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LAWSON HILLS MPD
WATER QUALITY TECHNICAL REPORT

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1.0 INTRODUCTION

1.1 Site Area Description

BD Lawson Partners, L.P. (Lawson Partners) proposes to develop an approximately 376-acre site northwest and east of the existing city center of Black Diamond, Washington (Figure 1-1).

The largest contiguous portion of the Lawson Hills site is named the "Main Property". The Main Property is bordered by Lawson Street and SE Green River Gorge Road to the northwest, developed properties in the City of Black Diamond to the west, and undeveloped and unincorporated forested lands to the south and east. One outparcel exists in the Main Property, located along both sides of the southern-most paved portion of Botts Drive which extends into the site from Lawson Street. A portion of the Main Property extends west from Lawson Street to SR 169 just north of the existing city center of Black Diamond. A second part of the site is accessed from SR 169 northwest of the existing city center on a parcel of land referred to as the "North Triangle Property" (Figure 1-2). The North Triangle Property was known in the past as the "North Triangle of the West Annexation Area" (Tetra Tech/KCM, Inc. 2000).

The site is largely undeveloped (Figure 1-3). There are some single family residences, logging roads, utility easements, and informal trails on various portions of the site. About 42 acres of the site has been cleared or is meadow; the remainder is predominantly forested. About 15 acres of the site is comprised of wetlands (refer to Water Resources, Inc. 2008) and about 0.5 acres is stream (refer to Cedarock Consultants, Inc. 2008). The main property east of Lawson Street is moderately sloped and west of Lawson Street is gently sloped to flat. The North Triangle slopes from an elevation of about 660 feet on the east to about 580 feet on the west. About 4.1 acres of the site has slopes greater than 40 percent.

The site has been divided into five drainage subbasins, four of which are located on the Main Property (Figure 1-4). The five drainage basins are identified below (Triad Associates, Inc. 2008))

1. Basin A is an approximately 70.8-acre area that drains via Lawson Creek. Lawson Creek bisects the main portion of the site. Lawson Creek flows to Jones Lake offsite, which outlets to Rock Creek flowing to Lake Sawyer.

2. Basin B is an approximately 38-acre area located southeast of SE Green River Gorge Road. This area drains via culverts offsite under SE Green River Gorge Road to Mud Lake, which forms Mud Lake Creek at its outlet. Mud Lake Creek is a tributary of Ginder Creek, which in turn is a tributary of Rock Creek downstream of Jones Lake.

3. Basin C is an approximately 37.9-acre area in the far southeastern portion of the site that drains via subsurface flow or sheetflow through numerous small dry ravines and slopes along the southern boundary of the site to recharge groundwater and Unnamed Creek offsite to the south. Unnamed Creek discharges to Jones Lake after passing under SR 169 south of the existing city center of Black Diamond.

4. Basin D is an approximately 45.6-acre area comprised of the portion of the site between Lawson Street and SR-169. This area drains to the confluence of Mud Lake Creek and Ginder Creek offsite on the west side of SR-169 just north of Roberts Road.

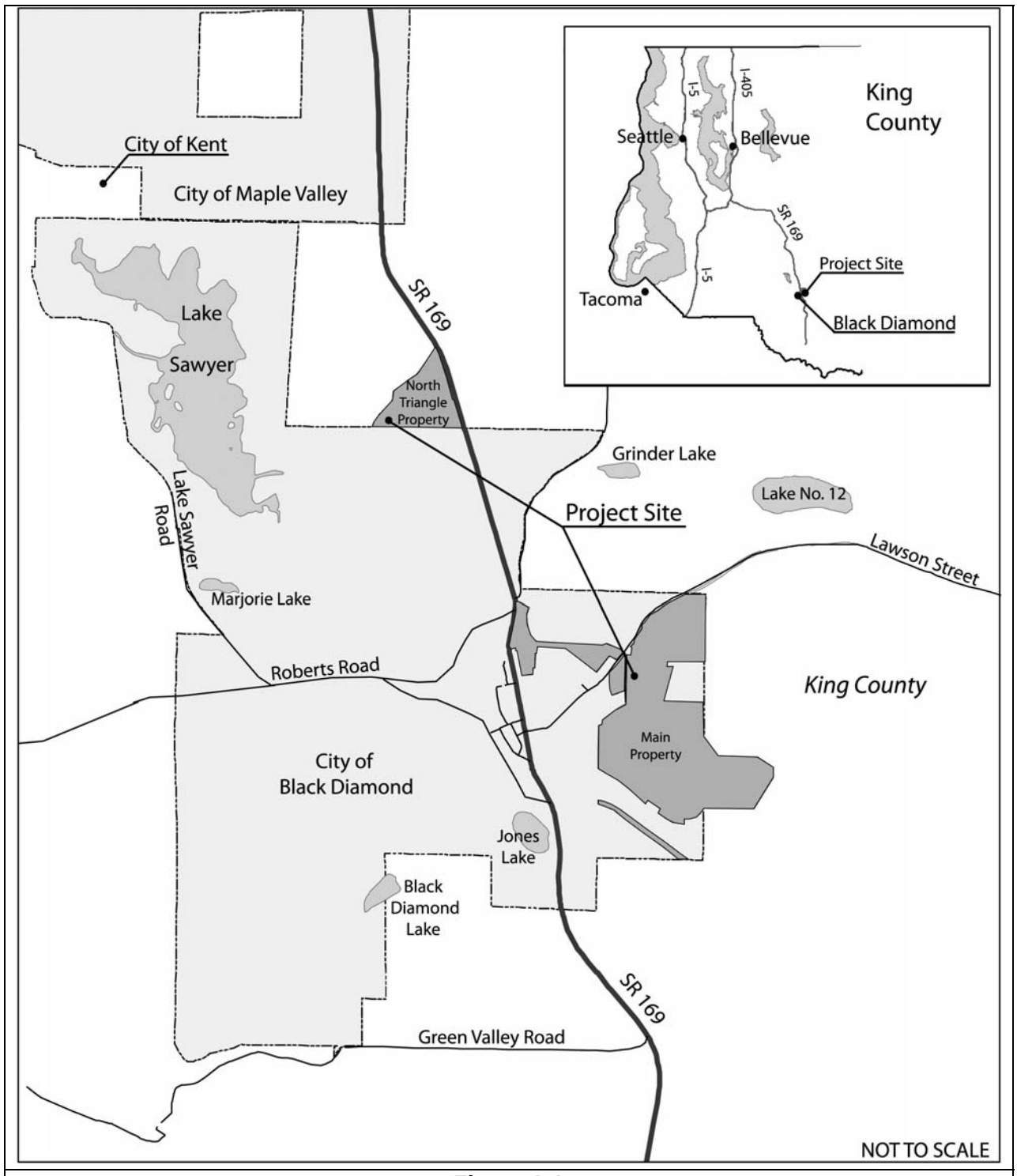


Figure 1-1
Lawson Hills Vicinity Map

Source: Triad Associates, Inc.

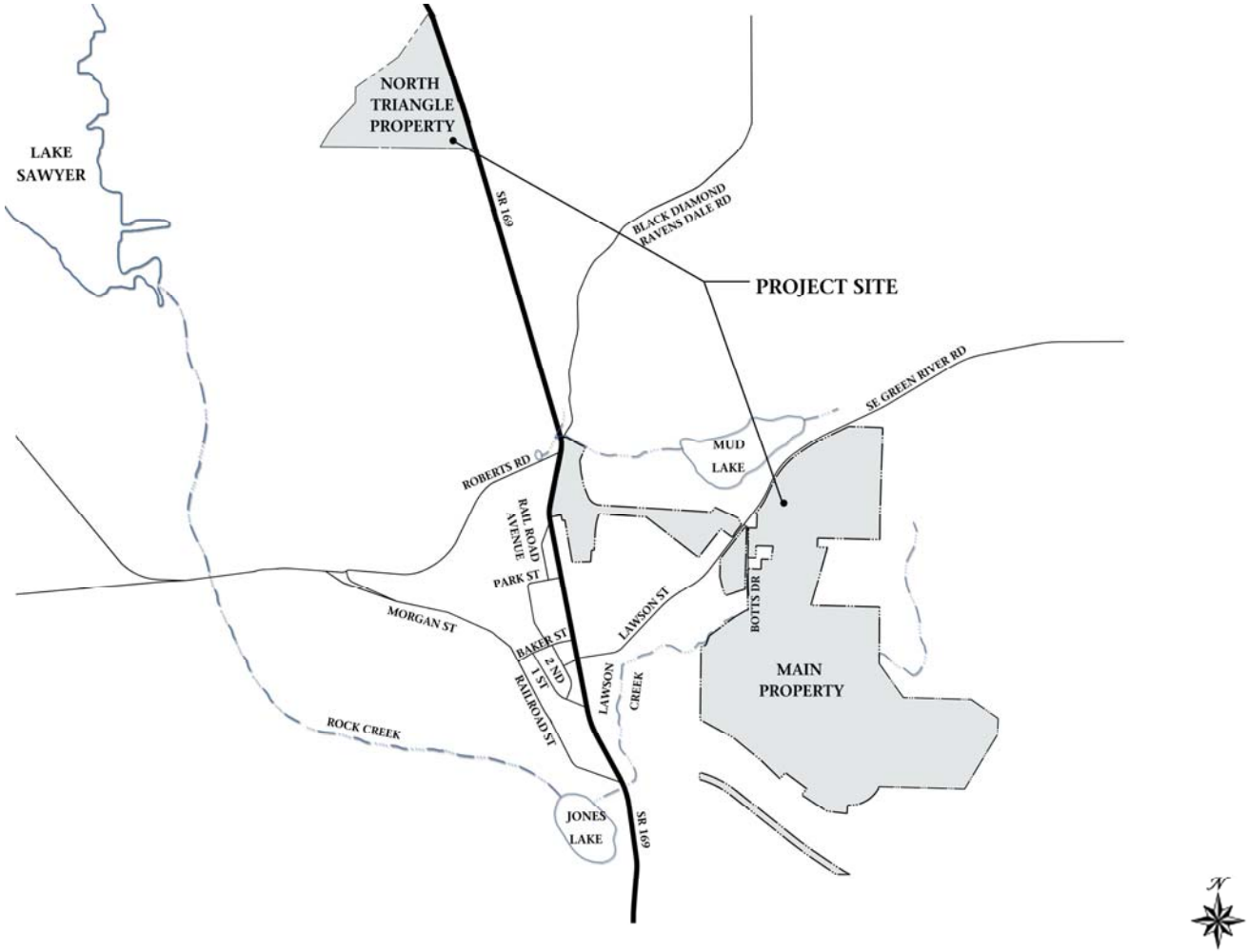


Figure 1-2
Lawson Hills Site Map

Source: Triad Associates, Inc.

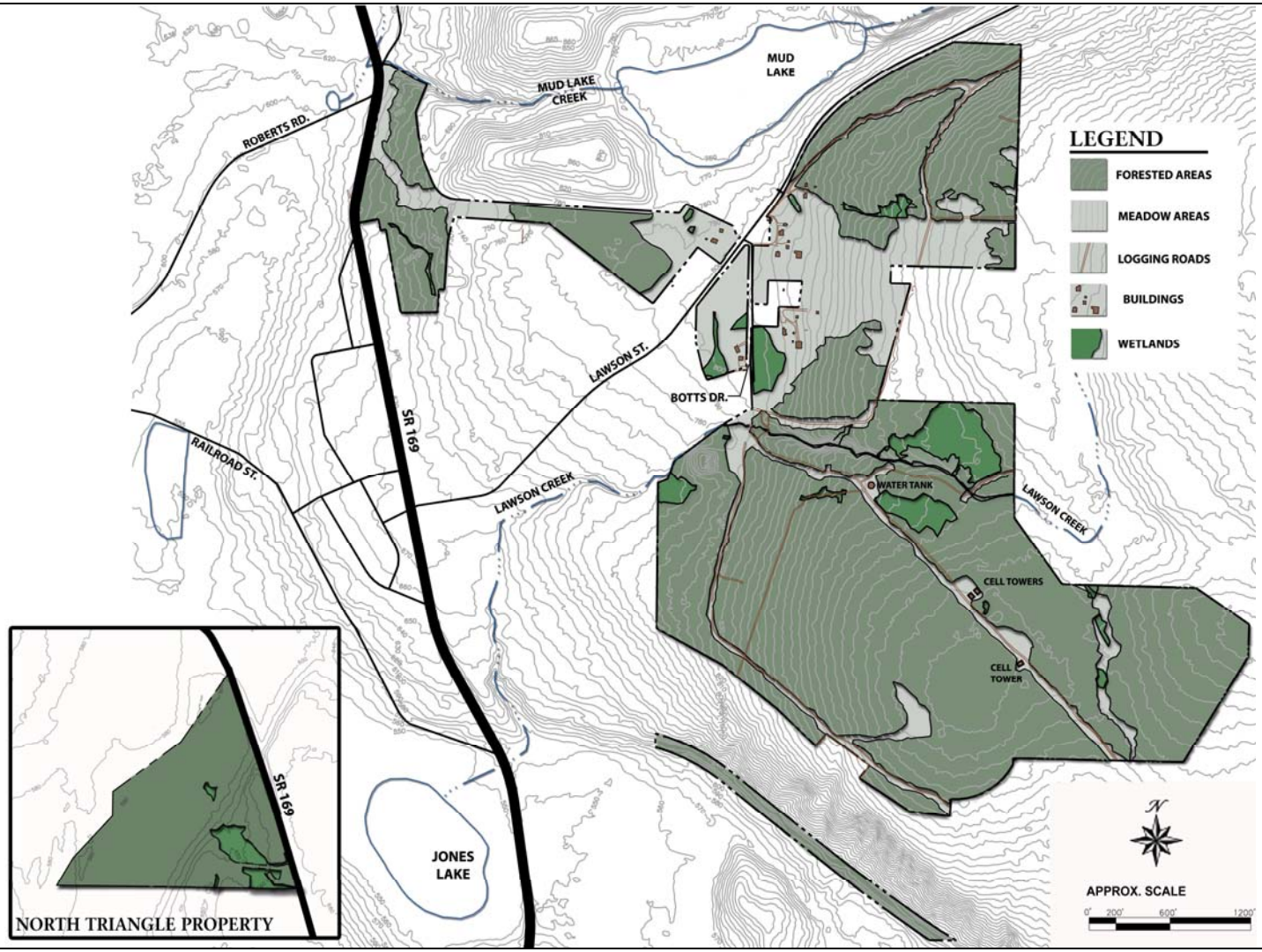


Figure 1-3
Lawson Hills Existing Conditions Map

Source: Triad Associates, Inc.

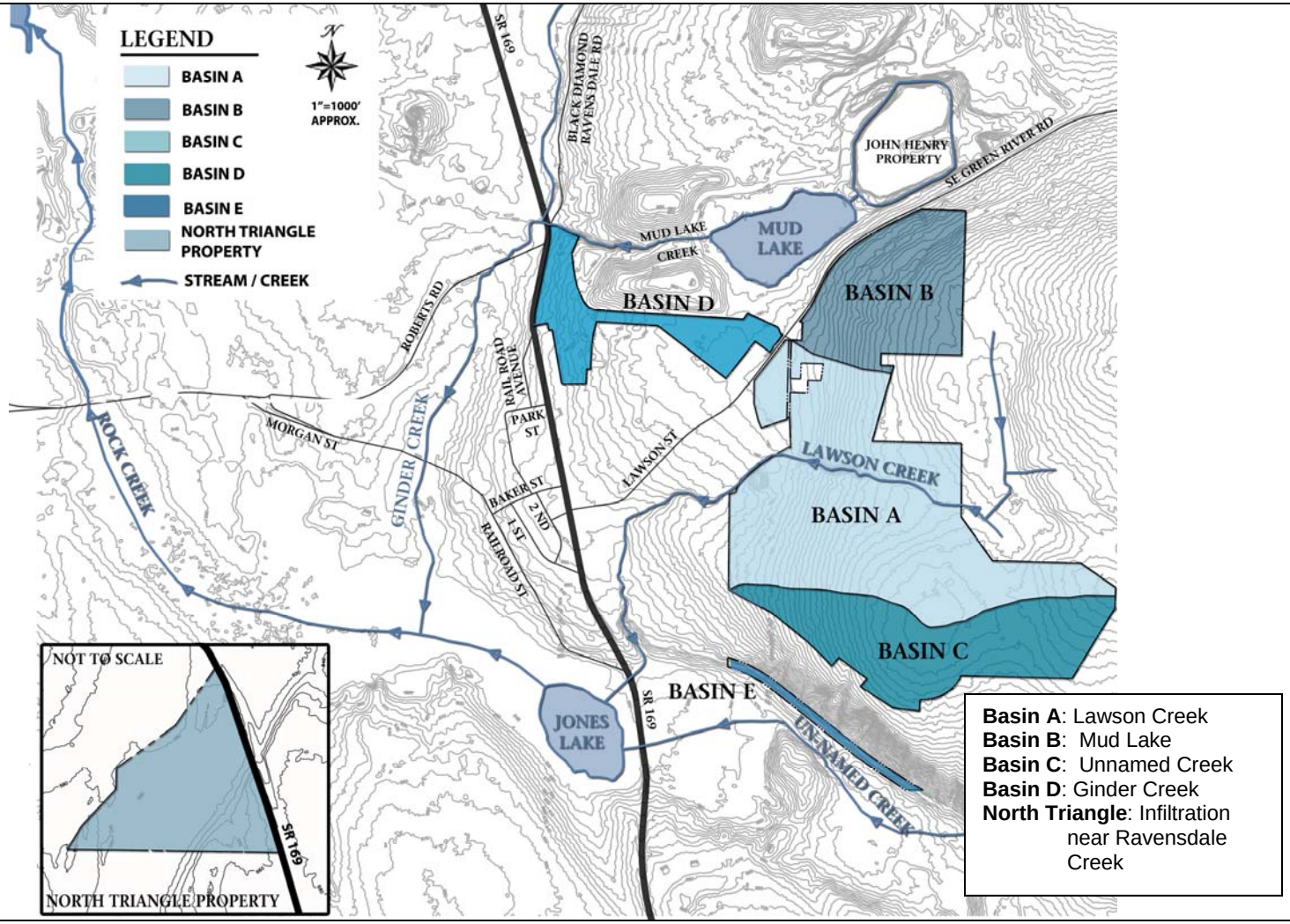


Figure 1-4
Lawson Hills Existing Drainage Basin Map

Source: Triad Associates, Inc.

5. The North Triangle area is 54.2 acres in size. All stormwater on this portion of the site infiltrates. No streams leave this area. Ravensdale Creek flows less than ¼ mile away from the North Triangle western site boundary at its closest point and is tributary to Lake Sawyer.

There are some waste piles from past mining on the Main Property. Cleanup of these waste piles and any other contaminants from past uses and avoidance of water quality impacts during cleanup is addressed by Golder Associates Inc. in separate analysis, and is not part of this report.

1.2 Alternatives Description

Lawson Partners proposes to develop the mostly vacant site with a combination of high, medium, and low density residences, mixed use, commercial/office, parks, school, and open space.

There are two action alternatives and a no action alternative under study which encompass a full range of land use intensities and densities that the site could potentially accommodate over the long term. These are described in detail in Chapter 2 of the DEIS.

The 50-acre East Annexation Area to the City of Black Diamond that is the Lawson Hills Main Property is designated as a Transferrable Development Rights (TDR) Receiving Area and is, therefore, eligible to accommodate urban residential development. A 50-acre In-City Forest Land, located to the south of the Main Property and owned by the applicant, is designated as a TDR Sending area by the City's TDR Program. The Lawson Hills applicant has exchanged development rights on the In-City Forest Land with the city and established a conservation easement on this area in order to preserve the area as permanent open space. For the exchange, TDR will be transferred to the East Annexation Area. The In-City Open Space specified in the Black Diamond Open Space Agreement also includes preservation of not less than 55 acres of property along SR 169 to create a visual buffer (or view corridor open space) on the Lawson Hills North Triangle Property and the adjacent property to the east, and a trail corridor on the adjacent property to the east. The intent of the visual buffer is to obscure any future development on the North Triangle Property and the property to the east from views along SR 169 with existing or new vegetation. Protection of these two 50-acre and 55-acre areas from future development will have a positive water quality benefit on Rock Creek, Jones Lake, and Lake Sawyer unrelated to other water quality-related mitigation for the proposed project.

Water quality impacts from a separate project in the Black Diamond area are included as a cumulative assessment with the Lawson Hills project in this report. That project is The Villages Master Planned Development.

The Proposed Action (Figure 1-5) is a clustered Master Planned Development (MPD) with a total of approximately 1,250 residential units (930 single family and 320 multifamily), 190,000 square feet of retail, 200,000 square feet of office, 6 acres of school buildings, and approximately 145 acres of open space which includes 5 acres of parks and 9 acres of school playfields. Water would be provided by the City of Black Diamond. Stormwater would be detained and treated in accordance with the 2005 Washington Department of Ecology *Stormwater Management Manual for Western Washington* (Ecology 2005 Manual). The Proposed Action would be sewered. See Chapter 2 of the DEIS for a detailed description of this and the other two alternatives.

Alternative 1 (Figure 1-6) is a clustered MDP with more office space, less retail, and fewer (but higher density) residences than under the Proposed Action. A total of approximately 1,125 residential units (790 single family and 335 multifamily), 90,000 square feet of retail, and 300,000 square feet of offices is proposed. Approximately 6 acres of school buildings would be constructed. With the different mix of land uses and more clustering, Alternative 1 would have more open space (approximately 167 acres including 5 acres of parks and 9 acres of school playfields). Water, sewer, and stormwater would be constructed as for the Proposed Alternative, but less infrastructure for each would be required.

Alternative 2 is the No Action Alternative. Under this alternative, the land parcels comprising the proposed site would not be developed by a master plan under the MPD Ordinance of the City. Each parcel is assumed to be developed independently by different owners based on market demands at the time, within the limitations of city zoning. Natural areas and hazard areas would continue to be preserved and protected by the City's critical areas ordinance, and a view buffer in the North Triangle would still be required. However, additional contiguous open space that would be required under an MPD would not exist. Stormwater would be managed on each parcel as required by city stormwater codes in place at the time of vesting for each project. Buildout of the site under multiple owners is anticipated to take about 30 years, adding about 2,152 single family homes, 220 multi-family residences, 200,000 square feet of retail, and 575,000 square feet of office/light industrial.

The DEIS evaluates most elements for the two action alternatives in the year 2015 which is assumed to represent build out of the project. Because the greatest stormwater quality impacts would occur at the time of greatest pollution generating surfaces and occupancy, this water quality analysis evaluates the 2015 built-out time period for the two action alternatives, except where the discussion pertains to construction-related impacts.

The Proposed Action and Alternative 1 are assessed quantitatively. Alternative 2 (no action) is evaluated qualitatively relative to the results for the two action alternatives assuming full build out (after 30 years).

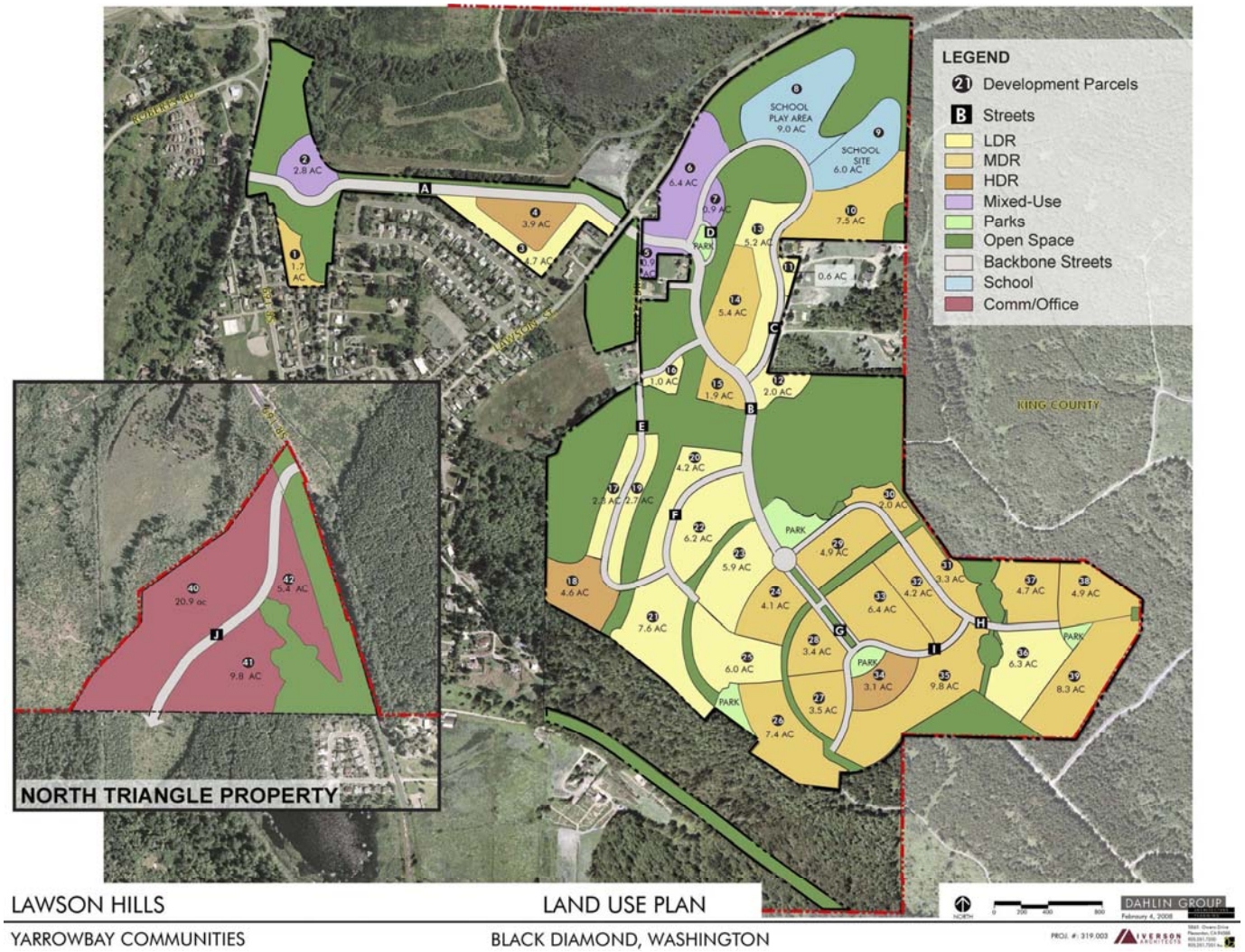


Figure 1-5
Lawson Hills Proposed Action

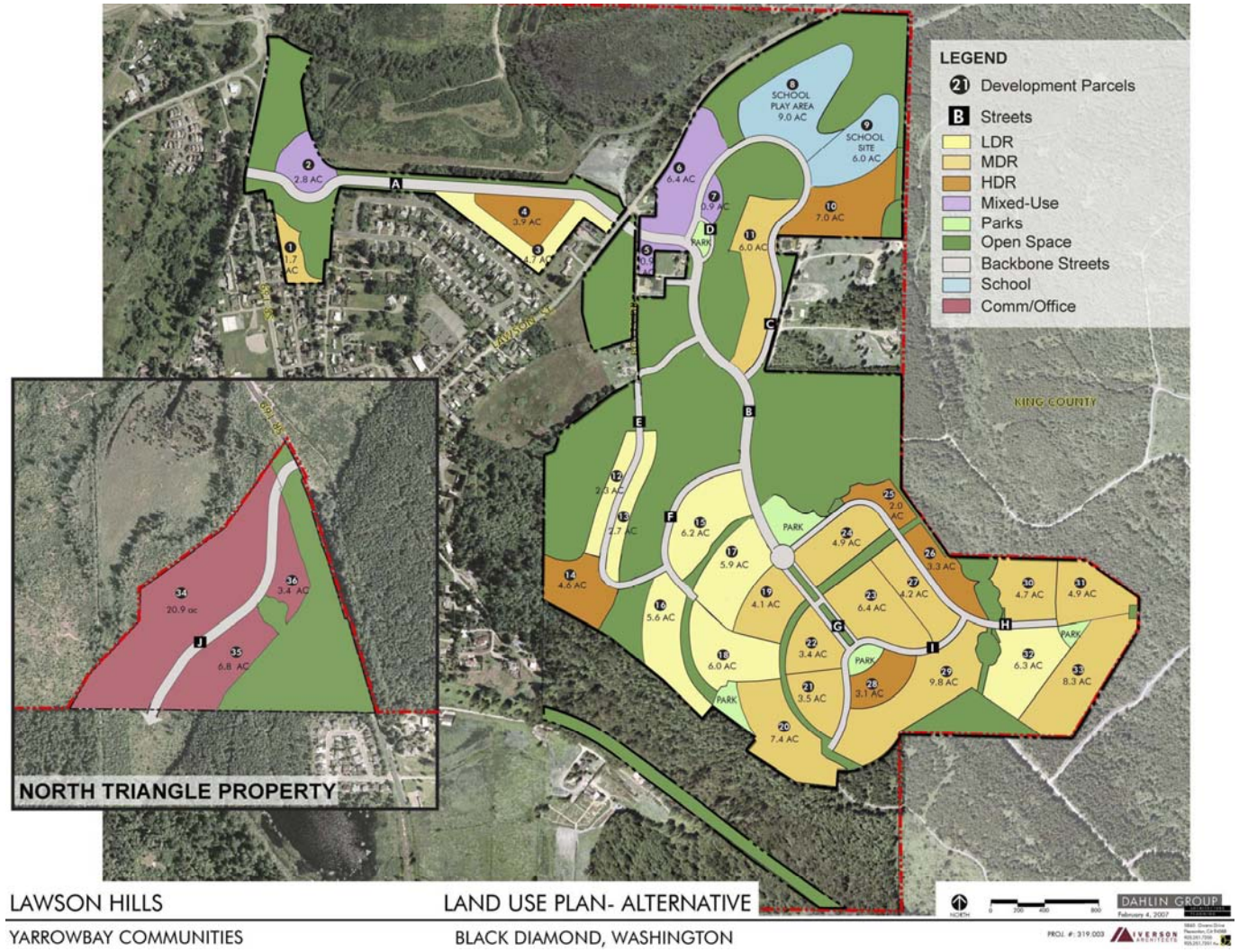


Figure 1-6
Lawson Hills Alternative 1

2.0 AFFECTED ENVIRONMENT

2.1 Hydrologic Setting

All of the Lawson Hills site lies within the Duwamish-Green River Drainage Basin (Water Resource Inventory Area [WRIA] 09) (Washington State Department of Fisheries [WDF], 1975). All of the surface runoff from the project site drains indirectly to Lake Sawyer, either via Ginder Creek and Rock Creek (WRIA 09-0085), or via Lawson Creek (09-0085C) or Unnamed Creek (09-0085D) to Jones Lake and Rock Creek (Figure 1-2). Lake Sawyer drains to the Green River via Covington Creek and Big Soos Creek. Covington Creek flows 9.5 miles southwest into Big Soos Creek at River Mile (RM) 2.8. Big Soos Creek flows westerly to its confluence with the Green River (09-0001) at RM 34. The Green River becomes known as the Duwamish River Waterway at RM 11 and flows into Elliot Bay and the Puget Sound.

Lake Sawyer is about 1 mile away as the crow flies from the portions of the site with surface runoff (as opposed to infiltration); about 2.9 miles from the site via Lawson Creek, Jones Lake, and Rock Creek; and about 3 miles from the site via Ginder Creek and Rock Creek (Figure 1-2). Because of the distances involved, this analysis extends through all streams and lakes between the site and Lake Sawyer downstream, but does not extend to Covington Creek which drains Lake Sawyer. If impacts are adequately avoided and/or mitigated to protect all water quality parameters in Ravensdale Creek and Rock Creek, and phosphorus loading to Lake Sawyer about 3 river miles (RM) downstream of the project, then water quality is assumed to be protected further downstream.

Groundwater hydrogeology is described by Golder Associates Inc. (Golder) (2008a) based on existing information and test pits for basins A through D on the Main Property. Golder found two groundwater flow systems in these basins. The first occurs atop bedrock and flows through overlying glacial materials, following the general contour of the land surface and discharges to Lawson Creek, wetlands, and springs. The second deeper groundwater flow system is in the deeper coal seams, underground mine workings, and fractured bedrock. The deeper system is recharged from water that infiltrates into the mine workings and discharges at the Lawson Mine Drainage spring located south of the site. This spring was created from the abandonment and collapse of the historic Lawson Mine entrance. This water creates a channel that enters Unnamed Creek after passing through a small reservoir on private property. Unnamed Creek flows west to Jones Lake (Golder, 2008b).

None of the site has surface flow connection to Ravensdale Creek (09-0083) which flows to Lake Sawyer, but one corner of the North Triangle Property extends to within about ¼ mile of the creek. Water from this portion of the site infiltrates. The North Triangle Property contains a steeply incised stream (Stream S1) draining a wetland and discharging onto a debris fan at the toe of the slope in the southeastern portion of the North Triangle. The stream water infiltrates into recessional outwash at this location and ultimately recharges Ravensdale Creek. The lower elevation portions of the North Triangle Property (north and west) have recessional outwash deposits at least 11 feet deep which convey groundwater to Ravensdale Creek following surface topography in a west/northwesterly direction (Golder 2008a). The recessional outwash shallow aquifer flows through relatively coarse material from the North Triangle and discharges to Ravensdale Creek. Ravensdale Creek is analyzed for that reason. There are no water supply wells between the North Triangle Property and Ravensdale Creek, which forms a barrier to further shallow aquifer movement.

Each of the water bodies evaluated in this report is described in Section 2.3.

2.2 Water Quality-Related Regulations

2.2.1 State Surface Water Quality Standards

Surface waters in the State of Washington are regulated for quality by Chapter 173-201A WAC, administered by Ecology. State water quality standards are intended to protect all beneficial uses of surface waters, including the protection of aquatic biota. State Water Quality Standards were last amended on November 20, 2006.

All of the surface waters onsite and between the site and Lake Sawyer, including Lake Sawyer, have the following use designations;

- Core summer salmonid habitat;
- Extraordinary primary contact recreation;
- Domestic, industrial, and agricultural water supply;
- Stock watering;
- Wildlife Habitat;
- Harvesting;
- Commerce and navigation;
- Boating; and
- Aesthetic values.

These use designations result in the water quality standards summarized in Table 2-1.

Table 2-1
Use Designations for Lawson Hills Onsite and Offsite Streams and Offsite Lakes
(Chapter 173-201A-600 WAC)

Core Summer Salmonid Habitat *(see WAC 173-201A-200 for details beyond this summary)*	
Dissolved oxygen	The lowest 1-day minimum is **9.5** mg/L as the lowest 1-day minimum, measured to represent dominant aquatic habitat. When a water body's dissolved oxygen is lower than 9.5 mg/L or within 0.2 mg/L of the criterion, and that condition is due to natural conditions, then human actions considered cumulatively may not cause the dissolved oxygen of that water body to decrease more than 0.2 mg/L. Concentrations of dissolved oxygen are not to fall below the criterion at a probability frequency of more than once every ten years on average.
Total Dissolved Gas	Shall not exceed **110** percent of saturation at any point of sample collection.
Temperature	Shall not exceed **16**°C (60.8°F) measured as a 7-day average of the daily maximum temperature (7-DADMax). When a water body's temperature is warmer than 16°C or within 0.3°C of the criterion, and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C.
pH	Shall be within the range of **6.5 to 8.5** with a human-caused variation within a range of less than 0.2 units.
Turbidity	Shall not exceed **5** nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
Toxic substances	Shall not be introduced above natural background levels in waters of the state that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity of the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department. (Toxic substances include dissolved metals and ammonia-nitrogen).

Extraordinary Primary Contact Recreation *(see WAC 173-201A-200 for details beyond this summary)*	
Fecal coliforms	Fecal coliform organism levels must not exceed a geometric mean value of **50** colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.

Source: Ecology (2006)

The state water quality standards also include guidance on establishing nutrient criteria for lakes. In the Puget lowlands, the nutrient criteria are set equal to the upper range of total phosphorus for lakes with low to moderate nutrient enrichment (0 to 0.020 mg/L or 0 to 20 µg/L total phosphorus), and determined by site-specific studies for lakes with higher phosphorus concentrations.

2.2.2 State Groundwater Standards (Chapter 173-200 WAC)

The goal of the Washington State groundwater quality standards is to protect groundwater quality and existing and future beneficial uses through an antidegradation policy (Chapter 173-200-030 WAC) and definition of maximum contaminant level (MCL) criteria (Table 2-2) (Chapter 173-200-040 WAC) (Ecology 1990). Regulations require that contaminants proposed for entry to groundwater shall be provided with all known, available and reasonable methods of prevention, control and treatment prior to entry.

Table 2-2
Groundwater Quality Standards for Primary and Secondary Contaminants (1)

Primary or Secondary Designation	Contaminant	Maximum Contaminant Level (MCL)
Primary	Barium	1.0 mg/L
	Cadmium	0.01 mg/L
	Chromium	0.05 mg/L
	Lead	0.05 mg/L
	Mercury	0.002 mg/L
	Selenium	0.01 mg/L
	Silver	0.05 mg/L
	Fluoride	4 mg/L
	Nitrate-Nitrogen	10 mg/L
	Total Coliform Bacteria	1/100 mL
Secondary	Copper	1.0 mg/L
	Iron	0.30 mg/L
	Manganese	0.05 mg/L
	Zinc	5.0 mg/L
	Chloride	250 mg/L
	Sulfate	250 mg/L
	Total Dissolved Solids	500 mg/L
	pH	6.5-8.5 standard units

(1) Partial listing of primary and secondary contaminants criteria. All heavy metal standard criteria are for total metals.

2.2.3 Section 303(d) Threatened and Impaired Water Bodies

Section 303(d) of the 1972 Federal Clean Water Act (CWA) requires states to identify and list threatened and impaired water bodies. The CWA requires the list to be updated and submitted for review and approval by the U.S. Environmental Protection Agency (EPA) every 2 years. The purpose of the listing is to identify water body segments where, with technology-based pollution control measures, applicable standard(s) are not expected to be met for the listed water quality parameter(s). The EPA allowed states to skip the year 2000 303(d) list due to the ongoing development of new federal rules affecting the listing process and the Total Maximum Daily Load (TMDL) program. TMDLs are prepared to restore state waters to all beneficial uses, or to prevent anticipated degradation of beneficial uses (see below).

Washington State's Water Quality Assessments list the status of water quality in one of 5 categories recommended by EPA. Category 1 indicates water quality standards are being met, and Category 5 indicates water quality impairment. Categories 1 through 4 represent the status of waters for the Section 303(b) Report. Category 5 listings form the Section 303(d) list of threatened and impaired water bodies.

The 2004 Integrated Water Quality Assessment is the current 303(b) and 303(d) listing. Ecology is in the process of updating its 303(b) and 303(d) lists. A draft 2008 Water Quality Assessment was released for public review from February 5 to May 5, 2008. After public review and comment, the Water Quality Assessment will be finalized and submitted to EPA for approval of the Category 5 (impaired water quality) 303(d) listings in spring of 2008.

Neither Lawson Creek, the only waterway flowing off of the Main Property nor Stream S1 on the North Triangle Property (which infiltrates) are listed as impaired for any parameters under the current 303(d) listing.

The following offsite streams and lakes are included on the current 2004 303((b) or (d) listing for water quality-related parameters:

Ravensdale Creek
The reach of Ravensdale Creek with potential for influence from the North Triangle Property (and downstream from there to Lake Sawyer) is not listed as impaired for any parameter. Ravensdale Creek is 303(d) listed as "Category 5"[1] impaired for temperature for a reach upstream of any possible project influence (upstream of Ravensdale Lake). The 303(d) and 303(b) listings for Ravensdale Creek are not changed in the draft 2008 Water Quality Assessment Report.

Jones Lake
Jones Lake is 303(b) listed as "Category 2"[2] for total phosphorus. This means that total phosphorus "may be a concern" for this lake, but the available data do not warrant listing as impaired for total phosphorus on the 303(d) list. The 303(b) listing for Jones Lake is not changed in the draft 2008 Water Quality Assessment Report.

[1] Category 5 is defined as *"waters for which at least one characteristic or designated use is impaired, as evidenced by failure to attain the applicable water quality standard for one or more pollutants."*
[2] Category 2 is defined as *"waters where the data are not sufficient for listing a waterbody segment as impaired but may still raise a concern about water quality."*

Lake Sawyer
Lake Sawyer is 303(d) listed as "Category 5" impaired for total phosphorus. The 2004 303(d) listing is based on data collected from 1989 to 1991, when City of Black Diamond wastewater discharged to the lake. King County small lakes volunteer monitoring data from 1998 to 2002 did not exceed the phosphorus nutrient criterion, following implementation of the Total Maximum Daily Load (TMDL) program described below in Section 2.2.4, but peak summer total phosphorus exceeded the TMDL summer limits described below. Because of the TMDL exceedence, total phosphorus remains Category 5 listed in the draft 2008 Water Quality Assessment Report. Lake Sawyer is designated by King County as a phosphorus sensitive lake (King County 2005a).

Lake Sawyer is also 303(d) listed as "Category 5" impaired for fecal coliforms based on unpublished data collected by King County in 1999. However, Ecology notes in the listing that *"reassessment of the data in January 2006 indicates Lake Sawyer should be changed from Category 5 to Category 2 because the geometric mean was incorrectly applied to the fewer than 5 samples collected by King County in 1999. In fact, there was no exceedence of water quality criteria for fecal coliforms in 1999. "* The draft 2008 Water Quality Assessment Report re-designates fecal coliforms as a Category 2 303(b) parameter and removed it from the 303(d) list of impaired parameters. Analysis in this report assumes the Category 2 status for fecal coliforms (concern may exist but does not warrant listing as impaired) is the relevant 303(b) status.

2.2.4 Total Maximum Daily Load (TMDL)

A TMDL was prepared for Lake Sawyer in March 1992 and approved by the U.S. Environmental Protection Agency (EPA) in February 1993 (EPA 1993). The TMDL was based on building an interceptor for the City of Black Diamond wastewater discharge. A maximum in-lake summer total phosphorus concentration of 16 µg/L was established for Lake Sawyer to prevent further eutrophication (excessive algae growth).

2.2.5 National Pollutant Discharge Elimination System (NPDES) Permit for Construction Discharge

For all new construction activity disturbing at least one acre, a Notice of Intent (NOI) must be filed to obtain a National Pollutant Discharge Elimination System (NPDES) Permit (General or Individual) from Ecology for discharge of stormwater. The NPDES permit requires preparation and implementation of a stormwater pollution prevention plan (SWPPP). The current General NPDES permit was issued November 16, 2005 and became effective December 16, 2005. The current General NPDES permit differs from the prior permit in a number of ways which are as follows (Ecology 2005):

- Sites with 1 to 5 acres of disturbed soils were added to the permit coverage. This is a requirement of EPA's Phase II Stormwater Rule. Previously only sites with greater than 5 acres of disturbed soils were required to be permitted.
- Monitoring (both visual inspections and sampling of pH, turbidity, and total petroleum hydrocarbons (TPH) are required to verify proper implementation of the Stormwater Pollution Prevention Plan (SWPPP) as required in RCW 90.48.555. The pH and TPH analyses are dependent on significant concrete work (pH) or whether a visual sheen or petroleum odor is observed. Turbidity monitoring is required from all stormwater ponds at least weekly when stormwater discharge occurs.

- The permit establishes a benchmark for turbidity of 25 Nephelometric Turbidity Units (NTUs), which presumes that construction BMPs are effectively controlling sediment if site discharge is less than the benchmark value.
- The permit allows turbidity monitoring for smaller sites (less than 20 acres) to be measured using a less expensive transparency tube. Sites that disturb greater than 20 acres are required to measure turbidity with a turbidimeter.
- A Stormwater Pollution Prevention Plan (SWPPP) must be completed by the time of application for permit coverage and must be made available for public review upon request during the application period.
- Additional monitoring requirements may apply for sites discharging to 303(d) listed waterbodies and waterbodies with applicable TMDLs for construction-related parameters (turbidity/fine sediment, high pH, and phosphorus); and sites may be required to perform additional monitoring by Ecology administrative order under a General permit or under an Individual permit. Since all surface discharges from the project site occur to Jones Lake and directly to Lake Sawyer which has a 303(d) listing for phosphorus, the need for specific best management practices (BMPs) to prevent phosphorus impact and the need for any monitoring will likely be made by Ecology on a site-specific basis in an Individual Permit for this project.

2.2.6 City of Black Diamond Stormwater Management

The City of Black Diamond is reviewing its stormwater-related code requirements. This report and project planning assumes the city will adopt the Ecology 2005 Manual described below.

2.2.7 Stormwater Management Manual for Western Washington (2005)

The Proposed Project would utilize Best Management Practices from the Ecology (2005) *Stormwater Management Manual for Western Washington* (Ecology 2005 Manual) for stormwater management. The Ecology 2005 Manual contains water quality treatment and quantity control measures that are a mixture of source control, performance, and design standard requirements. The project assumes that phosphorus-sensitive treatment is required for all stormwater discharged to surface waters, and that enhanced treatment is required for all portions of the project with multifamily or commercial/retail, office, or multi uses.

2.3 Surface Water Quality

Surface water quality for each of the major on- and off-site water features that could be influenced by the Lawson Hills proposal are described in this section. Water quality monitoring was conducted during storms and during between-storm baseflows by A.C. Kindig & Co. at locations shown in Figure 2-1. Field notes documenting specific station observations, measurements, and grab samples were collected at each sampling station. *In situ* samples were measured with a Hydrolab Reporter ® (temperature, dissolved oxygen, conductivity, and pH) and Hach 2100 P® turbidimeter calibrated on the day of sampling according to the manufacturer's instruction. Calibration results and any required corrections were recorded on the original field forms.

Samples were stored and transported on ice to AmTest, Inc., a state-certified laboratory in Redmond, Washington the day of sampling. The analytical procedures are derived from the protocols of the EPA, U.S. Department of Agriculture (USDA), U.S. Food and Drug Administration (FDA), or the U.S. Army Corps of Engineers. Sample tracking included chain of

custody documentation signed by field personnel and laboratory staff on receipt of samples. Samples were delivered to the laboratory on the same day of sampling and all holding time limits were met.

Blind field splits were collected for approximately five percent of the samples, which are paired samples from a particular station. The pairing identity is not known by the laboratory, and the reported results can be evaluated to determine the accuracy of the laboratory results. The laboratory quality assurance/quality control includes duplicate analyses, matrix spikes and duplicates, standard reference materials, and analytical blanks to verify the accuracy of the reported results. The quantification methods, detection limits, laboratory analyst, and date of analyses are included with the original results.

Monitoring by A.C. Kindig & Co. included some parameters not summarized in the sections that follow; consisting of inductively coupled plasma total metals results and some minerals. These results, original field notes, sample tracking, and original analytical results are on file at A.C. Kindig & Co. in Redmond, Washington.

2.3.1 Onsite Watercourse Surface Water Quality – Lawson Creek

Lawson Creek is an intermittent stream that drains Basin A of the site area (Figure 1-4). Golder (2007a) monitored flow in Lawson Creek and found it to be dry in the flatter reaches from July to September, but to have flow in the steeper reaches where bedrock is exposed. Cedarock Consultants, Inc. (2008) describes Lawson Creek in more detail as it pertains to fish habitat.

Golder (2007a) monitored flow at four locations in Lawson Creek onsite (one continuous and three periodic). Turbidity was monitored beginning in May 2005 and continuing through August 2006 at a point upstream of Botts Drive, both continuously and periodically (manually). Temperature was measured continuously at two of the Lawson Creek stations, where flow was continuously measured and where turbidity was measured. pH was periodically measured at all four Golder Lawson Creek stations. Golder's continuous turbidity results showed extreme spikes in turbidity in the 200 to 450+ NTU range; spikes in turbidity were not closely associated with precipitation or stream flow and thus may be suspect as representative of stream turbidity conditions very far beyond the immediate monitored location. Most of the time, turbidity reported by Golder was low, in the vicinity of 10 NTU, which correlates well with the baseflow (non-storm) turbidity measured by A.C. Kindig & Co. that is described below. Temperatures measured by Golder in Lawson Creek near Botts Drive ranged from a high of 20.3^{o}C in July 2005 when the creek was likely reduced to non-flowing static pools as it seasonally dried, to a low of 0.9^{o}C in February 2006 (J. Pietraszek, pers. comm.. January 23, 2008).

A.C. Kindig & Co. monitored water quality at two stations in Lawson Creek. The downstream station (station L) was sampled offsite at the end of Pacific Place five times in 2007 (February 14, February 15, February 28, March 8, and April 12). The upstream Lawson Creek station (station LU) was sampled twice onsite at the end of the paved portion of Botts Road (Figure 2-1) (March 8 and April 12, 2007). The results of the monitoring at both stations are shown in Tables 2-3 and 2-4.

The results show that water quality in upstream (onsite) Lawson Creek (Station UL) is good, as should be expected for a largely forested basin (Figure 1-3 and Table 2-4). All parameters are within state water quality standards (where criteria are named) with the possible exception of dissolved lead. Lawson Creek water is very soft, which results in a very low numeric standard

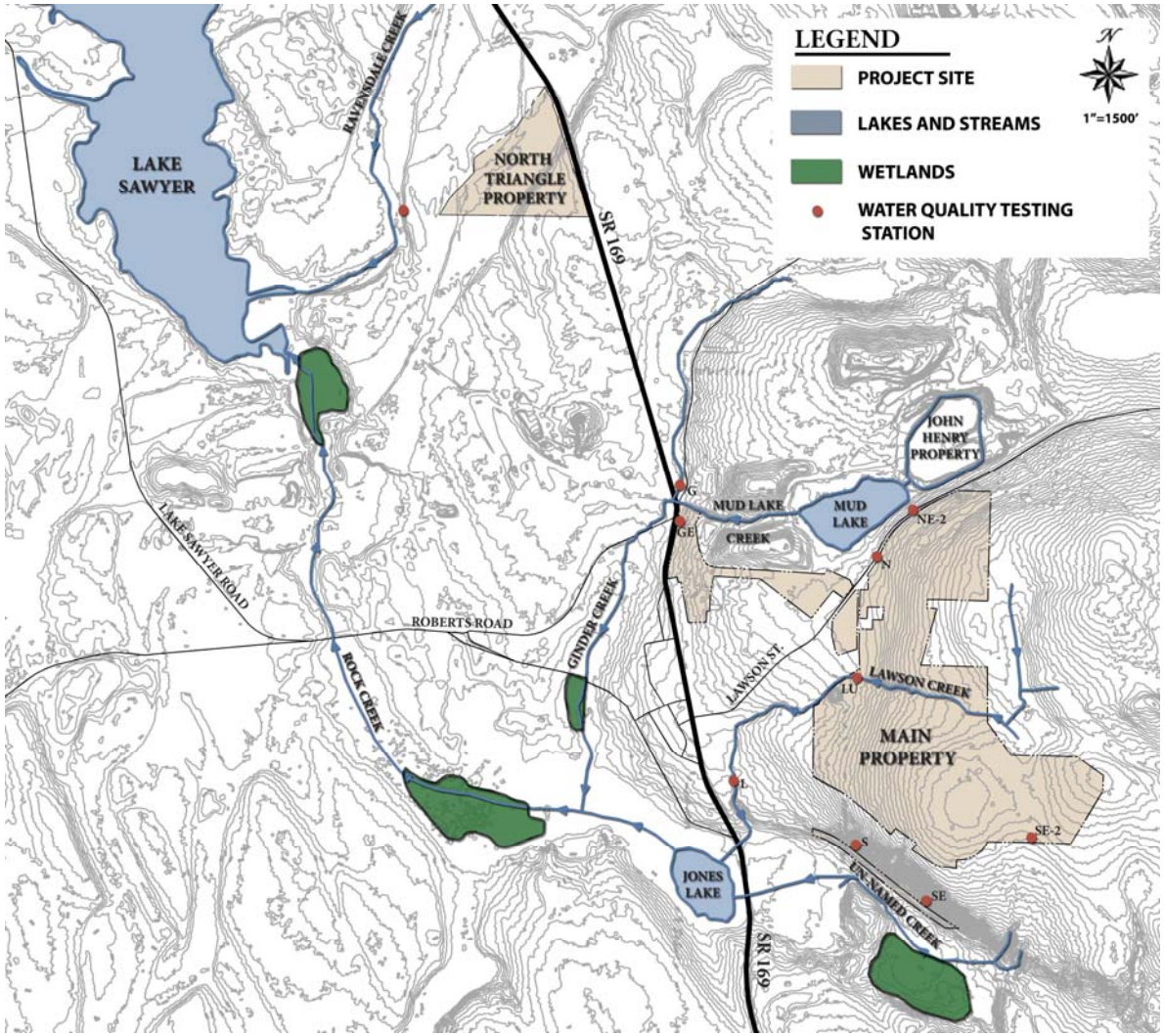


Figure 2-1
Lawson Hills Water Quality Monitoring Stations

Figure prepared by Triad Associates, Inc.

Table 2-3
Water Quality Monitoring Results for Lawson Creek at Station L (Lower Lawson)

Parameter	Units	Baseflow 2/14/2007	Storm 2/15/2007	Storm 2/28/2007	Storm 3/8/2007	Baseflow 4/12/2007	Baseflow Average	Storm Average	Combined Average	State Standards[(a)]
Mean Daily Flow	CFS	0.44	0.78	0.73	1.83	0.41	0.42	1.11	0.84	n/a
Temperature	^{o}C	0.4	0.6	-1.3	6.6	14.0				<16
Dissolved Oxygen	mg/L	14.43	14.90	13.69	11.76	13.24	13.84	13.45	13.60	>9.5
Dissolved Oxygen	% saturation	100	103	91.4	95.9	111	105	96.9	100	<110% total gasses
pH		6.91	7.10	6.86	7.11	7.33	7.12	7.02	7.06	6.5 – 8.5
Conductivity	µmhos/cm^2	80	58	74	53	66	73.05	61.67	66.22	n/a
Turbidity	NTU	9.0	51.4	20.5	8.5	6.7	7.8	26.8	19.2	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	46	5	4	1	0.75	18.33	11.30	n/a
Oil and Grease	mg/L	<1	1.1	<1	<1	2.2	1.35	0.70	0.96	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	<1	<1	<1	1	<1	<1	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	n/a
Alkalinity	mg/L	16	14	10	14	16	16	13	14	n/a
Ammonia-nitrogen	mg/L	0.005	0.01	<0.005	<0.005	0.094	0.050	0.005	0.023	2.3[(b)]
Total Nitrogen	mg/L	0.28	0.65	<0.1	<0.1	<0.1	0.16	0.25	0.31	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.82	0.58	2.3	1.6	1	0.91	1.49	1.26	n/a
Ortho Phosphate	mg/L	<0.005	0.047	0.022	0.017	0.009	0.010	0.030	0.020	n/a
Total Phosphorus	mg/L	0.023	0.068	0.021	0.020	0.018	0.021	0.036	0.030	n/a
Hardness	mg/L	25	21	25	22	25	25	23	24	n/a
Dissolved Copper	µg/L	<1	<1	3	1	<1	<1	2	1	3.35[(c)]
Dissolved Lead	µg/L	<1	<1	<1	<1	1.1	1	<1	<1	0.52[(c)]
Dissolved Zinc	µg/L	6	2	9	4	<1	6	5	5	31.19[(c)]
Fecal Coliforms	CFU/100 mL	11	256	32	24	17	14 Geometric Mean	58 Geometric Mean	33 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second* *Daily flow data provided by Golder Associates Inc.*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown. Flows from Golder Associates, February 22, 2008.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (24 mg/L).

Table 2-4
Water Quality Monitoring Results for Lawson Creek at Station LU (Upper Lawson)

Parameter	Units	Storm 3/8/2007	Baseflow 4/12/2007	Combined Average	State Standards[(a)]
Mean Daily Flow	CFS	1.83	0.41		
Temperature	^{o}C	6.0	7.3		<16
Dissolved Oxygen	mg/L	11.8	13.2	12.51	>9.5
Dissolved Oxygen	% saturation	95.1	109	102	<110% total gasses
pH		6.51	7.06	6.79	6.5 – 8.5
Conductivity	µmhos/cm^2	43	42	43	n/a
Turbidity	NTU	11.7	9.7	10.7	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	4	2	3	n/a
Oil and Grease	mg/L	1.6	1.4	1.5	"no sheen"
Petroleum Hydrocarbons	mg/L	1.2	<1	1.2	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	n/a
Alkalinity	mg/L	10	12	11	n/a
Ammonia-nitrogen	mg/L	<0.005	<0.005	<0.005	2.3[(b)]
Total Nitrogen	mg/L	<0.1	0.11	0.08	n/a
Nitrate and Nitrite-Nitrogen	mg/L	1.30	0.98	1.14	n/a
Ortho Phosphate	mg/L	0.017	0.011	0.014	n/a
Total Phosphorus	mg/L	0.030	0.014	0.014	n/a
Hardness	mg/L	15	17	16	n/a
Dissolved Copper	µg/L	1	<1	<1	2.37[(c)]
Dissolved Lead	µg/L	<1	1.2	<1	0.33[(c)]
Dissolved Zinc	µg/L	4	<1	2	22.1[(c)]
Fecal Coliforms	CFU/100 mL	10	4	6 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second* *Flow data provided by Golder Associates Inc.*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (24 mg/L).

Table 2-5
Water Quality Monitoring Results for Mud Lake Culvert under Lawson Street at Station N

Parameter	Units	Baseflow 2/14/2007	Storm 2/15/2007	Storm 2/28/2007	Storm 3/8/2007	Baseflow 4/12/2007	Baseflow Average	Storm Average	Combined Average	State Standards[(a)]
Estimated Flow	CFS	0.01	0.67	0.22	0.50	0.06				
Temperature	^{o}C	1.5	1.0	-0.5	6.7	9.0				<16
Dissolved Oxygen	mg/L	9.55	13.42	12.33	10.18	9.05	9.30	11.98	10.91	>9.5
Dissolved Oxygen	% saturation	69.2	91.2	84.1	83.6	78.4	73.8	86.3	81.3	<110% total gasses
pH		5.8	6.5	6.4	6.4	6.3	6.0	6.4	6.3	6.5 – 8.5
Conductivity	µmhos/cm^2	61	92	71	56	53	57	73	67	n/a
Turbidity	NTU	3.3	37.0	11.3	10.0	4.9	4.1	19.4	13.3	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	93	5	5	2	1	34	21	n/a
Oil and Grease	mg/L	2	2.3	<1	<1	1.8	1.9	1.1	2.0	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	<1	<1	<1	1	0.75	<1	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	n/a
Alkalinity	mg/L	14	20	14	14	18	16	16	16	n/a
Ammonia-nitrogen	mg/L	<0.005	0.20	<0.005	<0.005	<0.005	<0.005	0.068	0.042	2.3[(b)]
Total Nitrogen	mg/L	<0.1	0.80	0.19	<0.1	0.22	0.14	0.35	0.26	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.28	0.78	1.2	0.86	0.21	0.25	0.95	0.67	n/a
Ortho Phosphate	mg/L	<0.005	0.057	0.008	0.016	<0.005	<0.005	0.027	0.017	n/a
Total Phosphorus	mg/L	0.014	0.072	0.019	0.019	0.011	0.013	0.037	0.027	n/a
Hardness	mg/L	17	28	23	20	20	19	24	22	n/a
Dissolved Copper	µg/L	2	1	1	<1	<1	1	1	1	3.11[(c)]
Dissolved Lead	µg/L	<1	<1	<1	<1	0.8	1	<1	1	0.47[(c)]
Dissolved Zinc	µg/L	6	<1	<1	3	<1	3	1	2	28.97[(c)]
Fecal Coliforms	CFU/100 mL	<1	<1	11	6	<1	<1 Geometric Mean	3.2 Geometric Mean	1.5 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (22 mg/L).

of 0.52 µg/L for dissolved lead (about ½ part per billion) because the standard is calculated from water hardness. One baseflow measure for dissolved lead was 1.2 µg/L, and the remaining values were below the detection level of 1.0 µg/L. Absent any probable significant human-caused influence at this location, we consider this value to represent natural background. It is not unusual for natural metals concentrations to be above calculated state standards in soft waters, and in those cases the background value becomes the standard.

Total phosphorus in the upstream Lawson Creek station (UL) ranged from 0.014 to 0.030 mg/L, which is well within natural conditions expected for largely forested basins. Similar measurements were taken from tributary streams in forested (largely undeveloped) basins in Sammamish, Washington before and after development. Total phosphorus concentrations averaged 0.043 to 0.040 mg/L prior to development (in 1992) and ranged from 0.016 mg/L to 0.039 mg/L after development commenced (1997-2000) (Walton, 2000). Storm measurements at the downstream Lawson Creek station averaged a turbidity of 27 NTU while baseflow (non-storm) averaged 8 NTU, indicating minor increases in turbidity with storms are common in the lower reaches of the creek (downstream of the site).

Downstream results for Lawson Creek (Table 2-3) are very similar to the upstream station in most respects, except for higher concentrations of fecal coliforms, total phosphorus, suspended solids, and turbidity all associated with a storm on February 15, 2007. It is probable that this storm increased stream erosion at the monitoring location, which would also increase total suspended solids and total phosphorus associated with fine sediments. A fecal coliform count of 256 CFU/100 mL on this date at this location greatly exceeded the state standard for a geometric mean of 50 CFU/100 mL. This may indicate that the storm had introduced pet waste in runoff from the homes along the creek at this location, or it may indicate that a septic influence caused by the storm runoff was introduced to the creek. All other fecal coliform measures at both stations were well within state standards, though they were higher at the downstream station than at the onsite upstream station and were always highest during storms. Wildlife including birds are a source of fecal coliform contamination, and are the probable sources of fecal coliforms measured at the upstream station. Wildlife and pets are the most likely sources of fecal coliforms measured at the downstream station. Aside from the one elevated total phosphorus concentration of 0.068 mg/L measured at the downstream station during the February 15, 2007 storm, total phosphorus ranged from 0.018 to 0.023 mg/L, which is low and well within expected natural background conditions.

2.3.2 Offsite Watercourse Surface Water Quality

2.3.2.1 Mud Lake and Mud Lake Creek

Basin B of the site drains to Mud Lake and Mud Lake Creek via culverts under Lawson Street / SE Green River Road. Water quality samples were collected by A.C. Kindig & Co. five times from a culvert 300 feet north of Botts Drive at Lawson Street (Station N in Figure 2-1) and once from a culvert about 1,000 feet north of Botts Drive at Lawson Street (Station NE-2 in Figure 2-1). There are no streams in Basin B contributing flow from the site to these culverts, but the culverts are collection points for sheetflow or shallow groundwater discharges that produce water collected in ditches along the road. The water passing through these culverts drains to Mud Lake via channels on the west side of Lawson Street / SE Green River Road. Mud Lake is a large wetland area that is a manmade mining relic, which discharges via Mud Lake Creek to Ginder Creek at the western end of the site's Basin D. Flow measurements by Golder (2007a) show water in both of these culverts is intermittent, drying during the summer months and flowing during the wettest part of the season or during large storms.

Water quality monitoring results for the two Mud Lake culverts are shown in Tables 2-5 (Station N) and 2-6 (Station NE-2). The two stations gave strikingly different results. It is clear that the culvert nearest Botts Drive (Station N) is conveying surface water because its quality is nearly identical to that of Lawson Creek described above, with the exception that fecal coliforms are lower during storms (Table 2-5). There is no evidence of Lawson Street influence on water quality at this station.

In contrast, during baseflow periods the water in the culvert further north (Station NE-2) is characteristic of ground water springs with little surface influence at the immediate point of collection (Table 2-6). This is evidenced by high conductivity (361 µmhos/cm^2 compared to an average of 66 µmhos/cm^2 for lower Lawson Creek and 67 µmhos/cm^2 for Station N); high alkalinity (140 mg/L compared to an average of 14 for lower Lawson Creek and 16 for Station N); total phosphorus below detection level, and high hardness (180 mg/L compared to 24 mg/L for lower Lawson Creek and 22 for Station N).

Table 2-6
Water Quality Monitoring Results for Mud Lake Culvert under Lawson Street at Station NE-2

Parameter	Units	Baseflow 4/19/2007	State Standards[(a)]
Estimated Flow	CFS	<0.001	
Temperature	^{o}C	7.8	<16
Dissolved Oxygen	mg/L	10.5	>9.5
Dissolved Oxygen	% saturation	88.8	<110% total gasses
pH		6.7	6.5 – 8.5
Conductivity	µmhos/cm^2	361	n/a
Turbidity	NTU	1.4	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	n/a
Oil and Grease	mg/L	<1	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	140	n/a
Ammonia-nitrogen	mg/L	0.014	2.3[(b)]
Total Nitrogen	mg/L	0.12	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.79	n/a
Ortho Phosphate	mg/L	0.005	n/a
Total Phosphorus	mg/L	<0.005	n/a
Hardness	mg/L	180	n/a
Dissolved Copper	µg/L	<1	18.8[(c)]
Dissolved Lead	µg/L	1	4.74[(c)]
Dissolved Zinc	µg/L	<1	172[(c)]
Fecal Coliforms	CFU/100 mL	<1	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (180 mg/L).

2.3.2.2 Ginder Creek

Basin D of the site area drains to Ginder Creek, as does Mud Lake Creek and Basin B (Figure 1-4). A.C. Kindig & Co. monitored two locations at Ginder Creek one time each. The first station

was Ginder Creek at SR169 and Roberts Road (Station G in Figure 2-1), at the upstream end of the culvert passing Ginder Creek under SR 169. The second station was from a culvert passing under SR 169 that conveys water to Ginder Creek from the Basin D site area east of SR 169 (Station GE in Figure 201). There is no tributary stream flowing from the site to the culvert at Station GE.

Water quality results are summarized below for Ginder Creek (Station G, Table 2-7) and the SR-167 culvert draining to Ginder Creek (Station GE, Table 2-8). Data from the two stations indicate they have the same water quality characteristics, all of which are within state standards. Dissolved oxygen is high, biochemical oxygen demand is low, and conductivity, hardness, and alkalinity are all moderately high, likely as a result of groundwater discharge contributing to baseflow to Ginder Creek. The harder water in Ginder Creek contrasts with the very soft water measured higher in the basin in Lawson Creek and in runoff from Basin A at Station N. With regard to conductivity, hardness and alkalinity, Ginder Creek is between the values measured from culvert NE-2 in Basin B which is suspected to reflect shallow groundwater discharge, and those from Lawson Creek higher in the basin. The harder water also raises the numeric state standards for dissolved copper, lead, and zinc as shown in Table 2-7 and 2-8, putting Ginder Creek well within compliance with standards for these metals by orders of magnitude.

Table 2-7
Water Quality Monitoring Results for Ginder Creek at SR-169 and Roberts Road (Station G)

Parameter	Units	Baseflow 4/19/2007	State Standards[(a)]
Estimated Flow	CFS	4	
Temperature	^{o}C	10.3	<16
Dissolved Oxygen	mg/L	12.0	>9.5
Dissolved Oxygen	% saturation	107	<110% total gasses
pH		7.6	6.5 – 8.5
Conductivity	µmhos/cm^2	236	n/a
Turbidity	NTU	3.2	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	n/a
Oil and Grease	mg/L	1.5	“no sheen”
Petroleum Hydrocarbons	mg/L	<1	“no sheen”
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	90	n/a
Ammonia-nitrogen	mg/L	0.029	2.3[(b)]
Total Nitrogen	mg/L	0.25	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.12	n/a
Ortho Phosphate	mg/L	0.014	n/a
Total Phosphorus	mg/L	0.018	n/a
Hardness	mg/L	92	n/a
Dissolved Copper	µg/L	<1	10.6[(c)]
Dissolved Lead	µg/L	1	2.30[(c)]
Dissolved Zinc	µg/L	<1	97.4[(c)]
Fecal Coliforms	CFU/100 mL	10	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (92 mg/L).

Table 2-8
Water Quality Monitoring Results for the Culvert Draining to Ginder Creek under SR-169 from Basin D Site Area (Station GE)

Parameter	Units	Baseflow 4/19/2007	State Standards[(a)]
Estimated Flow	CFS	0.02	
Temperature	^{o}C	11.2	<16
Dissolved Oxygen	mg/L	12.0	>9.5
Dissolved Oxygen	% saturation	109	<110% total gasses
pH		8.0	6.5 – 8.5
Conductivity	µmhos/cm^2	234	n/a
Turbidity	NTU	1.8	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	n/a
Oil and Grease	mg/L	1.6	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	98	n/a
Ammonia-nitrogen	mg/L	0.030	2.3[(b)]
Total Nitrogen	mg/L	0.15	n/a
Nitrate and Nitrite-Nitrogen	mg/L	1.50	n/a
Ortho Phosphate	mg/L	0.005	n/a
Total Phosphorus	mg/L	0.011	n/a
Hardness	mg/L	110	n/a
Dissolved Copper	µg/L	<1	12.3[(c)]
Dissolved Lead	µg/L	1	2.79[(c)]
Dissolved Zinc	µg/L	<1	113[(c)]
Fecal Coliforms	CFU/100 mL	4	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (110 mg/L).

2.3.2.3 Basin C Runoff and Unnamed Creek

Three drainages topographically linked to Basin C were monitored by A.C. Kindig and Co. (Figure 2-1). These were offsite Stations S and SE, located along Old Lawson Road below Basin C, and Station SE-2 on the site boundary at a logging road culvert located approximately 1,000 feet east of the cell tower on the site. Station S is a culvert conveying groundwater discharge from the abandoned Lawson Hills Mine entry. The path of this water as it drains to Unnamed Creek is described by Golder (2008b). This water originates from a deeper groundwater aquifer described by Golder (2008a,b) under the site and has little relationship to surface water on the site, except to the extent surface runoff from the site enters fractured bedrock to recharge the deeper aquifer. Offsite station SE water likely originates from groundwater seeps and may also convey sheetflow from the slope south of the site to the ditch along Old Lawson Road. Onsite station SE-2 water is concentrated along the logging road at the culvert from storm runoff sheetflow and perhaps shallow groundwater flow during the wet season. Results of sampling at these three locations are summarized in Tables 2-9 to 2-11.

Table 2-9
Water Quality Monitoring Results for the Lawson Mine Groundwater Discharge at Station S

Parameter	Units	Baseflow 2/14/2007	Storm 2/15/2007	Storm 2/28/2007	Storm 3/8/2007	Baseflow 4/12/2007	Baseflow Average	Storm Average	Combined Average	State Standards[(a)]
Estimated Flow	CFS	0.17	0.17	0.17	0.33	0.17				
Temperature	^{o}C	3.5	2.0	2.8	7.8	9.5				<16
Dissolved Oxygen	mg/L	12.2	12.7	12.9	11.6	12.1	12.1	12.4	12.3	>9.5
Dissolved Oxygen	% saturation	90.8	93.6	94.3	98.2	106.4	98.6	95.4	96.7	<110% total gasses
pH		7.4	7.4	7.3	7.6	7.6	7.5	7.5	7.5	6.5 – 8.5
Conductivity	µmhos/cm^2	660	667	601	488	484	572	585	580	n/a
Turbidity	NTU	2.6	16.8	3.7	2.9	2.4	2.5	7.8	5.7	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	2	8	2	2	1	2	4	3	n/a
Oil and Grease	mg/L	<1	1.4	1.1	<1	1.9	1.2	1.0	1.1	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	<1	<1	<1	1.2	0.9	<1	0.6	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	n/a
Alkalinity	mg/L	270	260	230	240	250	260	243	250	n/a
Ammonia-nitrogen	mg/L	<0.005	<0.005	0.019	<0.005	0.012	0.007	0.008	0.008	2.3[(b)]
Total Nitrogen	mg/L	0.19	0.20	0.12	<0.1	0.10	0.15	0.12	0.13	n/a
Nitrate and Nitrite-Nitrogen	mg/L	<0.01	0.10	0.14	0.38	0.20	0.10	0.21	0.17	n/a
Ortho Phosphate	mg/L	<0.005	<0.005	<0.005	<0.005	0.009	0.006	<0.005	0.004	n/a
Total Phosphorus	mg/L	0.008	0.012	0.013	<0.005	0.010	0.009	0.009	0.009	n/a
Hardness	mg/L	220	236	207	180	200	210	208	209	n/a
Dissolved Copper	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	21.3[(c)]
Dissolved Lead	µg/L	<1	<1	<1	<1	7	4	<1	2	5.56[(c)]
Dissolved Zinc	µg/L	4	<1	<1	2	<1	2	1	2	195[(c)]
Fecal Coliforms	CFU/100 mL	<2	<2	<1	<2	<1	<2 Geometric Mean	<2 Geometric Mean	<2 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (209 mg/L).

Table 2-10
Water Quality Monitoring Results at the Offsite Culvert under Old Lawson Road (Station SE)

Parameter	Units	Baseflow 4/12/2007	Baseflow 4/19/2007	Baseflow Average	State Standards[(a)]
Estimated Flow	CFS	0.01	<0.01		
Temperature	^{o}C	9.1	10.0		<16
Dissolved Oxygen	mg/L	12.6	10.5	11.6	>9.5
Dissolved Oxygen	% saturation	110	93	101	<110% total gasses
pH		7.6	7.0	7.3	6.5 – 8.5
Conductivity	µmhos/cm^2	133	226	180	n/a
Turbidity	NTU	1.9	2.3	2.1	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	<1	5	3	n/a
Oil and Grease	mg/L	1.3	1.4	1.4	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	<1	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	n/a
Alkalinity	mg/L	48	86	67	n/a
Ammonia-nitrogen	mg/L	<0.005	0.018	0.010	2.3[(b)]
Total Nitrogen	mg/L	<0.1	0.22	0.14	n/a
Nitrate and Nitrite-Nitrogen	mg/L	4.90	1.50	3.20	n/a
Ortho Phosphate	mg/L	0.006	0.008	0.007	n/a
Total Phosphorus	mg/L	0.017	0.012	0.015	n/a
Hardness	mg/L	58	100	79	n/a
Dissolved Copper	µg/L	<1	<1	<1	9.28[(c)]
Dissolved Lead	µg/L	<1	2	1	1.95[(c)]
Dissolved Zinc	µg/L	<1	<1	<1	85.6[(c)]
Fecal Coliforms	CFU/100 mL	<1	<1	<1 geometric mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (79 mg/L).

Table 2-11
Water Quality Monitoring Results at the Onsite Culvert at the Basin C Site Boundary (Station SE-2)

Parameter	Units	Baseflow 4/19/2007	State Standards[(a)]
Estimated Flow	CFS	2	
Temperature	^{o}C	13.2	<16
Dissolved Oxygen	mg/L	10.3	>9.5
Dissolved Oxygen	% saturation	99.6	<110% total gasses
pH		7.1	6.5 – 8.5
Conductivity	µmhos/cm^2	17	n/a
Turbidity	NTU	21.5	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	22	n/a
Oil and Grease	mg/L	1.4	"no sheen"

Parameter	Units	Baseflow 4/19/2007	State Standards[(a)]
Petroleum Hydrocarbons	mg/L	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	4	n/a
Ammonia-nitrogen	mg/L	<0.005	2.3[(b)]
Total Nitrogen	mg/L	0.43	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.35	n/a
Ortho Phosphate	mg/L	0.030	n/a
Total Phosphorus	mg/L	0.042	n/a
Hardness	mg/L	5	n/a
Dissolved Copper	µg/L	1.2	0.88[(c)]
Dissolved Lead	µg/L	1	0.09[(c)]
Dissolved Zinc	µg/L	1	8.26[(c)]
Fecal Coliforms	CFU/100 mL	<1	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (5 mg/L).

The abandoned offsite Lawson Hills Mine discharge (Station S, Table 2-9) has a groundwater quality signature much like that measured at Station NE-2 (Table 2-6) in that conductivity, alkalinity, and hardness are all relatively high and total phosphorus and fecal coliforms are very low.

Water collecting at the Station SE culvert under Old Lawson Road offsite (Table 2-10) is similar in quality to Ginder Creek, showing moderate conductivity, alkalinity and hardness, and low phosphorus and fecal coliforms. There is somewhat more nitrate and nitrite-nitrogen at this station than measured at other water quality stations.

Water leaving Basin C on the site at the Station SE-2 culvert has the characteristic low conductivity, alkalinity and hardness observed in Lawson Creek on the site. Hardness is so low at 5 mg/L that both dissolved copper and dissolved lead naturally exceed the state standard defined by hardness, meaning the background condition becomes the standard. As this water moves down the slope towards Unnamed Creek, it likely increases in hardness as groundwater discharge contributions increase, bringing the metals into numeric standard ranges. This is evidenced by sampling at all stations lower in the basins, where groundwater influence significantly increases water hardness and raises dissolved copper, lead, and zinc standards orders of magnitude above the background concentrations.

2.3.2.4 Jones Lake

Lawson Creek, Unnamed Creek (09-0085D) and a third tributary from the south drain to Jones Lake. Rock Creek is formed at the outlet of Jones Lake and flows to Lake Sawyer. The lake is approximately 23 acres in size with a total watershed area of 742 acres (WDF 1975). The mean lake depth is approximately 4 feet and the maximum depth is 7 feet (Associated Earth Sciences, Inc. 2000). The City of Black Diamond's Comprehensive Plan (City of Black Diamond 1996) characterizes Jones Lake as having high concentrations of acidic organic materials, as well as having bottom deposits consisting of unrated organic material that accumulate as peat.

Reconnaissance of the lake by Wetland Resources, Inc. in 2007 did not reveal evidence of sphagnum moss, but other vegetation typical of bogs was present (S. Brainard, personal communication, January 16, 2008). The conclusion from the reconnaissance is that Jones Lake meets the U.S. Army Corps of Engineers definition of a "bog-like" wetland, but is not a sphagnum bog under the definition of Ecology that would trigger bog protection standards.

King County Department of Natural Resources began a volunteer monitoring program in Jones Lake in 2000 and has published results through 2002 (King County 2003) and through 2003 on the county website. The county found the lake to be moderate to high in primary productivity (labeled as mesotrophic to eutrophic) with good to fair water quality.

The data collected for Jones Lake were evaluated using a Trophic State Index (TSI) metric to determine the nutrient and algal growth status of the lake. The more nutrients and the greater algal growth are in a lake, the higher the TSI metric. Lakes naturally have a broad range of conditions from crystal clear, low nutrient lakes with little algae growth (known as oligotrophic) to moderately clear, moderate nutrient lakes with moderate algal growth at some times of year (known as mesotrophic) to low clarity, high nutrient lakes with high algal growth at some times of the year (known as eutrophic). The TSI index was first proposed by Carlson (1977) as a numeric measure based on Secchi disk water transparency measures to determine if human actions were accelerating the natural progression in most lakes from oligotrophic to eutrophic conditions. TSI can also be calculated from total phosphorus (Porcella *et al.* 1980) and chlorophyll-a (Chapra and Tarapchak 1976), and a TSI average is often calculated from the three combined parameter-based TSI measures. TSI values below 40 are usually labeled oligotrophic; TSI values between 40 and 49 are labeled mesotrophic; and TSI values over 50 are usually labeled eutrophic.

In 2002 and in 2003, the county concluded the lake was at the mesotrophic-eutrophic boundary. In 2003, the most recent year with published data, bi-monthly sampling results from mid-April through mid-October gave a TSI average (calculated from Secchi disk, chlorophyll-a, and total phosphorus values) of 50.6. Total phosphorus ranged from 0.017 to 0.096 mg/L with an average of 0.033 mg/L. Water transparency measured by Secchi disk varied from 2.0 meters to 2.3 meters with an average of 2.1 meters. Total nitrogen ranged from 0.45 mg/L to 1.02 mg/L with an average of 0.63 mg/L.

Water samples were collected in Jones Lake near the Lawson Creek inlet on May 1, 2000 for the Black Diamond potential annexation area analysis (Associated Earth Sciences, Inc. 2000). That single assessment showed dissolved oxygen was very low at 5.71 mg/L, which is not unusual for wetland-character water bodies. Dissolved lead, copper, and zinc were within state numeric standards for the hardness measured at the same time. These data and the most recent King County data for 2003 are summarized in Table 2-12.

Ecology assessed the 2000 through 2002 King County volunteer monitoring data for summer mean epilimnetic (water closest to the surface) total phosphorus and found that they exceeded the water quality standards nutrient criterion. Ecology's response was to put Jones Lake on the 303(d) list with a Category 2 total phosphorus listing, meaning it is a "parameter of concern" as described in Section 2.2.3 above. In the mesotrophic to eutrophic threshold range, nutrient criteria for lakes are based on lake specific studies warranted by local conditions, and have no numeric standard, although Ecology often considers that "healthy" lakes should have mean summer epilimnetic total phosphorus concentrations of 0.020 mg/L or less. However, Ecology is not required to set lake specific criteria or investigate further if existing water quality

conditions naturally have a higher TP than 0.020 and beneficial uses are not being lost or degraded (Chapter 173-201A-230 WAC). Since Jones Lake is a "wetland character" lake with no current public access points, it is reasonably concluded the conditions are natural and existing beneficial uses for fish and wildlife are being maintained.

Table 2-12
Water Quality in Jones Lake

Parameter	Units	AESI 5/1/2000	King County Apr – Oct 2003 (12 samples)	State Standards[(a)]
Temperature	^{o}C	15.4	Range 9.5-25.5	<16
Dissolved Oxygen	mg/L	5.71	nm	>9.5
Dissolved Oxygen	% saturation	58	nm	<110% total gasses
pH		6.9	nm	6.5 – 8.5
Conductivity	µmhos/cm^2	97	nm	n/a
Turbidity	NTU	2.0	nm	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	2	nm	n/a
Oil and Grease	mg/L	<0.2	nm	"no sheen"
Petroleum Hydrocarbons	mg/L		nm	"no sheen"
Biochemical Oxygen Demand	mg/L	1.6	nm	n/a
Alkalinity	mg/L	nm	nm	n/a
Ammonia-nitrogen	mg/L	<0.005	nm	2.3[(b)]
Total Nitrogen	mg/L	nm	Range 0.45 – 1.02 Average 0.63	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.51	nm	n/a
Ortho Phosphate	mg/L	<0.005	nm	n/a
Total Phosphorus	mg/L	0.015	Range 0.017 – 0.086 Average 0.033	n/a
Hardness	mg/L	39	nm	n/a
Dissolved Copper	µg/L	<1	nm	5.08[(c)]
Dissolved Lead	µg/L	0.3	nm	0.89[(c)]
Dissolved Zinc	µg/L	1.0	nm	47.1[(c)]
Fecal Coliforms	CFU/100 mL	4	nm	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
nm – not measured
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (39 mg/L).

2.3.2.5 Ravensdale Creek

The City of Black Diamond's Comprehensive Plan (City of Black Diamond 1996) indicates Ravensdale Creek is regarded as the most important and sensitive corridor for fish use in the Black Diamond area. Ravensdale Lake is 2.5 miles upstream of the Ravensdale Creek mouth into Lake Sawyer. The lake is a spring-fed water body and the origin of most of the flow in the creek. Ravensdale Creek is considered a regionally significant resource area by King County (King County 1989) because of the excellent spawning habitat, pristine condition of the creek, and the intact riparian corridor.

Ravensdale Creek is entirely off-site. There is no surface water connection between the Lawson Hills site and Ravensdale Creek. However, the creek runs within ¼ mile of the westernmost point of the North Triangle Property, and is recharged with water infiltrated to alluvial soils on the North Triangle Property.

Ravensdale Creek was sampled once by AESI (2000) at its mouth into Lake Sawyer and five times by A.C. Kindig & Co. in 2007 at the creek's closest point to The North Triangle Property. The water quality results are summarized in Table 2-13. These data confirm Ravensdale Creek has excellent water quality with moderately low hardness, low dissolved metals, and low total phosphorus concentrations.

2.3.2.6 Rock Creek

Rock Creek is entirely offsite, draining Jones Lake and flowing into Lake Sawyer. There are broad areas of wetlands associated with the Rock Creek drainage and its tributaries which influence its water quality. The total watershed of Rock Creek is about 4,450 acres. Historically, until November 1992 wastewater treatment plant effluent recharged Rock Creek near its confluence with Lake Sawyer, which affected water quality in Rock Creek at that location. Total phosphorus concentrations at the mouth of Rock Creek have fallen considerably since the wastewater effluent was diverted to a sewer line. High concentrations of phosphorus occur seasonally during late summer, as a result of natural wetland processes by which die-back and decay of vegetation leads to low dissolved oxygen which in turn causes mineralized phosphorus bound to sediments to dissolve into the water column (King County 2000). Between July 199 and March 2000 total phosphorus at the mouth of Rock Creek varied from 0.022 mg/L to 43.2 mg/L (King County 2000).

Rock Creek was monitored by A.C. Kindig & Co. five times in 2006 and 2007 just upstream of the Auburn/Black Diamond Road crossing. The results are summarized in Table 2-14. Compared to Ravensdale Creek, Rock Creek water has higher conductivity, hardness, and alkalinity, modestly lower dissolved oxygen, and higher ammonia. These are all indicators of the stronger wetland influence on Rock Creek than on Ravensdale Creek. Fecal coliforms are higher in Rock Creek than in Ravensdale Creek, which is also likely a result of wildlife use of the extensive wetlands associated with the creek. Dissolved copper, lead, and zinc were all very low in both creeks, as was total phosphorus. Overall, Rock Creek water quality is very good.

2.3.2.7 Lake Sawyer

Lake Sawyer is about 280 acres in size with a watershed of about 13 square miles in the Big Soos Creek Subbasin of the Green River drainage (King County 2000). Lake Sawyer's water surface elevation is controlled by a concrete weir constructed at the outlet to Covington Creek in 1952. Ravensdale Creek and Rock Creek and its tributaries (including Ginder Creek, Lawson Creek, and Unnamed Creek) all drain to Lake Sawyer, which is downstream of and therefore subject to influence from all of the Lawson Hills site.

The lake has generally good water quality, but has elevated phosphorus concentrations. Historically, in the 1970's Black Diamond lacked sewage treatment plant facilities and effluent was treated by septic tanks and drainfields, including a city septic tank located just south of Auburn-Black Diamond Road that discharged to Ginder Creek. These influences caused very

Table 2-13
Water Quality Monitoring Results for Ravensdale Creek

Parameter	Units	AESI Baseflow 5/1/2000	Storm 12/12/2006	Baseflow 2/6/2007	Storm 2/15/2007	Storm 3/8/2007	Baseflow 4/12/2007	Baseflow Average	Storm Average	Combined Average	State Standards[(a)]
Estimated Flow	CFS		40	20	25	25	35				
Temperature	^{o}C	10.8	7.7	14.0	0.8	8.2	8.8				<16
Dissolved Oxygen	mg/L	10.8	12.2	12.4	12.1	11.6	12.8	12	11.9	12.0	>9.5
Dissolved Oxygen	% saturation	98	102	104	84	98	111	104	95	100	<110% total gasses
pH		7.4	6.7	7.0	7.0	7.0	7.3	7.2	6.9	7.1	6.5 – 8.5
Conductivity	µmhos/cm^2	97	101	102	124	107	108	102	111	106	n/a
Turbidity	NTU	1.1	0.3	1.3	2.5	1.3	1.8	1.4	1.4	1.4	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	4	<1	4	2.5	1	<1	2.8	1.3	2.1	n/a
Oil and Grease	mg/L	<0.2	<1	6.2	<1	1.7	3.5	3.3	0.9	2.1	"no sheen"
Petroleum Hydrocarbons	mg/L	nm	<1	<1	<1	1	2	1.3	<1	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	2.2	<2	<2	<2	<2	<2	1.4	<2	<2	n/a
Alkalinity	mg/L	nm	36	32	28	32	34	33	32	32	n/a
Ammonia-nitrogen	mg/L	<0.005	0.063	0.012	0.026	<0.005	<0.005	0.006	0.031	0.018	2.3[(b)]
Total Nitrogen	mg/L	nm	<0.1	<0.1	0.46	<0.1	<0.1	0.05	0.19	0.13	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.52	0.98	0.78	0.78	0.84	0.89	0.73	0.87	0.80	n/a
Ortho Phosphate	mg/L	<0.005	0.025	0.008	0.006	0.007	<0.005	0.004	0.013	0.009	n/a
Total Phosphorus	mg/L	0.010	0.028	0.012	0.007	0.011	<0.005	0.008	0.015	0.012	n/a
Hardness	mg/L	40	47	39	44	40	44	41	44	42	n/a
Dissolved Copper	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	5.41[(c)]
Dissolved Lead	µg/L	0.3	<1	<1	<1	<1	<1	<1	<1	<1	0.97[(c)]
Dissolved Zinc	µg/L	30	<1	6	<1	5	<1	12	2	7	50.1[(c)]
Fecal Coliforms	CFU/100 mL	4	<1	<1	<1	<2	1	1 Geometric Mean	<1 Geometric Mean	1 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units
n/a – not applicable or no numeric standard
CFS – cubic feet per second
nm – not measured
To calculate averages, values below detection are estimated at ½ of the detection level
CFU – Colony-forming units
(a) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15oC and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (42 mg/L).

Table 2-14
Water Quality Monitoring Results for Rock Creek at Auburn/Black Diamond Road

Parameter	Units	Storm 12/12/2006	Baseflow 2/6/2007	Storm 2/15/2007	Storm 3/8/2007	Baseflow 4/12/2007	Baseflow Average	Storm Average	Combined Average	State Standards[a]
Average Daily Flow	CFS	20.5	7.5	12.2	14.2	10.7				
Temperature	°C	6.0	5.9	0.8	7.5	9.5				<16
Dissolved Oxygen	mg/L	11.0	11.16 (7.3)	11.5	11.2	10.6	11.1	11.2	11.2	>9.5
Dissolved Oxygen	% saturation	87.8	89.5	78.5	93.9	93.2	91.4	86.7	88.6	<110% total gasses
pH		6.2	7.0	7.0	7.1	7.4	7.2	6.8	6.9	6.5 – 8.5
Conductivity	µmhos/cm^2	163	225	266	202	209	217	210.33	213.00	n/a
Turbidity	NTU	4	2.2	2.5	2.9	5.0	3.6	3.1	3.3	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	1	3	2.5	<1	3	3.0	16.5	2.0	n/a
Oil and Grease	mg/L	<1	<1	2	1.6	2.3	1.4	1.4	1.4	"no sheen"
Petroleum Hydrocarbons	mg/L	<1	<1	<1	1.5	<1	<1	0.8	<1	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	n/a
Alkalinity	mg/L	90	96	96	84	88	92	90	91	n/a
Ammonia-nitrogen	mg/L	0.20	0.005	0.026	<0.005	<0.005	0.004	0.076	0.047	2.3[b]
Total Nitrogen	mg/L	0.44	0.25	0.50	<0.1	0.17	0.21	0.48	0.37	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.42	0.43	0.32	0.45	0.64	0.54	0.40	0.45	n/a
Ortho Phosphate	mg/L	0.022	0.010	0.017	0.010	0.014	0.012	0.016	0.015	n/a
Total Phosphorus	mg/L	0.035	<0.005	0.030	0.008	0.027	0.015	0.024	0.021	n/a
Hardness	mg/L	65	65	75	64	67	66	68	67	n/a
Dissolved Copper	µg/L	<1	3	<1	<1	<1	2	<1	1	8.06[c]
Dissolved Lead	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	1.62[c]
Dissolved Zinc	µg/L	2	3	<1	3	<1	3	2	2	74.4[c]
Fecal Coliforms	CFU/100 mL	20	7	46	14	8	7 Geometric Mean	23 Geometric Mean	15 Geometric Mean	Geometric mean of <50

NTU – Nephelometric turbidity units *CFS – cubic feet per second* *Flow data from Golder Associates Inc.*
n/a – not applicable or no numeric standard *CFU – Colony-forming units*
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Chapter 173-201A WAC. *(b) Total ammonia criterion for 15oC and pH of 7.0* *(c) Dissolved metal chronic standard at average hardness (67 mg/L).*

high fecal coliform, nitrogen, and biochemical oxygen demand to be measured in Ginder Creek (Thielen 1978). The high nutrients undoubtedly included high phosphorus, which would have increased phosphorus loadings to Lake Sawyer. In 1981, the Black Diamond Wastewater Treatment Plant began operation, which discharged effluent to a natural wetland associated with Rock Creek just upstream of its mouth to Lake Sawyer after aerated lagoon treatment. At that time, Lake Sawyer was classified as "mesoeutrophic" on the verge of becoming "eutrophic". Shortly thereafter, algal blooms were reported in Lake Sawyer (Peterson, 1990; Zentner 1998) and the lake reached the eutrophic range for total phosphorus (Phillips 1998). Ecology completed a water quality assessment of the lake in 1989 to evaluate nutrient loads and predicted adverse changes in water quality from the effluent discharge. In 1993, EPA approved a TMDL for Lake Sawyer, at which time King County measured phosphorus concentrations of 18 µg/L. In 1992, all effluent discharge was eliminated from discharge to Rock Creek by transfer to a new interceptor line to the regional Metro secondary treatment facility in Renton. This transfer action was the basis for the Lake Sawyer TMDL approved in 1993 by EPA. That TMDL set a maximum mean summer total phosphorus concentration limit of 16 µg/L in Lake Sawyer in order to deter progression of eutrophication. Ecology has monitored for effectiveness of the TMDL measures since that time, and determined that short term noncompliance for the total phosphorus maximum limit may be occurring; however Ecology concluded *"Lake Sawyer seems to be meeting the TMDL target limit as a long term average"* (Ecology 2002). According to King County (2000), about 5 percent of the summer total phosphorus concentrations are due to cumulative loadings from internal phosphorus stored in the lake sediments that is released to the lake during "turnover" (when oxygen-poor and phosphorus-rich bottom water is mixed with higher oxygen and phosphorus-poor shallow water by winds). Another 14 percent of the internal load on an annual basis occurs during turnover in the non-summer months. These internal loadings are due to the history of high phosphorus inputs to the lake from past sewage practices in the city that will take years to move through Lake Sawyer and downstream. The remainder is due to external sources, which originates in the Rock Creek basin (35 percent), the Ravensdale Creek basin (17 percent), the immediate Lake Sawyer Subbasin (12 percent) septic tanks (8 percent) and aquatic plants, groundwater, and atmospheric inputs (9 percent). There are periods in the data record from 1998 to 2000 when summer total phosphorus objectives are met, which may mean progressive improvement in total phosphorus reductions are being realized over time. The mean concentration in total phosphorus from all years for which data are collected are at or below the TMDL target limit, but Ecology concludes more data are needed over a longer period to determine if an improvement trend has manifest.

King County completed the Lake Sawyer Management Plan in 2000 (King County 2000). Data from 1985 to 1999 were used to conclude the lake was mesoeutrophic (TSI average value of 40). The Lake Sawyer Management Plan goal is to maintain that mesotrophic state while accommodating future growth. The Lake Sawyer Management Plan used a lake response model to determine controls necessary to allow growth in the future and still maintain mesotrophic conditions through 2030. Stormwater control policies were recommended by the plan as follows (those most relevant to stormwater are summarized):

- *LS-1 Stormwater Controls*. The City of Black Diamond should adopt more stringent phosphorus control measures consistent with the 1998 King County Surface Water Design Manual (i.e., lake protection standards for stormwater runoff at 50 percent phosphorus removal; and temporary erosion and sediment control standards for construction including wet season specific measures).
- *LS-2 Forest Retention/Conservation* (i.e., open-space dedication with preservation of native vegetation).

- *LS-3 Native Growth Protection Easements and Sensitive Area Ordinance (SAO) Buffer Enhancements* (i.e., cluster developments to enhance protection of sensitive areas such as stream corridors and wetlands)/
- *LS-6 Homeowner Best Management Practices* (i.e., education on minimal use of fertilizers and lawns; alternative cultural practices to chemicals for landscaping and pest control; and best practices for detergents and other products containing phosphorus).
- *LS-10 Regional Stormwater and Phosphorus Control for Rock Creek and Ginder Creek* (i.e., regional ponds for existing or future development meeting lake protection standard criteria).

As described above in Sections 2.2.3 and 2.2.4, Lake Sawyer is currently 303(d) listed as water quality impaired for total phosphorus. The latest data for Lake Sawyer come from King County's volunteer monitoring program for water year 2002 to 2003 (King County 2005b). Lake Sawyer was sampled 14 times from April 20, 2003 to October 19, 2003 (summarized in Table 2-13).

Table 2-15
Phosphorus and TSI-Related Results for
King County Volunteer 2003 Monitoring in Lake Sawyer
(14 samples between April 20, 2003 and October 19, 2003)

Parameter	Units	Mean	Minimum	Maximum
Temperature	^{o}C	18.2	12.0	24.0
Secchi	meters	3.7	2.5	5.5
Chlorophyll-*a*	µg/L	4.2	1.5	9.8
Total Phosphorus	mg/L	0.010	0.005	0.014
Total Nitrogen	mg/L	0.33	0.21	0.65
TSI - Secchi	none	41.7	35.4	46.8
TSI – Chlorophyll-*a*		42.4	34.5	53.0
TSI – Total Phosphorus		37.4	27.4	42.0
TSI - Average		40.5	n/a	n/a

n/a = not applicable

2.4 Groundwater Quality

King County maps the entire Lawson Hills site, including the North Triangle Property, as being outside of any wellhead protection or critical recharge areas (Figure 2-2). Most of the Lawson Hills site is underlain by till and most of the site has bedrock at shallow depth below surface. The northwestern portion of the North Triangle Property infiltrates into alluvial soils over relatively shallow bedrock, and that portion of the site is indicated as having "moderate" sensitivity to groundwater contamination. The remainder of the North Triangle Property is located over till and, along with the rest of the Lawson Hills site, is indicated as having "low" sensitivity to groundwater contamination (Figure 2-2). There are no groundwater wells on or between the North Triangle Property and Ravensdale Creek that could be influenced by infiltration on the North Triangle Property. Ravensdale Creek acts as a barrier to north or west groundwater movement from the North Triangle Property.

King County has no groundwater sampling sites in the vicinity. The nearest indicator of shallow groundwater quality may be the groundwater seep measured at water quality Station NE-2 by A.C. Kindig & Co. described above (Table 2-6). Some of those results are compared to groundwater quality standards in Table 2-16 below.

Table 2-16
Water Quality Monitoring Results for Mud Lake Culvert under Lawson Street at Station NE-2 compared to Groundwater Standards

Parameter	Units	Baseflow 4/19/2007	Groundwater Standards[(a)]
Dissolved Oxygen	mg/L	10.5	n/a
pH		6.7	n/a
Conductivity	µmhos/cm^2	361	n/a
Turbidity	NTU	1.4	1
Total Suspended Solids (TSS)	mg/L	<1	n/a
Oil and Grease	mg/L	<1	Volatile organic compounds and other substances are regulated
Petroleum Hydrocarbons	mg/L	<1	
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	140	n/a
Ammonia-nitrogen	mg/L	0.014	n/a
Total Nitrogen	mg/L	0.12	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.79	10 for Nitrate-Nitrogen
Ortho Phosphate	mg/L	0.005	n/a
Total Phosphorus	mg/L	<0.005	n/a
Hardness	mg/L	180	n/a
Dissolved Copper	µg/L	<1	n/a
Dissolved Lead	µg/L	1	50 for total lead
Dissolved Zinc	µg/L	<1	5,000 for total zinc
Fecal Coliforms	CFU/100 mL	<1	<1

NTU – Nephelometric turbidity units *CFU – Colony-forming units*
n/a – not applicable or no numeric standard
To calculate averages, values below detection are estimated at ½ of the detection level shown.
(a) Drinking water standards Chapter 246-290-310 WAC and groundwater standards Chapter 173-200-040 WAC are identical for the parameters shown..

The seep met all groundwater standards with the possible exception of a slight turbidity exceedence. The turbidity value was likely influenced by passage as surface flow from the spring to the point of sampling.

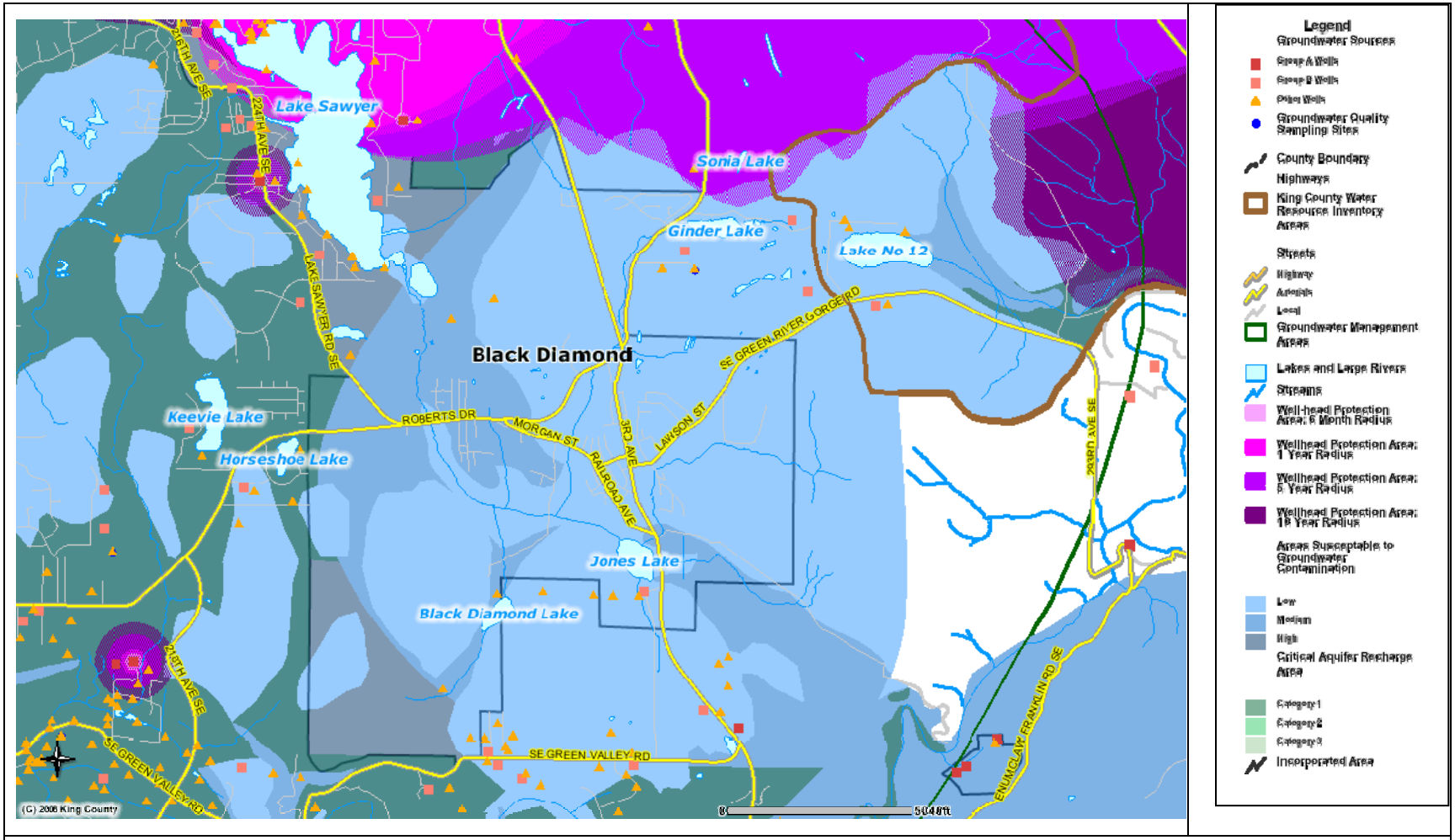


Figure 2-2
King County iMAP Groundwater Program Mapping of the Lawson Hills Site and Vicinity

3.0 IMPACT EVALUATION

3.1 Construction

Construction of Lawson Hills would occur in response to market demand but is expected to be complete by 2015 under the Proposed Action and Alternative 1. Under these two action alternatives, construction would be staged over a period of about 6 years. Under the No Action Alternative 2, there would be more construction covering more area (because there would be less open space) over a longer period of time, expected to be about 30 years.

Phasing of construction in two broad categories would occur as follows.

Phase I would consist of site preparation, stormwater pond construction, and infrastructure construction. That work involves clearing, grading, and demolition of existing structures. While this work is ongoing and prior to completion of the main ponds, stormwater would be collected in temporary sediment ponds and traps located at various points throughout the site. These temporary ponds would serve the site during the dry part of the first construction season while the larger pond system is constructed. The sediment ponds and traps would be sized to a 10-year storm flow criterion rather than a 2-year criterion to increase sediment and therefore phosphorus retention potential on site during the first phases of work. At the end of the dry season (by October 1st) areas disturbed but left unworked would be stabilized for the wet season, and other areas would be covered if left idle for 2 or more days. Additional stormwater treatment systems to the ponds, such as chitosan treatment or electrocoagulation (if issued a general use designation), are expected to be needed during the first wet season to meet NPDES permit limits for discharge. In the North Triangle Property, where stormwater infiltrates, Phase I stormwater protections in the form of temporary ponds and traps would be constructed during the early part of the first construction season, as described above. These ponds and traps would discharge to temporary infiltration facilities away from the permanent facilities. If the discharge occurs to the permanent infiltration facility location(s), then grading of the ponds would cease well above the finished grade elevation for the pond so that fine sediments from construction are removed during final infiltration pond construction. If necessary to maintain NPDES permit limitations, enhanced treatment by chitosan or electrocoagulation would be employed prior to infiltration.

Phase II would consist of clearing, grading, utility construction and development of individual parcels on the site. During the dry season, individual ponds and traps sized to the 10-year runoff would be used on the individual parcels. During the wet season, temporary sediment ponds or tanks along with mobile enhanced treatment systems (as described above) would be installed. Treated stormwater from these systems would discharge to the finished, permanent stormwater facilities.

3.1.1 <u>Construction Impacts Under the Proposed Action and Alternative 1</u>

Under the two action alternatives the potential for construction impacts related to water quality, and the best management practices to manage stormwater to avoid and minimize construction related impacts, would be very similar. However, the exact scale of construction in any given year through 2015 under either alternative cannot be predicted except as described under construction phasing above. Consequently, this section discusses the nature and likely intensity of construction impacts in any given year under the assumption the impact potential risk from

the Alternatives is similar on a year by year basis, and mitigating measures to avoid or minimize such impacts would be similar.

The nature of the construction that could lead to erosion includes the following: removal of some structures and foundations, grading for infrastructure improvements, trenching for utility placement, lot grading, placing and compacting structural fill, and exposure of soils during final lot contouring and construction of structures. This work could all occur to various degrees over time, leaving exposed soil and soil stockpiles that could be vulnerable to erosion if not properly mitigated. Discharge of stormwater during construction would require site coverage under an NPDES permit issued by Ecology under Federal Clean Water Act authorization. It is likely but not certain that an Individual NPDES permit would be issued for construction discharge under the Proposed Action and Alternative 1 because of the size of the project and the six year duration of earthwork that would occur. No matter what type of NPDES permit Ecology determines, Temporary Erosion and Sediment Control (TESC) best management practices (BMPs) would be implemented and maintained in accordance with a Stormwater Pollution Prevention Plan (SWPPP) that would be prepared as required by the NPDES permit under either action alternative.

TESC BMPs would be required by the NPDES permit to prevent the potential for uncontrolled sediment release to any water of the state, including on- and off-site wetlands and streams. Sediment discharge could adversely affect water quality. Because of Jones Lake and Lake Sawyer downstream, increased nutrient loading from phosphorus attached to soil particles could occur if sediment was released from the construction site and conveyed to them by streams. These risks of impact would rise during construction in the wet season because of the increased difficulty in preventing erosion when soils are saturated and exposed during wet weather. Ecology's 2005 Manual defines the wet season as October 1 through April 30. However, relatively rare summer storms could also have the same result. Minor turbidity and minor sediment-related impacts would not have long-lasting adverse impacts. Nonetheless, water quality impairment and related habitat degradation could occur if inputs were sustained or if sustained and significant turbidity reached Lawson Creek, Jones Lake, Ginder Creek, or Rock Creek, and phosphorus loading to Jones Lake and Lake Sawyer could be exacerbated if fine sediment reached those waterbodies as a result of construction. Short-term water quality impacts could include increases in turbidity, suspended and settleable solids, and phosphorus.

The Ecology 2005 Manual construction BMPs include establishment of marked clearing limits before construction, construction entrance stabilization, stormwater sediment and flow control, soil stabilization, slope protection, inlet and outlet protection, channel protection, pollutant protection, dewatering control, site maintenance, and site management. We anticipate that the City of Black Diamond will require use of the Ecology 2005 Manual, and the action alternatives are proposed utilizing the Ecology 2005 Manual BMPs. Golder Associates Inc. characterizes the risk of erosion at the Lawson Hills site as being high where slopes are greater than 15 percent, which includes a narrow portion of the North Triangle and a substantial portion of the Main Property. Erosion control BMPs in these areas would be addressed by the geotechnical consultant during preparation of the SWPPP for the NPDES permit for construction discharge; however this analysis considers that a combination of seasonal limitations, BMPS targeting steeper graded slope controls, and other BMPs applicable to steeper slope work would be applied to these areas (see Table 3-1).

During the October 1 to April 30 wet season, clearing, grading, and other soil-disturbing activities would only occur if runoff containing silt can be prevented from leaving the site. We

anticipate this would require stricter limitations on activity in the high erosion hazard areas when the Stormwater Pollution Prevention Plan (SWPPP) for construction discharge is prepared for the NPDES permit. The seasonal limitations may be modified under the NPDES permit by Ecology based on site conditions at the time of construction, construction activities, extent of disturbed areas, degree of hazard, and proposed TESC BMPs. During the wet season exposed soil may be uncovered for up to 2 days if it is actively worked. During the dry season from May 1 to September 30, exposed soil may be left uncovered for up to 7 days if it is actively worked. BMPs from the Ecology 2005 Manual that could be employed in various combinations for the SWPPP are shown in Tables 3-1 and 3-2. The objective of the source control, management, and interception BMPs is to prevent water with higher than 5 NTU over background from being discharged, which is expected to prevent both sediment and phosphorus loading impacts downstream.

Table 3-1
Summary of Temporary Erosion and Sediment Control (TESC) Best Management Practices (BMPs) from the Ecology 2005 Manual to Prevent Erosion or Sediment Transport

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Preserve Natural Vegetation	Limit site disturbance	Mark clearing limits, preserve buffers and sensitive areas as shown on construction plans and SWPPP.	BMP C101: Preserving Natural Vegetation Vol. II Page 4-2
Buffer Zones	Use of undisturbed vegetation as buffer.	During construction phasing, it may be possible to leave temporarily undisturbed vegetative strips. This BMP does not refer to sensitive area buffers.	BMP C102: Buffer Zones Vol. II Page 405
Clearing Limits	High visibility fencing to mark clearing limits	High visibility plastic or metal fence would be used to mark clearing limits at the boundaries of native vegetation or (as warranted) adjoining properties	BMP C103 & C104: High Visibility Fence Vol. II Page 4-6 and 4-7
Construction Entrance Control	Stabilize construction entrances	Quarry spalls will be used to stabilize controlled construction entry; asphalt treated base will be lain as soon as practicable to minimize sediment tracking by vehicles.	BMP C105: Stabilized Construction Entrance Vol. II Page 4-8

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Wheel Wash	To be used if construction entrance sediment tracking occurs	To prevent sediment from leaving the site, a constructed wheel wash in addition to a stabilized construction entrance is anticipated at all entrances with significant traffic, in the form of a passive wheel wash or a recycling wheel wash system as warranted by conditions.	BMP C106: Wheel Wash Vol. II Page 4-10.
Construction Road/Parking	Stabilizing roads and parking areas	Roadways and parking areas would be stabilized with rock as soon as possible after grading to minimize traffic and rainfall erosion. Haul roads would be placed where permanent roads are located and be covered with asphalt treated base (ATB) as soon as practical following structural fill and utility installation.	BMP C107: Construction Road Stabilization Vol. II Page 4-12
Temporary Cover	Temporary vegetation cover for unworked disturbed areas.	Early fall hydroseeding or other cover measures could be applied to over-winter disturbed areas that would not otherwise be worked.	BMP C120: Temporary and Permanent Seeding Vol. II Page 4-13
Temporary Cover	Mulching and matting (gravel, slag or crushed stone; hay or straw; wood fiber).	See above. Mulching and matting could be employed in disturbed over-wintered areas, especially where worked too late in the season to hydroseed.	BMP C121: Mulching Vol. II Page 4-20
Temporary Cover	Use of nets or blankets	Nets (matting) or blankets could be used to hold seed or mulch together in steep areas and channels and/or aid vegetation establishment.	BMP C122: Nets and Blankets Vol. II Page 4-22
Temporary Cover	Use of clear plastic covering	Plastic cover could be employed short-term to protect stockpiles from erosion, protect disturbed areas of the site during bad weather, or protect storm runoff from recently poured concrete in the event of rain.	BMP C123: Plastic Covering Vol. II Page 4-26

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Permanent Seeding and Planting	Permanent vegetation planting on final graded and cleared areas.	Landscaping vegetation would be planted as soon as practical as the site is constructed and temporary site stabilization measures are replaced.	BMP C120: Temporary and Permanent Seeding Vol. II Page 4-13
Permanent Planting	Sod placement for landscaping.	Sod may be used in turf landscape, or if immediate landscaping is desired as development on the site proceeds.	BMP C124: Sodding Vol. II Page 4-28
Topsoil	Providing appropriate growth medium for planted areas.	Contracts would ensure that contractors plant permanent landscaping or restore native vegetation where applicable on soils suitable for growth and survival.	BMP C125: Topsoil Vol. II Page 4-29
Soil Stabilization	Polyacrylamide (PAM) for soil stabilization	PAM would be an option applied to bare soil in advance of rain to reduce storm runoff turbidity.	BMP C126: PAM for Soil Erosion Protection Vol. II Page 4-32
Soil Stabilization	Tracking or furrows at 90 degrees to steep slopes	Surface roughening by use of caterpillar tracks or furrowing perpendicular to slopes to catch seed and rainfall and reduce runoff.	BMP C130: Surface Roughening Vol. II Page 4-36
Terracing	Construct terraces on steep slopes	Gradient terraces are intended for bare land slopes with water erosion problems. Terracing is not expected to be used, but could be employed if warranted.	BMP C131: Gradient Terraces Vol. II Page 4-38
Dust Control	Reduce dust during land clearing, grading, and construction.	On-site control of dust emissions from grading and construction activity would be implemented. Re-used water from temporary storm treatment traps or ponds would preferentially be used for dust control.	C140: Dust Control Vol. II Page 4-40
Erosion Materials	On-site supply of erosion materials	Adequate supplies of erosion materials dictated by the SWPPP or adaptive responses to situations would be maintained on site and planned in advance of need.	C150: Materials on Hand Vol. II Page 4-42

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Management	Designated individual as CESCL lead	A CESCL lead will be designated as required by the NPDES permit and SWPPP for the project.	BMP C160: Certified Erosion and Sediment Control (CESCL) Lead
Conveyance and Treatment	Interceptor dike and swale	Stormwater would be controlled by dikes and or swales to intercept runoff from unprotected areas and direct it to controlled facilities.	BMP C200: Interceptor Dike and Swales Vol. II Page 4-57
Conveyance and Treatment	Grass-lined channels	Could be used where grades are less than about 5 percent and surface channelized flow conveyance with lower velocity is planed.	BMP C201: Grass-Lined Channels Vol. II Page 4-59
Conveyance and Treatment	Channel lining	Blankets or riprap cover could be employed where grades are steeper than about 5 percent and surface channelized flow conveyance is planned	BMP C202: Channel Lining Vol. II Page 4-63
Conveyance and Treatment	Water bar installation	Water bars could be used to prevent channelized flow down narrow rights of way or construction roads over steeper terrain	BMP C203: Water Bars Vol. II Page 4-65
Conveyance and Treatment	Pipe slope drains	Drainage would be piped down steep slopes during construction as warranted to prevent gullies, channel erosion and/or saturation of slide prone soils.	BMP C204: Pipe Slope Drains Vol. II Page 4-67
Conveyance and Treatment	Temporary outlet across a vegetated or filter strip slope.	Level spreaders may have limited utility to disperse pumped construction pond water between storms to vegetated areas.	BMP C206: Level Spreader Vol. II. Page 4-73
Conveyance and Treatment	Check dams	Check dams would be used as needed to reduce concentrated flow velocity and dissipate energy.	BMP C207: Check Dams Vol. II Page 4-75
Conveyance and Treatment	Geotextile encased check dam	As above, and could be used as a temporary interceptor dike or as temporary perimeter protection for drainage control from small vulnerable areas.	BMP C208: Triangular Silt Dike Vol. II Page 4-78

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Outlet Protection	Lined aprons or energy dissipaters at outlet to prevent scour.	Dewatering and construction stormwater discharge would include outlet protection as warranted.	BMP C209: Outlet Protection Vol. II Page 4-80
Inlet Protection	Protection for permanent storm drain inlets	Where permanent storm inlets are employed before catchment stabilization is complete, inlet protection measures would be used to trap sediments.	BMP C220: Storm Drain Inlet Protection. Vol. II Page 4-82
Temporary sediment barrier	Straw Bale Barrier	Straw bale barriers could be used to create small temporary sediment traps from time to time as isolated situations may warrant, but are not expected to be required or useful to prevent turbid discharge at this site.	BMP C230: Straw Bale Barrier Vol. II Page 4-89
Temporary Sediment Barrier	Brush Barrier	Brush barriers could be used as above for straw bales, but are not expected to be required or useful to prevent turbid discharge at this site.	BMP C231: Brush Barrier Vol. II Page 4-92
Temporary Sediment Barrier	Gravel Filter Berm	Could be used temporarily to retain sediment from right of way or traffic area in problem areas.	BMP C232: Gravel Filter Berm Vol. II Page 4-93
Temporary sediment barrier	Filter Fence	Filter fence would be used as a perimeter sediment interception measure as warranted.	BMP C233: Silt Fence Vol. II Page 4-94
Temporary Sediment Barrier	Vegetated Strip	See BMP C102 above. Vegetated strips can treat disperse low level flows in limited areas, but are not expected to be applied at this site.	BMP C234: Vegetated Strip Vol. II Page 4-99
Temporary Sediment Barrier	Straw Wattles	Straw wattles are tubular materials set perpendicular on slopes to reduce flow velocities and disperse water. They could be used in short-term or for overwintering in some areas of the site as warranted.	BMP C235: Straw Wattles Vol. II Page 4-100
Sediment Ponds	Sediment traps	Sediment traps would be used during all phases of construction.	BMP C240: Sediment Trap Vol. II Page 4-102

Measure	Manual Description and Site Applicability	Lawson Hills Utilization	Ecology 2005 Manual BMP Reference
Sediment Ponds	Temporary Sediment Pond	Temporary ponds and future permanent ponds would be used during construction to treat runoff to remove sediments down to medium silts in size.	BMP C241: Temporary Sediment Pond [(a)] Vol. II Page 4-105

(a) See Section 3.3.1 for alternative or additional treatment BMPs to sediment ponds

Table 3-2
Summary of Construction Contaminant (non-sediment) Control Best Management Practices (BMPs) under the Ecology 2005 Manual

Measure	Manual Description and Site Applicability	Ecology 2005 Manual BMP Reference (Vol. II)
Pesticide Control	Proper management, storage and handling of pesticides.	Page 3-12
Handling of Petroleum Products	Proper transport, storage and handling of petroleum products.	Page 3-12
Nutrient Application and Control	Proper transport, storage and handling of fertilizer products.	Page 3-12
Solid Waste Handling and Disposal	Building debris.	Page 3-12
Use of Construction Chemicals	Paints, acids, cleaning solvents, asphalt products.	Page 3-12
Handling Hazardous Products	General guidelines for managing or minimizing the above hazardous wastes.	Page 3-12
Equipment Washing	Cleaners and solvents associated with vehicle washing.	Page 3-12
Spill Control Planning and Cleanup	Spill Control Plan with contact list.	Volume IV, Page 2-53
Treatment and Disposal of Soils Contaminated by Construction	Contaminated soils caused by spill or leak during construction.	Page 3-12

A construction monitoring plan would be prepared as required by the NPDES permit that describes weekly TESC inspection, monitoring locations, sampling frequency, sampling trigger, corrective actions, follow up monitoring, reporting to Ecology, and a record of site TESC inspections. The elements of the construction monitoring plan would follow any NPDES permit requirements issued specifically for the Lawson Hills project.

Conveyance of existing stormwater entering from offsite areas that discharge to the Lawson Hills site would continue through the Lawson Hills site during and after construction via protection and preservation of streams, wetlands, and their buffers.

3.1.2 On Site Stormwater BMPs

On-site stormwater would be collected and directed to temporary sediment trap(s) or to ponds constructed for permanent stormwater treatment in accordance with the 2005 Ecology Manual (BMP C240, C241). Construction storm drainage conceptual plans are included in the Preliminary Technical Information Report (Triad Associates 2008).

Prior to the first stages of development, construction best management practices would be installed in accordance with the 2005 Ecology Manual and local ordinances, including construction entrance construction, pond and drainage construction, and perimeter protections for those areas included in the first phase(s) of construction. Construction entrance sediment control methods may vary according to the number of truck trips and cubic yards of material to be added to various areas of the site under future specific grading plans. Construction entrance BMPs could also vary depending on the amount of material planned for import or export in any given construction season. If final grading plans for any given season dictate heavy demand on entrances, then a wheel wash that prevents sediment track-out (BMP C106) would be constructed, which could be a closed loop wheel wash system with an asphalt-treated base, pressurized spraying, daily maintenance, and polymers to remove sediment. If soil import or export is estimated to be smaller or easily managed at some entrances during some construction seasons, more conventional dry or wet wheel washes may be suitable, so long as state water quality standards can be maintained and track-out of sediment is avoided.

3.1.3 Alternative Methods for Sediment Control

Stormwater discharge is required by NPDES permit to comply with the WAC 173-201A standard of a 5 nephelometric turbidity unit (NTU) change over background. This standard would be achieved by any combination of BMP source control measures (Table 3 -1), and by treatment of stormwater by any combination of the following Ecology 2005 Manual measures, which may vary as warranted by stormwater quality, season, and extent of construction activity:

- Multiple Stormwater Ponds (BMP C241),
- Stormwater Filtration (BMP C251),
- Polyacrylamide for Soil Erosion Protection (BMP C126),
- Chemical Treatment (BMP C250). The Project may employ the use of a chemical treatment system (Chitosan Enhanced Sand Filtration) approved by Ecology if warranted to meet permit discharge requirements.
- Electrocoagulation Subtractive Technology (ECST) by Water Tectonics, Inc. was granted a conditional use designation (CUD) as an emerging technology in February 2005. The CUD has been extended to May 1, 2009 (Hoppin 2008) to allow additional testing and analysis time before submittal of a technical report to Ecology. Data collected during the CUD period will be evaluated by Ecology to determine if electrocoagulation should have a general use designation. If elevation to a general use designation is granted, this technology would then be available as an option for continuous water treatment use on the Lawson Hills site during construction if allowed under the NPDES permit from Ecology.

In addition to standard TESC measures, and if warranted to meet NPDES permit requirements, the Lawson Hills project proposes the use of treatments that reduce sediment mobilization in storm runoff or to remove sediment from TESC ponds. Anionic polyacrylamide (PAM) could be used for soil stabilization purposes to prevent sediment mobilization. This product is applied to

exposed soils and forms a temporary nontoxic barrier to the impact energy of rainfall, which greatly reduces soil mobilization during storms. PAM is listed as an approved BMP for soil stabilization for TESC purposes in Ecology's 2005 Manual. Use of PAM would require site specific NPDES Permit approvals and its inclusion in the SWPPP.

The Lawson Hills project expects to propose to Ecology that chitosan enhanced sand filtration (CESF) using a trained operator be used to remove sediment from water in TESC ponds (or electrocoagulation if granted general use designation). Several local field tests of CESF have been performed locally with favorable results and are reported here. Use of CESF or electrocoagulation would require site specific NPDES Permit approvals.

The U.S. Department of Transportation (Western Federal Lands Highway Division [FLHD]) treated construction runoff from the I-90 Sunset Interchange Project in Issaquah, Washington with Chitosan© in February 2002. Water from that project's steep graded hill slopes typically had turbidity in the range of 150 NTU before Chitosan (Liqui-Floc©) treatment, and around 1 NTU after treatment. Water was pumped from collection ponds and routed by pipe to a Baker Tank sand filtration system, which had Chitosan© additive. Liquid Chitosan© was also added to the water as it passed through the pipe (0.5 mg/L, or 1 gallon per 20,000 gallons of stormwater), which caused the fine sediments to bind together for removal in the sand filter. A similar system was used for the Lakeside Construction Project in Redmond, Washington in early 2001, which obtained similar results. Phosphorus, heavy metals, and oils that are associated with the fine particles are removed with the sediment. Chitosan© is non-toxic and biodegradable (U.S. Department of Transportation, March 19, 2002). The water must be within the pH range of 6 to 8, which is met by all area waters. Chitosan© has no effect on pH level after treatment. Ecology issued a general use designation for CESF updated in January 2008 (Ecology 2008) for use as a TESC BMP. CESF may not be needed everywhere or at all times to prevent adverse impacts from construction, but would be identified as a valuable BMP management tool in the SWPPP to be employed as conditions warrant to keep storm discharge within the NPDES permit requirements and prevent or minimize construction impacts.

3.1.4 Work Below Ordinary High Water Mark

Roadway crossings of Lawson Creek on the Main Property occur at two locations. It is assumed that the culverts at both crossings would be removed, and one crossing would be retained and reconstructed. Both of these work locations occur where Lawson Creek is non-fish bearing and seasonally dry (see Cedarock Consultants, Inc. 2008). The work on these crossings is proposed to occur when the creek is dry and would occur under other conditions established for the Hydraulics Project Approval (HPA) that would be required for the work from the Washington State Department of Fish and Wildlife. Other construction BMPs described above applicable to the work would be employed. The site would be stabilized and replanted prior to seasonal flow beginning the next season (see Cedarock Consultants, Inc. 2008 for mitigating measures to protect fisheries). With these control measures, no adverse impacts from construction at these two crossings are anticipated.

3.1.5 Petroleum-Based Products and Spill Response and Prevention

The use of heavy equipment during construction may require on-site fueling and often limited storage of products such as lubricating oil and hydraulic fluid, which may create a risk for accidental spills. Unintended release of fuels, oil, or hydraulic fluid could contaminate soils and,

if untended or uncontrolled, migrate to shallow groundwater or into Lawson Creek or Unnamed Creek or Mud Lake. The SWPPP would identify plans for control measures and spill response to prevent or control construction equipment leakage of fuel, oil or hydraulic fluid. Water quality impacts from construction spills can typically be prevented or limited to very local areas by BMPs and accidental spill provisions as required by the NPDES permit. Spill response plans would provide for emergency, local and state agency notification, provision for on-site storage of spill response and cleanup materials, training, and response and cleanup procedures.

3.1.6 Concrete Work

Construction of foundations, structures, curbing, driveways, sidewalks and other infrastructure includes concrete work which can raise pH in stormwater if contact of stormwater occurs during curing. Curing times vary with weather conditions and concrete types. Use of concrete products to achieve soil compaction standards can have the same effect.

Management of the higher pH runoff where concrete is used, along with pH monitoring, is a best management practice to avoid introducing high pH water into the natural environment and could be handled through a variety of options at the site. Concrete affected runoff could be isolated from other non pH-affected construction runoff depending on the scale of work. Options available to the construction on the site include the following:

- Sequestering pH affected water in ponds and treatment by carbon dioxide sparging with dry ice or compressed CO_2 to return it to neutral pH;
- Discharge to sanitary sewers (if feasible) with appropriate permits;
- Use of pH affected water for dust control; and
- Re-use of pH affected water by the off-site batch plants providing concrete for the project.

Rinsing of concrete-related equipment also raises pH, and would be stringently controlled by provisions in the SWPPP. These could include the following:

- Concrete truck rinsate could be returned with the trucks to the off-site batch plants for re-use as process water.
- Minor rinsate from other concrete equipment could be controlled by confining it to plastic-lined pits or temporary holding tanks that are separately managed from the storm drainage control system (with contents legally disposed off-site or as described immediately above).

Although not anticipated necessary, if concrete amendment to soils is deemed necessary to achieve compaction standards, then:

- Delivery and distribution/mixing of the concrete amendment, if any, would be done in a manner to protect against airborne dust;
- Concrete soil amendment percentages, if any, would not exceed 10 percent by weight, and would be established by a soils specialist;
- Temporary or permanent cover would be installed over soil amended areas, if such amendment is found necessary during construction, as soon as practical after mixing and lifts are completed;
- On-site storage of the concrete amendment would be limited to that volume left at the end of the working day, which would not exceed one tanker truckload; and
- Soil amendment would only be made while the weather is dry.

3.1.7 Offsite Work

A stormwater bypass is planned to take higher flow discharges to Lawson Creek below the steep and erosive offsite canyon. There are two routes for this discharge described by Triad Associates (2008). Under Option 1, the bypass pipe would begin at the southern pond in Basin A and run downgradient through the site to cross Lawson Creek by attachment to a railroad crossing, and then south along SR-169 to discharge to both Lawson Creek and Unnamed Creek via flow splitter. The discharges would tie into existing culverts under SR-169. Under Option 2, the bypass pipeline would begin at the northern pond in Basin A, travel west along Lawson Street and south along SR-169 to the same flow splitter configuration.

For either of the two routing options, linear construction activity BMPs proposed for storm trenching and pipeline installation would be similar to those used on-site for utility construction. These BMPs include limiting the area of exposed soil, covering soil stockpiles or trenches with plastic sheeting, stabilized construction access points, dust control, street cleaning, preventing untreated surface discharge from utility areas, and treatment of any sediment laden dewatering that is necessary. The relatively shallow trenching expected for almost all of the off-site storm drainage would help minimize the amount of earthwork, duration of construction, and need for any dewatering. Both on- and off-site, installation of the bedding materials, roadbeds, structures, pipelines and re-stabilizing disturbed soils would occur such that the wet season (2 day exposure limit) and dry season (7 day exposure limit) soil cover requirements would be met. All outfall construction work would take place during the dry season, and other BMPs for construction applicable to this trenching would apply (see Section 3.1.4).

Connection of the Lawson Creek stormwater flow discharge at the Unnamed Creek and Lawson Creek culverts under SR-169 would be constructed during the low flow season using mitigating measures described in Cedarock Consultants, Inc. (2008). Appropriate measures to protect fisheries would be placed and water would be diverted or pumped around the work area, if work below the low flow level was required. By diverting or pumping flow around the work area (should work below the water line be required) all work could be completed during the dry season and the area stabilized before flow was reintroduced. Other BMPs to prevent sediment introduction to wetted areas of the streams would be implemented as described above. These measures are reasonably expected to avoid adverse water quality impacts during storm outlet connection.

Stormwater discharges would also be constructed to Ginder creek by connection to culverts under Roberts Road. These would be managed during the low flow season as described above for the SR-169 culvert connections.

Offsite trenching for sewer placement would occur to varying degrees depending on the routing option that is finally implemented. This trenching would not directly impact any stream or wetland under either of the option routings (see Triad Associates 2008 for a description). BMPs for this work would be as described above for the stormwater trenching.

With the mitigating measures described, no adverse temporary impacts from construction of offsite improvements are anticipated.

3.1.8 Features Incorporated into the Lawson Hills Proposal

With the proper employment of construction best management measures it would be possible to adequately prevent long term or severe turbidity impacts to surface waters during construction that could adversely affect aquatic habitat. Monitoring, site cleanup, and on-site inspections as required by the NPDES permit would be expected to locate and rectify problems shortly after their occurrence, or prevent them altogether.

The following features would be incorporated into the Lawson Hills construction plan (under the Proposed Action and Alternative 1) to reduce or off-set the potential construction-related water quality impacts:

- An NPDES Permit for Stormwater Discharges Associated with Construction Activities would be obtained from Ecology, which would contain monitoring and erosion control requirements deemed necessary by Ecology.

- A Stormwater Pollution Prevention Plan (SWPPP) would be prepared and implemented as required by the NPDES permit and would be updated as warranted, which would contain specific best management practices for each construction season.

- Monitoring requirements determined by Ecology for the NPDES permit would be implemented and reported.

- Best management practices would be implemented from the menu of measures listed in Tables 3-1 and 3-2. The major TESC measures detailed in the SWPPP would include (but are not limited to) the following:
    - Marking the construction limits (i.e., marking limits on plans and in the field using plastic, metal, or fence);
    - Installation of temporary construction access (stabilized entrances) and staging areas (i.e., limiting construction vehicles to points stabilized with quarry spall or rock with wheel wash pad);
    - Road cleaning (i.e., shoveling or sweeping sediment, followed by street sweeping);
    - Perimeter protection such as silt fencing when necessary to intercept fine sediments and fencing or flagging of clearing limits;
    - Soil stabilization: temporary or permanent cover such as seeding, mulching, sodding, plastic covering, erosion control fabrics and matting, application of polyacrylamide (PAM) to the soil, or gravel base, over disturbed areas or stockpiles to prevent erosion (after 7 days unused/unworked from May 1 through September 30; after 2 days unused/unworked from October 1 through April 30 or as needed to respond to weather forecasts);
    - Utilize a certified on-site TESC inspector and conduct inspections weekly and following each rainfall in excess of 0.25 inches/ 24 hours;
    - Convey offsite existing drainage through construction areas via pipelines to prevent mixing with construction stormwater;
    - Treat runoff to remove sediment;
    - Cover measures (for example, hydroseed, straw cover, polyacrylamide [PAM],

and/or plastic);
  - Stabilize channels and outlets (i.e. armoring as necessary to prevent erosion or scour);
  - Control of all pollutants on-site, including removal and legal disposal of construction waste or soils contaminated by construction activity or accidental spills;
  - Maintenance and inspection of BMPs and TESC measures;
  - Compliance with all federal, state, and City of Black Diamond code and permit requirements; and
  - Accidental spill response plans, on-site clean-up materials storage, and worker training;

- Construction entrances would include truck wheel washes in addition to quarry spalls to dislodge sediment if warranted by truck traffic and soil export volumes; and routine street cleaning;

- Use of specialized products such as Chitosan or Electrocoagulation and other water treatment systems if warranted and approved by Ecology under the NPDES permit;

- BMPs proposed for concrete work are the following:
  - Cement trucks wash water would not be disposed on-site, but would be returned to the off-site batch plant for recycling as process water;
  - New concrete work would be covered and protected from rainfall until cured; and
  - Monitoring of pH would occur in areas with active concrete work; and

- In-water construction would employ conditions to be established in federal, state, and local permits and use mitigation described by Cedarock Consultants Inc (2008) to prevent adverse impacts to water quality.

3.1.9 Probable Scale of Construction Impacts under the Alternatives

Proposed Action and Alterative 1: With proper control of storm drainage, BMPs defined for culvert work below the OHWM (see Cedarock Consultants Inc. 2008), and good accidental spill response planning, adverse impacts from fine sediment, alkaline (high) pH, and construction-related accidental hazardous material spills would be reasonably expected to be avoided or limited to small short-term and mainly on-site occurrences with no lasting adverse effects. Some minor introductions of fine sediments to stormwater leaving the site during heavy rainstorms may occur from time to time, but stringent implementation of SWPPP measures and countermeasures required by federal, state, and City of Black Diamond permits should identify and rapidly correct such occurrences so they would not adversely affect habitat through water quality impacts.

Alternative 2: Work under this no action alternative would be less in any given year than under the two action alternatives for the period between start of construction and buildout under the action alternatives by 2015. However, incremental construction under the no action alternative would take place over 30 years, or 24 years longer than under the action alternative. The construction would likely occur through many separate permits managed independently. Some

projects may develop without triggering the need for NPDES permit coverage where land disturbance is under 1 acre in size. However, these smaller projects are far more likely to occur under a General NPDES permit for construction discharge, most of which would not trigger 303(d) phosphorus controls because in Basins A and C Jones Lake is the more immediate receiving water and it is not designated as impaired for total phosphorus. Therefore, the degree of control of fine sediments and the level of treatment before discharge is unlikely to be equivalent to that proposed for Lawson Hills by all projects that may occur under the no action Alternative 2.

3.1.10 Significant Unavoidable Adverse Impacts from Construction

None are anticipated with mitigation developed as part of the proposal as described above.

3.2 Stormwater Quality Impact Evaluation

Stormwater management under the various alternatives is summarized below and described in more detail by Triad Associates Inc. (2008). Section 3.2 describes typical stormwater contaminants expected from the types of land use that are proposed, quantitatively analyzes performance of the stormwater facilities that are proposed or could be employed under the alternatives, and discusses results. State water quality standards are concentration-based, and concentrations of typical stormwater constituents under the various alternatives are quantitatively evaluated and compared to these standards. Water quality under the alternatives is forecast by using data from the literature to estimate untreated water quality for major categories of land use (for example, office, commercial/retail, arterial roads, and various housing densities), mixed in proportion to the volume of runoff each is expected to contribute from pollution-generating surfaces. These untreated concentrations are then reduced by the expected performance of the stormwater facilities to predict discharge water quality.

3.2.1 Conceptual Stormwater Quality Management Plan

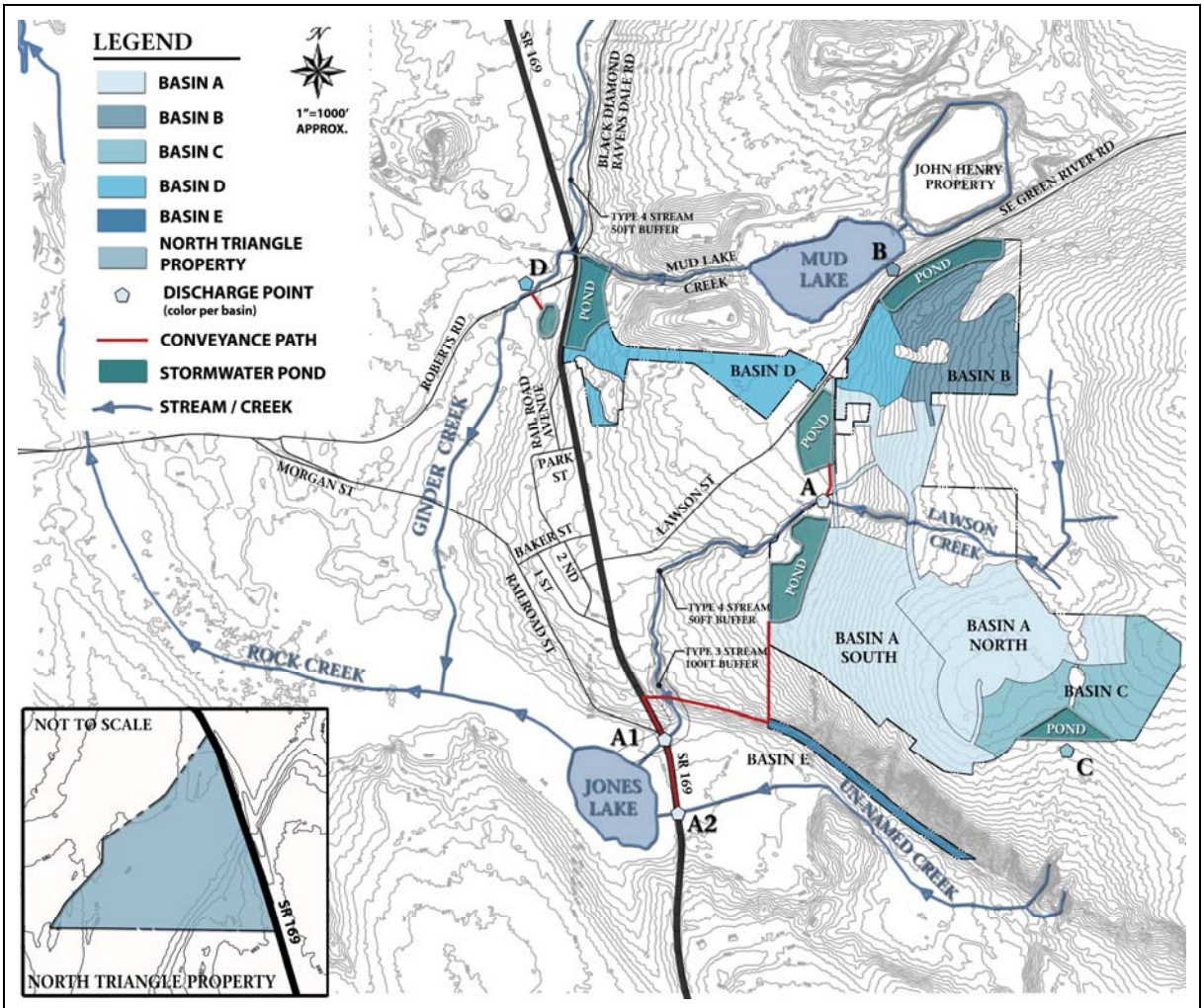
Conceptual stormwater management on the site is described below for the Proposed Action and Alternative 1. See Figure 3-1 for a map of the developed basins A through D and their discharge locations. Runoff from the North Triangle would be infiltrated on-site.

1. Runoff from developed Basins A, B, and C would be treated by large wetponds / detention ponds (wet detention ponds). These basins would contain almost entirely single family residential development. The large wetponds would meet criteria for treatment to protect phosphorus sensitive lakes (for protection of Lake Sawyer offsite and downstream). These large wet detention ponds would also detain water to meet flow control standards of the 2005 Washington Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2005 Ecology Manual).
    - Developed Basin A would have two large wet ponds, the first discharging treated stormwater to:
        i. Lawson Creek on site; and

      The second Basin A large wet pond would discharge split flows (to avoid increasing erosion in Lawson Creek below the site) into:
        ii. Lawson Creek offsite near Jones Lake and the Lawson Creek SR 169 culvert; and
        iii. Unnamed Creek offsite near Jones Lake and close to the Unnamed Creek SR 169 culvert.

- Developed Basin B would discharge treated stormwater to Mud Lake.
- Developed Basin C would discharge treated stormwater to Unnamed Creek.

2. In developed Basin D planned for multifamily and commercial development, the 2005 Ecology Manual requires stormwater treatment satisfying both phosphorus sensitive lake requirements (for Lake Sawyer offsite downstream) and "enhanced" treatment (for protection of salmonids in streams). Runoff from these areas would be treated by a basic wetpond followed by a basic sand filter to satisfy both requirements. Flow control would be provided as described above in the wet detention pond. Developed Basin D would discharge treated stormwater to Ginder Creek.



Source: Triad Associates

Figure 3-1
Developed Drainage Basins A through D
(Showing Option 1 Basin A Routing)

3. The North Triangle Property Basin would be developed with commercial and office space under both action alternatives. Drainage on this property now flows from the southeastern till-mantled portion of the site down to the north and western portion of the

site with outwash that readily infiltrates. Runoff from rooftops and non-pollution generating surfaces would be infiltrated directly into the outwash. Water quality protection for other stormwater is proposed using systems meeting both "enhanced treatment menu" and "phosphorus treatment menu" designs from the Ecology 2005 Manual. Enhanced treatment is required for discharge from these land uses to fisheries streams (i.e., Ravensdale Creek) and phosphorus treatment is required for Lake Sawyer downstream. Although the North Triangle Property does not directly discharge to Ravensdale Creek or Lake Sawyer, evaluation of the shallow alluvial material through which groundwater would move to Ravensdale Creek shows it is relatively coarse. Therefore water quality treatment is conservatively proposed as if the project discharged by surface conveyance or pipe, even though all stormwater from the North Triangle would be infiltrated. There are many options for water quality treatment that would meet both the enhanced and phosphorus treatment design and performance criteria under this conservative assumption. The most probable treatments, and the treatments analyzed in this report, are (1) "large" sand filters (which may be integrated into landscaping) followed by infiltration, and/or (2) biofiltration followed by "basic sand filters" and then infiltration. Both of these alternatives could be fit within landscaping, median strips, and other project features, and are consistent with and aided by other Low Impact Development (LID) methodologies (see below). Rooftops and non-pollutant generating surfaces in the North Triangle would be infiltrated directly near the points of runoff wherever feasible.

4. A combination of LID concepts are proposed throughout the Main Property and most particularly on the North Triangle Property that has infiltration potential. LID measures are described in a separate section in this report.

There are two options for the closed pipe system that would convey a portion of the flow from Basin A to Lawson Creek near Jones Lake under the Proposed Action and Alternative 1. These are the following:

Option 1: The pipe system would begin at the southern pond in Basin A and be routed along a railroad grade to an alignment along SR 169. The northern pond would discharge directly to Lawson Creek onsite.

Option 2: The pipe system would begin at the northern pond in Basin A and be routed along Lawson Road to and along SR 169. The southern pond would discharge directly to Lawson Creek onsite.

Large-sized facilities treat approximately 95 percent of the average annual volume of storm runoff, whereas basic-sized facilities treat approximately 91 percent of the average annual volume of storm runoff. The remaining storm runoff volume occurs during very large and relatively rare storms and can bypass the water quality facility treatment, but not the flow control facility. Water passing through either a large or basic facility receives the same treatment and would have the same water quality after treatment assuming the same inflow quality; the difference is that by design more runoff is treated by a large-sized facility. This is important where the mass "loading" of a stormwater contaminant, for example kilograms per year of phosphorus, has potential to affect water quality downstream in Lake Sawyer.

The analysis assumes storm runoff from Basins A through D and the North Triangle Property would be treated as described above. At final design, any facility type (and any combination of

facilities) meeting the phosphorus treatment and enhanced treatment criteria described above (as defined in the Ecology 2005 Manual) could be employed. The resultant discharge is assessed in relation to the existing water quality condition and water quality standards to describe impacts for "conservative" water quality constituents at discharge to each of the receiving waters. "Non-conservative" constituents are evaluated qualitatively, or by analysis using other separate studies from the literature. The terms "conservative" and "non-conservative" in this context are scientific terms used to classify different types of water quality constituents or characteristics. Conservative parameters are, for example, metals, nitrogen and phosphorus compounds, solids, and petroleum hydrocarbons that may degrade or convert to other compounds, but can be sensibly described in mass quantity terms. Non-conservative parameters, for example temperature, pH, and dissolved oxygen, do not have meaningful mass quantity characteristics.

Because the greatest stormwater quality impacts would occur at the time of greatest pollution generating surfaces, this water quality analysis evaluates the 2015 built-out condition.

3.2.2 Description of Stormwater Contaminants

Vehicular traffic is the greatest local cause of stormwater pollution. Data for urban storm runoff quality have shown a dramatic decline in all automotive pollutants from roadways and parking lots since the 1980s, due to improvements in automobile design, fuels, automotive emission controls and catalytic converters (Martin 1989; Schueler *et al.* 1991; CH2M Hill 1992; Urbonas 1994; King County 1995; Brown and Schueler 1997; Comings, Booth, and Horner 1999; Associated Earth Sciences, Inc. 2000; A.C. Kindig & Co. 2002a, 2003a). This has led to significant improvements in urban runoff quality over the past 25 years.

Vehicles deposit an array of organic and inorganic pollutants to roadways and parking areas, which accumulate and then wash off with storm runoff. These include heavy metals, petroleum products, and solids. Oils and greases contain lead and zinc, tire wear contributes zinc, moving parts of automobiles wear and deposit lead and copper, and brake linings and protective coatings to undercarriages contain copper. Streets themselves degrade to some extent, also contributing suspended sediments to storm runoff (Harper 2000). Roadways also collect runoff from driveways and landscaping around residential lots and structures when rainfall is heavy enough to saturate soils. Concentrations of pollutants in stormwater are highly variable by site, and are affected by numerous factors such as traffic and parking characteristics, storm intensity, rainfall pattern within a given storm, amount of time since the last storm, road maintenance (such as street sweeping), and airborne contributions from adjacent land use (Maestri *et al.* 1988; Harper 2000). The following section is a brief overview of stormwater contaminants typical of the land use categories used in the analysis.

3.2.2.1 Metals

Three of the heavy metals are typically used to assess stormwater quality and its impacts. These are lead, zinc and copper. Lead (Pb) in stormwater runoff on streets is mainly associated with particulates and mainly originates from wear of moving vehicle parts. The primary source of roadway copper (Cu) is wear from vehicle parts, such as brakes, alternators, and radiators. Low concentrations of the cupric ion of copper are extremely toxic to phytoplankton (Metro 1982). Zinc (Zn) is an abundant trace mineral that occurs naturally in water bodies. A substantial source of zinc on roadways is tire wear. Lesser amounts of zinc originate from brake linings and exhaust emissions. Galvanized metal in structures are also a source of zinc in

stormwater. Studies show roadways adjacent to lakes contribute to zinc accumulations in lake sediments, where zinc is effectively immobilized (Gjessing *et al*. 1984; Yousef *et al.* 1984). Zinc is not considered a carcinogenic metal and federal agencies have no specified health limits for zinc. However, Washington State water quality standards for zinc do exist and are used in this analysis. Once in sediments (for example, trapped in the bottom of stormwater ponds or by sand filters, or entrained in bioswales or similar facilities), heavy metals tend to be immobile unless the sediments are disturbed (Yousef *et al*. 1984). The dissolved, divalent (double positive charge) ion of heavy metals is generally the toxic form. Dissolved metals are the basis for state water quality standards which vary according to water hardness; the harder the water, the lower the toxicity because divalent ion concentrations decline.

3.2.2.2 Oil, Grease, and Total Petroleum Hydrocarbons (TPH)

Oil and grease have natural vegetative and manmade components. Total petroleum hydrocarbons (TPH) are a subset of oil and grease derived solely from petroleum products that are more volatile than oil and grease. Natural oils from vegetation generally comprise the remainder. TPH results from automotive spills, leaks, antifreeze, hydraulic fluids, and asphalt leachate (Washington State Department of Transportation [WSDOT] 1997). Oil and grease and TPH have poor solubility in water and are hydrophobic, which means they readily separate from the aqueous (water) phase and adhere to solid surfaces when the opportunity is afforded (for example, to grasses in bioswales). Appreciable amounts of oil and grease can remain dispersed in water in emulsified form where there is sufficient mixing energy in the water to cause and maintain emulsification. Oil and grease and TPH that adhere to emergent surfaces are degraded by microbial digestion, sunlight (photochemical degradation), and volatilization.

3.2.2.3 Total Suspended Solids (TSS)

Suspended solids are comprised of inorganic and organic material and can be transported by, suspended in, or deposited from stormwater. Suspended solids are generally considered one of the most substantial nonpoint source contaminants (nonpoint meaning no single discrete source), because other contaminants bind to fine particulates (Waters 1995, Crawford and Mansue 1996). Metal ions, organic chemicals, and phosphorus bind to and are transported by mobile fines or immobilized with settled fines (Waters 1995, Simmons 1993).

3.2.2.4 Nutrients

Nutrients tend to build-up on impervious surfaces. Nitrogen (N) and phosphorus (P) occur in stormwater runoff from roadways, from fertilizers used in landscaping, from exterior use of detergents, and from sediment erosion. Nitrogen occurs in numerous forms, including dissolved molecular nitrogen, ammonia-nitrogen (NH_3-N), and nitrate- and nitrite-nitrogen (NO_2-N and NO_3-N, respectively). Nitrogen is also reduced to nitrogen gas and volatilized (lost to the atmosphere) through microbial activity (denitrifying bacteria). This nitrogen loss mechanism usually occurs under anaerobic (no or low oxygen) conditions that naturally occur in some soils, riparian zones, and in many wetlands. Forest riparian zones have been shown to remove about 61 percent of nitrate-nitrogen through a combination of denitrification and plant uptake during the early growing season, and denitrification alone during the rest of the year (Schoonover and Williard, 2003). Gaseous nitrogen can be fixed (converted to organic form) by microbes symbiotic with some plants, such as red alders. Phosphorus, unlike nitrogen, readily binds to aluminum and iron in sediments where it is immobilized, though still available to plant root

uptake. Phosphorus can be converted from mineral form in sediments to dissolved form in water under anaerobic (low oxygen) conditions. In lakes, this phenomenon is referred to as "internal loading" of phosphorus (in contrast with "external loads" contributed by sources outside of the lake). Internal loading happens following breakdown of a thermal water barrier (called a thermocline) that is common in lakes in the summer. A thermocline is a sharp change with depth from warmer surface water to colder bottom water. That temperature change forms a physical barrier to mixing between the two layers, which allows deep water to become oxygen depleted and phosphorus rich as mineralized phosphorus in the lake sediments dissolves into the low oxygen water. The deeper water with its phosphorus supply is mixed into the lake as a whole when winds and weather cause the thermocline barrier to break down, where it can lead to algal blooms. Rooted aquatic vegetation can also move mineralized phosphorus from soils into the water column. Phosphorus is the nutrient that controls algal growth in Lake Sawyer and most other freshwater lakes, because it is the nutrient in shortest supply relative to algal growth requirements.

3.2.2.5 Pesticides: Insecticides and Herbicides

Some landscaping insecticides and herbicides can be transported in stormwater runoff. The mobility and persistence of pesticides varies greatly. Where measured, the appearance of landscape chemicals in urban settings tends to be sporadic and has not been associated with toxic effect to surface waters. Metro (1982) first reported tentative identification of seven pesticides in five of twenty-one samples collected during its survey of residential and urban areas in the early 1980s, before there were requirements for stormwater quality treatment. Of the seven pesticides found, all had concentrations in untreated surface runoff above chronic standards at least once; however, no violations of standards in receiving waters were noted and the report concluded *"due to dilution, flushing, adsorption, and sediment deposition, no acute toxicity problems were discovered in the sites studied"* (Metro 1982). Subsequently, USGS and Ecology conducted a survey of pesticides in 13 small streams in the Puget Sound Basin, using data collected between 1987 and 1995 (Bortleson and Davis 1997). Stormwater quality treatment requirements began during this period of time. None of the pesticides detected exceeded existing state or federal freshwater aquatic life criteria. Although no violations of state toxicity standards were found, four pesticides (diazinon, mevinphos, malathion [all insecticides], and diuron [an herbicide]) were found in surface waters at levels exceeding maximum concentrations recommended for the protection of aquatic life (National Academy of Sciences and National Academy of Engineering 1973). As a result, these products came under increasing scrutiny. Although there was no definite conclusion of impact in the Bortleson and Davis (1997) study, it did highlight the importance of minimizing pesticide use as a source control measure.

In a more recent study concluded in 1998, USGS, Ecology, and King County tested 10 streams in King County for pesticides. The streams studied were subject to influence from single family yard maintenance practices that should be applicable to similar land use proposed for Lawson Hills, and the results are indicative of conditions that may exist wherever homeowner discretion in landscape maintenance predominates. Diazinon was the only pesticide shown to be a problem, but this product was found at levels considered toxic to aquatic life in 9 of the 10 streams. In addition to direct toxicity, diazinon inhibits olfactory-mediated alarm responses and homing behavior in salmonids (Scholz *et al.* 2000). Diazinon was used by homeowners to control European cranefly (*Tipula paludosa*) larvae in their lawns. On May 19, 2000, EPA's Office of Pesticide Programs published a Federal Register notice announcing a preliminary human health risk assessment for diazinon, which reclassified this insecticide to "restricted use,"

and all indoor household use retail sales ended in December 2002. Manufacturing of diazinon for all lawn and garden uses ceased in June 2003, and all sales and distribution stopped in August 2003.

Other pesticides have come under scrutiny and are now restricted. On December 31, 2000 Dursban became prohibited for food and crop uses; on December 31, 2001 retail sale of Dursban was prohibited; and Dursban was eliminated from use as a pre- and post-construction control for termites and carpenter ants on December 31, 2005.

3.2.2.6 Fecal Coliforms

Fecal coliforms in stormwater are an inevitable result of development because natural filtering pathways for storm runoff that used to remove them, such as interflow through shallow soils and sheetflow through forest duff and vegetation, are replaced by impervious surfaces and stormwater treatment facilities. Even absent residential pet influences which can be considerable, wildlife including birds are sources of fecal coliforms that collect on roadways and impervious surfaces until storms wash them to and through stormwater facilities. Fecal bacteria densities have been shown to be related to housing density, percent impervious surface, and domestic animal density (Young and Thackston 1999). Fecal coliforms tend to be extremely variable and peak values are immediately responsive to storms, making average stormwater discharge concentrations difficult to predict.

3.2.2.7 Biochemical Oxygen Demand (BOD)

BOD is a measure of the amount of oxygen required for aerobic micro-organisms to oxidize the organic content of water or sediments under the water over a fixed period of time, usually five days (Chapman 1996). This type of metabolism consumes oxygen, and thereby lowers the oxygen content in water. Generally, stormwater runoff from mixed use development carries a very low biochemical oxygen demand, unlike for example runoff from agricultural areas with significant livestock use, or discharge from wastewater treatment plants. Because the alternatives would all comprise various urban mixed uses or residential use, BOD and dissolved oxygen are not included in the quantitative water quality model.

3.2.2.8 Temperature

Urban runoff from summer storms is often thought to be warm because of the influence of impervious surfaces and wet ponds which warm from sunlight and warm air temperatures. However, measurement of air and wet pond temperatures during the summer demonstrates that storm runoff in western Washington rarely coincides with warmer weather. In the Puget Lowlands, most storms and the vast majority of runoff volume occurs during the cooler weather seasons (late fall through early spring). A temperature monitoring study was conducted by A.C. Kindig & Co. at Trossachs, a residential development in the City of Sammamish, Washington in the Puget Lowlands. Continuous gages measured stormwater and air temperatures from May 2000 through September 2000. Temperature gages were installed at inflow to the combined wet detention pond, in the wet pond, at the wet pond outflow (which was inflow to a sand filter), and at the sand filter outflow (A.C. Kindig 2000). An ambient air temperature gage was installed out of direct sunlight at the site. From July through September runoff from summer storms never overcame evaporative losses in the wet pond to cause discharge to occur. From May through September storm runoff entered the wet pond at temperatures consistently below 62 ºF (16.7^{o}C)

due to evaporative cooling, and because of the cooler air temperatures measured during all storms (A.C. Kindig 2000). Water within the wet pond cooled rapidly during all storms, both because of cooler air temperatures and because of mixing with the cooler inflow water. Pond discharge occurred for the first time after several days of rain between September 5th and September 11th. The series of storms that resulted in pond outflow followed periodic storms and cooler weather starting in late August. When pond outflow began, the pond temperature had dropped to about 60 to 61ºF (15.6 to 16.1°C), and continued to drop as the storm and discharge continued. The peak water temperature expected in discharge from wet ponds in late summer is therefore under or around 16 °C. On an average annual basis, discharge would be far cooler.

These discharge temperatures are within the range of water quality standard criteria. Therefore, stormwater discharge temperature from ponds is expected to be well within water quality standards and is not analyzed further.

3.2.3 Water Quality Analysis Methods Summary

The project is analyzed for each of the six stormwater catchments: two for basin A; one each for basins B through D; and the North Triangle Property that would discharge to infiltration from scattered locations. In each catchment, stormwater quality was determined for each of the six major land use categories that are assumed under the redevelopment alternatives: office (which was also used to forecast school runoff), retail or mixed use, single family (both low and medium density), multi-family, arterial roadway, and managed park. All assessments are for built-out conditions assumed by 2015. The stormwater contributions from each category were proportionately mixed based on runoff volumes estimated by pervious/impervious surface ratios for each land use in each catchment. The stormwater assessment includes storm runoff from parking, sidewalks, landscaping, and access roadways associated with each land use category. The main “spine road” connecting SR 169 to Lawson Street was analyzed in a separate “arterial road” category because it is the only project roadway projected by The Transpo Group to have greater than 10,000 average daily trips. All other roadways were proportionately assigned to the different land use categories on an areal basis in each catchment. Pass-through stormwater from off-site areas is not included in this analysis.

Stormwater quality was forecast by the following method:

1. Untreated stormwater runoff quality for each proposed land use category was estimated using data from previous studies at sites with similar land uses to each proposed category.
2. Storm runoff from different land use categories was proportionately mixed on the basis of contributing area as described above.
3. The quality of the combined inflow to each stormwater facility was modified by the expected performance of (1) large wet ponds (for phosphorus treatment[3]) for largely single family residential Basins A, B, and C; (2) basic wet ponds followed by basic sand filters (for phosphorus treatment and enhanced treatment[4]) for the multifamily and mixed use Basin D; and (3) large sand filters (for phosphorus treatment and enhanced

[3] Phosphorus treatment is required by the 2005 Ecology Manual for storm drainage in watersheds determined to have phosphorus sensitive lakes due to a 303(d) listing for phosphorus; in this case Lake Sawyer.

[4] Enhanced treatment is required by the 2005 Ecology Manual for storm drainage to fish-bearing streams from multi-family, commercial / office, and mixed use areas.

treatment) in the commercial/office use North Triangle AND/OR biofiltration followed by basic sand filter treatment.

4. The forecast quality of the treated discharge was directly compared (prior to dilution or mixing) to surface water quality standards (and to ground water quality standards for the North Triangle basin) and to background water quality.

3.2.4 Stormwater Quality Treatment Facilities

3.2.4.1 Bioretention / Biofiltration Swale

Stormwater runoff could be treated by bioretention, biofiltration swale, or filter strip before "standard" sand filter treatment and infiltration in the North Triangle. Bioretention (sometimes referred to as a "rain garden") is a Low Impact Development (LID) type of facility that infiltrates at least 91 percent of the average annual runoff volume through a planted basin containing a specific blend of soils that remove contaminants through sorption, filtration, degradation, and volatilization. Bioretention minimizes storm runoff through evaporation and plant transpiration. Bioretention does use a fairly large amount of space (about 5% of the contributing catchment) but fits well into landscaping and could be employed on the site under the Proposed Action and Alternative 1. These facilities could be constructed with an underlying sand filter that then infiltrates to native soils in the North Triangle. A biofiltration swale is an open, gently sloped, vegetated channel with design features that make it more difficult to employ in dense urban settings. Biofiltration swales treat the same volume of storm runoff by physical filtration, settling of suspended particles and absorbed contaminants, and to a very minor degree, uptake and sorption of nutrients and metals by the vegetation itself during the growing season. A biofiltration swale could convey stormwater to a basic sized sand filter in the North Triangle. Filter strips are a type of biofiltration generally employed to treat runoff generated as sheetflow from any linear feature (such as a roadway) but require a very broad roadway shoulder for adequate treatment, and may not be suitable in dense urban settings for that reason. If utilized, stormwater would have secondary treatment in a basic sand filter on the North Triangle, which could be a linear sand filter trench at the base of the filter strip, and then infiltrated to native soils. Filter strip treatment occurs by sheetflow filtration through a vegetated slope and works by the same principles as biofiltration swales. The length of the biofiltration channel and the width of the filter strip or strips are established by the Ecology 2005 Manual to provide enough distance/time for contaminant removal. Grass-lined swales can be very effective at removing sediments, particle-bound toxicants like metals, and oil and grease from surface runoff. Data in the literature indicate that these types of facilities have similar contaminant removal capabilities except for fecal coliforms, as shown in Table 3-3.

Table 3-3
Bioretention / Biofiltration Swale Contaminant Removal Efficiency (%)

Reference	TSS	Tur-bidity	TP	Ammonia-Nitrogen	NOx	Diss. Lead	Diss. Zinc	Diss. Copper	Fecal Coli-forms	Oil and Grease / TPH
AESI 2000 (Swale filtration)	88		63		91		66		0	
Barrett 1995 (Swale filtration)	74		31		59	35	74	49		88
USEPA 1999 (Swale filtration)	81		9	50	38	67	71	51		62

Reference	TSS	Tur-bidity	TP	Ammonia-Nitrogen	NOx	Diss. Lead	Diss. Zinc	Diss. Copper	Fecal Coli-forms	Oil and Grease / TPH
Goldberg 1993 (Swale filtration)	68		5	16	31	62		42	0	
Metro 1992 (Swale filtration)	83		29		0	67	63	46	0	75
Schueler *et al.* 1991 (Swale filtration)	70		30			50-90	50-90	50-90		
Schueler 1997 (Swale filtration)	81		29		38	14-55	14-55	14-55	0	62
Davis et al. 1998 (Bioretention)	81		29		38	51-71				58
PDGER 1993 (Bioretention)	90								90	
Coffman1998 (Bioretention)			81	79	23	99	99	93		
USEPA 2000 (Bioretention)					15	79	78	48		
Hsieh and Davis 2005 (Bioretention)	91		63	13	0	>98				>97
Winer 2000 (Bioretention)			65			95-97				
(Average) Removal Efficiency Used in this Analysis	80	80(1)	39	40	33	71	71	59	80(2)	74

TSS= total suspended solids; TP=total phosphorus; NOx = nitrate plus nitrite-nitrogen
(1) Turbidity estimated as the same as TSS removal.
(2) Bioretention facilities are assumed the most likely application over filter strips and biofiltration swales for the New Whatcom Project, because they fit more easily into landscaping features. Consequently, the bioretention rate of fecal coliform removal was used in the analysis. The 90% literature value for fecal coliform removal by bioretention was reduced to 80% using professional judgment, because only one datum was available.

3.2.4.2 Wet Ponds

"Large wet ponds" are assumed in all areas of the site dominated by single family residential use (developed Basins A, B, and C) in order to meet the Phosphorus Treatment requirements triggered by Lake Sawyer off-site downstream. Other options could be employed under City code that meet the Phosphorus Treatment requirements of the Ecology 2005 Manual. Basic wet ponds followed by basic sand filters are assumed for stormwater treatment from multifamily and other more intense land uses in Basin D.

Wet vaults are a type of wet pond but are not as effective in removing nitrogen as open wet ponds, because they lack algal uptake which is dependant on sunlight. Otherwise mechanisms of contaminant removal in vaults are similar to those in ponds. Open ponds are assumed in this analysis.[5] The processes that remove contaminants in wet ponds include microbial degradation,

[5] Vaults could be employed to treat and detain runoff from a minor area of frontage improvements on Lawson Street. However, the area would be so small that this area is not significant relative to the arterial and other land use runoff in the same drainage catchment.

volatilization, degradation, and most importantly removal through settling of particulates (Nussbaum 1990). The pond volume also dilutes the first portion of stormwater inflow from each storm with higher quality water treated since the previous storm. Quiescent, or between-storm, settling of particulates and attached contaminants is very effective if the time between storms is a period of days. However, most runoff volume is treated under dynamic conditions during storms while pond inflow and outflow is occurring simultaneously. Overall performance in removing particulates and the dissolved constituents that they attract and bind is a function of hydraulic residence time and dissipation of hydraulic energy, which relates to the amount of time slowly settling small particles have to settle to the pond bottom. The size, shape, and dead water depth in ponds are designed to dissipate hydraulic energy of water passing through the vault or pond to promote settling of particulates, as well as prevent re-suspension of settled material. Efficiency for fine particle removal measured as the percentage of outflow over inflow concentrations is extremely variable from start to finish of a given storm and from storm to storm. Contaminant removal varies with storm intensity, time between storms, and inflow concentrations of contaminants. Recently measured stormwater inflow concentrations in the Puget Lowlands for new master plan developments have been lower than predictions based on studies in the literature would suggest (A.C. Kindig & Co. 2002a and 2003a; AESI 2000c). It is recognized that very dilute or low stormwater constituent inflow concentrations are more difficult to reduce in stormwater facilities than high concentration inflows. Stormwater facility functions are presented in the literature as averaged percent removal efficiencies for individual contaminants based on an assumed average inflow concentration. However, the best measure of performance is treated discharge concentrations of contaminants, since most water quality standards and water quality influence on habitat are concentration-based. Wet pond contaminant removal efficiencies were derived from the literature as shown in Table 3-4.

Table 3-4
Basic and Large Wet Pond Contaminant Removal Efficiencies (%)

Reference	TSS	Turb	TP	Ammonia-Nitrogen	Nitrate +Nitrite-Nitrogen	Dissolved Lead	Dissolved Zinc	Dissolved Copper	Fecal Coliforms	Oil and Grease / TPH
AESI 2000c	73		95				11			
A.C. Kindig & Co. 2003a (wet pond)	25		25-50 (30)		75-95 (83)		20-76 (49)			
Brown and Schueler 1997 (wet pond)	77		47		24	73	51	57	65	83
Comings, Booth, and Horner 1999 (wet pond)	71		33			75	59	42		
Ecology 2005 (wet pond)	80									
King County 1995 (wet pond)	53-86 (70)		43-61 (50)	72	67	25-80 (53)	28-53 (40)			
Herrera 2004 (wet pond)	96		80				81			

Reference	TSS	Turb	TP	Ammonia-Nitrogen	Nitrate +Nitrite-Nitrogen	Dissolved Lead	Dissolved Zinc	Dissolved Copper	Fecal Coliforms	Oil and Grease / TPH
Shapiro 1999 (wet vault) (1)	21-51 (36)		<1-23 (7)	<1-36 (12)(1)	5-28 (17)(1)	2-58 (30)	17-36 (26)	13-13 (13)		
Basic Wet Pond Efficiencies Used in this Analysis	**80(2)**	**80(2)**	**48**	**12**	**17**	**57**	**45**	**37**	**55(3)**	**75(4)**
Large Wet Pond Efficiencies Used in this Analysis	**80(2)**	**80(2)**	**50** (2)	**12**	**17**	**57**	**45**	**37**	**55(3)**	**75(4)**

TSS= total suspended solids; TP=total phosphorus

(1) Wet vault performance for Lakemont facilities in Bellevue, Washington; water passing through the vault only. A wet vault lacks sunlight, which lowers biological uptake performance, particularly for nitrogen compounds, but also to some extent for phosphorus. Vault data for nitrate+nitrite-nitrogen, ammonia-nitrogen, and total phosphorus removal were excluded from this analysis.

(2) Treatment assumed by Ecology based on its research for wet pond design in the 2005 Stormwater Management Manual for Western Washington. Turbidity removal was assumed equal to TSS removal.

(3) Fecal coliforms are not well removed by saturated flow paths, meaning that when inflow and outflow from a vault occur simultaneously, the method of fecal coliform removal is mainly dilution from the stored water volume, wherein fecal coliforms die and diminish between storms. Because the literature datum of 65 percent removal is based on one source and fecal coliform occurrence is highly variable, the value was conservatively lowered to 55 percent based on professional judgment.

(4) Because the 83 percent removal figure for oil and grease is based on one literature reference the predicted removal was conservatively lowered by about 10 percent to a 75 percent removal efficiency, on the basis of professional judgment.

3.2.4.3 Large and Basic Sand Filters

Water quality enhancement in sand filters accrues from filtration, which removes particulates and associated contaminants; adherence (known as sorption) of contaminants to sand particles within the filter; and mineralization, the binding and immobilization of phosphorus to aluminum, iron and calcium in sand (Table 3-5). Turf-capped sand filters reduce clogging because the grass roots facilitate water flow into the sand matrix while the turf traps fines. This occurs even when the grass is dormant. Grass cover is allowed over sand filters; sport-field sod is recommended. Turf covers on sand filters, which work well when sand filters are integrated into landscaping, also simplify and improve the accuracy of visual facility inspections, because areas that infiltrate poorly over time are readily apparent and can be scheduled for maintenance based on inspection of the grass at any time of the year. Lab tests by this reports' author evaluated the clogging potential of sand filters by applying a one time exposure of highly turbid water with 2,000 to 3,500 NTU (Associated Earth Sciences, Inc. unpublished data [AESI 1998b]). Turbidities this high are essentially silt slurry in vast excess of any possible developed runoff condition. All of the sand filters plugs tested were clogged to 10 percent of their initial hydraulic conductivity by this treatment. Turf-covered sand filter plugs recovered to 50 percent within a month, whereas the no-turf control sand filter plug remained at about 10 to 25 percent of its original hydraulic conductivity.

Table 3-5
Basic and Large Sand Filter Contaminant Removal Efficiencies (%) Reported in the Literature

Reference	TSS	Turb [5]	TP	Ammonia-Nitrogen	Nitrate +Nitrite-Nitrogen	Lead	Zinc	Copper	Fecal Coliform	Oil & Grease/ TPH
City of Austin (1990)	87		60	76		80	80	59	36	
Ecology (2005)	80		<50							
Shapiro (1999) [1]	94		69	36	0	64	92 82*	60 27*		
Urbonas (1999) [2]	80-94		50-75				80-90	20-40		
AESI (unpublished 1998b) [3]	75		35				77			
Claytor and Schueler (1996)										85
A.C. Kindig (2000) [4]	80		65	45		60	80	50	35	
Average Removal Efficiency	**84**	**84**	**57**	**52**	**0**	**68**	**83** **82***	**46** **27***	**35**	**85**

* Dissolved metals. TSS = Total suspended solids. Turb = turbidity. TP = total phosphorus

(1) Data for water passing through a sand filter after wet vault treatment, data from 1996-1998.

(2) National review, most common data range for field measured performance.

(3) Data from Trossachs plat Tract R sand filter with grass turf cover, January 1998. Outlet TP concentrations were very low, ranging from 0.008 mg/L to 0.030 mg/L.

(4) Data from Trossachs plat Tract R sand filter with grass turf cover. The sand filter is approximately ½ the "basic" size established by the King County 1998 and 2005 SWDM. Performance monitoring based on composite sampling from January 15 through February 25, 1999. Mean Total Phosphorus inflow was 0.064 mg/L (A.C. Kindig 2000).

(5) Turbidity assumed equal to total suspended solids.

3.2.4.4 Combined Basic Wet Pond and Basic Sand Filter Treatment

To evaluate the combined influence of the basic wet pond and sand filter paired facility proposed for "enhanced" and "phosphorus" water quality treatment in Basin D, performance calculations derived from independent studies on wet ponds (Table 3-4) and sand filters (Table 3-5) were compared to field measures from a combined wet vault and sand filter facility in Lakemont, Washington (Table 3-6). This combined system is a regional facility that serves a mixed use suburban development in the Puget Sound lowlands, and has 3 years of published flow-proportionate field data.

For the calculated contaminant removal efficiency estimate, contaminant removal in the second facility (sand filter) was reduced by 25 percent. This reduction is meant to account for the drop in removal efficiency that typically occurs in the second facility, because inflow concentrations of stormwater constituents are lower as a result of treatment in the first facility. These values are shown in the first column in Table 3-6. The combined efficiency calculations for wet ponds and sand filters in tandem were compared to 3 years of measured data from the Lakemont wet vault plus sand filter system (Shapiro 1999). The match between measured and calculated values

was for most parameters very close. To be conservative, the lowest removal efficiency was used except where noted in Table 3-6.

Table 3-6
Basic Wet Pond Plus Basic Sand Filter Combined Contaminant Removal Efficiencies

Parameter	Calculated Wet Pond and Sand Filter Removal Efficiency (%) (1)	Lakemont (Combined Wet Vault and Sand Filter Facility Direct Measures) Efficiency (%) (2)	Contaminant Removal Used in this Analysis for Basic Wet Pond plus Basic Sand Filter(%)(3)
Total Suspended Solids	93	96	93
Turbidity	93	96	93
Total Phosphorus	70	71	70
Ammonia-Nitrogen	46	44	44
Nitrate+Nitrite-Nitrogen	17	0	17(5)
Dissolved Lead	79	75(4)	75
Dissolved Zinc	79	77	77
Dissolved Copper	50	37	37
Fecal coliforms	67	Not measured	67
Oil and grease / TPH	91	Not measured	91

*Dissolved metals TPH = total petroleum hydrocarbons

(1) Wet pond plus sand filter series, the latter discounted 25 percent. Facility efficiencies for wet vault and sand filter from Tables 3-4 and 3-5.
(2) Data for stormwater passing through the combined wet vault and sand filter at Lakemont (Shapiro 1999).
(3) To be conservative, the lowest value was used except where noted.
(4) Total lead measured for Lakemont Study was converted to dissolved form using Ecology (2004) "translator" value of 0.466.
(5) Vaults do not remove nitrate-nitrogen unlike open wet ponds. The value used in this analysis is the calculated value for wet ponds and sand filters.

3.2.4.5 Combined Biofiltration and Basic Sand Filter Treatment

Combined biofiltration and basic sand filter treatment is one possibility for stormwater treatment in the North Triangle, the other being large sand filter treatment. Unlike combined wet ponds and sand filters, no data for these two paired facilities is known to have been measured at any working facility. Because the calculated values shown in Table 3-6 appear so close to measured facility performance, the same method was used to estimate combined biofiltration and sand filter performance in Table 3-7.

Table 3-7
Biofiltration Plus Basic Sand Filter Combined Efficiencies

Parameter	Calculated Biofiltration and Sand Filter Removal Efficiency (%) (1)
Total Suspended Solids	93
Turbidity	93
Total Phosphorus	65

Parameter	Calculated Biofiltration and Sand Filter Removal Efficiency (%) (1)
Ammonia-Nitrogen	63
Nitrate+Nitrite-Nitrogen	33
Dissolved Lead	86
Dissolved Zinc	89
Dissolved Copper	67
Fecal coliforms	85
Oil and grease / TPH	91

TPH = total petroleum hydrocarbons

3.2.4.6 Stormwater Facility Maintenance

Maintenance for all facility types is specified in the Ecology 2005 Manual. Maintenance procedures are briefly summarized below.

Biofiltration Systems

To be effective, water quality facilities must be maintained. Bioretention / biofiltration swale /filter strip maintenance measures include mowing to the design height (for the bioswale and filter strip), vegetation maintenance, sediment and debris removal, repair of eroded or scoured sections by re-grading, and replanting or reseeding as warranted. Accumulations of noxious or nuisance vegetation (morning glory, English Ivy, reed canary grass, Japanese knotweed, purple loosestrife, blackberry, Scotch broom, tansy, poison oak, stinging nettles, devils club) or visible oil, gas, or other contaminants should be removed. Obstructions should be removed to maintain proper water flow through the swale.

Wet Pond Systems

Wet pond maintenance measures include the following:

1. The pond or vault should be inspected annually and floating debris and accumulated petroleum products should be removed as needed and at least annually;
2. Sediment should be removed when sediments accumulate to 18 inches (one foot of intentional sediment storage allowance plus an additional 6 inches). Sediment should be tested for toxicants in compliance with local disposal requirements if land uses in the catchment include commercial or industrial zones; otherwise disposal to any approved offsite location for the purpose is allowed;
3. Water drained or pumped from ponds or vaults prior to sediment removal usually can be discharged to storm drains if it is not excessively turbid and if floatable debris and visual petroleum sheens are removed;
4. For ponds, drain lines, berms and sideslopes, and outlets should be checked for proper operation and repaired as needed; and
5. For vaults, drain lines, oil absorbent pads, baffles, inlet grates, outlet control structures, air vents, and access ladders should be checked for proper operation and repaired as needed.

Sand Filter Systems
Sand filter maintenance requirements include the following:

1. Inspections of sand filters should be conducted every 6 months and after storms as needed during the first year of operation, and annually thereafter if the filter performs as designed; and
2. Removal of accumulated silt and debris on top of the sand filter when their depth exceeds ½ inch.

In landscaping settings with turf covered filters, leaves, lawn clippings and accumulating debris should be removed; the turf should be provided with adequate sunlight exposure; fertilizers containing phosphorus should be avoided; and herbicides should not be used.

3.2.5 Water Quality Analysis Model

Untreated stormwater quality was forecast for each of the six stormwater catchments described above for the Action Alternative and Alternative 1. The types of land uses proposed under the alternatives were placed into 6 categories, each of which would generate a different quality of stormwater (Table 3-8). The stormwater quality predicted for each land use category was based on site-measured and/or data from the literature as described below. The data used to derive runoff quality all come from sites with exposed parking and associated roadway influences, which are the greatest source of stormwater contaminants. Rooftop runoff and landscaping associated with each category of land use are also included in the measurements described below.

Table 3-8
Land Use Categories and Sources of Untreated Stormwater Data for the Water Quality Assessment

Land Use Category	Included in Alternatives	Land Use Description and Source of Untreated Water Quality Data
Single Family Residential (Low to Medium Density)	Proposed Action and Alternative 1	**Single Family Residential** use is single family residential structures, landscaping, and associated access roadways. Single-family untreated runoff quality was forecast using residential runoff literature data from housing densities at Snoqualmie Ridge in Snoqualmie, Washington in the approximate range of 5.5 to 7 DU/acre, including associated roadways and plat infrastructure (A.C. Kindig & Co. 2002b, 2003c).
Multi-Family (High Density)	Proposed Action and Alternative 1	**Multi-Family Residential** includes multifamily structures 1 or more stories, including associated access roads, parking, and landscaping. Untreated runoff quality was estimated using data for townhomes with a mean density of 13 to 14 DU/acre at the Snoqualmie Ridge project in Snoqualmie, Washington (A.C. Kindig & Co. 2002a); TPH was conservatively (likely over-) estimated from industrial use employee and visitor parking areas in Bellingham because these data were not otherwise available (A.C. Kindig & Co. 2007). Fecal coliforms were taken from the geometric mean from the Segale Business Park (A.C. Kindig & Co. 2005a) under the assumption that measures would be taken to properly dispose of pet waste.

Land Use Category	Included in Alternatives	Land Use Description and Source of Untreated Water Quality Data
Mixed Use	Proposed Action and Alternative 1	**Mixed Use** includes small and midsize neighborhood retail services, restaurants, and associated access roadway surfaces, parking, and landscaping. Untreated runoff quality data were used from the Pine Lake Shopping Center in Sammamish, Washington (TP and turbidity) (King County 1993); the Kirkland Office Park in Kirkland, Washington (dissolved metals and total suspended solids) (AESI 1998a). These data are considered conservative because they do not include roof contributions that tend to dilute storm measurements as the other literature sources do. Parameters not measured in these studies were estimated from other sources: retail stores and restaurants in Marquette, Michigan ((dissolved lead, ammonia, and nitrate-nitrogen) (Steuer *et al.* 1997); fecal coliforms using the geometric mean from impervious surfaces and TPH conservatively from industrial use measured from the Segale Business Park (A.C. Kindig & Co. 2005a), on-site; and oil and grease from a Tampa, Florida office park (Southwest Florida management District 1995). *NOTE: Some limited areas of retail parking may require additional oil control where/if more than 100 vehicles per 1,000 square feet of gross building area could occur. Oil control options include API or coalescing plate oil/water separators, catch basin inserts, or linear sand filters. The need for added oil control would be determined at final design. The analysis assumes these limited areas, if any, would generate stormwater quality after oil control treatment as described below for untreated retail (mixed use) stormwater, prior to entering the other stormwater treatment systems that are described.*
Commercial /Office	Proposed Action and Alternative 1	**Commercial/Office** includes offices, research facilities, professional services, schools, related shipping and receiving, and associated landscaping, pedestrian, parking (including structured parking), and access roadway surfaces. Untreated runoff quality was forecast using stormwater data from the literature for the Eastgate business park in Bellevue, Washington for most parameters (Comings, Booth, and Horner 1999), and a Tampa, Florida business park for nitrogen compounds and oil and grease, which were not measured at Eastgate (Southwest Florida management District 1995). Fecal coliforms were based on the geometric mean measured at the Segale Business Park, a light industrial office park in Tukwila, Washington (A.C. Kindig & Co. 2005a). TPH was conservatively based on industrial use measures from a North Bay, Seattle site (A.C. Kindig & Co. 2005b).

Land Use Category	Included in Alternatives	Land Use Description and Source of Untreated Water Quality Data
Arterial Road	Proposed Action and Alternative 1	**Arterial** The "Spine Road" through Basin D between SR 169 and Lawson Street would have an estimated Average Daily Trip (ADT) count from 10,720 to 12,520. Roadways over 10,000 ADT are separately modeled from other land uses. Roadways under 10,000 ADT are proportionately combined with the other land uses. Data were used from Lake Washington Blvd. in Renton, Washington. This road has an ADT of approximately 21,000, or double that estimated for the Lawson Spine Road, but the land use in the vicinity of Lake Washington Blvd. is comparable in intensity to that in the vicinity of the site once developed. Lake Washington Boulevard data were collected during a first flush storm on August 18th 2000 (AESI 2001). The fecal coliform concentration measured at the time of sample collection (14,000 cfu/100 mL) was much greater than data in other literature sources, so much so that this datum appeared to be a non-representative outlier. Stormwater runoff sampled on the same date from I-405 in Renton (where the ADT is 136,000) had a first flush fecal coliform concentration of 6,000 cfu/100 mL, which was less than half that measured from Lake Washington Blvd., confirming the value as an outlier. Fecal coliform concentration reported for an urban arterial roadway in Michigan with an ADT of 10,600 was substituted in this analysis (Steuer et al. 1997). *NOTE: Improvements to Lawson Street frontage and/or entrance to the project are expected to be large enough to require stormwater treatment for the added area, although specific requirements are unknown at this time. Runoff from this area would be treated if required using an enhanced and phosphorus treatment and flow control facility. The area would be small relative to other arterial roads and is not itemized separately in this analysis. Treated water quality would be the same as described for arterial roads.*
Parks	Proposed Action and Alternative 1	**Parks** All developed open areas not comprised of sensitive areas or their buffers are conservatively assumed to be managed parks in this analysis. Untreated runoff quality for these areas is assumed to be influenced by landscaping management. Park untreated runoff quality was forecast using golf course and background water quality data from the site as follows: Runoff from managed golf course was measured at Snoqualmie Ridge in King County for dissolved zinc, nitrate-nitrogen, TP, TSS, and turbidity (AESI 2000c); ammonia nitrogen was measured from a managed golf course at Trilogy in King County (A.C. Kindig 2003b); and dissolved lead and copper, oil and grease, total petroleum hydrocarbons, and fecal coliforms were assumed equal to background values measured on the site at the upper Lawson Creek station.

Untreated water quality for each of the land use categories is summarized in Table 3-9. The sources of data in Table 3-9 are listed in Table 3-8.

Table 3-9
Untreated Water Quality for Each Land Use Category

Parameter	Units	Single Family Resid.	Multi-Family Resid.	Mixed Use	Comm. / Office / School	Arterial	Parks
Dissolved Copper	µg/L	2.4	0.5	1.6	1.4	7.0	0.5
Dissolved Zinc	µg/L	4.7	32	16	33	36	2.3
Dissolved Lead	µg/L	0.22	0.03	2.1	1.2	1.5	0.5
Total Ammonia-N	mg/L	0.02	0.003	0.19	0.12	0.55	0.13
Nitrate + Nitrite-N	mg/L	0.45	0.12	0.30	0.45	0.39	0.07
Total Phosphorus	mg/L	0.075	0.040	0.160	0.170	0.170	0.200
Turbidity *(NTU=nephalometric turbidity units)*	NTU	4.1	10	24	20	33	1.7
Total Suspended Solids	mg/L	40	1	27	16	42	4.8
Fecal Coliforms *(CFU = colony forming units)*	CFU/100 mL	67	250	250	250	280	6
Total Petroleum Hydrocarbons	mg/L	0.57 (a)	0.57	0.57	0.57	2.0	0.5
Oil and Grease	mg/L	0.7	0.8	3.2	3.2	2.0	1.5

(a) not measured, but value is conservatively assumed equal to other more intense land uses.

The types and amounts of land use under the various alternatives within each of the six outfall catchments were defined by the Dahlin Group and Triad Associates within each catchment on the site at buildout in 2015. Storm runoff in each catchment was proportionately distributed from each land use category. The runoff was proportioned using tables showing pervious and impervious surface breakdowns for each land use category and runoff estimates per acre pervious and impervious surface for the 2-year peak return flow provided by Triad Associates. The weighting of impervious to pervious surface runoff was 1.00 to 0.23. The proportionate contributions of each land use category to storm runoff are shown in Table 3-10.

Table 3-10
Proportionate Contribution of Land Use Categories to Storm Runoff in Each Catchment
(Rounded to nearest whole %, including sidewalks, roadway access, and landscaping allocations to each land use category)

Alternative	Catch-ment	Single Family Resid.	Multi-Family Resid.	Mixed Use	Comm. / Office / School	Arterial	Parks
Proposed Action	A North	88%	0%	2%	0%	0%	10%
	A South	84%	10%	0%	0%	0%	6%
	B	42%	0%	0%	28%	0%	30%
	C	88%	11%	0%	0%	0%	1%
	D	18%	13%	37%	0%	26%	6%
	North Triangle	0%	0%	67%	33%	0%	0%
Alternative 1	A North	72%	12%	2%	0%	0%	14%
	A South	77%	11%	0%	0%	0%	12%
	B	10%	32%	0%	27%	0%	31%
	C	88%	11%	0%	0%	0%	1%
	D	18%	13%	37%	0%	26%	6%
	North Triangle	0%	0%	20%	80%	0%	0%

NOTE: The Table 3-10 percentages are runoff-based, not acreage-based.

3.2.6 Water Quality Forecast Under the Proposed Action and Alternative 1

Using the methods described above, treated storm water quality was quantitatively estimated for the Proposed Action and Alternative 1 at buildout in 2015 (Tables 3-11 through 3-28). The results for each discharge location are compared to state standards (WAC 173A-201A) and to existing condition data for the receiving waters (described in Section 2 of this report). In addition, the cumulative impacts of multiple project discharges on Ginder Creek, Jones Lake, and Rock Creek are conservatively estimated by volume-proportionate combinations of the discharges that would influence each receiving water (for example, combining the Basin C and Basin D discharges as if they were one discharge to Ginder Creek, even through Basin C discharges to a tributary to Ginder Creek).

3.2.6.1 Individual Discharge Impacts to Receiving Waters for the Proposed Action

Quantitative forecasts for water quality in each stormwater discharge to each receiving water (before any dilution or mixing) are listed in Tables 3-11 through 3-16. After treatment for water quality all stormwater discharges to all receiving waters would comply with water quality standards prior to any mixing or dilution, with some possible exceptions for fecal coliforms as discussed below. Most discharge parameters would be less than or near background water quality averages for the receiving waters for most of the stormwater outlets, except for fecal coliforms and total phosphorus which would have higher concentrations in most discharges. Slight increases in total phosphorus would have no adverse impact on Lawson Creek, Ginder Creek, Unnamed Creek, or Rock Creek downstream. Impacts of increased phosphorus loading on Jones Lake and Lake Sawyer are evaluated below (see “Total Phosphorus Loading and Lake Impacts”). Some increases in stormwater parameter concentrations over background averages are an inevitable and predicted outcome as shown in the quantitative results tables; however none of the parameters are reasonably expected to rise to levels that would degrade habitat or reduce beneficial uses of the receiving waters as a result of the Proposed Action, based on the forecast data. Please refer to the quantitative forecast tables for specific parameter forecasts for individual receiving waters and comparison to background and water quality standards.

3.2.6.2 Combined Discharge Impacts to Receiving Waters for the Proposed Action

Forecasts for volume-proportionate combinations of multiple discharges to or eventually reaching Rock Creek, Jones Lake, and Ginder Creek offsite are listed in Tables 3-17 through 3-19. Unlike the individual discharge impact assessments described immediately above, these forecasts are abstractions. Individual discharges contributing to each off-site receiving water’s watershed are volume-proportionately combined and assessed as though they were one discharge, in order to evaluate potential cumulative impacts on reach downstream water body.

- Individual project discharges to Lawson Creek and Unnamed Creek (and its tributary) are in the Jones Lake contributing watershed (Table 3-18).
- Individual project discharges to Mud Lake and Ginder Creek are in the Ginder Creek contributing watershed (Table 3-19).
- All individual project discharges except those in the North Triangle are in the Rock Creek watershed (Table 3-17).
- All individual project discharges are in the Lake Sawyer watershed (see Section 3.2.6.4).

The results show that all water quality parameters from combined discharges in each receiving water watershed are forecast to be well within water quality standards intended to be protective of all beneficial uses, including fish and wildlife. Many parameters are forecast near or below average background concentrations. Please refer to Section 2.3.6.3 below for specific discussion of fecal coliforms for individual and combined discharges. Please refer to Section 2.3.6.4 for specific discussion of phosphorus loading impacts to Jones Lake and Lake Sawyer from the combined discharges.

Table 3-11
Basin A Discharges to Upper and Lower Lawson Creek – Proposed Action

Parameter	Units	Discharge Water Quality		Background Water Quality (avg)		Water Quality Standards	
		Basin A-North	Basin A-South	Upper Lawson	Lower Lawson	Upper Lawson	Lower Lawson
Dissolved Copper	µg/L	1	1	<1	1	2	3
Dissolved Zinc	µg/L	3	4	2	5	22	31
Dissolved Lead	µg/L	0.1	0.1	<1	<1	0.3	0.5
Total Ammonia-N	mg/L	0.030	0.022	<0.005	0.023	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.34	0.33	1.14	1.26	n/a	n/a
Total Phosphorus	mg/L	0.044	0.040	0.014	0.030	n/a	n/a
Turbidity	NTU	0.9	0.9	10.7	19.2	<5 over background	<5 over background
TSS	mg/L	7.3	6.8	3.0	11.3	n/a	n/a
Fecal Coliforms	CFU/100 mL	29	36	6	33	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	0.1	1.2	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	0.2	1.5	1.0	no sheen	no sheen

Table 3-12
Basin A Discharges to Unnamed Creek near Jones Lake – Proposed Action

Parameter	Units	Discharge Water Quality		Background Water Quality (avg)		Water Quality Standards	
		Basin A-North	Basin A-South	Unnamed Ck. Station S	Unnamed Ck. Station SE	Unnamed Ck. Station S	Unnamed Ck. Station SE
Dissolved Copper	µg/L	1	1	<1	<1	21	9
Dissolved Zinc	µg/L	3	4	2	<1	195	86
Dissolved Lead	µg/L	0.1	0.1	2.0	1.0	5.6	2.0
Total Ammonia-N	mg/L	0.030	0.022	0.008	0.010	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.34	0.33	0.17	3.20	n/a	n/a
Total Phosphorus	mg/L	0.044	0.040	0.009	0.015	n/a	n/a
Turbidity	NTU	0.9	0.9	5.7	2.1	<5 over background	<5 over background
TSS	mg/L	7.3	6.8	3.0	3.0	n/a	n/a
Fecal Coliforms	CFU/100 mL	29	36	<2	<1	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	0.1	0.6	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	0.2	1.1	1.4	no sheen	no sheen

Table 3-13
Basin C Discharge to an Onsite Tributary to Unnamed Creek – Proposed Action

Parameter	Units	Discharge Water Quality	Background Water Quality	Water Quality Standards
		Basin C	**Station SE-2** *(see Table 2-11)*	**Station SE-2**
Dissolved Copper	µg/L	1	1	1
Dissolved Zinc	µg/L	4	1	8
Dissolved Lead	µg/L	0.1	1.0	0.1
Total Ammonia-N	mg/L	0.017	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.34	0.35	n/a
Total Phosphorus	mg/L	0.037	0.042	n/a
Turbidity	NTU	0.9	21.5	<5 over background
TSS	mg/L	7.1	22.0	n/a
Fecal Coliforms	CFU/100 mL	39	<1	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

Table 3-14
Basin B Discharge to a Tributary to Mud Lake – Proposed Action

Parameter	Units	Discharge Water Quality	Background Water Quality	Water Quality Standards
		Basin b	**Station NE-2** *(see Table 2-6)*	**Station NE-2**
Dissolved Copper	µg/L	1	1	1
Dissolved Zinc	µg/L	4	1	8
Dissolved Lead	µg/L	0.1	1.0	0.1
Total Ammonia-N	mg/L	0.017	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.34	0.35	n/a
Total Phosphorus	mg/L	0.037	0.042	n/a
Turbidity	NTU	0.9	21.5	<5 over background
TSS	mg/L	7.1	22.0	n/a
Fecal Coliforms	CFU/100 mL	39	<1	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

Table 3-15
Basin D Discharge to Ginder Creek – Proposed Action

Parameter	Units	Discharge Water Quality	Background Water Quality (average)		Water Quality Standards	
		Basin D	Ginder Ck. Station G	Ginder Ck. Station GE	Ginder Ck. Station G	Ginder Ck. Station GE
Dissolved Copper	µg/L	2	<1	<1	11	12
Dissolved Zinc	µg/L	5	<1	<1	97	113
Dissolved Lead	µg/L	0.3	1.0	1.0	2.3	2.8
Total Ammonia-N	mg/L	0.125	0.029	0.030	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.19	0.12	1.50	n/a	n/a
Total Phosphorus	mg/L	0.036	0.018	0.011	n/a	n/a
Turbidity	NTU	1.3	3.2	1.8	<5 over background	<5 over background
TSS	mg/L	1.5	<1	<1	n/a	n/a
Fecal Coliforms	CFU/100 mL	65	10	4	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	<1	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	1.5	1.6	no sheen	no sheen

Table 3-16
North Triangle Infiltration to Shallow Aquifer – Proposed Action
(Compared to Ravensdale Creek which derives Base Flow from the Shallow Aquifer)

Parameter	Units	Large Sand Filter Treatment Option	Biofiltration & Basic Sand Filter Treatment Option	Background Water Quality in Ravensdale Ck. (average)	Water Quality Standard for Ravensdale Ck.
		North Triangle	North Triangle		
Dissolved Copper	µg/L	1	1	<1	5
Dissolved Zinc	µg/L	5	3	7	50
Dissolved Lead	µg/L	0.4	0.2	<1	1.0
Total Ammonia-N	mg/L	0.064	0.050	0.018	2.300
Nitrate + Nitrite-N	mg/L	0.42	0.28	0.80	n/a
Total Phosphorus	mg/L	0.072	0.059	0.012	n/a
Turbidity	NTU	3.3	1.5	1.4	<5 over background
TSS	mg/L	2.9	1.3	2.1	n/a
Fecal Coliforms	CFU/100 mL	163	38	1	<50 geometric mean
TPH	mg/L	0.1	0.1	<1	no sheen
Oil and Grease	mg/L	0.5	0.3	2.1	no sheen

Table 3-17
Combined Discharges to Rock Creek – Proposed Action

Parameter	Units	Combined Discharge Water Quality	Background Water Quality in Rock Creek (average)	Water Quality Standards for Rock Creek
		Basins A-N, A-S, B, C, D		
Dissolved Copper	µg/L	1	1	8
Dissolved Zinc	µg/L	4	2	74
Dissolved Lead	µg/L	0.2	<1	1.6
Total Ammonia-N	mg/L	0.046	0.047	2.300
Nitrate + Nitrite-N	mg/L	0.31	0.45	n/a
Total Phosphorus	mg/L	0.044	0.021	n/a
Turbidity	NTU	1.0	3.3	<5 over background
TSS	mg/L	5.9	2.0	n/a
Fecal Coliforms	CFU/100 mL	40	15	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

Table 3-18
Combined Discharges to Jones Lake – Proposed Action

Parameter	Units	Combined Discharge Water Quality	Background Water Quality in Jones Lake (average)	Water Quality Standards for Jones Lake
		Basins A-N, A-S, C		
Dissolved Copper	µg/L	1	<1	5
Dissolved Zinc	µg/L	3	1	47
Dissolved Lead	µg/L	0.1	0.3	0.9
Total Ammonia-N	mg/L	0.025	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.33	0.51	n/a
Total Phosphorus	mg/L	0.041	0.033	n/a
Turbidity	NTU	0.9	2.0	<5 over background
TSS	mg/L	7.0	2.0	n/a
Fecal Coliforms	CFU/100 mL	34	4	<50 geometric mean
TPH	mg/L	0.1	nm	no sheen
Oil and Grease	mg/L	0.2	<0.2	no sheen

nm = not measured

Table 3-19
Combined Discharges to Ginder Creek – Proposed Action

Parameter	Units	Combined Discharge Water Quality Basins B & D	Background Water Quality in Ginder Creek	Water Quality Standards for Ginder Creek
Dissolved Copper	µg/L	1	<1	11
Dissolved Zinc	µg/L	5	<1	97
Dissolved Lead	µg/L	0.3	1.0	2.3
Total Ammonia-N	mg/L	0.101	0.029	2.300
Nitrate + Nitrite-N	mg/L	0.23	0.12	n/a
Total Phosphorus	mg/L	0.051	0.018	n/a
Turbidity	NTU	1.4	3.2	<5 over background
TSS	mg/L	2.8	<1	n/a
Fecal Coliforms	CFU/100 mL	56	10	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.3	1.5	no sheen

3.2.6.3 Fecal Coliforms

Fecal coliforms are not expected to violate state water quality standards in discharge to Ginder Creek (via individual or combined surface discharges), although their concentrations will rise during storms. Fecal coliform peaks could be above water quality standard allowance in infiltrated discharge reaching Ravensdale Creek before any mixing and dilution under the large sand filter treatment option. Combined biofiltration swales and basic sand filter treatment would lower fecal coliforms to well within surface water standard compliance. The indirect discharge to Ravensdale Creek occurs only by infiltration on site in the North Triangle. As described earlier in this report, the outwash material conveying the infiltrated discharge as groundwater to Ravensdale Creek is coarse, so to be conservative the assessment evaluates this stormwater as if it were a direct surface discharge without attenuation by filtration in soils.

Fecal coliforms originate from wildlife, including bird droppings, and thus occur wherever storm runoff is generated from impervious surfaces. Pet waste exacerbates fecal coliform concentrations when it is left to run off with stormwater in residential areas. In commercial and retail areas, fecal coliforms increase in response to added impervious surfaces which collect fecal matter from birds and other wildlife to be washed off during storms. Fecal coliforms tend to peak erratically and are therefore very difficult to model and predict. Water quality compliance is determined by calculation of a geometric mean over many storms to account for this variability; therefore the predicted results may occur from time to time, but are not expected during all storms or for the full duration of any storm. Even though Ginder Creek discharge peaks above the geometric mean standard may occur, as long as the peaks are 100 CFU/100 mL or less (see Table 2-1) they would not cause a violation of water quality standards unless they occurred over extended periods, which is unlikely. Peak concentrations are expected to be about 65 CFU/100 mL (see Table 3-15) which are well below the 100 CFU/100 mL maximum peak under state standards. Combined discharges to Ginder Creek would have a peak concentration of about 56 CFU/100 mL. Although dilution is not required to reasonably comply with water quality standards, the amount of dilution that would bring the expected peak concentration down to the geometric mean standard was calculated. At the peak short-term concentration for the individual discharge, mixing of less than 1 part discharge flow to 0.38 parts Ginder Creek flow would lower fecal coliforms to the state geometric mean standard. No impairment of beneficial uses due to fecal coliforms in stormwater runoff is reasonably expected to Ginder Creek under the Proposed Action from individual or combined discharges.

For Ravensdale Creek, peaks of up to 163 CFU/100 mL are forecast under the large sand filter treatment option (see Table 3-16), which would be a violation of water quality standard peak allowance regardless of the calculated geometric mean. Use of the biofiltration swales and basic sand filter option would reduce peaks to less than the geometric mean maximum, which should ensure compliance with state standards. Fecal coliforms are difficult to remove because they readily pass through all saturated flow systems and are small enough for some to pass through filtration-based systems including sand filters. Nonetheless, past measurements indicate the more extended treatment flow path through a biofiltration swale and basic sand filter would remove more fecal coliforms than a large sand filter alone. If biofiltration swales and basic sand filters are employed in the North Triangle, no impairment of beneficial uses (including primary contact recreation) due to fecal coliforms in stormwater runoff is reasonably expected to Ravensdale Creek or in Lake Sawyer downstream.

Infiltration of North Triangle stormwater after treatment would meet all groundwater quality standards (Table 2-2) with the exception of fecal coliforms, for which the standard is 1 CFU/ 100 mL. Natural surface runoff that infiltrates would not meet this standard under any circumstances, but groundwater moving through fine material or moving slowly (because of low hydraulic gradients in the aquifer) tend to filter out coliforms or they die through attrition because of the time durations of groundwater flow. In the case of the North Triangle, there are no wells between the site and Ravensdale Creek where all groundwater from the site would be discharged as surface flow. Consequently fecal coliforms in stormwater would have no adverse effect on beneficial use of groundwater over the short flowpath between the site and Ravensdale Creek.

3.2.6.4 Total Phosphorus Loading to Jones Lake and Lake Sawyer – Proposed Action

Jones Lake
Existing conditions in Jones Lake are described in Section 2.3.4 of this report. King County last assessed the lake as being at the mesotrophic-eutrophic boundary. Ecology considered the same data to classify Jones Lake as Category 2 for total phosphorus. At the Category 2 level (on a scale of 1 meaning no concerns and 5 requiring an 'impaired' 303(d) listing and further action) Ecology is not required to set lake specific criteria or investigate further if existing water quality conditions naturally have a high or variable total phosphorus and whether beneficial uses are being lost or degraded (Chapter 173-201A-230 WAC). Since Jones Lake is a "wetland character" lake with no current public access points, it is reasonably concluded the conditions are natural and existing beneficial uses for fish and wildlife are being maintained. The background range of total phosphorus in Jones Lake varies between 0.017 and 0.086 mg/L based on data collected by King County.

Lake Sawyer
Existing conditions in Lake Sawyer are described in Section 2.3.2.7 of this report. The lake has generally good water quality, but has elevated phosphorus concentrations due to historic discharge of treated sewage and effluent from septic tanks and drainfields in the lake's watershed. In 1992, all effluent discharge was eliminated from Rock Creek by transfer to a new interceptor line to the regional Metro secondary treatment facility in Renton. This transfer was the basis for the Lake Sawyer TMDL approved in 1993 by EPA. That TMDL set a maximum mean summer total phosphorus concentration limit of 16 µg/L in Lake Sawyer in order to deter progression of eutrophication. Ecology has monitored for effectiveness of the TMDL measures since that time, and determined that short term noncompliance for the total phosphorus maximum limit may be occurring; however Ecology concluded *"Lake Sawyer seems to be meeting the TMDL target limit as a long term average"* (Ecology 2002). There are periods in the data record from 1998 to 2000 when summer total phosphorus objectives are met, which may mean progressive improvement in total phosphorus reduction is occurring over time. The mean concentration in total phosphorus from all years for which data are collected are at or below the TMDL target limit, but Ecology concludes more data are needed over a longer period to determine if an improvement trend has manifest. King County found that weather differences from year to year impose a great deal of natural variability in lake phosphorus conditions.

In order to determine how future growth in the Lake Sawyer basin could co-exist with the TMDL objectives for phosphorus limitations in Lake Sawyer, King County completed the Lake Sawyer Management Plan in 2000 (King County 2000). The Lake Sawyer Management Plan included a mass-balance numeric model calibrated to phosphorus measured in the lake. That model was used to predict the outcome of converting rural and forest to urban areas at build out in the

Black Diamond urban growth area over 30 years, and determine the effectiveness of phosphorus loading control strategies and in-lake control measures.

The lake response model determined controls necessary to allow growth in the future and still maintain mesotrophic conditions through 2030. Assuming internal sediment loading in Lake Sawyer does not change, the model predicted that future building could be accommodated and phosphorus loading increases limited to 36 percent if all recommended control were implemented. The controls most relevant to discharges of stormwater in the watershed by the Lawson Hills Project are summarized and project compliance with those objectives are evaluated as follows:

- *LS-1 Stormwater Controls*.
  The City of Black Diamond should adopt more stringent phosphorus control measures consistent with the 1998 King County Surface Water Design Manual (i.e., lake protection standards for stormwater runoff at 50 percent phosphorus removal; and temporary erosion and sediment control standards for construction including wet season specific measures).
    - The Lawson Hills Project would comply by using the phosphorus treatment menu in the 2005 Ecology Manual which is expected to achieve 50 percent phosphorus removal. The 2005 Ecology Manual is more recent and generally superior to the 1998 King County Surface Water Design Manual for stormwater mitigation.
    - The Lawson Hills Project would comply by employing Low Impact Development practices to reduce stormwater runoff where soils and conditions are feasible, and by infiltrating stormwater after treatment where infiltrative soils occur, both of which would tend to reduce total phosphorus further.
    - The Lawson Hills Project would employ temporary erosion and sediment control standards from the 2005 Ecology Manual as indicated in Section 3.1 of this report.
- *LS-2 Forest Retention/Conservation* (i.e., open-space dedication with preservation of native vegetation).
    - The Lawson Hills Project would preserve native vegetation open areas on about 23 percent of the site under the Proposed Action and about 28 percent under Alternative 1.
    - Under the Black Diamond TDR Program, about 50 acres south of the Main Property would be preserved as forestland with development rights transferred onto the Main Property.
    - Under the Black Diamond Area Open Space Agreement, about 55 acres would be preserved in native growth as visual buffer and trail corridor.
- *LS-3 Native Growth Protection Easements (NGPE) and Sensitive Area Ordinance (SAO) Buffer Enhancements* (i.e., cluster developments to enhance protection of sensitive areas such as stream corridors and wetlands).
    - The Lawson Hills Project would establish NGPEs on sensitive areas and their buffers, and cluster development under the MPD to enhance sensitive area protection.
- *LS-6 Homeowner Best Management Practices* (i.e., education on minimal use of fertilizers and lawns; alternative cultural practices to chemicals for landscaping and pest control; and best practices for detergents and other products containing phosphorus).
    - The Lawson Hills Project or its builders could provide this information to homeowners at the time of sale.

- *LS-10 Regional Stormwater and Phosphorus Control for Rock Creek and Ginder Creek* (i.e., regional ponds for existing or future development meeting lake protection standard criteria).
    - The Lawson Hills Project proposes wet detention ponds meeting the phosphorus (lake protection) treatment menu requirements in the 2005 Ecology Manual for all discharges to Lawson Creek, Mud Lake, Ginder Creek, and Unnamed Creek, and facilities meeting phosphorus treatment menu requirements before infiltrating stormwater in the North Triangle.

The Lawson Hills action alternatives would fully comply with measures identified by King County's modeling for Lake Sawyer protection. While phosphorus loading increases are expected with future development, including Lawson Hills, the source control and phosphorus removal measures proposed would maintain those increases to levels the Lake Sawyer Management Plan expects to maintain the current lake condition and beneficial uses.

3.2.6.5 Individual Discharge Impacts to Receiving Waters for Alternative 1

Under Alternative 1 the individual discharges (Tables 3-20 through 3-25) are forecast to have very similar water quality characteristics as under the Proposed Action described above in Section 3.2.6.1. All parameters are expected to be within state water quality standards except for fecal coliform peaks under the large sand filter treatment option for the North Triangle. As with the Proposed Action, if the biofiltration swale and basic sand filter option is employed for North Triangle stormwater then fecal coliforms are reasonably expected to meet water quality standards at recharge to Ravensdale Creek. Fecal coliforms in discharge to Mud Lake would be slightly higher than under the Proposed Action, but neither the short term peaks nor long term geometric means are reasonably expected to be higher than state water quality standards (see the prior discussion on fecal coliforms in stormwater in Section 3.2.6.3).

Storm water quality treatment under Alternative 1 is expected to protect all beneficial uses of the receiving waters.

3.2.6.6 Combined Discharge Impacts to Receiving Waters for Alternative 1

Under Alternative 1 the combined discharges (Tables 3-26 through 3-28) are forecast to be very similar in water quality characteristics as under the Proposed Action described above in Section 3.2.6.2. The conclusions remain the same as for the Proposed Action, which is that all beneficial uses of the receiving waters will be protected. This includes phosphorus protection for Lake Sawyer, as described above in Section 3.2.6.4.

3.2.7 Water Quality under No Action Alternative 2

We assume that development under the No Action Alternative 2 would occur in conformance with the 2005 Ecology Manual as for the two action alternatives. Even under this assumption, greater water quality impacts are likely to occur under Alternative 2 relative to the Proposed Action and Alternative 1 for several reasons. First, Alternative 2 would have the least open space of any of the alternatives, which would reduce the water quality benefits of preserving natural drainage pathways, preserving natural recharge to summer baseflows, and undisturbed native vegetation. Second, Alternative 2 would have more retail and much more office/light industrial development than either of the two action alternatives. These categories of land use generate more fecal coliforms than other types of land use, which would increase potential for recreation use impacts downstream. These categories of land use also generate more

Table 3-20
Basin A Discharges to Upper and Lower Lawson Creek – Alternative 1

Parameter	Units	Discharge Water Quality		Background Water Quality (avg)		Water Quality Standards	
		Basin A-North	Basin A-South	Upper Lawson	Lower Lawson	Upper Lawson	Lower Lawson
Dissolved Copper	µg/L	1	1	<1	1	2	3
Dissolved Zinc	µg/L	4	4	2	5	22	31
Dissolved Lead	µg/L	0.1	0.1	<1	<1	0.3	0.5
Total Ammonia-N	mg/L	0.032	0.028	<0.005	0.023	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.29	0.31	1.14	1.26	n/a	n/a
Total Phosphorus	mg/L	0.045	0.043	0.014	0.030	n/a	n/a
Turbidity	NTU	1.0	0.9	10.7	19.2	<5 over background	<5 over background
TSS	mg/L	6.0	6.3	3.0	11.3	n/a	n/a
Fecal Coliforms	CFU/100 mL	38	36	6	33	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	0.1	1.2	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	0.2	1.5	1.0	no sheen	no sheen

Table 3-21
Basin A Discharges to Unnamed Creek near Jones Lake – Alternative 1

Parameter	Units	Discharge Water Quality		Background Water Quality (avg)		Water Quality Standards	
		Basin A-North	Basin A-South	Unnamed Ck. Station S	Unnamed Ck. Station SE	Unnamed Ck. Station S	Unnamed Ck. Station SE
Dissolved Copper	µg/L	1	1	<1	<1	21	9
Dissolved Zinc	µg/L	4	4	2	<1	195	86
Dissolved Lead	µg/L	0.1	0.1	2.0	1.0	5.6	2.0
Total Ammonia-N	mg/L	0.032	0.028	0.008	0.010	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.29	0.31	0.17	3.20	n/a	n/a
Total Phosphorus	mg/L	0.045	0.043	0.009	0.015	n/a	n/a
Turbidity	NTU	1.0	0.9	5.7	2.1	<5 over background	<5 over background
TSS	mg/L	6.0	6.3	3.0	3.0	n/a	n/a
Fecal Coliforms	CFU/100 mL	38	36	<2	<1	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	0.1	0.6	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	0.2	1.1	1.4	no sheen	no sheen

Table 3-22
Basin C Discharge to an Onsite Tributary to Unnamed Creek – Alternative 1

Parameter	Units	Discharge Water Quality	Background Water Quality	Water Quality Standards
		Basin C	**Station SE-2** *(see Table 2-11)*	**Station SE-2**
Dissolved Copper	µg/L	1	1	1
Dissolved Zinc	µg/L	4	1	8
Dissolved Lead	µg/L	0.1	1.0	0.1
Total Ammonia-N	mg/L	0.017	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.34	0.35	n/a
Total Phosphorus	mg/L	0.037	0.042	n/a
Turbidity	NTU	0.9	21.5	<5 over background
TSS	mg/L	7.1	22.0	n/a
Fecal Coliforms	CFU/100 mL	39	<1	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

Table 3-23
Basin B Discharge to a Tributary to Mud Lake – Alternative 1

Parameter	Units	Discharge Water Quality	Background Water Quality	Water Quality Standards
		Basin b	**Station NE-2** *(see Table 2-6)*	**Station NE-2**
Dissolved Copper	µg/L	1	1	1
Dissolved Zinc	µg/L	11	1	8
Dissolved Lead	µg/L	0.2	1.0	0.1
Total Ammonia-N	mg/L	0.066	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.19	0.35	n/a
Total Phosphorus	mg/L	0.064	0.042	n/a
Turbidity	NTU	1.9	21.5	<5 over background
TSS	mg/L	2.1	22.0	n/a
Fecal Coliforms	CFU/100 mL	70	<1	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.4	1.4	no sheen

Table 3-24
Basin D Discharge to Ginder Creek – Alternative 1

Parameter	Units	Discharge Water Quality	Background Water Quality		Water Quality Standards	
		Basin D	Ginder Ck. Station G	Ginder Ck. Station GE	Ginder Ck. Station G	Ginder Ck. Station GE
Dissolved Copper	µg/L	2	<1	<1	11	12
Dissolved Zinc	µg/L	5	<1	<1	97	113
Dissolved Lead	µg/L	0.3	1.0	1.0	2.3	2.8
Total Ammonia-N	mg/L	0.127	0.029	0.030	2.300	2.300
Nitrate + Nitrite-N	mg/L	0.26	0.12	1.50	n/a	n/a
Total Phosphorus	mg/L	0.040	0.018	0.011	n/a	n/a
Turbidity	NTU	1.4	3.2	1.8	<5 over background	<5 over background
TSS	mg/L	2.0	<1	<1	n/a	n/a
Fecal Coliforms	CFU/100 mL	70	10	4	<50 geometric mean	<50 geometric mean
TPH	mg/L	0.1	<1	<1	no sheen	no sheen
Oil and Grease	mg/L	0.2	1.5	1.6	no sheen	no sheen

Table 3-25
North Triangle Infiltration to Shallow Aquifer – Alternative 1
(Compared to Ravensdale Creek which derives Base Flow from the Shallow Aquifer)

Parameter	Units	Large Sand Filter Treatment Option	Biofiltration & Basic Sand Filter Treatment Option	Background Water Quality in Ravensdale Ck. (average)	Water Quality Standard for Ravensdale Ck.
		North Triangle	North Triangle		
Dissolved Copper	µg/L	1	0	<1	5
Dissolved Zinc	µg/L	5	3	7	50
Dissolved Lead	µg/L	0.4	0.2	<1	1.0
Total Ammonia-N	mg/L	0.064	0.050	0.018	2.300
Nitrate + Nitrite-N	mg/L	0.42	0.28	0.80	n/a
Total Phosphorus	mg/L	0.072	0.059	0.012	n/a
Turbidity	NTU	3.3	1.5	1.4	<5 over background
TSS	mg/L	2.9	1.3	2.1	n/a
Fecal Coliforms	CFU/100 mL	163	38	1	<50 geometric mean
TPH	mg/L	0.1	0.1	<1	no sheen
Oil and Grease	mg/L	0.5	0.3	2.1	no sheen

Table 3-26
Combined Discharges to Rock Creek – Alternative 1

Parameter	Units	Combined Discharge Water Quality	Background Water Quality in Rock Creek (average)	Water Quality Standards for Rock Creek
		Basins A-N, A-S, B, C, D		
Dissolved Copper	µg/L	1	1	8
Dissolved Zinc	µg/L	5	2	74
Dissolved Lead	µg/L	0.2	<1	1.6
Total Ammonia-N	mg/L	0.049	0.047	2.300
Nitrate + Nitrite-N	mg/L	0.29	0.45	n/a
Total Phosphorus	mg/L	0.045	0.021	n/a
Turbidity	NTU	1.1	3.3	<5 over background
TSS	mg/L	5.1	2.0	n/a
Fecal Coliforms	CFU/100 mL	47	15	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

Table 3-27
Combined Discharges to Jones Lake – Alternative 1

Parameter	Units	Combined Discharge Water Quality	Background Water Quality in Jones Lake (average)	Water Quality Standards for Jones Lake
		Basins A-N, A-S, C		
Dissolved Copper	µg/L	1	<1	5
Dissolved Zinc	µg/L	4	1	47
Dissolved Lead	µg/L	0.1	0.3	0.9
Total Ammonia-N	mg/L	0.027	<0.005	2.300
Nitrate + Nitrite-N	mg/L	0.31	0.51	n/a
Total Phosphorus	mg/L	0.042	0.033	n/a
Turbidity	NTU	0.9	2.0	<5 over background
TSS	mg/L	6.4	2.0	n/a
Fecal Coliforms	CFU/100 mL	38	4	<50 geometric mean
TPH	mg/L	0.1	nm	no sheen
Oil and Grease	mg/L	0.2	<0.2	no sheen

nm = not measured

Table 3-28
Combined Discharges to Ginder Creek – Alternative 1

Parameter	Units	Combined Discharge Water Quality	Background Water Quality in Ginder Creek (average)	Water Quality Standards for Ginder Creek
		Basins B & D		
Dissolved Copper	µg/L	1	<1	11
Dissolved Zinc	µg/L	8	<1	97
Dissolved Lead	µg/L	0.3	1.0	2.3
Total Ammonia-N	mg/L	0.100	0.029	2.300
Nitrate + Nitrite-N	mg/L	0.23	0.12	n/a
Total Phosphorus	mg/L	0.051	0.018	n/a
Turbidity	NTU	1.6	3.2	<5 over background
TSS	mg/L	2.0	<1	n/a
Fecal Coliforms	CFU/100 mL	70	10	<50 geometric mean
TPH	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.3	1.5	no sheen

phosphorus than other types of land use, which would increase potential for interference with TMDL efforts to control eutrophication in Lake Sawyer. Third, the no action alternative would have 2.3 to 2.7 times more single family residences than under the two action alternatives, which would have increased potential for landscape chemical impacts, particularly since educational efforts to restrain or eliminate homeowner use of inorganic fertilizers and pesticides are less likely outside of a MPD format. Fourth, the stormwater facilities would not be organized on a regional basis as buildout occurs on individual properties over 30 years, as recommended under the Lake Sawyer Management Plan. While this would not necessarily impede stormwater facility effectiveness, it would increase the complexity and cost of maintenance. Stormwater facilities need to be maintained to maintain effectiveness.

3.2.8 Assessment of Potential for Reduced Summer Baseflow Affecting Water Quality – All Alternatives

If base flows are significantly reduced to streams during the summer, those reductions could potentially lead to increased water temperatures and indirectly through temperature changes to reductions in dissolved oxygen in streams. Golder (2008c) evaluated the potential for added impervious surfaces resulting from the Proposed Action or Alternative 1 to reduce groundwater recharge that could affect base flows. Golder's (2008c) assessment concluded there could be a slight but likely non-measurable change in mine drain discharge to Unnamed Creek (less than 1 percent flow reduction). No alterations to recharge to Ginder Creek or Lawson Creek are predicted by Golder. Groundwater recharge in the North Triangle is expected to increase as a result of development under the Proposed Action and Alternative 1 due to clearing (reducing evapotranspiration losses of water from vegetation) and infiltration of all stormwater on that portion of the site. Therefore, there would be no adverse alteration of baseflow to Ravensdale Creek or to wetlands in the vicinity of the North Triangle. No adverse changes to summer baseflows that could affect water quality are reasonably expected to occur under either action alternative.

The Proposed Action and Alternative 1 are both clustered MDPs. The No Action Alternative 1 would have 2.3 to 2.7 times more residences, 1.1 to 2.2 times more retail, 1.9 to 2.9 times more office, and less preserved open space than the two action alternatives. No Action Alternative 1 would not be clustered, but would avoid critical areas and their buffers as would also occur under both action alternatives. The increased area of development and the greater density of development under Alternative 2 would have greater potential for reduced baseflow recharge to streams than under the two action alternatives.

3.2.9 Assessment of the Benefit of Low Impact Development Measures that are Proposed

In recent years alternative means to maintain natural system hydrology, protect streams from increases in storm water runoff, and protect wetlands have been developed under the collective term of "low impact development" or LID (Puget Sound Action Team 2005). LID is also encouraged for the protection of Puget Sound by the Puget Sound Partnership (2006). The Puget Sound Partnership was formed by Governor Gregoire to develop an action plan for protection of the Puget Sound watershed (of which the subject site is a portion). With regard o stormwater the Puget Sound Partnership recommends maximizing stormwater infiltration, use of the 2005 Ecology Manual, and promotion of LID, among others. As described above, the

Lawson Hills project would maximize infiltration and proposes to use the 2005 Ecology Manual for storm management under both action alternatives. In addition, Lawson Hills proposes to utilize LID to the extent feasible and productive.

Many LID methods seek to infiltrate stormwater in localized areas over infiltrative soils where it is generated in order to reduce hydraulic impact. Examples of these that are proposed for the Lawson Hills action alternatives include the following:

- Biofiltration and sand filter treatment associated with discharge infiltration in the North Triangle,
- Direct infiltration of roofs and non-pollution generating surfaces in the North Triangle,
- Pervious/porous hard surface treatments such as porous pavers that infiltrate directly in the North Triangle and elsewhere as feasible,

Other LID methods seek to reduce stormwater runoff volumes by reducing impervious surface coverage. One example is use of narrower than standard roadways. The Lawson Hills action alternatives would proposed to narrow roadways below typically applied standards as feasible for public safety and other concerns, and as approved by the City. Another example employed by Lawson Hills is clustering under the MPD, which tends to reduce the amount of roadway and other impervious surfaces and thereby reduces storm runoff.

Another category of LID methods seek to retain water on-site to be lost through evaporation or evapotranspiration by plants. Examples of these that are proposed for use or consideration under the Lawson Hills action alternatives include the following:

- Street and other urban tree plantings intercept and evaporate rainfall, preventing it from reaching the ground and forming runoff. So-called “urban forests” can reduce storm runoff by about 7 percent (Taylor 2000) on an overall basis, and up to 38% during the summer (Xiao 1998).
- Clustering under the master plan for Lawson Hills that (a) preserves 50 percent undeveloped open space, to minimize land surface alterations that change stormwater runoff patterns and (b) tends to minimize the amount of road surface infrastructure.
- Retaining soil strippings and mixing them with organic matter as a top dressing for landscaping to enhance soil moisture retention.
- Bioretention and rain garden incorporation in landscaped areas, where water is held in small local basins to evaporate during the drier seasons.

The existing site is largely comprised of till soils over relatively shallow bedrock, except for large portions of the North Triangle where soils with infiltration potential exist. On the urbanized scale assumed under all alternatives, meaningful infiltration is not feasible except on the North Triangle, where it is proposed under the Proposed Action and Alternative 1 for Lawson Hills. LID treatments such as porous pavement or other semi-permeable treatments are not required to further mitigate water quality, and would not be able to do so on this site where till soils and shallow bedrock exist in a meaningful way. Nonetheless, to the extent that porous pavements or other semi-permeable treatments are feasible and employed, they would reduce stormwater generation from smaller storms or from the earlier stages of storms, even if the change would be minor and would not be necessary to avoid adverse impacts from stormwater. Other LID water retention methods and efforts to reduce impervious surfaces (i.e., narrower streets and clustering) are applicable throughout the site. These methods would allow more runoff to be held on the site and more runoff to be treated in the stormwater facilities, and would help

minimize phosphorus loadings to Lake Sawyer. These are beneficial results even if the realized benefits are modest or small.

Under the no action Alternative 2, it is less likely that LID measures would be incorporated, since development would not occur in a master-planned fashion supportive of clustering, narrower or fewer streets, incorporation of storm features in landscaping or use of porous paver or other similar treatments.

3.3 Cumulative Impacts

Cumulative impacts of the two action alternatives are qualitatively assessed with The Villages MPD. The Villages project is in preliminary stages of planning and there is no defined proposal to evaluate at this time. However, only the portion of The Villages site in the Rock Creek basin has any potential for cumulative water quality effects with Lawson Hills. The remainder of The Villages site infiltrates to groundwater flowing away from Rock Creek (recharging the Green River or Crisp Creek, a tributary to the Green River). The Villages may discharge to Rock Creek by infiltration to shallow groundwater recharging Rock Creek and/or to Rock Creek by pipeline. Either way, the cumulative impacts of Lawson Hills and The Villages would manifest downstream of Jones Lake, Ginder Creek, Lawson Creek, and Unnamed Creek. Cumulative impacts could occur to Rock Creek below Jones Lake and to Lake Sawyer.

It is assumed that The Villages would treat and detain stormwater in the Rock Creek basin to, at minimum, the same standards using the same 2005 Ecology Manual as proposed for Lawson Hills. A portion of The Villages site drains to Black Diamond Lake, which may contribute headwaters to Rock Creek via tributary 09-0085A (Associated Earth Sciences 2000). Black Diamond Lake is a bog. It is possible that if The Villages proposes to discharge stormwater to Black Diamond Lake (other than non-pollutant generating roof runoff) then a higher level of stormwater quality treatment to protect bog functions may be necessary for that portion of the drainage.

During construction, it is assumed that the same BMPs described in Section 3.1 of this report would be applied to the portion of The Villages in the Rock Creek basin. If that is the case, and each project maintained compliance with its NPDES permit for construction discharge seeking to limit discharges to 5 NTU turbidity above background then no adverse cumulative impacts would be expected and would be managed by monitoring required under each project's NPDES permit. This is particularly true since The Villages would likely have additional NPDES construction discharge limitations for phosphorus control for any surface discharges or infiltration within ¼ mile of recharge to Rock Creek due to its proximity to Lake Sawyer.

For long term stormwater discharge, The Villages stormwater quality in the Rock Creek basin is uncertain, since the project is not yet proposed with regard to land use, stormwater treatment, or discharge or infiltration locations. However, the range of probable stormwater quality is likely similar to that described for the various land use types for Lawson Hills in Section 3.2. All stormwater constituent concentrations for Lawson Hills are reasonably expected to be within applicable state water quality standards with the mitigation measures listed in Section 3.4 below. On a concentration basis, it is expected that The Villages would have the same level of treatment producing the same level of results, thereby avoiding cumulative impacts because dilution is not required to meet standards. For phosphorus impacts to Lake Sawyer, like Lawson Hills, development of The Villages site is anticipated in the phosphorus modeling and

reflected in recommendations in the Lake Sawyer Management Plan. Those recommendations are Section 3.2.6.4. If The Villages proposes to follow those recommendations germane to stormwater runoff from that site in equivalent fashion to those proposed for Lawson Hills, then unanticipated changes in phosphorus impacts to Lake Sawyer would be avoided and the plan recommendations are reasonably expected to control adverse impacts.

3.4 Mitigating Measures

Mitigation measures for water quality include the following:

- Use of the 2005 Ecology Stormwater Management Manual for Western Washington, including use of the phosphorus treatment and enhanced treatment menus where they apply;
- Construction mitigation measures described in Section 3.1 from the 2005 Ecology Manual;
- Minimizing fecal coliforms by emphasizing (through educational materials at the time of sale) pet waste removal by residents for yards, sidewalks and sidewalk plantings, and in parks;
- Minimizing fecal coliforms on the North Triangle portion of the site by employing biofiltration swale and basic sand filter combinations for stormwater treatment, rather than large sand filters;
- Minimizing phosphorus, fecal coliforms, and storm runoff volumes by use of LID methods described in Section 3.2.9 as feasible;
- Minimizing phosphorus loading impacts through use of the Lake Sawyer Management Plan recommendation measures described in Section 3.2.6.4; and
- Minimizing storm runoff through preservation of 50 percent open space, including preservation of sensitive areas and buffers as required by the City of Black Diamond.

3.5 Unavoidable Adverse Impacts

With the application of mitigating measures described above and in this report, no unavoidable long term adverse impacts to water quality are reasonably expected to occur, nor is impairment of beneficial uses of water reasonably expected.

4.0 REFERENCES

A.C. Kindig & Co. 2000. Unpublished runoff data from Trossachs Residential Development inflow, wet pond and sand filter. Issaquah, Washington.

A.C. Kindig & Co. 2002a. Post Construction Monitoring Plan 2002 Summary Report for Snoqualmie Ridge. Prepared for Quadrant Corporation. November, 2002.

A.C. Kindig & Co. 2002b. Snoqualmie Ridge II Water Quality Technical Report. Prepared for Quadrant Corporation. December 18, 2002. (Appendix to Snoqualmie Ridge II Draft EIS by the City of Snoqualmie).

A.C. Kindig & Co. 2003a. Post Construction Monitoring Plan 2003 Summary Report for Snoqualmie Ridge. Prepared for Quadrant Corporation. November 2003.

A.C. Kindig & Co. 2003b. Unpublished data from SWD-1 outfall at Trilogy UPD, King County, Washington.

A.C. Kindig & Co. 2003c. Unpublished Pond DP1 outfall monitoring at Snoqualmie Ridge, Snoqualmie, Washington.

A.C. Kindig & Co. 2005a. Tukwila South Project Water Quality Technical Report. March 8, 2005. IN Tukwila South Project Draft EIS, City of Tukwila.

A.C. Kindig & Co. 2005b. North Bay Water Quality Technical Report. March 25, 2005 IN North Bay Draft EIS, Port of Seattle.

A.C. Kindig & Co. 2006. Des Moines Creek Business Park Technical Report for Water Quality, Groundwater, Fisheries, Wetlands, and Wildlife, Draft EIS. October 11, 2006.

A.C. Kindig & Co. 2007. New Whatcom Redevelopment Project Water Quality Technical Report. December 18, 2007. Appendix G in the New Whatcom Redevelopment Project Draft EIS, January 2008.

Associated Earth Sciences, Inc. (AESI). 1998a. Unpublished office parking lot data from 911 Fifth Avenue office complex, Kirkland, Washington.

Associated Earth Sciences, Inc. (AESI). 1998b. Unpublished research experimental data on grass capped sand filter performance and recovery under various ranges of inflow turbidity. A. Kindig, investigator.

Associated Earth Sciences, Inc. 2000a. Water Quality and Fisheries Technical Report, Black Diamond PAA. October 18, 2000.

Associated Earth Science, Inc. 2000b. Post Construction Monitoring Plan 1999 Summary Report for Snoqualmie Ridge. Prepared for Weyerhaeuser Real Estate Company, October 19, 2000.

Associated Earth Sciences, Inc. 2000c. Snoqualmie Ridge Post Construction Monitoring Plan, 2000 Annual Report. November 6, 2000.

Associated Earth Sciences, Inc. (AESI). 2001. Unpublished runoff data from Lake Washington Blvd. North and I-405/NE 44th Street Interchange, Renton, Washington.

Austin, City of. 1990. Removal efficiencies of stormwater control structures. Environmental Resource Management Division, City of Austin, Texas.

Barber, M.E., M.G. Brown, K.M. Lingenfelder, and D.R. Yonge. 2006. Phase I: Preliminary Environmental Investigation of Heavy Metals in Highway Runoff. Washington State Transportation Center, Washington State University. Report to Washington State Department of Transportation, November 21, 2006.

Barrett, M.E., J.F. Malina, R.J. Charbeneau, and G.H. Ward. 1995. Water Quality and Quantity Impacts of Highway Construction and Operation: Summary and Conclusions. Center for Research in Water Resources. University of Texas at Austin. Technical Report CRWR 266.

Bortleson, G.C. and D.A. Davis. 1997. Pesticides in selected small streams in the Puget Sound Basin, 1987-1995. U.S. Geological Survey Fact Sheet 067-97. 4 p.

Brainard, S. Wetland Resources, Inc. personal communication with A. Kindig, A.C. Kindig & Co. January 16, 2008.

Brown, W. and T. Schueler. 1997. Comparative pollutant removal capability of urban BMPs: a reanalysis. Watershed Protection Techniques, Vol. 2, No. 4. June 1997. Median pollutant removal based on 30 samples.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22(2):361-369.

Cedarock Consultants Inc. 2008. Lawson Hills Fisheries Technical Report.

CH2M Hill. 1992. Suitability of the Mill Pond at Lakeland Hill at the location of Put and Take Trout Fishery in conjunction with its modification to serve as a detention facility. Bellevue, Washington.

Chapman, D. 1996. Water quality assessments: a guide to the use of biota, sediments, and water in environmental monitoring, second edition. 1996.

Chapra, S.C. and S.J. Tarapchak. 1976. A chlorophyll *a* model and its relationship to phosphorus loading plots for lakes. Water Resources Research 12:1260-1264 pp

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Chesapeake Research Consortium, Inc. with funding from U.S. EPA.

City of Black Diamond. 1996. City of Black Diamond Comprehensive Plan. August 8, 1996.

Coffman, L.S. 1998. Low-Impact Development Design: A new paradigm for stormwater management mimicking and restoring the natural hydrologic regime; an alternative stormwater management technology.; Data from the University of Maryland, Department of Engineering, unpublished.

Comings, K., D.B. Booth, R.R. Horner. 1999. Stormwater pollutant removal by two wet ponds in Bellevue, Washington. University of Washington.

Crawford, C.G. and L.J. Mansue. 1996. Suspended sediment characteristics of Indiana streams, 1952-84. U.S. Geological Survey Water Supply Paper 2404. 55 pp.

Davis, A., M. Shokouhian, H. Sharma, and C. Henderson. 1998. Optimization of Bioretention Design for Water Quality and Hydrologic Characteristics. Department of Civil Engineering, University of Maryland, College Park.

Gjessing, E., E. Lygren, L. Berglind, T. Gulbrandsen, and R. Skaane. 1984. Effect of highway runoff on lake water quality. The Science of the Total Environment 33:245-257.

Goldberg. 1993. Dayton Avenue Swale Biofiltration Study. Seattle Engineering Department, Seattle, Washington.

Golder Associates Inc. 2007a. Lawson Hills Interim Water Monitoring Summary Report. January 19, 2007.

Golder Associates Inc. 2008a. Summary of Hydrology/Hydrogeology: Lawson Hills and North Triangle. Memorandum to Ryan Kohlmann, BD Lawson Partners, LP. February 1, 2008.

Golder Associates Inc. 2008b. Lawson Hills Mine Drain Discharge Downstream Reconnaissance. Memorandum to Ryan Kohlmann, BD Lawson Partners, LP. January 23, 2008.

Golder Associates Inc. 2008c. Summary of Hydrology/Hydrogeology: Lawson Hills and North Triangle. Memorandum to Ryan Kohlmann, BD Lawson Partners, LP. February 1, 2008.

Harper, H.H. 2000. Stormwater BMPs; Workshop at the North American Lake Management Society 2000 Meetings, November 8-10, 2000.

Herrera Environmental Consultants (Herrera). 2004. Personal communication with John Lenth, Herrera, and Dana Zlateff, A.C. Kindig & Co., March 17, 2004.

Hsieh, C.H. and A.P. Davis. 2005. Multiple-event study of bioretention for treatment of urban stormwater runoff. Water Science & Technology 51(3-4): 177-181.

Hoppin, M. January 30, 2008. Washington Department of Ecology. Personal Communication with T. Shugrue, A.C. Kindig & Co.

King County. 1989. Soos Creek Basin Plan and Draft Environmental Impact Statement. King County Department of Public Works, Surface Water Management Division.

King County. 1993. Pine Lake sand-filter mini-study, East Lake Sammamish Basin Shopping Center.

King County. 1995. Evaluation of Water Quality Ponds and Swales in Issaquah/Eastlake Sammamish Basin. King County SWM. Seattle, Washington.

King County. 2000. Lake Sawyer Management Plan. King County Surface Water Management. July 2000.

King County. 2003. King County Lake3 Monitoring Report. Lake Stewardship Program. Volunteer Lake Monitoring Results for the Water Year 2002.

King County. 2005a. Surface Water Design Manual.

King County 2005b. King County Lake Monitoring Report for Water Year 2002-2003.

Maestri, B., M.E. Dorman, and J. Hartigan. 1988. Managing pollution from highway stormwater runoff. Transportation Research Record 1166. p. 15-21.

Martin, E.H. 1989. Effectiveness of an urban runoff detention pond-wetlands system. ASCE Journal of Environmental Engineering 115(2):409-27.

Municipality of Metropolitan Seattle (Metro). 1982. Toxicants in urban runoff. Metro Toxicant Program No. 2. Water Quality Division, Seattle, Washington.

Municipality of Metropolitan Seattle (Metro). 1992. Biofiltration Swale Performance, Recommendations, and Design Considerations. Publication 657.

National Academy of Sciences and National Academy of Engineering. 1973. Water quality criteria, 1972, a report of the committee on water quality criteria. Washington, D.C., Environmental Studies Board, National Academy of Sciences, National Academy of Engineering. 594 p.

Peterson, J. 1990. Washington State Department of Ecology, Olympia, Washington. Memorandum to Interested Parties in Re: Black Diamond Wastewater Treatment Facility, January 3, 1990.

Phillips, A. 1998. Lake Sawyer water cleanup plan (TMDL) for phosphorus. Washington State Department of Ecology, January 1998. Publication No. 9802022-WQ.

Pietrazek, J., Golder Associates Inc. Personal Communication with A. Kindig, A.C. Kindig & Co., January 23, 2008.

Porcella, D.B., S.A. Peterson, and D.P. Larsen. 1980. Index to evaluate lake restoration. Journal of Environmental Engineering. 106:1151-1169 pp.

Prince George's County Department of Environmental Resources (PDGER). 1993. Design Manual for Use of Bioretention in Storm Water Management. Division of Environmental Management, Watershed Protection Branch. Landover, MD.

Puget Sound Action Team and Washington State University. 2005. Low Impact Development Technical Guidance Manual for Puget Sound. Revised May 2005.

Puget Sound Partnership. 2008. Sound Health, Sound Future: Protecting and Restoring Puget Sound. Puget Sound Partnership Recommendations. December 2006).

Scholz, N.L., N.K. Truelove, B.L. French, B.A. Berejikian, T.P. Quinn, E. Casillas, and T.K. Collier. 2000. Diazinon disrupts antipredator and homing behaviors in Chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. 57:1911-1918.

Schoonover, J.E. and K.W.J. Williard. 2003. Ground water nitrate reduction in giant cane and forest riparian buffer zones. J. of the American Water Resources Association. 39(2):347-354.

Schueler, T.R., P.A. Kumble, and M.A. Heraty. 1991. A current assessment of urban best management practices, techniques for reducing non-point source pollution in the coastal zone, review draft. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C.

Schueler, T. 1997. Comparative Pollutant Removal Capability of Urban BMPs: A reanalysis. Watershed Protection Techniques 2(2):379-383.

Shapiro & Associates, Inc. (Shapiro). 1999. Lakemont stormwater treatment facility monitoring program. Draft Final Report, July 1999.

Simmons, C.E. 1993. Sediment characteristics of North Caroline streams, 1970-79. U.S. Geological Survey Water Supply Paper 2364. 84 p.

Southwest Florida Management District. 1995. Tampa Office Pond. 1994-1995. Tampa, Florida.

Steuer, J., W. Selbig, N. Hornewer, J. Prey. 1997. Sources of contamination in an urban basin in Marquette, Michigan and an analysis of concentrations, loads, and data quality. U.S. Geological Survey, Water Resources Investigations Report 97-4242, Middleton, Wisconsin.

Taylor, J. 2000. The Hydrological Effects of Urban Forests, with Reference to the Maritime Pacific Northwest. University of British Columbia Technical Bulletin No. 6. October 2000.

Tetra Tech / KCM, Inc. 2000. Potential Annexation Area Final Environmental Impact Statement and Comprehensive Plan Amendments. October 2000. City of Black Diamond.

Thielen, J. 1978. Effects of Black Diamond on Ginder Creek. Memorandum to Ron Devitt, Washington Department of Ecology Publication No. 768-e20.

Triad Associates, Inc. 2008. Lawson Hills Preliminary Technical Information Report. February 1, 2008.

U.S. Environmental Protection Agency (EPA). 1993. Approval of Total Maximum Daily Load (TMDL) Number 09-002 for Lake Sawyer (Waterbody Segment No. WA-099260). EPA letter to Ecology approving TMDL and associated wasteload and load allocations for Total Phosphorus and compliance with the State's narrative water quality standards for aesthetics. EPA Region X. Seattle, Washington.

United States Environmental Protection Agency (USEPA). 1999. Stormwater Technology Fact Sheet, Biofiltration Swales. Office of Water, Washington, D.C. Report No. 832-F-99-012.

United States Environmental Protection Agency (USEPA). 2000. Bioretention Applications. Office of Water, Washington, D.C. EPA-841-B-00-005A.

Urbonas, B. 1994. Assessment of stormwater BMPs and their technology. Water Science and Technology 29(1):347-353.

Urbonas, B. 1999. Assessment of stormwater BMPs and their technology. Water Science Technology 29(1):347-353.

Walton, S. 2000. Beaver Lake Management Plan Update: A Report on the Quality of Beaver Lake for 1996-2000. Final Report for the Beaver Lake Management District No. 1 and Washington State Department of Ecology. King County Water and Land Resource Division. December, 2000.

Washington State Department of Fisheries (WDF). 1975. A catalog of Washington streams and salmon utilization, Volume I, Puget Sound region. Olympia, Washington.

Washington State Department of Ecology. 2002. Effectiveness Monitoring for Total Phosphorus Total Maximum Daily Loads in Fenwick and Sawyer Lakes. Publication No. 02-03-054. December, 2002.

Washington State Department of Ecology (Ecology). 2004. Water Quality Program Permit Writer's Manual.

Washington State Department of Ecology (Ecology). 2005. Stormwater Management Manual for Western Washington.

Washington State Department of Ecology. 2007a. Conditional Use Level Designation for Erosion and Sediment Control for Water Tectonics Electrocoagulation Subtractive Technology. Issued February 18, 2005 and updated August, 2007.

Washington State Department of Ecology. 2008. Use Designations for Erosion and Sediment Control for Chitosan-Enhanced Sand Filtration using StormKlearTM LiquiFlocTM. Issued March 2007 and updated January 2009.

Washington State Department of Transportation (WSDOT). 1997. Stormwater management plan, Vol. 5.3, 40 CFR 122.26 (d)2.iv. March 25, 1997.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society, Monograph No. 7. Bethesda, MD. 251 p.

Winer, R. 2000. National Pollution Removal Data Base. Center for Watershed Protection, Ellicott City, MD 21043 IN Ohio State University Extension Factsheet, Multi-functional landscaping: putting your parking lot design requirements to work for water quality. Publication CL-1000-01. Food, Agricultural and Biological Engineering. Columbus, OH.

Xiao, Q., E.G. McPherson, J.R. Simpson, and S.L. Ustin. 1998. Rainfall Interception by Sacramento's Urban Forest. Journal of Arboriculture 24(4):235-243.

Young K.D. and E.C. Thackston. 1999. Housing density and bacterial loading in urban streams. Journal of Environmental Engineering 125(12):1177-1180.

Yousef, Y.A., M.P. Wanielista, T. Hvitved-Jacobsen and H.H. Harper. 1984. Fate of Heavy Metals in Stormwater Runoff from Highway Bridges. The Science of the Total Environment 33::233-244.

Zentner, G. 1998. Treatment Wetlands – What Happened in Black Diamond. Puget Sound Research'98, pp 71-82.