Appendix F
Conceptual Stormwater Management Plan

Appendix F. Conceptual Stormwater Management Plan

INTRODUCTION

This memorandum describes the existing drainage system at the Bow Lake Transfer/Recycling Station, identifies applicable design criteria and regulatory requirements, and presents a conceptual stormwater management system that would be used to control and treat stormwater at the site. For the purpose of this memorandum, "site" refers to the area within the limits of the proposed Bow Lake station project boundary. The site is located along the east side of Interstate 5, just north of its intersection with Orillia Road and South 188th Street. The majority of the site is located within the City of Tukwila (the City). A small portion is located in unincorporated King County. The total developed site area is approximately 12 acres, 4.4 of which will be new impervious surface. Site improvements include demolition of all existing on site facilities and construction of two scale facilities, a transfer building, fee and free recycling areas, and other equipment and operator facilities. The surface water management facilities required for these improvements include:

- Stormwater quantity control (detention) facilities,
- Stormwater quality control facilities,
- Conveyance system including piping, curb and gutter and or ditches,
- Temporary erosion and sediment control and water quality source control during construction,
- Permanent water quality source controls.

This memorandum is divided into three sections: 1) a description of the existing affected environment in the vicinity of the project site and the downstream system, 2) a description of stormwater control design criteria and regulatory requirements, 3) a description of the conceptual design of stormwater management and impact mitigation facilities.

EXISTING DRAINAGE SYSTEM

The existing Bow Lake Transfer/Recycling Station was built almost 30 years ago on the site of a closed landfill. The area immediately north of the existing Transfer Station site is mostly undeveloped and is owned by WSDOT. This area includes a large stockpiled mound of fill. The portion of the WSDOT property closest to Interstate 5 (I-5) is used as a construction laydown yard for work along the I-5 corridor. The Bow Lake site is generally flat in the area of the existing facilities with a moderately steep down slope to the east.

Information about the existing site and downstream drainage system has been obtained from construction plans and site visits, through meetings with City staff,

and through research of the Tukwila South Project Draft Environmental Impact Statement (DEIS) prepared for a private development in the area.

The Transfer Station site includes approximately 4 acres of impervious area consisting of roads, trailer parking areas, and the roof of the transfer station building. Stormwater runoff from most of the site is collected in catch basins and trench drains and conveyed to one of four piped discharges along the top of the slope along the east site boundary. Runoff from the trailer parking and pit areas where stormwater has a greater potential to come into contact with solid waste operations is collected separately and routed to a retention vault. Vault contents are pumped out and trucked off site as wastewater. This portion of the runoff was separated from the stormwater collection system as part of site improvements made in 1991. Prior to these improvements, runoff from the entire site was discharged to the east slope.

Discharged stormwater travels down the slope either as surface flow in indistinct drainage swales or as groundwater that has infiltrated along the hillside. At the toe of the slope approximately 700 feet east of the transfer station, surface water and any re-emergent groundwater discharge to an existing ditch. The ditch, referred to as "Ditch E" in the proposed Tukwila South Project DEIS, flows to the north adjacent to a driving range and continues across pasture land before connecting to a culvert system along South Center Parkway that conveys flow north to the South 180th Street pump station where it is pumped into the Green River.

There are no known erosion or slope stability problems resulting from the concentrated discharges that have been occurring since the site was initially developed nearly 30 years ago.

The DEIS states that no fish sightings in Ditch E have been recorded during habitat surveys. However, it conservatively assumes that fish could be present in the stream. Because the pump station downstream at the Green River acts as a barrier, there are no anadromous fish in the stream.

Hydrologic Analysis of Existing Conditions

A King County Runoff Time Series (KCRTS) hydrologic model was developed to estimate existing runoff rates from the site. A summary of the analysis follows in Table 1. Model output is included in Attachment F1. Although some of the impervious area at the existing site is conveyed to the sanitary sewer system, it was assumed that all runoff enters the storm drain system.

Table 1
Hydrologic Results – Existing Conditions

Impervious Area (acres)	4.3
Till Grass Area (acres)	2.5
Till Forest Area (acres)	4.7
Total Area (acres)	11.5
Peak Flow (cfs)	

2-year	2.3
10-year	4.1
25-year	5.6
100-year	8.9

DESIGN CRITERIA AND REGULATORY REQUIREMENTS

The regulatory requirements governing this project were reviewed to determine the likely design criteria that would apply. The applications for permits for the project will likely be submitted sometime in late 2007. This section identifies permits that will likely be required for the project and describes the design criteria used to develop the conceptual stormwater management system and the required stormwater controls during construction.

Federal, state and local agencies may require permits for work related to stormwater associated with the transfer station improvements. A National Pollutant Discharge Elimination System (NPDES) permit, which would include a Stormwater Pollution Prevention Plan, will likely be required by the State Department of Ecology for construction activities including clearing, grading and excavation.

Per Tukwila Municipal code 14.30.070, the City has adopted the 1998 *King County Surface Water Design Manual* (KCSWDM, or Manual) except as amended by the City of Tukwila Public Works Development Guidelines and Design and Construction Standards. The City is currently considering adopting the 2005 Manual.. Because the City will likely have adopted the 2005 Manual prior to submission of permit applications for the Bow Lake Transfer/Recycling Station Improvement project, surface water facilities will be designed to follow the 2005 Manual guidelines and requirements. The 2005 manual guidelines are also appropriate because the project is being constructed by a King County agency that designs to the higher established standards.

The 2005 King County Manual uses thresholds to define the type of drainage review required for different sizes and types of projects. The type of drainage review generally defines which requirements apply. The manual applies eight "Core Requirements" plus "Special Requirements". Core Requirements apply to all projects meeting certain thresholds. Special Requirements also apply depending on the project location or site specific characteristics.

The Bow Lake Transfer/Recycling Station project will create more than 2,000 square feet of new impervious surface and will require a Full Drainage Review. As such, it will be required to meet all eight of the Core Requirements as follows. Further explanation of how the stormwater facilities will meet these requirements is included in the conceptual design discussion of this memorandum.

1. **Discharging surface water at the natural location**. Natural drainage patterns are to be maintained and discharges from the project site shall occur at the natural locations, to the maximum extent practicable.

2. **Providing an off-site analysis**. All projects must submit an offsite analysis report that assesses potential offsite drainage impacts associated with development of the project site and propose appropriate mitigation of those impacts. The objective of the requirement is to identify and evaluate offsite drainage problems that may be created or aggravated by the proposed project and to determine appropriate measures for preventing aggravation of those projects.
3. **Providing flow control.** All projects, including redevelopment projects such as the Transfer Station Improvement Project, must provide onsite flow control facilities or flow control BMPs or both to mitigate the impacts of storm and surface water runoff generated by new impervious surface, new pervious surface and replaced impervious surface. The transfer station project is within a "Basic Flow Control" area and requires detention such that outflows match the 2-and 10-year flows for existing conditions.
4. **Providing a conveyance system.** All engineered conveyance system elements for projects must be analyzed, designed and constructed to provide a minimal level of protection against overtopping, flooding, erosion, and structural failure. The conveyance system will be sized to handle 25-year peak flows calculated using 15-minute time steps in the King County Backwater Model (KCBW).
5. **Providing erosion and sediment control measures**. All projects that will clear, grade, or otherwise disturb the site must provide erosion and sediment controls to prevent, to the maximum extent practicable, the transportation of sediment and other construction–related pollutants from the project site to downstream drainage facilities, water resources, and adjacent properties.
6. **Maintaining and operating the surface water facilities**. The objective of this requirement is to ensure that the drainage facilities will be properly maintained and operated in perpetuity.
7. **Complying with financial guarantees**. Project proponents must comply with the financial guarantee requirements in King County Ordinance 12020 and the liability requirements of King County Code 9.04.100. Because the County is a government agency, the City of Tukwila will not likely require these financial guarantees.
8. **Providing water quality treatment.** All projects, including redevelopment projects, must provide water quality facilities to treat the runoff from those new and replaced pollution-generating impervious surfaces and new pollution-generating pervious surfaces targeted for treatment. For water quality treatment facilities upstream of detention facilities, the water quality treatment design flow is based on 60% of the developed 2-year peak flow as determined using the KCRTS model. Downstream of detention, the water quality treatment design flow is equal to the full 2-year release rate. The water quality treatment volume is a minimum of 95% of the average annual runoff volume in the time series as determined by the KCRTS model.

In addition to the Core Requirements, the project would be required to meet all applicable Special Requirements. Of the Special Requirements, the only one that would apply is Special Requirement 4, Source Controls. This requirement

would be triggered because the project will require a commercial site development permit. Water quality source controls will be required to prevent rainfall and runoff water from coming into contact with pollutants, thereby reducing the likelihood that pollutants will enter public waterways and violate water quality standards.

Projects subject to a Full Drainage Review are required to submit a Technical Information Report (TIR), stamped and dated by a Washington State licensed professional civil engineer. The TIR will include the drainage design plus supporting calculations as well as the proposed erosion and sediment control (ESC) plan.

In addition to meeting the local requirements in the 2005 Manual, an NPDES permit for construction will also be required. This permit, which is administered by the Department of Ecology, is required for projects that will create land disturbing activities in excess of 1 acre. For this permit a Storm Water Pollution Prevention Plan (SWPPP) must be prepared. Most of the requirements of the SWPPP are similar to the requirements of the Full Drainage Review.

The Green River Flood Control Zone District is a quasi-municipal corporation of the State of Washington that is primarily responsible for maintaining and operating flood protection facilities on the lower Green River within its boundaries. Discharges to the Green River in the Cities of Auburn, Kent, Renton, and Tukwila and in King County are regulated by the Green River Pump Operations Procedures Plan. The plan establishes guidelines for the design and operation of pumped and gravity outfalls to the Green River. Flood protection measures include limiting pump station operating hours and providing storage for the 100-year 7-day rainfall event. Because stormwater from the Bow Lake facility will be conveyed to an existing pump station, the requirements of this document do not apply.

Washington state law requires that any construction activity that will use, divert, obstruct, or change the bed or flow of state waters must do so under the terms of a Hydraulic Project Approval (HPA) permit issued by the Washington State Department of Fish and Wildlife. If site runoff is conveyed to Ditch E, the outfallmay include construction at Ditch E, and the possible requirement of a Hydraulic Project Approval (HPA), issued by the Washington State Department of Fish and Wildlife.. HPA permits typically require that the project comply with the provisions of the Washington State Department of Ecology (Ecology) 2005 Stormwater Management Manual for Western Washington. The Ecology manual's standard flow control requirement is more stringent than that of the 2005 King County manual. Stormwater discharges must meet pre-developed durations for discharge rates from 50% of the 2-year peak flow up to the 50-year peak flow. The pre-developed condition would likely be forested land cover unless an exception is approved.

Because Ditch E is tributary to a pump station and there is minimal potential for fish access, Ecology's level of flow control may not be required. Based on discussion with Tukwila City staff, recent development in this drainage basin

requiring an HPA has not been held to the Ecology flow control standard. If an HPA is required, the applicability of Ecology standards will be discussed with WDFW during the project design phase.

The hydrologic analysis and conceptual design presented in this memorandum assume that the project will be required to meet King County requirements. Where appropriate, a brief discussion identifies the potential impacts to design if the Ecology Manual must be adhered to.

CONCEPTUAL STORMWATER MANAGEMENT DESIGN AND MITIGATION APPROACH

This section describes a conceptual level approach for providing a drainage system for the proposed Transfer Station that meets the 2005 KCSWDM requirements. To meet the core requirements, the project will include both permanent storm water facilities as well as temporary measures for erosion and sediment control during construction. The permanent storm drainage system will include piping, detention vaults and stormwater quality treatment. Stormwater in areas with higher potential for pollution will be isolated and conveyed to the sanitary sewer system. A conceptual layout of the permanent facilities is shown in Figure 1.

Mitigation during Construction

The Bow Lake Transfer station will be constructed in phases. Throughout construction, temporary drainage and erosion control facilities and source controls will be provided. Erosion and sediment control measures may include:

- Providing temporary cover over exposed soils and stockpiles,
- Using silt fencing between construction activities and downstream water courses,
- Installing check dams along existing and temporary ditches,
- Directing runoff to temporary sediment traps or portable treatment tanks for treatment prior to discharge to the downstream system,
- Preventing track off of sediment onto offsite roadways,
- Installing permanent cover measures as soon as possible after construction is complete.
- Providing water quality source controls during construction to prevent pollutants from coming into contact with stormwater. Source control measures could include safe handling of petroleum products including proper storage and maintenance of vehicles and equipment.
- Implementing measures to minimize leachate generation during construction. The potential for leachate generation is discussed in a memorandum by R.W. Beck dated October 12, 2006 with the subject *Bow Lake Transfer/Recycling Station Facility Master Plan Update and Implementation – Evaluation of Potential for Leachate Generation at the Project Site During Construction and During Operation of the Completed Facility.*

Permanent Facilities

Hydrologic Analysis of Developed Conditions

The KCRTS model was used to evaluate the potential increase in runoff from the recycling and transfer station development at the Bow Lake site. The hydrologic model was used to estimate future runoff rates for the improved site conditions. Table 2 provides a summary of model input and results. Note that approximately 0.4 acres of impervious area will be conveyed to the sanitary sewer.

Table 2
Hydrologic Results – Developed Conditions

Impervious Area (acres)	8.8
Till Grass Area (acres)	2.3
Diverted to Sanitary Sewer (acres)	0.4
Total Area (acres)	11.5
Peak Flow (cfs)	
2-year	4.4
10-year	7.5
25-year	9.7
100-year	14.1

Conveyance

Core Requirement number four requires a conveyance system that provides minimal protection against overtopping, flooding, erosion and structural failure. The systems must be designed to convey the 25-year peak flow. Conceptual collection and conveyance systems for the Bow Lake Transfer/Recycling Station are shown schematically on Figure 1. A rainwater harvesting system will be in place to collect roof runoff for use in transfer station operations. The approximate roof area to be included is 1.5 acres. Roof drains will also be provided for use in the event that the harvesting system is taken off-line. A rough estimate is that up to one-half of the precipitation collected could be used for solid waste operations and then be discharged to the sanitary sewer system.

All paved surfaces including building roofs will be conveyed by 12 to 24-inch-diameter storm drain pipes. These pipe sizes are preliminary and will be confirmed by detailed hydraulic analysis during final design. The conveyance system will collect runoff from the site and direct it to an underground detention vault or vaults. Detained flows would flow to a water quality treatment system and then discharged down the eastern slope.

Flows will be discharged down the slope by one of two alternatives; a piped (tightline) system down the slope or a flow spreading and dispersion system. The tighline alternative would include piping flow down the slope to Ditch E in a pipe sized to convey the 100-year peak flow (likely a 24-inch-diameter pipe) Construction of this pipeline would require a drainage easement from the adjacent property owner.

The second alternative would be to discharge flows to the downstream drainage system by overland flow along the eastern slope. This option would consist of an engineered flow spreading and dispersion system(s) that would discharge flows along the eastern property line located on a bench further down the slope or higher up along the slope. Selection of a location for the discharge spreader(s) would give careful consideration of the issues of slope stability and leachate generation. The system would be designed to minimize erosion and mimic the current dispersed stormwater discharge conditions at the site.

Decisions about the discharge method and details will be made during development of the TIR and during design based on input from the City of Tukwila and other agencies having regulatory or oversight responsibilities and on the possibility of obtaining an easement from the adjacent property owner. The dispersion option will only be considered feasible if slope stability analysis by a licensed geotechnical engineer shows that discharge flows will not create or make worse any existing erosion problems downstream of the project site. If a dispersion option were implemented along the top of the slope, consideration would be given to planting high water consumption trees on the un-forested downhill slope as an additional means of taking up ground water to reduce the volume of site runoff. Consideration may also be given to increasing the volume of detention storage to further reduce peak flows leaving the site. As previously indicated, an HPA may be required for discharge to Ditch E.

Detention Facilities

A vault (or vaults) was selected to detain runoff rather than an open pond or infiltration facility due to the lack of space available to provide an open pond, soil conditions, and to avoid permanent open water at the site which might possibly attract waterfowl and birds to the site. Per the City of Tukwila Public Works Development Guidelines and Design and Construction Standards, the site is within a “Basic Flow Control Area” and therefore, the Level 1 flow control standard applies, which requires matching the existing site conditions 2- and 10-year peak flows. If during the downstream analysis, a Type 2 drainage problem (severe erosion) is identified, additional flow control may be required. The downstream analysis will be performed during the project design phase. Runoff will be discharged in a manner that does not cause or make worse any downstream erosion problems.

To size the detention facilities, the Manual requires the use of the KCRTS hydrologic model. Preliminary sizing suggests that an 18’x50’x11’ vault will be required to meet Level 1 flow control requirements. Release of stormwater from the vault will be controlled with a multiple orifice outlet control structure. Table 3 presents the mitigated outflows from the site.

Table 3
Hydrologic Results – Mitigated Peak Outflows (cfs)

2-year	2.27
10-year	4.15
25-year	6.49

100-year	11.05

If the project is subject to the requirements of the Ecology Manual, the required detention volume would be significantly greater.

Water Quality Treatment Facilities

The transfer station is not located in a drainage basin having sensitive lakes or sphagnum bog wetlands and therefore only requires basic water quality treatment. However, the Manual requires that certain land uses that generate high concentrations of metals in stormwater runoff provide Enhanced Basic Treatment. Defined thresholds for requiring Enhanced Basic Treatment are if 50% or more of the area draining to a treatment facility is industrial or multifamily development, if the project is a commercial development with an expected average daily traffic (ADT) count of 100 or more vehicles per 1,000 square feet of gross building area, or if the project is a commercial development involved with vehicle repair maintenance or sales.

Specific water quality measures (described below) will be applied to areas of the site with “industrial” type activities such as the recycle areas, the transfer station floor, and vehicle queuing areas. Expected ADT in the year 2030 is expected to be less than 20 vehicles per 1,000 square foot of building. Because the project will be below the threshold ADT and because special treatment / disposal will be provided for those areas having greater risk of pollution, Basic Treatment will be provided for the remainder of the site. This will be confirmed during development of the TIR and during design based on input from the City of Tukwila.

The Manual offers a menu of several different types of water quality treatment Best Management Practices (BMPs) for selection appropriate for the site conditions. Bioswales and wetponds are not feasible at the site due to lack of space for such facilities. Water quality could potentially be provided in a wet vault within the detention vault. “StormFilter” systems by Stormwater Management 360 are another potential method of providing water quality treatment. A StormFilter system is a media filtration system that consists of media-filled cartridges that can be installed in a manhole or vault depending on the number of cartridges required to treat the flow. The StormFilter cartridges can be filled with a various types of media, selected to treat the specific pollutant loadings at each site. Since this site is only required to provide basic treatment, the media would be selected primarily to remove sediment. As shown on Figure 1, The StormFilters, if used, will be located on the downstream side of the detention facility. The StormFilter systems typically require 2.3 feet of head differential between the inlet and the outlet. The StormFilter cartridges will need to be contained in vaults due to the anticipated large number of filter cartridges required. If selected as the preferred method of water quality treatment, sizing of the vaults will be done as part of final design based on discharge rates from the detention vault. Because the Basic Flow Control detention requirement in the KSCWDM is not as stringent as the Ecology Manual, discharges from the vault will be higher. Over-detention of stormwater runoff may be considered as a way

to reduce discharges from the detention vault, thus reducing the size of the StormFilter vault.

Additional water quality measures will be considered for areas with higher potential for pollution. As a method of source control, areas close to transfer station operations, including full trailer parking areas and the fee recycling area will be isolated, and the stormwater will either be routed to the storm or sanitary sewer system depending on operating conditions. Automatic wheel washes and track-off grates will be provided at receiving floor exit to prevent commercial customer vehicles from tracking out waste to outside pavement areas. In addition, although not required by the Manual, the trailer parking areas, scale facility areas, and queuing areas will be drained to one or more coalescing plate oil/water separators for additional treatment prior to release to the site drainage system. These areas are indicated on Figure 1.

Although the final facility design may include rainwater harvesting from the transfer building roof for non-potable uses within the building, to be conservative the conceptual drainage plan assumes that all roof runoff will collected and treated. The roofs of the new buildings will include coatings so that they will not be pollution-generating surfaces due to leaching of metals such as zinc, and therefore the roof runoff should not require treatment. However, because roof runoff is required to be detained, and it is not likely to be practical to keep this runoff separated from the runoff from the rest of the site, it will also be treated for water quality.

LEGEND

- CATCH BASIN
- SD — STORM DRAIN
- FLOW DIRECTION
- GRASS/LANDSCAPING

SOUTH SCALE FACILITY ±265

PAY RECYCLING AREA ±262

RECYCLE CONTAINER PADS DRAIN TO SANITARY SEWER, TYP

SELF-HAUL

TRAILER PARKING PADS DRAIN TO SANITARY SEWER

YARD WASTE/ COMPACTOR MANEUVERING AREA

COMMERCIAL TIPPING

TRAILER PARKING AND MANEUVERING AREA ±245

O/W SEPARATOR VAULT

O/W SEPARATOR VAULT

STORMWATER DETENTION VAULT

NORTH SCALE FACILITY ±265

MAINTENANCE BUILDING

TRAILER PARKING PADS DRAIN TO SANITARY SEWER

OFF-SITE DISCHARGE PIPE

PLAN
SCALE:1"=100'

1"=100'-0"
50 0 50 100
Scale Feet

Figure 1
Conceptual Surface Water Management Plan
Bow Lake Transfer Station
King County Solid Waste Division

RW BECK

ATTACHMENT F1

HYDROLOGIC MODELING RESULTS

Bow Lake Transfer Station
Preferred Site Plan
Land Use
5/1/2006

	Existing	Developed
Forest	4.7	0
Grass	2.5	2.32
Impervious	4.34	8.78
Sewer	0	0.45

PRE-DEVELOPED PEAK FLOWS

11-BLPreDev.pks

Flow Frequency Analysis
Time Series File:11-blpredev.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.396 StdDev= 0.164
Skew= 1.556

---Annual Peak Flow Rates--- Flow Rate (CFS)	Rank	Time of Peak
3.45	9	2/16/49 17:45
4.82	4	3/03/50 15:00
2.03	35	8/27/51 18:00
2.31	28	10/17/51 7:15
1.70	44	9/30/53 3:00
1.97	38	12/19/53 17:30
1.66	46	7/30/55 21:15
2.50	19	10/04/55 10:00
2.38	24	12/09/56 12:45
2.21	33	1/16/58 10:00
2.76	13	10/18/58 19:45
2.74	14	10/10/59 22:00
2.40	22	2/14/61 20:15
2.00	36	8/04/62 13:15
1.95	39	12/01/62 20:15
1.52	49	6/05/64 15:00
2.23	30	4/20/65 19:30
1.55	48	1/05/66 15:00
2.51	18	11/13/66 17:45
5.06	3	8/24/68 15:00
2.27	29	10/20/68 12:00
1.42	50	1/13/70 20:45
1.72	43	12/06/70 7:00
3.58	7	12/08/71 17:15
1.99	37	4/18/73 9:30
2.38	26	11/28/73 8:00
2.59	17	8/17/75 23:00
1.76	42	10/29/75 7:00
1.63	47	8/23/77 14:30
2.88	11	9/17/78 1:00
3.96	6	9/08/79 13:45
2.80	12	12/14/79 20:00
2.70	15	9/21/81 8:00
5.63	2	10/05/81 22:15
2.36	27	10/28/82 16:00
1.86	40	1/02/84 23:30
1.68	45	6/06/85 21:15
2.49	20	10/27/85 10:45
2.92	10	10/25/86 22:45
2.38	25	5/13/88 17:30
2.21	32	8/21/89 16:00
3.48	8	1/09/90 5:30
2.40	23	4/03/91 20:15
1.86	41	1/27/92 15:00
2.22	31	6/09/93 12:15
2.11	34	11/17/93 16:45
2.49	21	6/05/95 17:00
2.63	16	7/19/96 19:30
10.79	1	12/29/96 11:45
4.58	5	10/04/97 14:15
Computed Peaks		
Computed Peaks		
Computed Peaks		
Computed Peaks		
Computed Peaks		
Computed Peaks		
Computed Peaks		
Computed Peaks		

-----Flow Frequency Analysis------- - - Peaks - - (CFS)	Rank	Return Period	Prob
10.79	1	89.50	0.989
5.63	2	32.13	0.969
5.06	3	19.58	0.949
4.82	4	14.08	0.929
4.58	5	10.99	0.909
3.96	6	9.01	0.889
3.58	7	7.64	0.869
3.48	8	6.63	0.849
3.45	9	5.86	0.829
2.92	10	5.24	0.809
2.88	11	4.75	0.789
2.80	12	4.34	0.769
2.76	13	3.99	0.749
2.74	14	3.70	0.729
2.70	15	3.44	0.709
2.63	16	3.22	0.690
2.59	17	3.03	0.670
2.51	18	2.85	0.650
2.50	19	2.70	0.630
2.49	20	2.56	0.610
2.49	21	2.44	0.590
2.40	22	2.32	0.570
2.40	23	2.22	0.550
2.38	24	2.13	0.530
2.38	25	2.04	0.510
2.38	26	1.96	0.490
2.36	27	1.89	0.470
2.31	28	1.82	0.450
2.27	29	1.75	0.430
2.23	30	1.70	0.410
2.22	31	1.64	0.390
2.21	32	1.59	0.370
2.21	33	1.54	0.350
2.11	34	1.49	0.330
2.03	35	1.45	0.310
2.00	36	1.41	0.291
1.99	37	1.37	0.271
1.97	38	1.33	0.251
1.95	39	1.30	0.231
1.86	40	1.27	0.211
1.86	41	1.24	0.191
1.76	42	1.21	0.171
1.72	43	1.18	0.151
1.70	44	1.15	0.131
1.68	45	1.12	0.111
1.66	46	1.10	0.091
1.63	47	1.08	0.071
1.55	48	1.05	0.051
1.52	49	1.03	0.031
1.42	50	1.01	0.011
8.86		100.00	0.990
7.07		50.00	0.980
5.62		25.00	0.960
4.11		10.00	0.900
3.87		8.00	0.875
3.22		5.00	0.800
2.27		2.00	0.500
1.87		1.30	0.231

MATCH 2&10 for Level 1 Flow Control

DEVELOPED PEAK FLOWS

Flow Frequency Analysis
Time Series File:11-bldev.tsf
Project Location:Sea-Tac

11-BLDev.pks
LogPearson III Coefficients
Mean= 0.672 StdDev= 0.151
Skew= 1.243

---Annual Peak Flow Rates--- Flow Rate (CFS)	Rank	Time of Peak
6.12	8	2/16/49 17:45
7.87	6	3/03/50 15:00
4.11	32	8/27/51 18:00
4.44	25	10/17/51 7:15
3.37	42	9/30/53 3:00
3.66	38	12/19/53 17:30
3.35	43	7/30/55 21:15
5.05	17	10/04/55 10:00
4.19	31	10/19/56 23:45
4.02	35	1/16/58 10:00
5.43	13	10/18/58 19:45
5.23	16	10/10/59 22:00
4.31	28	2/14/61 20:15
4.05	34	8/04/62 13:15
3.63	39	12/01/62 20:15
3.06	48	6/05/64 15:00
3.97	36	4/20/65 19:30
2.89	49	9/17/66 17:45
4.76	22	11/13/66 17:45
9.45	3	8/24/68 15:00
4.33	27	10/20/68 12:00
2.63	50	5/29/70 7:45
3.12	47	12/06/70 7:00
6.25	7	12/08/71 17:15
3.96	37	4/18/73 9:30
4.43	26	11/28/73 8:00
5.24	15	8/17/75 23:00
3.30	44	10/29/75 7:00
3.29	45	8/23/77 14:30
5.71	11	9/17/78 1:00
7.92	5	9/08/79 13:45
5.03	18	12/14/79 20:00
5.45	12	9/21/81 8:00
10.32	2	10/05/81 22:15
4.57	23	10/28/82 16:00
3.47	40	1/02/84 23:30
3.28	46	6/06/85 19:15
4.82	20	10/27/85 10:45
5.77	9	10/25/86 22:45
4.81	21	5/13/88 17:30
4.48	24	8/21/89 16:00
5.72	10	1/09/90 5:00
4.31	29	4/03/91 20:15
3.42	41	1/27/92 15:00
4.11	33	6/09/93 12:15
4.26	30	11/17/93 16:45
4.99	19	6/05/95 17:00
5.31	14	7/19/96 19:30
16.10	1	12/29/96 11:45
8.25	4	10/04/97 14:15
Computed Peaks		
Computed Peaks		
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Computed Peaks		
Computed Peaks		

-----Flow Frequency Analysis------- - - Peaks - - (CFS)	Rank	Return Period	Prob
16.10	1	89.50	0.989
10.32	2	32.13	0.969
9.45	3	19.58	0.949
8.25	4	14.08	0.929
7.92	5	10.99	0.909
7.87	6	9.01	0.889
6.25	7	7.64	0.869
6.12	8	6.63	0.849
5.77	9	5.86	0.829
5.72	10	5.24	0.809
5.71	11	4.75	0.789
5.45	12	4.34	0.769
5.43	13	3.99	0.749
5.31	14	3.70	0.729
5.24	15	3.44	0.709
5.23	16	3.22	0.690
5.05	17	3.03	0.670
5.03	18	2.85	0.650
4.99	19	2.70	0.630
4.82	20	2.56	0.610
4.81	21	2.44	0.590
4.76	22	2.32	0.570
4.57	23	2.22	0.550
4.48	24	2.13	0.530
4.44	25	2.04	0.510
4.43	26	1.96	0.490
4.33	27	1.89	0.470
4.31	28	1.82	0.450
4.31	29	1.75	0.430
4.26	30	1.70	0.410
4.19	31	1.64	0.390
4.11	32	1.59	0.370
4.11	33	1.54	0.350
4.05	34	1.49	0.330
4.02	35	1.45	0.310
3.97	36	1.41	0.291
3.96	37	1.37	0.271
3.66	38	1.33	0.251
3.63	39	1.30	0.231
3.47	40	1.27	0.211
3.42	41	1.24	0.191
3.37	42	1.21	0.171
3.35	43	1.18	0.151
3.30	44	1.15	0.131
3.29	45	1.12	0.111
3.28	46	1.10	0.091
3.12	47	1.08	0.071
3.06	48	1.05	0.051
2.89	49	1.03	0.031
2.63	50	1.01	0.011
14.13		100.00	0.990
11.75		50.00	0.980
9.72		25.00	0.960
7.48		10.00	0.900
7.09		8.00	0.875
6.05		5.00	0.800
4.38		2.00	0.500
3.59		1.30	0.231

VAULT DISCHARGE PEAKS.

rdout.pks

Flow Frequency Analysis
Time Series File:rdout.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.435 StdDev= 0.171
Skew= 1.921

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------				
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	(ft)	Rank	Return Period	Prob
3.12	13	2/16/49 18:00	13.88	9.19	1	89.50	0.989
5.57	3	3/03/50 15:30	6.10	8.25	2	32.13	0.969
2.22	33	2/09/51 1:30	5.57	8.21	3	19.58	0.949
1.86	49	10/15/51 12:15	5.50	8.20	4	14.08	0.929
2.04	39	9/30/53 3:45	5.39	8.19	5	10.99	0.909
2.23	30	12/19/53 18:00	4.11	8.00	6	9.01	0.889
2.23	31	11/25/54 1:15	3.93	7.61	7	7.64	0.869
2.27	26	11/18/55 15:15	3.85	7.44	8	6.63	0.849
3.23	12	12/09/56 13:00	3.60	6.93	9	5.86	0.829
2.31	24	12/25/57 15:15	3.53	6.80	10	5.24	0.809
2.08	36	10/18/58 20:00	3.43	6.64	11	4.75	0.789
2.23	32	11/20/59 3:45	3.23	6.30	12	4.34	0.769
2.04	38	2/14/61 20:30	3.12	6.15	13	3.99	0.749
2.13	34	8/04/62 13:45	3.10	6.13	14	3.70	0.729
2.02	40	12/15/62 1:30	3.02	6.02	15	3.44	0.709
2.25	27	12/31/63 22:15	3.01	6.00	16	3.22	0.690
2.00	43	4/20/65 19:45	3.00	5.99	17	3.03	0.670
1.89	48	1/05/66 15:15	2.92	5.89	18	2.85	0.650
3.53	10	11/13/66 18:00	2.91	5.88	19	2.70	0.630
5.39	5	8/24/68 15:15	2.83	5.84	20	2.56	0.610
2.24	29	12/03/68 15:45	2.81	5.84	21	2.44	0.590
2.01	41	1/13/70 21:45	2.48	5.70	22	2.32	0.570
1.98	44	12/05/70 8:45	2.47	5.69	23	2.22	0.550
3.43	11	12/08/71 17:30	2.31	5.42	24	2.13	0.530
2.06	37	6/24/73 12:45	2.28	5.29	25	2.04	0.510
2.48	22	11/28/73 8:30	2.27	5.23	26	1.96	0.490
2.92	18	12/26/74 22:15	2.25	5.14	27	1.89	0.470
1.77	50	12/02/75 19:30	2.24	5.12	28	1.82	0.450
2.24	28	8/26/77 1:15	2.24	5.10	29	1.75	0.430
3.93	7	9/17/78 1:15	2.23	5.07	30	1.70	0.410
3.85	8	9/08/79 14:00	2.23	5.07	31	1.64	0.390
3.10	14	12/14/79 20:15	2.23	5.07	32	1.59	0.370
2.83	20	11/21/80 10:30	2.22	5.04	33	1.54	0.350
6.10	2	10/06/81 14:15	2.13	4.62	34	1.49	0.330
3.00	17	10/28/82 16:15	2.11	4.54	35	1.45	0.310
2.11	35	1/03/84 0:00	2.08	4.42	36	1.41	0.291
1.98	45	6/06/85 22:15	2.06	4.34	37	1.37	0.271
3.02	15	10/27/85 11:00	2.04	4.28	38	1.33	0.251
3.60	9	10/25/86 23:00	2.04	4.26	39	1.30	0.231
2.00	42	5/13/88 18:00	2.02	4.18	40	1.27	0.211
2.91	19	8/21/89 16:30	2.01	4.11	41	1.24	0.191
5.50	4	1/09/90 5:15	2.00	4.09	42	1.21	0.171
2.81	21	4/03/91 20:30	2.00	4.07	43	1.18	0.151
2.28	25	1/27/92 15:45	1.98	4.00	44	1.15	0.131
1.97	46	12/10/92 20:30	1.98	3.99	45	1.12	0.111
1.96	47	11/17/93 17:00	1.97	3.95	46	1.10	0.091
2.47	23	11/30/94 5:00	1.96	3.93	47	1.08	0.071
3.01	16	7/19/96 20:00	1.89	3.66	48	1.05	0.051
13.88	1	12/29/96 12:00	1.86	3.55	49	1.03	0.031
4.11	6	10/04/97 14:30	1.77	3.19	50	1.01	0.011
Computed Peaks			11.05	8.62		100.00	0.990
Computed Peaks			8.47	8.43		50.00	0.980
Computed Peaks			6.49	8.29		25.00	0.960
Computed Peaks			4.15	8.09		10.00	0.900
Computed Peaks			3.97	8.03		8.00	0.875
Computed Peaks			3.18	6.71		5.00	0.800
Computed Peaks			2.27	5.65		2.00	0.500
Computed Peaks			1.96	4.24		1.30	0.231