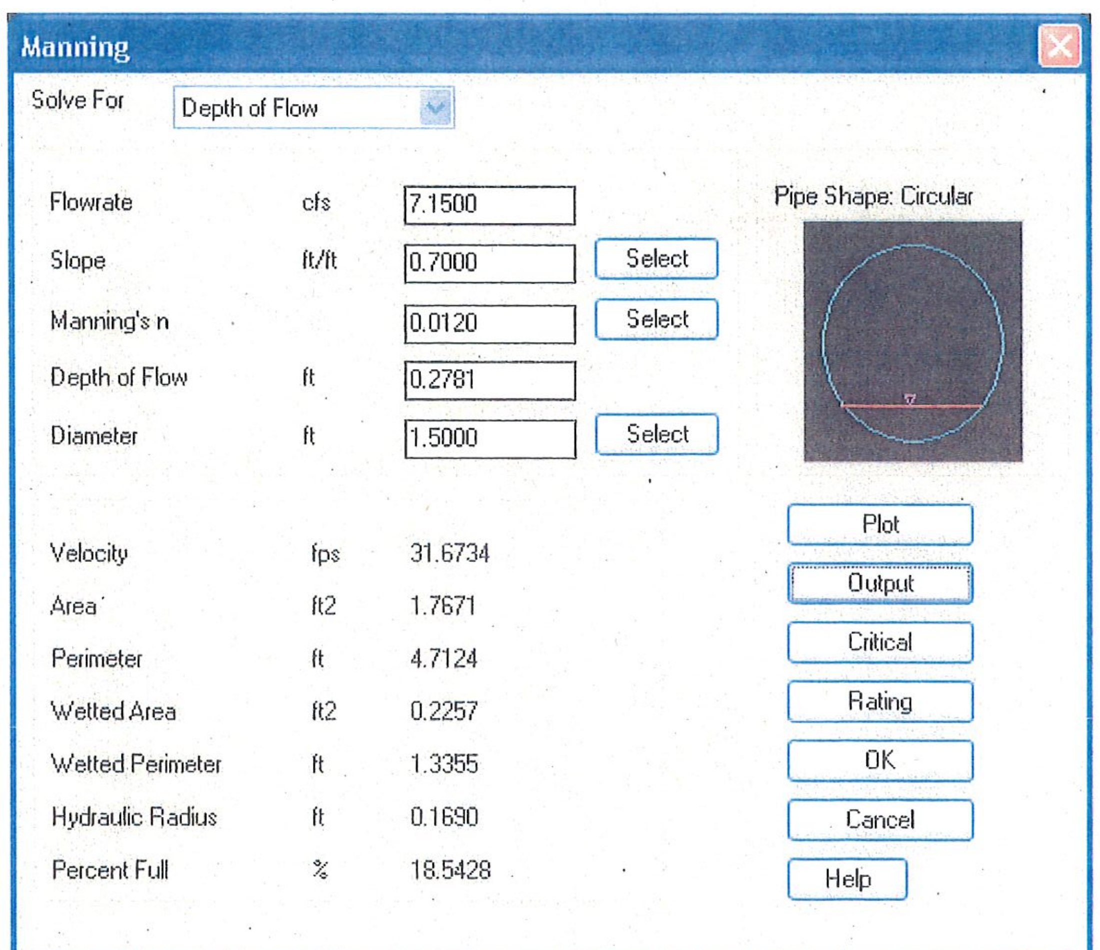


18" DIA AVG Frontage Pipe from Site to Outfall Manhole

Manning Pipe Calculator

```
Given Input Data:
     Shape .......................... Circular
     Solving for .................... Depth of Flow
     Diameter ....................... 1.5000 ft
     Flowrate ....................... 7.1500 cfs
     Slope .......................... 0.7000 ft/ft
     Manning's n .................... 0.0120
```

```
Computed Results:
     Depth ..........................  0.2781 ft
     Area ...........................  1.7671 ft2
     Wetted Area ....................  0.2257 ft2
     Wetted Perimeter ...............  1.3355 ft
     Perimeter ......................  4.7124 ft
     Velocity .......................  31.6734 fps
     Hydraulic Radius ...............  0.1690 ft
     Percent Full ...................  18.5428 %
     Full flow Flowrate .............  95.2094 cfs
     Full flow velocity .............  53.8775 fps

                    Critical Information
     Critical depth .................  1.0515 ft
     Critical slope .................  0.0054 ft/ft
     Critical velocity ..............  5.3527 fps
     Critical area ..................  1.3358 ft2
     Critical perimeter .............  2.9591 ft
     Critical hydraulic radius ......  0.4514 ft
     Critical top width .............  1.5000 ft
     Specific energy ................  15.8684 ft
     Minimum energy .................  1.5772 ft
     Froude number ..................  12.6903
     Flow condition .................  Supercritical
```



Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:

Shape	Circular
Number of Barrels	1
Solving for	Headwater
Chart Number	1
Scale Number	1
Chart Description	CONCRETE PIPE CULVERT; NO BEVELED RING ENTRANCE
Scale Decsription	SQUARE EDGE ENTRANCE WITH HEADWALL
Overtopping	Off
Flowrate	7.1500 cfs
Manning's n	0.0120
Roadway Elevation	185.9000 ft
Inlet Elevation	174.4100 ft
Outlet Elevation	86.0300 ft
Diameter	1.5000 ft
Length	1205.0000 ft
Entrance Loss	0.0000
Tailwater	0.0100 ft

Computed Results:

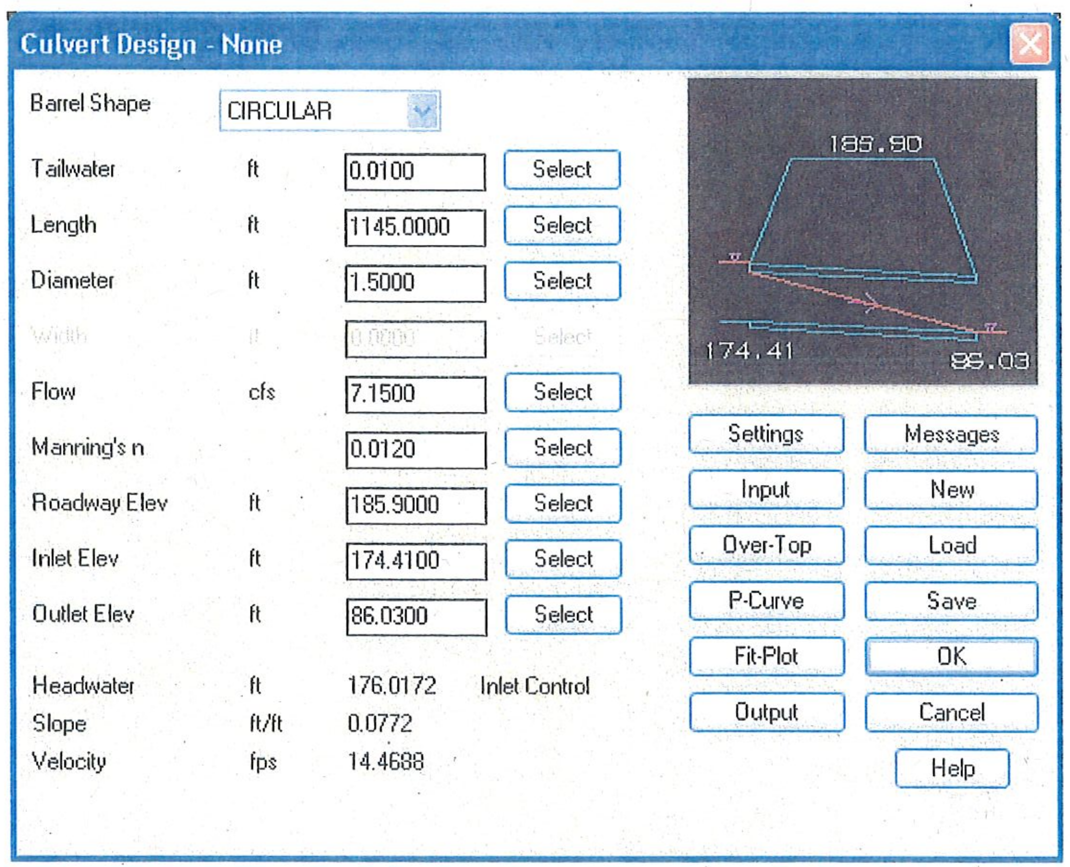
Headwater	176.0202 ft Inlet Control
Slope	0.0733 ft/ft
Velocity	14.2014 fps

Messages:
Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 176.0202 ft

Performance table - for single barrel only:

DIS-CHARGE Flow cfs	HEAD-WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH ft	CRITICAL DEPTH ft	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
1.43	174.46	0.00	0.05	NA	0.22	1.04	3.22	0.22	0.00	0.01
2.86	174.46	0.00	0.05	NA	0.31	1.04	3.96	0.31	0.00	0.01
4.29	174.46	0.00	0.05	NA	0.38	1.04	4.52	0.38	0.00	0.01
5.72	174.46	0.00	0.05	NA	0.44	1.04	5.01	0.44	0.00	0.01
7.15	174.46	0.00	0.05	NA	0.49	1.04	5.49	0.49	0.00	0.01
8.58	174.46	0.00	0.05	NA	0.54	1.04	5.98	0.54	0.00	0.01
10.01	174.46	0.00	0.05	NA	0.59	1.04	6.51	0.59	0.00	0.01
11.44	174.46	0.00	0.05	NA	0.63	1.04	7.07	0.63	0.00	0.01
12.87	174.46	0.00	0.05	NA	0.68	1.04	7.70	0.68	0.00	0.01
14.30	174.46	0.00	0.05	NA	0.72	1.04	8.37	0.72	0.00	0.01
15.73	174.46	0.00	0.05	NA	0.76	1.04	9.09	0.76	0.00	0.01
17.16	174.47	0.06	0.05	NA	0.80	1.44	17.91	0.80	0.00	0.01
18.59	175.12	0.71	0.05	NA	0.84	1.46	18.26	0.84	0.00	0.01

20.02	175.82	1.41	0.05	NA	0.88	1.47	18.57	0.88	0.00	0.01
21.45	176.58	2.17	0.05	NA	0.92	1.50	18.85	0.92	0.00	0.01
22.88	177.39	2.98	0.05	NA	0.96	1.50	19.11	0.96	0.00	0.01
24.31	178.25	3.84	0.05	NA	1.00	1.50	19.33	1.00	0.00	0.01
25.74	174.46	0.00	0.05	NA	1.05	1.50	14.57	1.05	0.00	0.01
27.17	174.46	0.00	0.05	NA	1.09	1.50	15.38	1.09	0.00	0.01
28.60	174.46	0.00	0.05	NA	1.14	1.50	16.18	1.14	0.00	0.01
30.03	174.46	0.00	0.05	NA	1.20	1.50	16.99	1.20	0.00	0.01
31.46	174.46	0.00	0.05	NA	1.50	1.50	17.80	1.50	0.00	0.01
32.89	174.46	0.00	0.05	NA	1.50	1.50	18.61	1.50	0.00	0.01
34.32	174.46	0.00	0.05	NA	1.50	1.50	19.42	1.50	0.00	0.01
35.75	174.46	0.00	0.05	NA	1.50	1.50	20.23	1.50	0.00	0.01



<u>36" DIA Outfall Pipe</u>
Manning Pipe Calculator

100 Year Unmitigated Flow = 59.43 cfs (using C/D soils)

Given Input Data:

Shape	Circular
Solving for	Depth of Flow
Diameter	3.0000 ft
Flowrate	59.4300 cfs
Slope	0.1490 ft/ft
Manning's n	0.0120

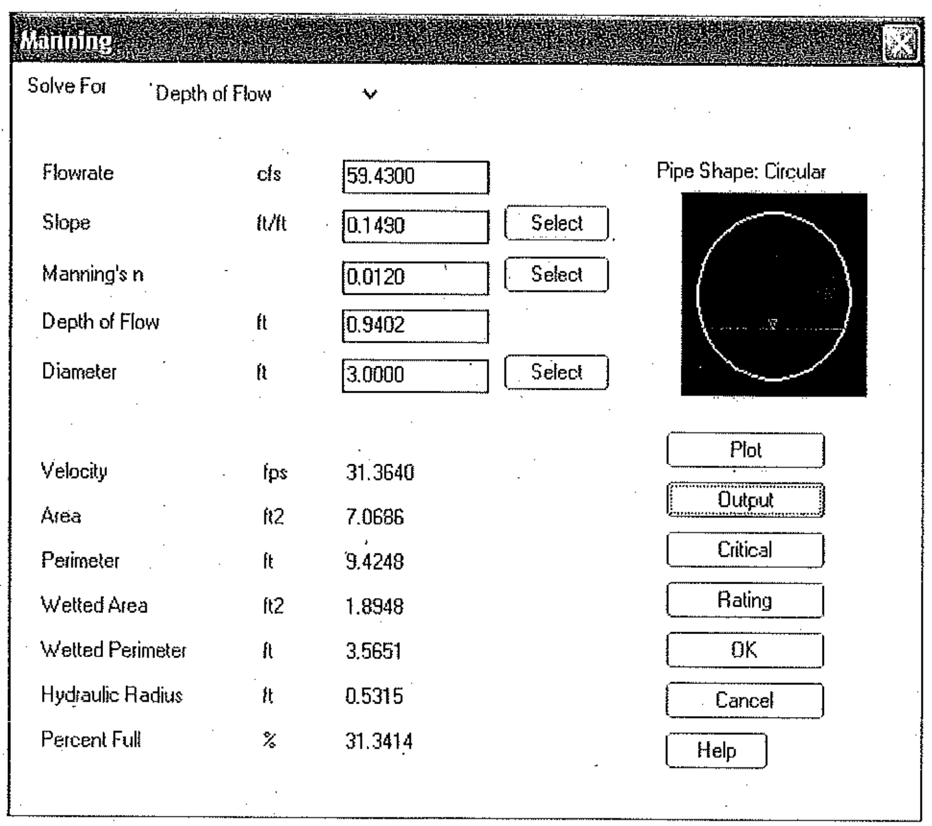
Carnoustie (TRLX0107)
Outfall Pipe Calculations
6:07:54 PM, 7/17/2007

Computed Results:

Depth	0.9402 ft
Area	7.0686 ft2
Wetted Area	1.8948 ft2
Wetted Perimeter	3.5651 ft
Perimeter	9.4248 ft
Velocity	31.3640 fps
Hydraulic Radius	0.5315 ft
Percent Full	31.3414 %
Full flow Flowrate	278.9142 cfs
Full flow velocity	39.4583 fps

Critical Information

Critical depth	2.6238 ft
Critical slope	0.0049 ft/ft
Critical velocity	8.6059 fps
Critical area	6.9057 ft2
Critical perimeter	6.9600 ft
Critical hydraulic radius	0.9922 ft
Critical top width	3.0000 ft
Specific energy	16.2274 ft
Minimum energy	3.9357 ft
Froude number	6.7015
Flow condition	Supercritical



Culvert Calculator

All calculator output should be verified prior to design use

Entered Data:
Shape .... Circular
Number of Barrels 1
Solving for .... Headwater
Chart Number 1
Scale Number 1
Chart Description .... CONCRETE PIPE CULVERT; NO BEVELED RING ENTRANCE
Scale Description .... SQUARE EDGE ENTRANCE WITH HEADWALL
Overtopping .... Off
Flowrate .... 59.4300 cfs
Manning's n 0.0120
Roadway Elevation .... 84.8700 ft
Inlet Elevation .... 75.9700 ft
Outlet Elevation .... 62.4000 ft
Diameter .... 3.0000 ft
Length .... 92.0000 ft
Entrance Loss 0.0000
Tailwater .... 0.0100 ft

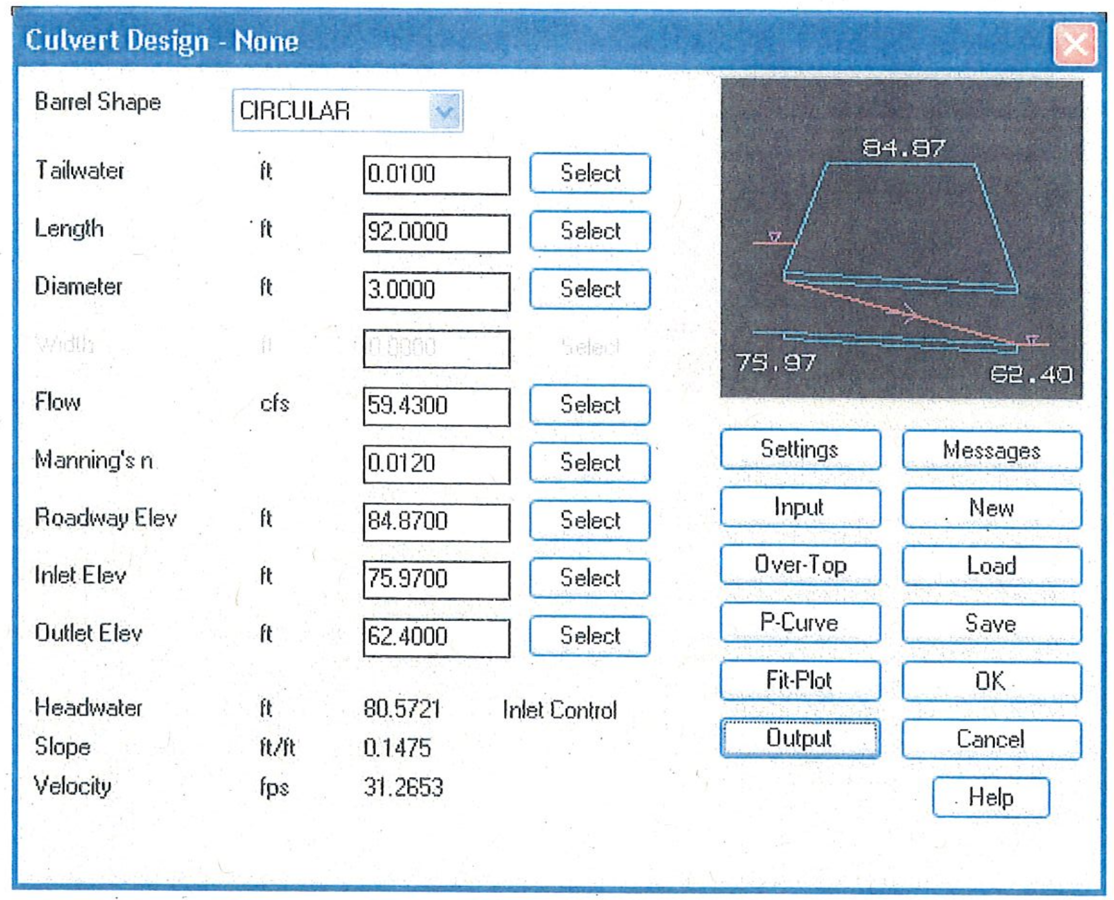
Computed Results:
Headwater .... 80.5721 ft Inlet Control
Slope .... 0.1475 ft/ft
Velocity .... 31.2653 fps

Messages:
Inlet head > Outlet head.
Computing Inlet Control headwater.
Solving Inlet Equation 26.
Solving Inlet Equation 28.
Headwater: 80.5721 ft

Performance table - for single barrel only:

DIS- CHARGE Flow cfs	HEAD- WATER ELEV. ft	INLET CONTROL DEPTH ft	OUTLET CONTROL DEPTH ft	FLOW TYPE	NORMAL DEPTH ft	CRITICAL DEPTH ft	OUTLET VEL. fps	OUTLET DEPTH ft	TAILWATER VEL. fps	TAILWATER DEPTH ft
1.43	76.02	0.00	0.05	NA	0.15	2.49	2.86	0.15	0.00	0.01
2.86	76.02	0.00	0.05	NA	0.21	2.49	3.43	0.21	0.00	0.01
4.29	76.02	0.00	0.05	NA	0.26	2.49	3.82	0.26	0.00	0.01
5.72	76.02	0.00	0.05	NA	0.30	2.49	4.14	0.30	0.00	0.01
7.15	76.02	0.00	0.05	NA	0.33	2.49	4.40	0.33	0.00	0.01
8.58	76.02	0.00	0.05	NA	0.36	2.49	4.64	0.36	0.00	0.01
10.01	76.02	0.00	0.05	NA	0.39	2.49	4.85	0.39	0.00	0.01
11.44	76.02	0.00	0.05	NA	0.42	2.49	5.04	0.42	0.00	0.01
12.87	76.02	0.00	0.05	NA	0.44	2.49	5.22	0.44	0.00	0.01
14.30	76.02	0.00	0.05	NA	0.46	2.49	5.39	0.46	0.00	0.01
15.73	76.02	0.00	0.05	NA	0.48	2.49	5.55	0.48	0.00	0.01
17.16	76.03	0.06	0.05	NA	0.51	1.32	21.80	0.51	0.00	0.01
18.59	76.68	0.71	0.05	NA	0.53	1.38	22.32	0.53	0.00	0.01
20.02	77.38	1.41	0.05	NA	0.55	1.44	22.82	0.55	0.00	0.01
21.45	78.14	2.17	0.05	NA	0.56	1.49	23.29	0.56	0.00	0.01
22.88	78.95	2.98	0.05	NA	0.58	1.54	23.73	0.58	0.00	0.01
24.31	79.81	3.84	0.05	NA	0.60	1.59	24.16	0.60	0.00	0.01

25.74	76.02	0.00	0.05	NA	0.62	1.59	6.52	0.62	0.00	0.01
27.17	76.02	0.00	0.05	NA	0.63	1.59	6.65	0.63	0.00	0.01
28.60	76.02	0.00	0.05	NA	0.65	1.59	6.77	0.65	0.00	0.01
30.03	76.02	0.00	0.05	NA	0.67	1.59	6.89	0.67	0.00	0.01
31.46	76.02	0.00	0.05	NA	0.68	1.59	7.02	0.68	0.00	0.01
32.89	76.02	0.00	0.05	NA	0.70	1.59	7.14	0.70	0.00	0.01
34.32	76.02	0.00	0.05	NA	0.71	1.59	7.26	0.71	0.00	0.01
35.75	76.02	0.00	0.05	NA	0.73	1.59	7.38	0.73	0.00	0.01



Carnoustie (TRLX0107)
Backwater Calculations
5:55 PM, 7/17/2007

100 YR UPSTREAM FROM POND I

Pipe Segment CB	CB	Q (cfs)	Length (ft)	Pipe Size	"n" Value	Outlet Elevation (ft)	Inlet Elevation (ft)	Barrel Area (sq.ft.)	Barrel Velocity (fps)	Barrel Vel. Head (ft)
		59.43								
Outfall	Ex SDCB #44	59.43	73.00	36.00	0.012	62.40	75.97	7.07	8.41	1.10
Ex SDCB #44	Ex SDCB	7.15	18.00	15.00	0.012	78.67	80.33	1.23	5.83	0.53
Ex SDCB	Swale	7.15	49.00	15.00	0.012	80.58	85.34	1.23	5.83	0.53
Swale	Swale	7.15	65.00	24.00	0.012	85.34	86.03	3.14	2.28	0.08
Swale	SDCB #45	7.15	16.00	18.00	0.012	86.03	87.00	1.77	4.04	0.25
SDCB #45	SDCB #46	7.15	159.00	18.00	0.012	87.00	98.78	1.77	4.04	0.25
SDCB #46	SDCB #47	7.15	98.00	18.00	0.012	98.78	106.82	1.77	4.04	0.25
SDCB #47	SDCB #48	7.15	299.00	18.00	0.012	106.82	131.07	1.77	4.04	0.25
SDCB #48	SDCB #49	7.15	300.00	18.00	0.012	131.07	155.54	1.77	4.04	0.25
SDCB #49	SDCB #50	7.15	268.00	18.00	0.012	155.54	174.41	1.77	4.04	0.25
SDCB #50	SDCB #51	7.15	29.00	18.00	0.012	174.41	180.23	1.77	4.04	0.25
SDCB #51	SDCB #2	5.97	218.00	18.00	0.012	180.23	183.41	1.77	3.38	0.18
SDCB #2	SDCB #52	5.97	19.00	18.00	0.012	183.41	187.26	1.77	3.38	0.18
SDCB #52	RDCB #4	1.59	25.00	12.00	0.012	187.76	187.90	0.79	2.02	0.06
		1.59								0.06

Pipe Segment CB	CB	Tailwater Elevation (ft)	Friction Loss (ft)	Entrance HGL Elev. (ft)	Entrance Head Loss (ft)	Exit Head Loss (ft)	Outlet Control Elevation (ft)	Inlet Control Elevation (ft)	Approach Velocity Head (ft)	Bend Head Loss (ft)	Junction Head Loss (ft)	Headwater Elevation (ft)	Rim Elevation (ft)
												75.97	
Outfall	Ex SDCB #44	75.97	0.20	76.17	0.55	1.10	77.81	80.51	0.53	2.63	0.56	83.18	84.87
Ex SDCB #44	Ex SDCB	83.18	0.07	83.25	0.26	0.53	84.04	82.46	0.53	0.11	0.00	83.62	85.08
Ex SDCB	Swale	83.62	0.20	83.82	0.26	0.53	84.61	87.47	0.08	0.00	0.00	87.39	89.40
Swale	Swale	87.39	0.02	87.41	0.04	0.08	87.53	87.57	0.25	0.00	0.00	87.31	88.80
Swale	SDCB #45	87.31	0.02	87.34	0.13	0.25	87.72	88.61	0.25	0.05	0.00	88.41	91.16
SDCB #45	SDCB #46	88.41	0.25	88.65	0.13	0.25	89.04	100.38	0.25	0.00	0.00	100.13	103.28
SDCB #46	SDCB #47	100.13	0.15	100.28	0.13	0.25	100.66	108.41	0.25	0.01	0.00	108.17	111.32
SDCB #47	SDCB #48	108.17	0.47	108.64	0.13	0.25	109.02	132.67	0.25	0.00	0.00	132.41	135.57
SDCB #48	SDCB #49	132.41	0.47	132.88	0.13	0.25	133.26	157.13	0.25	0.00	0.00	156.88	159.54
SDCB #49	SDCB #50	156.88	0.42	157.30	0.13	0.25	157.68	176.01	0.25	0.61	0.00	176.37	178.91
SDCB #50	SDCB #51	176.37	0.05	176.41	0.13	0.25	176.80	181.74	0.18	0.61	0.03	182.20	183.64
SDCB #51	SDCB #2	182.20	0.24	182.44	0.09	0.18	182.70	184.86	0.18	0.42	0.00	185.11	188.00
SDCB #2	SDCB #52	185.11	0.02	185.13	0.09	0.18	185.39	188.57	0.06	0.00	0.08	188.58	191.52
SDCB #52	RDCB #4	188.58	0.02	188.60	0.03	0.06	188.69	188.73	0.06	0.15	0.00	188.82	190.90

Pipe Segment CB	CB	Cover	Slope	Ke	c	Y	Kb	Q3	Q1
Outfall	Ex SDCB #44	1.69	18.6%	0.50	0.0398	0.67	2.40	52.28	59.43
Ex SDCB #44	Ex SDCB	1.46	9.2%	0.50	0.0398	0.67	0.20	0.00	7.15
Ex SDCB	Swale	2.01	9.7%	0.50	0.0398	0.67	0.00	0.00	7.15
Swale	Swale	1.49	1.1%	0.50	0.0398	0.67	0.00	0.00	7.15
Swale	SDCB #45	2.75	6.1%	0.50	0.0398	0.67	0.20	0.00	7.15
SDCB #45	SDCB #46	3.15	7.4%	0.50	0.0398	0.67	0.00	0.00	7.15
SDCB #46	SDCB #47	3.15	8.2%	0.50	0.0398	0.67	0.04	0.00	7.15
SDCB #47	SDCB #48	3.16	8.1%	0.50	0.0398	0.67	0.00	0.00	7.15
SDCB #48	SDCB #49	2.66	8.2%	0.50	0.0398	0.67	0.00	0.00	7.15
SDCB #49	SDCB #50	2.54	7.0%	0.50	0.0398	0.67	2.40	0.00	7.15
SDCB #50	SDCB #51	1.44	20.1%	0.50	0.0398	0.67	2.40	1.18	7.15
SDCB #51	SDCB #2	2.89	1.5%	0.50	0.0398	0.67	2.40	0.00	5.97
SDCB #2	SDCB #52	2.94	20.3%	0.50	0.0398	0.67	0.00	4.38	5.97
SDCB #52	RDCB #4	2.08	0.6%	0.50	0.0398	0.67	2.40	0.00	1.59

7/17/2007
Carnoustie (TRLX0107)
Conveyance Sizing

Basin ID	50	49	48	47	46	45	SWALE	SWALE	EX SDCB	SDCB 44
100-Year Flow	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15	7.15
Length	268	300	299	98	159	16	16	49	18	92
Upstream Structure	SDCB 50	SDCB 49	SDCB 48	SDCB 47	SDCB 46	SDCB 45	SWALE	SWALE	EX SDCB	SDCB 44
Upstream Invert:	174.41	155.54	131.07	106.82	98.78	87.00	86.03	85.34	80.33	75.97
Downstream Structure:	SDCB 49	SDCB 48	SDCB 47	SDCB 46	SDCB 45	SWALE	SWALE	EX SDCB	SDCB 44	OUTFALL
Downstream Invert:	155.54	131.07	106.82	98.78	87.00	86.03	85.34	80.58	78.67	65.28
Pipe Size	18	18	18	18	18	18	18	15	15	36
Slope	7.04%	8.16%	8.11%	8.20%	7.41%	6.06%	4.31%	9.71%	9.22%	11.62%
Capacity	16.83	16.83	16.83	16.83	16.83	16.83	16.83	14.03	14.03	33.66
25-Year Flow	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23
25-Year Depth	5.07	4.88	4.89	4.88	5.00	5.27	5.75	5.00	5.07	3.63
25-Year Velocity	12.81	13.50	13.47	13.52	13.04	12.14	10.74	14.60	14.33	14.05
10-Year Flow	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
10-Year Depth	4.48	4.32	4.32	4.31	4.42	4.65	5.07	4.41	4.47	3.23
10-Year Velocity	11.94	12.58	12.56	12.61	12.16	11.32	10.03	13.63	13.38	13.05
Alternate Slope										
Up Rim	178.91	159.54	135.57	111.32	103.28	91.16	88.80	88.80	85.08	84.87
Cover	3.00	2.50	3.00	3.00	3.00	2.66	1.27	2.21	3.50	5.90
Alt. Up Invert										
Down Rim	159.54	135.57	111.32	103.28	91.16	88.80	88.80	85.08	84.87	62.00
Cover	2.50	3.00	3.00	3.00	2.66	1.27	1.96	3.25	4.95	-6.28
Alt. Down Invert										

APPENDIX C

Stormwater Facilities Operations and Maintenance Manual

CARNOUSTIE - SEMIAHMOO
BLAINE, WASHINGTON

STORMWATER FACILITIES
OPERATION & MAINTENANCE PLAN

Prepared for:
Trillium Corporation
4350 Cordata Parkway
Bellingham, WA 98226

Prepared by:
DAVID EVANS AND ASSOCIATES, INC
119 Grand Avenue, Suite D
Bellingham, Washington 98225
(360) 647-7151

Table of Contents

INTRODUCTION

This plan has been prepared for use by the owner for the operation and maintenance of the site's stormwater facilities. This manual describes each of the stormwater system components, how they are intended to operate, and what maintenance activities shall be followed. The main components are the stormwater conveyance system, the stormwater detention pond, and the stormwater treatment biofiltration swale. Each component is designed to operate with a minimum of maintenance; however some maintenance will be required.

1.0 STORMWATER CONVEYANCE SYSTEM

1.1 Description:

The stormwater conveyance system is comprised of a separate pipe systems for each of the two basins. The first system collects stormwater runoff from the landscape areas, access roads and driveways in catch basins located along the roadway. The stormwater is then conveyed through storm drain pipe to the stormwater splitter. The treatment flows are then split off and directed through the biofiltration swale. The high flows are routed to the projects release point along Drayton Harbor Road.

The second system collects runoff from the building's roof and footing drains. The runoff is collected through a series of pipes and catch basins. The stormwater is then conveyed through storm drain pipe to the projects release point along Drayton Harbor Road.

1.2 Operation:

The stormwater conveyance system is designed to operate trouble free for many years. There are no operational needs for the system other than the maintenance functions listed below.

1.3 Maintenance:

Catch Basins and Manholes:
Catch basins shall be visually inspected each year. The grates shall be removed, and a light directed at the pipe invert and catch basin sump. Any debris shall be removed from the catch basin. Any large build up of sediment in the sump areas shall also be removed.

Storm Piping and Culverts:
Storm conveyance pipes and culverts shall be inspected at the same time as stormwater manholes. Careful attention shall be given to the build up of sediment and debris within the invert (bottom) of the pipe. If more than one-inch of sediment is observed, then the sediments shall be removed through cleaning. Any line flushing to remove sediment or debris shall only be done during periods of dry weather. This is to avoid the potential of sediment laden cleaning water from entering the downstream system and diminishing the function of the stormwater treatment or detention facilities.

Perform additional maintenance as required as described in the Department of Ecology (DOE) *Maintenance Standards for Drainage Facilities*, from Volume V, Section 4.5 of the 2005 DOE Manual – see Attachments.

2.0 STORMWATER TREATMENT BIOFILTRATION SWALE

2.1 Description:

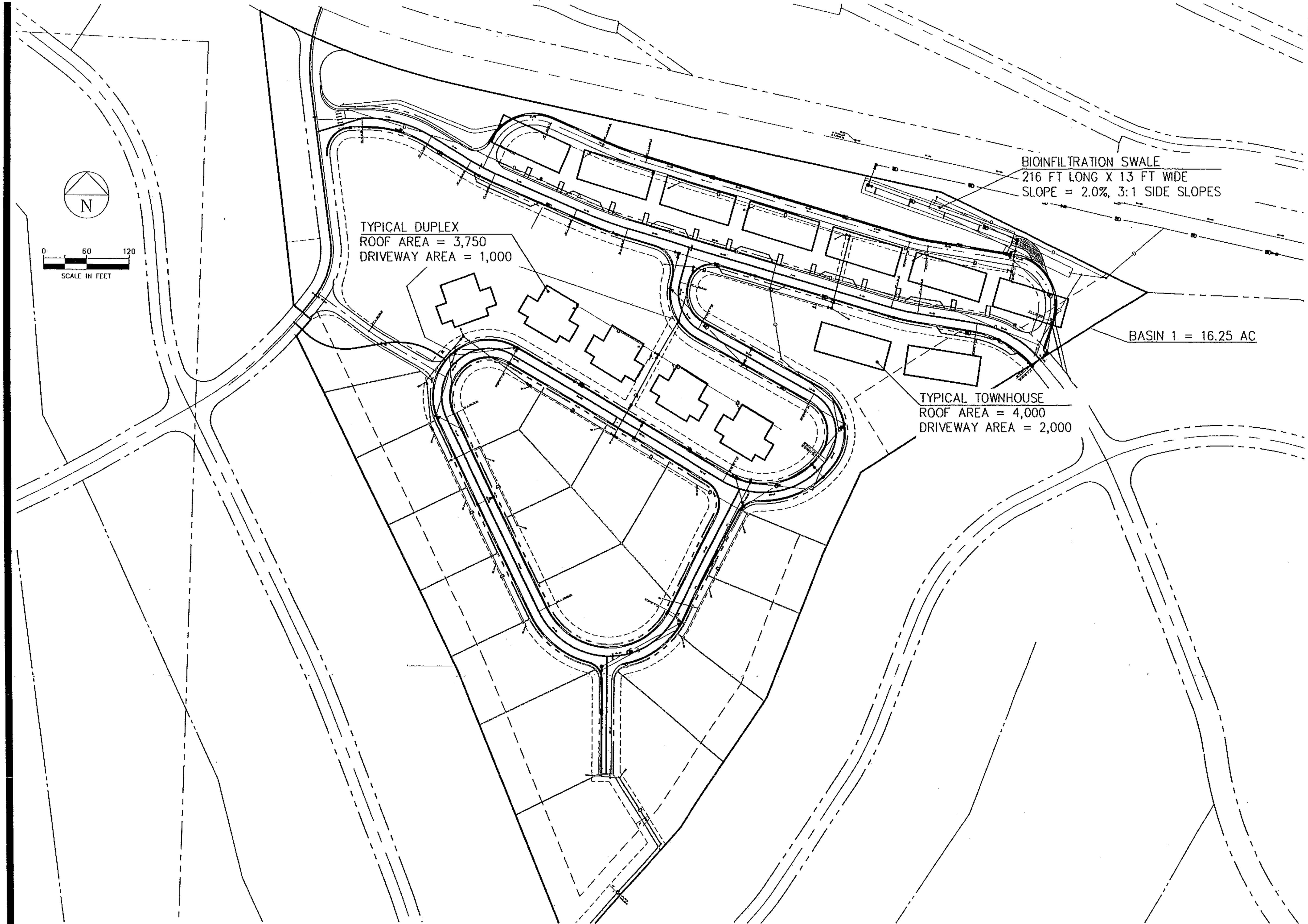
Treatment of stormwater is achieved in the biofiltration swale. The swales shall receive and treat the stormwater from the landscape area, access roads, and driveways. The swale is a grass lined depression that acts as a filter for the stormwater runoff flowing through. It utilizes a clay liner to prevent infiltration, a minimum of eight inches of amended soil and grass vegetation. The pollution removal mechanisms include filtration and intake by vegetative root zones. The swale has been design to treat the six-month flow from the respective basin.

2.2 Operation and Maintenance:

- Debris shall be removed as needed, but at least annually.
- The swale shall be uniformly covered in grass. Bare spots shall be reseeded and irrigated as required until the grass is established. The grass shall be mowed and site vegetation around the swale area shall be trimmed as necessary to keep the swale free of leaves and to maintain the aesthetic appearance of the site. Eroded areas shall be re-graded and re-vegetated as well as any slope areas that have become bare.
- Supplemental soil shall be added to the filter soil layer where the layer appears to be less than 8 inches thick. A soil mixture consisting of 60-90% sandy loam, 0-10% clay, and 10-30% composted organic matter (excluding animal waste and toxics) shall be used as replacement soil for the treatment layer.
- The biofiltration swale shall be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe grass coverage and erosion. Swale configuration and water depth shall also be observed for sediment build up. Provide corrective measures as required.
- Surrounding landscaping may require watering, mulching, weed removal, or replanting during the first three years.
- Nuisance plant species shall be removed and desirable species shall be replanted.
- Perform additional maintenance as required as described in the Department of Ecology (DOE) *Maintenance Standards for Drainage Facilities*, from Volume V, Section 4.5 of the 2005 DOE Manual – see Attachments.

3.0 ATTACHMENTS

- Post-Developed Stormwater Exhibit (Site Plan)
- WDOE Section 4.6 Maintenance Standards for Drainage Facilities



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NO. REVISIONS: APPD.

DAVID EVANS AND ASSOCIATES INC.
119 Grand Avenue, Suite D
Bellingham Washington 98225
Phone: 360.647.7151
Fax: 360.647.7160

TRILLIUM CORPORATION
BLAINE, WA

CARNOUSTIE-SEMIAHMOO

POST DEVELOPED LAYOUT STORMWATER EXHIBIT

PROJECT NUMBER: TRLX0107

DATE: 1-10-06
DESIGN: MJD
DRAWN: JSB
CHECKED:

SCALE: 1"= 120'

SHEET NO. 2 OF 3

No. 4 – Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).
Catch Basin	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 8 – Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.