ENGINEERS PLANNERS SURVEYORS

# TECHNICAL INFORMATION REPORT

for

# BURKE GILMAN TRAIL RECONSTRUCTION

## 90% Submittal

**August 27, 2007**

Prepared For:

MacLeod Reckord
231 Summit Avenue East
Seattle, WA 98102

*Prepared By:*

PACE

PACE Engineers, Inc.
1601 2nd Avenue, Suite 1000
Seattle, Washington 98101-3511

PACE
An Engineering Services Company

8/27/07

AMIE L. BROADSWORD
STATE OF WASHINGTON
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REGISTERED
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EXPIRES: 5/2/09

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## APPENDICES

## I. PROJECT OVERVIEW

The Burke-Gilman Trail Reconstruction project consists of widening the existing Burke-Gilman Trail through the City of Lake Forest Park. The City of Lake Forest Park is the permitting authority for this project. The 2005 King County Surface Water Design Manual ('05 KCSWDM) has been adopted as the drainage manual for this City and has been used for the design of drainage improvements to the trail.

The overall length of the proposed improvements is approximately 2.2-miles and begins and NE 145$^{th}$ Street and continues northerly and easterly through the City of Lake Forest Park to the boundary with the City of Kenmore at Log Boom Park. The proposed reconstructed trail section consists of a 12-foot wide asphalt paved trail, with a 3-foot gravel shoulder on the downstream (lakeside) of the trail, and a 1-foot gravel shoulder on the upstream side of the trail. Intersections shall be resurfaced with a 15-foot wide strip of concrete to delineate the trail location where it crosses local access streets. Trail widening in some areas will require cuts into existing soils and also some areas of fill. Figures 4 and 5 show schematic design of cut and fill trail sections. The existing trail varies a foot or two in width, and is approximately 9 feet wide asphalt surface.

The existing soils per the Preliminary Geotechnical Investigation (attached in Appendix C) consist of dense to very dense, glacially consolidated deposits forming the steep slopes, with loose to medium dense deposits derived from post-glacial erosion and landsliding forming colluvium in the low areas. The existing trail is built on top of an old railroad track alignment, which Is built on cuts into the dense soils and fills built over dense soils, as well as over loose colluvium, alluvium and beach deposits. The May 30, 2006 Zipper Zeman Report of Predesign Geotechnical Services give more specific soils information per trail stationing (attached in Appendix D).

Much of the project site is located in areas that are subject to erosion and landslide hazards. The southern portion of the trail has steep slopes both upstream and downstream of the trail. Moving northerly along the trail, the slopes flatten out near the McAleer and Lyons Creek crossings. Further north and east of those crossings, there are again steep slopes upstream of the trail, but topography is relatively flat on the lakeside of the trail.

The existing runoff patterns will be maintained post construction. This site is using a direct discharge exemption from flow control, as all runoff discharges directly to Lake Washington, a major receiving water body. This site is exempt from water quality treatment because all threshold discharge areas have less than 5,000 square feet of new and replaced PGIS proposed. Since the trail itself is only subject to intermittent vehicular use for maintenance activities, it is non-PGIS pre the '05 KCSWDM. The only areas considered PGIS are where the trail improvements intersect local access streets.

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**FIGURE 1: TIR Worksheet**

**King County Department of Development and Environmental Services**

**TECHNICAL INFORMATION REPORT (TIR) WORKSHEET**

| Part 1 PROJECT OWNER AND .PROJECT ENGINEER | Part 2 PROJECT LOCATION AND .DESCRIPTION |
|---|---|
| Project Owner: **King County**<br>Address: **xxx**<br>Phone: **xxx**<br>Project Engineer: **Amie Broadsword, P.E.**<br>Company: **PACE Engineers, Inc.**<br>Address/Phone: **1601 2nd Ave. Suite 1000 Seattle, WA (206) 441-1855** | Project Name: **Burke Gilman Trail Redevelopment**<br>Location<br>Township: **26N**<br>Range: **04**<br>Section: **10,11,15** |

**Part 3 TYPE OF PERMIT APPLICATION**

☐ Subdivision
☐ Short Subdivision
X **Grading and Drainage**
☐ Commercial
☐ Other

**Part 4 OTHER REVIEWS AND PERMITS**

| | |
|---|---|
| x DFW HPA | x Shoreline Management |
| ☐ COE 404 | ☐ Rockery |
| ☐ DOE Dam Safety | ☐ Structural Vaults |
| ☐ FEMA Floodplain | ☐ Other |
| x COE Wetlands | |

**Part 5 SITE COMMUNITY AND DRAINAGE BASIN**

Community: **Lake Forest Park**

Drainage Basin: **West Lake Washington – Lake Forest Park**

**Part 6 SITE CHARACTERISTICS**

| | |
|---|---|
| ☐ River ______ | ☐ Floodplain ______ |
| X **Streams-McAleer and Lyons Creek** | X **Wetlands-Mapped** |
| X **Critical Stream Reach-McAleer and Lyons** | X **Seeps/Springs-Present along trail** |
| X **Depressions/Swales** | X **High Groundwater Table** |
| X **Lake-Within ¼ mile of Lake Washington** | ☐ Groundwater Recharge ______ |
| X **Steep Slopes** | ☐ Other ______ |

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**FIGURE 1: TIR Worksheet (cont.)**

Part 7 SOILS

| Soil Type | Slopes | Erosion Potential | Erosive Velocities |
|---|---|---|---|
| **Various Types of dense to very dense glacially consolidated deposits forming steep slopes.** | **Steep** | **High** | **Fast** |
| **Also loose colluvium, alluvium and beach deposits.** | **Flat** | **Slight** | **Slow** |

☐ Additional Sheets Attached

Part 8 DEVELOPMENT LIMITATIONS

| | REFERENCE | LIMITATION/SITE CONSTRAINT |
|---|---|---|
| X | **Ch. 4 – Downstream Analysis** | **Protect offsite downstream properties from erosion.** |
| ☐ | | |
| ☐ | | |
| ☐ | | |
| ☐ | | |

☐ Additional Sheets Attached

Part 9 ESC REQUIREMENTS

MINIMUM ESC REQUIREMENTS DURING CONSTRUCTION

- X **Sedimentation Facilities**
- X **Stabilized Construction Entrance**
- X **Perimeter Runoff Control**
- X **Clearing and Grading Restrictions**
- X **Cover Practices**
- X **Construction Sequence**
- ☐ Other

MINIMUM ESC REQUIREMENTS AFTER CONSTRUCTION

- X **Stabilize Exposed Surface**
- X **Remove and Restore Temporary ESC Facilities**
- X **Clean and Remove All Silt and Debris**
- X **Ensure Operation of Permanent Facilities**
- X **Flag Limits of SAO and open space preservation areas**
- ☐ Other

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**FIGURE 1: TIR Worksheet (cont.)**

Part 10 SURFACE WATER SYSTEM

X Grass Lined Channel
X Pipe System
X Open Channel
☐ Dry Pond
☐ Wet Pond

☐ Tank
☐ Vault
X Energy Dissipater
X Wetland
X Stream

☐ Infiltration
☐ Depression
X Flow Dispersal
☐ Waiver
☐ Regional Detention

Method of Analysis
**KCRTS v.4.42b**

Compensation/Mitigation of Eliminated Site Storage

Brief Description of System Operation

**Site is eligible for direct discharge to Lake Washington, and will utilize existing manmade conveyance paths from the trail to the lake. Runoff from hillside slope to maintain current drainage pattern, and will continue to be directed to existing open vegetated swales, prior to entry into piped storm drainage system for conveyance to Lake Washington. Runoff from trail will sheetflow towards lake, and be conveyed in the existing drainage systems in place between the trail and Lake Washington. This site is exempt from water quality treatment because all threshold discharge areas have less than 5,000 square feet of new and replaced PGIS proposed. Since the trail itself is only subject to intermittent vehicular use for maintenance activities, it is non-PGIS pre the '05 KCSWDM. The only areas considered PGIS are where the trail improvements intersect local access streets.**

Facility Related Site Limitations

| Reference | Facility | Limitation |
|---|---|---|
| **Core Req. 3** | **Direct Discharge Exemption** | |
| **Core Req. 8** | **Waived with Surface Area Exemption #1** | |

Part 11 STRUCTURAL ANALYSIS

☐ Cast in Place Vault
X Retaining Wall
☐ Rockery > 4' High
☐ Structural on Steep Slope
☐ Other:

Part 12 EASEMENTS/TRACTS

☐ Drainage Easement / Tract
☐ Access Easement
☐ Native Growth Protection Easement
☐ Tract
☐ Other

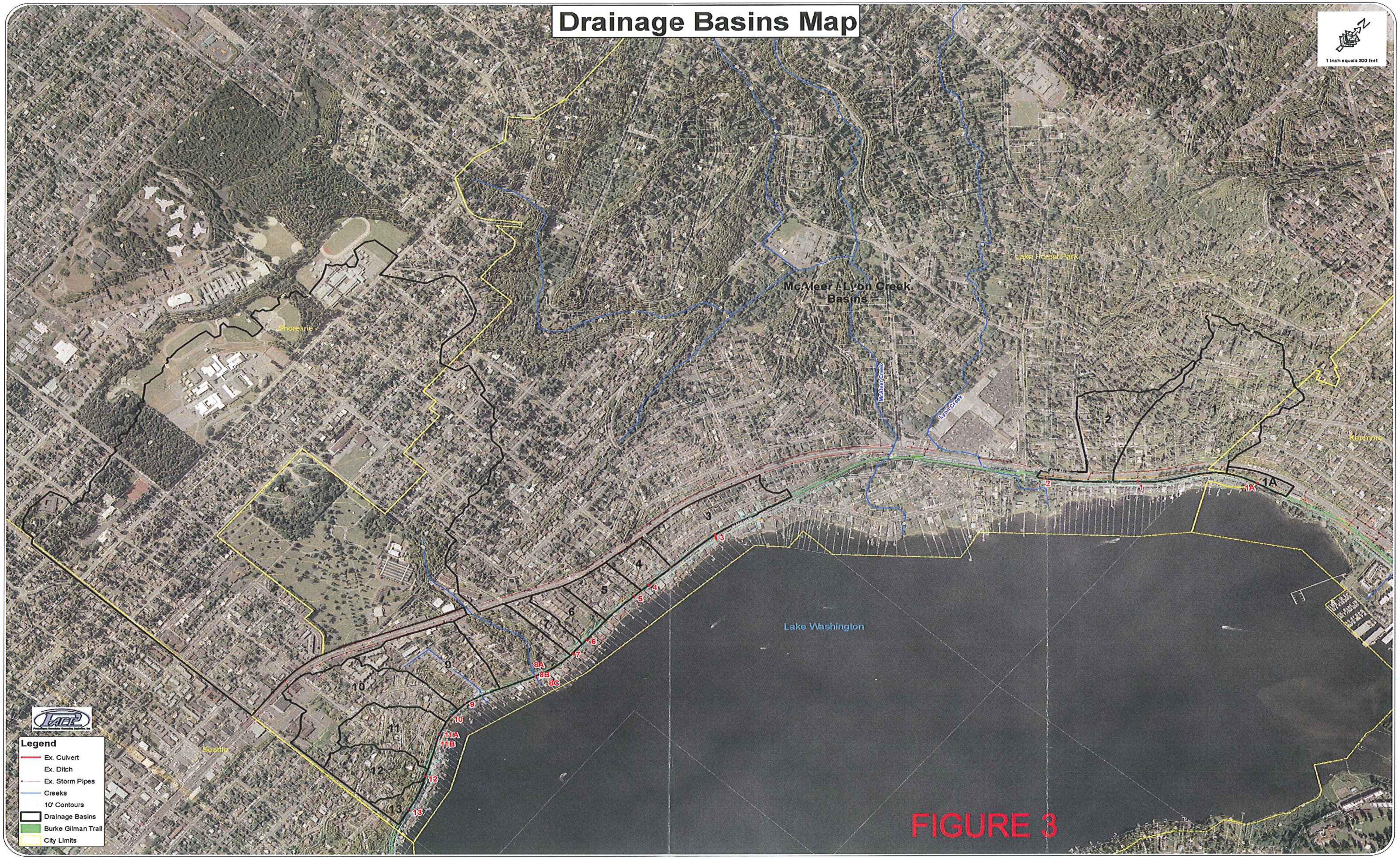
Part 13 SIGNATURE OF PROFESSIONAL ENGINEER

I or a civil engineer under my supervision has visited the site. Actual site conditions as observed were incorporated into this worksheet and the attachments. To the best of my knowledge the information provided here is accurate.

[signature] 8/27/07

**Signed/Date**

**FIGURE 2: SITE LOCATION**



Drainage Basins Map
1 inch equals 300 feet
McAleer / Lyon Creek Basins
Lake Forest Park
Shoreline
Kenmore
Seattle
Lake Washington
Legend
Ex. Culvert
Ex. Ditch
Ex. Storm Pipes
Creeks
10' Contours
Drainage Basins
Burke Gilman Trail
City Limits

FIGURE 3

## II. CONDITIONS AND REQUIREMENTS SUMMARY

Conditions and requirements for this project include all eight Core Requirements listed in the 2005 King County Surface Water Design Manual (KCSWDM) as adopted by the City of Lake Forest Park.

### Core Requirements (KCSWDM Section 1.2)

**Core Requirement #1: Discharge at the Natural Location**
This site has multiple discharge locations due to the linear nature of the project area, which runs parallel to the shoreline of Lake Washington along an old railroad alignment. Two major streams cross the project trail section, McAleer and Lyons Creeks. Drainage post construction will be maintained at the current discharge locations.

**Core Requirement #2: Offsite Analysis**
A level one downstream analysis is included in this report. Refer to Section III: Offsite Analysis for a more detailed description.

**Core Requirement #3: Flow Control**
This site is using a direct discharge exemption, as all runoff discharges directly to Lake Washington, a major receiving water body. Flow control BMPs are to be utilized to further attenuate flows. Refer to Section IV: Flow Control and Water Quality Facility Analysis and Design for a more detailed description.

**Core Requirement #4: Conveyance System**
The conveyance system has been designed to collect and convey the 25-year peak flow. Refer to Section V: Conveyance System Analysis and Design for a more detailed description.

**Core Requirement #5: Erosion and Sediment Control**
Much of the project site is located in areas that are subject to erosion and landslide hazards. The southern portion of the trail has steep slopes both upstream and downstream of the trail. Moving northerly along the trail, the slopes flatten out near the McAleer and Lyons Creek crossings. Further north and east of those crossings, there are again steep slopes upstream of the trail, but topography is relatively flat on the lakeside of the trail. A temporary erosion and sediment control (TESC) plan will be submitted with the final trail reconstruction plans to limit and mitigate for erosion and sedimentation during construction. A Stormwater Pollution Prevention Plan (SWPPP) shall also be prepared for this project and the project will apply for coverage under the Washington Department of Ecology Construction Stormwater General Permit.

Refer to Section VIII: ESC Analysis and Design for a more detailed description of erosion and sediment control measures.

**Core Requirement #6: Maintenance and Operations**
The proposed drainage improvements require an operations and maintenance manual. Refer to Appendix A: Operations and Maintenance Manual.

**Core Requirement #7: Financial Guarantees and Liability**
The owner and developer, King County, will post financial guarantees and liabilities, as required by the City of Lake Forest Park.

**Core Requirement #8: Water Quality**
The project site is exempt from water quality treatment per the Surface Area Exemption. Refer to Section IV: Flow Control and Water Quality Facility Analysis and Design for a more detailed description.

## III. OFFSITE ANALYSIS

The analysis consists of information and data obtained through site visit observations and research of King County and City of Lake Forest Park resources.

### Task 1. Study Area Definition and Maps

For the purpose of task 2 below, the study area shall extend 1 mile downstream of the proposed project discharge location, and also includes the upstream offsite area tributary to the site. For purposes of tasks 3, 4, and 5, the study area shall extend downstream to a point on the drainage system where the proposed project site constitutes a minimum of 15% of the total tributary drainage area, but not less than ¼ mile. This project will not produce backwater effects upstream of the site, and therefore the upstream area was excluded from tasks 3 and 4 of this offsite analysis.

The 2.2-mile stretch of trail is located on an old railroad grade that runs parallel to the shore of Lake Washington. The project area is entirely contained within the City of Lake Forest Park and starts at 145th and extends northerly and easterly along the shoreline to Tracy Owen Station (Log Boom Park) at the City boundary with Kenmore. The site spans several sections including 10, 11, and 15 of Township 26N, Range 04 East. For general location, see Figure 2: Site Location. The study area for the downstream analysis is shown in Figure 3: Drainage Basins.

### Task 2. Resource Review

A resource review was conducted to determine potential problems downstream of the project site. The following is a list of references used in gathering information for the downstream analysis.

- King County iMAP Data – iMAP data
- Flood Insurance Rate Maps (FIRM) No's. 53033C0331 F, 53033C0032 F, 53033C0043 F, and 53033C0044 F. Review of the FIRMs indicates that the subject site is located in an area determined to be outside of the 500-year floodplain. (Source http://msc.fema.gov)
- USGS Mapping

### Task 3. Field Inspection

A downstream analysis was performed to assess potential offsite drainage impacts associated with development of the project site, and to propose appropriate mitigations of those impacts. The primary discharge locations from the trail to Lake Washington were evaluated. Many of the outfalls were on private property, and were not surveyed. However, the design team inspected the outfall locations and field notes were taken as to condition, length, material, size and other pertinent information of these pipes and outfalls. Culvert crossings of the trail were each inspected.

## Task 4. Drainage System Description and Problem Description

### Drainage System Description

The Burke-Gilman Trail follows an abandoned railroad grade and is nearly flat for the 2.2-mile stretch of the proposed redevelopment project. The trail is generally located at the toe of a steep slope, except within the McAleer and Lyon Creek basins where the surrounding topography is mainly flat upstream and gently sloping toward Lake Washington on the downstream side.

The existing conveyance system along the Burke-Gilman Trail is made up of a network of drainage ditches running parallel to the trail on the upstream side, interconnected with cross culverts which convey seepage and runoff across the trail to Lake Washington. Runoff and seepage that makes its way to these culvert crossings is generated upstream of the trail and is conveyed to the trail in a number of ways, including storm drainage piping, manmade ditches and natural drainage courses. Surface water runoff originates from rainfall and other precipitation falling within the drainage basins. Impervious surfaces such as roadways and roofs contribute to the amount of runoff generated in each drainage basin. As part of the proposed reconstruction and widening of the trail, the existing cross culverts were analyzed to determine if they have adequate capacity to convey flows across the trail, and prevent flooding of the trail.

There are 13 drainage basins associated with 15 culvert crossings of this stretch of the Burke-Gilman Trail. In addition, there are 2 bridge crossings that convey McAleer and Lyon Creeks under the trail, that are part of a larger basin area not included in the PACE analysis. These stream basins have been studied extensively in the past by King County. As a result of these studies, several CIP projects have been constructed to reduce flooding. Further analysis based on a regional drainage basin study may be required to address predicted peak flows and conveyance capacity of the bridge crossings under the trail and is not part of this study. For an analysis of conveyance capacity of the existing culverts, see Appendix B, Drainage Analysis. The drainage analysis was completed early in the design phase. Additional survey has allowed us to update the findings in Appendix B, and they are now summarized in Section V of this report, along with an analysis of proposed ditch capacity within each basin.

### Problem Descriptions

There are a number of existing problems identified along the trail. Near the south end there is a history of landslides and erosion, both on the upstream and downstream (lakeside) side of the trail. Also, the trail in this area generally sits at the toe of a steep slope. Water from both seeps and surface water tends to collect at the toe of the slope adjacent to the trail. Some minor flooding of the trail has occurred as a result, with ponding of water generally on the upstream side of the trail. Additionally, adjacent property owners have identified several drainage problems through the public meeting process. Areas of concern identified by property owners include:

- Landslide issues west of the trail near 15208 38th Place NE
- Inadequate drainage between 15550 and 15524 Beach Drive NE
- Concerns about drainage at 16835 Beach Drive NE
- Drainage problems at 17729 Beach Drive NE
- Drainage from trail damages road, even during summer and groundwater drains under trail causing property damage at 17753 Beach Drive NE

## Task 5. Mitigation of Existing or Potential Problems

Seeps and surface water runoff contribute water to the ditches and culverts associated with the existing trail. Due to steep slopes in the vicinity and existing conveyance that is at some points inadequate, there are some existing drainage, erosion, and landslide problems associated with the trail. In order to address these problems, the geotechnical consultant shall recommend mitigation for the existing landslide problems and the civil plans will incorporate drainage recommendations per the geotechnical report. This will likely include drainage elements at the toe of slope and tight-lining of wall drains to an appropriate discharge location. BMPs including surface swales for conveyance and attenuation of flows shall be utilized to the fullest extent practicable. In areas where there is not sufficient space to construct a surface swale to receive hillside runoff, a shallow surface swale shall be constructed over a trench drain system. See Figure 4 for a typical shallow ditch section with trench drain. This project will not aggravate existing problems, and in general seeks to improve the trail over and above the existing condition.

## IV. FLOW CONTROL AND WATER QUALITY FACILITY ANALYSIS AND DESIGN

Flow control and water quality treatment for the project are subject to the requirements of the 2005 King County Surface Water Design Manual ('05 KDSWDM). The site is exempt from both flow control and water quality treatment. See Parts D and E of this section for more information on how this project meets exemption criteria listed in the '05 KCSWDM.

### Existing Site Hydrology (Part A)

The existing site hydrology is described in detail in Appendix B of this report, within the April 17, 2005 Drainage Analysis. In all, 13 drainage basins draining to culvert crossings were identified. (Basin 1a shown in the April $17^{th}$ 2005 Report is north of the improvements and outside of the project limits.) Some basins are drained by more than one culvert, and therefore there are fewer basins than culvert crossings. See Figure 3, Drainage Basins Map for overall basin and culvert identification. The culverts are also numbered on the civil plans using the associated sub-basin as the base culvert number.

The existing soils per the Preliminary Geotechnical Investigation (attached in Appendix C) consist of dense to very dense, glacially consolidated deposits forming the steep slopes, with loose to medium dense deposits derived from post-glacial erosion and landsliding forming colluvium in the low areas. The existing trail is built on top of an old railroad track alignment, which is built on cuts into the dense soils and fills built over dense soils, as well as over loose colluvium, alluvium and beach deposits.

### Developed Site Hydrology (Part B)

The proposed improvements will not significantly change the existing hydrology of the site. New conveyance elements are planned along the trail to improve collection of hillside runoff. The trail will generally be sloped to sheetflow runoff towards the lakeside. The downstream side of the trail will be vegetated to attenuate flows being dispersed off of the side of the trail. Runoff that does not infiltrate into the ground at the edge of the trail will be collected in the existing stormwater collection systems between the trail and the lake, and conveyed via manmade paths to Lake Washington. The existing cross culverts will be utilized for conveying hillside runoff across the trail, the same as in the existing condition. There are no planned upgrades of existing cross culverts. Only culvert 8 has been identified as having a potential capacity problem, and more survey data is needed at this time to determine actual capacity. This will be determined between the 90 and 100% submittals.

## Performance Standards (Part C)

The subject site is located within the City limits of Lake Forest Park, and is owned by King County. The City of Lake Forest Park has adopted the 2005 King County Surface Water Design Manual, and performance standards are per the design manual. However, the site is exempt from both flow control and water quality treatment per exemption criteria given in the '05 KCSWDM. The performance standards are listed for reference as follows.

*Basic Water Quality Treatment*
Basic Water Quality performance goals are to remove 80 percent of total suspended solids (TSS) for flows or volumes up to and including the water quality design flow or volume. The water quality design flow is defined as 60% of the developed two-year peak flow rate as determined using the KCRTS model with 15-minute time steps calibrated to site conditions.

*Conservation Flow Control*
Conservation Flow Control applies the historic Level 2 flow control standard, which matches historic durations for 50% of the 2-year through 50-year peaks and matches historic 2- and 10-year peaks, if no drainage problems are identified. More stringent controls are required if drainage problems are identified downstream of the site

## Flow Control System (Part D)

Per the 2005 King County Surface Water Design Manual, this project is eligible for a direct discharge exemption from flow control. Criteria for this exemption is listed in section 1.2.3, page 1-30 of the manual. Lake Washington is a major receiving water body, and may receive direct discharge of clean surface water runoff. Manmade conveyance elements extend from the trail to the lake, including direct piping, manmade channels, and landscaped area (urban fill). As such, no flow control facilities have been designed. Flow control BMPs such as grass lined swales and dispersion across vegetated areas will be used to the extent practicable to attenuate flows prior to discharging to Lake Washington.

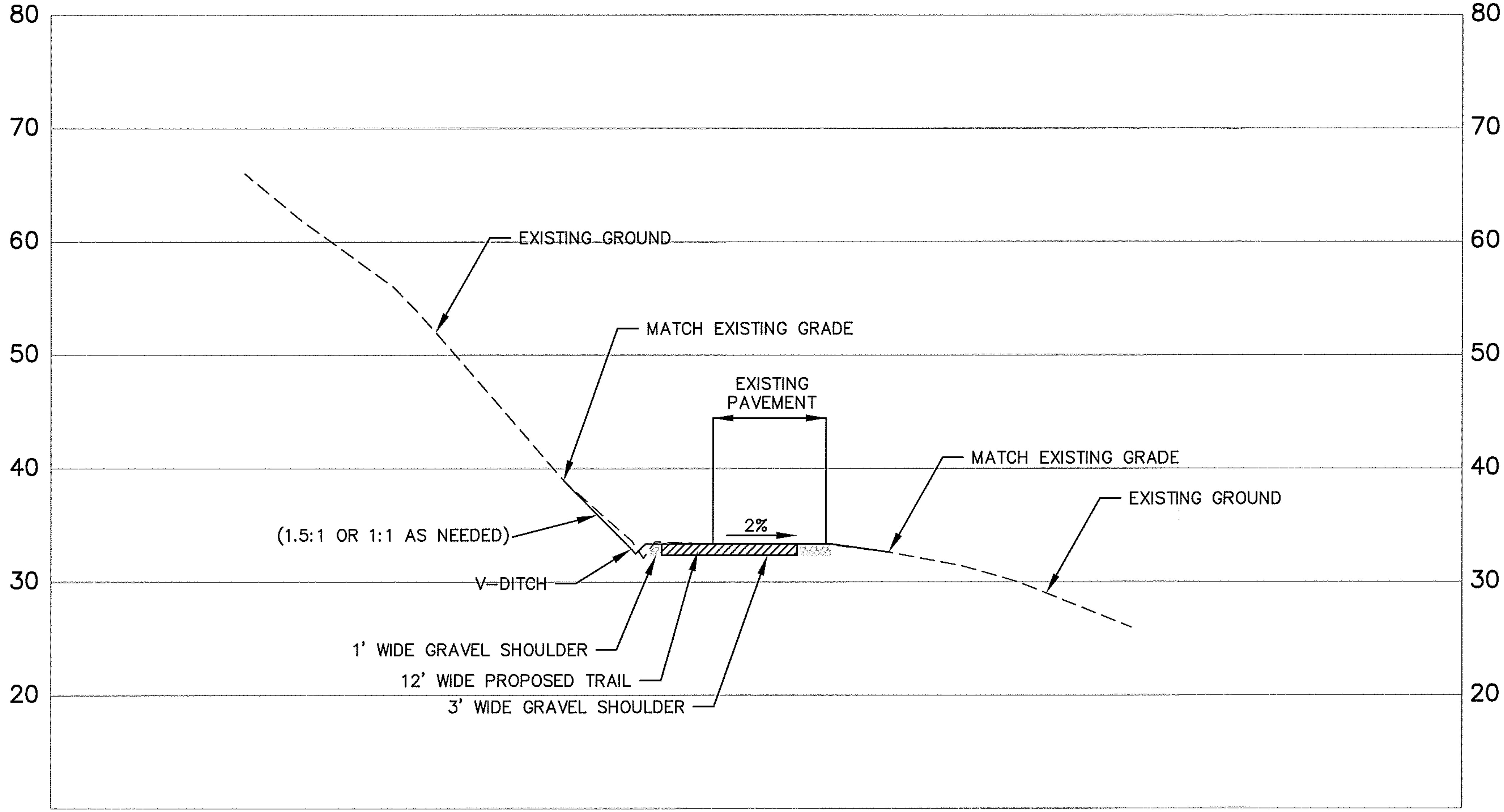
## Water Quality System (Part E)

Per the definition given on page 15 of the definitions section of the '05 KCSWDM, the Burke-Gilman Trail is not a pollution generating impervious surface (PGIS). However, there are nine intersection crossings that will be improved, which include the replacement of PGIS. The intersections and their corresponding PGIS with in each basin can be seen in the following table.

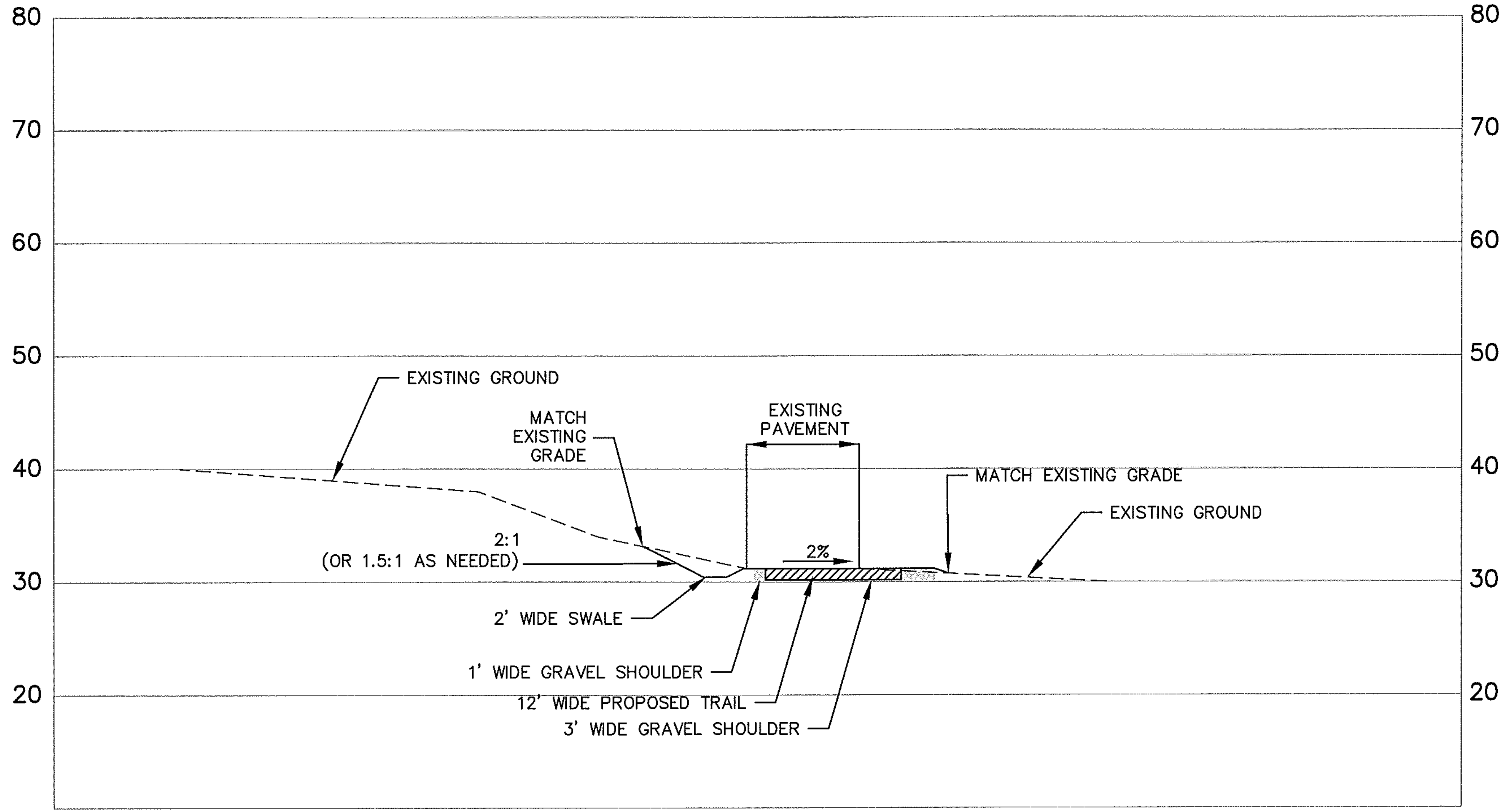
**Table 1. PGIS by Intersection**

| Basin | Intersection | PGIS per Intersection (Sq. Ft.) | Total PGIS per Basin (Sq. Ft.) |
|---|---|---|---|
| 1 | None | 0 | 0 |
| 2 | None | 0 | 0 |
| 3 | NE 165th St. | 1,101 | 1,101 |
| 4 | None | 0 | 0 |
| 5 | NE 175th Pl. | 450 | 450 |
| 6 | Res. Drive | 506 | 1,112 |
| | Res. Drive | 606 | |
| 7 | NE 155th St. | 768 | 768 |
| 8 | NE 153rd St. | 749 | 1,128 |
| | NE 155th St. | 379 | |
| 9 | NE 151th St. | 2,178 | 2,178 |
| 10 | None | 0 | 0 |
| 11 | NE 147th St. | 627 | 627 |
| 12 | None | 0 | 0 |
| 13 | None | 0 | 0 |

The total amount of proposed replaced PGIS has been estimated as 7,364 square feet. For purposes of estimating, 5-feet on either side of the proposed 15-foot wide concrete trail section was included in the PGIS estimate. This number takes into account grading improvements that will be necessary to match the trail grade to the existing grade on the uphill and downhill sides at each crossing. This site is eligible for the Surface Area Exemption (#1) from water quality treatment because no basin along the length of the project has greater than 5,000 square feet of replaced PGIS. Conservatively, each basin is larger than an individual threshold discharge area, which is used to determine eligibility for the exemption. Water quality BMPs (grass lined ditches) will be used to the extent practicable to prevent pollutants from entering the piped storm system and discharging to Lake Washington.




| | | | | | |
|---|---|---|---|---|---|
| DESIGNED ALB<br>DRAWN SCM<br>CHECKED ALB | PACE An Engineering Services Company<br>1601 2nd Avenue Suite 1000<br>Seattle, WA 98101<br>p. 206.441.1855 \| f. 206.448.7167<br>Civil \| Structural \| Planning \| Survey<br>paceengrs.com | **MACLEOD RECKORD**<br>231 SUMMIT AVENUE E.<br>SEATTLE, WA 98102 | DATE<br>8/26/07<br>SCALE<br>1"=10'(H)<br>1"=10'(V) | **BURKE-GILMAN TRAIL REDEVELOPMENT**<br>FIGURE 4 –TYPICAL TRAIL SECTION WITH V–DITCH | JOB NUMBER<br>**06601.00**<br>DWG NO. SECTIONS<br>SHEET **FIG 4** |




| | | | | | |
|---|---|---|---|---|---|
| DESIGNED ALB<br>DRAWN SCM<br>CHECKED ALB | PACE An Engineering Services Company<br>1601 2nd Avenue Suite 1000 Seattle, WA 98101<br>p. 206.441.1855 \| f. 206.448.7167<br>Civil \| Structural \| Planning \| Survey<br>paceengrs.com | **MACLEOD RECKORD**<br>231 SUMMIT AVENUE E.<br>SEATTLE, WA 98102 | DATE 8/26/07<br>SCALE 1"=10'(H) 1"=10'(V) | **BURKE-GILMAN TRAIL REDEVELOPMENT**<br>FIGURE 5 –TYPICAL TRAIL SECTION WITH TRAPEZOIDAL DITCH | JOB NUMBER **06601.00**<br>DWG NO. SECTIONS<br>SHEET **FIG 5** |


| | | | | | |
|---|---|---|---|---|---|
| DESIGNED AMB<br>DRAWN SCM<br>CHECKED AMB | PACE An Engineering Services Company<br>1601 2nd Avenue Suite 1000<br>Seattle, WA 98101<br>p. 206.441.1855 \| f. 206.448.7167<br>Civil \| Structural \| Planning \| Survey<br>paceengrs.com | **MACLEOD RECKORD**<br>231 SUMMIT AVENUE E.<br>SEATTLE, WA 98102 | DATE 8/26/07<br>SCALE 1"=10' | **BURKE-GILMAN TRAIL REDEVELOPMENT**<br>FIGURE 6–TYPICAL INTERSECTION (PGIS) | JOB NUMBER **06601.00**<br>DWG NO. P6601CALCS<br>SHEET **FIG 6** |

## V. CONVEYANCE SYSTEM ANALYSIS AND DESIGN

### Sub-Basin Analysis

A Drainage Analysis was completed by PACE in April of 2007. This analysis is included in Appendix B of this report. Peak 25-year and 100-year flows were calculated for each sub-basin draining to this section of trail. In all, 13 drainage sub-basins draining to existing culvert crossings were identified. Basin 1a shown in the Drainage Analysis is north of the improvements and outside of the project limits. Basin 9 has since been found to outlet at culvert 10.

### *Conveyance Capacity – Existing Culverts*

Conveyance capacity was checked for the existing culvert crossings using the 25-year peak storm event calculated with KCRTS using 15-minute timesteps to calculate peak flows within each drainage sub-basin.

The capacity of each culvert crossing was compared with the 25-year peak flows from the corresponding tributary drainage basin. The following table summarizes the results. This table is similar to the one given on page 4 of the April 17, 2005 Drainage Analysis. However, some culverts have had additional survey since the 2005 Drainage Analysis, and thus the existing capacities given in this table have been updated to reflect more current data. Other updates have been included and described in the notes following this table.

**Table 2. Culvert Capacity Analysis**

| Culvert # | Culvert Capacity (cfs) | Drainage Basin # | Design Flow 25-year (cfs) | Design Flow 100-year (cfs) |
|---|---|---|---|---|
| 1a | 52.0 | 1 | 20.8 | 37.3 |
| 1b | 32.1 | 1 | 20.8 | 37.3 |
| 1c | 75.5 | 1 | 20.8 | 37.3 |
| 2 | 28.2 | 2 | 7.2 | 12.8 |
| 3 | 48.4 | 3 | 7.8 | 13.0 |
| 4 | 77.9 | 4 | 2.9 | 4.7 |
| 5 | 63.1 | 5 | 3.4 | 5.5 |
| 6 | 86.3 | 6 | 4.0 | 6.0 |
| 7 | 10.5 | 7 | 2.8 | 4.2 |
| 8[i] | Insufficient Data | 8 | 175.7 | 311.2 |
| 9[ii] | N/A | 9 | 11.6 | 17.8 |
| 10 | 99.8 | 10 | 16.2 | 24.3 |
| 11[iii] | 26.0 | 11 | 6.5 | 10.8 |
| 12a | 14.6 | 12 | 6.0 | 10.0 |
| 12b[iv] | 354.9 | 12 | 6.0 | 10.0 |
| 13 | 16.2 | 13 | 1.2 | 2.1 |

[i]Culvert crossing 8 needs additional survey at this time to verify inverts and pipe material. There may not be sufficient capacity at this crossing in the existing condition.

[ii]Basin 9 was originally thought to have its own culvert crossing. However, upon additional visits to field verify data, it was found that all of the basin mapped as 9 on the original drainage analysis, crosses the trail at culvert 10. Culvert crossing 10 has enough capacity to convey both the basin 9 and basin10, 25-year and 100-year peak flows.

[iii]Originally it was though that there were two culvert crossings in Basin 11. Field verification confirmed there is only one culvert crossing in basin 11.

[iv]Culvert 12b was not in the original drainage analysis.

Based on the results shown above, all culverts except culvert 8 appear to have adequate capacity. More information is needed for culvert 8. This information will be obtained prior to finalizing engineering plans.

### ***Conveyance Capacity – Proposed Ditch Sections***

Conveyance capacities for proposed ditch sections were calculated by two methods as was appropriate.

The first method was to assign a percentage of the total sub-basin flow (calculated with KCRTS and 15 minute timesteps) to the appropriate ditch section based on the percentage of the sub-basin that was draining to that section of ditch. Aerial photos overlaid with contours were consulted help assign percentages. This assignment was very conservative, and for areas of greater uncertainty, a factor of safety was used.

The other method for determining 25-year peak flows at the ditch sections was using the Rational Method as described in Chapter 3 of the '05 KCSWDM. This method was used in the Lyon Creek sub-basin, because the majority of the sub-basin flows are being conveyed across the trail directly to Lake Washington, and the ditches on the upstream side of the trail clearly would not be receiving flows from the majority of the sub-basin. See Appendix B for a general description of how flows for each sub-basin were computed.

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JOB NO. 06601
JOB NAME BURKE GILMAN TRAIL
SHEET NO. 1 OF
CALCULATED BY ALB DATE 8/25/07
CHECKED BY DATE

PEAK FLOW ESTIMATES 25-YR USING RATIONAL METHOD

LYONS CREEK – DITCH TO SOUTH SECTION A

STA 63+12 TO STA 67+10

$Q = CIA$ $A = 0.37$ AC (FROM SURVEY)

ESTIMATE 50% IMP. FROM AERIAL PHOTO AND SURVEY
(VERY CONSERVATIVE)

$$C = \frac{(0.50 * 0.37) * 0.90 + (0.50 * 0.37) * 0.25}{0.37}$$

$C = 0.575$

$I_{25} = P_{25}(i_{25})$ $P_{25} = 2.75$ (FIG 2.3.1 C)

$i_{25} = a_{25}(T_c)^{-b_{25}}$ $T_c \approx 6.3$ MIN (MIN. ESTIMATE)

$a_{25} = 2.66$ (TABLE 2.3.1. B)

$b_{25} = 0.65$ (TABLE 2.3.1. B)

$i_{25} = 2.66 \cdot 6.3^{-0.65}$

$i_{25} = 0.804$

$I_{25} = 2.75 * 0.804 \Rightarrow I_{25} = 2.21$

$Q_{25} = 0.575 * 2.21 * 0.37$

$Q_{25} = 0.47$ CFS

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SHEET NO. 2 OF
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LYONS CREEK - DITCH TO SOUTH - SECTION B

STA 53+48 TO STA 67+10

$Q = CIA$ $A = 2.50$ AC (FROM SURVEY)

ESTIMATE 4.5 DU/GA ⟹ 46% IMPERVIOUS (TABLE 3.2.2.D)

$$C = \frac{(0.46 * 2.50) * 0.90 + (.54 * 2.50) * 0.25}{2.50}$$

$C = 0.549$

$I_R = P_R i_R$ $P_R = 2.75$ (FIG 2.3.1.C)

$i_{25} = a_{25}(T_c)^{-b_{25}}$ $T_c \approx 6.3$ MIN (MINIMUM ESTIMATE)

$a_{25} = 2.66$ (TABLE 2.3.1.B)

$b_{25} = 0.65$ (TABLE 2.3.1.B)

$i_{25} = 2.66(6.3)^{-.65}$

$i_{25} = 0.804$

$I_{25} = 2.75 \times 0.804 \Rightarrow I_{25} = 2.21$

$Q_{25} = 0.549 * 2.21 * 2.50$

$Q_{25} = 3.03$

The following table presents findings of the ditch flow capacity analysis for proposed ditch sections on the upstream side of the trail. Typical ditch sections were chosen with capacity adequate to convey the maximum ditch flow as shown in the following table.

**Table 3. Ditch Capacity Analysis**

| Ditch ID | 25-year Peak Subbasin Flow | % Flow to Ditch Section | Estimated Ditch Flow | Factor of Safety | Max Ditch Flow |
|---|---|---|---|---|---|
| 1a (W) | 20.8 | 22% | 4.58 | 2 | 9.15 |
| 1b (E) | 20.8 | 7% | 1.46 | 2 | 2.91 |
| 1b (W) | 20.8 | 14% | 2.91 | 2 | 5.82 |
| 1c (E) | 20.8 | 29% | 6.03 | 2 | 12.06 |
| 1c (W) | 20.8 | 28% | 5.82 | 2 | 11.65 |
| 2 (E) | 7.2 | 100% | 7.20 | 1 | 7.20 |
| 2 (W) | 7.2 | 25% | 1.80 | 1 | 1.80 |
| 3 (N) | 7.8 | 75% | 5.85 | 1 | 5.85 |
| 3 (S) | 7.8 | 75% | 5.85 | 1 | 5.85 |
| 4 (N) | 2.9 | 100% | 2.90 | 1 | 2.90 |
| 5 (N) | 3.4 | 25% | 0.85 | 1 | 0.85 |
| 5 (S) | 3.4 | 100% | 3.40 | 1 | 3.40 |
| 6 (N) | 4 | 100% | 4.00 | 1 | 4.00 |
| 6 (S) | 4 | 100% | 4.00 | 1 | 4.00 |
| 7 (N) | 2.8 | 100% | 2.80 | 1 | 2.80 |
| 7 (S) | 2.8 | 100% | 2.80 | 1 | 2.80 |
| 8 (N) | 11.6 | 50% | 5.80 | 1 | 5.80 |
| 8 (S) | 11.6 | 60% | 6.96 | 1 | 6.96 |
| 9 (N) | 11.6 | 50% | 5.80 | 1 | 5.80 |
| 9 (S) | 11.6 | 25% | 2.90 | 1 | 2.90 |
| 10 (N) | 16.2 | 50% | 8.10 | 1 | 8.10 |
| 10 (S) | 16.2 | 50% | 8.10 | 1 | 8.10 |
| 11a (N) | 6.5 | 25% | 1.63 | 1 | 1.63 |
| 11a (S) | 6.5 | 75% | 4.88 | 1 | 4.88 |
| 12a (N) | 6 | 50% | 3.00 | 2 | 6.00 |
| 12a (S) | 6 | 50% | 3.00 | 2 | 6.00 |
| 12b (S) | 6 | 50% | 3.00 | 2 | 6.00 |
| 13 (N) | 1.2 | 50% | 0.60 | 1 | 0.60 |

Manning's equation was used to calculate the typical sections chosen for proposed ditch geometries. The following tables represent typical ditch geometries chosen to convey flows. In order of priority, the design team utilized a trapezoidal ditch section with 2:1 side slope, followed by a trapezoidal ditch section with 1.5:1 side slope. Where limited space was available on the upstream side of the trail, a v-ditch section was used with 1.5:1 or 1:1 side slopes. A gentler side slope was always utilized first. All ditch sections were designed with 1 foot of freeboard.

**Table 4. Trapezoidal Ditch Geometry**

| Burke Gilman Trail - Ditch Capacity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECTION – trapazoid, triangle or rectangle | | | | | | | | | |
| | Sides | mannings | | WIDTH | | | Hydraulic | Velocity | flow Q |
| Depth | ? : 1 | n | SLOPE | Top | Bottom | Area | Radius | fps | cfs |
| 0.3 | 1.5 | 0.027 | 0.005 | 2.9 | 2.00 | 0.735 | 0.24 | 1.50 | 1.10 |
| 0.4 | 1.5 | 0.027 | 0.005 | 3.2 | 2.00 | 1.04 | 0.30 | 1.76 | 1.83 |
| 0.5 | 1.5 | 0.027 | 0.005 | 3.5 | 2.00 | 1.375 | 0.36 | 1.98 | 2.72 |
| 0.6 | 1.5 | 0.027 | 0.005 | 3.8 | 2.00 | 1.74 | 0.42 | 2.18 | 3.80 |
| 0.7 | 1.5 | 0.027 | 0.005 | 4.1 | 2.00 | 2.135 | 0.47 | 2.37 | 5.05 |
| 0.8 | 1.5 | 0.027 | 0.005 | 4.4 | 2.00 | 2.56 | 0.52 | 2.54 | 6.49 |
| 0.9 | 1.5 | 0.027 | 0.005 | 4.7 | 2.00 | 3.015 | 0.57 | 2.70 | 8.13 |
| 1 | 1.5 | 0.027 | 0.005 | 5 | 2.00 | 3.5 | 0.62 | 2.85 | 9.98 |
| 1.1 | 1.5 | 0.027 | 0.005 | 5.3 | 2.00 | 4.015 | 0.67 | 3.00 | 12.03 |
| 1.2 | 1.5 | 0.027 | 0.005 | 5.6 | 2.00 | 4.56 | 0.72 | 3.14 | 14.30 |
| 1.3 | 1.5 | 0.027 | 0.005 | 5.9 | 2.00 | 5.135 | 0.77 | 3.27 | 16.80 |
| 1.4 | 1.5 | 0.027 | 0.005 | 6.2 | 2.00 | 5.74 | 0.81 | 3.40 | 19.53 |
| 1.5 | 1.5 | 0.027 | 0.005 | 6.5 | 2.00 | 6.375 | 0.86 | 3.53 | 22.51 |
| | | | | | | | | | |
| 0.3 | 2 | 0.027 | 0.005 | 3.2 | 2.00 | 0.78 | 0.23 | 1.48 | 1.15 |
| 0.4 | 2 | 0.027 | 0.005 | 3.6 | 2.00 | 1.12 | 0.30 | 1.73 | 1.94 |
| 0.5 | 2 | 0.027 | 0.005 | 4 | 2.00 | 1.5 | 0.35 | 1.95 | 2.93 |
| 0.6 | 2 | 0.027 | 0.005 | 4.4 | 2.00 | 1.92 | 0.41 | 2.15 | 4.13 |
| 0.7 | 2 | 0.027 | 0.005 | 4.8 | 2.00 | 2.38 | 0.46 | 2.34 | 5.57 |
| 0.8 | 2 | 0.027 | 0.005 | 5.2 | 2.00 | 2.88 | 0.52 | 2.51 | 7.23 |
| 0.9 | 2 | 0.027 | 0.005 | 5.6 | 2.00 | 3.42 | 0.57 | 2.68 | 9.15 |
| 1 | 2 | 0.027 | 0.005 | 6 | 2.00 | 4 | 0.62 | 2.83 | 11.33 |
| 1.1 | 2 | 0.027 | 0.005 | 6.4 | 2.00 | 4.62 | 0.67 | 2.98 | 13.77 |
| 1.2 | 2 | 0.027 | 0.005 | 6.8 | 2.00 | 5.28 | 0.72 | 3.13 | 16.50 |
| 1.3 | 2 | 0.027 | 0.005 | 7.2 | 2.00 | 5.98 | 0.77 | 3.26 | 19.52 |
| 1.4 | 2 | 0.027 | 0.005 | 7.6 | 2.00 | 6.72 | 0.81 | 3.40 | 22.85 |
| 1.5 | 2 | 0.027 | 0.005 | 8 | 2.00 | 7.5 | 0.86 | 3.53 | 26.49 |
| | | | | | | | | | |
| COMMON SECTIONS FOR DITCHES | | | | | | velocity based on mannings equation | | | |

**Table 5. V-Ditch Geometry**

| Burke Gilman Trail - Ditch Capacity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| "V" DITCH SECTION | | | | | | | | | |
| Flow | Sides | mannings | | WIDTH | | | Hydraulic | Velocity | flow Q |
| Depth | ? : 1 | n | SLOPE | Top | Bottom | Area | Radius | fps | cfs |
| 0.3 | 1 | 0.027 | 0.005 | 0.6 | 0.00 | 0.09 | 0.11 | 0.87 | 0.079 |
| 0.4 | 1 | 0.027 | 0.005 | 0.8 | 0.00 | 0.16 | 0.14 | 1.06 | 0.169 |
| 0.5 | 1 | 0.027 | 0.005 | 1 | 0.00 | 0.25 | 0.18 | 1.23 | 0.307 |
| 0.6 | 1 | 0.027 | 0.005 | 1.2 | 0.00 | 0.36 | 0.21 | 1.39 | 0.500 |
| 0.7 | 1 | 0.027 | 0.005 | 1.4 | 0.00 | 0.49 | 0.25 | 1.54 | 0.754 |
| 0.8 | 1 | 0.027 | 0.005 | 1.6 | 0.00 | 0.64 | 0.28 | 1.68 | 1.076 |
| 0.9 | 1 | 0.027 | 0.005 | 1.8 | 0.00 | 0.81 | 0.32 | 1.82 | 1.473 |
| 1 | 1 | 0.027 | 0.005 | 2 | 0.00 | 1 | 0.35 | 1.95 | 1.951 |
| 1.1 | 1 | 0.027 | 0.005 | 2.2 | 0.00 | 1.21 | 0.39 | 2.08 | 2.516 |
| 1.2 | 1 | 0.027 | 0.005 | 2.4 | 0.00 | 1.44 | 0.42 | 2.20 | 3.173 |
| 1.3 | 1 | 0.027 | 0.005 | 2.6 | 0.00 | 1.69 | 0.46 | 2.32 | 3.928 |
| 1.4 | 1 | 0.027 | 0.005 | 2.8 | 0.00 | 1.96 | 0.49 | 2.44 | 4.786 |
| 1.5 | 1 | 0.027 | 0.005 | 3 | 0.00 | 2.25 | 0.53 | 2.56 | 5.752 |
| 1.6 | 1 | 0.027 | 0.005 | 3.2 | 0.00 | 2.56 | 0.57 | 2.67 | 6.833 |
| 1.7 | 1 | 0.027 | 0.005 | 3.4 | 0.00 | 2.89 | 0.60 | 2.78 | 8.032 |
| 1.8 | 1 | 0.027 | 0.005 | 3.6 | 0.00 | 3.24 | 0.64 | 2.89 | 9.354 |
| 1.9 | 1 | 0.027 | 0.005 | 3.8 | 0.00 | 3.61 | 0.67 | 2.99 | 10.805 |
| 2 | 1 | 0.027 | 0.005 | 4 | 0.00 | 4 | 0.71 | 3.10 | 12.389 |
| | | | | | | | | | |
| 0.3 | 1.5 | 0.027 | 0.005 | 0.9 | 0.00 | 0.135 | 0.12 | 0.97 | 0.132 |
| 0.4 | 1.5 | 0.027 | 0.005 | 1.2 | 0.00 | 0.24 | 0.17 | 1.18 | 0.283 |
| 0.5 | 1.5 | 0.027 | 0.005 | 1.5 | 0.00 | 0.375 | 0.21 | 1.37 | 0.514 |
| 0.6 | 1.5 | 0.027 | 0.005 | 1.8 | 0.00 | 0.54 | 0.25 | 1.55 | 0.835 |
| 0.7 | 1.5 | 0.027 | 0.005 | 2.1 | 0.00 | 0.735 | 0.29 | 1.71 | 1.260 |
| 0.8 | 1.5 | 0.027 | 0.005 | 2.4 | 0.00 | 0.96 | 0.33 | 1.87 | 1.799 |
| 0.9 | 1.5 | 0.027 | 0.005 | 2.7 | 0.00 | 1.215 | 0.37 | 2.03 | 2.463 |
| 1 | 1.5 | 0.027 | 0.005 | 3 | 0.00 | 1.5 | 0.42 | 2.17 | 3.262 |
| 1.1 | 1.5 | 0.027 | 0.005 | 3.3 | 0.00 | 1.815 | 0.46 | 2.32 | 4.206 |
| 1.2 | 1.5 | 0.027 | 0.005 | 3.6 | 0.00 | 2.16 | 0.50 | 2.46 | 5.304 |
| 1.3 | 1.5 | 0.027 | 0.005 | 3.9 | 0.00 | 2.535 | 0.54 | 2.59 | 6.566 |
| 1.4 | 1.5 | 0.027 | 0.005 | 4.2 | 0.00 | 2.94 | 0.58 | 2.72 | 8.001 |
| 1.5 | 1.5 | 0.027 | 0.005 | 4.5 | 0.00 | 3.375 | 0.62 | 2.85 | 9.617 |

## VI. SPECIAL REPORTS AND STUDIES

The following is a list of reports and studies related to this project.

- Preliminary Geotechnical Investigation by HWA Geosciences, Inc. dated April 15, 2005
- Burke-Gilman Trail Redevelopment: Drainage Analysis by PACE Engineers, Inc. dated April 17, 2005
- Burke-Gilman Trail: Wildlife Study by Adolfson dated April 6, 2005
- Burke-Gilman Trail Wetlands and Streams by Adolfson dated March 2005
- Arborists Report by Northwest Arborvitae dated March 31, 2005
- Draft Sensitive Areas Study by The Watershed Company dated March 30, 2006
- Draft Limited Phase I Environmental Site Assessment by Zipper Zeman Associates, Inc. dated April 5, 2006
- Phase One Final Report by Burke Gilman Trail Citizens Advisory Group dated February 17, 2006
- Burke Gilman Trail Standards review by Huitt-Zollars dated April 27, 2006
- Report of Predesign Geotechnical Services by Zipper Zeman Associates, Inc. dated May 30, 2006
- Draft 165th Crossing Recommendations by Transportation Engineering NorthWest, LLC dated May 21, 2006

## VII. OTHER PERMITS

Other permits that may be required for this project include:

| | |
|---|---|
| • Right-of-way Permit | King County |
| • Right-of-way Permit | City of Lake Forest Park |
| • Land Clearing, Grading, Excavating Permit | City of Lake Forest Park |
| • Sensitive Area Work Permit | City of Lake Forest Park |
| • Tree Removal Permit | City of Lake Forest Park |
| • Shoreline Permit | City of Lake Forest Park |
| • HPA | Washington DFW |
| • Wetlands | Corp of Engineers |
| • NPDES Permit for Construction Stormwater | Department of Ecology |

## VIII. ESC ANALYSIS AND DESIGN

All temporary erosion and sediment control requirements have been designed in accordance with Core Requirement #5 of the 2005 KCSWDM section 1.2.5 Erosion and Sediment Control. These standards prevent or reduce pollution of stormwater runoff caused by construction activities. The Temporary Erosion and Sediment Control Plan has been designed to minimize the amount of sediment laden runoff that leaves the project site, protecting downstream properties from construction and grading activities.

The site is 2.2 miles long and the improvements are a minimum of 16 feet wide. This equates to over four acres of land disturbing activities associated with the project. Therefore the project is required to seek coverage under the Department of Ecology's General Permit for Construction Stormwater. A Construction Stormwater Pollution Prevention Plan (CSWPPP) will be compiled per the terms of the permit coverage. Temporary erosion and sediment control plans will also be prepared by PACE as part of the final design plans for the project.

The following is a narrative describing proposed TESC measures:

Clearing Limits: Clearing limits will be shown clearly on TESC plans with details sufficient to install and maintain during construction.

Cover Measures: The type and location of temporary cover measures to be used onsite will be shown on the TESC plans. This may include mulch, compost, hydroseed, and/or plastic sheeting.

Perimeter Protection: Silt fencing location and details for installation will be shown on TESC plans. Compost filter socks may also be used in areas where a silt fence would cause more disturbance than it would mitigate. Silt fences are to be used at wetland buffers to protect wetlands during construction.

Traffic Area Stabilization: Construction entrance locations are limited to as few as possible and are shown on the TESC plans. Dust control measures per D.3.8 of the '05 KCSWDM shall also be utilized, and is indicated on the plans.

Sediment Retention: Due to the long narrow nature of the project and limited area available, a sediment trap or pond will not be feasible for this project. Silt fencing and catch basin inserts shall be used primarily to trap sediments. Also stabilization of the site will help prevent sediments from migrating. Sand bags, triangle silt dikes, and compost socks may also be used, especially within the ditch sections to trap sediments while allowing runoff to continue downstream.

Surface Water Control: All surface water controls to be shown on final TESC plans per requirements of 2.3.1 of the '05 KCSWDM.

Wet Season Requirements: A list of applicable wet season requirements shall be shown on the TESC plans. From October 1st through April 30th, no soils shall be exposed for more than two consecutive working days. Also, exposed soils shall be stabilized at the end of the workday prior to a weekend, holiday, or predicted rain event.

Critical Areas Restrictions: The site has adjacent critical areas including streams, wetlands, and steep slopes. Critical areas shall be shown clearly on the TESC plans with protections as required.

## IX. BOND QUANTITIES, FACILITY SUMMARIES, AND DECLARATION OF COVENANT

Bond quantities shall be provided with the final engineering documents. No Facility Summary or Declaration of Covenant will be filed for this site.

## X. OPERATIONS AND MAINTENANCE MANUAL

The operations and maintenance manual has been compiled from Appendix A of the KCSWDM and is provided in Appendix A of this report.

# APPENDIX A: OPERATIONS AND MAINTENANCE MANUAL

## NO. 5 – CATCH BASINS

| Maintenance Component | Defect or Problem | Conditions When Maintenance is Needed | Results Expected When Maintenance is performed |
|---|---|---|---|
| General | Trash & Debris (Includes Sediment) | Trash or debris of more than ½ cubic foot which is located immediately in front of the catch basin opening or is blocking capacity of the basin by more than 10%. | No Trash or debris located immediately in front of catch basin opening. |
| | | Trash or debris (in the basin) that exceeds $^1/_3$ the depth from the bottom of basin to invert the lowest pipe into or out of the basin. | 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. |
| | | Deposits of garbage exceeding 1 cubic foot in volume. | No condition present which would attract or support the breeding of insects or rodents. |
| | Structure Damage to Frame and/or Top Slab | Corner of frame extends more than ¾ inch past curb face into the street (If applicable). | Frame is even with curb. |
| | | Top slab has holes larger than 2 square inches or cracks wider than ¼ inch (intent is to make sure all 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 ¾ inch of the frame from the top slab. | Frame is sitting flush on top slab. |
| | Cracks in Basin Walls/Bottom | Cracks wider than ½ inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that structure is unsound. | Basin replaced or repaired to design standards. |
| | | Cracks wider than ½ 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. | No cracks more than $^1/_4$ inch wide at the joint of inlet/outlet pipe. |
| | Settlement/ Misalignment | Basin has settled more than 1 inch or has rotated more than 2 inches out of alignment. | Basin replaced or repaired to design standards. |
| | Fire Hazard | Presence of chemicals such as natural gas, oil and gasoline. | No flammable chemicals present. |
| | 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 6 inches tall and less than 6 inches apart. | No vegetation or root growth present. |
| | Pollution | Nonflammable chemicals of more than ½ cubic foot per three feet of basin length. | No pollution present other than surface film. |
| 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 on maintenance person with proper tools. Bolts into frame have less than ½ inch of thread. | Mechanism opens with proper tools. |
| | Cover Difficult to Remove | One maintenance person cannot remove lid after applying 80 lbs. of lift; 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, misalignment, rust, cracks, or sharp edges. | Ladder meets design standards and allows maintenance person safe access. |

## NO. 5 – CATCH BASINS

| Maintenance Component | Defect or Problem | Conditions When Maintenance is Needed | Results Expected When Maintenance is performed |
|---|---|---|---|
| Metal Grates (If Applicable) | Unsafe Grate Opening | 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. | 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 Component | Defect or Problem | 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 clear to receive capacity flow. |
| Metal | Damaged/Missing Bars. | Bars are bent out of shape more than 3 inches. | Bars in place with no bends more than ¾ 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. | Repair or replace barrier to design standards. |

## NO. 7 – ENERGY DISSIPATERS

| Maintenance Component | Defect or Problem | Conditions When Maintenance is Needed | Results Expected When Maintenance is Performed. |
|---|---|---|---|
| External: | | | |
| Rock Pad | Missing or Moved Rock | Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil. | Replace rocks to design standards. |
| Dispersion Trench | Pipe Plugged with Sediment | Accumulated sediment that exceeds 20% of the design depth. | Pipe cleaned/flushed so that it matches design. |
| | Not Discharging Water Properly | Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage. | Trench must be redesigned or rebuilt to standards. |
| | Perforations Plugged. | Over ½ of perforations in pipe are plugged with debris and sediment. | Clean or replace perforated pipe. |
| | Water Flows Out Top of "Distributor" Catch Basin. | Maintenance person observes water flowing out during any storm less than the design storm or its causing or appears likely to cause damage. | Facility must be rebuilt or redesigned to standards. |
| | Receiving Area Over-Saturated | Water in receiving area is causing or has potential of causing landslide problems. | No danger of landslides. |
| Internal: | | | |
| Manhole/Chamber | Worn or Damaged Post, Baffles, Side of Chamber | Structure dissipating flow deteriorates to ½ or original size or any concentrated worn spot exceeding one square foot which would make structure unsound. | Replace structure to design standards. |

## NO. 10 – CONVEYANCE PIPES AND DITCHES

| Maintenance Component | Defect or Problem | Conditions When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| Pipes | Sediment & Debris | Accumulated sediment that exceeds 20% of the diameter of the pipe. | Pipe cleaned of all sediment and debris. |
| | Vegetation | Vegetation that reduces free movement of water through pipes. | All vegetation removed so water flows freely through pipes. |
| | Damaged | Protective coating is damaged; rust is causing more than 50% deterioration to any part of pipe. | Pipe repaired or replaced. |
| | | Any dent that decreases the cross section area of pipe by more than 20%. | Pipe repaired or replaced. |
| Open Ditches | Trash & Debris | Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes. | Trash and debris cleared from ditches. |
| | Sediment | Accumulated sediment that exceeds 20% of the design depth. | Ditch cleaned/flushed of all sediment and debris so that it matches design. |
| | Vegetation | Vegetation that reduces free movement of water through ditches. | Water flows freely through ditches. |
| | Erosion Damage to Slopes | See "Detention Ponds" Table No. 1 | See "Detention Ponds" Table No. 1 |
| | Rock Lining Out of Place or Missing (If Applicable). | Maintenance person can see native soil beneath the rock lining. | Replace rocks to design standards. |

## NO. 11 – GROUNDS (LANDSCAPING)

| Maintenance Component | Defect or Problem | Conditions When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| General | Weeds (Nonpoisonous, not noxious) | Weeds growing in more than 20% of the landscaped area (trees and shrubs only). | Weeds present in less than 5% of the landscaped area. |
| | Safety Hazard | Any presence of poison ivy or other poisonous vegetation. | No poisonous vegetation present in landscaped area. |
| | Trash or Litter | Paper, cans, bottles, totaling more than 1 cubic foot within a landscaped area (trees and shrubs only) of 1,000 square feet. | Area clear of litter. |
| Trees and Shrubs | Damaged | Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub. | Trees and shrubs with less than 5% of total foliage with split or broken limbs. |
| | | Trees or shrubs that have been blown down or knocked over. | Tree or shrub in place free of injury. |
| | | Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots. | Tree or shrub in place and adequately supported; remove any dead or diseased trees. |

## APPENDIX B: DRAINAGE ANALYSIS BY PACE DATED APRIL 17, 2005

## I PROJECT OVERVIEW

The Burke-Gilman Trail Redevelopment project consists of widening the existing Burke-Gilman Trail through the City of Lake Forest Park and providing where feasible a soft surface trail adjacent to the main trail. The overall length of the proposed improvements is approximately 2.2-miles.

This drainage analysis gives preliminary findings related to the capacity analysis of culverts crossing the Burke-Gilman trail, including a hydrologic analysis of the upstream drainage basins for each culvert in order to estimate the peak 25-year and 100-year flow rates at each culvert crossing.

## II BACKGROUND

There are 14 drainage basins associated with 17 culvert crossings of the Burke-Gilman Trail. In addition, there are 2 bridge crossings that convey McAleer and Lyon Creeks under the trail, that are part of a larger basin area that have been studied extensively in the past by King County. As a result of these studies, several CIP projects have been constructed to reduce flooding. Further analysis based on a regional drainage basin study may be required to address predicted peak flows and conveyance capacity of the bridge crossings under the trail and is not part of this study.

Conveyance:

The Burke-Gilman Trail follows an abandoned railroad grade and is nearly flat for the two-mile stretch of the proposed redevelopment project. The trail is generally located at the toe of a steep slope, except within the McAleer and Lyon Creek basins where the surrounding topography is mainly flat upstream and gently sloping toward Lake Washington on the downstream side.

The existing conveyance system along the Burke-Gilman Trail is made up of a network of drainage ditches running parallel to the trail on the upstream side, interconnected with cross culverts which convey seepage and runoff across the trail to Lake Washington. Runoff and seepage that makes its way to these culvert crossings is generated upstream of the trail and is conveyed to the trail in a number of ways, including storm drainage piping, manmade ditches and natural drainage courses. Surface water runoff originates from rainfall and other precipitation falling within the drainage basin. Impervious surfaces such as roadways and roof contribute to the amount of runoff generated in each drainage basin. A discussion of how runoff from these surfaces is calculated is included in the methodology section of this analysis.

As part of the redevelopment and widening of the trail, the existing cross culverts will be analyzed to determine if they have adequate capacity to convey flows across the trail, and prevent flooding of the trail.

Flow Control:
Per the 2005 King County Surface Water Design Manual, this project is eligible for a direct discharge exemption from flow control. Criteria for this exemption is listed in section 1.2.3, page 1-30 of the manual. Lake Washington is a major receiving water body, and may receive direct discharge of surface water runoff. As such, no flow control facilities have been designed.

Water Quality Treatment:
Per the definition given on page 15 of the 2005 King County Surface Water Design Manual, the Burke-Gilman Trail is not a pollution generating impervious surface. Therefore, water quality treatment is not required for the improved area.

## III METHODOLOGY

Existing Hydrology
The drainage analysis for this project was done per the KCRTS/Runoff Files Method described in Chapter 3 of the 2005 King County Surface Water Design Manual (KCSWDM). Runoff time series files were generated using 15-minute timesteps and a full historical record as required by table 3.2.2.A of the design manual. Impervious and pervious areas were calculated using GIS parcel data, and the guidelines in chapter 3 of the design manual. The following is a brief summary of the hydrologic analysis. Please note, as-built drawings of SR-522 were used to help determine drainage basin boundaries. The majority of runoff from SR-522 is conveyed in a piped system to McAleer and Lyon Creeks, upstream of crossing the Burke-Gilman Trail.

1. Culvert crossings of the trail were identified using the site survey and site visit for additional verification. In all, 17 culvert crossings and 2 bridges have been identified.
2. Upstream drainage basins for each culvert were mapped using topographic and drainage information provided by GIS mapping and as-built drawings of SR-522 provided by WSDOT. In all, 14 drainage basins draining to culvert crossings were identified. Some basins are drained by more than one culvert, and therefore there are fewer basins than culvert crossings. .
3. Using the GIS database, zoning within each mapped drainage basin was identified. The zoning was categorized into three groups: Single Family Residential (SF), Multi-Family/Commercial (MF/COM), and ROW.
4. The ROW area was divided and applied using a weighted average to either the SF grouping, or the MF/COM grouping.

5. For the SF areas within each sub-basin, the number of dwelling units per gross acre was calculated. Then, using Table 3.2.2.D of the KCSWDM, the percent impervious area was found. Next, the effective impervious fraction (EIF) from Table 3.2.2.E of the KCSWDM was used to give the total impervious area for the single family residential (SF) areas within each sub-basin. All pervious area was considered grass for this analysis.
6. For MF/COM areas within each drainage basin, a total impervious area of 90% was estimated based on an aerial photograph of the basins. Then, an EIF of 95% from Table 3.2.2.E was applied to the impervious areas. All pervious area was considered as grass for this analysis.
7. The impervious and pervious areas was totaled per sub-basin, and input into KCRTS using 15 minute timesteps and the full historical record.

<u>Existing Conveyance Capacity of Culverts Crossing Trail:</u>
A separate conveyance capacity analysis was completed for each culvert crossing of the Burke-Gilman Trail. Some assumptions were made where there was insufficient data from the survey. In particular, many of the outfalls were unable to be located due to their location on private property. All culverts where there was no survey information and we were unable to locate the inlet or outlet a minimum slope of 1% was applied. Manning's equation was used to calculate the full flow capacity of each culvert. Manning's equation was used to calculate flow based on cross-sectional area of pipe, pipe slope, and a roughness coefficient, which was assigned based on the type of pipe material. A smoother pipe (such as concrete or PVC) will have a greater capacity to convey stormwater than a corrugated pipe such as CMP.

## IV FINDINGS

The capacity of each culvert was compared with the peak flows from the corresponding tributary drainage basin. The following table summarizes the results:

| Culvert # | Culvert Capacity (cfs) | Drainage Basin # | Design Flow 25-year (cfs) | Design Flow 100-year (cfs) |
|---|---|---|---|---|
| 1 | 16.0 | 1 | 20.8 | 37.3 |
| 1a | 55.4 | 1a | 1.7 | 2.5 |
| 2 | 25.1 | 2 | 7.2 | 12.8 |
| 3 | 22.6 | 3 | 7.8 | 13.0 |
| 4 | 22.6 | 4 | 2.9 | 4.7 |
| 5 | 22.6 | 5 | 3.4 | 5.5 |
| 6 | 66.7 | 6 | 4.0 | 6.0 |
| 7 | 33.2 | 7 | 2.8 | 4.2 |
| 8a | insufficient data | *8 | 175.7 | 311.2 |
| 8b | insufficient data | | | |
| 8c | insufficient data | | | |
| 9 | 36.1 | 9 | 11.6 | 17.8 |
| 10 | 36.1 | 10 | 16.2 | 24.3 |
| 11a | 22.6 | *11 | 6.5 | 10.8 |
| 11b | 1.9 | | | |
| 12 | 10.5 | 12 | 6.0 | 10.0 |
| 13 | 3.6 | 13 | 1.2 | 2.1 |

*Basins 8 and 11 are drained by multiple culverts. A more detailed analysis is needed of basin 8 to determine culvert capacity.

Based on the results shown above, culvert number 1 may be undersized, and may need to be upgraded as part of the redevelopment of the trail. This will need to be analyzed in more detail during the final design. Also, the capacity of culverts draining basin 8 will need a more detailed evaluation during the final design phase since there is insufficient data based on the survey to determine the capacity of the existing culvert crossings for the drainage basin.

# Drainage Basins Map

Flow Frequency Analysis
Time Series File:db_1.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.806 StdDev= 0.248
Skew= 1.112

---Annual Peak Flow Rates---

| Flow Rate (CFS) | Rank | Time of Peak |
|---|---|---|
| 11.45 | 8 | 2/16/49 17:45 |
| 20.56 | 3 | 3/03/50 15:15 |
| 6.21 | 25 | 2/09/51 12:45 |
| 5.97 | 27 | 10/17/51 7:15 |
| 3.16 | 47 | 9/30/53 3:00 |
| 5.66 | 31 | 12/19/53 17:45 |
| 4.04 | 38 | 2/07/55 18:15 |
| 5.67 | 30 | 11/18/55 15:00 |
| 8.35 | 10 | 12/09/56 12:45 |
| 6.86 | 19 | 1/16/58 10:15 |
| 5.75 | 28 | 10/18/58 19:45 |
| 7.76 | 11 | 10/10/59 22:00 |
| 7.18 | 15 | 2/14/61 20:15 |
| 2.90 | 48 | 11/22/61 0:45 |
| 4.96 | 35 | 12/01/62 20:15 |
| 3.53 | 44 | 12/31/63 22:00 |
| 7.38 | 12 | 4/20/65 19:30 |
| 3.85 | 40 | 1/06/66 1:00 |
| 7.37 | 13 | 11/13/66 17:45 |
| 16.75 | 5 | 8/24/68 15:00 |
| 7.04 | 18 | 12/03/68 15:30 |
| 3.40 | 45 | 1/13/70 20:45 |
| 4.36 | 37 | 12/06/70 7:00 |
| 12.29 | 7 | 12/08/71 17:15 |
| 3.79 | 41 | 1/13/73 3:15 |
| 7.16 | 16 | 11/28/73 8:15 |
| 7.08 | 17 | 12/26/74 22:15 |
| 4.68 | 36 | 10/29/75 7:00 |
| 2.80 | 50 | 8/26/77 1:00 |
| 6.58 | 21 | 4/19/78 15:30 |
| 6.53 | 22 | 9/08/79 13:45 |
| 9.30 | 9 | 12/14/79 20:00 |
| 6.29 | 23 | 12/25/80 23:15 |
| 21.05 | 2 | 10/05/81 22:15 |
| 5.73 | 29 | 10/28/82 16:00 |
| 5.39 | 33 | 1/02/84 23:45 |
| 3.94 | 39 | 6/06/85 22:00 |
| 6.09 | 26 | 10/27/85 10:45 |
| 5.61 | 32 | 10/25/86 22:45 |
| 3.23 | 46 | 5/13/88 17:30 |
| 3.62 | 43 | 4/05/89 14:00 |
| 15.11 | 6 | 1/09/90 5:30 |
| 7.23 | 14 | 4/03/91 20:15 |
| 5.10 | 34 | 1/27/92 15:15 |
| 6.27 | 24 | 6/09/93 12:15 |
| 2.89 | 49 | 11/17/93 16:45 |
| 3.75 | 42 | 6/05/95 17:00 |
| 6.82 | 20 | 5/19/96 11:30 |
| 42.80 | 1 | 12/29/96 11:45 |
| 17.86 | 4 | 10/04/97 14:15 |

-----Flow Frequency Analysis-------

| | - - Peaks - - (CFS) | Rank | Return Period | Prob |
|---|---|---|---|---|
| | 42.80 | 1 | 89.50 | 0.989 |
| | 21.05 | 2 | 32.13 | 0.969 |
| | 20.56 | 3 | 19.58 | 0.949 |
| | 17.86 | 4 | 14.08 | 0.929 |
| | 16.75 | 5 | 10.99 | 0.909 |
| | 15.11 | 6 | 9.01 | 0.889 |
| | 12.29 | 7 | 7.64 | 0.869 |
| | 11.45 | 8 | 6.63 | 0.849 |
| | 9.30 | 9 | 5.86 | 0.829 |
| | 8.35 | 10 | 5.24 | 0.809 |
| | 7.76 | 11 | 4.75 | 0.789 |
| | 7.38 | 12 | 4.34 | 0.769 |
| | 7.37 | 13 | 3.99 | 0.749 |
| | 7.23 | 14 | 3.70 | 0.729 |
| | 7.18 | 15 | 3.44 | 0.709 |
| | 7.16 | 16 | 3.22 | 0.690 |
| | 7.08 | 17 | 3.03 | 0.670 |
| | 7.04 | 18 | 2.85 | 0.650 |
| | 6.86 | 19 | 2.70 | 0.630 |
| | 6.82 | 20 | 2.56 | 0.610 |
| | 6.58 | 21 | 2.44 | 0.590 |
| | 6.53 | 22 | 2.32 | 0.570 |
| | 6.29 | 23 | 2.22 | 0.550 |
| | 6.27 | 24 | 2.13 | 0.530 |
| | 6.21 | 25 | 2.04 | 0.510 |
| | 6.09 | 26 | 1.96 | 0.490 |
| | 5.97 | 27 | 1.89 | 0.470 |
| | 5.75 | 28 | 1.82 | 0.450 |
| | 5.73 | 29 | 1.75 | 0.430 |
| | 5.67 | 30 | 1.70 | 0.410 |
| | 5.66 | 31 | 1.64 | 0.390 |
| | 5.61 | 32 | 1.59 | 0.370 |
| | 5.39 | 33 | 1.54 | 0.350 |
| | 5.10 | 34 | 1.49 | 0.330 |
| | 4.96 | 35 | 1.45 | 0.310 |
| | 4.68 | 36 | 1.41 | 0.291 |
| | 4.36 | 37 | 1.37 | 0.271 |
| | 4.04 | 38 | 1.33 | 0.251 |
| | 3.94 | 39 | 1.30 | 0.231 |
| | 3.85 | 40 | 1.27 | 0.211 |
| | 3.79 | 41 | 1.24 | 0.191 |
| | 3.75 | 42 | 1.21 | 0.171 |
| | 3.62 | 43 | 1.18 | 0.151 |
| | 3.53 | 44 | 1.15 | 0.131 |
| | 3.40 | 45 | 1.12 | 0.111 |
| | 3.23 | 46 | 1.10 | 0.091 |
| | 3.16 | 47 | 1.08 | 0.071 |
| | 2.90 | 48 | 1.05 | 0.051 |
| | 2.89 | 49 | 1.03 | 0.031 |
| | 2.80 | 50 | 1.01 | 0.011 |
| Computed Peaks | 37.34 | | 100.00 | 0.990 |
| Computed Peaks | 28.01 | | 50.00 | 0.980 |
| Computed Peaks | 20.80 | | 25.00 | 0.960 |
| Computed Peaks | 13.73 | | 10.00 | 0.900 |
| Computed Peaks | 12.61 | | 8.00 | 0.875 |
| Computed Peaks | 9.77 | | 5.00 | 0.800 |

| | | | |
|---|---|---|---|
| | db_1.pks | | |
| Computed Peaks | 5.76 | 2.00 | 0.500 |
| Computed Peaks | 4.10 | 1.30 | 0.231 |

db_2.pks

Flow Frequency Analysis
Time Series File:db_2.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.384 StdDev= 0.226
Skew= 1.274

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 4.11 | 8 | 2/16/49 17:45 | 14.60 | 1 | 89.50 | 0.989 |
| 6.92 | 3 | 3/03/50 15:15 | 7.46 | 2 | 32.13 | 0.969 |
| 2.17 | 30 | 2/09/51 12:45 | 6.92 | 3 | 19.58 | 0.949 |
| 2.29 | 27 | 10/17/51 7:15 | 6.27 | 4 | 14.08 | 0.929 |
| 1.32 | 47 | 9/30/53 3:00 | 6.07 | 5 | 10.99 | 0.909 |
| 2.07 | 32 | 12/19/53 17:45 | 5.16 | 6 | 9.01 | 0.889 |
| 1.50 | 41 | 2/07/55 18:15 | 4.38 | 7 | 7.64 | 0.869 |
| 2.13 | 31 | 11/18/55 15:00 | 4.11 | 8 | 6.63 | 0.849 |
| 2.96 | 10 | 12/09/56 12:45 | 3.35 | 9 | 5.86 | 0.829 |
| 2.46 | 22 | 1/16/58 10:15 | 2.96 | 10 | 5.24 | 0.809 |
| 2.33 | 25 | 10/18/58 19:45 | 2.91 | 11 | 4.75 | 0.789 |
| 2.91 | 11 | 10/10/59 22:00 | 2.84 | 12 | 4.34 | 0.769 |
| 2.63 | 16 | 2/14/61 20:15 | 2.74 | 13 | 3.99 | 0.749 |
| 1.26 | 49 | 8/04/62 13:15 | 2.65 | 14 | 3.70 | 0.729 |
| 1.89 | 34 | 12/01/62 20:15 | 2.65 | 15 | 3.44 | 0.709 |
| 1.35 | 45 | 12/31/63 22:00 | 2.63 | 16 | 3.22 | 0.690 |
| 2.65 | 14 | 4/20/65 19:30 | 2.60 | 17 | 3.03 | 0.670 |
| 1.45 | 43 | 1/06/66 1:00 | 2.58 | 18 | 2.85 | 0.650 |
| 2.74 | 13 | 11/13/66 17:45 | 2.53 | 19 | 2.70 | 0.630 |
| 6.07 | 5 | 8/24/68 15:00 | 2.51 | 20 | 2.56 | 0.610 |
| 2.51 | 20 | 12/03/68 15:30 | 2.47 | 21 | 2.44 | 0.590 |
| 1.31 | 48 | 1/13/70 20:45 | 2.46 | 22 | 2.32 | 0.570 |
| 1.66 | 38 | 12/06/70 7:00 | 2.36 | 23 | 2.22 | 0.550 |
| 4.38 | 7 | 12/08/71 17:15 | 2.34 | 24 | 2.13 | 0.530 |
| 1.48 | 42 | 4/18/73 9:30 | 2.33 | 25 | 2.04 | 0.510 |
| 2.60 | 17 | 11/28/73 8:15 | 2.32 | 26 | 1.96 | 0.490 |
| 2.53 | 19 | 12/26/74 22:15 | 2.29 | 27 | 1.89 | 0.470 |
| 1.77 | 36 | 10/29/75 7:00 | 2.28 | 28 | 1.82 | 0.450 |
| 1.19 | 50 | 8/26/77 1:00 | 2.22 | 29 | 1.75 | 0.430 |
| 2.47 | 21 | 9/22/78 18:15 | 2.17 | 30 | 1.70 | 0.410 |
| 2.84 | 12 | 9/08/79 13:45 | 2.13 | 31 | 1.64 | 0.390 |
| 3.35 | 9 | 12/14/79 20:00 | 2.07 | 32 | 1.59 | 0.370 |
| 2.28 | 28 | 12/25/80 23:15 | 1.99 | 33 | 1.54 | 0.350 |
| 7.46 | 2 | 10/05/81 22:15 | 1.89 | 34 | 1.49 | 0.330 |
| 2.22 | 29 | 10/28/82 16:00 | 1.88 | 35 | 1.45 | 0.310 |
| 1.99 | 33 | 1/02/84 23:45 | 1.77 | 36 | 1.41 | 0.291 |
| 1.53 | 39 | 6/06/85 22:00 | 1.68 | 37 | 1.37 | 0.271 |
| 2.36 | 23 | 10/27/85 10:45 | 1.66 | 38 | 1.33 | 0.251 |
| 2.32 | 26 | 10/25/86 22:45 | 1.53 | 39 | 1.30 | 0.231 |
| 1.51 | 40 | 5/13/88 17:30 | 1.51 | 40 | 1.27 | 0.211 |
| 1.39 | 44 | 8/21/89 16:00 | 1.50 | 41 | 1.24 | 0.191 |
| 5.16 | 6 | 1/09/90 5:30 | 1.48 | 42 | 1.21 | 0.171 |
| 2.65 | 15 | 4/03/91 20:15 | 1.45 | 43 | 1.18 | 0.151 |
| 1.88 | 35 | 1/27/92 15:15 | 1.39 | 44 | 1.15 | 0.131 |
| 2.34 | 24 | 6/09/93 12:15 | 1.35 | 45 | 1.12 | 0.111 |
| 1.34 | 46 | 11/17/93 16:45 | 1.34 | 46 | 1.10 | 0.091 |
| 1.68 | 37 | 6/05/95 17:00 | 1.32 | 47 | 1.08 | 0.071 |
| 2.58 | 18 | 5/19/96 11:30 | 1.31 | 48 | 1.05 | 0.051 |
| 14.60 | 1 | 12/29/96 11:45 | 1.26 | 49 | 1.03 | 0.031 |
| 6.27 | 4 | 10/04/97 14:15 | 1.19 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 12.76 | | 100.00 | 0.990 |
| Computed Peaks | | | 9.64 | | 50.00 | 0.980 |
| Computed Peaks | | | 7.23 | | 25.00 | 0.960 |
| Computed Peaks | | | 4.86 | | 10.00 | 0.900 |
| Computed Peaks | | | 4.49 | | 8.00 | 0.875 |
| Computed Peaks | | | 3.53 | | 5.00 | 0.800 |

| | db_2.pks | | |
|---|---|---|---|
| Computed Peaks | 2.18 | 2.00 | 0.500 |
| Computed Peaks | 1.62 | 1.30 | 0.231 |

db_3.pks

Flow Frequency Analysis
Time Series File:db_3.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.488 StdDev= 0.189
Skew= 1.464

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 4.71 | 8 | 2/16/49 17:45 | 14.99 | 1 | 89.50 | 0.989 |
| 6.86 | 4 | 3/03/50 15:15 | 8.29 | 2 | 32.13 | 0.969 |
| 2.34 | 36 | 2/09/51 12:30 | 7.07 | 3 | 19.58 | 0.949 |
| 2.94 | 24 | 10/17/51 7:15 | 6.86 | 4 | 14.08 | 0.929 |
| 1.95 | 46 | 9/30/53 3:00 | 6.84 | 5 | 10.99 | 0.909 |
| 2.46 | 33 | 12/19/53 17:45 | 5.29 | 6 | 9.01 | 0.889 |
| 1.96 | 45 | 11/25/54 1:00 | 4.93 | 7 | 7.64 | 0.869 |
| 2.65 | 31 | 11/18/55 15:00 | 4.71 | 8 | 6.63 | 0.849 |
| 3.31 | 14 | 12/09/56 12:45 | 4.39 | 9 | 5.86 | 0.829 |
| 2.85 | 28 | 1/16/58 10:00 | 3.85 | 10 | 5.24 | 0.809 |
| 3.27 | 15 | 10/18/58 19:45 | 3.60 | 11 | 4.75 | 0.789 |
| 3.60 | 11 | 10/10/59 22:00 | 3.37 | 12 | 4.34 | 0.769 |
| 3.13 | 19 | 2/14/61 20:15 | 3.34 | 13 | 3.99 | 0.749 |
| 2.11 | 42 | 8/04/62 13:15 | 3.31 | 14 | 3.70 | 0.729 |
| 2.41 | 34 | 12/01/62 20:15 | 3.27 | 15 | 3.44 | 0.709 |
| 1.74 | 49 | 12/31/63 22:00 | 3.26 | 16 | 3.22 | 0.690 |
| 3.04 | 22 | 4/20/65 19:30 | 3.26 | 17 | 3.03 | 0.670 |
| 1.86 | 47 | 1/05/66 15:00 | 3.14 | 18 | 2.85 | 0.650 |
| 3.34 | 13 | 11/13/66 17:45 | 3.13 | 19 | 2.70 | 0.630 |
| 7.07 | 3 | 8/24/68 15:00 | 3.10 | 20 | 2.56 | 0.610 |
| 2.89 | 26 | 10/20/68 12:00 | 3.10 | 21 | 2.44 | 0.590 |
| 1.70 | 50 | 1/13/70 20:45 | 3.04 | 22 | 2.32 | 0.570 |
| 2.10 | 43 | 12/06/70 7:00 | 2.99 | 23 | 2.22 | 0.550 |
| 4.93 | 7 | 12/08/71 17:15 | 2.94 | 24 | 2.13 | 0.530 |
| 2.23 | 39 | 4/18/73 9:30 | 2.93 | 25 | 2.04 | 0.510 |
| 3.10 | 21 | 11/28/73 8:00 | 2.89 | 26 | 1.96 | 0.490 |
| 2.99 | 23 | 12/26/74 20:15 | 2.87 | 27 | 1.89 | 0.470 |
| 2.23 | 40 | 10/29/75 7:00 | 2.85 | 28 | 1.82 | 0.450 |
| 1.78 | 48 | 8/26/77 1:00 | 2.84 | 29 | 1.75 | 0.430 |
| 3.26 | 17 | 9/17/78 1:00 | 2.69 | 30 | 1.70 | 0.410 |
| 4.39 | 9 | 9/08/79 13:45 | 2.65 | 31 | 1.64 | 0.390 |
| 3.85 | 10 | 12/14/79 20:00 | 2.52 | 32 | 1.59 | 0.370 |
| 2.84 | 29 | 9/21/81 8:00 | 2.46 | 33 | 1.54 | 0.350 |
| 8.29 | 2 | 10/05/81 22:15 | 2.41 | 34 | 1.49 | 0.330 |
| 2.93 | 25 | 10/28/82 16:00 | 2.40 | 35 | 1.45 | 0.310 |
| 2.40 | 35 | 1/02/84 23:45 | 2.34 | 36 | 1.41 | 0.291 |
| 2.03 | 44 | 6/06/85 21:15 | 2.33 | 37 | 1.37 | 0.271 |
| 3.10 | 20 | 10/27/85 10:45 | 2.30 | 38 | 1.33 | 0.251 |
| 3.37 | 12 | 10/25/86 22:45 | 2.23 | 39 | 1.30 | 0.231 |
| 2.52 | 32 | 5/13/88 17:30 | 2.23 | 40 | 1.27 | 0.211 |
| 2.33 | 37 | 8/21/89 16:00 | 2.23 | 41 | 1.24 | 0.191 |
| 5.29 | 6 | 1/09/90 5:30 | 2.11 | 42 | 1.21 | 0.171 |
| 3.14 | 18 | 4/03/91 20:15 | 2.10 | 43 | 1.18 | 0.151 |
| 2.30 | 38 | 1/27/92 15:00 | 2.03 | 44 | 1.15 | 0.131 |
| 2.87 | 27 | 6/09/93 12:15 | 1.96 | 45 | 1.12 | 0.111 |
| 2.23 | 41 | 11/17/93 16:45 | 1.95 | 46 | 1.10 | 0.091 |
| 2.69 | 30 | 6/05/95 17:00 | 1.86 | 47 | 1.08 | 0.071 |
| 3.26 | 16 | 5/19/96 11:30 | 1.78 | 48 | 1.05 | 0.051 |
| 14.99 | 1 | 12/29/96 11:45 | 1.74 | 49 | 1.03 | 0.031 |
| 6.84 | 5 | 10/04/97 14:15 | 1.70 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 13.01 | | 100.00 | 0.990 |
| Computed Peaks | | | 10.11 | | 50.00 | 0.980 |
| Computed Peaks | | | 7.81 | | 25.00 | 0.960 |
| Computed Peaks | | | 5.50 | | 10.00 | 0.900 |
| Computed Peaks | | | 5.13 | | 8.00 | 0.875 |
| Computed Peaks | | | 4.16 | | 5.00 | 0.800 |

| | db_3.pks | | |
|---|---|---|---|
| Computed Peaks | 2.77 | 2.00 | 0.500 |
| Computed Peaks | 2.20 | 1.30 | 0.231 |

db_4.pks

Flow Frequency Analysis
Time Series File:db_4.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.073 StdDev= 0.181
Skew= 1.450

---Annual Peak Flow Rates---

| Flow Rate (CFS) | Rank | Time of Peak | |
|---|---|---|---|
| 1.76 | 8 | 2/16/49 | 17:45 |
| 2.47 | 5 | 3/03/50 | 15:00 |
| 0.906 | 38 | 10/08/50 | 4:15 |
| 1.13 | 26 | 10/17/51 | 7:15 |
| 0.772 | 45 | 9/30/53 | 3:00 |
| 0.942 | 34 | 12/19/53 | 17:30 |
| 0.761 | 46 | 11/25/54 | 1:00 |
| 1.07 | 31 | 10/04/55 | 10:00 |
| 1.23 | 17 | 12/09/56 | 12:45 |
| 1.08 | 30 | 1/16/58 | 10:00 |
| 1.29 | 14 | 10/18/58 | 19:45 |
| 1.38 | 11 | 10/10/59 | 22:00 |
| 1.19 | 19 | 2/14/61 | 20:15 |
| 0.859 | 41 | 8/04/62 | 13:15 |
| 0.929 | 35 | 12/01/62 | 20:15 |
| 0.672 | 49 | 12/31/63 | 21:00 |
| 1.14 | 23 | 4/20/65 | 19:30 |
| 0.717 | 47 | 1/05/66 | 15:00 |
| 1.27 | 15 | 11/13/66 | 17:45 |
| 2.66 | 3 | 8/24/68 | 15:00 |
| 1.11 | 27 | 10/20/68 | 12:00 |
| 0.658 | 50 | 1/13/70 | 20:45 |
| 0.805 | 43 | 12/06/70 | 7:00 |
| 1.84 | 7 | 12/08/71 | 17:15 |
| 0.892 | 39 | 4/18/73 | 9:30 |
| 1.18 | 21 | 11/28/73 | 8:00 |
| 1.13 | 25 | 12/26/74 | 20:15 |
| 0.855 | 42 | 10/29/75 | 7:00 |
| 0.710 | 48 | 8/26/77 | 1:00 |
| 1.30 | 13 | 9/17/78 | 1:00 |
| 1.76 | 9 | 9/08/79 | 13:45 |
| 1.44 | 10 | 12/14/79 | 20:00 |
| 1.15 | 22 | 9/21/81 | 8:00 |
| 3.08 | 2 | 10/05/81 | 22:15 |
| 1.14 | 24 | 10/28/82 | 16:00 |
| 0.911 | 36 | 1/02/84 | 23:45 |
| 0.793 | 44 | 6/06/85 | 21:15 |
| 1.20 | 18 | 10/27/85 | 10:45 |
| 1.33 | 12 | 10/25/86 | 22:45 |
| 1.02 | 32 | 5/13/88 | 17:30 |
| 0.949 | 33 | 8/21/89 | 16:00 |
| 1.91 | 6 | 1/09/90 | 5:30 |
| 1.19 | 20 | 4/03/91 | 20:15 |
| 0.882 | 40 | 1/27/92 | 15:00 |
| 1.09 | 28 | 6/09/93 | 12:15 |
| 0.907 | 37 | 11/17/93 | 16:45 |
| 1.09 | 29 | 6/05/95 | 17:00 |
| 1.25 | 16 | 5/19/96 | 11:30 |
| 5.42 | 1 | 12/29/96 | 11:45 |
| 2.52 | 4 | 10/04/97 | 14:15 |

-----Flow Frequency Analysis-------

| | - - Peaks - - (CFS) | Rank | Return Period | Prob |
|---|---|---|---|---|
| | 5.42 | 1 | 89.50 | 0.989 |
| | 3.08 | 2 | 32.13 | 0.969 |
| | 2.66 | 3 | 19.58 | 0.949 |
| | 2.52 | 4 | 14.08 | 0.929 |
| | 2.47 | 5 | 10.99 | 0.909 |
| | 1.91 | 6 | 9.01 | 0.889 |
| | 1.84 | 7 | 7.64 | 0.869 |
| | 1.76 | 8 | 6.63 | 0.849 |
| | 1.76 | 9 | 5.86 | 0.829 |
| | 1.44 | 10 | 5.24 | 0.809 |
| | 1.38 | 11 | 4.75 | 0.789 |
| | 1.33 | 12 | 4.34 | 0.769 |
| | 1.30 | 13 | 3.99 | 0.749 |
| | 1.29 | 14 | 3.70 | 0.729 |
| | 1.27 | 15 | 3.44 | 0.709 |
| | 1.25 | 16 | 3.22 | 0.690 |
| | 1.23 | 17 | 3.03 | 0.670 |
| | 1.20 | 18 | 2.85 | 0.650 |
| | 1.19 | 19 | 2.70 | 0.630 |
| | 1.19 | 20 | 2.56 | 0.610 |
| | 1.18 | 21 | 2.44 | 0.590 |
| | 1.15 | 22 | 2.32 | 0.570 |
| | 1.14 | 23 | 2.22 | 0.550 |
| | 1.14 | 24 | 2.13 | 0.530 |
| | 1.13 | 25 | 2.04 | 0.510 |
| | 1.13 | 26 | 1.96 | 0.490 |
| | 1.11 | 27 | 1.89 | 0.470 |
| | 1.09 | 28 | 1.82 | 0.450 |
| | 1.09 | 29 | 1.75 | 0.430 |
| | 1.08 | 30 | 1.70 | 0.410 |
| | 1.07 | 31 | 1.64 | 0.390 |
| | 1.02 | 32 | 1.59 | 0.370 |
| | 0.949 | 33 | 1.54 | 0.350 |
| | 0.942 | 34 | 1.49 | 0.330 |
| | 0.929 | 35 | 1.45 | 0.310 |
| | 0.911 | 36 | 1.41 | 0.291 |
| | 0.907 | 37 | 1.37 | 0.271 |
| | 0.906 | 38 | 1.33 | 0.251 |
| | 0.892 | 39 | 1.30 | 0.231 |
| | 0.882 | 40 | 1.27 | 0.211 |
| | 0.859 | 41 | 1.24 | 0.191 |
| | 0.855 | 42 | 1.21 | 0.171 |
| | 0.805 | 43 | 1.18 | 0.151 |
| | 0.793 | 44 | 1.15 | 0.131 |
| | 0.772 | 45 | 1.12 | 0.111 |
| | 0.761 | 46 | 1.10 | 0.091 |
| | 0.717 | 47 | 1.08 | 0.071 |
| | 0.710 | 48 | 1.05 | 0.051 |
| | 0.672 | 49 | 1.03 | 0.031 |
| | 0.658 | 50 | 1.01 | 0.011 |
| Computed Peaks | 4.69 | | 100.00 | 0.990 |
| Computed Peaks | 3.69 | | 50.00 | 0.980 |
| Computed Peaks | 2.89 | | 25.00 | 0.960 |
| Computed Peaks | 2.07 | | 10.00 | 0.900 |
| Computed Peaks | 1.93 | | 8.00 | 0.875 |
| Computed Peaks | 1.58 | | 5.00 | 0.800 |

db_4.pks

| | | | |
|---|---|---|---|
| Computed Peaks | 1.07 | 2.00 | 0.500 |
| Computed Peaks | 0.860 | 1.30 | 0.231 |

Flow Frequency Analysis
Time Series File:db_5.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.143 StdDev= 0.181
Skew= 1.450

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 2.07 | 8 | 2/16/49 17:45 | 6.36 | 1 | 89.50 | 0.989 |
| 2.90 | 5 | 3/03/50 15:00 | 3.61 | 2 | 32.13 | 0.969 |
| 1.06 | 37 | 10/08/50 4:15 | 3.12 | 3 | 19.58 | 0.949 |
| 1.33 | 25 | 10/17/51 7:15 | 2.96 | 4 | 14.08 | 0.929 |
| 0.906 | 45 | 9/30/53 3:00 | 2.90 | 5 | 10.99 | 0.909 |
| 1.10 | 34 | 12/19/53 17:30 | 2.25 | 6 | 9.01 | 0.889 |
| 0.893 | 46 | 11/25/54 1:00 | 2.15 | 7 | 7.64 | 0.869 |
| 1.25 | 31 | 10/04/55 10:00 | 2.07 | 8 | 6.63 | 0.849 |
| 1.44 | 17 | 12/09/56 12:45 | 2.06 | 9 | 5.86 | 0.829 |
| 1.27 | 30 | 1/16/58 10:00 | 1.69 | 10 | 5.24 | 0.809 |
| 1.51 | 14 | 10/18/58 19:45 | 1.62 | 11 | 4.75 | 0.789 |
| 1.62 | 11 | 10/10/59 22:00 | 1.56 | 12 | 4.34 | 0.769 |
| 1.39 | 20 | 2/14/61 20:15 | 1.52 | 13 | 3.99 | 0.749 |
| 1.01 | 41 | 8/04/62 13:15 | 1.51 | 14 | 3.70 | 0.729 |
| 1.09 | 35 | 12/01/62 20:15 | 1.49 | 15 | 3.44 | 0.709 |
| 0.789 | 49 | 12/31/63 21:00 | 1.47 | 16 | 3.22 | 0.690 |
| 1.33 | 23 | 4/20/65 19:30 | 1.44 | 17 | 3.03 | 0.670 |
| 0.840 | 47 | 1/05/66 15:00 | 1.41 | 18 | 2.85 | 0.650 |
| 1.49 | 15 | 11/13/66 17:45 | 1.39 | 19 | 2.70 | 0.630 |
| 3.12 | 3 | 8/24/68 15:00 | 1.39 | 20 | 2.56 | 0.610 |
| 1.30 | 27 | 10/20/68 12:00 | 1.38 | 21 | 2.44 | 0.590 |
| 0.772 | 50 | 1/13/70 20:45 | 1.35 | 22 | 2.32 | 0.570 |
| 0.944 | 43 | 12/06/70 7:00 | 1.33 | 23 | 2.22 | 0.550 |
| 2.15 | 7 | 12/08/71 17:15 | 1.33 | 24 | 2.13 | 0.530 |
| 1.05 | 39 | 4/18/73 9:30 | 1.33 | 25 | 2.04 | 0.510 |
| 1.38 | 21 | 11/28/73 8:00 | 1.33 | 26 | 1.96 | 0.490 |
| 1.33 | 26 | 12/26/74 20:15 | 1.30 | 27 | 1.89 | 0.470 |
| 1.00 | 42 | 10/29/75 7:00 | 1.28 | 28 | 1.82 | 0.450 |
| 0.833 | 48 | 8/26/77 1:00 | 1.27 | 29 | 1.75 | 0.430 |
| 1.52 | 13 | 9/17/78 1:00 | 1.27 | 30 | 1.70 | 0.410 |
| 2.06 | 9 | 9/08/79 13:45 | 1.25 | 31 | 1.64 | 0.390 |
| 1.69 | 10 | 12/14/79 20:00 | 1.20 | 32 | 1.59 | 0.370 |
| 1.35 | 22 | 9/21/81 8:00 | 1.11 | 33 | 1.54 | 0.350 |
| 3.61 | 2 | 10/05/81 22:15 | 1.10 | 34 | 1.49 | 0.330 |
| 1.33 | 24 | 10/28/82 16:00 | 1.09 | 35 | 1.45 | 0.310 |
| 1.07 | 36 | 1/02/84 23:45 | 1.07 | 36 | 1.41 | 0.291 |
| 0.930 | 44 | 6/06/85 21:15 | 1.06 | 37 | 1.37 | 0.271 |
| 1.41 | 18 | 10/27/85 10:45 | 1.06 | 38 | 1.33 | 0.251 |
| 1.56 | 12 | 10/25/86 22:45 | 1.05 | 39 | 1.30 | 0.231 |
| 1.20 | 32 | 5/13/88 17:30 | 1.03 | 40 | 1.27 | 0.211 |
| 1.11 | 33 | 8/21/89 16:00 | 1.01 | 41 | 1.24 | 0.191 |
| 2.25 | 6 | 1/09/90 5:30 | 1.00 | 42 | 1.21 | 0.171 |
| 1.39 | 19 | 4/03/91 20:15 | 0.944 | 43 | 1.18 | 0.151 |
| 1.03 | 40 | 1/27/92 15:00 | 0.930 | 44 | 1.15 | 0.131 |
| 1.28 | 28 | 6/09/93 12:15 | 0.906 | 45 | 1.12 | 0.111 |
| 1.06 | 38 | 11/17/93 16:45 | 0.893 | 46 | 1.10 | 0.091 |
| 1.27 | 29 | 6/05/95 17:00 | 0.840 | 47 | 1.08 | 0.071 |
| 1.47 | 16 | 5/19/96 11:30 | 0.833 | 48 | 1.05 | 0.051 |
| 6.36 | 1 | 12/29/96 11:45 | 0.789 | 49 | 1.03 | 0.031 |
| 2.96 | 4 | 10/04/97 14:15 | 0.772 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 5.50 | | 100.00 | 0.990 |
| Computed Peaks | | | 4.33 | | 50.00 | 0.980 |
| Computed Peaks | | | 3.39 | | 25.00 | 0.960 |
| Computed Peaks | | | 2.42 | | 10.00 | 0.900 |
| Computed Peaks | | | 2.27 | | 8.00 | 0.875 |
| Computed Peaks | | | 1.86 | | 5.00 | 0.800 |

| | db_5.pks | | |
|---|---|---|---|
| Computed Peaks | 1.26 | 2.00 | 0.500 |
| Computed Peaks | 1.01 | 1.30 | 0.231 |

db_6.pks

Flow Frequency Analysis
Time Series File:db_6.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.257 StdDev= 0.161
Skew= 1.357

| ---Annual Flow Rate (CFS) | Peak Rank | Flow Rates--- Time of Peak | -----Flow Frequency Analysis------- - - Peaks - - (CFS) | Rank | Return Period | Prob |
|---|---|---|---|---|---|---|
| 2.47 | 8 | 2/16/49 17:45 | 6.91 | 1 | 89.50 | 0.989 |
| 3.29 | 5 | 3/03/50 15:00 | 4.22 | 2 | 32.13 | 0.969 |
| 1.49 | 35 | 8/27/51 18:00 | 3.78 | 3 | 19.58 | 0.949 |
| 1.72 | 25 | 10/17/51 7:15 | 3.41 | 4 | 14.08 | 0.929 |
| 1.25 | 43 | 9/30/53 3:00 | 3.29 | 5 | 10.99 | 0.909 |
| 1.42 | 38 | 12/19/53 17:30 | 2.92 | 6 | 9.01 | 0.889 |
| 1.22 | 45 | 7/30/55 21:15 | 2.54 | 7 | 7.64 | 0.869 |
| 1.84 | 20 | 10/04/55 10:00 | 2.47 | 8 | 6.63 | 0.849 |
| 1.69 | 28 | 12/09/56 12:45 | 2.44 | 9 | 5.86 | 0.829 |
| 1.58 | 33 | 1/16/58 10:00 | 2.15 | 10 | 5.24 | 0.809 |
| 2.05 | 12 | 10/18/58 19:45 | 2.12 | 11 | 4.75 | 0.789 |
| 2.04 | 13 | 10/10/59 22:00 | 2.05 | 12 | 4.34 | 0.769 |
| 1.71 | 26 | 2/14/61 20:15 | 2.04 | 13 | 3.99 | 0.749 |
| 1.47 | 36 | 8/04/62 13:15 | 2.02 | 14 | 3.70 | 0.729 |
| 1.40 | 39 | 12/01/62 20:15 | 1.98 | 15 | 3.44 | 0.709 |
| 1.12 | 48 | 6/05/64 15:00 | 1.93 | 16 | 3.22 | 0.690 |
| 1.60 | 32 | 4/20/65 19:30 | 1.90 | 17 | 3.03 | 0.670 |
| 1.09 | 49 | 1/05/66 15:00 | 1.87 | 18 | 2.85 | 0.650 |
| 1.87 | 18 | 11/13/66 17:45 | 1.85 | 19 | 2.70 | 0.630 |
| 3.78 | 3 | 8/24/68 15:00 | 1.84 | 20 | 2.56 | 0.610 |
| 1.67 | 29 | 10/20/68 12:00 | 1.83 | 21 | 2.44 | 0.590 |
| 1.00 | 50 | 1/13/70 20:45 | 1.75 | 22 | 2.32 | 0.570 |
| 1.21 | 46 | 12/06/70 7:00 | 1.75 | 23 | 2.22 | 0.550 |
| 2.54 | 7 | 12/08/71 17:15 | 1.74 | 24 | 2.13 | 0.530 |
| 1.47 | 37 | 4/18/73 9:30 | 1.72 | 25 | 2.04 | 0.510 |
| 1.74 | 24 | 11/28/73 8:00 | 1.71 | 26 | 1.96 | 0.490 |
| 1.90 | 17 | 8/17/75 23:00 | 1.71 | 27 | 1.89 | 0.470 |
| 1.28 | 42 | 10/29/75 7:00 | 1.69 | 28 | 1.82 | 0.450 |
| 1.20 | 47 | 8/23/77 14:30 | 1.67 | 29 | 1.75 | 0.430 |
| 2.12 | 11 | 9/17/78 1:00 | 1.63 | 30 | 1.70 | 0.410 |
| 2.92 | 6 | 9/08/79 13:45 | 1.61 | 31 | 1.64 | 0.390 |
| 2.02 | 14 | 12/14/79 20:00 | 1.60 | 32 | 1.59 | 0.370 |
| 1.98 | 15 | 9/21/81 8:00 | 1.58 | 33 | 1.54 | 0.350 |
| 4.22 | 2 | 10/05/81 22:15 | 1.55 | 34 | 1.49 | 0.330 |
| 1.75 | 22 | 10/28/82 16:00 | 1.49 | 35 | 1.45 | 0.310 |
| 1.34 | 40 | 1/02/84 23:30 | 1.47 | 36 | 1.41 | 0.291 |
| 1.25 | 44 | 6/06/85 21:15 | 1.47 | 37 | 1.37 | 0.271 |
| 1.85 | 19 | 10/27/85 10:45 | 1.42 | 38 | 1.33 | 0.251 |
| 2.15 | 10 | 10/25/86 22:45 | 1.40 | 39 | 1.30 | 0.231 |
| 1.75 | 23 | 5/13/88 17:30 | 1.34 | 40 | 1.27 | 0.211 |
| 1.63 | 30 | 8/21/89 16:00 | 1.33 | 41 | 1.24 | 0.191 |
| 2.44 | 9 | 1/09/90 5:30 | 1.28 | 42 | 1.21 | 0.171 |
| 1.71 | 27 | 4/03/91 20:15 | 1.25 | 43 | 1.18 | 0.151 |
| 1.33 | 41 | 1/27/92 15:00 | 1.25 | 44 | 1.15 | 0.131 |
| 1.61 | 31 | 6/09/93 12:15 | 1.22 | 45 | 1.12 | 0.111 |
| 1.55 | 34 | 11/17/93 16:45 | 1.21 | 46 | 1.10 | 0.091 |
| 1.83 | 21 | 6/05/95 17:00 | 1.20 | 47 | 1.08 | 0.071 |
| 1.93 | 16 | 7/19/96 19:30 | 1.12 | 48 | 1.05 | 0.051 |
| 6.91 | 1 | 12/29/96 11:45 | 1.09 | 49 | 1.03 | 0.031 |
| 3.41 | 4 | 10/04/97 14:15 | 1.00 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 6.00 | | 100.00 | 0.990 |
| Computed Peaks | | | 4.89 | | 50.00 | 0.980 |
| Computed Peaks | | | 3.96 | | 25.00 | 0.960 |
| Computed Peaks | | | 2.96 | | 10.00 | 0.900 |
| Computed Peaks | | | 2.80 | | 8.00 | 0.875 |
| Computed Peaks | | | 2.35 | | 5.00 | 0.800 |

db_6.pks

| | | | |
|---|---|---|---|
| Computed Peaks | 1.67 | 2.00 | 0.500 |
| Computed Peaks | 1.36 | 1.30 | 0.231 |

db_7.pks

Flow Frequency Analysis
Time Series File:db_7.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.095 StdDev= 0.163
Skew= 1.375

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 1.72 | 9 | 2/16/49 17:45 | 4.87 | 1 | 89.50 | 0.989 |
| 2.30 | 5 | 3/03/50 15:00 | 2.95 | 2 | 32.13 | 0.969 |
| 1.02 | 35 | 8/27/51 18:00 | 2.63 | 3 | 19.58 | 0.949 |
| 1.18 | 27 | 10/17/51 7:15 | 2.39 | 4 | 14.08 | 0.929 |
| 0.859 | 43 | 9/30/53 3:00 | 2.30 | 5 | 10.99 | 0.909 |
| 0.978 | 38 | 12/19/53 17:30 | 1.99 | 6 | 9.01 | 0.889 |
| 0.832 | 46 | 7/30/55 21:15 | 1.77 | 7 | 7.64 | 0.869 |
| 1.25 | 20 | 10/04/55 10:00 | 1.72 | 8 | 6.63 | 0.849 |
| 1.18 | 28 | 12/09/56 12:45 | 1.72 | 9 | 5.86 | 0.829 |
| 1.10 | 33 | 1/16/58 10:00 | 1.47 | 10 | 5.24 | 0.809 |
| 1.40 | 14 | 10/18/58 19:45 | 1.45 | 11 | 4.75 | 0.789 |
| 1.41 | 12 | 10/10/59 22:00 | 1.41 | 12 | 4.34 | 0.769 |
| 1.19 | 25 | 2/14/61 20:15 | 1.41 | 13 | 3.99 | 0.749 |
| 1.00 | 37 | 8/04/62 13:15 | 1.40 | 14 | 3.70 | 0.729 |
| 0.969 | 39 | 12/01/62 20:15 | 1.35 | 15 | 3.44 | 0.709 |
| 0.765 | 48 | 6/05/64 15:00 | 1.31 | 16 | 3.22 | 0.690 |
| 1.11 | 31 | 4/20/65 19:30 | 1.30 | 17 | 3.03 | 0.670 |
| 0.752 | 49 | 1/05/66 15:00 | 1.29 | 18 | 2.85 | 0.650 |
| 1.30 | 17 | 11/13/66 17:45 | 1.27 | 19 | 2.70 | 0.630 |
| 2.63 | 3 | 8/24/68 15:00 | 1.25 | 20 | 2.56 | 0.610 |
| 1.15 | 29 | 10/20/68 12:00 | 1.25 | 21 | 2.44 | 0.590 |
| 0.692 | 50 | 1/13/70 20:45 | 1.20 | 22 | 2.32 | 0.570 |
| 0.836 | 45 | 12/06/70 7:00 | 1.20 | 23 | 2.22 | 0.550 |
| 1.77 | 7 | 12/08/71 17:15 | 1.19 | 24 | 2.13 | 0.530 |
| 1.00 | 36 | 4/18/73 9:30 | 1.19 | 25 | 2.04 | 0.510 |
| 1.20 | 23 | 11/28/73 8:00 | 1.19 | 26 | 1.96 | 0.490 |
| 1.29 | 18 | 8/17/75 23:00 | 1.18 | 27 | 1.89 | 0.470 |
| 0.885 | 42 | 10/29/75 7:00 | 1.18 | 28 | 1.82 | 0.450 |
| 0.813 | 47 | 8/23/77 14:30 | 1.15 | 29 | 1.75 | 0.430 |
| 1.45 | 11 | 9/17/78 1:00 | 1.11 | 30 | 1.70 | 0.410 |
| 1.99 | 6 | 9/08/79 13:45 | 1.11 | 31 | 1.64 | 0.390 |
| 1.41 | 13 | 12/14/79 20:00 | 1.11 | 32 | 1.59 | 0.370 |
| 1.35 | 15 | 9/21/81 8:00 | 1.10 | 33 | 1.54 | 0.350 |
| 2.95 | 2 | 10/05/81 22:15 | 1.05 | 34 | 1.49 | 0.330 |
| 1.20 | 22 | 10/28/82 16:00 | 1.02 | 35 | 1.45 | 0.310 |
| 0.922 | 40 | 1/02/84 23:30 | 1.00 | 36 | 1.41 | 0.291 |
| 0.855 | 44 | 6/06/85 21:15 | 1.00 | 37 | 1.37 | 0.271 |
| 1.27 | 19 | 10/27/85 10:45 | 0.978 | 38 | 1.33 | 0.251 |
| 1.47 | 10 | 10/25/86 22:45 | 0.969 | 39 | 1.30 | 0.231 |
| 1.19 | 24 | 5/13/88 17:30 | 0.922 | 40 | 1.27 | 0.211 |
| 1.11 | 32 | 8/21/89 16:00 | 0.915 | 41 | 1.24 | 0.191 |
| 1.72 | 8 | 1/09/90 5:30 | 0.885 | 42 | 1.21 | 0.171 |
| 1.19 | 26 | 4/03/91 20:15 | 0.859 | 43 | 1.18 | 0.151 |
| 0.915 | 41 | 1/27/92 15:00 | 0.855 | 44 | 1.15 | 0.131 |
| 1.11 | 30 | 6/09/93 12:15 | 0.836 | 45 | 1.12 | 0.111 |
| 1.05 | 34 | 11/17/93 16:45 | 0.832 | 46 | 1.10 | 0.091 |
| 1.25 | 21 | 6/05/95 17:00 | 0.813 | 47 | 1.08 | 0.071 |
| 1.31 | 16 | 7/19/96 19:30 | 0.765 | 48 | 1.05 | 0.051 |
| 4.87 | 1 | 12/29/96 11:45 | 0.752 | 49 | 1.03 | 0.031 |
| 2.39 | 4 | 10/04/97 14:15 | 0.692 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 4.22 | | 100.00 | 0.990 |
| Computed Peaks | | | 3.42 | | 50.00 | 0.980 |
| Computed Peaks | | | 2.76 | | 25.00 | 0.960 |
| Computed Peaks | | | 2.06 | | 10.00 | 0.900 |
| Computed Peaks | | | 1.94 | | 8.00 | 0.875 |
| Computed Peaks | | | 1.62 | | 5.00 | 0.800 |

db_7.pks

| | | | |
|---|---|---|---|
| Computed Peaks | 1.14 | 2.00 | 0.500 |
| Computed Peaks | 0.932 | 1.30 | 0.231 |

db_8.pks

Flow Frequency Analysis
Time Series File:db_8.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 1.764 StdDev= 0.230
Skew= 1.248

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 99.35 | 8 | 2/16/49 17:45 | 356.19 | 1 | 89.50 | 0.989 |
| 169.08 | 3 | 3/03/50 15:15 | 180.55 | 2 | 32.13 | 0.969 |
| 52.61 | 30 | 2/09/51 12:45 | 169.08 | 3 | 19.58 | 0.949 |
| 54.70 | 28 | 10/17/51 7:15 | 152.04 | 4 | 14.08 | 0.929 |
| 31.29 | 46 | 9/30/53 3:00 | 146.47 | 5 | 10.99 | 0.909 |
| 49.93 | 32 | 12/19/53 17:45 | 125.83 | 6 | 9.01 | 0.889 |
| 35.92 | 40 | 2/07/55 18:15 | 106.17 | 7 | 7.64 | 0.869 |
| 51.12 | 31 | 11/18/55 15:00 | 99.35 | 8 | 6.63 | 0.849 |
| 71.74 | 10 | 12/09/56 12:45 | 80.88 | 9 | 5.86 | 0.829 |
| 59.58 | 21 | 1/16/58 10:15 | 71.74 | 10 | 5.24 | 0.809 |
| 55.34 | 25 | 10/18/58 19:45 | 69.82 | 11 | 4.75 | 0.789 |
| 69.82 | 11 | 10/10/59 22:00 | 66.83 | 12 | 4.34 | 0.769 |
| 63.39 | 16 | 2/14/61 20:15 | 65.82 | 13 | 3.99 | 0.749 |
| 29.31 | 49 | 8/04/62 13:15 | 64.10 | 14 | 3.70 | 0.729 |
| 45.26 | 35 | 12/01/62 20:15 | 63.75 | 15 | 3.44 | 0.709 |
| 32.38 | 45 | 12/31/63 22:00 | 63.39 | 16 | 3.22 | 0.690 |
| 64.10 | 14 | 4/20/65 19:30 | 62.75 | 17 | 3.03 | 0.670 |
| 34.69 | 43 | 1/06/66 1:00 | 61.89 | 18 | 2.85 | 0.650 |
| 65.82 | 13 | 11/13/66 17:45 | 61.11 | 19 | 2.70 | 0.630 |
| 146.47 | 5 | 8/24/68 15:00 | 60.72 | 20 | 2.56 | 0.610 |
| 60.72 | 20 | 12/03/68 15:30 | 59.58 | 21 | 2.44 | 0.590 |
| 31.29 | 47 | 1/13/70 20:45 | 59.11 | 22 | 2.32 | 0.570 |
| 39.67 | 37 | 12/06/70 7:00 | 56.40 | 23 | 2.22 | 0.550 |
| 106.17 | 7 | 12/08/71 17:15 | 56.18 | 24 | 2.13 | 0.530 |
| 34.84 | 42 | 4/18/73 9:30 | 55.34 | 25 | 2.04 | 0.510 |
| 62.75 | 17 | 11/28/73 8:15 | 55.07 | 26 | 1.96 | 0.490 |
| 61.11 | 19 | 12/26/74 22:15 | 55.03 | 27 | 1.89 | 0.470 |
| 42.43 | 36 | 10/29/75 7:00 | 54.70 | 28 | 1.82 | 0.450 |
| 28.10 | 50 | 8/26/77 1:00 | 53.15 | 29 | 1.75 | 0.430 |
| 59.11 | 22 | 9/22/78 18:15 | 52.61 | 30 | 1.70 | 0.410 |
| 66.83 | 12 | 9/08/79 13:45 | 51.12 | 31 | 1.64 | 0.390 |
| 80.88 | 9 | 12/14/79 20:00 | 49.93 | 32 | 1.59 | 0.370 |
| 55.07 | 26 | 12/25/80 23:15 | 47.92 | 33 | 1.54 | 0.350 |
| 180.55 | 2 | 10/05/81 22:15 | 45.28 | 34 | 1.49 | 0.330 |
| 53.15 | 29 | 10/28/82 16:00 | 45.26 | 35 | 1.45 | 0.310 |
| 47.92 | 33 | 1/02/84 23:45 | 42.43 | 36 | 1.41 | 0.291 |
| 36.43 | 39 | 6/06/85 22:00 | 39.67 | 37 | 1.37 | 0.271 |
| 56.40 | 23 | 10/27/85 10:45 | 39.42 | 38 | 1.33 | 0.251 |
| 55.03 | 27 | 10/25/86 22:45 | 36.43 | 39 | 1.30 | 0.231 |
| 35.10 | 41 | 5/13/88 17:30 | 35.92 | 40 | 1.27 | 0.211 |
| 32.67 | 44 | 4/05/89 14:00 | 35.10 | 41 | 1.24 | 0.191 |
| 125.83 | 6 | 1/09/90 5:30 | 34.84 | 42 | 1.21 | 0.171 |
| 63.75 | 15 | 4/03/91 20:15 | 34.69 | 43 | 1.18 | 0.151 |
| 45.28 | 34 | 1/27/92 15:15 | 32.67 | 44 | 1.15 | 0.131 |
| 56.18 | 24 | 6/09/93 12:15 | 32.38 | 45 | 1.12 | 0.111 |
| 31.25 | 48 | 11/17/93 16:45 | 31.29 | 46 | 1.10 | 0.091 |
| 39.42 | 38 | 6/05/95 17:00 | 31.29 | 47 | 1.08 | 0.071 |
| 61.89 | 18 | 5/19/96 11:30 | 31.25 | 48 | 1.05 | 0.051 |
| 356.19 | 1 | 12/29/96 11:45 | 29.31 | 49 | 1.03 | 0.031 |
| 152.04 | 4 | 10/04/97 14:15 | 28.10 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 311.16 | | 100.00 | 0.990 |
| Computed Peaks | | | 234.77 | | 50.00 | 0.980 |
| Computed Peaks | | | 175.71 | | 25.00 | 0.960 |
| Computed Peaks | | | 117.74 | | 10.00 | 0.900 |
| Computed Peaks | | | 108.57 | | 8.00 | 0.875 |
| Computed Peaks | | | 85.13 | | 5.00 | 0.800 |

| | db_8.pks | | |
|---|---|---|---|
| Computed Peaks | 52.14 | 2.00 | 0.500 |
| Computed Peaks | 38.51 | 1.30 | 0.231 |

db_9.pks

Flow Frequency Analysis
Time Series File:db_9.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.713 StdDev= 0.165
Skew= 1.386

| ---Annual Peak Flow Rates--- | | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 7.18 | 9 | 2/16/49 | 17:45 | 20.56 | 1 | 89.50 | 0.989 |
| 9.68 | 5 | 3/03/50 | 15:00 | 12.33 | 2 | 32.13 | 0.969 |
| 4.18 | 35 | 8/27/51 | 18:00 | 10.96 | 3 | 19.58 | 0.949 |
| 4.91 | 27 | 10/17/51 | 7:15 | 10.01 | 4 | 14.08 | 0.929 |
| 3.54 | 43 | 9/30/53 | 3:00 | 9.68 | 5 | 10.99 | 0.909 |
| 4.06 | 38 | 12/19/53 | 17:30 | 8.20 | 6 | 9.01 | 0.889 |
| 3.42 | 46 | 7/30/55 | 21:15 | 7.41 | 7 | 7.64 | 0.869 |
| 5.13 | 20 | 10/04/55 | 10:00 | 7.26 | 8 | 6.63 | 0.849 |
| 4.94 | 26 | 12/09/56 | 12:45 | 7.18 | 9 | 5.86 | 0.829 |
| 4.56 | 32 | 1/16/58 | 10:00 | 6.09 | 10 | 5.24 | 0.809 |
| 5.80 | 14 | 10/18/58 | 19:45 | 5.98 | 11 | 4.75 | 0.789 |
| 5.87 | 13 | 10/10/59 | 22:00 | 5.89 | 12 | 4.34 | 0.769 |
| 4.95 | 25 | 2/14/61 | 20:15 | 5.87 | 13 | 3.99 | 0.749 |
| 4.11 | 37 | 8/04/62 | 13:15 | 5.80 | 14 | 3.70 | 0.729 |
| 4.02 | 39 | 12/01/62 | 20:15 | 5.53 | 15 | 3.44 | 0.709 |
| 3.15 | 48 | 6/05/64 | 15:00 | 5.40 | 16 | 3.22 | 0.690 |
| 4.65 | 30 | 4/20/65 | 19:30 | 5.39 | 17 | 3.03 | 0.670 |
| 3.12 | 49 | 1/05/66 | 15:00 | 5.32 | 18 | 2.85 | 0.650 |
| 5.39 | 17 | 11/13/66 | 17:45 | 5.27 | 19 | 2.70 | 0.630 |
| 10.96 | 3 | 8/24/68 | 15:00 | 5.13 | 20 | 2.56 | 0.610 |
| 4.80 | 29 | 10/20/68 | 12:00 | 5.13 | 21 | 2.44 | 0.590 |
| 2.87 | 50 | 1/13/70 | 20:45 | 5.00 | 22 | 2.32 | 0.570 |
| 3.47 | 45 | 12/06/70 | 7:00 | 4.99 | 23 | 2.22 | 0.550 |
| 7.41 | 7 | 12/08/71 | 17:15 | 4.95 | 24 | 2.13 | 0.530 |
| 4.13 | 36 | 4/18/73 | 9:30 | 4.95 | 25 | 2.04 | 0.510 |
| 5.00 | 22 | 11/28/73 | 8:00 | 4.94 | 26 | 1.96 | 0.490 |
| 5.32 | 18 | 8/17/75 | 23:00 | 4.91 | 27 | 1.89 | 0.470 |
| 3.68 | 42 | 10/29/75 | 7:00 | 4.89 | 28 | 1.82 | 0.450 |
| 3.34 | 47 | 8/23/77 | 14:30 | 4.80 | 29 | 1.75 | 0.430 |
| 5.98 | 11 | 9/17/78 | 1:00 | 4.65 | 30 | 1.70 | 0.410 |
| 8.20 | 6 | 9/08/79 | 13:45 | 4.64 | 31 | 1.64 | 0.390 |
| 5.89 | 12 | 12/14/79 | 20:00 | 4.56 | 32 | 1.59 | 0.370 |
| 5.53 | 15 | 9/21/81 | 8:00 | 4.54 | 33 | 1.54 | 0.350 |
| 12.33 | 2 | 10/05/81 | 22:15 | 4.33 | 34 | 1.49 | 0.330 |
| 4.99 | 23 | 10/28/82 | 16:00 | 4.18 | 35 | 1.45 | 0.310 |
| 3.83 | 40 | 1/02/84 | 23:45 | 4.13 | 36 | 1.41 | 0.291 |
| 3.54 | 44 | 6/06/85 | 21:15 | 4.11 | 37 | 1.37 | 0.271 |
| 5.27 | 19 | 10/27/85 | 10:45 | 4.06 | 38 | 1.33 | 0.251 |
| 6.09 | 10 | 10/25/86 | 22:45 | 4.02 | 39 | 1.30 | 0.231 |
| 4.89 | 28 | 5/13/88 | 17:30 | 3.83 | 40 | 1.27 | 0.211 |
| 4.54 | 33 | 8/21/89 | 16:00 | 3.80 | 41 | 1.24 | 0.191 |
| 7.26 | 8 | 1/09/90 | 5:30 | 3.68 | 42 | 1.21 | 0.171 |
| 4.95 | 24 | 4/03/91 | 20:15 | 3.54 | 43 | 1.18 | 0.151 |
| 3.80 | 41 | 1/27/92 | 15:00 | 3.54 | 44 | 1.15 | 0.131 |
| 4.64 | 31 | 6/09/93 | 12:15 | 3.47 | 45 | 1.12 | 0.111 |
| 4.33 | 34 | 11/17/93 | 16:45 | 3.42 | 46 | 1.10 | 0.091 |
| 5.13 | 21 | 6/05/95 | 17:00 | 3.34 | 47 | 1.08 | 0.071 |
| 5.40 | 16 | 7/19/96 | 19:30 | 3.15 | 48 | 1.05 | 0.051 |
| 20.56 | 1 | 12/29/96 | 11:45 | 3.12 | 49 | 1.03 | 0.031 |
| 10.01 | 4 | 10/04/97 | 14:15 | 2.87 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | | 17.80 | | 100.00 | 0.990 |
| Computed Peaks | | | | 14.38 | | 50.00 | 0.980 |
| Computed Peaks | | | | 11.56 | | 25.00 | 0.960 |
| Computed Peaks | | | | 8.57 | | 10.00 | 0.900 |
| Computed Peaks | | | | 8.07 | | 8.00 | 0.875 |
| Computed Peaks | | | | 6.75 | | 5.00 | 0.800 |

| | | | | |
|---|---|---|---|---|
| | db_9.pks | | | |
| Computed Peaks | 4.74 | | 2.00 | 0.500 |
| Computed Peaks | 3.85 | | 1.30 | 0.231 |

Flow Frequency Analysis
Time Series File:db_10.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.873 StdDev= 0.159
Skew= 1.336

---Annual Peak Flow Rates---

| Flow Rate (CFS) | Rank | Time of Peak |
|---|---|---|
| 10.10 | 8 | 2/16/49 17:45 |
| 13.37 | 5 | 3/03/50 15:00 |
| 6.23 | 35 | 8/27/51 18:00 |
| 7.08 | 25 | 10/17/51 7:15 |
| 5.21 | 43 | 9/30/53 3:00 |
| 5.84 | 38 | 12/19/53 17:30 |
| 5.10 | 45 | 7/30/55 21:15 |
| 7.66 | 19 | 10/04/55 10:00 |
| 6.91 | 29 | 12/09/56 12:45 |
| 6.50 | 33 | 1/16/58 10:00 |
| 8.48 | 12 | 10/18/58 19:45 |
| 8.41 | 13 | 10/10/59 22:00 |
| 7.02 | 26 | 2/14/61 20:15 |
| 6.14 | 36 | 8/04/62 13:15 |
| 5.79 | 39 | 12/01/62 20:15 |
| 4.67 | 48 | 6/05/64 15:00 |
| 6.55 | 32 | 4/20/65 19:30 |
| 4.51 | 49 | 1/05/66 15:00 |
| 7.69 | 18 | 11/13/66 17:45 |
| 15.50 | 3 | 8/24/68 15:00 |
| 6.91 | 28 | 10/20/68 12:00 |
| 4.15 | 50 | 1/13/70 20:45 |
| 4.99 | 46 | 12/06/70 7:00 |
| 10.38 | 7 | 12/08/71 17:15 |
| 6.10 | 37 | 4/18/73 9:30 |
| 7.15 | 24 | 11/28/73 8:00 |
| 7.94 | 17 | 8/17/75 23:00 |
| 5.28 | 42 | 10/29/75 7:00 |
| 4.99 | 47 | 8/23/77 14:30 |
| 8.82 | 11 | 9/17/78 1:00 |
| 12.14 | 6 | 9/08/79 13:45 |
| 8.30 | 14 | 12/14/79 20:00 |
| 8.27 | 15 | 9/21/81 8:00 |
| 17.24 | 2 | 10/05/81 22:15 |
| 7.23 | 23 | 10/28/82 16:00 |
| 5.52 | 40 | 1/02/84 23:30 |
| 5.15 | 44 | 6/06/85 21:15 |
| 7.63 | 20 | 10/27/85 10:45 |
| 8.94 | 10 | 10/25/86 22:45 |
| 7.30 | 22 | 5/13/88 17:30 |
| 6.79 | 30 | 8/21/89 16:00 |
| 9.88 | 9 | 1/09/90 5:30 |
| 7.02 | 27 | 4/03/91 20:15 |
| 5.47 | 41 | 1/27/92 15:00 |
| 6.63 | 31 | 6/09/93 12:15 |
| 6.46 | 34 | 11/17/93 16:45 |
| 7.62 | 21 | 6/05/95 17:00 |
| 8.06 | 16 | 7/19/96 19:30 |
| 28.00 | 1 | 12/29/96 11:45 |
| 13.91 | 4 | 10/04/97 14:15 |

-----Flow Frequency Analysis-------

| | - - Peaks - - (CFS) | Rank | Return Period | Prob |
|---|---|---|---|---|
| | 28.00 | 1 | 89.50 | 0.989 |
| | 17.24 | 2 | 32.13 | 0.969 |
| | 15.50 | 3 | 19.58 | 0.949 |
| | 13.91 | 4 | 14.08 | 0.929 |
| | 13.37 | 5 | 10.99 | 0.909 |
| | 12.14 | 6 | 9.01 | 0.889 |
| | 10.38 | 7 | 7.64 | 0.869 |
| | 10.10 | 8 | 6.63 | 0.849 |
| | 9.88 | 9 | 5.86 | 0.829 |
| | 8.94 | 10 | 5.24 | 0.809 |
| | 8.82 | 11 | 4.75 | 0.789 |
| | 8.48 | 12 | 4.34 | 0.769 |
| | 8.41 | 13 | 3.99 | 0.749 |
| | 8.30 | 14 | 3.70 | 0.729 |
| | 8.27 | 15 | 3.44 | 0.709 |
| | 8.06 | 16 | 3.22 | 0.690 |
| | 7.94 | 17 | 3.03 | 0.670 |
| | 7.69 | 18 | 2.85 | 0.650 |
| | 7.66 | 19 | 2.70 | 0.630 |
| | 7.63 | 20 | 2.56 | 0.610 |
| | 7.62 | 21 | 2.44 | 0.590 |
| | 7.30 | 22 | 2.32 | 0.570 |
| | 7.23 | 23 | 2.22 | 0.550 |
| | 7.15 | 24 | 2.13 | 0.530 |
| | 7.08 | 25 | 2.04 | 0.510 |
| | 7.02 | 26 | 1.96 | 0.490 |
| | 7.02 | 27 | 1.89 | 0.470 |
| | 6.91 | 28 | 1.82 | 0.450 |
| | 6.91 | 29 | 1.75 | 0.430 |
| | 6.79 | 30 | 1.70 | 0.410 |
| | 6.63 | 31 | 1.64 | 0.390 |
| | 6.55 | 32 | 1.59 | 0.370 |
| | 6.50 | 33 | 1.54 | 0.350 |
| | 6.46 | 34 | 1.49 | 0.330 |
| | 6.23 | 35 | 1.45 | 0.310 |
| | 6.14 | 36 | 1.41 | 0.291 |
| | 6.10 | 37 | 1.37 | 0.271 |
| | 5.84 | 38 | 1.33 | 0.251 |
| | 5.79 | 39 | 1.30 | 0.231 |
| | 5.52 | 40 | 1.27 | 0.211 |
| | 5.47 | 41 | 1.24 | 0.191 |
| | 5.28 | 42 | 1.21 | 0.171 |
| | 5.21 | 43 | 1.18 | 0.151 |
| | 5.15 | 44 | 1.15 | 0.131 |
| | 5.10 | 45 | 1.12 | 0.111 |
| | 4.99 | 46 | 1.10 | 0.091 |
| | 4.99 | 47 | 1.08 | 0.071 |
| | 4.67 | 48 | 1.05 | 0.051 |
| | 4.51 | 49 | 1.03 | 0.031 |
| | 4.15 | 50 | 1.01 | 0.011 |
| Computed Peaks | 24.33 | | 100.00 | 0.990 |
| Computed Peaks | 19.88 | | 50.00 | 0.980 |
| Computed Peaks | 16.17 | | 25.00 | 0.960 |
| Computed Peaks | 12.17 | | 10.00 | 0.900 |
| Computed Peaks | 11.49 | | 8.00 | 0.875 |
| Computed Peaks | 9.68 | | 5.00 | 0.800 |

db_10.pks

| | | | |
|---|---|---|---|
| Computed Peaks | 6.89 | 2.00 | 0.500 |
| Computed Peaks | 5.62 | 1.30 | 0.231 |

Flow Frequency Analysis
Time Series File:db_11.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.409 StdDev= 0.188
Skew= 1.462

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 3.91 | 8 | 2/16/49 17:45 | 12.39 | 1 | 89.50 | 0.989 |
| 5.67 | 5 | 3/03/50 15:15 | 6.89 | 2 | 32.13 | 0.969 |
| 1.95 | 37 | 2/09/51 12:30 | 5.89 | 3 | 19.58 | 0.949 |
| 2.45 | 24 | 10/17/51 7:15 | 5.68 | 4 | 14.08 | 0.929 |
| 1.63 | 46 | 9/30/53 3:00 | 5.67 | 5 | 10.99 | 0.909 |
| 2.05 | 33 | 12/19/53 17:45 | 4.38 | 6 | 9.01 | 0.889 |
| 1.64 | 45 | 11/25/54 1:00 | 4.09 | 7 | 7.64 | 0.869 |
| 2.22 | 31 | 10/04/55 10:00 | 3.91 | 8 | 6.63 | 0.849 |
| 2.75 | 14 | 12/09/56 12:45 | 3.69 | 9 | 5.86 | 0.829 |
| 2.37 | 29 | 1/16/58 10:00 | 3.20 | 10 | 5.24 | 0.809 |
| 2.74 | 15 | 10/18/58 19:45 | 3.01 | 11 | 4.75 | 0.789 |
| 3.01 | 11 | 10/10/59 22:00 | 2.83 | 12 | 4.34 | 0.769 |
| 2.61 | 19 | 2/14/61 20:15 | 2.79 | 13 | 3.99 | 0.749 |
| 1.78 | 42 | 8/04/62 13:15 | 2.75 | 14 | 3.70 | 0.729 |
| 2.02 | 34 | 12/01/62 20:15 | 2.74 | 15 | 3.44 | 0.709 |
| 1.46 | 49 | 12/31/63 22:00 | 2.74 | 16 | 3.22 | 0.690 |
| 2.53 | 22 | 4/20/65 19:30 | 2.72 | 17 | 3.03 | 0.670 |
| 1.55 | 47 | 1/05/66 15:00 | 2.62 | 18 | 2.85 | 0.650 |
| 2.79 | 13 | 11/13/66 17:45 | 2.61 | 19 | 2.70 | 0.630 |
| 5.89 | 3 | 8/24/68 15:00 | 2.59 | 20 | 2.56 | 0.610 |
| 2.41 | 26 | 10/20/68 12:00 | 2.59 | 21 | 2.44 | 0.590 |
| 1.42 | 50 | 1/13/70 20:45 | 2.53 | 22 | 2.32 | 0.570 |
| 1.75 | 43 | 12/06/70 7:00 | 2.49 | 23 | 2.22 | 0.550 |
| 4.09 | 7 | 12/08/71 17:15 | 2.45 | 24 | 2.13 | 0.530 |
| 1.87 | 40 | 4/18/73 9:30 | 2.45 | 25 | 2.04 | 0.510 |
| 2.59 | 21 | 11/28/73 8:00 | 2.41 | 26 | 1.96 | 0.490 |
| 2.49 | 23 | 12/26/74 20:15 | 2.39 | 27 | 1.89 | 0.470 |
| 1.86 | 41 | 10/29/75 7:00 | 2.39 | 28 | 1.82 | 0.450 |
| 1.50 | 48 | 8/26/77 1:00 | 2.37 | 29 | 1.75 | 0.430 |
| 2.74 | 16 | 9/17/78 1:00 | 2.26 | 30 | 1.70 | 0.410 |
| 3.69 | 9 | 9/08/79 13:45 | 2.22 | 31 | 1.64 | 0.390 |
| 3.20 | 10 | 12/14/79 20:00 | 2.12 | 32 | 1.59 | 0.370 |
| 2.39 | 27 | 9/21/81 8:00 | 2.05 | 33 | 1.54 | 0.350 |
| 6.89 | 2 | 10/05/81 22:15 | 2.02 | 34 | 1.49 | 0.330 |
| 2.45 | 25 | 10/28/82 16:00 | 2.00 | 35 | 1.45 | 0.310 |
| 2.00 | 35 | 1/02/84 23:45 | 1.96 | 36 | 1.41 | 0.291 |
| 1.70 | 44 | 6/06/85 21:15 | 1.95 | 37 | 1.37 | 0.271 |
| 2.59 | 20 | 10/27/85 10:45 | 1.92 | 38 | 1.33 | 0.251 |
| 2.83 | 12 | 10/25/86 22:45 | 1.88 | 39 | 1.30 | 0.231 |
| 2.12 | 32 | 5/13/88 17:30 | 1.87 | 40 | 1.27 | 0.211 |
| 1.96 | 36 | 8/21/89 16:00 | 1.86 | 41 | 1.24 | 0.191 |
| 4.38 | 6 | 1/09/90 5:30 | 1.78 | 42 | 1.21 | 0.171 |
| 2.62 | 18 | 4/03/91 20:15 | 1.75 | 43 | 1.18 | 0.151 |
| 1.92 | 38 | 1/27/92 15:00 | 1.70 | 44 | 1.15 | 0.131 |
| 2.39 | 28 | 6/09/93 12:15 | 1.64 | 45 | 1.12 | 0.111 |
| 1.88 | 39 | 11/17/93 16:45 | 1.63 | 46 | 1.10 | 0.091 |
| 2.26 | 30 | 6/05/95 17:00 | 1.55 | 47 | 1.08 | 0.071 |
| 2.72 | 17 | 5/19/96 11:30 | 1.50 | 48 | 1.05 | 0.051 |
| 12.39 | 1 | 12/29/96 11:45 | 1.46 | 49 | 1.03 | 0.031 |
| 5.68 | 4 | 10/04/97 14:15 | 1.42 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 10.75 | | 100.00 | 0.990 |
| Computed Peaks | | | 8.37 | | 50.00 | 0.980 |
| Computed Peaks | | | 6.48 | | 25.00 | 0.960 |
| Computed Peaks | | | 4.57 | | 10.00 | 0.900 |
| Computed Peaks | | | 4.27 | | 8.00 | 0.875 |
| Computed Peaks | | | 3.47 | | 5.00 | 0.800 |

| | db_11.pks | | |
|---|---|---|---|
| Computed Peaks | 2.32 | 2.00 | 0.500 |
| Computed Peaks | 1.84 | 1.30 | 0.231 |

db_12.pks

Flow Frequency Analysis
Time Series File:db_12.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.371 StdDev= 0.189
Skew= 1.465

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 3.60 | 8 | 2/16/49 17:45 | 11.47 | 1 | 89.50 | 0.989 |
| 5.25 | 4 | 3/03/50 15:15 | 6.35 | 2 | 32.13 | 0.969 |
| 1.79 | 36 | 2/09/51 12:30 | 5.41 | 3 | 19.58 | 0.949 |
| 2.25 | 24 | 10/17/51 7:15 | 5.25 | 4 | 14.08 | 0.929 |
| 1.49 | 46 | 9/30/53 3:00 | 5.23 | 5 | 10.99 | 0.909 |
| 1.88 | 33 | 12/19/53 17:45 | 4.05 | 6 | 9.01 | 0.889 |
| 1.50 | 45 | 11/25/54 1:00 | 3.77 | 7 | 7.64 | 0.869 |
| 2.03 | 31 | 11/18/55 15:00 | 3.60 | 8 | 6.63 | 0.849 |
| 2.53 | 14 | 12/09/56 12:45 | 3.36 | 9 | 5.86 | 0.829 |
| 2.18 | 28 | 1/16/58 10:00 | 2.94 | 10 | 5.24 | 0.809 |
| 2.50 | 15 | 10/18/58 19:45 | 2.76 | 11 | 4.75 | 0.789 |
| 2.76 | 11 | 10/10/59 22:00 | 2.58 | 12 | 4.34 | 0.769 |
| 2.40 | 19 | 2/14/61 20:15 | 2.56 | 13 | 3.99 | 0.749 |
| 1.62 | 42 | 8/04/62 13:15 | 2.53 | 14 | 3.70 | 0.729 |
| 1.85 | 34 | 12/01/62 20:15 | 2.50 | 15 | 3.44 | 0.709 |
| 1.34 | 49 | 12/31/63 22:00 | 2.50 | 16 | 3.22 | 0.690 |
| 2.33 | 22 | 4/20/65 19:30 | 2.50 | 17 | 3.03 | 0.670 |
| 1.42 | 47 | 1/05/66 15:00 | 2.40 | 18 | 2.85 | 0.650 |
| 2.56 | 13 | 11/13/66 17:45 | 2.40 | 19 | 2.70 | 0.630 |
| 5.41 | 3 | 8/24/68 15:00 | 2.38 | 20 | 2.56 | 0.610 |
| 2.21 | 26 | 10/20/68 12:00 | 2.37 | 21 | 2.44 | 0.590 |
| 1.30 | 50 | 1/13/70 20:45 | 2.33 | 22 | 2.32 | 0.570 |
| 1.61 | 43 | 12/06/70 7:00 | 2.29 | 23 | 2.22 | 0.550 |
| 3.77 | 7 | 12/08/71 17:15 | 2.25 | 24 | 2.13 | 0.530 |
| 1.71 | 39 | 4/18/73 9:30 | 2.25 | 25 | 2.04 | 0.510 |
| 2.37 | 21 | 11/28/73 8:00 | 2.21 | 26 | 1.96 | 0.490 |
| 2.29 | 23 | 12/26/74 20:15 | 2.19 | 27 | 1.89 | 0.470 |
| 1.70 | 41 | 10/29/75 7:00 | 2.18 | 28 | 1.82 | 0.450 |
| 1.37 | 48 | 8/26/77 1:00 | 2.17 | 29 | 1.75 | 0.430 |
| 2.50 | 16 | 9/17/78 1:00 | 2.06 | 30 | 1.70 | 0.410 |
| 3.36 | 9 | 9/08/79 13:45 | 2.03 | 31 | 1.64 | 0.390 |
| 2.94 | 10 | 12/14/79 20:00 | 1.93 | 32 | 1.59 | 0.370 |
| 2.17 | 29 | 9/21/81 8:00 | 1.88 | 33 | 1.54 | 0.350 |
| 6.35 | 2 | 10/05/81 22:15 | 1.85 | 34 | 1.49 | 0.330 |
| 2.25 | 25 | 10/28/82 16:00 | 1.84 | 35 | 1.45 | 0.310 |
| 1.84 | 35 | 1/02/84 23:45 | 1.79 | 36 | 1.41 | 0.291 |
| 1.55 | 44 | 6/06/85 21:15 | 1.79 | 37 | 1.37 | 0.271 |
| 2.38 | 20 | 10/27/85 10:45 | 1.76 | 38 | 1.33 | 0.251 |
| 2.58 | 12 | 10/25/86 22:45 | 1.71 | 39 | 1.30 | 0.231 |
| 1.93 | 32 | 5/13/88 17:30 | 1.71 | 40 | 1.27 | 0.211 |
| 1.79 | 37 | 8/21/89 16:00 | 1.70 | 41 | 1.24 | 0.191 |
| 4.05 | 6 | 1/09/90 5:30 | 1.62 | 42 | 1.21 | 0.171 |
| 2.40 | 18 | 4/03/91 20:15 | 1.61 | 43 | 1.18 | 0.151 |
| 1.76 | 38 | 1/27/92 15:00 | 1.55 | 44 | 1.15 | 0.131 |
| 2.19 | 27 | 6/09/93 12:15 | 1.50 | 45 | 1.12 | 0.111 |
| 1.71 | 40 | 11/17/93 16:45 | 1.49 | 46 | 1.10 | 0.091 |
| 2.06 | 30 | 6/05/95 17:00 | 1.42 | 47 | 1.08 | 0.071 |
| 2.50 | 17 | 5/19/96 11:30 | 1.37 | 48 | 1.05 | 0.051 |
| 11.47 | 1 | 12/29/96 11:45 | 1.34 | 49 | 1.03 | 0.031 |
| 5.23 | 5 | 10/04/97 14:15 | 1.30 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 9.95 | | 100.00 | 0.990 |
| Computed Peaks | | | 7.73 | | 50.00 | 0.980 |
| Computed Peaks | | | 5.98 | | 25.00 | 0.960 |
| Computed Peaks | | | 4.21 | | 10.00 | 0.900 |
| Computed Peaks | | | 3.92 | | 8.00 | 0.875 |
| Computed Peaks | | | 3.18 | | 5.00 | 0.800 |

db_12.pks

| | | | |
|---|---|---|---|
| Computed Peaks | 2.12 | 2.00 | 0.500 |
| Computed Peaks | 1.68 | 1.30 | 0.231 |

db_13.pks

Flow Frequency Analysis
Time Series File:db_13.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= -0.415 StdDev= 0.232
Skew= 1.229

| ---Annual Peak Flow Rates--- | | | -----Flow Frequency Analysis------- | | | |
|---|---|---|---|---|---|---|
| Flow Rate (CFS) | Rank | Time of Peak | - - Peaks - - (CFS) | Rank | Return Period | Prob |
| 0.662 | 8 | 2/16/49 17:45 | 2.39 | 1 | 89.50 | 0.989 |
| 1.14 | 3 | 3/03/50 15:15 | 1.21 | 2 | 32.13 | 0.969 |
| 0.352 | 29 | 2/09/51 12:45 | 1.14 | 3 | 19.58 | 0.949 |
| 0.362 | 27 | 10/17/51 7:15 | 1.02 | 4 | 14.08 | 0.929 |
| 0.205 | 47 | 9/30/53 3:00 | 0.975 | 5 | 10.99 | 0.909 |
| 0.332 | 32 | 12/19/53 17:45 | 0.844 | 6 | 9.01 | 0.889 |
| 0.239 | 40 | 2/07/55 16:15 | 0.707 | 7 | 7.64 | 0.869 |
| 0.339 | 31 | 11/18/55 15:00 | 0.662 | 8 | 6.63 | 0.849 |
| 0.479 | 10 | 12/09/56 12:45 | 0.539 | 9 | 5.86 | 0.829 |
| 0.397 | 21 | 1/16/58 10:15 | 0.479 | 10 | 5.24 | 0.809 |
| 0.364 | 26 | 10/18/58 19:45 | 0.463 | 11 | 4.75 | 0.789 |
| 0.463 | 11 | 10/10/59 22:00 | 0.437 | 12 | 4.34 | 0.769 |
| 0.421 | 16 | 2/14/61 20:15 | 0.436 | 13 | 3.99 | 0.749 |
| 0.190 | 49 | 8/04/62 13:15 | 0.427 | 14 | 3.70 | 0.729 |
| 0.300 | 35 | 12/01/62 20:15 | 0.424 | 15 | 3.44 | 0.709 |
| 0.214 | 45 | 12/31/63 22:00 | 0.421 | 16 | 3.22 | 0.690 |
| 0.427 | 14 | 4/20/65 19:30 | 0.418 | 17 | 3.03 | 0.670 |
| 0.230 | 41 | 1/06/66 1:00 | 0.410 | 18 | 2.85 | 0.650 |
| 0.437 | 12 | 11/13/66 17:45 | 0.408 | 19 | 2.70 | 0.630 |
| 0.975 | 5 | 8/24/68 15:00 | 0.405 | 20 | 2.56 | 0.610 |
| 0.405 | 20 | 12/03/68 15:30 | 0.397 | 21 | 2.44 | 0.590 |
| 0.207 | 46 | 1/13/70 20:45 | 0.391 | 22 | 2.32 | 0.570 |
| 0.263 | 37 | 12/06/70 7:00 | 0.373 | 23 | 2.22 | 0.550 |
| 0.707 | 7 | 12/08/71 17:15 | 0.372 | 24 | 2.13 | 0.530 |
| 0.228 | 42 | 1/13/73 3:15 | 0.367 | 25 | 2.04 | 0.510 |
| 0.418 | 17 | 11/28/73 8:15 | 0.364 | 26 | 1.96 | 0.490 |
| 0.408 | 19 | 12/26/74 22:15 | 0.362 | 27 | 1.89 | 0.470 |
| 0.281 | 36 | 10/29/75 7:00 | 0.361 | 28 | 1.82 | 0.450 |
| 0.184 | 50 | 8/26/77 1:00 | 0.352 | 29 | 1.75 | 0.430 |
| 0.391 | 22 | 9/22/78 18:15 | 0.351 | 30 | 1.70 | 0.410 |
| 0.436 | 13 | 9/08/79 13:45 | 0.339 | 31 | 1.64 | 0.390 |
| 0.539 | 9 | 12/14/79 20:00 | 0.332 | 32 | 1.59 | 0.370 |
| 0.367 | 25 | 12/25/80 23:15 | 0.319 | 33 | 1.54 | 0.350 |
| 1.21 | 2 | 10/05/81 22:15 | 0.301 | 34 | 1.49 | 0.330 |
| 0.351 | 30 | 10/28/82 16:00 | 0.300 | 35 | 1.45 | 0.310 |
| 0.319 | 33 | 1/02/84 23:45 | 0.281 | 36 | 1.41 | 0.291 |
| 0.241 | 39 | 6/06/85 22:00 | 0.263 | 37 | 1.37 | 0.271 |
| 0.372 | 24 | 10/27/85 10:45 | 0.256 | 38 | 1.33 | 0.251 |
| 0.361 | 28 | 10/25/86 22:45 | 0.241 | 39 | 1.30 | 0.231 |
| 0.228 | 43 | 5/13/88 17:30 | 0.239 | 40 | 1.27 | 0.211 |
| 0.217 | 44 | 4/05/89 14:00 | 0.230 | 41 | 1.24 | 0.191 |
| 0.844 | 6 | 1/09/90 5:30 | 0.228 | 42 | 1.21 | 0.171 |
| 0.424 | 15 | 4/03/91 20:15 | 0.228 | 43 | 1.18 | 0.151 |
| 0.301 | 34 | 1/27/92 15:15 | 0.217 | 44 | 1.15 | 0.131 |
| 0.373 | 23 | 6/09/93 12:15 | 0.214 | 45 | 1.12 | 0.111 |
| 0.203 | 48 | 11/17/93 16:45 | 0.207 | 46 | 1.10 | 0.091 |
| 0.256 | 38 | 6/05/95 17:00 | 0.205 | 47 | 1.08 | 0.071 |
| 0.410 | 18 | 5/19/96 11:30 | 0.203 | 48 | 1.05 | 0.051 |
| 2.39 | 1 | 12/29/96 11:45 | 0.190 | 49 | 1.03 | 0.031 |
| 1.02 | 4 | 10/04/97 14:15 | 0.184 | 50 | 1.01 | 0.011 |
| Computed Peaks | | | 2.09 | | 100.00 | 0.990 |
| Computed Peaks | | | 1.57 | | 50.00 | 0.980 |
| Computed Peaks | | | 1.18 | | 25.00 | 0.960 |
| Computed Peaks | | | 0.786 | | 10.00 | 0.900 |
| Computed Peaks | | | 0.724 | | 8.00 | 0.875 |
| Computed Peaks | | | 0.567 | | 5.00 | 0.800 |

| | db_13.pks | | |
|---|---|---|---|
| Computed Peaks | 0.345 | 2.00 | 0.500 |
| Computed Peaks | 0.254 | 1.30 | 0.231 |

Burke Gilman Trail - Corrected Areas

04/19/05

| SB # | SF/RES (ac.) | DU/GA | % IMP | EIF | EIA (ac.) | Till Grass (ac.) | MF/COM (ac.) | % IMP | EIF | EIA (ac.) | Till Grass (ac.) | TOTALS EIA (ac.) | TOTALS Till Grass (ac.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 43.92 | 1.91 | 0.24 | 0.55 | 5.80 | 38.12 | 0 | | | | | **5.80** | **38.12** |
| 1a | | | | | | | 1.90 | 0.90 | 0.95 | 1.62 | 0.28 | **1.62** | **0.28** |
| 2 | 14.39 | 2.71 | 0.32 | 0.59 | 2.72 | 11.67 | 0 | | | | | **2.72** | **11.67** |
| 3 | 13.29 | 4.13 | 0.43 | 0.80 | 4.57 | 8.72 | 0 | | | | | **4.57** | **8.72** |
| 4 | 4.64 | 5.60 | 0.50 | 0.80 | 1.86 | 2.78 | 0 | | | | | **1.86** | **2.78** |
| 5 | 5.45 | 5.50 | 0.50 | 0.80 | 2.18 | 3.27 | 0 | | | | | **2.18** | **3.27** |
| 6 | 2.86 | 5.59 | 0.50 | 0.80 | 1.14 | 1.72 | 2.39 | 0.90 | 0.95 | 2.04 | 0.35 | **3.19** | **2.06** |
| 7 | 2.26 | 5.31 | 0.49 | 0.80 | 0.89 | 1.37 | 1.50 | 0.90 | 0.95 | 1.28 | 0.22 | **2.17** | **1.59** |
| 8 | 340.03 | 2.22 | 0.27 | 0.57 | 52.33 | 287.70 | 12.88 | 0.90 | 0.95 | 11.01 | 1.87 | **63.34** | **289.57** |
| 9 | 10.8 | 5.65 | 0.51 | 0.80 | 4.41 | 6.39 | 5.27 | 0.90 | 0.95 | 4.51 | 0.76 | **8.91** | **7.16** |
| 10 | 10.26 | 5.85 | 0.51 | 0.80 | 4.19 | 6.07 | 10.67 | 0.90 | 0.95 | 9.12 | 1.55 | **13.31** | **7.62** |
| 11 | 10.94 | 4.30 | 0.44 | 0.80 | 3.85 | 7.09 | 0 | | | | | **3.85** | **7.09** |
| 12 | 10.16 | 4.13 | 0.43 | 0.80 | 3.50 | 6.66 | 0 | | | | | **3.50** | **6.66** |
| 13 | 2.38 | 2.52 | 0.30 | 0.58 | 0.41 | 1.97 | 0 | | | | | **0.41** | **1.97** |
| **TOTAL** | | | | | | | | | | | | **117.43** | **388.56** |

Assumptions and Methodology

1. Sub-basins were divided into 3 zoning areas, single family residential, multi-family/commercial, and ROW.
2. Next, the ROW area was applied to the SF and MF/COM areas as a weighted average.
3. For SF areas, the King County Methodology was used to determine % impervious and effective impervious area.
4. For MF/COM areas, there is an assumed 90% impervious area. An additional EIF of 95% was applied per KC methodology.
5. Peak flows were determined using KCRTS with 15-minute timesteps and the full historical record, per manual.

```
                              KCRTS Command
                              -------------
                         CREATE a new Time Series
                         ------------------------
                    Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_1.tsf
Regional Scale Factor :    1.00
           Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass             38.12 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              5.80 acres
                      --------------
         Total Area :   43.92 acres
Peak Discharge:  42.81 CFS at 11:45 on Dec 29 in 1996
                                       Storing Time Series File:db_1.tsf      :
                            Time Series Computed

                              KCRTS Command
                              -------------
                     Enter the Analysis TOOLS Module
                     -------------------------------

                         Analysis Tools Command
                         ----------------------
                   Compute PEAKS and Flow Frequencies
                   ----------------------------------
                                 Loading Stage/Discharge curve:db_1.tsf      :
          Flow Frequency Analysis      LogPearson III Coefficients
          --------------------------------------------------------
  Time Series File:db_1.tsf             Mean=   0.806 StdDev=  0.248
  Project Location:Sea-Tac                      Skew=  1.112
                              Frequencies & Peaks saved to File:db_1.pks      :

                         Analysis Tools Command
                         ----------------------
                   Compute PEAKS and Flow Frequencies
                   ----------------------------------
                                 CANCELLED

                         Analysis Tools Command
                         ----------------------
                         RETURN to Previous Menu
                         -----------------------

                              KCRTS Command
                              -------------
                         CREATE a new Time Series
                         ------------------------
                    Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_2.tsf
Regional Scale Factor :    1.00
           Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass             11.67 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              2.72 acres
                      --------------
```

```
        Total Area :   14.39 acres
Peak Discharge:  14.62 CFS at 11:45 on Dec 29 in 1996
                                     Storing Time Series File:db_2.tsf   :
                         Time Series Computed

                            KCRTS Command
                            -------------
                     Enter the Analysis TOOLS Module
                     -------------------------------

                        Analysis Tools Command
                        ----------------------
                    Compute PEAKS and Flow Frequencies
                    ----------------------------------
                                 Loading Stage/Discharge curve:db_2.tsf   :
        Flow Frequency Analysis       LogPearson III Coefficients
        ---------------------------------------------------------
  Time Series File:db_2.tsf              Mean=    0.384 StdDev=  0.226
  Project Location:Sea-Tac                        Skew=  1.274
                             Frequencies & Peaks saved to File:db_2.pks   :

                        Analysis Tools Command
                        ----------------------
                        RETURN to Previous Menu
                        -----------------------

                            KCRTS Command
                            -------------
                       CREATE a new Time Series
                       ------------------------
                     Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_3.tsf
Regional Scale Factor :    1.00
            Data Type : Historic
Creating 15-minute Time Series File
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass            8.72 acres
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious            4.57 acres
                      --------------
        Total Area :   13.29 acres
Peak Discharge:  14.98 CFS at 11:45 on Dec 29 in 1996
                                     Storing Time Series File:db_3.tsf   :
                         Time Series Computed

                            KCRTS Command
                            -------------
                     Enter the Analysis TOOLS Module
                     -------------------------------

                        Analysis Tools Command
                        ----------------------
                    Compute PEAKS and Flow Frequencies
                    ----------------------------------
                                 Loading Stage/Discharge curve:db_3.tsf   :
        Flow Frequency Analysis       LogPearson III Coefficients
        ---------------------------------------------------------
  Time Series File:db_3.tsf              Mean=    0.488 StdDev=  0.189
  Project Location:Sea-Tac                        Skew=  1.464
                             Frequencies & Peaks saved to File:db_3.pks   :

                        Analysis Tools Command
```

```
                    ----------------------
                    RETURN to Previous Menu
                    -----------------------

                         KCRTS Command
                         -------------
                   CREATE a new Time Series
                   ------------------------
               Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_4.tsf
Regional Scale Factor :    1.00
           Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass              2.78 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              1.86 acres
                      --------------
         Total Area :    4.64 acres
Peak Discharge:   5.42 CFS at 11:45 on Dec 29 in 1996
                                         Storing Time Series File:db_4.tsf   :
                     Time Series Computed

                         KCRTS Command
                         -------------
                 Enter the Analysis TOOLS Module
                 -------------------------------

                     Analysis Tools Command
                     ----------------------
                 Compute PEAKS and Flow Frequencies
                 ----------------------------------
                                 Loading Stage/Discharge curve:db_4.tsf   :
        Flow Frequency Analysis      LogPearson III Coefficients
        --------------------------------------------------------
  Time Series File:db_4.tsf            Mean=   0.073 StdDev=  0.181
  Project Location:Sea-Tac                      Skew=  1.450
                             Frequencies & Peaks saved to File:db_4.pks   :

                     Analysis Tools Command
                     ----------------------
                     RETURN to Previous Menu
                     -----------------------

                         KCRTS Command
                         -------------
                   CREATE a new Time Series
                   ------------------------
               Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_5.tsf
Regional Scale Factor :    1.00
           Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass              3.27 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              2.18 acres
                      --------------
         Total Area :    5.45 acres
Peak Discharge:   6.36 CFS at 11:45 on Dec 29 in 1996
                                         Storing Time Series File:db_5.tsf   :
```

```
                           Time Series Computed

                              KCRTS Command
                              -------------
                      Enter the Analysis TOOLS Module
                      -------------------------------

                          Analysis Tools Command
                          ----------------------
                    Compute PEAKS and Flow Frequencies
                    ----------------------------------
                                Loading Stage/Discharge curve:db_5.tsf     :
      Flow Frequency Analysis       LogPearson III Coefficients
      ------------------------------------------------------------
 Time Series File:db_5.tsf             Mean=    0.143 StdDev=   0.181
 Project Location:Sea-Tac                       Skew=   1.450
                            Frequencies & Peaks saved to File:db_5.pks     :

                          Analysis Tools Command
                          ----------------------
                          RETURN to Previous Menu
                          -----------------------

                              KCRTS Command
                              -------------
                         CREATE a new Time Series
                         ------------------------
                    Production of Runoff Time Series
  Project Location : Sea-Tac
   Computing Series : db_6.tsf
Regional Scale Factor :     1.00
         Data Type : Historic
Creating 15-minute Time Series File
                 Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf     :
Till Grass              2.06 acres
                 Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf     :
Impervious              3.19 acres
                      --------------
      Total Area :      5.25 acres
Peak Discharge:    6.91 CFS at 11:45 on Dec 29 in 1996
                                    Storing Time Series File:db_6.tsf     :
                           Time Series Computed

                              KCRTS Command
                              -------------
                      Enter the Analysis TOOLS Module
                      -------------------------------

                          Analysis Tools Command
                          ----------------------
                    Compute PEAKS and Flow Frequencies
                    ----------------------------------
                                Loading Stage/Discharge curve:db_6.tsf     :
      Flow Frequency Analysis       LogPearson III Coefficients
      ------------------------------------------------------------
 Time Series File:db_6.tsf             Mean=    0.257 StdDev=   0.161
 Project Location:Sea-Tac                       Skew=   1.357
                            Frequencies & Peaks saved to File:db_6.pks     :

                          Analysis Tools Command
                          ----------------------
                          RETURN to Previous Menu
                          -----------------------
```

```
                              KCRTS Command
                              -------------
                         CREATE a new Time Series
                         ------------------------
                    Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_7.tsf
Regional Scale Factor :    1.00
          Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf    :
Till Grass              1.59 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf    :
Impervious              2.17 acres
                    --------------
        Total Area :    3.76 acres
Peak Discharge:   4.87 CFS at 11:45 on Dec 29 in 1996
                                          Storing Time Series File:db_7.tsf    :
                       Time Series Computed

                              KCRTS Command
                              -------------
                     Enter the Analysis TOOLS Module
                     -------------------------------

                         Analysis Tools Command
                         ----------------------
                    Compute PEAKS and Flow Frequencies
                    ----------------------------------
                                   Loading Stage/Discharge curve:db_7.tsf    :
         Flow Frequency Analysis      LogPearson III Coefficients
         ------------------------------------------------------------
  Time Series File:db_7.tsf              Mean=    0.095 StdDev=  0.163
  Project Location:Sea-Tac                        Skew=  1.375
                           Frequencies & Peaks saved to File:db_7.pks    :

                         Analysis Tools Command
                         ----------------------
                         RETURN to Previous Menu
                         -----------------------

                              KCRTS Command
                              -------------
                         CREATE a new Time Series
                         ------------------------
                    Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_8.tsf
Regional Scale Factor :    1.00
          Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf    :
Till Grass            289.57 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf    :
Impervious             63.34 acres
                    --------------
        Total Area :  352.91 acres
Peak Discharge: 356.00 CFS at 11:45 on Dec 29 in 1996
                                          Storing Time Series File:db_8.tsf    :
                       Time Series Computed

                              KCRTS Command
```

```
                                   -------------
                         Enter the Analysis TOOLS Module
                         -------------------------------

                             Analysis Tools Command
                             ----------------------
                       Compute PEAKS and Flow Frequencies
                       ----------------------------------
                                          Loading Stage/Discharge curve:db_8.tsf    :
           Flow Frequency Analysis      LogPearson III Coefficients
           --------------------------------------------------------
   Time Series File:db_8.tsf            Mean=    1.764 StdDev=  0.230
   Project Location:Sea-Tac                      Skew=  1.248
                                    Frequencies & Peaks saved to File:db_8.pks    :

                             Analysis Tools Command
                             ----------------------
                             RETURN to Previous Menu
                             -----------------------

                                  KCRTS Command
                                  -------------
                            CREATE a new Time Series
                            ------------------------
                         Production of Runoff Time Series
     Project Location : Sea-Tac
      Computing Series : db_9.tsf
 Regional Scale Factor :    1.00
             Data Type : Historic
 Creating 15-minute Time Series File
                      Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf    :
 Till Grass               7.16 acres
                      Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf    :
 Impervious               8.91 acres
                        --------------
        Total Area :   16.07 acres
 Peak Discharge:  20.55 CFS at 11:45 on Dec 29 in 1996
                                               Storing Time Series File:db_9.tsf    :
                              Time Series Computed

                                  KCRTS Command
                                  -------------
                         Enter the Analysis TOOLS Module
                         -------------------------------

                             Analysis Tools Command
                             ----------------------
                       Compute PEAKS and Flow Frequencies
                       ----------------------------------
                                          Loading Stage/Discharge curve:db_9.tsf    :
           Flow Frequency Analysis      LogPearson III Coefficients
           --------------------------------------------------------
   Time Series File:db_9.tsf            Mean=    0.713 StdDev=  0.165
   Project Location:Sea-Tac                      Skew=  1.386
                                    Frequencies & Peaks saved to File:db_9.pks    :

                             Analysis Tools Command
                             ----------------------
                             RETURN to Previous Menu
                             -----------------------

                                  KCRTS Command
                                  -------------
```

```
                    CREATE a new Time Series
                    ------------------------
                 Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_10.tsf
Regional Scale Factor :    1.00
            Data Type : Historic
Creating 15-minute Time Series File
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass              7.62 acres
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious             13.31 acres
                       --------------
         Total Area :   20.93 acres
Peak Discharge:  27.99 CFS at 11:45 on Dec 29 in 1996
                              Storing Time Series File:db_10.tsf   :
                     Time Series Computed

                         KCRTS Command
                         -------------
                   Enter the Analysis TOOLS Module
                   -------------------------------

                      Analysis Tools Command
                      ----------------------
                  Compute PEAKS and Flow Frequencies
                  ----------------------------------
                           Loading Stage/Discharge curve:db_10.tsf   :
      Flow Frequency Analysis      LogPearson III Coefficients
      --------------------------------------------------------
  Time Series File:db_10.tsf           Mean=   0.873 StdDev=  0.159
  Project Location:Sea-Tac                     Skew=  1.336
                        Frequencies & Peaks saved to File:db_10.pks   :

                      Analysis Tools Command
                      ----------------------
                      RETURN to Previous Menu
                      -----------------------

                         KCRTS Command
                         -------------
                    CREATE a new Time Series
                    ------------------------
                 Production of Runoff Time Series
    Project Location : Sea-Tac
     Computing Series : db_11.tsf
Regional Scale Factor :    1.00
            Data Type : Historic
Creating 15-minute Time Series File
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass              7.09 acres
                  Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              3.85 acres
                       --------------
         Total Area :   10.94 acres
Peak Discharge:  12.39 CFS at 11:45 on Dec 29 in 1996
                              Storing Time Series File:db_11.tsf   :
                     Time Series Computed

                         KCRTS Command
                         -------------
                   Enter the Analysis TOOLS Module
                   -------------------------------
```

```
                    Analysis Tools Command
                    ----------------------
              Compute PEAKS and Flow Frequencies
              ----------------------------------
                          Loading Stage/Discharge curve:db_11.tsf   :
     Flow Frequency Analysis     LogPearson III Coefficients
     --------------------------------------------------------
  Time Series File:db_11.tsf          Mean=   0.409 StdDev=  0.188
  Project Location:Sea-Tac                    Skew=  1.462
                      Frequencies & Peaks saved to File:db_11.pks   :

                    Analysis Tools Command
                    ----------------------
                    RETURN to Previous Menu
                    -----------------------

                         KCRTS Command
                         -------------
                    CREATE a new Time Series
                    ------------------------
               Production of Runoff Time Series
   Project Location : Sea-Tac
    Computing Series : db_12.tsf
Regional Scale Factor :    1.00
            Data Type : Historic
Creating 15-minute Time Series File
             Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass             6.66 acres
             Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious             3.50 acres
                     --------------
         Total Area :   10.16 acres
Peak Discharge:  11.46 CFS at 11:45 on Dec 29 in 1996
                            Storing Time Series File:db_12.tsf   :
                    Time Series Computed

                         KCRTS Command
                         -------------
               Enter the Analysis TOOLS Module
               -------------------------------

                    Analysis Tools Command
                    ----------------------
              Compute PEAKS and Flow Frequencies
              ----------------------------------
                          Loading Stage/Discharge curve:db_12.tsf   :
     Flow Frequency Analysis     LogPearson III Coefficients
     --------------------------------------------------------
  Time Series File:db_12.tsf          Mean=   0.371 StdDev=  0.189
  Project Location:Sea-Tac                    Skew=  1.465
                      Frequencies & Peaks saved to File:db_12.pks   :

                    Analysis Tools Command
                    ----------------------
                    RETURN to Previous Menu
                    -----------------------

                         KCRTS Command
                         -------------
                    CREATE a new Time Series
                    ------------------------
               Production of Runoff Time Series
```

```
    Project Location : Sea-Tac
     Computing Series : db_13.tsf
Regional Scale Factor :    1.00
            Data Type : Historic
Creating 15-minute Time Series File
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STTG15H.rnf   :
Till Grass              1.97 acres
                    Loading Time Series File:C:\KC_SWDM\KC_DATA\STEI15H.rnf   :
Impervious              0.41 acres
                     --------------
         Total Area :    2.38 acres
Peak Discharge:   2.39 CFS at 11:45 on Dec 29 in 1996
                                        Storing Time Series File:db_13.tsf   :
                              Time Series Computed

                                  KCRTS Command
                                  -------------
                          Enter the Analysis TOOLS Module
                          -------------------------------

                              Analysis Tools Command
                              ----------------------
                         Compute PEAKS and Flow Frequencies
                         ----------------------------------
                                 Loading Stage/Discharge curve:db_13.tsf   :
          Flow Frequency Analysis      LogPearson III Coefficients
          -------------------------------------------------------
  Time Series File:db_13.tsf            Mean=  -0.415 StdDev=  0.232
  Project Location:Sea-Tac                       Skew=  1.229
                                  Frequencies & Peaks saved to File:db_13.pks   :

                              Analysis Tools Command
                              ----------------------
                              RETURN to Previous Menu
                              -----------------------

                                  KCRTS Command
                                  -------------
                                eXit KCRTS Program
                                ------------------
```

# APPENDIX C: PRELIMINARY GEOTECHNICAL INVESTIGATION BY HWA GEOSCIENCES

April 15, 2005
HWA Project No. 2005-027

**Atelier Landscape Architects**
**120 Belmont Ave East**
**Seattle, Washington 98102-5603**

Attention: Mr. Alex Shkerich

Subject: **PRELIMINARY GEOTECHNICAL INVESTIGATION**
**Burke-Gilman Trail Redevelopment**
**NE 145th Street to Logboom Park**
**King County, Washington**

Dear Alex,

This report presents our conclusions regarding potential geotechnical issues with redevelopment of the Burke-Gilman Trail along the subject section. We understand the County plans to redevelop the trail. Proposed improvements include widening the paved trail and providing a separate soft surface trail. The 2.3-mile long section of trail is located in Lake Forest Park and Kenmore, from the NE 145th Street alignment (boundary with City of Seattle) to Logboom Park in Kenmore.

Our understanding of the geotechnical issues for widening the trail in the subject section are based in part on our previous familiarity of the trail and surrounding areas, pre-design and design work conducted by HWA for other regional trails, a previous landslide study by HWA for the southern 500 feet or so of this section, and a limited reconnaissance of this section by HWA geologists on March 29, 2005.

## EXISTING SITE CONDITIONS

The trail is parallel to, and a short distance from, the northwestern shore of Lake Washington, on a former railroad right of way. The trail gradient is generally flat, and at an elevation of around 35 feet. The trail at present consists of a 10-foot wide asphalt pavement, typically with a grass shoulder on one or both sides. In most areas the grass shoulder slopes away from the pavement, at various inclinations, from flat to 3H:1V (Horizontal:Vertical). In some cases the ground slopes steeply into a ditch, starting right at edge of pavement. In general, the width of the top of the old railroad bed is on the order of 11 to 16 feet, with considerable variation in short distances along the trail.

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Houses are present adjacent to the lake side of the trail along most of the section. On the upslope side, houses are farther from the trail, though near the top of the adjacent slopes. Streets and driveways both intersect, and are in close proximity, with the trail. The topographic configuration of the trail falls under the following scenarios when headed north on the trail:

1) **Uphill cut slope on left downhill fill slope on right:** This configuration is present along the majority of the section. The uphill slopes vary from a steep, high bluff at the south end (chronic landslide area in the southern 500 or so feet), to moderately steep slopes up to 50 feet high, to 10 to 15 foot high cuts with shallow slopes. The steep cut slopes appear to be within dense to very dense soils, with a thin covering (1/2 to 1 foot) of loose soil, derived from weathering and raveling of the slope (colluvium). At higher slopes with a shallow toe adjacent to the trail, the toe consists of an accumulation of colluvium and /or slide debris. A portion of the trail has a 10 to 15 foot high slope with the 10 to 15 foot high concrete retaining wall for Bothell Way at the top. A drainage ditch is present adjacent to the trail at the toe of the uphill slope. The downhill fill slope ranges from 2 to 10 feet high, and in most cases ranges between 4 and 8 feet. Where bordered by driveways or streets, the fill is retained by some type of wall, typically a concrete block wall or rockery. Where the slope is into a yard or natural area, it typically consists of a vegetated slope at an inclination from 1½ H:1V to 3H:1V.

2) **Downhill slope on both sides:** From the vicinity of NE 170th Street northeastward to just past Ballinger Way, the adjacent ground is at approximately the same grade as, to somewhat lower than, the trail. Deep, wet ditches are present on the left side in places, and McAleer and Lyon Creeks are crossed by the trail.

## Geology

In general, the surficial geology in the study area consists of dense to very dense, glacially consolidated deposits forming the steep slopes, with loose to medium dense deposits derived from post-glacial erosion and landsliding forming colluvium in the low areas. The trail is atop the old track alignment, which is built on cuts into the dense soils and fills built over dense soils, as well as over loose colluvium, alluvium, and beach deposits.

Geologic information for the trail section was obtained from the *Preliminary Geologic Map of Seattle and Vicinity, Washington* (Waldron et al, 1962) and *Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangles, Washington (Minard, 1983).*

Various geologic units are encountered along the project corridor. Very few geologic units have precise boundaries. The geology of an area can change drastically, both horizontally and vertically, within a few feet or, in some instances, can remain fairly consistent for hundreds of feet. In general, glacially consolidated, dense to very dense deposits are present within cuts and natural slopes upslope from the trail, and colluvium, alluvium or beach deposits are present downslope from the trail.

### Geologic Hazards

The southern portion of the trail section, from NE 145$^{th}$ to approximately NE 162$^{nd}$ Street, is within a Landslide Hazard Area as mapped in the King County Sensitive Areas Map Folio.

The northern portion of the trail section, from approximately NE 162nd Street to Logboom Park, is through a Seismic Hazard Area as mapped in the folio. Seismic hazard areas are generally defined as areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. Seismically induced liquefaction typically occurs in loose, saturated, sandy material commonly associated with recent stream, lake, and beach sedimentation, as well as with loose saturated fill.

## Geotechnical Design and Construction Considerations

Redevelopment of the trail by constructing a wider paved trail and a separate soft surface trail may require widening of the existing trail bed / old railroad bed. This widening can be accomplished by placing fill on the downslope side, cutting into the upslope side, or a combination of the two. Downslope filling would, at most locations, require a retaining wall parallel to the trail due to right of way limitations. Upslope cutting would definitely require retaining walls since there is no place where the slope can be cut back to the top without impacting neighboring land. There are no significant geotechnical issues with widening in either direction. Both slope stability and drainage issues can be mitigated by proper design. However, cutting into the upslope side poses a potential liability risk. Once the toe of a steep slope is cut into, even when adequately retained, slides may still occur along the slope above and property owners might blame the cut and wall. Using the appropriate seismic design parameters in design can reduce the impact of seismic shaking on the redeveloped trail. Liquefaction susceptibility at critical structures should be identified by the geotechnical subsurface investigations during the design phase.

### Downslope Widening

Widening the trail on the downslope side can be accomplished with fill, either retained by a wall or sloped to a stable inclination. Geotechnical issues with downslope widening include the potential for differential settlement of new fill where it adjoins existing grade, which may result in pavement cracking and settling. This possibility can be prevented with design of the fill, and proper fill placement and compaction methods during construction. Also, improper placement of fill over a slope can result in slope failure. This can be prevented with proper geotechnical design of the earthwork and retaining walls, and construction methods and performance that meet the design criteria.

Widening without the need for a retaining wall may be accomplished where there is sufficient width for placement of fill with a maximum sideslope inclination of 2H:1V. Fill placement would require removal of vegetation and organic soils, and benching the existing ground such that fill can be placed on level ground in horizontal lifts.

**Upslope Widening**

Widening by cutting into the existing uphill slope is complicated by two factors:

1) Maintaining adequate surface water and ground water drainage; and
2) The potential for destabilizing the slope downhill from existing homes or driveways.

Cuts into the slope may result in needing to export unsuitable soil and needing to import structural fill and/or drainage material.

Upslope widening would likely require moving or reconfiguring the existing ditch (see the "Drainage" section below). A drainage ditch would need to be maintained at the toe of the wall. Drainage measures behind the wall would be needed to capture ground water seepage.

Wall design will need to consider the potential for seasonally high runoff and ground water seepage volumes infiltrating into the wall backfill. For slopes significantly higher than the proposed wall, it is best to avoid cutting the wide footprint needed for an MSE or gravity wall. Soldier pile and lagging walls are preferable for such cuts, as the piles can be installed prior to cutting the slope, and the cut will only extend horizontally to between the piles, reducing potential impacts to the slope. For cuts that will be as high as the slope, or most of the height (e.g. steep slopes 10 feet high or less, with flat or gently sloping ground above), gravity walls could be considered. Concrete cantilevered walls may be suitable in this situation as well.

**Potential Retaining Walls**

There are numerous types of walls, each with its own advantages and disadvantages, depending on engineering considerations such as retained earth properties, foundation conditions, height, construction access and water. Outside influences such as property ownership, cost, and aesthetics are also factors.

**Gravity Walls:** There are many readily available alternatives for gravity walls. Some of the more common types include filled units such as gabion baskets; segmental concrete units such as Ultra-block, Lock-Block, or ecology blocks, and large rocks (rockeries). These walls are typically excavated in short segments (along the length of the wall) and the units are then placed with compacted backfill behind the wall. This type of wall is particularly well suited to areas with a minimum backslope and space for construction behind the wall. Stability of these walls depends on the inherent stability of the cut slope, e.g. slopes with stability issues should not be retained with gravity walls.

**Mechanically Stabilized Earth (MSE) Walls:** MSE walls include any wall that relies upon the interaction between a mechanical device (such as geogrid) and the soil to stabilize the soil and allow it to stand near vertical. A common type of MSE wall is a geogrid reinforced segmented masonry unit (SMU) wall such as Mesa, Lock-Block, or Keystone. The wall site is prepared by clearing and grubbing the wall and fill footprint. If unsuitable soils are exposed at the wall footing, they are removed and replaced with structural fill. Generally the over-excavation is limited to immediately under the footprint of the wall. If the wall footing is in a low-lying area, localized dewatering, typically with sumps and pumps in the excavation, may be required.

One of the requirements for MSE walls is the need for adequate room behind the wall to lay out the reinforcing. For some of the potential wall locations, additional room may need to be created (i.e., soil removed) in order to install the reinforcing. Alternatively, anchors are sometimes used to hold the back of short reinforcing. Generally, the reinforcing is tied into the facing units and holds the facing up. The sequence for construction can involve placing the reinforcing, backfilling and compacting a lift of fill, placing another layer of reinforcing, tying it into the facing, backfilling on top of the second layer of reinforcing, and repeating.

MSE walls are particularly well suited for use as high walls where there is, or can easily be made, a wide bench on which to construct the wall. They will work under some circumstances where the foundation soils are marginal. Advantages of MSE walls include non-specialized construction, neat appearance, and ability to withstand differential settlement without failure. Disadvantages include the need for placing geogrid behind the blocks a distance equal to about 3/4ths the height of the wall. This would require excavating into the existing fill embankment or cut slope. For higher downslope walls, the excavation may extend into existing utilities within the trail bed. For less than about 3 feet in total height, it may be possible to eliminate the geogrid.

**Concrete Cantilever Walls:** Cantilever walls are constructed by building a concrete structure on a prepared surface and backfilling behind. They are particularly well suited for low walls where the foundation conditions are good. The necessary footprint behind the wall is typically narrower than for an MSE or gravity wall.

**Soldier Pile and Lagging Walls:** Soldier pile and lagging walls are constructed by installing vertical soldier piles and then placing lagging to hold back the soil between the piles. These walls derive their support from lateral pressure on the soldier piles below the front of the wall. They are particularly appropriate where there is limited area for structure behind the wall face. They can be constructed from either the top or bottom of the wall so the disturbance on the other side can be minimized. The soldier piles are usually either driven, auger-cast or cast in place piles placed on 4 to 8-foot spacing. Driven piles are usually H-piles. Driven piles can create construction vibrations and possibly settlement near the pile. Auger-cast and cast in place piles are drilled and cause less vibration. If necessary, the hole may be cased with the auger, a steel pipe, or filled with drilling fluid. Drilling fluid is usually a naturally occurring bentonite clay-based mud. Steel, usually an H-pile, is placed in the augured hole and structural concrete is tremied down, as the casing is lifted or the drill fluid is displaced. If drilling mud is used, there is a discharge of bentonite mud in a contained area on the ground surface that must be removed.

**Sheet Pile Walls**: Sheet pile walls may be used if the ground is soft. The sheet piles are usually driven with a vibratory hammer which creates significant vibration.

### Drainage

Existing ditches may need to be partially filled in some areas. In many areas, slough and eroded soils that have partially filled the ditch will need to be removed to obtain the preferred ditch geometry. In either case, the adequacy of surface water drainage along the trail vicinity will depend on maintaining the ditches at the preferred depth range. Subgrade strength and therefore integrity of the trail pavement will also depend on keeping the trail bed in an unsaturated condition to a minimum of about 18 inches below pavement finish grade.

We recommend that ditch fill consist of compacted, structural fill. Prior to placement of the fill, existing vegetation, organic soils, and slough should be removed from the ditch. Structural fill for the new ditch bottom should then be placed and compacted in horizontal lifts. Fill placed for shallower sideslopes should be overbuilt, then trimmed to a 2H:1V inclination, and protected with long-term erosion control measures.

### Existing Landslide Area

The existing slide area at the southern end of the section exhibits the worst case scenario. A cut into this slope should only be retained by a soldier pile wall, possibly with tiebacks, and would need some regrading of the slope above and structural fill placement behind the wall to improve stability of the slope (per our report dated 2/18/02). Cutting into this slope and constructing a retaining wall would not result in decreased slope stability; nor would the wall prevent future slides coming down from above.

### Bridges

The existing bridges over McAleer and Lyon Creeks have decks that are 12 and 8 ½ feet wide, respectively. Either the bridge structures would need to be rebuilt wider over the existing foundations, or the bridges would need to be completely rebuilt. If new foundations are necessary, the bridge foundations may be either driven, auger-cast, or cast in place piles. The driven piles could be H-piles, pipe piles, timber piles, or pre-cast concrete piles. Selection of pile type, size, and spacing would depend upon the soil properties, potential for obstructions, design loads, and availability of construction equipment and materials. Impacts from driving piles would be vibrations and noise. Driving piles requires large construction equipment and a laydown area nearby. The biggest impact of constructing auger cast or cast in place piles is the removal and disposal of native materials and perhaps drilling mud.

### Pavements

Settled pavements were observed in a few areas, within the outer couple of feet of the downslope side of the trail, in a linear fashion – e.g, settlement appears to have occurred along utility trench backfill. The potential for differential settlement between new fill and existing trail grade can be reduced by removing all of the old pavement, and proof-rolling to identify any soft areas (which can be improved by over-excavation and replacement with structural fill).

Access to, and along, the existing trail with dump trucks and heavy equipment will need to be considered. Pavements on the existing trail, as well as streets and driveways used for access, are likely to experience distress from construction traffic.

## LIMITATIONS

We have prepared this preliminary report for Atelier Landscape Architects and King County Parks for use in pre-design of a portion of this project. Experience has shown that soil and ground water conditions can vary significantly over small distances and there was no subsurface exploration done for this study. Therefore variations from the information presented herein should be expected.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, expressed or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site.

We appreciate this opportunity to be of service.

**HWA GEOSCIENCES INC.**

Brad W. Thurber, L.E.G.
Engineering Geologist

Thomas C. Kinney, PhD, P.E.
Vice President

BWT:TCK:bwt

# APPENDIX D: REPORT OF PREDESIGN GEOTECHNICAL SERVICES BY ZIPPER ZEMAN ASSOICATES, INC.

**ZZA Zipper Zeman Associates, Inc.**
Geotechnical and Environmental Consulting
A Terracon Company

J-2367
May 30, 2006

MacLeod Reckord
231 Summit Avenue East
Seattle, Washington 98102

Attention: Mr. Terry Reckord

Subject: Report of Predesign Geotechnical Services
Burke-Gilman Trail Redevelopment
King County, Washington
King County Contract No. E53012E

Dear Mr. Reckord:

We are pleased to submit 3 copies of our report of geotechnical services for the Burke-Gilman Trail Redevelopment in King County, Washington.

Our services were completed in accordance with the work plan outlined in Attachment A of the Professional Services Agreement Contract between Macleod Record and ZZA (as amended by our Recommended Modifications to Work Plan letter dated May 9, 2006), and King County Contract No. E503012E. Preliminary results of this investigation were provided to you as information became available.

We appreciate the opportunity to provide geotechnical services on this project. Please contact us if you have any questions regarding this report or if we can provide assistance with other aspects of the project.

Sincerely,
**Zipper Zeman Associates, Inc.**

James P. Georgis, L.E.G.
Project Geologist

James B. Thompson, Ph.D., P.E.
Principal

18905 33rd Avenue West #117, Lynnwood, WA 98036 (425) 771-3304 Fax: (425) 771-3549

# Zipper Zeman Associates Inc.

Geotechnical & Environmental Consulting

A Terracon Company

## Report of Predesign Geotechnical Services

Burke-Gilman Trail Redevelopment

King County, Washington

May 30, 2006

MacLeod Reckord

Landscape Architects

KING COUNTY

DEPARTMENT OF PARKS, CULTURAL AND NATURAL RESOURCES

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# REPORT OF PREDESIGN GEOTECHNICAL SERVICES
# BURKE-GILMAN TRAIL REDEVELOPMENT
# KING COUNTY, WASHINGTON

## INTRODUCTION

This report presents the results of our predesign geotechnical services for the proposed Burke-Gilman Trail Redevelopment in King County, Washington. The planned trail redevelopment includes widening the asphalt surfaced portion of the trail to approximately 12 feet and providing 1-foot and 3-foot wide gravel shoulders on the left and right sides (looking upstation) of the trail, respectively.

The purpose of our services has been to observe surface conditions and review existing geologic and geotechnical literature relative to subsurface soil and groundwater conditions in the vicinity of the trail redevelopment area in order to formulate predesign geotechnical recommendations and criteria for use by others in schematic trail design and cost estimating. Our services included a literature review, site reconnaissance, geotechnical engineering analysis, and preparation of this report. These services were completed in accordance with the work plan outlined in Attachment A of the Professional Services Agreement Contract between Macleod Record and ZZA (as amended by our Recommended Modifications to Work Plan letter dated May 9, 2006), and King County Contract No. E503012E.

## PROJECT DESCRIPTION

The trail corridor planned for redevelopment is about 2 miles long and located in portions of Sections 10, 11, and 15 of Township 26 North, Range 4 East in the City of Lake Forest Park. The southern end of the trail redevelopment (Station 0+00) is located at the boundary between the City of Seattle and the City of Lake Forest Park, near the east-west alignment of NE 145$^{th}$ Street. The northern end of the trail redevelopment (Station 104+40) is located near the west side of Log Boom Park. The approximate location of the trail redevelopment area is shown on the Site Vicinity Map, Figure 1.

The orientation of the Burke-Gilman trail within the redevelopment area varies from roughly north-south to approximately east-west making the description of site features relative to cardinal directions confusing. Therefore, we have described site features in terms of trail Station number and the feature's location right, center, or left of the trail alignment looking upstation. The location of the existing trail, surrounding site features and topography, and the trail redevelopment Station alignment are shown on Figure 2 (sheets L1.0 through L20.0).

In general, the existing asphalt trail within the redevelopment area is about 10 feet wide. The trail generally includes dirt shoulders and has discontinuous gravel shoulders up to about 2 feet wide. We understand that the trail redevelopment includes widening the asphalt surfaced portion of the trail to approximately 12 feet and providing 1-foot and 3-foot wide gravel shoulders on the left and right sides of the trail, respectively. We understand that the trail redevelopment may also include the following items in support of trail widening.

- Repaving or overlaying the existing 10 foot wide asphalt trail.
- Constructing new bridges to replace the existing McAleer and Lyon Creek pedestrian bridges.
- Replace existing retaining walls that are considered to be in poor condition and/or inadequate to support surcharge loads imposed by the new trail configuration.
- Construct additional retaining walls in new locations, as needed, to support cuts and fills associated with the new trail configuration.
- Install new culverts and/or modify existing culverts that cross the trail alignment.
- Implement trial protection and/or stabilization measures in areas of recent slope instability.

## SITE CONDITIONS

### GENERAL

ZZA completed a reconnaissance of the trail redevelopment area and immediate vicinity in April and May of 2006. Our reconnaissance included observations of surficial geologic conditions as well as existing trail, bridge, and trail-side retaining wall conditions. A summary of our observations is presented below.

### SURFACE CONDITIONS

#### General

The Burke-Gilman trail is constructed on a former railroad embankment and is located a short distance from the northwestern shore of Lake Washington within the redevelopment area. The trail gradient is relatively flat and ranges from about elevation 30 to 36 feet. In the southern and northern portions of the alignment (Station 0+00 to 51+00 and Station 83+50 to 104+40), the embankment is located near the toe of steep to moderately steep slopes. In these areas, the embankment appears to be of side-cast construction, where the left portion of the alignment is cut into the slope and the right potion of the alignment consists of fill derived from the cut. The central portion of the alignment (Station 51+00 to 83+50) is located within a relatively flat alluvial valley and crosses McAleer Creek and Lyon Creek by means of pedestrian bridges.

The existing asphalt surface trail is about 10 feet wide and has discontinuous grass and gravel shoulders on one or both sides of the trail. In general, the width of the old railroad bed appears to range from about 11 to 18 feet. A system of drainage ditches is located along the left side of the trail and existing retaining walls are located on both sides of the trail, although the majority of the walls in close proximity to the trail are located on the right side.

Single-family residences are located on both sides of the trail along most of the alignment. In general, the houses on the right side of the trail are closer to the trail. The houses on the left side of the trail are typically constructed near the top of the moderately steep to steep slopes located along the left side of the trail in the southern portion of the trail alignment. Residential streets and driveways intersect and parallel portions of the trail alignment.

Existing site features including roads, residential structures, bridges, and retaining walls are shown on Figure 2. More detailed descriptions of existing retaining walls, bridges, trial conditions, areas of obvious slope instability, and wet soil conditions and surface water are presented below and in Tables 2 through 6.

**Retaining Walls**

There are approximately 13 and 42 existing retaining walls located on the left and right sides of the trail alignment, respectively. Existing wall types include rockery walls, cast-in-place concrete walls, timber pile walls, soldier pile walls, mechanically stabilized earth walls, modular block walls, timber crib walls, and railroad tie walls. Our reconnaissance included observations of the existing walls and an evaluation of wall conditions. A summary of our observations is presented in Tables 2 and 3.

**McAleer Creek Bridge**

The trail crosses McAleer Creek by means of a pedestrian bridge at about Station 67+50. The existing bridge is of steel construction with a concrete deck and is supported on concrete abutments. The bridge is about 12 feet wide and has a clear span of about 40 feet. The concrete abutments and bridge span appeared to be in serviceable condition with no obvious indications of distress. A high-flow bypass structure and rockery wall are located near the north side of the east bridge abutment.

**Lyon Creek Bridge**

The trail crosses Lyon Creek by means of a pedestrian bridge at about Station 78+15. The existing bridge span is constructed of timber with an asphalt surface. The bridge has a clear span of about 20 feet and is supported on driven timber piles. The timber piles appeared to be treated with creosote. In general, the visually observable portions of the bridge span and timber piles appeared to be in serviceable condition. The bridge approach fills are retained by timber lagging placed behind the driven timber abutment piles. The timber lagging appeared to be in serviceable condition at both abutments. However, the east abutment lagging has been undermined by creek scour and voids have developed within the approach fill.

**Wet Soil Conditions and Surface Water**

A system of drainage ditches is located along the left side of the trail over the majority of the alignment. These ditches appear to primarily receive water from overland flow, groundwater seepage, and from pipes and culverts servicing upgradient developed areas. Our reconnaissance included observations of wet soil conditions and surface water in the vicinity of the trail alignment. The reconnaissance disclosed numerous areas of wet soil and standing water along the alignment. The most extensive wet areas were located between Station 0+00 and 6+50 and Station 31+10 and 48+30. The southern area exhibited wet soil conditions, surface water within the trail side ditch, and obvious indications of groundwater seepage. The northern area also exhibited wet soil conditions and surface water in the trail side ditches. However, it appeared that a significant portion of the surface water in this area was conveyed to the ditches by existing pipes and culverts. A summary of our observations is presented on Tables 4 and 5. These tables include smaller areas of wet soil and surface water not discussed above.

### Areas of Obvious Slope Instability

The existing trail was constructed on a former railroad embankment and the surrounding areas have undergone extensive development. The construction of the railroad embankment and development of the surrounding area have altered the original ground topography and vegetation. This alteration has eliminated many of the geomorphic features that could be used to assess past slope instability. However, our reconnaissance did identify two areas that exhibit obvious indications of past slope instability and one area that exhibits indications of past and recent instability.

Areas of past slope instability were observed on the left side of the trail between Station 6+80 and 16+60 and Station 91+00 and 92+80. Indications of past and recent slope instability were observed on the left side of the trail from Station 0+00 to about Station 6+80. Detailed descriptions of these areas are presented on Table 6 of this report.

### Trail Condition

In general, the existing asphalt trail appears to be in serviceable condition. We did not observe any obvious or extensive areas of distress such as "alligator" cracking or en-echelon cracks that are sometimes indicative of yielding subgrade conditions or embankment instability, respectively. However, localized areas of distress interpreted as tree root damage were observed along much of the alignment. The observed root damage typically consisted of cracks and ridges in the asphalt surface.

## GEOLOGIC CONDITIONS

### General

The project site is located within the Puget Lowland near the northwestern shoreline of Lake Washington. The Puget Lowland is a north-south trending depression bounded on the east and west by the Cascade and Olympic mountain ranges, respectively. The topography and geology of the Puget Lowland are a direct result of several cycles of regional glaciation during the Pleistocene epoch. The most recent cycle of glaciation, known as the Vashon Stade of the Fraser Glaciation, ended approximately 13,500 years ago. The Vashon Stade is believed to have covered the Puget Lowland with up to 3,000 feet of glacial ice in the deeper portion of the Lowland.

Most of the Puget Lowland, including the project area, is underlain by a thick, complex sequence of Quaternary age sediments deposited by continental glacial advance and recession. These sediments overly Tertiary age bedrock of sedimentary and igneous origin. Sediments deposited during periods of glacial advance were densely compacted by the weight of the glacial ice. Looser, unconsolidated sediments were deposited during periods of glacial retreat.

Geologic conditions in the northern portion of the trail alignment were assessed by reviewing the *Composite Geologic Map of the Sno-King Area, Central Puget Lowland, Washington, 2004*. This map was produced by a joint effort between the Seattle-Area Geologic Mapping Project, the University of Washington, and the United States Geologic Survey. The *Geologic Map of the Edmonds East and part of the Edmonds West Quadrangles, Washington* (USGS Map MF 1541, 1983) was also reviewed relative to geologic conditions in the northern portion of the trail alignment. Geologic conditions in the southern portion of the trail alignment were primarily assessed by reviewing the *Geologic Map of Seattle, Washington* (USGS Open File Report 2005-1252). This report was prepared by the USGS in cooperation with the City of Seattle and the University of Washington.

Based on the mapped geologic conditions and our reconnaissance level site observations, we have divided the trail alignment into four geologic domains. A generalized description of the geologic conditions in each area is presented below.

**Station 0+00 to 40+00**

From Station 0+00 to about Station 40+00, the trail alignment is located near the toe of a moderately steep to steep east-facing slope. In general, the ground surface to the right of the trail embankment slopes gently towards Lake Washington. The steep slope to the left of the trail is primarily mapped as Quaternary age undifferentiated pre-Fraser sediments (Qpf). These deposits are described as interbedded sand, gravel, silt, and diamict (till). The deposits have been glacially overridden and are generally dense to hard in their undisturbed state. The gently sloping area to the right of the trial embankment is mapped as Quaternary lake deposits (Ql). These deposits are described as silt and clay with local sand layers, peat, and other organic sediments. The lake deposits were exposed by the lowering of Lake Washington around 1916.

Numerous indications of past slope instability and several areas of recent slope movement were observed on the steep slope on the left side of the trail in this area. Based on our observations, we anticipate that the mapped pre-Frasier deposits are overlain by colluvial soils of an indeterminate depth. The trail embankment (former railroad bed) appears to be of side-cast construction, where the left portion of the alignment is cut into the slope and the right potion of the alignment consists of fill derived from the cut. We anticipate that much of the trial embankment in this section is composed of fill and colluvium.

**Station 40+00 to 51+00**

From about Station 40+00 to about Station 51+00, the trail alignment is located near the toe of a moderately steep east-facing slope. In general, the ground surface to the right of the trail embankment slopes gently towards Lake Washington. The moderately steep slope to the left of the trail is primarily mapped as Quaternary recessional outwash (Qvr). The recessional outwash is described as moderately sorted to well sorted, stratified sand and gravel with some silty sand and silt. The outwash was deposited as the Vashon glacier retreated and has not been glacially overridden. The gently sloping area to the right of the trial embankment is mapped as Quaternary lake deposits (Ql). These deposits are described as silt and clay with local sand layers, peat, and other organic sediments.

The trail embankment (former railroad bed) appears to be of side-cast construction, where the left portion of the alignment is cut into the slope and the right potion of the alignment consists of fill derived from the cut. We anticipate that much of the trial embankment in this section is composed of recessional outwash and fill.

**Station 51+00 to 83+50**

From about Station 51+00 to about Station 83+50, the trail alignment is located within an area that slopes gently towards Lake Washington. Some moderately steep slopes are located to the left of the trail in the southern portion of this section. In general, this section of the alignment is mapped as Quaternary lake deposits (Ql) and Quaternary older alluvium (Qoal). The lake deposits are described as silt and clay with local sand layers, peat, and other organic sediments. The older alluvium is described as sand and gravel with some sandy, pebbly, organic rich silt. Portions of the trail embankment (former railroad bed) in this area are slightly higher then the surrounding area and probably includes some fill soils along with the mapped geologic units.

**Station 83+50 to 104+40**

From about Station 83+50 to about Station 104+40, the trail alignment is located near the toe of a moderately steep slope. In general, the ground surface to the right of the trail embankment slopes gently towards Lake Washington. The moderately steep slope to the left of the trail is primarily mapped as Quaternary older alluvium (Qoal). The older alluvium is described as sand and gravel with some sandy, pebbly, organic rich silt. The gently sloping area to the right of the trial embankment is mapped as Quaternary lake deposits (Ql). These deposits are described as silt and clay with local sand layers, peat, and other organic sediments.

The trail embankment (former railroad bed) appears to be of side-cast construction, where the left portion of the alignment is cut into the slope and the right potion of the alignment consists of fill derived from the cut. We anticipate that much of the trial embankment in this section is composed of fill and the mapped alluvial and lake deposits.

## CONCLUSIONS AND RECOMMENDATIONS

### GENERAL

It is our opinion that the proposed Burke-Gilman Trail Redevelopment is feasible from a geotechnical perspective. The following sections of this report present predesign geotechnical recommendations and criteria for use by others in schematic trail design and cost estimating. Our recommendations are divided into 7 primary categories which include; Geologic Hazard Areas; Preferred Trail Alignment; Trail Subgrade Considerations; Landslide Area Considerations; Retaining Wall Considerations; Bridges; and Culverts.

## GEOLOGIC HAZARD AREAS

### General

ZZA completed an evaluation of the surface conditions observed along the trail redevelopment area and published geologic maps and geotechnical reports for the project vicinity relative to Geologic Hazard Areas as defined in Chapter 16.16 *Environmentally Sensitive Areas* of the City of Lake Forest Park Municipal Code. Chapter 16.16 was adopted by the City on December 1, 2005 through Ordinance No. 930 and replaced Chapters 16.16 and 16.18 of the City Municipal Code. A summary of our findings and recommendations relative to Erosion Hazard Areas, Steep Slope Areas, Landslide Hazard Areas, and Seismic Hazard Areas are presented in the following sections.

### Erosion Hazard Areas

Erosion Hazard Areas are defined by Chapter 16.16.040 of the City Municipal Code as those areas containing soils which, according to the USDA Soil Conservation Service, may experience severe to very severe erosion hazard, including slopes greater than 15 percent with exposed erodible soils. Soils which are considered by the City to be particularly susceptible to erosion include fill soils of virtually all soil types, loose sandy soils such as Vashon recessional outwash (Qvr), Esperance sand (Qe), weathered Vashon till (Qvt), and dense fine-grained clay (Qcl).

We reviewed the *Soil Survey of King County Area, Washington* (November 1973) and *Soil Survey of Snohomish County Area, Washington* (July 1993) prepared by the USDA Soil Conservation Service relative to mapped soil types along the trail alignment. The referenced publications do not include soil mapping or soil descriptions for the project area due to the developed nature of the area.

Our reconnaissance level observations and geologic map review suggest that the majority of the trail alignment and near surface soils on the adjacent slopes are primarily composed of fill, colluvium, recessional outwash, alluvium, and lake deposits. We therefore recommend that all areas disturbed by the trail redevelopment with slope inclinations greater than 15 percent be considered Erosion Hazard Areas. Development standards for Erosion Hazard Areas are presented in Chapter 16.16.280 of the City Municipal Code.

Based on our observations, it is our opinion that trail redevelopment within site Erosion Hazard Areas is geotechnically feasible provided that a temporary sediment and erosion control plan implementing Best Management Practices is developed to minimize erosion from disturbed areas with preventative measures. Preventative temporary erosion control measures may include, but are not limited to, silt fences, straw waddles, gravel check dams, sedimentation ponds, plastic sheeting on temporary construction slopes during wet weather, or other measures approved by the City planning department. It should be noted that development standards for Erosion Hazard Areas (Chapter 16.16.280 of the City Municipal Code) restrict site clearing between April 1 and September 30.

We recommend that permanent vegetation be established as soon as feasible and within one growing season. Permanent revegetation may include the use of hydroseed. Revegetation of permanent slopes steeper than 3H:1V may be enhanced through the use of rolled erosion control and root reinforcement materials such as Jute matting or Curlex II.

**Steep Slope Hazard Areas**

Steep Slope Hazard Areas are defined by Chapter 16.16.040 of the City Municipal Code as those areas not composed of consolidated rock with slope gradients of 40 percent or greater and with a vertical elevation change of at least 10 feet. Based on our observations and review of published geologic maps, it is our opinion that consolidated rock is not present near the ground surface along the trail alignment or on the adjacent slopes. We therefore recommend that slopes within and adjacent to the trail redevelopment area that exhibit inclinations of 40 percent or greater and at least 10 feet of relief be considered Steep Slope Hazard Areas. Development standards for Steep Slope Hazard Areas are presented in Chapter 16.16.310 of the City Municipal Code. Some of the development standards from Chapter 16.16.310 that appear most applicable to the trail redevelopment project are presented below. Please refer to Chapter 16.16.310 for a complete listing of development standards.

Section 16.16.310, Subsection A indicates that a minimum buffer shall be established at a horizontal distance of 50 feet from the top, toe, and along all sides of any slope 40 percent or greater. The buffer may be reduced to a minimum of 25 feet when a qualified professional demonstrates to the Planning Director's satisfaction that the reduction will adequately protect the proposed development, adjacent developments, and uses, and the Steep Slope Hazard Area.

Section 16.16.310, Subsection A, Number 2 indicates that removal of existing vegetation from a Steep Slope Hazard Area or buffer is prohibited unless otherwise provided for in an approved alteration plan.

Section 16.16.310, Subsection B, Number 2 indicates that approval of public and private trails may be allowed on steep slopes subject to compliance with recognized construction and maintenance standards. Construction of impervious surfaces, such as asphalt and concrete, that would contribute to surface water runoff, is prohibited unless the applicant demonstrates to the satisfaction of the Planning Director such action is necessary for soil stabilization or prevention of soil erosion.

Section 16.16.310, Subsection C, Number 1 indicates that alteration of slopes that are 40 percent or steeper with a vertical elevation change of up to 20 feet may be permitted provided that, a soils report prepared by a qualified professional satisfies the Planning Director that no adverse impact will result from the exception.

Section 16.16.310, Subsection C, Number 2 indicates that any slope that was created through legal grading activities may be regraded as part of an approved development plan; provided that, any slope that remains 40 percent or steeper following site development shall be subject to all requirements for steep slopes.

Section 16.16.310, Subsection D, indicates that when steep slope alterations are allowed under Section 16.16.310, subsections A through C, the proposal shall:

- Not decrease the slope stability on the site or on adjacent properties; and
- Be subject to certification by a qualified professional that the landslide hazard area can be modified safely or that the development proposal eliminates or mitigates the landslide hazard risk to the property or adjacent property; and
- Not adversely impact other sensitive areas, such as streams; and
- Not result in an increase in peak surface water flows or sedimentation to adjacent properties.

Given the conceptual nature of the project and the lack of a grading plan, it is not geotechnically feasible to fully address these Steep Slope Hazard concerns at this time. However, we anticipate that it will be feasible to meet the geotechnical requirements of Section 16.16.310, Subsection D during the design phase of the project.

In addition to the Steep Slope Hazard Area and buffer area exceptions outlined above, Chapter 16.16.220 of the City Municipal Code outlines projects and/or activities that are exempt from the regulations of Chapter 16.16. Chapters 16.16.230 through 16.16.260 outline additional exceptions to the development standards of Chapter 16.16 and allow work within sensitive areas and buffers. In particular, Chapter 16.16.230, Subsection 4 allows for activities within the improved right-of-way and Chapter 16.16.260 allows an exception for developments proposed by public agencies or public utilities.

We anticipate that some of the exemptions and/or exceptions presented in Chapters 16.16.220 through 16.16.260 may be applicable to the planned trail redevelopment. However, it appears that the Exemptions and Exceptions presented in the referenced sections of the Code are subject to interpretation and approval by the City Planning Director. We therefore recommend that the design team meet with the Planning Director early in the project to help define the standards to which the project will be subject.

**Landslide Hazard Areas**

Landslide Hazard Areas are defined by Chapter 16.16.040 of the City Municipal Code as a slope that is potentially subject to landslides. All Landslide Hazard Areas are classified as:

A. Class I: A slope that is less than 15 percent and is considered relatively stable;
B. Class II: A slope that is greater than 15 percent and is underlain by permeable soils that are relatively stable in their natural state but may become unstable if slope configurations or drainage conditions are modified;
C. Class III: A slope that is greater than 15 percent and is underlain by impermeable soils, and may be characterized by springs or seeping groundwater during the wet season.

Landslide Hazard Areas include Class II and Class III if any of the following are present:

1. Any area that has shown movement during the Holocene epoch (from 10,000 years ago to present) or which is underlain by significant waste debris of that epoch; or
2. An area potentially unstable on an alluvial fan or delta potentially subject to inundation by debris flows; or
3. An area with a slope of 40 percent or greater and with a vertical relief of 10 or more feet except an area composed of consolidated rock.

Our reconnaissance of the trail alignment included observations of groundwater seepage zones and site features suggesting past and recent slope instability. Based on our reconnaissance level observations and review of published geologic maps, we recommend that slopes within and adjacent to the trail redevelopment area from Station 0+00 to about 50+00 and from about Station 91+00 to about 92+80 with slope inclinations greater than 15 percent be considered Landslide Hazard Areas. This designation is primarily due to the interbedded nature of the mapped geologic unit, observed groundwater seepage, and our observations which suggest that the slopes may be mantled by significant deposits of colluvium. The extent of the recommended Landslide Hazard Area is in general accordance with the mapped Steep Slope and Landslide Areas presented on Map 4 of the City of Lake Forest Park Comprehensive Plan. Development standards for Landslide Hazard Areas are presented in Chapter 16.16.290 of the City Municipal Code. Some of the development standards from Chapter 16.16.290 that appear most applicable to the trail redevelopment project are presented below. Please refer to Chapter 16.16.290 for a complete listing of development standards.

Section 16.16.290, Subsection A indicates that a minimum 50 foot buffer shall be established from all sides of a Landslide Hazard Area. Buffer widths shall be extended or adjusted as needed to mitigate a steep slope or erosion hazard or to promote the health and safety of the public. The buffer may be reduced to a minimum of 25 feet when a qualified professional demonstrates to the Planning Director's satisfaction that the reduction will adequately protect the proposed development, adjacent developments, and uses, and the Landslide Hazard Area.

Section 16.16.290, Subsection B indicates that vegetation may not be removed from a Landslide Hazard Area or buffer unless permitted by a sensitive area permit.

Section 16.16.290, Subsection D indicates that permitted alterations to landslide hazards areas and buffers are only allowed as follows;

1. Landslide Hazard Areas located on slopes of 40 percent or steeper may only be altered if the alteration meets the standards and limitations established for Steep Slope Hazard Areas;
2. Alteration of Landslide Hazard Areas located on slopes less than 40 percent are permitted only under the following conditions and circumstances:
   A. The development proposal will not decrease slope stability on the site or on adjoining properties; and
   B. A licensed geologist or geotechnical engineer certifies that the Landslide Hazard Area can be safely modified or the development proposal designed so the landslide hazard risk to the property or adjacent properties is eliminated or mitigated;

C. The alteration will not adversely impact other sensitive areas, such as streams; and
D. The alteration will not result in an increase in peak surface water flow or sedimentation to adjacent properties.

3. Where such alterations are approved, buffers may not be required.

Given the conceptual nature of the project and the lack of a grading plan, it is not geotechnically feasible to fully address these Landslide Hazard concerns at this time. However, we anticipate that it will be feasible to meet the geotechnical requirements of Section 16.16.290, Subsection D during the design phase of the project.

In addition to the Landslide Hazard Areas and buffer area exceptions outlined above, Chapter 16.16.220 of the City Municipal Code outlines projects and/or activities that are exempt from the regulations of Chapter 16.16. Chapters 16.16.230 through 6.16.260 outline additional exceptions to the development standards of Chapter 16.16 and allow work within sensitive areas and buffers. In particular, Chapter 16.16.230, Subsection 4 allows for activities within the improved right-of-way and Chapter 16.16.260 allows an exception for developments proposed by public agencies or public utilities.

We anticipate that some of the exemptions and/or exceptions presented in Chapters 16.16.220 through 16.16.260 may be applicable to the planned trail redevelopment. However, it appears that the Exemptions and Exceptions presented in the referenced sections of the Code are subject to interpretation and approval by the City Planning Director. We therefore recommend that the design team meet with the Planning Director early in the project to help define the standards to which the project will be subject.

### Seismic Hazard Areas

Seismic Hazard Areas are defined by Chapter 16.16.040 of the City Municipal Code as those areas underlain by low-strength fill and flood plain deposits with soil and groundwater conditions that are more susceptible to seismic hazard than other areas.

Our reconnaissance level observations and reviewed geologic maps of the area suggest that the majority of the trail alignment and near surface soils in the immediate vicinity from about Station 51+00 to 104+40 are primarily composed of fill, alluvium, and lake deposits. Given the low-lying nature of the trail in this portion of the alignment, we anticipate that near surface groundwater may be present and that these soils may be susceptible to liquefaction during a design seismic event. We therefore recommend that the alignment from about Station 51+00 to 104+40 be considered a Seismic Hazard Area. Development standards for Seismic hazard Areas are presented in Chapter 16.16.300 of the City Municipal Code.

## PREFERRED TRAIL ALIGNMENT

Based on geotechnical site conditions observed during our reconnaissance of the trail redevelopment area and our review of readily available geotechnical reports and geologic maps, we have developed alignment recommendations for the proposed trail widening. Our recommendations are presented in Table 1 and are arranged into Station intervals. Please note that these recommendations are based on geotechnical considerations. We anticipate that the final trail location will be a compromise between geotechnical considerations and other factors including, but not limited to, the location of the trail easement, the location of adjacent private properties, the location of sensitive areas such as wetlands and streams, public input, and regulatory requirements.

## TRAIL SUBGRADE CONSIDERATIONS

### General

We understand that the trail redevelopment includes widening the existing 10 foot wide asphalt surfaced portion of the trail to approximately 12 feet and providing 1-foot and 3-foot wide gravel shoulders on the left and right sides of the trail, respectively. Predesign level recommendations for the trail redevelopment are presented below under the following headings: Earthwork Considerations; Drainage Considerations; and Construction Consideration.

### Earthwork Considerations

<u>General</u>

Preliminary recommendations for use in the development of schematic trail layouts and cost estimates have been developed by ZZA based on our reconnaissance level site observations and limited literature review. Our recommendations are presented below under the following headings: Site Preparation; Structural Fill; and Permanent Cut and Fill Slopes.

<u>Site Preparation</u>

Site preparation should include the removal of all vegetation, root mass, organic soils, existing structures, and any deleterious debris from the planned trail alignment, or those locations where "structural fill" is to be placed. Preparation for site grading and construction should begin with procedures intended to drain ponded water and control surface water runoff. It will not be possible to successfully utilize on-site soils as "structural fill" if accumulated water is not drained prior to grading, or if drainage is not controlled during construction. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use, increase the amount of select import fill materials required, and ultimately increase the cost of the earthwork.

Following clearing and grubbing, organic-rich topsoil will need to be stripped along the planned trail alignment, as well as those areas to receive structural fill. The extent and thickness of topsoil within the trail redevelopment area is uncertain at this time and is expected to be variable. Any excavations that extend below finish grades should be backfilled with structural fill as outlined subsequently in this report. In our opinion, topsoil is not suitable for reuse as structural fill and should therefore be exported from the site or used for landscaping purposes.

After stripping of topsoil is completed, the exposed soils are anticipated to consist primarily of fill soils derived from variable parent geologic deposits. We anticipate that much of the fill will have moderate to high fines contents. After stripping, and prior to placement of structural fill, we recommend that pavement subgrade areas, and areas to receive structural fill be proofrolled and compacted to a firm and unyielding condition in order to achieve a minimum compaction level of 95 percent of the modified Proctor maximum dry density as determined by the ASTM:D-1557 test procedure. Due to the anticipated silty nature of the near-surface soils, proofrolling and adequate compaction can only be achieved when the soils are within approximately ± 2 percent of the optimum moisture content. Proofrolling should be accomplished with a heavy compactor, loaded double-axle dump truck, or other heavy equipment under the observation of a qualified geotechnical engineer. This observer will assess the subgrade conditions prior to filling. Areas where loose surface soils exist due to grubbing and stripping operations should be considered fill to the depth of the disturbance and treated as subsequently recommended for structural fill placement. The need for or advisability of proofrolling due to soil moisture conditions should determined at the time of construction. We recommend that a representative of our firm observe the soil conditions prior to and during proofrolling to evaluate the suitability of stripped subgrades.

Structural Fill

All fill material within the planned trail alignment should be placed in accordance with the recommendations herein for structural fill. Prior to placement, the surfaces to receive structural fill should be prepared as previously described. All structural fill should be free of organic material, debris, or other deleterious material. Individual particle size should be less than 6 inches in maximum dimension.

Structural fill should be placed in lifts no greater than 8 inches in loose thickness. The structural fill should be mechanically compacted to a firm and unyielding condition and to at least 95 percent of the modified Proctor maximum dry density as determined by the ASTM:D-1557 test procedure. We recommend that a qualified geotechnical engineer be present during grading so that an adequate number of density tests can be conducted as structural fill placement occurs. In this way, the adequacy of the earthwork may be evaluated as it proceeds. In the case of roadway and utility trench filling and wall backfilling in municipal rights-of-way, the backfill should be placed and compacted in accordance with current local codes and standards.

The suitability of soils for structural fill use depends primarily on the gradation and moisture content of the soil when it is placed. As the amount of fines (that soil fraction passing the U.S. No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult, or impossible, to achieve. Generally, soils containing more than about 5 percent fines by weight (based on that soil fraction passing the U.S. No. 4 sieve) cannot be compacted to a firm, non-yielding condition when the moisture content is more than a few percent from optimum. The optimum moisture content is that which yields the greatest soil density under a given compactive effort.

At the time of reconnaissance, the near surface site soils appeared to have moisture contents above their optimum moisture content relative to their possible use as structural fill.

However, soil moisture conditions should be expected to change throughout the year. Consequently, use of the on-site soil as structural fill will require that strict control of the moisture content be maintained during the grading process. Selective drying of over-optimum moisture soils may be achieved by scarifying or windrowing surficial materials during extended periods of dry weather. Soils which are dry of optimum may be moistened through the application of water and thorough blending to facilitate a uniform moisture distribution in the soil prior to compaction.

In the event that inclement weather or wet site conditions prevent the use of on-site soil or non-select material as structural fill, we recommend that a "clean", free-draining pit-run sand and gravel be used. Such materials should generally contain less than 5 percent fines, based on that soil fraction passing the U.S. No. 4 sieve, and not contain discrete particles greater than 6 inches in maximum dimension. It should be noted that the placement of structural fill is, in many cases, weather-dependent. Delays due to inclement weather are common, even when using select granular fill. We recommend that site grading and earthwork be scheduled for the drier months.

Permanent Cut and Fill Slopes

In general, we recommend that permanent fill slopes be constructed no steeper than 2H:1V. However, fill slopes composed of fine grained soils should be no steeper than 3H:1V. If the slopes are exposed to prolonged rainfall before vegetation becomes established, the surficial soils will be prone to erosion and possible shallow sloughing. Surficial repairs, such as armoring affected areas with quarry spalls, may be necessary until vegetation is established.

When the ground surface slopes more than 5H:1V beneath proposed fills, the fill should be keyed and benched in suitable undisturbed native soils per the minimum requirements of the Uniform Building Code (UBC), Volume 1, Section 33.3.2, Preparation of Ground. We recommend that all benches be at least 8 feet wide and the key at the toe of the fill be at least 8 feet wide and 4 feet deep.

We generally recommend all permanent cut slopes be designed at a 2H:1V inclination or flatter. It has been our experience that permanent cut slopes steeper than 2H:1V will tend to ravel and slough to a flatter inclination over time. In addition, with the steeper slopes, topsoil erodes readily and it is more difficult and takes longer to establish vegetation for slope protection.

Permanent unsupported cuts into the toe of steep slopes located on the left side of the trail should be avoided, where feasible, particularly in the southern portion of the alignment. Cuts of this nature could result in destabilization of the slope.

## Drainage Considerations

A system of existing drainage ditches is located along the left side of the trail over the majority of the alignment. These ditches appear to primarily receive water from overland flow, groundwater seepage, and from pipes and culverts servicing upgradient developed areas. Water collected in the ditches appears to cross the trail alignment within existing culverts to undisclosed discharge locations.

The trail redevelopment plan should include provisions to maintain positive drainage along the alignment to reduce the potential for overland flow across the trail and saturation of trail subgrade soils. Overland flow across the trail could result in the deposition of sediment on the trail and hazardous conditions for trail users. Saturated trail subgrade conditions could lead to premature pavement distress and migration of fines into trail base and gravel shoulder materials, which would decrease their support characteristics. Drainage measures could include:

- A drainage ditch system located along the left side of the trail similar to the existing system.
- Subsurface groundwater interceptor drains, and
- Below grade pipe culverts or surface ditches to direct collected surface water and hillside drainages across the trail.

We recommend that the design team consider the use of an open drainage ditch system along the left side of the trail similar to the existing drainage system. An open ditch drainage system is advantageous in that it effectively collects and conveys surface water and groundwater seepage, provides a temporary catchment area for small amounts of slide debris, provides some measure of water treatment and infiltration, and is easy to maintain using standard equipment and practices.

Subsurface groundwater interceptor drains effectively collect groundwater seepage and can collect surface water flow for some time if the drainage aggregate is extended to the ground surface. However, in our experience, drainage aggregate exposed at the surface tends to clog with sediment and organic debris and the ability of the system to collect surface water decreases over time. Maintenance of interceptor drains, particularly clogging of surficial aggregate, is very difficult to complete and typically requires partial or complete reconstruction of the system. We therefore recommend that subsurface interceptor drains be limited to the collection of groundwater seepage and not be used for the collection of surface water.

As mentioned above, trail subgrade strength and therefore the design life of the trail pavement, will depend on keeping the trail subgrade in a drained condition. We recommend that the bottom elevation of the drainage system be located at least 18 inches below the trail pavement, where feasible.

Collected water should be discharged at City approved locations. Water should not be discharged to Geologic Hazard Areas.

### Construction Considerations

Earthwork may be difficult or impossible during periods of elevated soil moisture and wet weather due to the anticipated moisture sensitive nature of the site soils. Excavated site soils may not be reusable as structural fill depending on the moisture content and weather conditions at the time of construction. If soils are stockpiled for future reuse and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored. If on-site soils become unusable, it may become necessary to import clean, granular soils to complete wet weather site work.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to expose firm, non-yielding, non-organic soils and backfilled with compacted structural fill. We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season (typically November through May) it may be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork may require additional mitigative measures beyond that which would be expected during the drier summer and fall months. This could include diversion of surface runoff around exposed soils, draining of ponded water on the site, and collection and rerouting of groundwater seepage from upgradient on- and off-site sources. Once subgrades are established, it may be necessary to protect the exposed subgrade soils from construction traffic. Placing quarry spalls, crushed recycled concrete, or clean pit-run sand and gravel over these areas would further protect the soils from construction traffic.

Access along the existing asphalt surfaced trail with heavy construction equipment will need to be considered. Pavements along the existing trail may experience distress from construction traffic loads.

## LANDSLIDE AREA CONSIDERATIONS

### General

Our reconnaissance of the trail redevelopment area disclosed three areas exhibiting obvious surficial indications of past and/or recent landslide activity. A brief summary of our observations and recommendations is presented below.

### Station 0+00 to 6+80

This portion of the alignment includes a near vertical upper scarp with about 5 to 15 feet of relief located above a colluvial slope ranging from about 15 to 50 degrees. The colluvial slope has about 15 to 25 feet of relief, pistol butted trees, and hummocky topography.

Recent earth movements were observed about 50 feet south of Stations 0+00 and near 4+60. The earth movement observed about 50 feet south of Station 0+00 appears to be located within the City of Seattle and south of the trail redevelopment area. The earth movement appears to consist of an earth slide in which soil from the upper scarp and from the colluvial slope moved down slope to the ditch located on the west side of the trail. It is unclear if the slide material extended onto the trail and was subsequently removed. The earth movement observed at Station 4+60 appears to consist of an earth topple in which clasts of hard silt with some fine sand and silty clay soils spalled from the upper scarp and toppled down the colluvial slope. Clasts of toppled soil were observed on the colluvial slope and in the trailside drainage ditch. Moderate groundwater seepage was observed near the base of the upper scarp and from the colluvial slope at numerous locations as outlined in Tables 4 and 5.

The steep slopes observed in this area appear to be more susceptible to slope instability than the remainder of the trail redevelopment area. This appears to be due to the interbedded nature of the soil deposits and widespread groundwater seepage. In general, this portion of the alignment is considered to be unstable and it is unclear where or when the next slope movement will occur.

We understand that the County would like to mitigate the potential for the recent landslide areas located within the redevelopment area to adversely impact the use of the trail, if feasible. Stabilization of the recent earth movement observed near Station 4+60 does not appear feasible because much of the unstable colluvial slope and the entire upper scarp appear to be located on private property and outside the trail right-of-way. A retaining structure completed within the right-of-way would not prevent the development of earth movements up slope of the structure. Furthermore, drainage improvements typically utilized to enhance slope stability, such as horizontal drains, due not appear well suited to this area due to the thinly interbedded nature of the soils and the tendency for horizontal drains to loose effectiveness over time.

The County may want to consider the construction of a catchment wall near the edge of the trailside ditch in areas of recent landslide activity. The wall would not stabilize the steep slope, but could be used to create a catchment area to collect and hold debris from small to moderate earth movements. This could reduce the need for emergency trail repairs and cleanup. Periodic cleaning of the catchment area behind the wall would be required to maintain the effectiveness of the system. It should be noted that large scale earth movement could damage the catchment wall.

We anticipate that catchment wall types could include gravity block walls, such as ecology or Ultra-Blocks, or soldier pile walls with timber lagging. A design phase geotechnical evaluation, including borings, would be required to develop design recommendations for a catchment wall system.

The recent landslide observed about 50 feet south of Station 0+00 appears to be located within the City of Seattle. It is our understanding that the trail redevelopment will not extend this far south.

**Station 6+80 to 16+60**

Moderately steep to steep slopes with somewhat hummocky topography and scattered pistol butted maple and alder trees were observed in this area. The slopes appear to be primarily mantled by colluvial soils. Indications of earth movement, interpreted as creep, were observed above the trail on the east side of NE 147th Street near Station 7+40. The observed indications of slope movement included leaning guardrails and tension cracks within the asphalt surface. It appears that the tension cracks have been sealed on several occasions. A timber crib wall interpreted to be in poor condition is located between the trail and the observed cracks in NE 147th Street. An area exhibiting slope morphology and vegetation maturity differing from the surrounding slope was observed near Station 12+00. This area is interpreted as an older landslide area.

In general, slope gradients in this area are flatter than between Stations 0+00 and 6+80 and there does not appear to be an extensive over steepened scarp near the top of the slope. Groundwater seepage was not observed in this area during our site reconnaissance. Based on these conditions, we anticipate that the potential for future landsliding in this area is lower that the previously described section from Station 0+00 to 6+80. As discussed in the previous section, a significant portion of the slopes located above the trail alignment appear to be located outside of the trail right-of-way and within private property. As such, stabilization of these slopes does not appear geotechnically feasible since a retaining structure completed within the right-of-way would not prevent the development of earth movements up slope of the structure. Furthermore, drainage improvements typically utilized to enhance slope stability, such as horizontal drains, due not appear well suited to this area due to the thinly interbedded nature of the soils and the tendency for horizontal drains to loose effectiveness over time.

Pavement distress was observed on the east side of NE 147th Street near Station 7+40 and a timber crib wall located between the trail and the distressed pavement area was observed to be in poor condition. It is unclear if this area is within the trail right-of way, the City street right-of-way, or both. The City and/or County may want to consider evaluating this area relative to stabilization considerations. We anticipate that this evaluation, if considered appropriate, could be completed as part of this project or separately.

### Station 91+00 to 92+80

We observed severely leaning and overturned deciduous trees along the left side of the trail in this area. Groundwater seepage was also observed at the toe of the trail embankment along the northern side of Beach Drive Northeast. This area is interpreted as a possible landslide deposit. A relatively new soldier pile retaining wall is located along the southeastern side of Bothell Way NE in this area and may have increased the stability of the slope in this area by reducing driving forces.

We recommend that a design phase geotechnical evaluation of this portion of the alignment be completed, including geotechnical borings, to determine the stability of the trail embankment and provide recommendations for embankment stabilization if the calculated stability is considered unacceptable.

## RETAINING WALL CONSIDERATIONS

### General

Approximately 55 existing retaining walls are located along the trail alignment. Some of these walls could be affected by new loads associated with the trail redevelopment depending on the final trail layout. In addition to the existing retaining walls, we anticipate that new retaining walls will be needed on the right side of the trail to support fills placed to widen the roadbed and that new retaining walls may be needed on the left side of the trail to support cuts. Geotechnical considerations relative to schematic level project design and cost estimating for existing and new retaining walls are presented below.

### Existing Retaining Walls

There are approximately 13 and 42 existing retaining walls located along the left and right sides of the trail alignment, respectively. The existing walls range from about 1 to 25 feet in exposed height and include rockery walls, cast-in-place concrete walls, timber pile walls, soldier pile walls, mechanically stabilized earth walls, modular block walls, timber crib walls, and railroad tie walls. These existing walls appear to be constructed within the trail right of way and on private property. Our reconnaissance included observations of the existing walls and an evaluation of wall conditions. A summary of our observations and our assessment of the condition of these walls is presented in Tables 2 and 3.

The majority of the existing retaining walls are of low to moderate height and are set back a reasonable distance from the current trail alignment. Most of these walls are not expected to be subject to significant load increases associated with trail redevelopment. However, our reconnaissance disclosed several rockery walls in the southern portion of the site that may be adversely affected by the trail redevelopment depending on the final trail location. Two walls that meet these criteria are located between Station 3+20 to 4+10 and Station 9+35 to 11+50.

We recommend that a design phase geotechnical evaluation of the existing retaining walls be completed once a trail layout and grading plan have been developed in order to identify walls of geotechnical concern. We anticipate that the design level effort will include several borings behind walls of concern to evaluate their stability relative to trail support. For cost estimating purposes, we recommend that a contingency be established for the replacement of existing retaining walls.

### New Retaining Walls

We anticipate that new retaining walls will be needed to support fills on the right side of the trail and that new walls may be needed on the left side of the trail to support cuts. We understand that cast-in-place concrete walls are being used for schematic trail layout and cost estimating purposes. It is felt that this wall type can be constructed to the anticipated wall heights and will provide a reasonable representation of likely wall construction impacts and costs. It is likely that different types of retaining walls could be selected at specific locations during the design phase depending on an evaluation of site factors including the local soil and groundwater conditions, whether the wall supports a cut or fill, height of wall, backslope configuration, and foundation support considerations.

## BRIDGES

### General

Existing pedestrian bridges cross McAleer and Lyon Creeks at Stations 67+50 and 78+15, respectively. In general, the McAleer Creek Bridge is newer, wider, and in better condition than the Lyon Creek Bridge. We understand that the trail redevelopment will more likely than not include replacement of the Lyon Creek Bridge and may include the replacement of the McAleer Creek Bridge. A summary of pertinent site conditions in the vicinity of the existing bridges and geotechnical considerations relative to schematic level project design and cost estimating are presented below.

## McAleer Creek Bridge

The McAleer Creek Bridge is constructed of steel with a concrete deck and is supported on concrete abutments. The bridge is about 12 feet wide and has a clear span of about 40 feet. The concrete abutments and bridge span appeared to be in serviceable condition with no obvious indications of distress.

As part of our literature review, we searched the GeoMap NW database for geotechnical reports completed in the vicinity of the bridge. Our search resulted in the following two geotechnical reports.

- *Geotechnical Evaluation, Burke-Gilman Trail Footbridge, Lake Forest Park, Washington, NCA File No.* 207497. This report was prepared by Nelson-Couvrette & Associates, Inc. and dated June 10, 1997. The report was completed for the McAleer Creek Crossing and includes four shallow hand excavated explorations in the vicinity of the existing bridge abutments. The explorations ranging from about 2.5 to 8 feet below the ground surface. In general, the exploration logs report loose to medium dense sand with variable silt and gravel content and soft silt with variable sand, gravel, and organic content. These deposits were interpreted as fill and alluvium. The report includes schematic drawings which appear to be consistent with the existing bridge configuration and recommendations for conventional shallow concrete abutment foundations.

- *Report, Geotechnical Engineering Services, McAleer Creek Bypass Pipeline, Lake Forest Park, Washington.* This report was prepared by GeoEngineers and dated April 23, 1993. The report includes the log of a geotechnical boring located about 20 feet east of the eastern bridge abutment. The boring extended to a depth of about 54 feet below the ground surface. The boring log reported about 2 feet of fill over alluvium consisting of interbedded loose to medium dense sand with variable silt content and soft to medium stiff silt to a depth of about 52 feet. Dense fine to medium sand was reported from 52 feet to the total depth explored at 54 feet below the ground surface. Groundwater was not explicitly reported on the log, but appeared to be about 8 feet below the ground surface based on soil moisture descriptions.

Based on conversations with MacLeod Record, we anticipate that the existing bridge might not be replaced. Based on our site observations, the existing bridge and concrete abutments appear to be in serviceable condition and functioning as intended under current and past loading conditions. However, if the bridge abutments are supported on shallow foundations as suggested by the Nelson-Couvrette report, the structure could be susceptible to unacceptable levels of seismic induced total and differential settlement.

If it is determined that the existing bridge will be retained, we recommend that a design phase effort be completed to determine if the existing abutments are supported on shallow or deep foundations. If it is determined that the structure is supported on shallow foundations, a design phase geotechnical study, including borings at the existing abutment locations, should be considered to determine the magnitude of potential seismic induced settlement. This information could be used to develop foundation underpinning recommendations if the calculated seismic settlements are considered unacceptable.

If it is determined that the existing bridge will be replaced, we recommend that a design phase geotechnical evaluation of the new bridge be completed once the abutment locations and loads have been identified. The design phase evaluation would include geotechnical borings, engineering analyses, and geotechnical foundation design recommendations.

For schematic planning and cost estimating purposes, we recommend that a contingency be established for foundation underpinning if the existing bridge is retained. We recommend that deep foundation support, such as auger-cast piles, be considered for a new bridge.

### Lyon Creek Bridge

The Lyon Creek Bridge span is constructed of timber with an asphalt surface and is about 8.5 feet wide. The bridge has a clear span of about 20 feet and is supported on driven timber piles. The timber piles appeared to be treated with creosote. In general, the visually observable portions of the bridge span and timber piles appeared to be in serviceable condition. The bridge approach fills are retained by timber lagging placed behind the driven timber abutment piles. The timber lagging appeared to be in serviceable condition at both abutments. However, the east abutment lagging has been undermined by creek scour and voids have developed within the approach fill.

Our literature search did not yield any existing subsurface information in the vicinity of the Lyon Creek Bridge. However, the bridge is mapped within the same alluvial deposit as the McAleer Creek Bridge and our reconnaissance observations are in agreement with the mapped geologic unit. As such, we anticipate that the soils at the bridge location may consist of interbedded sand, silt, and gravel and may be susceptible to liquefaction and seismic induced settlement.

For schematic planning and cost estimating purposes, we recommend that deep foundation support, such as auger-cast piles, be considered for the new bridge. We recommend that a design phase geotechnical evaluation of the new bridge be completed once the abutment locations and loads have been identified. The design phase evaluation would include geotechnical borings, engineering analyses, and geotechnical foundation design recommendations.

## CULVERTS

The existing trail is crossed by several culverts that appear to service the drainage ditch system located on the left side of the trail. Additional culverts are located parallel to the trail along the drainage ditch alignment where private driveways and public roads cross the trail. We anticipate that widening of the trail may require the installation of additional culverts at new locations and/or modification or replacing existing culverts.

At the time this report was prepared, the project was in the schematic phase and information regarding the location and depth of new culverts and which existing culverts may need modification was not available. We therefore recommend that a design phase geotechnical evaluation of new and modified culverts be completed once a final trail layout, grading plan, and drainage plan have been established. However, for schematic planning and cost estimating purposes, we anticipate that the installation of new culverts and the modification of existing culverts will be geotechnically feasible utilizing conventional construction practices, based on our reconnaissance level observations and literature review.

## USE OF THIS REPORT

We have prepared this report for use by MacLeod Reckord, King County, and other members of the project team, for schematic design and cost estimating for the Burke-Gilman Trail Redevelopment. The data and report may be provided to prospective contractors for cost estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of surface or subsurface conditions.

Design phase geotechnical services, including subsurface explorations and analyses, should be anticipated to evaluate areas of geotechnical concern outlined in this report once a final trail layout has been established. Areas that may require subsurface explorations and additional geotechnical analysis include the McAleer and Allen Creek bridge abutment areas, areas of obvious past landslide activity, existing retaining walls that are in questionable condition and may affect the new trail, and new trail side retaining wall and catchment wall locations.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

We trust that this report meets your present needs. Please call if you have any questions concerning the report.

**TABLE 1**
**PREFERRED TRAIL ALIGNMENT BASED ON OBSERVED GEOTECHNICAL SITE CONDITIONS**

| Station | Preferred Direction of Widening * | | | Comments |
|---|---|---|---|---|
| | Left | Center | Right | |
| 0+00 to 5+90 | | x | x | Steep unstable slope to left. Stay right of drainage ditch. |
| 5+90 to 9+10 | | x | | Moderately steep to steep slopes to left and right. |
| 9+10 to 15+80 | | x | x | Stay right of drainage ditch. |
| 15+80 to 16+60 | | | x | Steep slope to left of trail. Slope does not appear to be accurately depicted on topographic plan. Significant retaining wall needed to shift trail left. |
| 16+60 to 27+10 | | x | x | Stay right of drainage ditch. |
| 27+10 to 31+60 | | x | x | Deep ditch to left on the order of 3 to 4 feet deep. Ditch appears to receive surface water from several culverts. Consider replacing ditch with buried pipe. |
| 31+60 to 33+10 ** | | | | No obvious geologic constraints. |
| 33+10 to 52+00 | | x | x | Moderately steep to steep slopes to left of trail with deep ditch and wet soil conditions/standing water in ditch. |
| 52+00 to 66+80 ** | | | | No obvious geologic constraints. |
| 66+80 to 58+10 | | x | | McAleer Creek crossing area. |
| 68+10 to 77+20 ** | | | | No obvious geologic constraints. |
| 77+20 to 78+20 | | x | x | Lyon Creek to left. |
| 78+20 to 80+90 | x | x | | Lyon Creek to right. |
| 80+90 to 83+60 ** | | | | No obvious geologic constraints. |
| 83+60 to 102+80 | | x | x | Stay right of drainage ditch. |
| 102+80 to 104+40 | | | x | Steep slope to left of trail approaching 70 degrees. Slope does not appear to be accurately depicted on topographic plan. Significant retaining wall needed to shift trail left. |

* Preferred direction of trail widening within existing roadbed looking upstation.
** No Preference

**TABLE 2**
**EXISTING RETAINING WALL CONDITIONS**
**WALLS LOCATED TO LEFT* OF TRAIL**

| Station | Wall Type | Wall Height (ft) | Distance from Centerline of Existing Trail (ft) | Wall Condition | Comments |
|---|---|---|---|---|---|
| 4+00 to 4+40 | Rockery Wall | 2 | 10 to 15 | Poor | Overgrown by ivy and blackberry brush. |
| 7+00 to 7+45 | Timber Crib Wall | 2 to 4 | 10 | Poor | No obvious deflection. Moderate to severe wood rot. Guardrail posts on east side of NE 147th Street (upslope from wall) leaning east. Tension cracks in pavement |
| 17+05 to 17+45 | R/R Tie Wall | 1.5 | 10 to 15 | Good | |
| 35+45 to 36+10 | MSE Block Wall | 20 to 25 | 30 to 35 | Good | Relatively new wall with near vertical face. |
| 38+45 to 40+85 | CIP Concrete Wall | 4 to 8 | 30 to 40 | Good | |
| 43+90 to 44+50 | Timber Wall | 3 to 4 | 25 | Fair to Good | |
| 48+65 to 48+90 | Rockery Wall | 5 to 6 | 20 to 30 | Fair | Two tier rockery wall. Each tier is about 3 feet high. |
| 67+25 | CIP Concrete Wall | 2 to 3 | 0 | Good | Western McAleer Creek bridge abutment. |
| 67+65 | CIP Concrete Wall | 2 to 3 | 0 | Good | Eastern McAleer Creek bridge abutment. |
| 67+60 to 68+00 | Rockery Wall | 3 to 5 | 3 to 15 | Good | Wall extends below McAleer Creek bridge. |
| 78+07 | Timber Pile Wall | 3 to 5 | 0 | Fair | Western Lyon Creek bridge abutment. Creosote treated piles with timber lagging. |
| 78+27 | Timber Pile Wall | 3 to 5 | 0 | Poor | Eastern Lyon Creek bridge abutment. Creosote treated piles with timber lagging. Lagging undermined by creek scour. |
| 85+00 to 96+00 | Soldier Pile Wall | 5 to 15 | 25 to 50 | Good | Soldier pile wall along Bothell Wall NE with concrete panel lagging. |

* Looking upstation

**TABLE 3**
**EXISTING RETAINING WALL CONDITIONS**
**WALLS LOCATED TO RIGHT* OF TRAIL**

| Station | Wall Type | Wall Height (ft) | Distance from Centerline of Existing Trail (ft) | Wall Condition | Comments |
|---|---|---|---|---|---|
| 0+00 to 0+35 | Rockery Wall | 2.5 to 4 | 30 | Fair | |
| 1+00 to 2+05 | Rockery Wall | 3 to 4 | 20 to 25 | Fair | Rockery covered in ivy with poor exposure. |
| 2+05 to 2+40 | Rockery Wall | 5 to 6 | 15 | Fair | |
| 2+40 to 2+80 | Rockery Wall | 3 to 4 | 15 to 20 | Fair to Poor | Large gaps between facing stones. |
| 2+80 to 3+20 | Rockery Wall | 5 | 20 | Fair | Groundwater seepage from face of wall. |
| 3+20 to 4+10 | Rockery Wall | 6 to 7 | 12 to 15 | Fair to Good | Groundwater seepage from face of wall. |
| 8+45 to 9+35 | Rockery Wall | 2 to 3.5 | 15 to 20 | Fair to Good | |
| 9+35 to 11+50 | Rockery Wall | 5 to 9 | 15 to 20 | Fair to Good | Some large voids between facing stones. Relatively new wall. |
| 19+60 to 22+65 | Rockery Wall | 1 to 3 | 10 to 15 | Good | |
| 24+05 to 24+70 | Rockery Wall | 2 to 3 | 15 to 20 | Good | |
| 24+70 to 25+40 | Concrete Block Wall | 3.5 to 4 | 12 to 15 | Good | Wall backfill does not appear to be geogrid reinforced. |
| 25+40 to 25+90 | CIP Concrete Wall | 3.5 | 12 to 15 | Good | |
| 27+60 to 27+95 | Concrete Block Wall | 3 | 15 to 20 | Good | Wall backfill does not appear to be geogrid reinforced. |
| 28+40 to 28+90 | Rockery Wall | 4 to 5 | 13 to 16 | Fair | Some moderately weathered, fractured facing stones. |
| 31+70 to 33+20 | Brick & Stucco Wall | 3 to 3.5 | 15 to 20 | Good | |
| 33+50 to 33+95 | CIP Concrete Wall | 2.5 | 20 | Good | |
| 33+95 to 34+90 | Rockery Wall | 2 to 3.5 | 10 to 20 | Poor to Fair | Weathered rock with large voids between facing stones. |
| 35+35 to 36+85 | CIP Concrete Wall | 4 | 10 to 17 | Good | |
| 36+85 to 37+25 | Rockery Wall | 2 to 3 | 20 | Fair to Good | |
| 37+25 to 38+15 | Concrete Block Wall | 2.5 to 5 | 20 to 25 | Good | Unclear if wall backfill is geogrid reinforced. |
| 38+25 to 38+65 | Concrete Block Wall | 2 | 25 to 30 | Good | Wall backfill does not appear to be geogrid reinforced. |
| 39+25 to 39+65 | Rockery/Rubble Wall | 2 to 3 | 30 | Poor | Wall constructed of natural stone and concrete rubble. |
| 40+25 to 40+90 | Rockery Wall | 1 to 2 | 22 to 25 | Poor to Fair | |
| 42+55 to 43+40 | Rockery Wall | 1 to 2 | 22 to 24 | Fair to Good | |
| 45+10 to 45+75 | Concrete Block Wall | 3 to 3.5 | 2 to 25 | Good | Unclear if wall backfill is geogrid reinforced. |

* Looking upstation

**TABLE 3 (CONTINUED)**
**EXISTING RETAINING WALL CONDITIONS**
**WALLS LOCATED TO RIGHT* OF TRAIL**

| Station | Wall Type | Wall Height (ft) | Distance from Centerline of Existing Trail (ft) | Wall Condition | Comments |
|---|---|---|---|---|---|
| 67+25 | CIP Concrete Wall | 2 to 3 | 0 | Good | Western McAleer Creek bridge abutment. |
| 67+65 | CIP Concrete Wall | 2 to 3 | 0 | Good | Eastern McAleer Creek bridge abutment. |
| 78+07 | Timber Pile Wall | 3 to 5 | 0 | Fair | Western Lyon Creek bridge abutment. Creosote treated piles with timber lagging. |
| 78+27 | Timber Pile Wall | 3 to 5 | 0 | Poor | Eastern Lyon Creek bridge abutment. Creosote treated piles with timber lagging. Lagging undermined by creek scour. |
| 84+65 to 85+65 | Concrete Block Wall | 2 | 20 | Poor to Fair | Wall backfill does not appear to be geogrid reinforced. Western 40 feet of wall is destressed and overturning. |
| 85+65 to 86+20 | CIP Concrete Wall | 2 | 20 | Good | Exposed aggregate wall. |
| 88+10 to 88+60 | Concrete Block Wall/CIP Concrete | 3.5 | 13 | Good | 1.5 foot high modular concrete block wall stacked on a 1.5 to 2 foot high CIP wall. |
| 89+80 to 90+45 | Concrete Block Wall | 1.5 to 2 | 20 | Good | Wall backfill does not appear to be geogrid reinforced. |
| 90+45 to 91+80 | Timber Wall | 1 | 15 to 18 | Poor | Railroad tie wall, distressed and moderately rotten. |
| 95+60 to 96+00 | Concrete Block Wall | 2 to 2.5 | 15 to 20 | Good | Unclear if wall backfill is geogrid reinforced. |
| 96+00 to 96+85 | CIP Concrete Wall | 1 to 2 | 15 to 25 | Good | Retaining wall for angled parking. |
| 96+85 to 97+30 | Concrete Block Wall | 1.5 to 2 | 20 | Good | Wall backfill does not appear to be geogrid reinforced. |
| 97+30 to 97+85 | Timber Wall | 1.5 | 20 | Good | No significant rot observed. |
| 98+80 to 99+65 | CIP Concrete Wall | 2.5 | 18 to 20 | Good | |
| 99+65 to 100+20 | Concrete Block Wall | 2 | 20 | Good | |
| 100+20 to 101+35 | Ecology Block Wall | 2 | 18 to 20 | Good | Modular concrete block planters on the order of 1 to 1.5 feet tall located above the ecology block wall. |
| 101+35 to 101+90 | CIP Concrete Wall | 1.5 | 15 | Good | |
| 101+90 to 104+10 | Ecology Block Wall | 2 | 12 to 25 | Good | Retaining wall for angled parking. |

* Looking upstation

## TABLE 4
## WET SOIL CONDITIONS AND SURFACE WATER OBSERVED TO LEFT* OF TRAIL

| Station | Observed Conditions | Distance from Centerline of Trail (ft) | Comments |
|---|---|---|---|
| 0+00 to 6+50 | Standing water in ditch & hydrophillic vegetation | 7 to 40 | Obvious groundwater seepage zones observed on steep slope to west of trail near stations 0+00, 1+00, 1+40, 6+00. |
| 31+10 to 31+35 | Flowing water in ditch | 10 | Water appears to be discharged from a drain pipe extended up-slope (west). |
| 31+80 to 32+10 | Wet soil and hydrophillic vegetation | 20 to 30 | |
| 34+00 to 35+60 | Standing water in ditch & hydrophillic vegetation | 10 | Discharge of about 1/2 gpm to ditch from up-slope pipe located at Station 39+25. |
| 36+70 to 37+15 | Standing water in ditch & hydrophillic vegetation | 15 to 35 | |
| 37+40 to 37+85 | Wet soil and hydrophillic vegetation | 10 to 15 | |
| 38+25 to 41+40 | Wet soil and hydrophillic vegetation | 10 to 25 | Discharge of about 1/2 gpm to ditch from up-slope pipe located at Station 44+80. Standing water in ditch near discharge pipe. |
| 42+70 to 45+85 | Standing water in ditch & hydrophillic vegetation | 10 to 20 | Ditch may receive surface water from pipe located at Station 46+60. No discharge observed at time of evaluation. |
| 47+70 to 48+30 | Flowing water in ditch & hydrophillic vegetation | 10 to 15 | Ditch receives surface water flow from up-slope property to west. |
| 68+45 to 69+40 | Standing water in ditch & hydrophillic vegetation | 20 to 30 | |
| 72+35 to 73+00 | Wet soil and hydrophillic vegetation | 20 to 35 | |
| 85+80 to 88+05 | Standing water in concrete lined ditch | 11 to 13 | |
| 102+60 to 103+80 | Wet soil | 8 to 10 | |

* Looking upstation

| TABLE 5<br>WET SOIL CONDITIONS AND SURFACE WATER OBSERVED TO RIGHT* OF TRAIL | | | |
|---|---|---|---|
| **Station** | **Observed Conditions** | **Distance from Centerline of Trail (ft)** | **Comments** |
| 0+40 to 0+65 | Slight groundwater seepage and standing water | 25 to 30 | Seepage from toe of slope extending east of trail. |
| 2+10 to 2+30 | Wet soil at toe of rockery wall | 20 | |
| 2+80 to 3+80 | Flowing water at toe of rockery wall | 18 to 25 | Groundwater seepage observed from face of rockery wall between Station 3+15 and 3+60. |
| 4+10 to 6+20 | Standing water & hydrophillic vegetation | 12 to 16 | Standing water observed along west edge of Edge Water Lane and wet soils on slope between Edge Water Lane and trail. |
| 91+10 to 91+80 | Standing water with algae | 17 to 26 | Standing water in gravel parking area with well developed algae growth. |

* Looking upstation

**TABLE 6**
**SLOPE AREAS EXHIBITING OBVIOUS INDICATIONS OF PAST SLOPE INSTABILITY**

**Areas of past slope instability located to left* of trail**

| Station | Comments |
|---|---|
| 0+00 to 6+80 | This portion of the alignment includes a near vertical upper scarp with about 5 to 15 feet of relief located above a colluvial slope ranging from about 15 to 50 degrees. The colluvial slope has about 15 to 25 feet of relief, pistol butted trees, and hummocky topography. Recent earth movements were observed about 50 feet south of Stations 0+00 and near Station 4+60. The earth movement observed about 50 feet south of Station 0+00 appears to be located within the City of Seattle and south of the trail redevelopment area. The earth movement appears to consist of an earth slide in which soil from the upper scarp and from the colluvial slope moved down slope to the ditch located on the west side of the trail. It is unclear if the slide material extended onto the trail and was subsequently removed. The earth movement observed at Station 4+60 appears to consist of an earth topple in which clasts of hard silt with some fine sand and silty clay soils spalled from the upper scarp and toppled down the colluvial slope. Clasts of toppled soil were observed on the colluvial slope and in the drainage ditch. Moderate groundwater seepage was observed near the base of the upper scarp and from the colluvial slope. |
| 6+80 to 16+60 | Moderately steep to steep slopes with somewhat hummocky topography and scattered pistol butted maple and alder trees. The slope appears to be primarily mantled by colluvial soils. Indications of earth movement, interpreted as creep, were observed above the trail on the east side of NE 147th Street near Station 7+40. The observed indications of slope movement included leaning guardrails and tension cracks within the asphalt surface. It appears that the tension cracks have been sealed on several occasions. An area exhibiting slope morphology and vegetation maturity differing from the surrounding slope was observed near Station 12+00. This area is interpreted as on older landslide area. |
| 91+00 to 92+80 | We observed severely leaning and overturned deciduous trees. Possible colluvial mass. New soldier pile retaining wall located along southeastern side of Bothell Way NE may have increased stability of slope. Groundwater seepage observed on north side of Beach Drive NE in this area. |

**Areas of past slope instability located to right* of trail**

| Station | Comments |
|---|---|
| NA | No areas of obvious past slope instability were observed to the right of the trail. |

* Looking upstation

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting
A Terracon Company

J-2367
July 11, 2006

MacLeod Reckord
231 Summit Avenue East
Seattle, Washington 98102

Attention: Mr. Terry Reckord

Subject: Summary of Previous Geotechnical Reports
Burke-Gilman Trail Redevelopment
King County, Washington
King County Contract No. E53012E

Dear Mr. Reckord:

As requested, this letter provides a summary of the previous geotechnical studies which pertain to hazardous slopes along the segment of the Burke-Gilman Trail from the boundary between the City of Seattle and the City of Lake Forest Park on the south, and to the Logboom Park on the north. The letter also provides a summary of the conclusions and recommendations regarding hazardous slopes presented in the *Draft Report of Predesign Geotechnical Services* prepared by Zipper Zeman Associates dated May 30, 2006.

The following two previous geotechnical reports which deal with the hazardous slope issue have been provided to ZZA for review. These reports are summarized in this letter.

1. *Geotechnical Report, Burke-Gilman Trail Slides, Lake Forest Park, Washington, HWA Project No. 2000019-100, December 6, 2001, Revised February 18, 2002, prepared by HWA Geosciences, Inc.*
2. *Preliminary Geotechnical Investigation, Burke-Gilman Trail Redevelopment, NE 145th Street to Logboom Park, King County, Washington, HWA Project Nom 2005-027, April 15, 2005, prepared by HWA Geosciences, Inc*

The following two additional previous geotechnical reports pertain to the footbridge and bypass pipeline at McAleer Creek, not to the hazardous slope issue. These reports are **not** summarized in this letter.

1. *Geotechnical Evaluation, Burke-Gilman Trail Footbridge, Lake Forest Park, Washington, NCA File No. 207497*
2. *Report, Geotechnical Engineering Services, McAleer Creek bypass Pipeline, Lake Forest Park, Washington*

## DECEMBER, 2001 HWA GEOSCIENCES REPORT

This previous study was completed to evaluate a landslide area located along the uphill side of the Burke-Gilman Trail in Lake Forest Park. The study was limited to the segment of the trail between NE 145th and NE 147th Streets.

The study focuses on eleven (11) individual areas which have slid in recent history and provides the following information for each slide area: station, plan dimensions and estimated depth, type of landslide, estimated recurrence interval, and preliminary cost estimates for mitigation. Anchored shotcrete was the only mitigation measure considered for the upper slopes. Drainage and regrade, excavate and replace, and wall and regrade were the three options considered for the lower slopes. The total estimated cost to mitigate the eleven ( 11) individual slides is dependent on the mitigation option selected , but generally appears to be on the order of several hundred thousand dollars for the lower slopes and on the order of one million dollars for the upper slopes.

The HWA study also commented on the condition of the slope segments in this area which have not slid in recent history. HWA states: " It is possible the areas that failed in the recent past are geologically different from those that have not. However, it is not obvious that this is true and it is also possible that the other areas just haven't slid in recent history. Therefore, it may be advantageous to do a similar treatment along the entire 500-foot reach rather than to remediate isolated slide areas". Although the HWA report does not provide a cost estimate to remediate the entire area, it is apparent that the cost would be significantly higher.

ZZA has the following additional specific comments regarding the December, 2001 HWA report.

- The anchored shotcrete option for the upper slope would consist of installing soil nails into the slope, placing reinforcing mesh, and shooting shotcrete (pneumatically placed concrete) on the slope. We have a concern regarding the feasibility of using this method of slope stabilization. This concern is related primarily to the interbedded nature of the soil deposits exposed on the upper slope face and the presence of groundwater seepage. Unless groundwater is adequately drained, water pressures tending to develop behind the anchored shotcrete could result in result in cracking or even collapse of the shotcrete facing.
- The estimated unit cost for the anchored shotcrete option seems to be low.
- Much of the upper slope area appears to be located on adjacent private property and not within the trail right-of-way. An easement would be required for work on adjacent private property.
- As a general rule, mitigation of the lower slope would have only a limited beneficial effect unless the upper slope is also stabilized . This is due to the fact that slide material from the upper slope would tend to collect on the lower slope and eventually move downward toward the trail.

- The drainage and regrade option for the lower slope would involve the installation of "finger drains" up the center of the slide area along with limited regarding of the lower slope. In our opinion, the drainage option would likely have only a limited effect on the stability of the lower slope due to the difficulty of intercepting ground water and adequately draining the slope. In addition, the "finger" drains would have to be relatively deep and would be difficult to construct considering the loose/weak nature of the colluvium and the presence of seepage in the trench excavation.
- The excavate and replace option would involve removal of the colluvium which mantles the lower portion of the slope, and replacement with select fill of higher strength. It is difficult to imagine how this work could be completed without potentially endangering uphill property. In addition, this option would represent a massive earthwork project.
- The wall and regrade option for the lower slope would involve the construction of a catchment wall along the uphill side of the trail along with limited regarding behind the wall. ZZA considers a catchment wall to be a viable option. The preliminary cost estimates prepared by HWA Geosciences, Inc. for the catchment wall are based on the use of a soldier pile wall scheme. In our opinion, other less costly wall types should also be considered.

ZZA also completed an evaluation of the slope area between NE 145th and NE 147th Streets. Numerous indications of past slope instability and several areas of recent slope movement were observed on the steep uphill slopes. We concluded that stabilization of this steep slope area would be difficult and expensive considering the soil and groundwater conditions, and the fact that critical upper slope areas are located outside of the trail right of way. As an alternative, the ZZA Draft report recommends that the County consider the construction of a catchment wall along the west aside of the tail to catch and hold debris from small to moderate earth movements.

ZZA noted that a timber crib wall interpreted to be in poor condition is located between the trail and NE 147$^{th}$ Street at about Station 7+40. Indications of earth movement, interpreted as creep, were observed at this location including leaning guard rails, and tensions cracks of the asphalt surface. . It is unclear if this area is within the trail right-of-way, the City street right of-way, or both. The City and/or County may want to consider evaluating this area relative to stabilization considerations

ZZA evaluated the steep slope are between NE 147$^{th}$ Street lope It is important to note the three additional steep slope areas have been evaluated by ZZA. The slopes in this area appear are flatter that between NE 145$^{th}$ and NE 147$^{th}$ Streets and there does not appear to be an extensive over steepened scarps near the top of the slope. Groundwater seepage was not observed in this area during our site reconnaissance. Based on these conditions, we anticipate that the potential for future landslides in this area is lower than for the segment between NE 145the and NE 147$^{th}$ Street.

ZZA observed severely leaning and overturned deciduous trees along the left side of the trail between Station 91+00 and 92+00. Groundwater seepage was also observed at the toe of the trail embankment along the north side of Beach Drive. This area is interpreted as a possible landslide deposit.. We recommend that the stability of this area be evaluated during the design phase geotechnical investigation.

## APRIL 15, 2005 HWA PRELIMINARY INVESTIGATION

This previous study provides general comments regarding the proposed trail widening. The study notes that widening by cutting into the existing uphill slopes is complicated by two factors: 1) maintaining adequate drainage and 2) the potential for destabilizing the slopes downhill from existing homes or driveways. A number of different types of retaining walls are described in general terms. The use of soldier pile walls is suggested for taller slopes while gravity walls could be considered for shorter walls. The study suggests that soldier pile walls with possible tiebacks be considered for cuts in the existing slide area in the southern portion of this segment of the trail.

The information presented in the April 15, 2005 HWA preliminary investigation is generally consistent with the information presented in the ZZA *Draft Report of Predesign Geotechnical Services*. However, the ZZA report contains much more detailed information.

We trust that this letter provides the information needed at this time. Please contact us if you have any questions.

Sincerely,
**Zipper Zeman Associates, Inc.**

JAMES B. THOMPSON
STATE OF WASHINGTON
19429
REGISTERED
PROFESSIONAL ENGINEER
7/11/06
EXPIRES 04/0

James B. Thompson, Ph.D., P.E.
Principal

# APPENDIX E: DRAFT SENSITIVE AREAS STUDY BY THE WATERSHED COMPANY

# DRAFT
# SENSITIVE AREAS STUDY

## Burke-Gilman Trail Redevelopment
## Lake Forest Park, Washington

*Prepared for:*

King County Parks
c/o MacLeod Reckord, Landscape Architects
231 Summit Avenue East
Seattle, Washington 98102
(206) 323-7919

*Prepared by:*


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**30 March 2006**

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# SENSITIVE AREAS STUDY
# BURKE-GILMAN TRAIL REDEVELOPMENT
# LAKE FOREST PARK, WASHINGTON

## INTRODUCTION

This report presents the results of a sensitive areas study for redevelopment of a 2.3-mile section of the Burke-Gilman Trail that runs through the City of Lake Forest Park between NE 145th Street to the City of Kenmore's Log Boom Park (formerly known as Tracy Owen Station). The purpose of this study was to locate and delineate wetlands using the state-approved methodology for wetland delineation, to identify and delineate streams, to describe and classify delineated wetland areas and streams, and to discuss the regulatory implications of these findings. Wetlands and streams were classified according to the *Lake Forest Park Ordinance No. 930: Sensitive Areas Update* (adopted December 1, 2005).

The Burke-Gilman Trail is proposed to be widened and resurfaced from the Seattle City Limits at NE 145th Street to the Kenmore City Limits near Log Boom Park. The project is intended to improve safety issues and ease of use for trail users. The existing 10-foot-wide paved trail is proposed to be widened to 12 feet. Also included are features such as signage improvements, site furnishings, and fencing. The corridor is situated in portions of Sections 10, 11, and 15 of Township 26 North, Range 4 East in the City of Lake Forest Park (Figure 1).

## METHODS

The study area was screened for wetlands using methodology from the *Washington State Wetlands Identification and Delineation Manual* (Washington Department of Ecology [DOE] 1997). Vegetation, soils and hydrology were examined, and areas meeting the criteria set forth in the manual were determined to be wetland. Streams also were identified and the Ordinary High Water Marks (OHWM) were flagged on-site. Wetland and stream delineation field work was performed by Jennifer Creveling and Dan Nickel during March 2006.

Vegetation was evaluated across the site to determine the presence of hydrophytic communities. Plant communities are considered hydrophytic when more than 50 percent of the dominant species have a wetland indicator status of facultative (FAC), facultative wetland (FACW), or obligate wetland (OBL), as listed in the *National List of Plant Species That Occur in Wetlands, Region 9 - Northwest* (Reed 1996 and 1988).

Soil pits were dug to examine soil characteristics and to determine the presence of hydric soil. Soil color was determined using the *Munsell Soil Color Chart* (Munsell Color 1992). Soil texture, structure, moisture and other features also were noted. In general, a matrix chroma of 1 or less in un-mottled soils and a matrix chroma of 2 or less in mottled soils are considered indicative of hydric soil. Gleyed colors are also indicative of hydric soils.

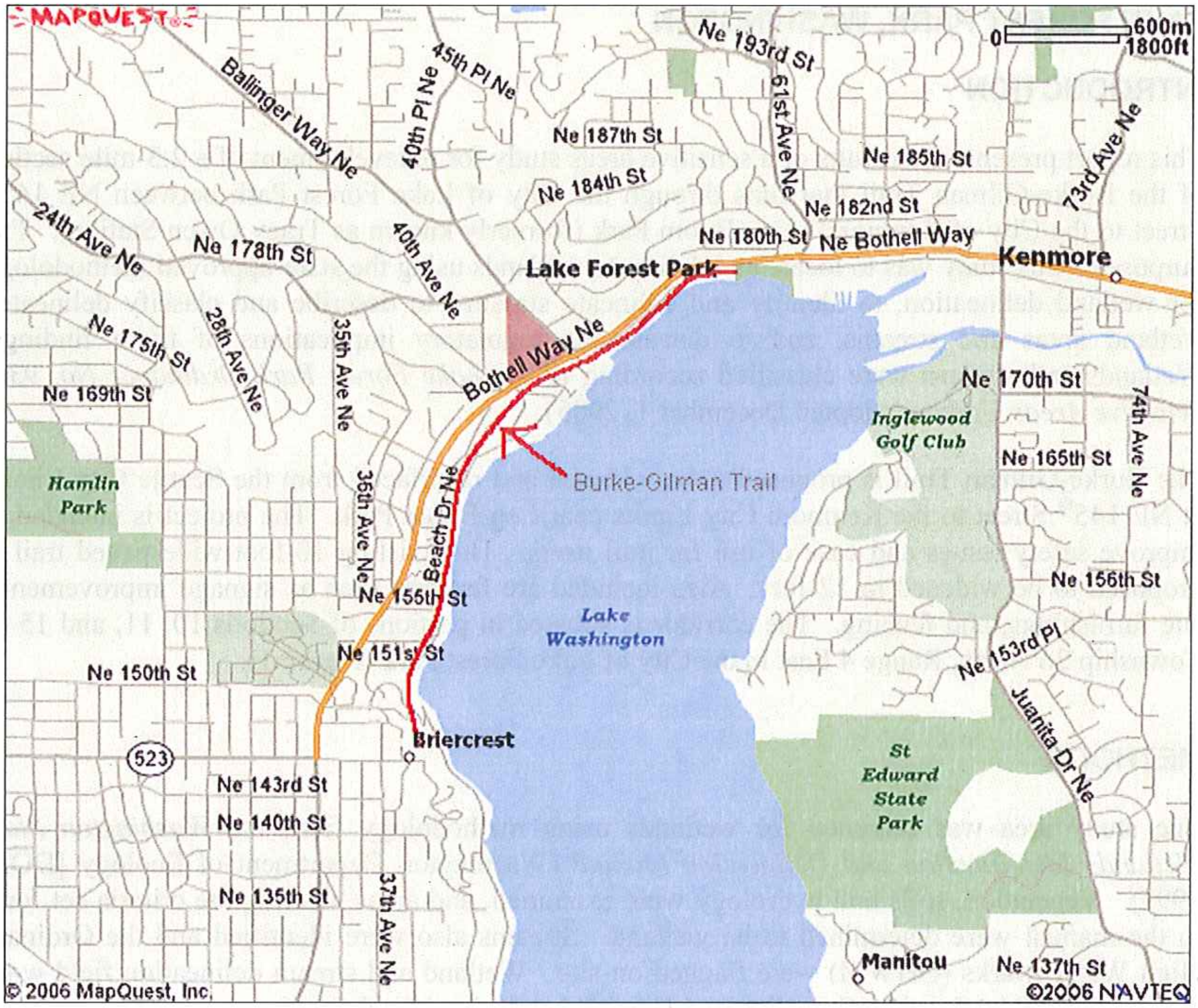


Figure 1. Vicinity map (from MapQuest).

Direct observations and indicators of wetland hydrology were evaluated and recorded. Wetland hydrology is considered present when soil is inundated or saturated in a major portion of the root zone consecutively for at least five percent of the growing season. The time of year and recent precipitation history were considered when evaluating hydrologic conditions on the site.

Delineated wetland boundaries were marked with pink/black-striped field flagging; wetland determination data points were marked with yellow/black-striped field flagging; and streams were marked with orange flagging. All flagging was located by PACE, Inc.

## RESULTS

Portions of eight wetlands were delineated and surveyed within the study area and labeled Wetlands 1 through 8. Portions of five streams also were identified including Lyon Creek, McAleer Creek, and three smaller unnamed streams. The Ordinary High Water Marks (OHWM) of Lyon and McAleer Creeks, and the centerlines of Streams 3 and 4, were delineated and surveyed. Stream 5 flows through a steel half-pipe adjacent to the trail and was located by surveyors.

### *General Site Description*

The study area is located in Water Resource Inventory Area (WRIA) 08 – North Lake Washington Drainage (Washington Department of Fisheries 1975). This area is also within the East Lake Washington, Lyon Creek, and McAleer Creek Sub-basins of the Cedar River Basin (King County 1990).

Topography within the study area slopes generally to the south and east toward Lake Washington. The existing trail is relatively flat as it is an old railroad grade. There are residential areas along most of this section of the Burke-Gilman Trail, as well as associated parks and commercial districts.

#### *Vegetation*

Vegetation within the study area is a mix of forest, shrub, and herbaceous plant communities. The upland portions of the study area are characterized by scattered trees such as Lombardy poplar, black cottonwood, red alder, bigleaf maple, and some conifers including Douglas-fir, western hemlock, and western red cedar. Dominant shrubs and ground cover include Himalayan blackberry, vine maple, osoberry, snowberry, English holly, English ivy, sword fern, dandelion, grasses and weeds.

Wetlands in the study area also support a variety of plant communities. Forested wetlands are primarily dominated by black cottonwood, Lombardy poplar, weeping willow, and red alder in the canopy. Shrubby areas include salmonberry, hardhack, red-osier dogwood, and blackberries. Emergent vegetation includes soft rush, creeping buttercup, horsetail, English ivy, reed canarygrass and other grasses.

### *Soils*

The study area is outside the limits of the *King County Soil Survey* (USDA 1973). Soils on-site were observed to be quite variable, as is typical in urban and other highly manipulated settings. As stated above, this section of the Burke-Gilman Trail is an old railroad grade along the western shore of Lake Washington. Soil conditions have been influenced over time by railroad and trail building, adjacent residential development, drainage management, and ditch maintenance. Fourteen test pits were recorded in the study area, and many more test pits were examined during the course of the study. The locations of all recorded test pits are indicated on the maps in Appendix A.

### *Hydrology*

There are maintained ditches along much of the length of the trail. Wetland hydrology in the form of saturated or inundated soils was evident in all of the delineated wetland areas. Wetland areas derive water primarily from hillside seepage, upland runoff, and direct precipitation.

## *Wetlands*

As stated above, partial boundaries of eight wetland areas were delineated and labeled Wetlands 1 through 8. Only the boundaries adjacent to the trail which were relevant to potential wetland impacts were flagged.

All of the wetlands flagged as part of this study are at least somewhat associated with ditches adjacent to the trail. Wetlands 2 and 4 are relatively broad and distinct depressions between the trail and road.

Wetland 2 is a primarily shrubby area on the west side of the trail south of Lyon Creek. There is a large weeping willow and several cottonwood trees in and adjacent to the wetland. It appears that a number of red-osier dogwood plants may have been installed in the wetland at some time in the past. Also present in the wetland are Himalayan blackberry, Watson's willow-herb, and horsetail. The buffer area surrounding the wetland is dominated by Lombardy poplar, blackberries, Robert's geranium, reed canarygrass, and other grasses. Soil within Wetland 2 was very dark gray (10YR 3/1) silty loam. Outside the wetland, soil was unmottled very dark grayish brown (10YR 3/2) gravelly sandy loam. Wetland 2 was saturated to the surface at the time of observation. A culvert from under Bothell Way NE directs water into the wetland which includes fairly large areas of mud and sediment.

Wetland 4 is a forested depression on the west side of the trail just south of McAleer Creek. It is dominated by large black cottonwoods, blackberries, reed canarygrass, English ivy, creeping buttercup, and Cooley's hedge nettle. The adjacent buffer area is primarily blackberry, grasses, dandelions, and small osoberry sprouts. Soil observed within Wetland 4 was black (10YR 2/1) gravelly sandy loam. Outside the wetland, soil was olive brown (2.5Y 4/3) silty clay loam. Wetland 4 was saturated at a depth of four inches below the ground surface at the time of observation. Water-stained leaves were present.

Wetlands 1, 3, 5, 6, 7, and 8 are specific sections of trailside ditches which met the criteria for jurisdictional wetland. As stated above, much of the trail is bordered by maintained and at least partially manmade ditches. Many of these are dominated by highly disturbed and manipulated plant communities, which nevertheless meet the criteria for hydrophytic vegetation. Similarly, essentially all of the ditch areas exhibit characteristics of wetland hydrology since their function is to capture and carry runoff. The greatest distinction between areas determined to be jurisdictional wetland and other similar areas was in their soil characteristics. Wetlands were delineated where there was evidence of apparently native soils with hydric characteristics (as well as evidence of hydrophytic vegetation and wetland hydrology). These areas appear more natural and tend to function more as wetlands, particularly in terms of water storage and wildlife habitat. In most instances, these areas also tend to be more closely associated with hillside seeps or stream flow, instead of primarily with residential storm runoff. Boundaries were identified between wetlands and adjacent non-wetland areas by identifying where the ditch ceased to support these more natural conditions and appeared to exist on top of old fill materials and compacted or cemented soils. In addition, most of the wetland ditches are broader and shallower in cross-section as opposed to steeper, V-shaped profiles of the non-wetland ditch sections.

The wetland determination data sheets are presented in Appendix B. Photographs of the wetlands and their buffer areas are in Appendix C.

### *Streams*

Portions of five streams were identified including Lyon Creek (Stream 1), McAleer Creek (Stream 2), and three small unnamed streams (Streams 3, 4, and 5). Lyon and McAleer Creeks are relatively large, well-defined, and mapped streams. The Ordinary High Water Marks of these two streams were marked in the vicinity of proposed trail improvements.

Stream 3 is a small drainage coming off the hillside north of NE 145th Street. It branches into three small channels, collects in a ditch at the base of the hill and flows into a culvert under the trail toward Lake Washington. Only the two outermost channels were flagged and surveyed; see map in Appendix A. Based on the site topography, channel size, deposition, and existing flow during the site visit, this stream likely does not flow year-round during years with normal rainfall and thus would be considered seasonal. Stream 4 is in a landscaped, artificial channel which flows through hillside rocks and a concrete flume, then into a culvert under the trail. Stream 5 is west of Log Boom Park at the east end of the study area. This stream is contained entirely within a corrugated steel half-pipe on the hillside and culverted under the trail. The characteristics of Streams 4 and 5 indicate that these streams probably flow year-round during years of normal rainfall and thus would be considered perennial. In addition to these streams, Bsche'tla Creek is shown on a city map included in *A Salmon's Guide to Lake Forest Park* (Lake Forest Park Stewardship Foundation, 2001). This stream flows through an underground culvert in the vicinity of the Burke-Gilman Trail near 153rd Street. Currently, there is asphalt trail surface up to a flow dissipater which is approximately four to five feet underground.

According to Washington Department of Fisheries (1975), Lyon Creek and McAleer Creek support chinook, coho, and sockeye salmon. Puget Sound chinook salmon has been listed as "Threatened" under the Endangered Species Act (U.S. Federal Register, 24 March 1999). Streams 3, 4, and 5 are steep hillside drainages that are unlikely to support fish. Photographs of each stream and their on-site buffer areas are presented in Appendix C.

### *Wetland Functions and Values*

Wetland functions, and their human assigned values, are diverse and numerous. Hydrologically, wetlands are important for flood and stormwater storage, water quality maintenance, and aquifer recharge. This is especially true in developed areas where runoff from impervious services is accelerated and concentrated. Wetlands can also supply a diversity of habitats for the foraging, breeding and rearing activities of wildlife in the area, and wetlands can often provide educational and recreational opportunities for surrounding communities.

Although every wetland serves some function, the type and the degree to which a particular function is served varies from wetland to wetland. This variation is guided by several factors. One of these is the size of the wetland, which can be limited by topography or by surrounding development. A second factor is the vegetation community types and other habitat features present in the wetland and neighboring areas. Other factors include the location of the wetland; proximity to habitat corridors; and hydrological connectivity to stream, lakes or other water bodies and/or to other wetlands. An evaluation of the functions and values of a wetland takes all of these factors into consideration.

The wetlands identified in this study are small, and subject to past and on-going disturbance and maintenance. Their primary function is for limited storage and conveyance of storm water. They also provide some limited water quality functions prior to discharge into the lake, and provide some edge habitat and plant diversity which contribute to the wildlife habitat values of the area.

## REGULATORY IMPLICATIONS

### *Local Regulations*

#### Wetlands

In Lake Forest Park, wetlands are regulated under *Ordinance No. 930: Sensitive Areas Update* (adopted December 1, 2005). Wetlands are rated into three categories based on size, vegetation classes, presence of open water, and other special features. Artificial wetlands intentionally created from non-wetland sites, including drainage ditches and grass-lined swales are excluded in Section 16.16.040.AA. This is consistent with the determination of jurisdictional wetlands described above.

Standard buffer widths are determined by wetland category with provisions for minimum reduced buffers with buffer enhancement. Wetland categories and required buffer widths are summarized in Table 1. Also shown are vegetation classes in the wetland and buffer areas within the study area.

Table 1. Wetland categories, required buffer widths, and vegetation classes.

| Wetland | Wetland Category | Standard Buffer Width (ft) | Minimum Buffer Width with Enhancement (ft) | Wetland Vegetation Classes in Project Area[1] | Buffer Vegetation Classes in Project Area[2] |
|---|---|---|---|---|---|
| **1** | 3 | 50' | 35' | PEM | F, H |
| **2** | 3 | 50' | 35' | PSS | F, H |
| **3** | 3 | 50' | 35' | PSS | F, S |
| **4** | 2 | 100' | 70' | PFO | F, S, H |
| **5** | 3 | 50' | 35' | PEM | S, H |
| **6** | 3 | 50' | 35' | PEM | S, H |
| **7** | 3 | 50' | 35' | PEM | S, H |
| **8** | 3 | 50' | 35' | PEM | F, S, H |

[1] PFO=forested, PSS=scrub/shrub, PEM=emergent, PAB=aquatic bed (according to Cowardin 1979)
[2] F=forested, S=shrub, H=herbaceous

*Streams*

In Lake Forest Park, streams are regulated under *Ordinance No. 930: Sensitive Areas Update* (adopted December 1, 2005). Streams are rated into three categories based on fish use and flow. Certain features such as irrigation ditches, canals, storm or surface water runoff devices, or other entirely artificial streams are excluded unless they are used by salmonids or to convey surface water naturally occurring prior to the alteration of the land (Section 16.16.040.X.). This is consistent with the stream determinations described above.

Standard buffer widths are determined by stream type with provisions for minimum reduced buffers with buffer enhancement. Stream types and required buffer widths are shown in Table 2. Also shown are vegetation classes in the stream buffer areas within the project site.

Table 2. Stream categories, required buffer widths, and vegetation classes.

| Aquatic Area | Stream Type | Standard Buffer Width (ft) | Minimum Buffer Width with Enhancement (ft) | Buffer Vegetation Classes in Project Area[1] |
|---|---|---|---|---|
| **Lyon Creek** | Type 1 | 115' | 70' | F, S, H |
| **McAleer Creek** | Type 1 | 115' | 70' | F, S, H |
| **Stream 3** | Type 3 | 35' | 25' | F, S, H |
| **Stream 4** | Type 2 | 50' | 35' | S, H |
| **Stream 5** | Type 2 | 50' | 35' | H |

[1] F=forested, S=shrub, H=herbaceous

*Mitigation Requirements*

When alterations to wetlands, streams, or their buffers are proposed, the mitigation sequence of avoidance, minimization, rectification, and compensation for proposed impacts is required. After these steps are completed, mitigation will need to be planned according to guidelines set forth by Lake Forest Park and other permitting agencies.

Under the Lake Forest Park Sensitive Areas Ordinance (SAO), mitigation ratios are determined according to the rating of the wetland or stream and type of impact, as well as the type and location of mitigation proposed. According to Section 16.16.340 (Wetlands – Mitigation requirements), replacement is required when a buffer is altered pursuant to an approved development proposal. Enhancement may be allowed when a wetland or buffer is altered, when water quality or wildlife habitat functions will be improved. Minimum requirements for enhancement are established in administrative rules. Similarly Section 16.16.370 (Streams – Mitigation requirements) specifies that replacement or enhancement will be required when a stream or buffer is altered pursuant to an approved development proposal. There is to be no net loss of stream functions, and no impact on stream functions above or below the site.

*Shorelines*

Since Lake Washington is considered a shoreline of statewide significance, this project is also subject to regulation under the Shoreline Management Act (SMA), a state program administered at the local level. Lake Forest Park is in the process of updating their Shoreline Master Program of 1995, which was never formally adopted. A shoreline permit will be required for the Burke-Gilman Trail Redevelopment Project.

### State and Federal Regulations

The U.S. Army Corps of Engineers (Corps) regulates streams and non-isolated wetlands under Section 404 of the Clean Water Act. If any fill is to be placed in streams or wetlands, the Corps must be notified and the appropriate permits obtained. Depending on the connection of any impacted stream or wetland to habitats containing species listed under the federal Endangered Species Act (ESA), the Corps may require that a Biological Evaluation be prepared to assess effects of the proposed project on listed species (e.g., chinook salmon). At a minimum, the permit application form would need to justify why the project would have no effect on listed species. ESA consultation with the federal services is likely because of anticipated work within Lyon Creek associated with potential bridge reconstruction. In addition, work within the OHWM would also require a Hydraulic Project Approval from the Washington Department of Fish and Wildlife (WDFW).

If any proposed stream or wetland alteration requires a federal permit, Washington Department of Ecology (DOE) Individual 401 Water Quality Certification and Coastal Zone Management Consistency determination would also be required. For impacts to wetlands, mitigation requirements are outlined in *Guidance on Wetland Mitigation in Washington State* (DOE et al. 2004). Neither the Corps nor DOE regulate stream or wetland buffers.

As stated above, this project is also subject to the Shoreline Management Act regulations, a state law that is administered locally by the City of Lake Forest Park. Washington Department of Ecology has primary responsibility to review issued permits for conformance with the SMA.

## PROPOSED IMPACTS AND MITIGATION

### Proposed Impacts

Specific impacts of the proposed Burke-Gilman Trail Redevelopment Project have not yet been identified. It is expected that wetland and stream buffers will be impacted by trail widening and that the bridge at Lyon Creek will need to be replaced, potentially impacting the banks of Lyon Creek below the OHWM.

Wetland and stream buffers will be impacted by widening the area of paved trail on either or both sides of the existing trail. These are primarily grassy and weedy areas adjacent to the existing trail and sideslopes of adjacent ditches. Once specific locations of impacts are identified, the type of impact and affected buffer functions will be characterized.

### *Mitigation Opportunities*

There are many opportunities to enhance buffer areas along the project by removing invasive plant species and planting other native species for improvement of wildlife food and cover features. The bridge replacement at Lyon Creek provides opportunity to improve water quality, as well as aesthetics, with removal and replacement of old creosote pilings. Mitigation opportunities within Lyon Creek both upstream and downstream of the bridge include revegetation along existing rip-rap banks and/or potential habitat improvements through placement of woody debris.

A detailed mitigation plan will be developed, pursuant to Section 16.16.120, when specific impacts are identified. This will include a five-year plan for monitoring and maintenance.

---

The findings of this wetland and stream delineation study are subject to review and acceptance by local, state and federal regulatory authorities.

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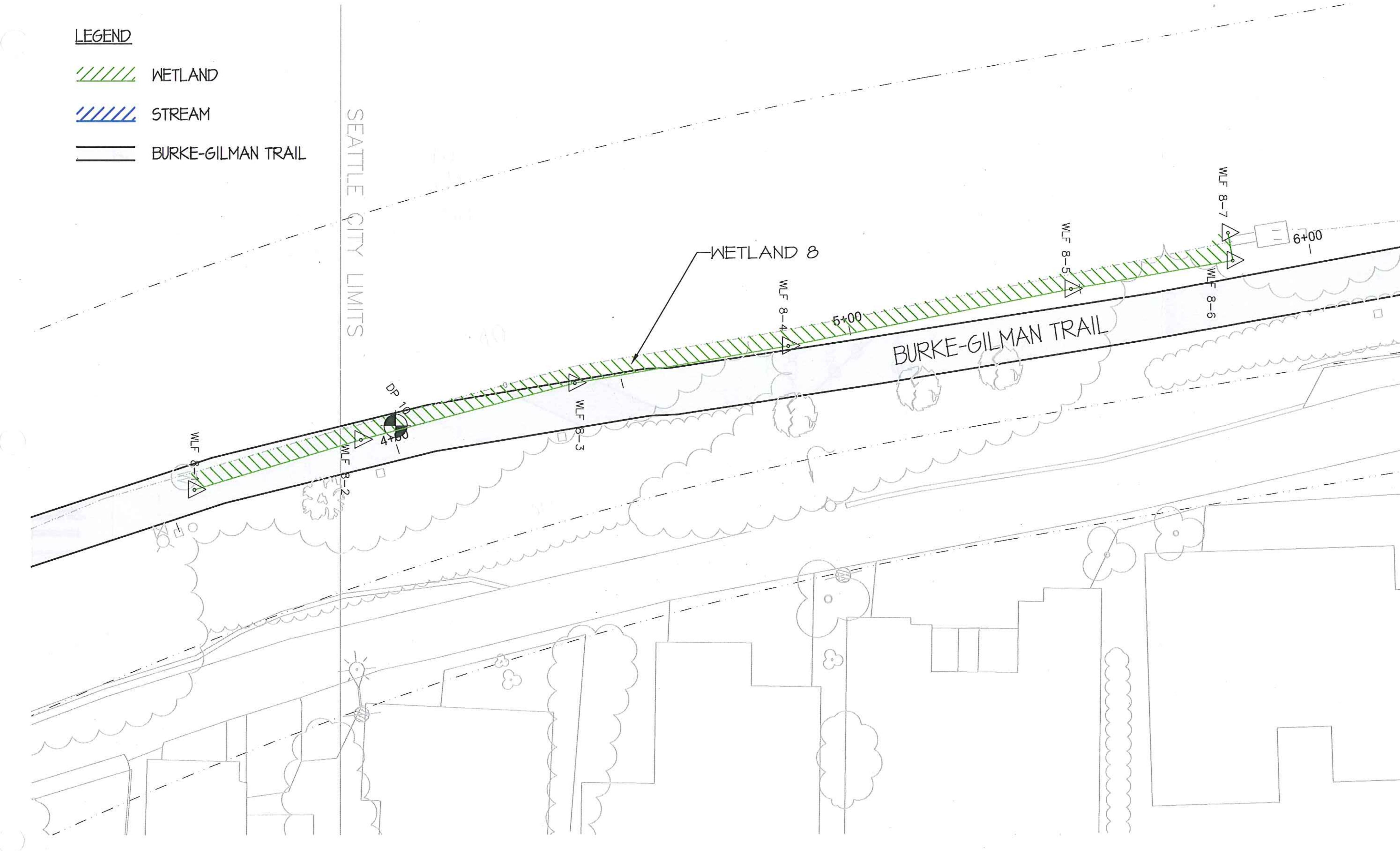
Washington Department of Ecology. 1997. *Washington State Wetlands Identification and Delineation Manual.* Ecology Publication #96-94. 88 p. plus appendices.

Washington Department of Fisheries. 1975. *A Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region.*

# APPENDIX A

## Wetland Delineation Survey Maps




SITE MAP: WETLAND 8
SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: GL
CHECKED: | FILE: WS-LAYOUT

BAR IS ONE INCH IN ORIGINAL DRAWING ADJUST ACCORDINGLY

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watershed@watershedco.com
www.watershedco.com

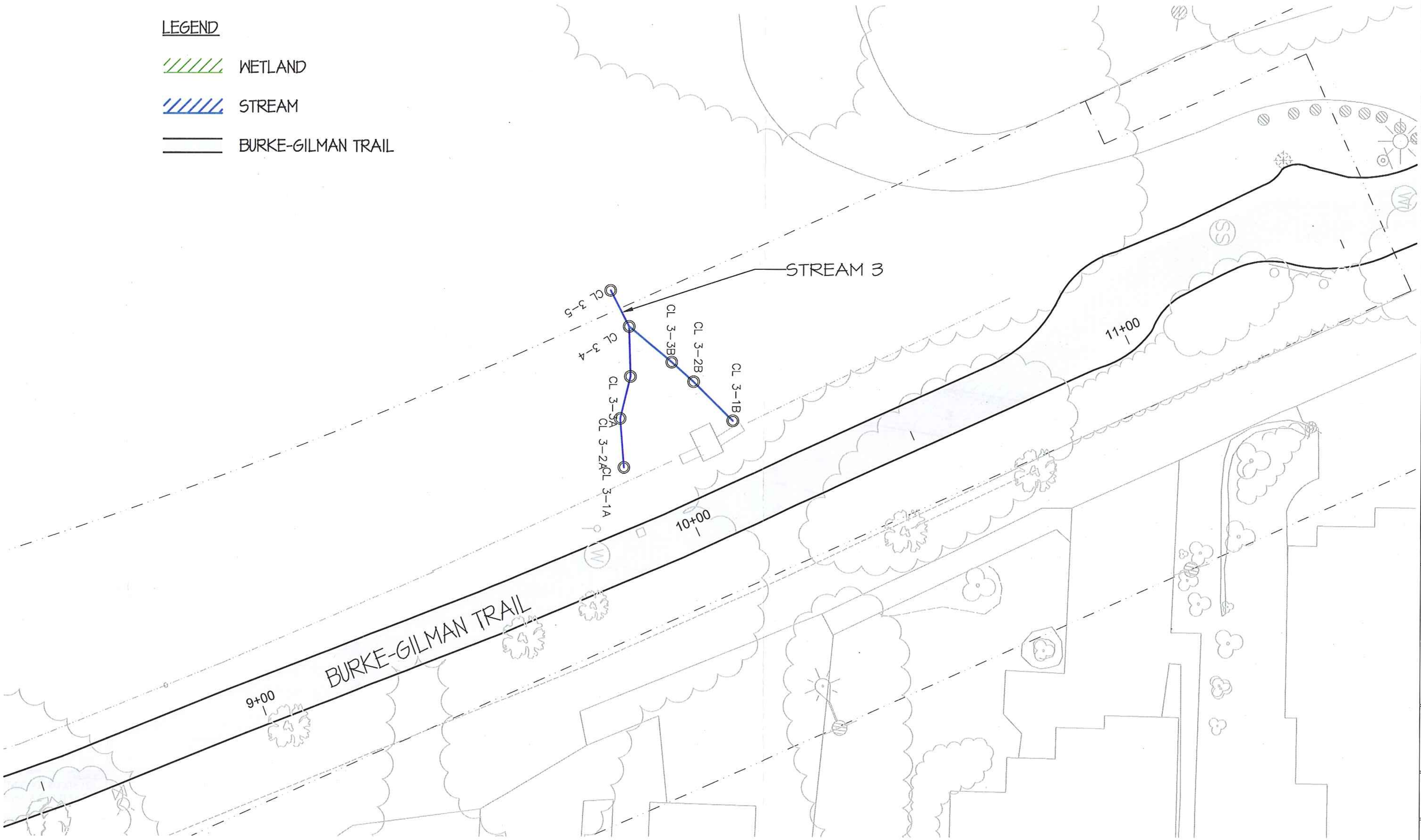
CLIENT: KING COUNTY PARKS

ADDRESS: 821 SECOND AVENUE SEATTLE, WA 98104

TITLE: BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 1 OF 11




# SITE MAP: STREAM 3

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: GL
CHECKED: | FILE: WS-LAYOUT

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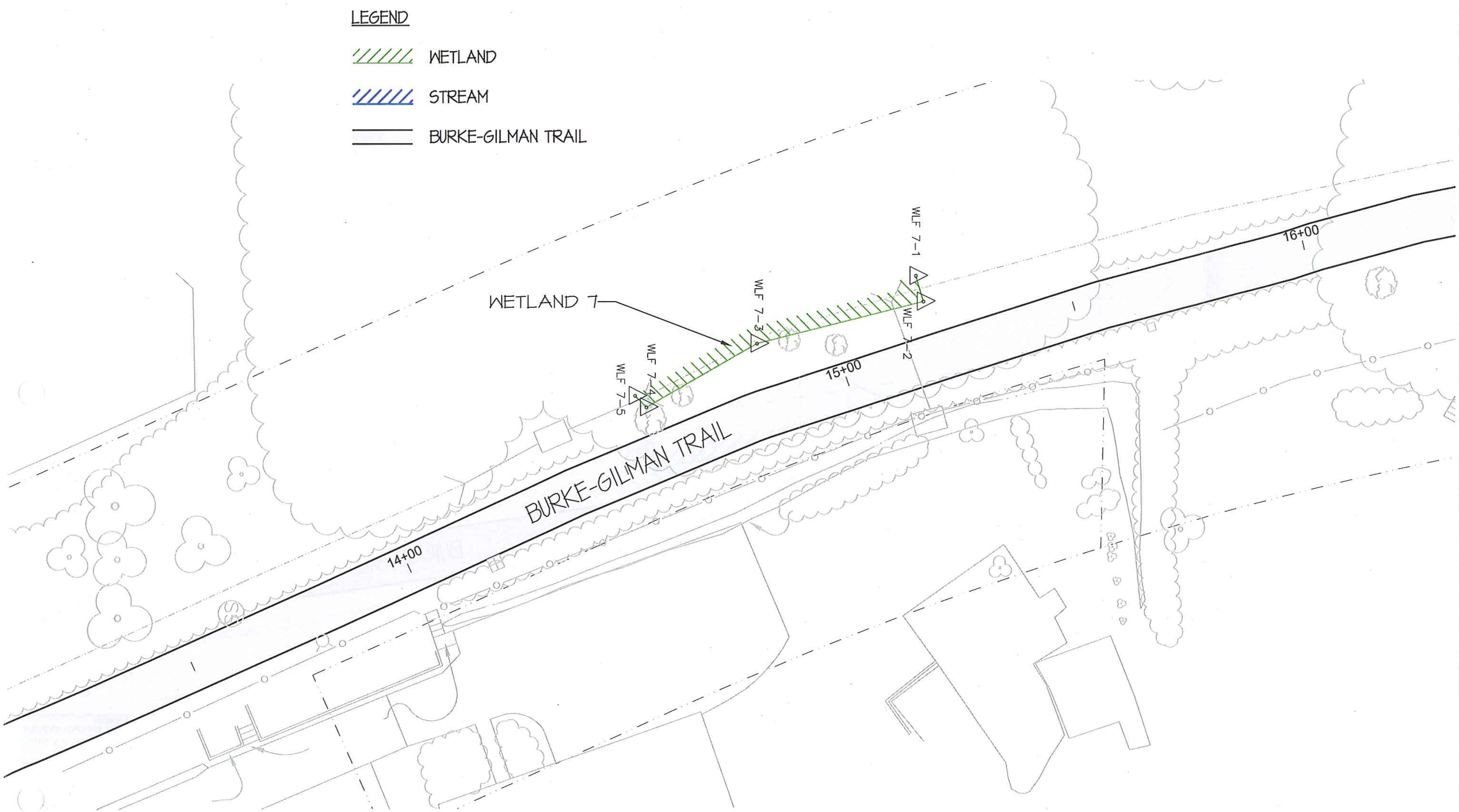
TITLE: BURKE-GILMAN TRAIL REDEVE[illegible]-MENT: SENSIT[illegible] AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 2 OF 11




SITE MAP: WETLAND 7

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: CL
CHECKED: | FILE: WS-LAYOUT

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CLIENT:
KING COUNTY PARKS

ADDRESS:
821 SECOND AVENUE
SEATTLE, WA 98104

TITLE:
BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 3 OF 11


SITE MAP: WETLAND 6

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: GL
CHECKED: | FILE: WS-LAYOUT

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TITLE: BURKE-GILMAN TRAIL REDEV P- MENT: SENSI AREAS STUDY

JOB NUMBER: 050510


| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: DRAFTING: CL
CHECKED: FILE: WS-LAYOUT

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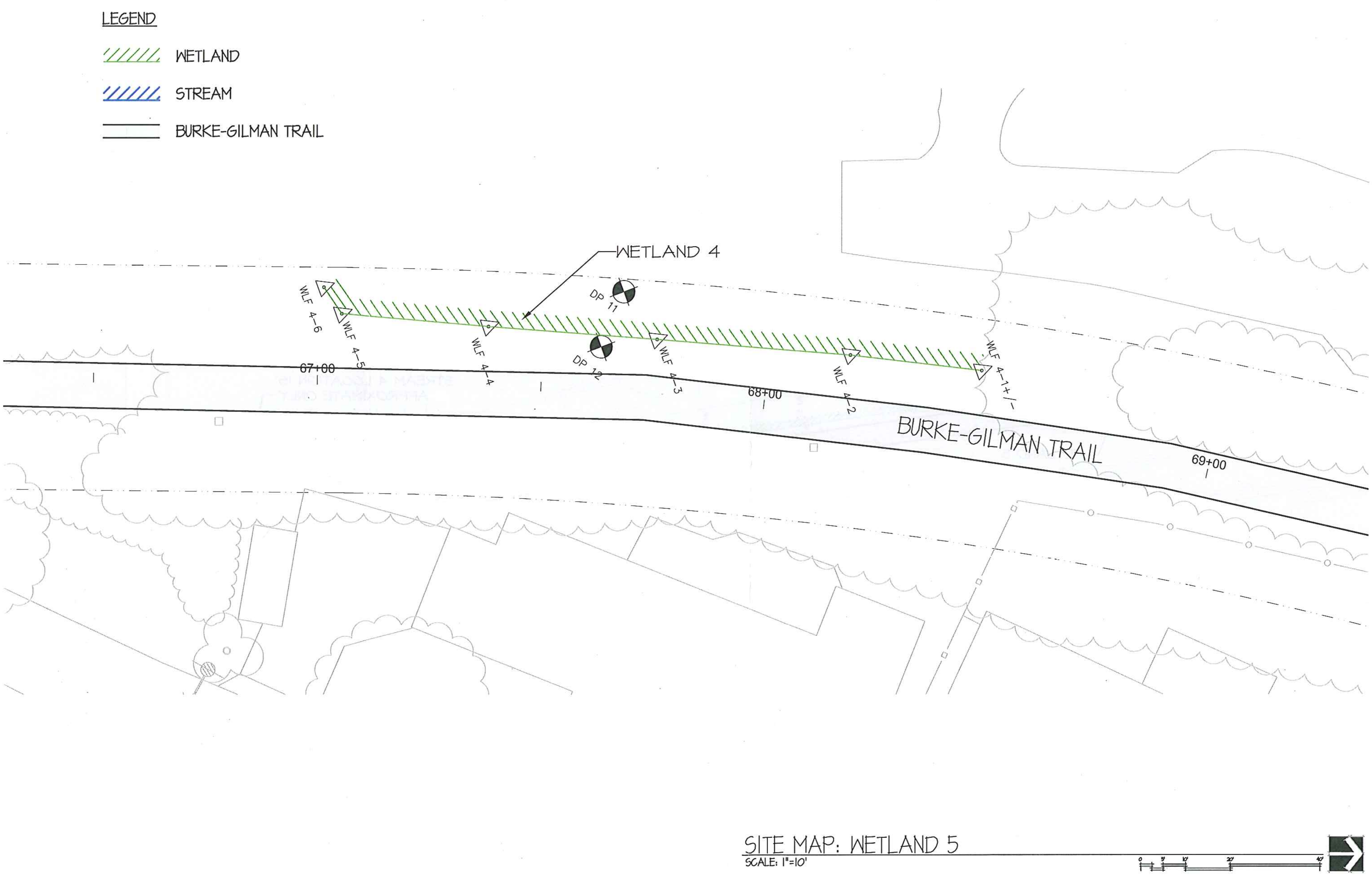
TITLE: BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 5 OF 11

# SITE MAP: WETLAND 5 & STREAM 4

SCALE: 1"=20'




# SITE MAP: WETLAND 5

SCALE: 1"=10'

| NO. | DATE | REVISION |
| --- | --- | --- |
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: CL
CHECKED: | FILE: WS-LAYOUT

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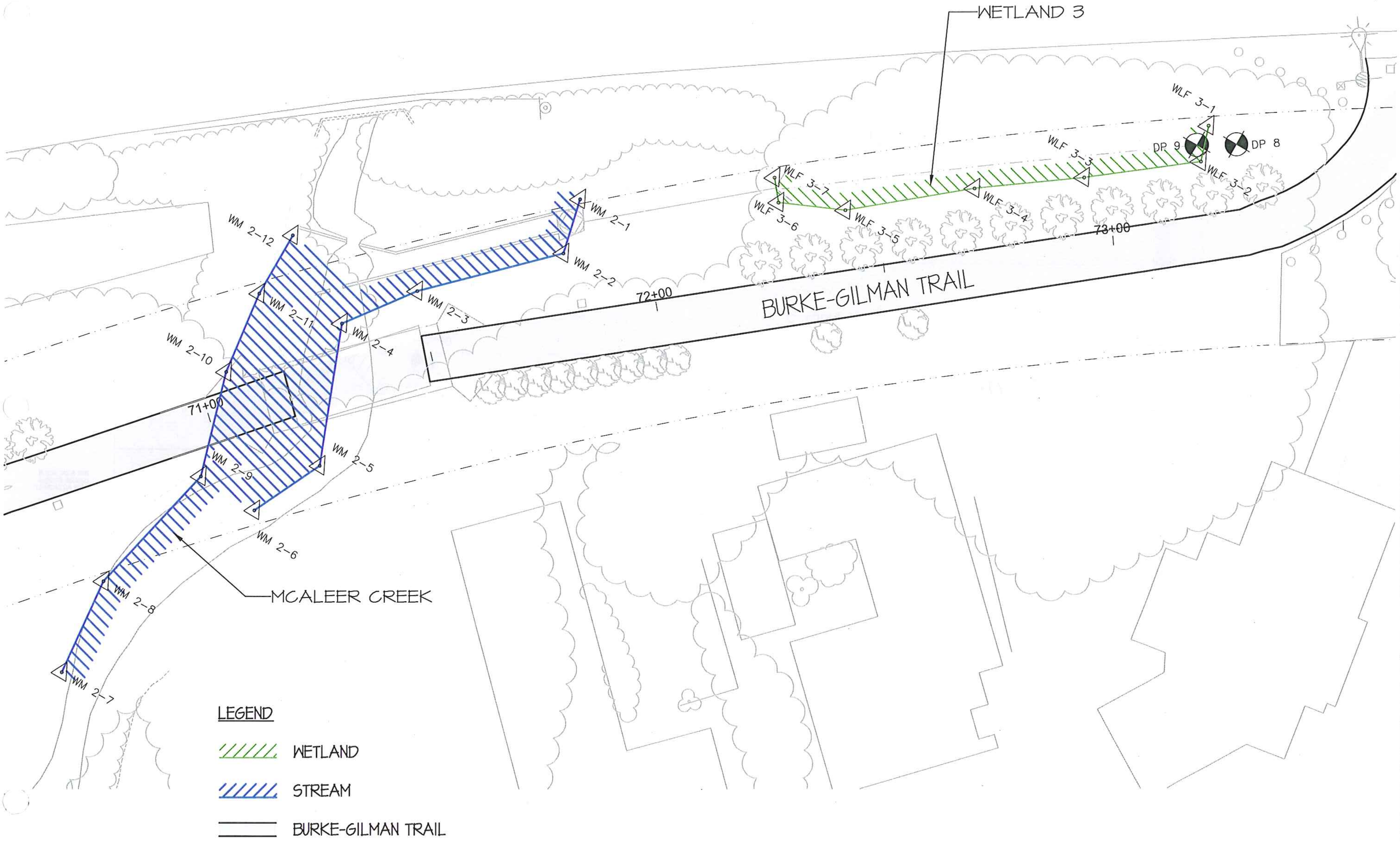
TITLE: BURKE-GILMAN TRAIL REDEVE[illegible]-MENT: SENSIT[illegible] AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 6 OF 11




SITE MAP: WETLAND 3 & MCALEER CREEK

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: CL
CHECKED: | FILE: WS-LAYOUT

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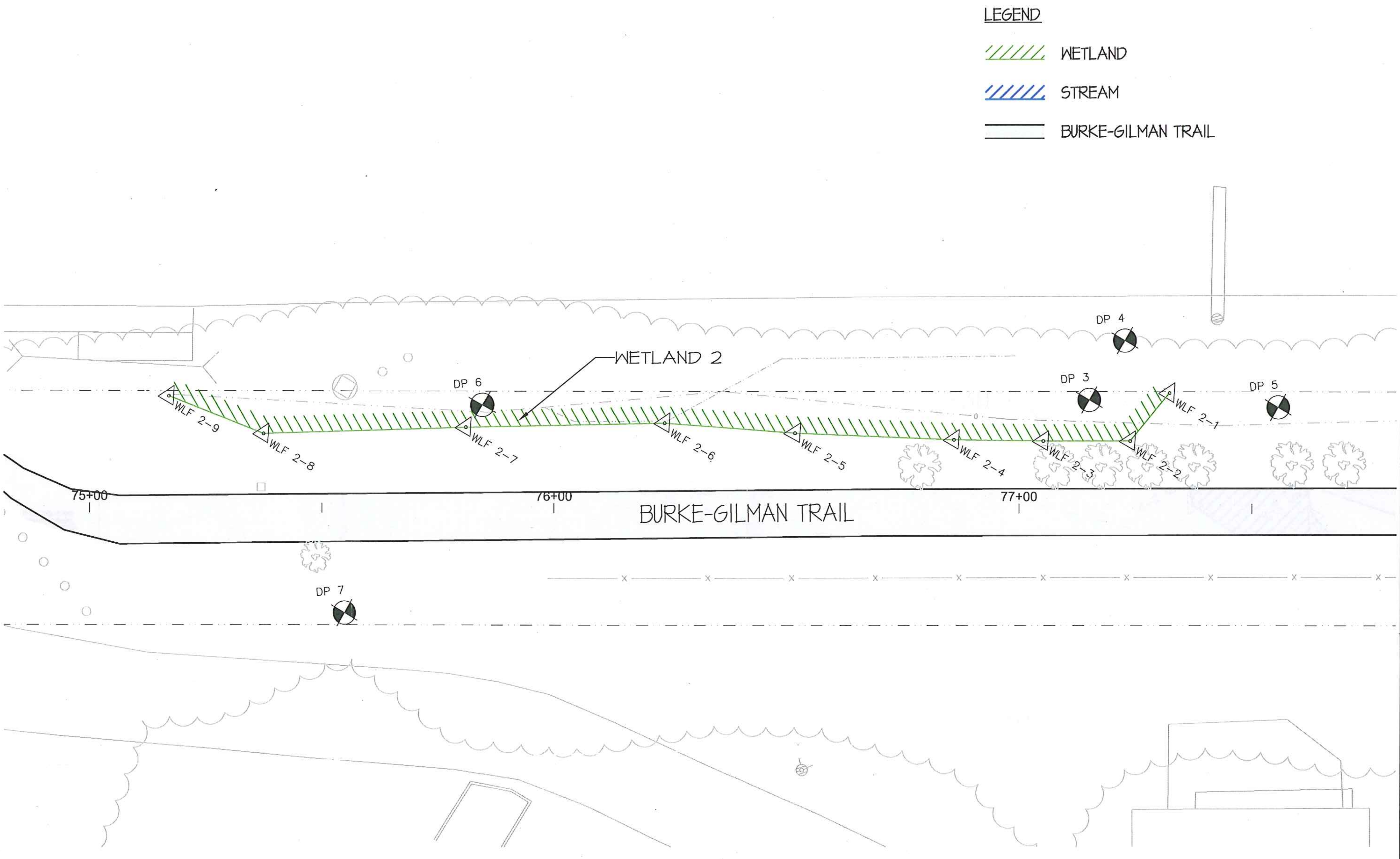
TITLE: BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 7 OF 11




SITE MAP: WETLAND 2

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: GL
CHECKED: | FILE: WS-LAYOUT

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TITLE:
BURKE-GILMAN TRAIL REDEVELOP-MENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

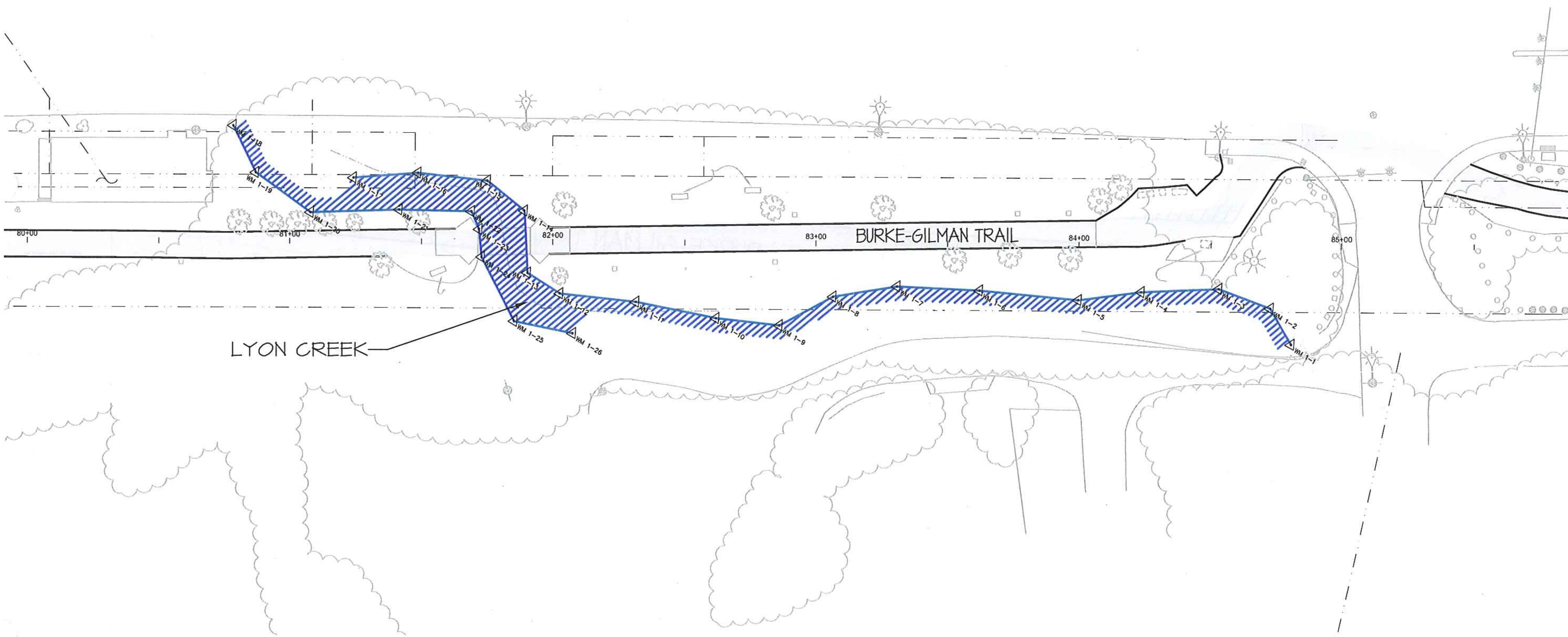
SHEET NUMBER: 8 OF 11

LEGEND

WETLAND

STREAM

BURKE-GILMAN TRAIL




SITE MAP: LYON CREEK

SCALE: 1"=20'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: CL
CHECKED: | FILE: WS-LAYOUT

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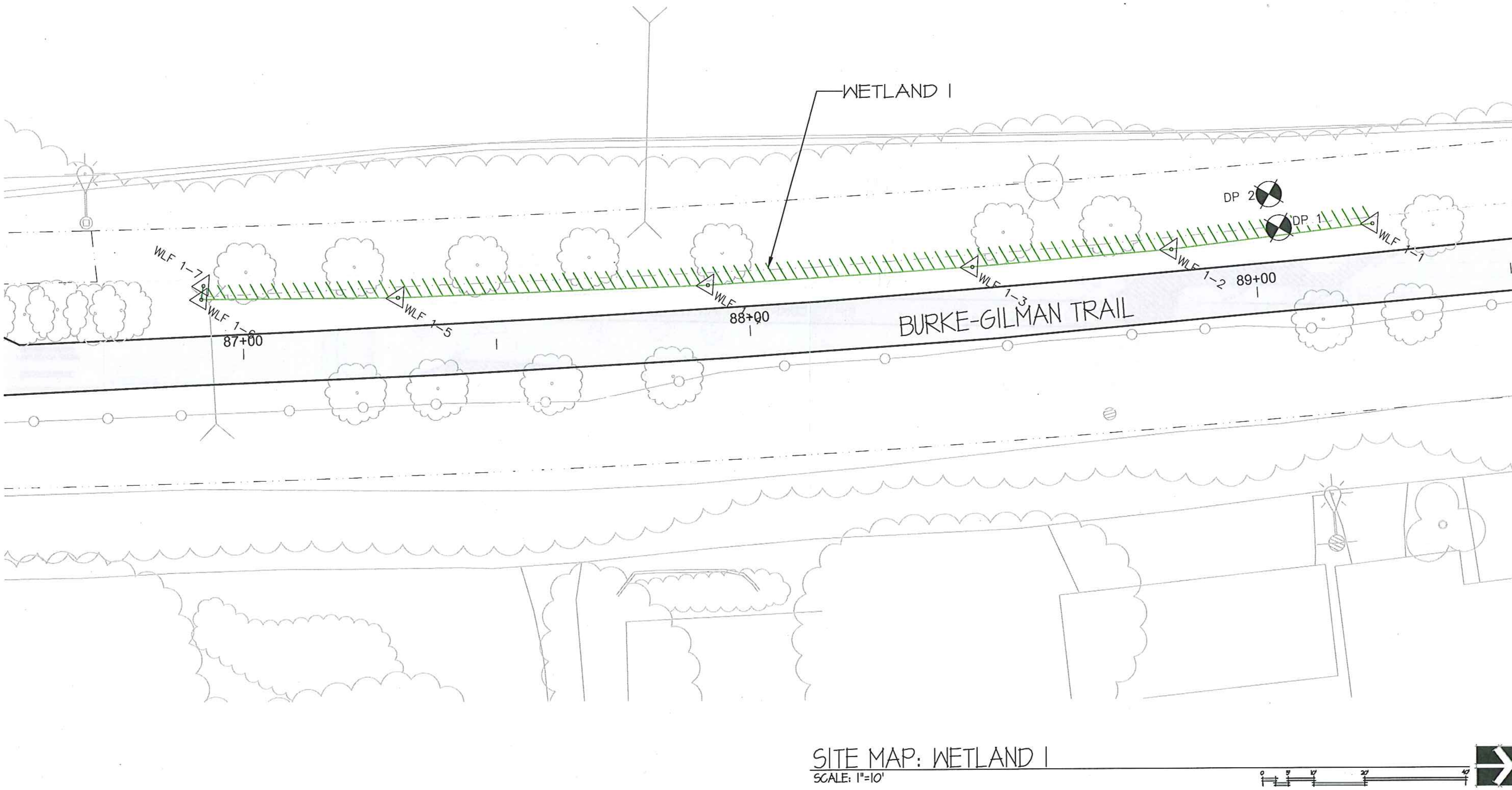
TITLE: BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 9 OF 11




| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

PROJECT MANAGER: JC
DESIGNED: | DRAFTING: CL
CHECKED: | FILE: WS-LAYOUT

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ADDRESS: 821 SECOND AVENUE SEATTLE, WA 98104

TITLE: BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER: 050510

SHEET NUMBER: 10 OF 11

SITE MAP: WETLAND 1

SCALE: 1"=10'

| NO. | DATE | REVISION |
|---|---|---|
| 1 | 3/27/06 | REVIEW SET |

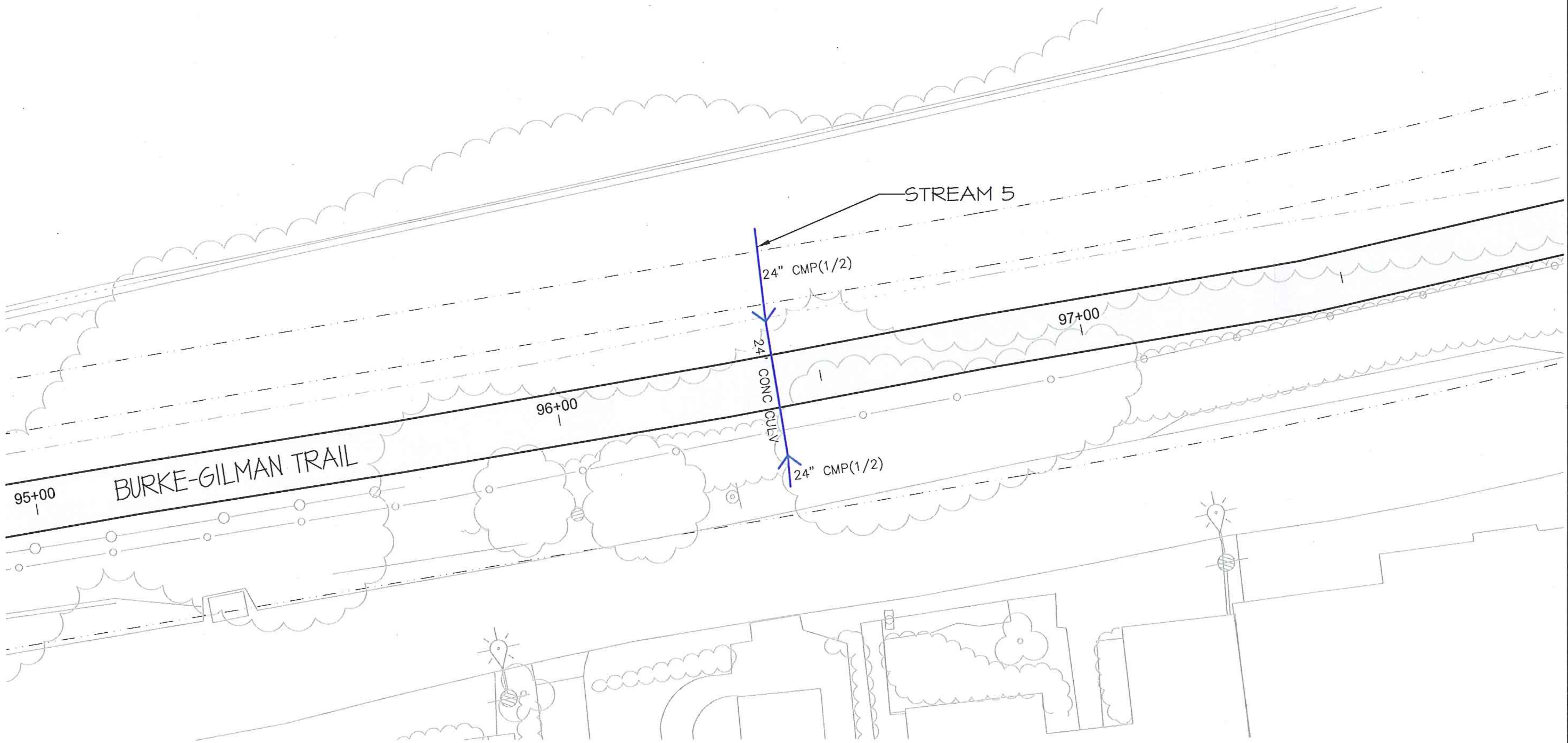
PROJECT MANAGER: JC
DESIGNED: | DRAFTING: GL
CHECKED: | FILE: WS-LAYOUT

LEGEND

WETLAND

STREAM

BURKE-GILMAN TRAIL




SITE MAP: STREAM 5
SCALE: 1"=10'

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www.watershedco.com


CLIENT:
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ADDRESS:
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SEATTLE, WA 98104

TITLE:
BURKE-GILMAN TRAIL REDEVELOPMENT: SENSITIVE AREAS STUDY

JOB NUMBER:
050510

SHEET NUMBER:
11 OF 11

# APPENDIX B

## Wetland Determination Data Forms

# WETLAND DETERMINATION DATA FORM

**The Watershed Company** – 1410 Market Street; Kirkland WA 98033
(425) 822-5242 Fax: (425) 827-8136 www.watershedco.com

**WETLAND?** [YES] NO

Date: 03/02/06

Data point: DP-1 Wetland: 1

Project Name: Burke-Gilman Trail
Data point location: N. side Beach Drive, east end
Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO
Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| (mud & sediment) | | | *Rumex crispus* | H | FAC+ |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 0%

Vegetation criteria met? YES [NO]
Notes: Wetland covered with bare mud & sediment, vegetation will likely sprout in spring/summer.

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 10"+ | B | 10YR 2/1 | no | muck |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO
Notes:

## *HYDROLOGY*

Surface saturation? [YES] NO
Depth to saturation: surface
Depth of inundation ___
Depth to free water in pit ___
Flow? YES [NO]
Channel? ___ Sheet? ___

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- x Drift lines or drainage patterns
- x Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- x Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

**The Watershed Company** – 1410 Market Street; Kirkland WA 98033
(425) 822-5242 Fax: (425) 827-8136 www.watershedco.com

**WETLAND?** YES **[NO]**

Date: 03/02/06

Data point: DP-2 Wetland: ______

Project Name: Burke-Gilman Trail Data point location: Upslope from DP-1

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Rubus discolor* | S | FACU | | | |
| *Ilex aquifolium* | S | NL | | | |
| *Geranium robertianum* | H | NL | | | |
| grasses | H | FAC | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 50%

Vegetation criteria met? YES [NO]

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 10YR 3/2 | no | gravelly sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- ____ Gleyed/Low Chroma
- ____ Sulfidic odor
- ____ Histosol
- ____ Other (list in notes)

Soil Criteria Met? YES [NO]

Notes:

## *HYDROLOGY*

Surface saturation? YES [NO]
Depth to saturation ______
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [NO]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ____ Observation of inundation
- ____ Observation of soil saturation
- ____ Water marks
- ____ Drift lines or drainage patterns
- ____ Sediment deposits

Secondary Indicators: (≥2 required)
- ____ Oxidized root channels
- ____ Water-stained leaves
- ____ Local soil survey data
- ____ FAC-neutral test

Hydrologic Criteria Met? YES [NO]

Recent rainfall: Very high [High] Normal Low Very low

Notes: Damp.

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

**The Watershed Company** – 1410 Market Street; Kirkland WA 98033
(425) 822-5242 Fax: (425) 827-8136 www.watershedco.com

**WETLAND?** [YES] NO

Date: 03/02/06

Data point: DP-3 Wetland: 2

Project Name: Burke-Gilman Trail Data point location:

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Salix babylonica* | T | FAC+ | | | |
| *Populus deltoides* | T | FAC | | | |
| *Cornus stolonifera* | S | FACW | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 100%

Vegetation criteria met? [YES] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 10YR 3/1 | no | silty loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO

Notes:

## *HYDROLOGY*

Surface saturation? [YES] NO
Depth to saturation surface
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [NO]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- ___ Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- x Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

**The Watershed Company** – 1410 Market Street; Kirkland WA 98033
(425) 822-5242 Fax: (425) 827-8136 www.watershedco.com

**WETLAND?** YES [NO]

Date: 03/02/06

Data point: DP-4 Wetland: ______

Project Name: Burke-Gilman Trail Data point location: adjacent to Wetland 2

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Rubus discolor* | S | FACU | | | |
| *Geranium robertianum* | H | NL | | | |
| grasses | H | FAC | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 50%

Vegetation criteria met? YES [NO]

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 10YR 3/2 | no | gravelly sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:

- ____ Gleyed/Low Chroma
- ____ Sulfidic odor
- ____ Histosol
- ____ Other (list in notes)

Soil Criteria Met? YES [NO]

Notes: Fill slope below road.

## *HYDROLOGY*

Surface saturation? YES [NO]

Depth to saturation ______

Depth of inundation ______

Depth to free water in pit ______

Flow? YES [NO]

Channel? ____ Sheet? ____

Primary Indicators: (1 required)

- ____ Observation of inundation
- ____ Observation of soil saturation
- ____ Water marks
- ____ Drift lines or drainage patterns
- ____ Sediment deposits

Secondary Indicators: (≥2 required)

- ____ Oxidized root channels
- ____ Water-stained leaves
- ____ Local soil survey data
- ____ FAC-neutral test

Hydrologic Criteria Met? YES [NO]

Recent rainfall: Very high [High] Normal Low Very low

Notes: Damp.

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

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WETLAND? YES [NO]

Date: 03/02/06

Data point: DP-5 Wetland: ______

Project Name: Burke-Gilman Trail

Data point location: Upslope from DP-4

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus deltoides* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 50%

Vegetation criteria met? YES [NO]

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 10"+ | B | 10YR 3/3 | yes | gravelly sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- ___ Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? YES [NO]

Notes:

## *HYDROLOGY*

Surface saturation? [YES] NO
Depth to saturation surface
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [NO]
Channel? ___ Sheet? ___

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- ___ Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- ___ Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

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**WETLAND?** [YES] NO

Date: 03/02/06

Data point: DP-6 Wetland: 2

Project Name: Burke-Gilman Trail Data point location: ______

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus balsamifera* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| *Spiraea douglasii* | S | FACW | | | |
| *Ilex aquifolium* | S | NL | | | |
| *Hedera helix* | V | NL | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 67%

Vegetation criteria met? [YES] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 10YR 2/1 | some | sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO

Notes:

## *HYDROLOGY*

Surface saturation? [YES] NO
Depth to saturation surface
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [NO]
Channel? _____ Sheet? _____

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- x Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- x Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes: Culvert empties into wetland from under road,

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

**The Watershed Company** – 1410 Market Street; Kirkland WA 98033
(425) 822-5242 Fax: (425) 827-8136 www.watershedco.com

**WETLAND?** **YES** [**NO**]

Date: 03/02/06

Data point: DP-7 Wetland: ______

Project Name: Burke-Gilman Trail Data point location: ______

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus balsamifera* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| *Phalaris arundinacea* | H | FACW | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 67%

Vegetation criteria met? [YES] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12" | B | 10YR 2/2 | very few | sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- ____ Gleyed/Low Chroma
- ____ Sulfidic odor
- ____ Histosol
- ____ Other (list in notes)

Soil Criteria Met? YES [NO]

Notes:

## *HYDROLOGY*

Surface saturation? YES [NO]
Depth to saturation 14"
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [NO]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ____ Observation of inundation
- x Observation of soil saturation
- ____ Water marks
- ____ Drift lines or drainage patterns
- ____ Sediment deposits

Secondary Indicators: (≥2 required)
- ____ Oxidized root channels
- ____ Water-stained leaves
- ____ Local soil survey data
- ____ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes: Marginal, distinct from other wetlands.

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

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**WETLAND?** YES [NO]

Date: 03/02/06

Data point: DP-8 Wetland: ____

Project Name: Burke-Gilman Trail
Data point location: Upslope Wetland 3
Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO
Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus deltoides* | T | FAC | | | |
| *Populus balsamifera* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| *Taraxacum officinale* | H | FACU | | | |
| grasses | H | FAC | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 60%

Vegetation criteria met? [YES] NO
Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 8"+ | B | 10YR 2/2 | no | gravelly sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- ___ Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? YES [NO]
Notes:

## *HYDROLOGY*

Surface saturation? YES [NO]
Depth to saturation ____
Depth of inundation ____
Depth to free water in pit ____
Flow? YES [NO]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ___ Observation of inundation
- ___ Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- ___ Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- ___ Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? YES [NO]

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

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**WETLAND?** [**YES**] NO

Date: 03/02/06

Data point: DP-9  Wetland: 3

Project Name: Burke-Gilman Trail  Data point location: ______

Biologist(s): JC, DN

Do normal environmental conditions exist? [**YES**] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [**NO**]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus balsamifera* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| *Rubus spectabilis* | S | FAC+ | | | |
| *Acer circinatum* | S | FAC- | | | |
| *Phalaris arundinacea* | H | FACW | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 60%

Vegetation criteria met? [**YES**] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 10YR 3/1 | no | silty loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [**YES**] NO

Notes:

## *HYDROLOGY*

Surface saturation? [**YES**] NO
Depth to saturation surface
Depth of inundation ______
Depth to free water in pit ______
Flow? YES [**NO**]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- ___ Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- ___ Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [**YES**] NO

Recent rainfall: Very high [**High**] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

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**WETLAND?** [YES] NO

Date: 03/07/06

Data point: DP-10 Wetland: 8

Project Name: Burke-Gilman Trail Data point location: South end near 145th

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Ranunculus repens* | H | FACW | | | |
| grasses (misc) | H | FAC | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 100%

Vegetation criteria met? [YES] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 8"+ | B | 10Y 3/1 | yes | gravelly silty loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:

- x Gleyed/Low Chroma
- x Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO

Notes:

## *HYDROLOGY*

Surface saturation? [YES] NO

Depth to saturation surface

Depth of inundation 2"

Depth to free water in pit ___

Flow? [YES] NO

Channel? x Sheet? ___

Primary Indicators: (1 required)

- x Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- x Drift lines or drainage patterns
- x Sediment deposits

Secondary Indicators: (≥2 required)

- ___ Oxidized root channels
- x Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

Fairly wide ditch at base of seeping hillside.

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**WETLAND?** [YES] NO

Date: 03/07/06

Data point: DP-11 Wetland: 4

Project Name: Burke-Gilman Trail Data point location: ______

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Populus balsamifera* | T | FAC | | | |
| *Rubus discolor* | S | FACU | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 50%

Vegetation criteria met? YES [NO]

Notes: Marginal, weedy

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 14" | B | 10YR 2/1 | no | gravelly sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- ___ Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO

Notes:

## *HYDROLOGY*

Surface saturation? YES [NO]

Depth to saturation 4"

Depth of inundation ______

Depth to free water in pit ______

Flow? YES [NO]

Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- ___ Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- ___ Drift lines or drainage patterns
- ___ Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- x Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# WETLAND DETERMINATION DATA FORM

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**WETLAND?** **YES** **NO** (boxed)

Date: 03/07/06

Data point: DP-12 Wetland: ____

Project Name: Burke-Gilman Trail Data point location: sideslope Wetland 4

Biologist(s): JC, DN

Do normal environmental conditions exist? **YES** NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES **NO**

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Rubus discolor* | S | FACU | | | |
| *Taraxacum officinale* | H | FACU | | | |
| grasses | H | FAC | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 33%

Vegetation criteria met? YES **NO**

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 10"+ | B | 2.5Y 4/3 | yes | silty clay loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:

- ____ Gleyed/Low Chroma
- ____ Sulfidic odor
- ____ Histosol
- ____ Other (list in notes)

Soil Criteria Met? YES **NO**

Notes:

## *HYDROLOGY*

Surface saturation? YES **NO**

Depth to saturation 4"

Depth of inundation ____

Depth to free water in pit ____

Flow? YES **NO**

Channel? ____ Sheet? ____

Primary Indicators: (1 required)

- ____ Observation of inundation
- x Observation of soil saturation
- ____ Water marks
- ____ Drift lines or drainage patterns
- ____ Sediment deposits

Secondary Indicators: (≥2 required)

- ____ Oxidized root channels
- ____ Water-stained leaves
- ____ Local soil survey data
- ____ FAC-neutral test

Hydrologic Criteria Met? **YES** NO

Recent rainfall: Very high **High** Normal Low Very low

Notes: Damp on surface, saturated at 4", downslope of trail

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

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**WETLAND?** [YES] NO

Date: 03/07/06

Data point: DP-13 Wetland: 5

Project Name: Burke-Gilman Trail Data point location: ____

Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO

Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Phalaris arundinacea* | H | FACW | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 100%

Vegetation criteria met? [YES] NO

Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 10"+ | B | 5GY 3/1 | yes | silty loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
- x Gleyed/Low Chroma
- x Sulfidic odor
- ___ Histosol
- ___ Other (list in notes)

Soil Criteria Met? [YES] NO

Notes: appears to be native soil

## *HYDROLOGY*

Surface saturation? [YES] NO

Depth to saturation ____

Depth of inundation 2"

Depth to free water in pit ____

Flow? YES [NO]

Channel? ____ Sheet? ____

Primary Indicators: (1 required)
- x Observation of inundation
- x Observation of soil saturation
- ___ Water marks
- x Drift lines or drainage patterns
- x Sediment deposits

Secondary Indicators: (≥2 required)
- ___ Oxidized root channels
- ___ Water-stained leaves
- ___ Local soil survey data
- ___ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

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**WETLAND?** YES [NO]

Date: 03/07/06

Data point: DP-14 Wetland: ____

Project Name: Burke-Gilman Trail
Data point location: Upslope of Wetland 5
Biologist(s): JC, DN

Do normal environmental conditions exist? [YES] NO
Has vegetation, soils &/or hydrology been significantly disturbed within the past 5 yrs? YES [NO]

## VEGETATION

*Stratum: T=tree, S=shrub, H=herb, V=vine*

| Dominant Species | Stratum | WIS | Other Species | Stratum | WIS |
|---|---|---|---|---|---|
| *Rubus discolor* | S | FACU | | | |
| *Phalaris arundinacea* | H | FACW | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Percent of dominant species that are FAC, FACW or OBL 50%

Vegetation criteria met? YES [NO]
Notes:

## *SOILS*

| Depth | Horizon | Matrix Color | Mottles (Distinct/Prominent) | Texture |
|---|---|---|---|---|
| 12"+ | B | 2.5Y 3/2 | no | sandy loam |
| | | | | |
| | | | | |
| | | | | |

Hydric Indicators:
____ Gleyed/Low Chroma
____ Sulfidic odor
____ Histosol
____ Other (list in notes)

Soil Criteria Met? YES [NO]
Notes: appears to be old fill lining ditch

## *HYDROLOGY*

Surface saturation? [YES] NO
Depth to saturation surface
Depth of inundation ____
Depth to free water in pit ____
Flow? YES [NO]
Channel? ____ Sheet? ____

Primary Indicators: (1 required)
____ Observation of inundation
x Observation of soil saturation
____ Water marks
x Drift lines or drainage patterns
x Sediment deposits

Secondary Indicators: (≥2 required)
____ Oxidized root channels
____ Water-stained leaves
____ Local soil survey data
____ FAC-neutral test

Hydrologic Criteria Met? [YES] NO

Recent rainfall: Very high [High] Normal Low Very low

Notes:

## *WILDLIFE OBSERVATIONS AND GENERAL NOTES*

# APPENDIX C

## Photographs of Wetlands, Streams, and Buffers

Wetland 1 – 7 March 2006.

Wetland 2 – 7 March 2006.

Wetland 3 – 7 March 2006.

Wetland 4 – 7 March 2006.

Wetland 5 – 7 March 2006.

Wetland 6 – 7 March 2006.

Wetland 7 – 7 March 2006.

Wetland 8 – 7 March 2006.

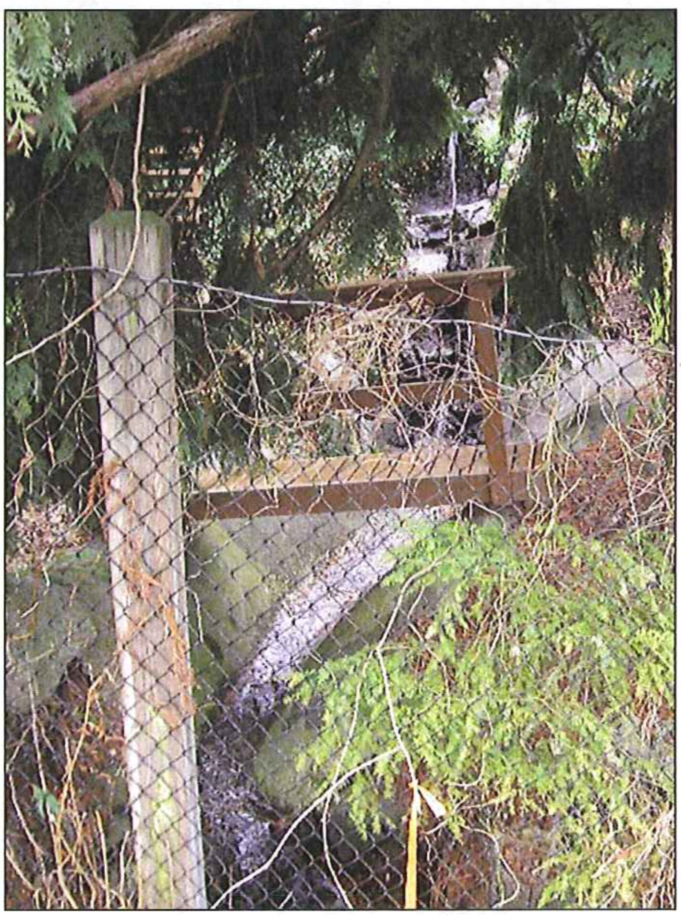
Lyon Creek – 7 March 2006.

Lyon Creek bridge – 7 March 2006.

McAleer Creek – 7 March 2006.

McAleer Creek sediment trap facility – 7 March 2006.

Stream 3 – 7 March 2006.



Stream 4 – 7 March 2006.

Stream 5 – 7 March 2006.

PACE
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