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THE VILLAGES MPD
WATER QUALITY TECHNICAL ANALYSIS

Draft EIS

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1.0 INTRODUCTION

1.1 Purpose for Water Quality Technical Analysis

This technical analysis is conducted to provide information input on water quality-related site features, proposed elements, regulations, impacts, and proposed mitigation to the City of Black Diamond's consultant writing the Draft Environmental Impact Statement (Draft EIS) for The Villages project. This analysis is not intended as a stand-alone report. This analysis evaluates stormwater for the Proposed Action at build out of the project, except where the discussion pertains to construction-related impacts. Build out for the Proposed Action is estimated to be complete by 2025. The No Action Alternative may take longer to build out. The Proposed Action is assessed quantitatively. The No Action Alternative is evaluated qualitatively relative to the results for the Proposed Action Alternative. Cumulative impacts are qualitatively evaluated for the combined impacts of The Villages MPD and Lawson Hills MPD. Lawson Hills MPD would be built out by 2015.

1.2 Site Area, Project, and Alternatives Description

BD Village Partners, L.P. (Village Partners) proposes to develop an approximately 1,190-acre site in Black Diamond, Washington. There are two portions to the site. The Main Property is approximately 1,108 acres in size. The approximately 82-acre North Property is about 2 miles north of the Main Property. Most of the site is annexed into the city; remaining portions are expected to be annexed prior to the proposed project.

The Proposed Action would be a Master Planned Development (MPD) with a Development Agreement and Preliminary Master Plat. 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; it is assumed the No Action Alternative would also be sewered.

It is possible no development other than timber harvesting would occur by 2025 under the No Action Alternative; full buildout may not occur until 2040 or beyond. Under the No Action Alternative, the land parcels comprising the proposed site may 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. Under city zoning there is potential for more than twice the office/light industrial square footage than under the Proposed Action, but market demand for that much area is not anticipated. Natural areas and hazard areas would continue to be preserved and protected by the City's critical areas ordinance, but the amount of parks and open space would not be dictated by MPD provisions and no clustering is assumed. Stormwater would be managed on each parcel as required by city stormwater codes in place at the time of vesting for each project.

1.3 Site Drainage Areas

The site has been divided into seven drainage subbasins. Basins 1 through 6 are located on the Main Property. Basin 7 is located on the North Property (see Triad Associates, Inc. July 2008 *Villages Stormwater Concept*). There is an eighth basin located on non-contiguous property east of the Main Property, but no development is proposed on this parcel and it is not considered further.

Drinking water wells in the vicinity have been identified and mapped by Associated Earth Sciences, Inc. (2008) to examine potential for influence from site infiltration. Associated Earth Sciences, Inc. concluded there are no drinking water wells offsite that are producing from aquifers in areas that have potential for water quality or quantity impact from the site. Specific drinking water wells are not examined further in this analysis, however potential offsite impacts to groundwater quality and its beneficial uses are examined.

2.0 AFFECTED ENVIRONMENT

2.1 Hydrologic Setting

All of The Villages site lies within the Duwamish-Green River Drainage Basin (Water Resource Inventory Area [WRIA] 09) (Washington State Department of Fisheries [WDF], 1975).

2.1.1 Site Drainage and Features

Portions of Basins 4, 5, and 6 on the Main Property drain directly or indirectly to Rock Creek (WRIA 09-0085), which drains to Lake Sawyer (Figure 2-1). A portion of Basin 4 drains towards Black Diamond Lake which is located partially on-site and partially off-site. Black Diamond Lake is a bog wetland that drains northwest via a small tributary (09-0085A) to Rock Creek. Basin 5 drains to Rock Creek downstream of Ginder Creek and the Black Diamond Lake tributary. Basin 6 drains to Stream 4, which was called "Unnamed Drainage B" in the Black Diamond Potential Annexation Area EIS analyses (Associated Earth Sciences 2000). Stream 4 is tributary to the south side of Jones Lake just west of SR 169. 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. A portion of Basin 4 drains via infiltration to aquifers underlying the site that flow generally westerly and are described below.

Basins 1, 2, 3, and 4 on the Main Property are not "topographic" basins in the typical sense, because this portion of the site drains to infiltration under existing conditions and is proposed to infiltrate after development. Basins 1 through 4 which have infiltration in common are distinguished by combinations of land use differences, sequential infrastructure construction as the project is built out, and ultimate offsite recharge receptors for water entering the shallow aquifer in each basin. Basins 5 and 6 are located on portions of the site underlain by till where infiltration is not possible.

All of the stormwater from the North Property drains indirectly to Lake Sawyer, via infiltration to shallow ground water and recharge to Ravensdale Creek (09-0083) or via Wetland B4. Basin 7 on the North Property is further subdivided into two catchments named Basin 7 North and Basin 7 South. Basin 7 North is underlain by soils suitable for infiltration. Basin 7 South is underlain by till where infiltration is not possible. Basin 7 South drains to wetland B4 located in the southwest corner (and extending offsite) of the North Property. Wetland B4 is a depressional wetland that does not have an open water component but floods/inundates seasonally (Hirsch, Pers. Comm. July 9, 2008) and drains to shallow infiltration within the Ravensdale Creek and Lake Sawyer basin.

All significant on-site and off-site waterbodies are described in more detail in Section 2.3.

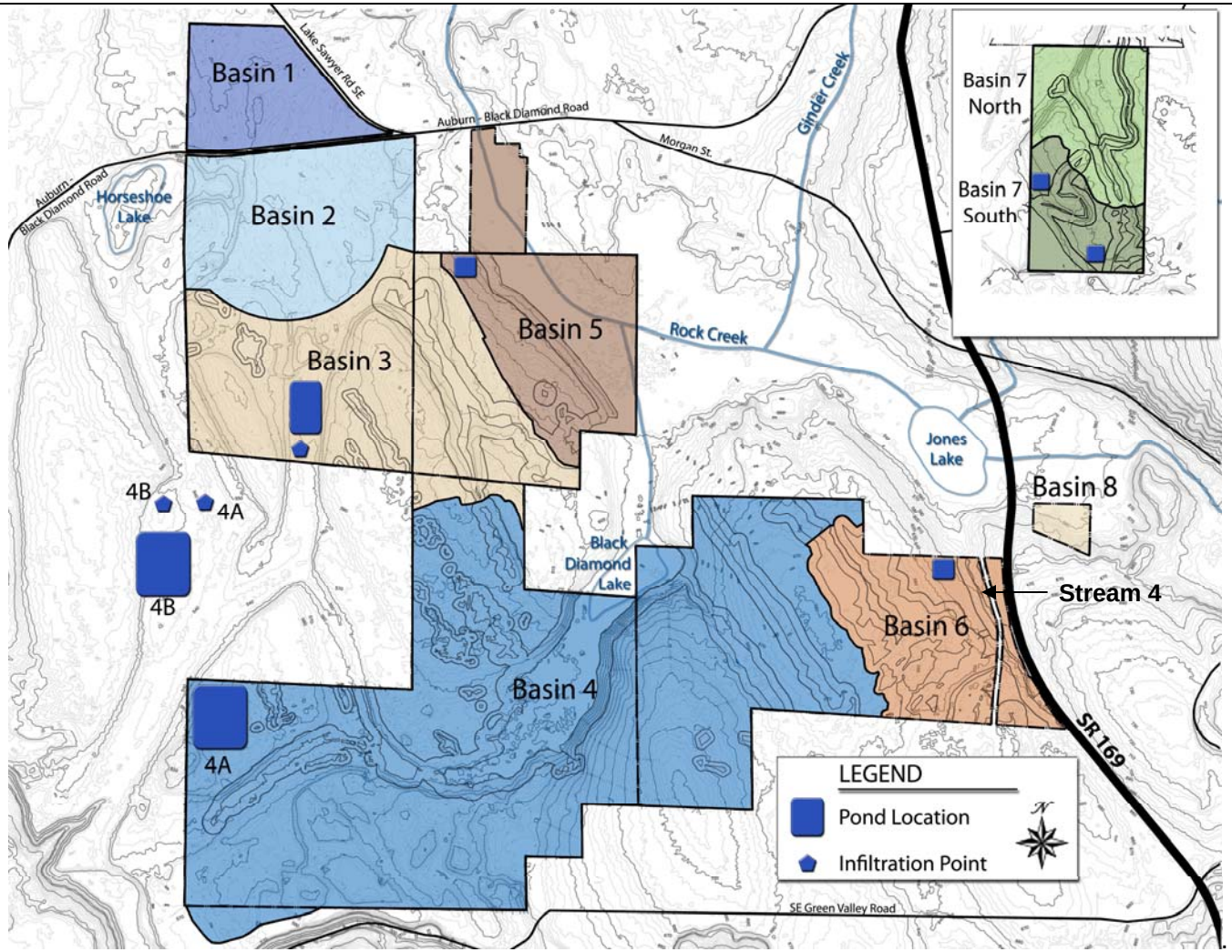

Figure 2-1. The Villages Stormwater Basins

Source: Triad Associates, Inc.

2.1.2 Groundwater Drainage and Features

Groundwater is described in detail by Associated Earth Sciences, Inc. (2008). This summary is derived from their findings. Basins 1 through 4 drain to Vashon recessional outwash deposits (Qvr) and non-recessional outwash (Qvic) which in some portions of the site contain the shallow aquifer. For Basins 1, 2, and portions of 3, recharge to the shallow aquifer flows to and recharges Horseshoe Lake offsite to the west. Although this aquifer recharges offsite Horseshow Lake seasonally, the Shallow Aquifer is not a viable aquifer (i.e., could reliably supply a domestic well), so beneficial use of this groundwater offsite to the west for year around or domestic well purposes is not possible. Horseshoe Lake extends down into a deeper pre-Olympia aquifer contained in quaternary pre-Olympia glacial and non-glacial coarse grained deposits ($Qpog_c$ and $Qpon_c$). The shallow aquifer and the pre-Olympia aquifers are separated over most of the site by a till aquitard up to about 48 feet in thickness, but generally ranging from 15 to 40 feet in thickness. In portions of the site, the separating till layer is absent. Where the till is absent, the outwash deposits are dry (the shallow aquifer is absent) or the shallow aquifer and pre-Olympia aquifer are hydraulically connected so that infiltrating water recharges the pre-Olympia aquifer directly. Flow velocities in the pre-Olympia Aquifer are estimated at about 2.5 feet per day based on limited aquifer testing data and hydraulic gradient measures of on-site wells. This equates to about 75 feet of horizontal movement per month. Horseshoe Lake recharge to the pre-Olympia aquifer flows south and recharges Crisp Creek (09-0113) near its confluence with the Green River at approximately RM 40. The Green River becomes known as the Duwamish River Waterway at RM 11 and flows into Elliot Bay and the Puget Sound.

For Basin 3, infiltration to the shallow aquifer flows southwesterly to eventually recharge the pre-Olympia aquifer which provides baseflow to Crisp Creek. Infiltrated stormwater to the shallow aquifer in most of Basin 4 flows westerly and recharges the pre-Olympia aquifer, which recharges lower Crisp Creek. Some areas in Basin 4 recharge the shallow aquifer flowing to the bog wetland Black Diamond Lake, which drains northerly to Rock Creek. A third aquifer, named the lower pre-Olympia aquifer, supplies springs which drain towards Black Diamond Lake from the southeast in Basin 4.

2.1.3 Offsite Features

Lake Sawyer is about 0.7 miles away from the closest portions of the main property area via surface runoff (as opposed to infiltration) to Rock Creek. The confluence of the Green River and Crisp Creek is about 1 mile as the crow flies west of the closest corner of the Main Property, and has no surface connection to the site. Horseshoe Lake is about 0.04 miles west of the main property and has no surface connection to the site. There is no surface connection between the site and the Green River to the south.

2.1.4 Study Area for Water Quality Analysis

This analysis extends through Black Diamond Lake, Rock Creek, and Rock Creek tributaries to Lake Sawyer downstream, and to Lake Sawyer via infiltration in the Ravensdale Creek basin, 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 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 in Covington Creek. The analysis also extends via groundwater quality assessment to Horseshoe Lake, and the Crisp Creek/Green River confluence offsite to the west and southwest.

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 in the Lake Sawyer watershed onsite and between the site and Lake Sawyer, including Lake Sawyer, Rock Creek, Black Diamond Lake and its tributary to Rock Creek, and Stream S4, 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.

Offsite Horseshoe Lake has the same use designations described for the Lake Sawyer watershed above.

The Green River and Crisp Creek offsite have the use designations described for the Lake Sawyer watershed above, except for the following difference:

- Primary contact recreation (not extraordinary primary contact recreation).

All on-site and offsite streams that infiltrate without surface connection to other waters of the state have the same use designations described for the Lake Sawyer watershed, except for the following differences:

- Salmonid spawning, rearing, and migration (and not core summer salmonid habitat) ; and
- Primary contact recreation (and not extraordinary primary contact recreation).

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

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

Core Summer Salmonid Habitat – All Connected Surface Waters and Lakes *(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).
Salmonid Spawning, Rearing and Migration – Unconnected streams *(see WAC 173-201A-200 for details beyond this summary)*	
Dissolved oxygen	The lowest 1-day minimum is **8.0** 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	Same as for Core Summer Salmonid Habitat.
Temperature	Shall not exceed **17.5**°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 0.5 units.
Turbidity	Same as for Core Summer Salmonid Habitat.
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 – Lake Sawyer and Tributaries *(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.

Primary Contact Recreation – Green River and Crisp Creek *(see WAC 173-201A-200 for details beyond this summary)*	
Fecal coliforms	Fecal coliform organism levels must not exceed a geometric mean value of **100** 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 200 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/Drinking Water 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.

Ecology is in the process of updating its 303(b) and 303(d) lists. A draft 2008 Water Quality Assessment was submitted to EPA on June 23, 2008 for approval of the Category 5 (impaired water quality) 303(d) listings. Until EPA approval is granted, the 2004 approved Integrated Water Quality Assessment is the current 303(b) and 303(d) listing

No onsite streams or waterbodies are listed as impaired for any parameters under the current 303(d) listing. Horseshoe Lake is not listed as impaired for any parameters under the current or proposed draft 2008 303(d) listing.

Offsite streams and lakes are included on the current 2004 303((b) or (d) listing for water quality-related parameters are listed below.

2.2.3.1 Ravensdale Creek

The reach of Ravensdale Creek with potential for influence from Parcel B (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.

2.2.3.2 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).

[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."*

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.

2.2.3.3 Crisp Creek

Crisp Creek is not 303(d) listed for any "Category 5" parameters under the 2004 current EPA-approved listing. Crisp Creek near its confluence with the Green River is proposed to the EPA for 303(d) listing in 2008 for fecal coliforms, based on 2004 and 2005 data showing 15 percent and 21 percent (respectively) of samples exceeded the 200 CFU/100 mL percent criterion. Sampling in 2006 met all criteria for fecal coliforms.

2.2.3.4 Green River

Green River in the vicinity of the project (at RM 41.5) exceeded the temperature criterion based on unpublished King County measurements in all years between 1998 and 2002. The Green River is included in the draft 2008 proposed list to EPA as Category 5 impaired for temperature in a reach from south of the project downstream to the Crisp Creek confluence based on exceedence of the 7 day mean maximum temperature criterion of 16°C in summer of 2006.

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.
- Sites that disturb greater than 20 acres are required to measure turbidity with a turbidimeter. The permit allows turbidity monitoring for smaller sites (less than 20 acres) to be measured using a less expensive transparency tube.
- 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 surface discharges from the project site occur to Rock Creek which drains 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 in the Lake Sawyer watershed, and that enhanced treatment is required for all portions of the project with multifamily or commercial/retail, office, or multi uses that discharge to surface waters.

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 Villages proposal are described in this section. Water quality monitoring was conducted during storms and during between-storm baseflows by A.C. Kindig & Co. at the following locations to supplement the historic data record for waterbodies in the vicinity of the site:

- Ravensdale Creek (offsite) at the closest point to the northwest corner of Basin 7 (by AESI on 5/1/2000 and by AC Kindig & Co 5 times between 12/12/2006 and 4/12/2007);
- Green River Springs (offsite) at SE Green Valley Road south of Basin 4 (on 3/8/2007);
- Rock Creek (offsite) at Auburn-Black Diamond Road (5 times between 12/12/2006 and 4/12/2007);

- Black Diamond Lake bog moat and bog mat stations (2/15/2007 and 2/28/2007); and
- Stream S4 at the north boundary of Basin 6 (5/9/2008).

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

2.3.1.1 Black Diamond Lake

Black Diamond Lake is a bog wetland partially located in Basin 4 of the site, with an outlet tributary to Rock Creek. Wetland Resources, Inc. (2008) describes Black Diamond Lake in more detail as it pertains to wetland characteristics. Black Diamond Lake is a shallow lake that drains through tributary WRIA 09-0085A to Rock Creek. The lake is about 13 acres in size with a total watershed area of 700 acres (city of Black Diamond 1996). The watershed that actually supports hydrology in Black Diamond Lake is relatively small, as is typical of bog wetlands (Associated Earth Sciences 2000a).

King County identified Black Diamond Lake as a sphagnum bog (Hansen 1999). Sphagnum bogs typically are formed in wet depressions that over time form thick peat and sphagnum deposits, are nutrient poor, acidic, anoxic (low oxygen) and have low temperatures.

The City of Black Diamond reported some historic water quality data for Black Diamond Lake in its Comprehensive Plan (City of Black Diamond 1996), collected at the wetland outlet to Tributary 09-0085A. These data showed low turbidity and total suspended solids, low dissolved oxygen, low hardness, and low nutrients. Fecal coliforms were moderate at 41 CFU/100 mL. A.C. Kindig & Co. monitored water quality twice for a suite of bog-related parameters during the

wet season at two stations in Black Diamond Lake bog; one located in the mat portion of the bog and one located in the moat. The results of the A.C. Kindig & Co. monitoring within the bog are shown in Tables 2-3 and 2-4.

The mat portion of a bog is where sphagnum moss regulates pH and vegetation unique to bogs forms a floating "raft" or mat. This area is typically surrounded by a "moat" of open water. Bog vegetation is adapted to low pH, low alkalinity, low mineral, and low nitrogen conditions. When those conditions change, other types of non-bog wetland vegetation will out-compete bog-adapted vegetation.

The Black Diamond Lake bog showed water quality typical of sphagnum bogs. Water quality in the central mat is low in pH (acidic), low in alkalinity and minerals, and low in nitrogen. Water quality in the moat, as expected was somewhat higher in pH, higher in alkalinity and minerals, and higher in nitrogen. Like most wetland systems but particularly bogs that form in near-stagnant water conditions where flow through water is low in volume and generally restricted to groundwater recharge, dissolved oxygen was naturally low in the moat due to decomposing vegetation. At the mat station, photosynthesis raises oxygen levels in the water (relative to the moat). Although some parameters were outside of water quality standard ranges intended for conventional waters, all parameters were consistent with those naturally expected in a healthy bog, and none would be considered in violation of water quality standards for that reason.

2.3.1.2 Stream S4

Stream S4 is a tributary with some influence from SR-169 runoff, which it parallels before flowing north off-site from Basin 6 to Jones Lake in the Rock Creek / Lake Sawyer basin. Cedarock Consultants, Inc. (2008) describes Stream 4 in more detail as it pertains to fish habitat characteristics.

A.C. Kindig & Co. monitored water quality once for conventional stormwater parameters during spring of 2008 as soon as stormwater plans by Triad Associates, Inc. indicated it would be a treated stormwater receiving water under the proposed action. The results of that monitoring are shown in Table 2-5. Stream S4 has poor water quality with regard to low dissolved oxygen and somewhat elevated total petroleum hydrocarbons. The low oxygen is attributed to ground-

Table 2-3. Water Quality Monitoring Results for Black Diamond Lake (Moat Station)

Bog Parameter Measurements

Parameter	Units	Storm 2/15/2007	Storm 2/28/2007	Combined Average	State Standards[(a)]
Temperature	^{o}C	1.3	3.5	2.4	<16
Dissolved Oxygen	mg/L	7.02	6.67	6.84	>9.5
Dissolved Oxygen	% saturation	50.5	43.8	47.2	<110% total gasses
pH		5.77	5.04	5.40	6.5 – 8.5
Conductivity	µmhos/cm^2	42	37	39	n/a
Turbidity	NTU	2.6	3.9	3.2	< 5 over natural background
Alkalinity ($CaCO_3$)	mg/L	6	4	5	n/a
Calcium	mg/L	4.2	4.0	4.1	"no sheen"
Potassium	mg/L	0.32	0.11	0.22	"no sheen"

Parameter	Units	Storm 2/15/2007	Storm 2/28/2007	Combined Average	State Standards[(a)]
Magnesium	mg/L	1.3	1.3	1.3	n/a
Sodium	mg/L	2.3	2.4	2.4	n/a
Ammonia-nitrogen	mg/L	0.056	0.050	0.053	2.3[(b)]
Nitrate and Nitrite-Nitrogen	mg/L	1.20	0.47	0.84	n/a
Total Phosphorus	mg/L	0.028	0.018	0.023	n/a
Hardness	mg/L	6	15	10.5	n/a

Table 2-4. Water Quality Monitoring Results for Black Diamond Lake (Mat Station)

Bog Parameter Measurements

Parameter	Units	Storm 2/15/2007	Storm 2/28/2007	Combined Average	State Standards[(a)]
Temperature	^{o}C	1.4	2.5	2.0	<16
Dissolved Oxygen	mg/L	10.4	13.5	12.0	>9.5
Dissolved Oxygen	% saturation	74	86	80	<110% total gasses
pH		6.05	4.12	5.08	6.5 – 8.5
Conductivity	µmhos/cm^2	11	25	18	n/a
Turbidity	NTU	5.2	14.8	10.0	< 5 over natural background
Alkalinity ($CaCO_3$)	mg/L	<1	<1	<1	n/a
Calcium	mg/L	0.26	1.5	0.88	"no sheen"
Potassium	mg/L	<0.1	0.32	0.18	"no sheen"
Magnesium	mg/L	0.05	0.31	0.18	n/a
Sodium	mg/L	0.34	0.71	0.52	n/a
Ammonia-nitrogen	mg/L	0.022	0.033	0.028	2.3[(b)]
Nitrate and Nitrite-Nitrogen	mg/L	<0.01	0.048	0.026	n/a
Total Phosphorus	mg/L	0.034	0.090	0.062	n/a
Hardness	mg/L	1.1	5	3.0	n/a

NTU – Nephelometric turbidity 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) Chapter 173-201A WAC.
(b) Total ammonia criterion for 15°C and pH of 7.0

Table 2-5. Water Quality Monitoring Results for Stream 4 at the North Boundary of Basin 6

Parameter	Units	Baseflow 05/09/2008	State Standards[(a)]
Estimated Flow	CFS	<0.1	n/a
Temperature	^{o}C	8	<16
Dissolved Oxygen	mg/L	7.0	>9.5
Dissolved Oxygen	% saturation	62	<110% total gasses
pH		6.8	6.5 – 8.5
Conductivity	µmhos/cm^2	72	n/a
Turbidity	NTU	2.9	< 5 over natural background

Parameter	Units	Baseflow 05/09/2008	State Standards[(a)]
Total Suspended Solids (TSS)	mg/L	2.0	n/a
Oil and Grease	mg/L	3.9	"no sheen"
Petroleum Hydrocarbons	mg/L	3.2	"no sheen"
Biochemical Oxygen Demand	mg/L	<2	n/a
Alkalinity	mg/L	12	n/a
Ammonia-nitrogen	mg/L	0.035	2.3[(b)]
Total Nitrogen	mg/L	0.13	n/a
Nitrate and Nitrite-Nitrogen	mg/L	0.52	n/a
Ortho Phosphate	mg/L	<0.005	n/a
Total Phosphorus	mg/L	0.008	n/a
Hardness	mg/L	21	n/a
Dissolved Copper	µg/L	<1	2.99[(c)]
Dissolved Lead	µg/L	<1	0.44[(c)]
Dissolved Zinc	µg/L	<1	27.8[(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 15°C and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (21 mg/L).

water recharge, which can be low in oxygen, because biochemical oxygen demand is very low. The elevated total petroleum hydrocarbon is attributed to SR 169 which discharges untreated stormwater to Stream S4. All other parameters including turbidity, suspended solids, nutrients, biochemical oxygen demand, fecal coliforms, and dissolved metals were low and are considered in the good water quality range.

2.3.2 Offsite Watercourse Surface Water Quality

2.3.2.1 Jones Lake

Stream S4 drains 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. 2000a). 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. 2000a). 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 2-6.

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 2-6. 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	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 15°C and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (39 mg/L).

2.3.2.2 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 Villages site and Ravensdale Creek. However, the creek runs within ¼ mile of the northwesternmost point of Basin 7 North, and is recharged with water infiltrated to alluvial soils in that basin.

Ravensdale Creek was sampled once by AESI (2000a) 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 2-7. These data confirm Ravensdale Creek has excellent water quality with moderately low hardness, low dissolved metals, and low total phosphorus concentrations.

2.3.2.3 Rock Creek

Rock Creek passes through part of Basin 5 onsite. Offsite, Rock Creek drarins Jones Lake and flows 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 2-8. 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.

Table 2-7. 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 15°C and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (42 mg/L).

Table 2-8. 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	^{o}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 15°C and pH of 7.0* *(c) Dissolved metal chronic standard at average hardness (67 mg/L).*

2.3.2.4 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 Basins 5, 6, and 7 of The Villages.

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 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 2-9).

Table 2-9. 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

2.3.2.5 Green River Springs

The Green River Springs (located offsite) are a surface water feature indicative of ground water discharged to the springs that originate from infiltration of water to landslide masses adjacent to the southern portion of Basin 4. These springs were monitored once for groundwater quality parameters in March 2007 and once for conventional surface water quality parameters in May 2000. The results are shown in Table 2-10. With the minor exception of turbidity, which could be related to sampling from the springs, all parameters were within surface quality standards.

Table 2-10. Water Quality Monitoring Results for the Green River Springs

Parameter	Units	Baseflow 5/1/2000	Baseflow 3/8/2007	State Standards[(a)]
Estimated Flow	CFS	not measured	0.2	n/a
Temperature	^{o}C	12.2	9.2	<16
Dissolved Oxygen	mg/L	6.8	11.0	>9.5
Dissolved Oxygen	% saturation	64	100.4	<110
pH		7.4	6.6	6.5 – 8.5
Conductivity	µmhos/cm^2	94	118	n/a
Turbidity	NTU	8.2	1.7	< 5 over natural background
Oil and Grease	mg/L	<0.2	not measured	"no sheen"
Biochemical Oxygen Demand	mg/L	2.0	not measured	n/a
Ammonia-nitrogen	mg/L	<0.005	not measured	2.3[(c)]
Nitrate and Nitrite-Nitrogen	mg/L	0.11	<0.05	n/a
Hardness	mg/L	43	53	n/a
Dissolved Copper	µg/L	1	1[(b)]	6.06[(d)]
Dissolved Lead	µg/L	0.24	1[(b)]	1.12[(d)]
Dissolved Zinc	µg/L	1	4[(b)]	56.1[(d)]
Fecal Coliforms	CFU/100 mL	7	<2	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*
(a) Chapter 173-200 WAC.
(b) Total metals
(c) Total ammonia criterion for 15°C and pH of 7.0
(d) Dissolved metal chronic standard at average hardness (48 mg/L).

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.

2.3.2.6 Green River

The lower Green/Duwamish River Drainage Basin Water Resources Inventory Area [WRIA] 9 (Washington Department of Fisheries [WDF], 1975). The headwaters of the Green River originate on Blowout Mountain in the Cascade Mountains, 30 miles northeast of Mount Rainer. The Green River generally flows west and northwest. The river's flow is regulated by the Howard Hanson Dam at RM 53, which maintains the flow at or below 12,000 cfs. The site is located near about RM 42.

The physical characteristics and hydrology of the lower Green River system have been greatly altered. Most of these alterations occurred downstream of the site with significant impact on the river and its floodplain below about RM 32. However, in 1911 the City of Tacoma constructed a diversion dam at RM 61, a little over 2 miles east of Kanaskat, on the mainstem Green River to capture water for municipal and industrial water supply. Since that time, Tacoma has been diverting up to 113 cubic feet per second (cfs) from the mainstem Green River to meet population needs in Puget Sound. In 1962, construction of the Howard Hanson Dam at RM 64.5 further changed the hydrologic regime of the river. As a result of the dam, floods greater than approximately 12,000 cfs have been prevented, while the duration of moderate flows between 3,000 and 5,000 cfs has increased due to metered release of floodwaters stored behind the

dam. The dam also stores water during the summer to augment late summer flows (Kerwin and Nelson 2000).

Ecology has not collected water quality data at a Green River ambient monitoring station near the site since 1971. King County has collected near-monthly data in the Green River near Black Diamond at Station B319. Data from January 2006 through June 2008 for conventional parameters are shown in Table 2-11, along with metals data which include samples collected January 2006 through May 2007. Values below detection are represented at ½ the detection level. There are occasional oxygen supersaturation data greater than the maximum 110 percent saturation, and turbidity and total suspended solids are high during periods of high flow, but overall Green River water quality is good and all parameters other than oxygen saturation are within water quality standard criteria.

Table 2-11. Water Quality Monitoring Results for the Green River 2006 to 2008

Parameter	Units	Number	Mean	Range	State Standards[(a)]
Temperature	^{o}C	40	8.5	3.3 – 16.4	<16
Dissolved Oxygen	mg/L	40	11.6	9.3 – 13.1	>9.5
Dissolved Oxygen	% saturation	40	102.5	94.6 – 113.1	<110
pH		40	7.6	7.0 – 8.4	6.5 – 8.5
Conductivity	µmhos/cm^2	40	53.9	27.0 – 98.0	n/a
Turbidity	NTU	41	17.1	<2 – 543	< 5 over natural background
Total Suspended Solids	mg/L	40	23.1	0.3 – 566	n/a
Ammonia-nitrogen	mg/L	40	0.006	<0.1 – 0.035	2.3[(c)]
Nitrate and Nitrite-Nitrogen	mg/L	40	0.215	0.076 – 0.423	n/a
Total Phosphorus	mg/L	39	0.020	<0.008 – 0.181	n/a
Hardness	mg/L	13	23.9	15.4 - 58	n/a
Dissolved Copper	µg/L	10	0.224	<0.4 to 0.55	3.34 [(d)]
Dissolved Lead	µg/L	10	<0.2	<0.2	0.51 [(d)]
Dissolved Zinc	µg/L	10	<0.5	<0.5	31.08 [(d)]
Fecal Coliforms	CFU/100 mL	41	5 Geometric Mean	0	Geometric mean of <100

NTU – Nephelometric turbidity units *CFU – Colony-forming units*
n/a – not applicable or no numeric standard
(a) Chapter 173-200 WAC.
(b) Total metals
(c) Total ammonia criterion for 15°C and pH of 7.0
(d) Dissolved metal chronic standard at average hardness (23.9 mg/L).

2.3.2.7 Crisp Creek

Crisp Creek (WRIA 09-0113) is located about 0.75 miles from The Villages site, but has no direct surface water connection to the site. The creek is 3.55 miles long and enters the Green River at approximately RM 40.1 (WDF 1975). The watershed for Crisp Creek is about 5 square miles (Carlson 1994). Crisp Creek is the main water supply for the Muckleshoot Indian Tribe's Keta Creek Hatchery and the Washington State Department of Fish and Wildlife rearing ponds located at RM 1.1. The supporting hydrology for Crisp Creek is dominated by ground water recharge which enters the creek as springs approximately ½ mile upstream of the hatchery and state rearing ponds (Carlson 1994). Crisp Creek is considered to be in good water quality

condition historically, because of the relatively undisturbed and forested watershed (Herrera Consultants Inc. 2005). King County's long term trend analysis from 1979 to 2004 using data from King County Station 0321 near the mouth of Crisp Creek indicate water turbidity, ortho phosphorus have increased over the period, while nitrate and total nitrogen have decreased. All temperature, fecal coliform, dissolved oxygen, and pH measures in 2007 data met state water quality standards.

Historic water quality data for Crisp Creek were reported by Carlson (1994). The US Geological Survey monitored temperature at RM 0.9 between July 1, 1998 through August 31, 1998. Temperature ranged from 9.8^{o}C to 15.6^{o}C during this time period, and met Class A standards in effect at the time. The Municipality of Metropolitan Seattle monitored the stream at inflow to the state rearing ponds from January to December 1993. Total phosphorus and orthophosphorus ranged from 0.019 to 0.056 mg/L and from 0.01 to 0.026 mg/L, respectively. Nitrate averaged 0.69 mg/L and ranged from 0.56 to 0.92 mg/L. Ammonia ranged from 0.008 to 0.02 mg/L, which is within state water quality standards. Turbidity, temperature, fecal coliforms, and dissolved oxygen all met Class A water quality standards in effect at the time.

King County measures water quality in Crisp Creek approximately monthly for most conventional water quality parameters, and occasionally for metals, upstream of the hatchery (Station F321). Only conventional parameters were collected at Crisp Creek near its mouth at the Green River (Station 0321). Conventional water quality data for January 2006 through June 2008 are shown in Table 2-12 for Crisp Creek near its confluence with the Green River along with dissolved metals data from the station above the hatchery collected between November 2001 and November 2003. Fecal coliforms are occasionally high; 17 percent of the 41 samples had values over 200 CFU/100 mL which exceeds the state criterion, which likely is a result of the artificial fish rearing upstream of the station. Otherwise, Crisp Creek has good water quality consistent with state standards.

Table 2-12. Water Quality Monitoring Results for the Crisp Creek 2006 to 2008

Parameter	Units	Number	Mean	Range	State Standards[(a)]
Temperature	^{o}C	40	9.7	6.4 – 13.5	<16
Dissolved Oxygen	mg/L	40	10.5	8.1 – 11.6	>9.5
Dissolved Oxygen	% saturation	40	96.0	77.5 – 107.5	<110
pH		40	7.5	6.8 – 8.3	6.5 – 8.5
Conductivity	µmhos/cm^2	40	116.6	86.0 – 135	n/a
Turbidity	NTU	41	1.9	<2 – 16.3	< 5 over natural background
Total Suspended Solids	mg/L	40	7.4	1.4 – 29.8	n/a
Ammonia-nitrogen	mg/L	40	0.068	<0.015 – 0.161	2.3[(c)]
Nitrate and Nitrite-Nitrogen	mg/L	40	0.739	0.527 – 1.60	n/a
Total Phosphorus	mg/L	39	0.048	0.029 – 0.127	n/a
Hardness	mg/L	20	44.1	30.1 – 52.0	n/a
Dissolved Copper	µg/L	17	0.196	<0.4 – 0.848	5.64[(d)]
Dissolved Lead	µg/L	17	0.013	<0.025	1.02 [(d)]
Dissolved Zinc	µg/L	17	0.229	<0.39	52.2 [(d)]
Fecal Coliforms	CFU/100 mL	41	47 Geometric Mean	3 - 710	Geometric mean of <100

NTU – Nephelometric turbidity units *CFU – Colony-forming units*
n/a – not applicable or no numeric standard
(a) Chapter 173-200 WAC.
(b) Total metals
(c) Total ammonia criterion for 15°C and pH of 7.0
(d) Dissolved metal chronic standard at average hardness (44.1 mg/L).

2.3.2.8 Horseshoe Lake

Horseshoe Lake is located in a topographic depression with no surface outlet. The lake receives discharge from the recessional outwash aquifer, including infiltration to the aquifer from portions of Basins 1 and 2 on the site. The lake recharges the pre-Olympia aquifer by extending down into it, which influences its water level. Discharge from Horseshoe Lake via the pre-Olympia aquifer recharges Crisp Creek near its confluence with the Green River.

Associated Earth Sciences (2000a) collected water quality data from Horseshoe Lake on May 1, 2000. Results are shown in Table 2-13.

Table 2-13. Water Quality Monitoring Results for Horseshoe Lake

Parameter	Units	Value on 5/1/2000	State Standards[(a)]
Temperature	°C	16.5	<16
Dissolved Oxygen	mg/L	6.8	>9.5
Dissolved Oxygen	% saturation	70	<110% total gasses
pH		6.9	6.5 – 8.5
Conductivity	µmhos/cm^2	51	n/a
Turbidity	NTU	1.2	< 5 over natural background
Total Suspended Solids (TSS)	mg/L	2.0	n/a
Oil and Grease	mg/L	0.23	"no sheen"
Biochemical Oxygen Demand	mg/L	1.0	n/a
Ammonia-nitrogen	mg/L	<0.005	2.3[(b)]
Nitrate and Nitrite-Nitrogen	mg/L	0.33	n/a
Ortho Phosphate	mg/L	<0.005	n/a
Total Phosphorus	mg/L	<0.005	n/a
Hardness	mg/L	17	n/a
Dissolved Copper	µg/L	1	2.5[(c)]
Dissolved Lead	µg/L	0.24	0.35[(c)]
Dissolved Zinc	µg/L	6	23.3[(c)]
Fecal Coliforms	CFU/100 mL	12	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 15°C and pH of 7.0
(c) Dissolved metal chronic standard at average hardness for station (17 mg/L).

2.4 Groundwater Quality

King County maps the entire Villages site, including the North Property, as being outside of any wellhead protection or critical recharge areas (Figure 2-2). Some of the Villages site is underlain by till but most of the site is suitable for infiltration. See Associated Earth Sciences, (2008) for detailed discussion pertaining to groundwater quality and the nature of soils on the site. See Section 2.1.2 for a brief summary of groundwater conditions relevant to this analysis.

King County has no groundwater sampling sites in the vicinity. Groundwater monitoring by Golder Associates (2008) in wells completed in the shallow aquifer (wells MW-08, MW-09, and DH-3) and in the pre-Olympia aquifer (wells MW-6, MW-7, MW-10, MW-12, MW-13, MW-17) on the site in November 2006. Some of the data from Golder Associates are summarized in Tables 2-14 and 2-15.

Table 2-14. Shallow Aquifer Water Quality

Parameter	Units	N	Average	Range	State Standard 246-290-310 WAC
pH		2	5.935	5.73 – 6.14	6.5 – 8.5
Temperature	^oC	2	7.9	5.7 – 10.1	n/a
Conductivity	µmhos/cm^2	2	30.15	17.2 – 43.1	700
Turbidity*	NTU	2	208.5	137 – 280	1
Fecal Coliforms	CFU/100mL	3	<1		1
Hardness	mg/L as $CaCO_3$	3	24	11 – 33	n/a
Total Phosphate	mg/L	0	<0.005		n/a
Total Copper	µg/L	3	2.5	<1 – 4	1,000
Total Lead	µg/L	0	<1		50
Total Zinc	µg/L	3	12	2 – 32	5,000

**The high turbidity values are assumed to be an artifact of sampling unlikely to occur in the aquifer.*

Table 2-15. Pre-Olympia Aquifer Water Quality

Parameter	Units	N	Average	Range	State Standard 246-290-310 WAC
pH		6	6.51	6.11 – 6.88	6.5 – 8.5
Temperature	^oC	6	9.3	8.7 – 10.0	n/a
Conductivity	µmhos/cm^2	6	58.2	31.9 – 74.8	700
Turbidity*	NTU	6	39.4	0.7 - 200	1
Fecal Coliforms	CFU/100mL	6	<1		1
Hardness	mg/L as $CaCO_3$	6	51	30 - 68	n/a
Total Phosphate	mg/L	4	0.031	0.019 – 0.048	n/a
Total Copper	µg/L	6	3	<1 - 4	1,000
Total Lead	µg/L	6	<1		50
Total Zinc	µg/L	6	7	3 - 13	5,000

**The high turbidity values are assumed to be an artifact of sampling unlikely to occur in the aquifer.*

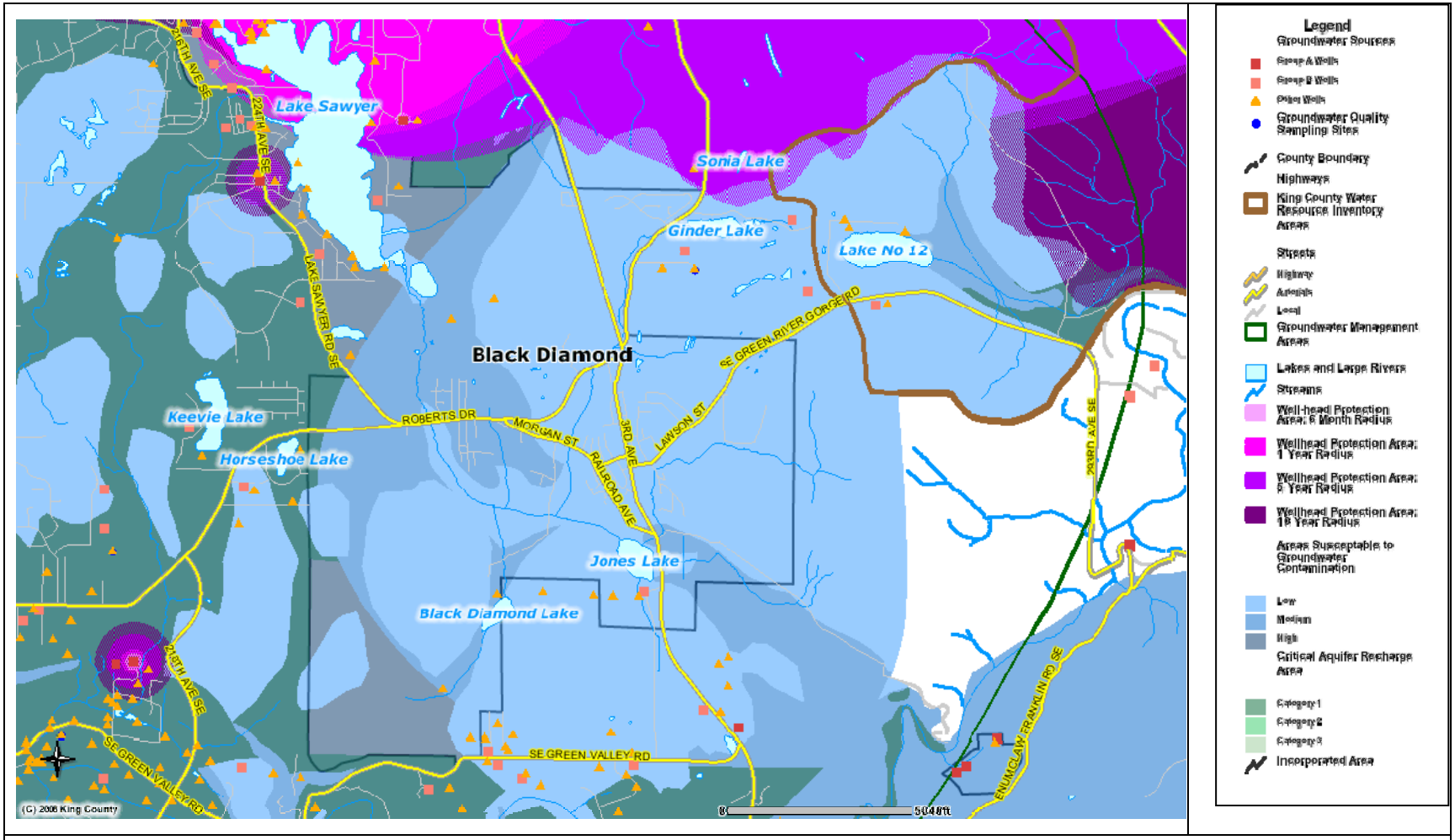

Figure 2-2. King County iMAP Groundwater Program Mapping of The Villages Site and Vicinity

3.0 IMPACT EVALUATION

3.1 Construction

Construction of The Villages would occur in response to market demand but is expected to commence in 2010 with construction complete by 2025 under the Proposed Action. Residential, commercial, and school construction would be staged over a period of about 15 years. Under the No Action Alternative 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 or longer.

Phasing of construction in two broad categories would occur over each portion of the property as described below. The order and number of basins developed at a time would be determined in response to market demand.

Phase I in each portion of the property would consist of site preparation, main stormwater pond and infiltration basin construction or storm pond and discharge outlet(s) (as applicable), and infrastructure construction. That work involves clearing and grading. While this work is ongoing and prior to completion of the main stormwater system, stormwater would be collected in temporary sediment ponds and traps located at various points throughout the site, that are pumped or gravity flow to temporary infiltration basins or permanent basins not excavated to final design depth to protect the permanent infiltration soils. The temporary ponds would serve the site during the dry part of the first construction season while the larger ponds and/or infiltration system(s) is constructed. The sediment ponds and traps would be sized to a 2-year storm flow criterion as required under the 2005 Manual, except for the Lake Sawyer watershed basis 5, 6, and 7 where the ponds and traps would be sized to the 10-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 Basins 6 and 7) or to remove fine sediments prior to infiltration (in Basins 1 through 5). In Basin 5 which drains to Rock Creek and Lake Sawyer, construction stormwater would be (temporarily) pumped after preliminary treatment to temporary infiltration site(s) in Basins 1 through 3 to prevent introduction of phosphorus-bearing fine sediments to Lake Sawyer. Over most portions of the site 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 beyond the first construction season in any portion of the property, enhanced treatment by chitosan or electrocoagulation would be employed prior to infiltration or discharge.

Phase II would consist of clearing, grading, utility construction and development of individual parcels in each area of the site under construction. 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 or to temporary infiltration basins, until each portion of the site is stabilized at the end of construction and the permanent stormwater facilities are brought online. Over most of the site (basins 1 through 4 and 7 north), these consist of localized Low Impact Development treatments and infiltration. Over till portions of the site (basins 5, 6, and 7 south), the permanent facilities would consist of ponds and surface discharges.

All outfalls under all phases would be constructed during the dry season and ground cover reestablished prior to the next wet season. Disturbed areas would be mitigated as described by Cedarock Consultants Inc. and Wetland Resources Inc. for the project.

3.1.1 Construction Impacts Under the Proposed Action

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 2025 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. 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.

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. AESI (2008) characterized the risk of erosion at The Villages site as falling into three categories (low, moderate, and high). Most of the site is in the low erosion hazard zone. Most areas with slopes over 15 percent are in the moderate erosion hazard zone, which are small in size and scattered throughout the site. A narrow band of steeper area just east of Black Diamond Lake is in the high erosion zone, along with a small portion of northern Basin 7 North. The entire high erosion hazard zone with the exception of parcel 53 in Basin 7 North is outside of the proposed construction footprint, and is protected by sensitive area ordinance buffer requirements for steep slopes and the Black Diamond Lake wetland. Erosion control BMPs in the moderate erosion hazard areas and the single small high erosion hazard area in Basin 7 North 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; and AESI 2008).

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 moderate 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.

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 Villages project.

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

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	The Villages 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, steep slopes 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
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

Measure	Manual Description and Site Applicability	The Villages Utilization	Ecology 2005 Manual BMP Reference
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
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

Measure	Manual Description and Site Applicability	The Villages Utilization	Ecology 2005 Manual BMP Reference
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
Management	Designated individual as CESCL lead	A CESCL lead would 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

Measure	Manual Description and Site Applicability	The Villages Utilization	Ecology 2005 Manual BMP Reference
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 steeper slopes during construction as warranted to prevent gullies, channel erosion and/or saturation of any 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 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
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

Measure	Manual Description and Site Applicability	The Villages Utilization	Ecology 2005 Manual BMP Reference
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
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 3.1.3 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

Measure	Manual Description and Site Applicability	Ecology 2005 Manual BMP Reference (Vol. II)
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

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).

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 Villages 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 Villages 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 Villages 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 or near the Ordinary High Water Mark

The following work below or near the ordinary high water mark (OHWM) is proposed under the Proposed Action:

- A 40-foot wide road crossing of Stream S2;
- A 40-foot wide road crossing of Wetland A6;
- A temporary 50-foot wide crossing of Wetland G for sewer and stormwater lines (subsurface placement);
- A 40-foot wide road crossing of Stream S4 and Wetlands S1/S2, S3/S4, S6/S7/S8, Q and S4 East;
- A temporary 50-foot wide crossing of Wetland S3/S4 and Wetland S6/S7/S8 for utilities lines (subsurface placement); and
- A stormwater outfall to Wetland S18/S19/S20 and Stream S4.

The new Stream S4 crossing would be a full span or bottomless arch-culvert, which would avoid work within the OHWM (see Cedarock Consultants, Inc. 2008). The new Stream S5 crossing would occur at or near an existing logging road crossing. Removal of the old crossing (if that occurs) and mitigation at the existing crossing removal would require work within the OHWM. The stream is small with very low flow, so crossing removal and restoration would occur during the summer when ordinary construction BMPs would suffice to prevent adverse water quality impacts. Stream S-2 is non fish bearing and infiltrates entirely, so work during the dry season and typical BMPs are reasonably expected to prevent direct impacts and there is no potential for downstream impacts. BMPs would include conditions established for the Hydraulics Project Approval (HPA) that would be required for the work from the Washington State Department of Fish and Wildlife and requirements of the NPDES SWPPP. Construction BMPs described above which are 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 the stream crossings are anticipated.

Offsite road improvements may require paving and shoulder work along the Auburn-Black Diamond Road near crossings of Rock Creek and one or two small tributaries. This work could also require HPA, as short extensions of existing crossings may be needed. This work would also be performed during low flow and no unusual construction BMPs are anticipated required to protect water quality until the sites are restabilized.

Wetland crossings and impacts, permitting, and mitigation are described by Wetland Resources, Inc. (2008). Construction BMPs, NPDES SWPPP requirements, and any conditions resulting from Section 404 permitting (if warranted) would be followed to prevent adverse water quality impacts from construction with direct impacts to wetlands.

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 wetlands or small streams near the construction activity. 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.

In the Black Diamond Lake (wetland bog) watershed, all construction drainage would be temporarily diverted for treatment and discharge to infiltration or other legal reuse or disposal outside of the bog basin.

3.1.7 Offsite Work

Some work may occur along the Auburn Black Diamond Road, as described above in Section 3.1.4.

For offsite utility work, 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 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 3.3.1).

Offsite trenching for sewer placement would occur to varying degrees depending on the routing that is implemented. Trenching is described in Section 3.1.4 above where it would impact wetlands. 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 Mitigating Features Incorporated into The Villages 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. Temporary conveyance of construction discharge from Basin 2 to Basins 1 and/or 3 and from the Black Diamond Lake watershed would prevent phosphorus loadings to Lake Sawyer and bog impacts to Black Diamond Lake respectively. In Basin 6, Jones Lake is the more immediate receiving water and it is not designated as impaired for total phosphorus. 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 Villages construction plan under the Proposed Action 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.

- Construction discharge from Basin 2 would be temporarily conveyed for infiltration in Basins 1 or 3 after treatment to prevent the potential for phosphorus loading increases to Lake Sawyer via Rock Creek
- Construction discharge generated in the Black Diamond Lake basin would be conveyed to infiltration after treatment elsewhere in Basin 4 to prevent bog impacts.

3.1.9 Probable Scale of Construction Impacts under the Alternatives

Proposed Action: 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.

No Action: 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 and are less likely to consider the use of new technologies for erosion control than the proposed Master Plan project. The degree of control of fine sediments and the level of treatment before discharge is unlikely to be equivalent to that proposed for The Villages by all projects that may occur under the No Action Alternative.

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 by Triad Associates (2008). See Figure 2-1 for a map of the developed basins 1 through 8. Stormwater would be managed consistent with the Ecology 2005 Manual as indicated in Table 3-3 for the Proposed Action. Table 3-3 shows the general routings for infiltrated and surface discharge from each of the basins (described in detail by Associated Earth Sciences, 2008); the proposed land uses which are described in more detail in Section 3.2.5 of this report; the Ecology 2005 Manual water quality design requirement; and the type of water quality facility assumed for this analysis. Note that although specific facility types are listed for the purposes of analysis, any facility option included in the Ecology 2005 Manual as satisfying the treatment standard could be employed at final design. Portions of the conceptual plan where more than the minimum required standard is proposed are indicated in the “comment” column in Table 3-3.

All stormwater runoff from pollution-generating surfaces Basins 1 through 4 (including the two pond basins 3 and 4) would be infiltrated after treatment. Rooftops are infiltrated directly where alluvial soils exist at the surface, and are relied upon to maintain water balance in some portions of the site, for example within the Black Diamond Lake bog watershed, which would only receive infiltrated rooftop runoff[2], and within ¼ mile of Horseshoe Lake. All pollution-generating surface runoff is planned to be directed out of the Black Diamond Lake bog watershed for treatment in Pond 4 and infiltration to the pre-Olympia Aquifer. All runoff from pollution generating runoff within ¼ mile of Horseshoe Lake in Basins 1 through 3 would be conveyed south for treatment and infiltration at Pond 3.

[2] The conceptual plan calls for maintaining the existing water balance to Black Diamond Lake using only natural rainfall in undisturbed open areas and infiltrated runoff from non pollution generating single family roofs. It is possible that final design calculations will determine it is necessary to augment the water balance with discharge of treated runoff from some single family yards (not driveways or roads) to non-bog wetlands above Black Diamond Lake, but this contribution is expected to be very minor if it is necessary at all. If necessary, bioretention or other LID-category method for storm treatment would be proposed on a local scale to promote infiltration within the basin. The small scale nature of this contribution, if any, would not cause a measurable impact because of the low impact use involved, the small scale involved, the LID treatment, and the dispersion to buffers of natural wetlands above the bog.

Table 3-3. Water Quality Treatment for the Proposed Action

Basin	Receiving Water(s)	Land Uses	Treatment Design Standard	Treatment Modeled	Comment
1-3	Infiltration to Shallow Aquifer recharges Horseshoe Lake (> ¼ Mile Distance*); which recharges the pre-Olympia Aquifer which recharges Crisp Ck / Green River confluence	HDR Commercial Civic	Basic	50% Bioretention 50% Biofiltration Swale	Basic is required; At least 50% of runoff is proposed to have enhanced treatment
		LDR, MDR	Basic	Biofiltration Swale	
Pond 3	Deep Infiltration to Pre-Olympia Aquifer which recharges Crisp Ck / Green River confluence	Arterial LDR MDR HDR Mixed Use Commercial School	Basic	Basic Wet Pond	
4	Infiltration to Shallow Aquifer recharges pre-Olympia Aquifer which recharges Crisp Ck / Green River confluence	Commercial HDR, MDR, LDR	Basic	50% Bioretention 50% Biofiltration Swale	Basic is required; At least 50% of runoff is proposed to have enhanced treatment
Pond 4	Deep Infiltration to pre-Olympia Aquifer which recharges Crisp Ck / Green River confluence**	Arterial HDR, MDR, LDR	Basic	Basic Wet Pond	
5	Rock Creek to Lake Sawyer	MDR, LDR	Basic / Phosphorus	Large Wet Pond	
6	Stream 4 to Jones Lake to Rock Creek to Lake Sawyer	Arterial LDR	Basic / Phosphorus	Large Wet Pond	
7 North	Infiltration to Shallow Aquifer which recharges Ravensdale Ck (<¼ mile), which flows to Lake Sawyer	Arterial, Commercial MDR	Enhanced / Phosphorus	Basic Wet Pond + Basic Sand Filter	
7 South	Wetland B4 to shallow infiltration which recharges Ravensdale Ck (> ¼ mile), which flows to Lake Sawyer		Basic	Large Wet Pond	Basic is required; Phosphorus treatment is proposed.

HDR = High Density Residential (~ 14 DU/ac); MDR = Medium Density Residential (~ 9 DU/ac); LDR = Low Density Residential (~ 5 DU/ac).
(HDR is assumed multifamily; MDR and LDR are single family)

***** *All impervious pollution generating surface w/in ¼ mile of Horseshoe Lake (Parcels 5, 6, & 14) is directed to Basin Pond 3. Water balance is maintained by infiltration of rooftops and pervious surfaces in Parcels 6 and 14. Parcel 5 would be filled with native till, preventing infiltration.*

*** Existing storm recharge in the Black Diamond Lake bog watershed would be matched by rooftop infiltration; all runoff from pollution-generating surfaces in the bog watershed would be conveyed to Pond 4.*

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 pollution-generating surfaces would be treated as described in Table 3-3. At final design, any facility type (and any combination of facilities) meeting the basic treatment, phosphorus treatment, and/or enhanced treatment criteria (as defined in the Ecology 2005 Manual) could be employed. In some cases more than minimum required treatment requirements are proposed in Table 3-3. The facilities to meet the more than minimum standard design that is proposed could still be varied at final design so long as they satisfied the greater-than-required standard that is proposed. 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 2025 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. 2000b and 2000c; A.C. Kindig & Co. 2002a and 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. In freshwater, the toxicity of all three dissolved metals varies with hardness, because the dissolved, divalent (double positive charge) ion of heavy metals is the toxic form. The harder the water, the lower the toxicity because divalent ion concentrations decline. Dissolved metals are the basis for state water quality standards which vary according to water hardness.

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) and to salmonids (Eisler 1998; Hansen et al. 1999). 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, although some sub-lethal fish behavioral avoidance has been noted in freshwater studies at relatively low levels for juvenile rainbow trout at a hardness below 6 mg/L as $CaCO_3$ (Sprague 1968). Zinc toxicity has not been noted in salmonids chronically exposed to concentrations at concentrations below 100 µg/L dissolved zinc for periods of 14 days to complete life cycles (Eisler 1993), except for a bull trout fry 120 day assay which found toxicity at about 36 µg/L dissolved zinc (Hansen et al 2002). These are very high concentration exceeding that generally found in untreated and undiluted urban stormwater, and lasting far longer than any stormwater runoff would occur. Washington State water quality standards for zinc 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).

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 The Villages, 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^{o}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 ^{o}C. On an average annual basis, discharge would be far cooler.

These discharge temperatures are within the range of water quality standard criteria where discharge to surface water occurs in basins 5 and 6. Basin 7 discharges to wetland B4 which lacks an open water component and then infiltrates, and basins 1 though 4 discharge to

infiltration. Stormwater discharge temperature to surface water is expected to be well within water quality standards and is not analyzed further.

3.2.3 Water Quality Analysis Methods Summary

Treated stormwater from the project is quantitatively analyzed for impacts to the following:

1. The two groundwater aquifers:
    a. Shallow Aquifer; and
    b. Pre-Olympian Aquifer; and
2. Each of direct or indirect surface receiving waters:
    a. Horseshoe Lake (indirect via the Shallow Aquifer);
    b. Crisp Creek / Green River confluence (indirect via the Shallow Aquifer, pre-Olympia Aquifer, and Horseshoe Lake);
    c. Rock Creek (direct);
    d. Stream 4 (direct);
    e. Ravensdale Creek (indirect via Wetland B4 and the Shallow Aquifer); and
    f. Lake Sawyer (indirect via Rock Creek, Stream 4, and Ravensdale Creek).

The stormwater influences on each of these receiving waters from the Proposed Action are quantified from contributing catchments as shown in Table 3-4.

Table 3-4. Receiving Water Contributing Basins Proportionately Combined for Stormwater Analysis

Receiving Water	Contributing Basins	Nature of Discharge	Comment
Shallow Aquifer (Basins 1-4)	Basins 1, 2, 3, and 4	Infiltration to Shallow Aquifer	Stormwater volumes are proportionately combined to evaluate combined impact from the project on the Shallow Aquifer from the main contiguous area of the project.
Pre-Olympian Aquifer	Ponds 3 and 4	Infiltration to Pre-Olympian Aquifer	Stormwater volumes are proportionately combined to evaluate combined impact from the project on the pre-Olympian Aquifer
Horseshoe Lake	Basins 1, 2, and 3	Infiltration to Shallow Aquifer	Stormwater volumes are proportionately combined to evaluate combined impact from the project on Horseshoe Lake. The analysis conservatively begins by direct comparison of the combined infiltrated stormwater to Horseshoe Lake background condition and water quality standards (in effect, as if the stormwater is piped directly to the lake, even though it is infiltrated and only indirectly reaches the lake via groundwater recharge).

Receiving Water	Contributing Basins	Nature of Discharge	Comment
Crisp Creek and Green River at Confluence	Basins 1, 2, 3, 4, and Ponds 3 and 4	Infiltration to Shallow and Pre-Olympian Aquifers	Stormwater volumes are proportionately combined to evaluate combined impact from the project on Crisp Creek and the Green River. The analysis conservatively begins by direct comparison of the combined infiltrated stormwater to background conditions and water quality standards of these surface waters (in effect, as if the stormwater is piped directly to them, even though it is infiltrated and only indirectly reaches Crisp Creek at its confluence with the Green River via groundwater recharge). The contributing area excludes the Horseshoe Lake contributing basin, which only indirectly reaches Crisp Creek via shallow aquifer groundwater flow into and pre-Olympian groundwater flow out of Horseshoe Lake.
Rock Creek	Basin 5	Discharge to Rock Creek	
Stream 4	Basin 6	Discharge to Stream 4	
Shallow Aquifer (Basin 7)	Basin 7 N and 7 S	Infiltration to Shallow Aquifer	Stormwater volumes are proportionately combined to evaluate combined impact from the project on the shallow aquifer from on-site infiltration from Basin 7N and offsite infiltration from Basin 7S.
Ravensdale Creek	Basin 7 N and 7 S	Infiltration to Shallow Aquifer (Basin 7N); and discharge to Wetland B4 followed by offsite infiltration to the Shallow Aquifer (with Basin 7S)	Stormwater volumes are proportionately combined to evaluate combined impact from the project on the shallow aquifer from on-site infiltration from Basin 7N and offsite infiltration from Basin 7S.
Black Diamond Lake Bog	None	Only rooftops are infiltrated	Because existing bog basin recharge would be matched by rooftop infiltration, and there is no treated discharge to this basin, there is no potential water quality impact to Black Diamond Lake bog requiring evaluation *(see earlier footnote 2).*

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 and civic runoff), retail or mixed use, single family (both low and medium density), multi-family (high density), arterial roadway, and managed park. All assessments are

for built-out conditions assumed by 2025. 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. Portions of the main "spine road" were analyzed in a separate "arterial road" category because where it was 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 (described in Section 3.2.5).
2. Storm runoff from different land use categories was proportionately mixed on the basis of contributing area (described in Section 3.2.5).
3. The quality of the combined inflow to each stormwater facility was modified by the expected performance of the stormwater facilities (described in Section 3.2.4).
4. The forecast quality of the treated discharge was directly compared (prior to dilution or mixing) to surface water quality standards or to ground water quality standards as appropriate, and to background water quality described in Section 2 of this analysis.

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 as shown in Table 3-3. 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 is expected to be employed on the site under the Proposed Action. These facilities could be constructed with an underlying sand filter that then infiltrates to native soils where they are suitable for that purpose. A biofiltration swale is an open, gently sloped, vegetated channel with design features that make it somewhat 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 some areas as shown in Table 3-3. 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. Filter strips are not assumed to be used, but they are a form of basic water quality treatment and when combined with sand filters provide enhanced and phosphorus treatments. 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 3-5. Dissolved metals removal is likely greater in bioretention facilities than in biofiltration facilities, but both were evaluated using the combined values shown in Table 3-5.

Table 3-5. 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 2000c (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
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				
Bioretention and Biofiltration (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) The bioretention rate of fecal coliform removal was used in the analysis where appropriate. The 90% literature value for fecal

coliform removal by bioretention was reduced to 80% using professional judgment, because only one datum was available. For biofiltration swales, zero fecal coliform removal was assumed.

3.2.4.2 Wet Ponds

"Large wet ponds" are assumed in Basins 5 and 6 that would be developed with single family residences in order to meet the Phosphorus Treatment requirements triggered by Lake Sawyer off-site and downstream. Other options could be employed under City codes that meet the Phosphorus Treatment requirements of the Ecology 2005 Manual. Basic wet ponds followed by basic sand filters are assumed for stormwater treatment in Basins 6 and 7. Basic wet ponds are assumed in Basins Pond 3 and Pond 4 before infiltration to the pre-Olympian Aquifer.

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.[3] The processes that remove contaminants in wet ponds include microbial degradation, 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 3-6.

[3] Vaults could be employed to treat and detain runoff from a minor area of frontage improvements on the Auburn Black Diamond Road if those improvements require water quality treatment when designed. 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 Rock Creek drainage catchment.

Table 3-6. 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			
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 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 3-7). 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 3-7. Basic 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 Basins 1 through 3 and 7 (Table 3-3), performance calculations derived from independent studies on wet ponds (Table 3-6) and sand filters (Table 3-7) were compared to field measures from a combined wet vault and sand filter facility in Lakemont, Washington (Table 3-8). 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 3-8. 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 3-8.

Table 3-8. 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 Ecology Embankments

The ecology embankment is a type of biofiltration facility developed by the Washington State Department of Transportation (WSDOT) and approved by Ecology with a general use designation for Basic, Enhanced, and Phosphorus Treatments (Ecology 2007b). The original general use designation issued by Ecology in November 2006 included a pilot use level designation for Oil Treatment; however that pilot designation was removed when the general use designation was updated in April 2007. Ecology embankments are linear flow-through facilities used along linear pollution-generating surfaces such as roadways. Stormwater flows from the sloped stormwater generating surface through a graveled non-vegetated zone, across a vegetated filter strip, filtered vertically through an "ecology mix bed" and collected in a gravel-filled underdrain trench or allowed to infiltrate where soils and conditions are suitable. Ecology embankments remove stormwater contaminants through physical filtration, ion exchange, carbonate precipitation, and biofiltration (WSDOT 2006; Herrera Environmental Consultants, Inc. 2006). Ecology's general use designation approval requires that ecology embankments be designed per RT.07 of the WSDOT 2008 Highway Runoff Manual including updates. The "ecology mix" filtration medium was updated (WSDOT 2007) since the general use designation issuance to clarify specifications for perlite, dolomite, gypsum, and crushed rock constituents of the mix.

To evaluate the systems as part of the Ecology approval process, WSDOT field-tested the ecology embankment system for 25 storms over a five-year period at a SR-167 site (Herrera Environmental Consultants, Inc. 2006). The median concentration-based contaminant removal findings are summarized in Table 3-6. Several parameters in Table 3-9 were not tested by WSDOT. Ecology embankment performance for these parameters was estimated using data from facilities similar to one or more of the ecology embankment features, such as sand filters, StormFilters™, and bioretention, as indicated in Table 3-9.

Table 3-9. Ecology Embankment Contaminant Removal Efficiencies (%)

Reference	TSS / Turbidity	TP	Ammonia-Nitrogen	Nitrate +Nitrite-Nitrogen	Dissolved Lead	Dissolved Zinc	Dissolved Copper	Fecal Coliforms	TPH
Herrera 2007 Ecology Embankment	94 / 82	86	nm	nm	nm	81	41	nm	47 (1)
City of Austin 1990 Sand Filter			76		80			36	
Shapiro 1999 Sand Filter				0	64				

Reference	TSS / Turbidity	TP	Ammonia-Nitrogen	Nitrate +Nitrite-Nitrogen	Dissolved Lead	Dissolved Zinc	Dissolved Copper	Fecal Coliforms	TPH
Associated Earth Sciences 2000 Sand Filter			45	0	60			35	
StormFilter™ Stormwater Management 1999, 2000a, 2000b.					30			45	75
Bioretention (Table 3-5)			40	33	71			80	74
Ecology Embankment Efficiencies	**90/80**	**85**	**40(2)**	**33(2)**	**70(2)**	**80**	**40**	**80(2)**	**70(2)**

TSS= total suspended solids; TP=total phosphorus; TPH = total petroleum hydrocarbons; nm = not measured.

(1) Herrera (2006) did not report ecology embankment removal of oil and grease, but did cite ACWA (2006) median removal shown for total petroleum hydrocarbon removal by media filters.

(2) The filter strip component is expected to perform as well as the ecology embankment for these parameters; since the ecology embankment has more removal mechanisms, actual performance is likely to be better than the estimate that was used in this analysis.

On The Villages site, ecology embankment facilities may be used for linear structures such as the main spine road. Since it meets basic, enhanced, and phosphorus treatment standards in the Ecology 2005 Manual, it could have broad utility on the site. At this stage of preliminary design, there are no locations where it would be applied with certainty. For that reason, ecology embankments are not included in this water quality analysis. If they are employed to any level, then water quality treatment would be equal to or increased over the level evaluated in this analysis, depending on parameter and land uses, as shown by the data presented in Table 3-9.

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.

<u>Bioretention and Biofiltration Swale Systems</u>
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.

<u>Wet Pond Systems</u>
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.

Ecology Embankment

If used, ecology embankment maintenance specifications by WSDOT (2006) include periodic inspection and repair of any physical damage. More specific maintenance responses to particular situations are listed in the Technology Evaluation and Engineering Report for Ecology Embankments (Herrera Environmental Consultants, Inc. 2006). These briefly include the following: restoration of the grass filter strip when sediment accumulations exceed two inches; re-leveling of the gravel flow spreader as needed to prevent channelized flow formation; replanting where more than 10% of the filter strip surface is bare, mowing to 3 to 4 inches to control weeds; replacement of ecology mix filter medium when ponding occurs during smaller storms, or on approximately a 10 year cycle; and removal of trash and debris.

Oil/Water Separators

Maintenance for oil/water separators includes monthly inspection monthly during the wet season of October 1st through April 30th, the removal of accumulated oil when thickness reaches 1-inch, removal of sludge deposits when thickness reaches 6-inches, and regular clean-out.

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. 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 3-10. Land Use Categories and Sources of Untreated Stormwater Data for the Water Quality Assessment

Land Use Category	Land Use Description and Source of Untreated Water Quality Data
Single Family Residential (Low to Medium Density)	**Single Family Residential** use is single family residential structures, landscaping, and associated access roadways. It includes medium density residential (averaging 9 dwelling units (DU)/acre) and low density residential (averaging 5 DU/acre). 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)	**Multi-Family Residential** includes multifamily structures 1 or more stories, including associated access roads, parking, and landscaping. The density would be approximately 14 DU/ac. 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	Land Use Description and Source of Untreated Water Quality Data
Mixed Use	**Mixed Use** includes small and midsize neighborhood retail services, and restaurants, multifamily residential (generally on the upper floors at a density of about 12 DU/ac) and associated access roadway surfaces, surface parking, and landscaping. Residential parking is often covered for mixed use development. 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, and overestimate parking lot influences since much mixed use parking would likely be covered. 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	**Commercial/Office** includes offices, research facilities, professional services, schools, civic buildings, related shipping and receiving, large box commercial, 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	Land Use Description and Source of Untreated Water Quality Data
Arterial Road	**Arterial** Roadways over 10,000 ADT are labeled "arterial" for the purposes of this analysis, and 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 busiest sections of The Villages 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: Offsite improvements to portions of the Auburn-Black Diamond Road frontage (including sidewalk) and/or entrance to the project may 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 and is assumed to be included with treatment and shallow infiltration in Basins 1 through 3 and with treatment and infiltration to the pre-Olympian Aquifer in Pond 3.*
Parks	**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 3-11. The sources of data in Table 3-11 are listed in Table 3-10.

Table 3-11. 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

Parameter	Units	Single Family Resid.	Multi-Family Resid.	Mixed Use	Comm. / Office / School	Arterial	Parks
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 Proposed Action within each of the eight receiving water category basins (see Table 3-4) were defined by the Dahlin Group and Triad Associates at buildout in 2025 (the ninth category basin, the Black Diamond Lake bog, is excluded because it would not receive storm runoff from pollution generating surfaces under any alternative). 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 3-12.

Table 3-12. Proportionate Contribution of Land Use Categories to Storm Runoff in Each Receiving Water Catchment *(Including sidewalks, roadway access, and landscaping allocations to each land use category)*

Direct or Indirect Receiving Water Catchment Categories	Single Family Resid.	Multi-Family Resid.	Mixed Use	Comm. / Office / Civic / School	Arterial	Parks
Shallow Aquifer (Basins 1-4)	54.4	20.7	6.4	16.9	0.4	1.1
Shallow Aquifer (Basin 7)	19.5	0.0	0.0	68.6	11.9	0.0
Pre-Olympian Aquifer	74.7	3.5	1.0	9.1	11.7	0.0
Horseshoe Lake	21.4	31.0	12.6	32.0	0.7	2.3
Crisp Creek at Green River	63.4	13.0	4.0	13.5	5.4	0.6
Rock Creek	100.0	0.0	0.0	0.0	0.0	0.0
Stream 4	68.4	0.0	0.0	0.0	31.6	0.0
Ravensdale Creek	19.5	0.0	0.0	68.6	11.9	0.0

NOTE: The Table 3-12 percentages are runoff-based, not acreage-based. There is overlap between some receiving water categories.

3.2.6 Water Quality Forecast Under the Proposed Action

Using the methods described above, treated storm water quality is quantitatively estimated for the Proposed Action at buildout in 2025 (Tables 3-13 through 3-19)[4]. The results for each discharge category are compared to surface or groundwater quality state standards as appropriate (Chapter 173A-201A WAC and Chapter 246-290-310 WAC, respectively) and to existing condition data for the receiving waters (described in Section 2 of this analysis). In the process, the cumulative impacts of dispersed infiltration on the Shallow and pre-Olympian Aquifers, Horseshoe Lake, Crisp Creek, Green River, and Ravensdale Creek are conservatively estimated by volume-proportionate combinations of the combined infiltrated discharges that would influence each receiving water (for example, combining the Basin 1 through 4 infiltration discharges as if they were one piped (and undiluted) discharge to Horseshoe Lake and Crisp Creek, even through the actual hydrologic pathway from the site is circuitous via the shallow aquifer to Horseshoe Lake, and via the shallow and pre-Olympian aquifers to Crisp Creek and the Green River. Actual impacts to these indirect receiving waters will be less than those conservatively estimated in this analysis because of the intervening aquifer passage and mixing of treated and infiltrated site stormwater with water in these aquifers.

3.2.6.1 Individual Discharge Impacts to Immediate Surface Receiving Waters for the Proposed Action

Quantitative forecasts for water quality in each surface stormwater discharge to each surface receiving water (before any dilution or mixing) are listed in Tables 3-13 and 3-14.

Rock Creek
After treatment for water quality stormwater discharges to Rock Creek would comply with water quality standards prior to any mixing or dilution (Table 3-13). Most stormwater constituents at discharge to Rock Creek would be below or near background water quality averages in the creek, except for total suspended solids, total phosphorus, and fecal coliforms, which would have slightly higher concentrations in most discharges. Impacts of increased phosphorus loading on Lake Sawyer are evaluated below (see “Total Phosphorus Loading and Lake Impacts” in Section 3.2.6.3). Some increases in stormwater parameter concentrations over background averages are an inevitable and predicted outcome of urban development 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 in Table 3-13 and comparison to background and water quality standards.

[4] For stormwater quality, as the site is stabilized and converted from construction discharge permit coverage under the Construction NPDES permit to long term coverage, requirements of the City’s drainage code would be required for stormwater management, which as described previously are expected to be equivalent to the 2005 Ecology Manual. Therefore, completion of each project portion and its occupancy requires that the stormwater infrastructure be constructed and completed for that project portion in tandem with other project construction. Water quality facilities and related infrastructure would be constructed in equal pace with other project features that they serve and would become operational as the project features they serve are completed. This would include homeowner education measures provided to new homeowners and all other mitigating measures described in Section 3.4.

Table 3-13. Storm Discharge to Rock Creek

Parameter	Units	Large Wet Pond Discharge Water Quality	Background Water Quality *(average from Table 2-8)*	Water Quality Standards (a)
		Basin 5	**Rock Creek**	**Rock Creek**
Dissolved Copper	µg/L	1.5	1.0	8.06 (b)
Dissolved Zinc	µg/L	2.6	2.0	74.4 (b)
Dissolved Lead	µg/L	0.09	<1.0	1.62 (b)
Total Ammonia-N	mg/L	0.02	0.05	2.30 (c)
Nitrate + Nitrite-N	mg/L	0.37	0.45	n/a
Total Phosphorus	mg/L	0.038	0.021	n/a
Turbidity	NTU	0.8	3.3	<5 over background
Total Suspended Solids	mg/L	8.0	2.0	n/a
Fecal Coliforms	CFU/100 mL	30	15 geometric mean	<50 geometric mean
Total Petroleum Hydrocarbons	mg/L	0.1	<1	no sheen
Oil and Grease	mg/L	0.2	1.4	no sheen

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
To calculate background averages, values below detection are estimated at ½ of the detection level.
(a) Chapter 173-201A WAC.
(b) Dissolved metal chronic standard at average hardness (67 mg/L).
(c) Total ammonia criterion for 15°C and pH of 7.0.

Stream 4 and Jones Lake Downstream

After treatment for water quality stormwater discharges to Stream 4 (and Jones Lake downstream and offsite) would comply with water quality standards prior to any mixing or dilution, with some possible exceptions for fecal coliforms as discussed below in Section 3.2.6.2.

Most stormwater constituents at discharge to Stream 4 would be below or near background water quality averages in the creek and in Jones Lake downstream, except for total suspended solids, total phosphorus, and fecal coliforms, which would have slightly higher concentrations in most discharges. Impacts of increased phosphorus loading on Lake Sawyer and Jones Lake are evaluated below (see "Total Phosphorus Loading and Lake Impacts" in Section 3.2.6.3). Some increases in stormwater parameter concentrations over background averages are an inevitable and predicted outcome of urban development 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 in Table 3-14 and comparison to background and water quality standards.

Table 3-14. Storm Discharge to Stream 4 and Jones Lake Downstream

Parameter	Units	Large Wet Pond Discharge	Background Water Quality *(averages from Tables 2-5 & 2-6)*		Water Quality Standards (a)	
		Basin 6	Stream 4	Jones Lake	Stream 4	Jones Lake
Dissolved Copper	µg/L	2.4	<1.0	<1.0	2.99 (b)	5.08 (c)
Dissolved Zinc	µg/L	8.0	<1.0	1.0	27.8 (b)	47.1 (c)
Dissolved Lead	µg/L	0.27	<1.0	0.3	0.44 (b)	0.89 (c)
Total Ammonia-N	mg/L	0.17	0.04	<0.005	2.30 (d)	2.30 (d)
Nitrate + Nitrite-N	mg/L	0.36	0.52	0.51	n/a	n/a
Total Phosphorus	mg/L	0.053	0.008	0.033	n/a	n/a
Turbidity	NTU	2.6	2.9	2.0	<5 over background	<5 over background
Total Suspended Solids	mg/L	8.1	2.0	2.0	n/a	n/a
Fecal Coliforms	CFU/100 mL	60	1 geometric mean	4	<50 geometric mean	<50 geometric mean
Total Petroleum Hydrocarbons	mg/L	0.3	3.2	not measured	no sheen	no sheen
Oil and Grease	mg/L	0.3	3.9	<0.2	no sheen	no sheen

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
To calculate background averages, values below detection are estimated at ½ of the detection level.
(a) Chapter 173-201A WAC.
(b) Dissolved metal chronic standard at average hardness (21 mg/L).
(c) Dissolved metal chronic standard at average hardness (39 mg/L).
(d) Total ammonia criterion for 15oC and pH of 7.0.

3.2.6.2 Fecal Coliforms in Surface Stormwater Discharge

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.

Fecal coliforms are not expected to violate state water quality standards in discharge to Rock Creek, although their concentrations will rise during storms.

Fecal coliform peaks could be above water quality standard allowance in discharge to Stream 4 before any mixing and dilution. Even though Stream 4 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 60 CFU/100 mL (see Table 3-15) which are well below the 100 CFU/100 mL maximum peak under state standards.

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 0.20 parts Stream 4 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 Stream 4 or Jones Lake downstream under the Proposed Action.

3.2.6.3 Total Phosphorus Loading to Jones Lake and Lake Sawyer under the Proposed Action

Jones Lake

Existing conditions in Jones Lake are described in Section 2.3..2.1 of this analysis. 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. The Basin 5 forecast discharge of 0.053 mg/L total phosphorus for stormwater is within this background level. There is no reasonable expectation that Jones Lake would be sensitive to the added phosphorus loading from the Proposed Action.

Lake Sawyer

Existing conditions in Lake Sawyer are described in Section 2.3.2.4 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 Villages 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 Villages Project would comply by using the phosphorus treatment menu in the 2005 Ecology Manual for all discharges contributing directly or indirectly to Lake Sawyer, 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 Villages 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 over most of the site, both of which would tend to reduce total phosphorus further.
  - The Villages Project would employ temporary erosion and sediment control standards from the 2005 Ecology Manual and seek to avoid surface discharge of construction stormwater to the Lake Sawyer basin 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 Villages Project would preserve native vegetation open areas on about 37 percent of the site.
- *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 Villages 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 Villages 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 Villages Project proposes large wet detention ponds meeting the phosphorus (lake protection) treatment menu requirements in the 2005 Ecology Manual for all discharges to Rock Creek and Stream 4, and facilities meeting phosphorus treatment menu requirements before infiltrating stormwater in Basin 7 near Ravensdale Creek.

The Villages 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 The Villages, 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.

3.2.7 Infiltrated Discharge Impacts to Aquifers and to Surface Waters Recharged by Aquifers

Quantitative forecasts for infiltrated stormwater quality after treatment are provided for the two aquifers and downstream (and offsite) surface waters that receive aquifer recharge in this section. The connections between infiltration, aquifers, and surface waters recharged by the aquifers are described in Section 2 of this analysis. The forecast for stormwater discharge at infiltration is calculated at the point of infiltration. No attenuation of any stormwater constituents is included in Tables 3-15 to 3-19 to account for subsurface passage, or for dilution or mixing with aquifer water, or for dilution or mixing with receiving waters recharged from the two aquifers.

<u>Shallow Aquifer</u>
At the points of infiltration, stormwater from Basins 1 through 4 would have less copper, zinc, and lead than exist in background shallow aquifer measures, and orders of magnitude less than drinking and groundwater quality standards allow (Table 3-15). Nitrate-nitrogen would be well within state standards for drinking water quality. At the point of infiltration, turbidity could be slightly over the standard of 1 NTU in drinking water, however there is reasonable expectation that this slight turbidity would be reduced by infiltration passage and would have no degrading effect by the time stormwater recharged the shallow aquifer or certainly by the time the aquifer water moved offsite, irrespective of aquifer background.

Fecal coliforms in stormwater will always be detectable for reasons described in Section 3.2.6.2. Groundwater and drinking water quality standards for fecal coliforms are far more stringent than surface water quality standards. Fecal coliforms attenuate rapidly under conditions of unsaturated flow, which occurs where water moves vertically downward through soils that are not completely saturated, or where aquifers only flow seasonally. This would occur to varying degrees where the depth to the shallow aquifer under the points of infiltration exceeded the depths of infiltration mounding, and the shallow aquifer extending offsite is seasonal in nature. Fecal coliforms also attenuate with distance, where finer grained particles exist, due to filtration or by electrical charge attraction to the soil particles. Fecal coliforms also attenuate with time, since they have a defined lifetime and do not reproduce in stormwater or groundwater. Davies et al. (1995) found that fecal coliform numbers fall by two to three orders of magnitude within 29

days in saturated freshwater sediments. Coyne et al. (1996) measured a half life of fecal coliforms of about 5 to 8 days (i.e., the numbers are reduced by 50 percent every 5 to 8 days). The rate of fecal coliform decline is sensitive to temperature. Niemela and Vaatanen (1982) measured the rate of fecal coliform count decline by distance and time from the source at various temperatures in lake water and derived a linear regression. The decimal reduction time (period of time for the counts to be reduced by 90%) ranged from 24 days at 0°C (32°F) to about 5 days at 20°C (68°F). Temperatures in the shallow aquifer measured by Golder Associates, Inc. ranged from about 5.7 to 10.1^{o}C. At 10°C, the decimal reduction time by regression would be about 14 days, meaning fecal coliform counts would decline by 90% every two weeks, which would mean the estimated 30 CFU/100 mL concentration of fecal coliforms infiltrated to the shallow aquifer from stormwater would fall below 1 CFU/100 mL in less than one month assuming the coarse grained shallow aquifer substrate provides negligible filtration. This also assumes no mixing or dilution in the aquifer. Associated Earth Sciences, Inc. (2008) found that downgradient from proposed LID areas, the shallow aquifer is not a viable aquifer (defined as an aquifer that could adequately supply a domestic well or drinking water supply). Therefore, although at infiltration the stormwater would have greater than 1 CFU/100 mL fecal coliforms, there is no potential beneficial use of the shallow groundwater for drinking water supply, and thus no potential for adverse offsite impact from the use of LID facilities and infiltration on the site.

Even though the shallow aquifer is not suitable for well production offsite, it should be noted that most of the adjacent offsite areas are within water district service areas. The entire offsite area between Basins 3 and 4 is within the City of Black Diamond urban area and would obtain water from the City, so there is no potential for drinking water impact to this area. The property adjacent to the Site west of the City of Black Diamond, south of Horseshoe Lake, and north of the Green River is in within the service area of the Covington Water District. The service area is shown in the King County coordinated water system plan. It is not annexed into the district's corporate boundary. Pursuant to KCC 13.24.138, areas in the rural area (i.e., the Covington Water District service area adjacent to the site) must first be served by a Group A water system through direct service, if the proposed development is in an approved service area that has been assigned to a Group A Water System through a King County-approved coordinated water system plan and direct service can be provided by that system in a timely and reasonable manner. Thus, service by Covington Water District would be required unless it could not be provided in a timely and reasonable fashion. If a well was constructed because water could not be supplied by the District in a timely and reasonable fashion, it would need to be completed in the pre-Olympia or deeper aquifer in order to produce water. The pre-Olympia aquifer is evaluated below.

Table 3-15. Basin 1 through 4 at Infiltration to the Shallow Aquifer

Parameter	Units	Storm Water Quality at Infiltration	Background Water Quality *(average from Table 2-14)*	Water Quality Standards (a)
		Basins 1-4	Shallow Aquifer	Shallow Aquifer
Dissolved Copper	µg/L	0.7	2.5 (b)	1,000 (b)
Dissolved Zinc	µg/L	4.6	12 (b)	5,000 (b)
Dissolved Lead	µg/L	0.14	<1.0 (b)	50 (b)

Parameter	Units	Storm Water Quality at Infiltration	Background Water Quality *(average from Table 2-14)*	Water Quality Standards (a)
		Basins 1-4	**Shallow Aquifer**	**Shallow Aquifer**
Total Ammonia-N	mg/L	0.03	nm	n/a
Nitrate + Nitrite-N	mg/L	0.25	nm	10.0
Total Phosphorus	mg/L	0.056	<0.005	n/a
Turbidity	NTU	1.9	no reliable measure	1
Total Suspended Solids	mg/L	5.3	nm	500 for total dissolved solids
Fecal Coliforms	CFU/100 mL	30	<1	<1
Total Petroleum Hydrocarbons	mg/L	0.1	nm	Volatile organic standards are listed by compound
Oil and Grease	mg/L	0.3	nm	

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
(a) Chapter 246-290-310 WAC
(b) Values listed are for total copper, zinc, and lead.

Pre-Olympian Aquifer

Under the Proposed Action stormwater would be infiltrated after treatment in Ponds 3 and 4 serving portions of Basins 1 through 4. Water infiltrating at these two locations would enter the pre-Olympian Aquifer (the shallow aquifer is absent or continuous with the pre-Olympian aquifer at these locations). There are two alternative locations for Pond 4 and the infiltration sites; one is near the northwest corner of Basin 4 and the other is offsite to the west, but the potential impacts and area of impact extending from each of the alternative infiltration locations would be similar. If the offsite and west pond option is used for Pond 4, then added recirculation of the pond water for additional bioretention treatment may be applied before infiltration. However, at this stage of design planning, the pond location and degree of potential for added treatment before infiltration is uncertain, so this analysis conservatively assumes only basic wet pond treatment occurs for both Ponds 3 and 4 before infiltration.

The water quality forecast for the combined infiltration discharge from Ponds 3 and 4 to the pre-Olympian Aquifer are shown in Table 3-16. The results and conclusions are very similar to those described for the shallow aquifer in the immediately preceding section, except that fecal coliforms would be somewhat higher at the point of infiltration (about 53 CFU/100 mL). Temperatures measured in the pre-Olympian aquifer at several locations by Golder Associates (see Table 2-15) were similar to those in the shallow aquifer, ranging from 8.7 to 10.0^{o}C. Assuming the coarse material comprising the pre-Olympian aquifer unit fails to filter any fecal coliforms, the regression by Niemela and Vaatanen (1982) suggests this discharge would have less than 1 CFU/100 mL fecal coliforms in less than 1 month of transit. This also assumes no mixing or dilution or unsaturated (vertical) flow. Associated Earth Sciences, Inc. calculated transit times for the pre-Olympian aquifer moving offsite from the points of infiltration (including the alternative location for Pond 4), and found that after one month the water would have moved horizontally about 75 feet to the west-southwest (downgradient) and a shorter distance in the upgradient direction from the points of entry to the pre-Olympia Aquifer. To mitigate any impact

from fecal coliforms to groundwater from Pond 3 or 4 discharges, an easement would be acquired from the affected offsite property owner(s) to include 75 feet around the infiltration structures that would prevent the drilling of wells.

Table 3-16. Pond 3 and 4 Infiltration to the pre-Olympian Aquifer

Parameter	Units	Storm Water Quality at Infiltration	Background Water Quality *(average from Table 2-15)*	Water Quality Standards (a)
		Ponds 3 and 4	**Pre-Olympian Aquifer**	**Pre-Olympian Aquifer**
Dissolved Copper	µg/L	1.7	3 (b)	1,000 (b)
Dissolved Zinc	µg/L	6.6	7 (b)	5,000 (b)
Dissolved Lead	µg/L	0.20	<1.0 (b)	50 (b)
Total Ammonia-N	mg/L	0.08	nm	n/a
Nitrate + Nitrite-N	mg/L	0.36	nm	10.0
Total Phosphorus	mg/L	0.049	0.031	n/a
Turbidity	NTU	1.9	no reliable measure	1
Total Suspended Solids	mg/L	7.3	nm	500 for total dissolved solids
Fecal Coliforms	CFU/100 mL	53	<1	<1
Total Petroleum Hydrocarbons	mg/L	0.2	nm	Volatile organic standards are listed by compound
Oil and Grease	mg/L	0.3	nm	

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
(a) WAC 246-290-310
(b) Values listed are for total copper, zinc, and lead.

Horseshoe Lake

Horseshoe Lake receives some of its inflow as recharge to the Shallow Aquifer from onsite Basins 1 through 3, although there is an extensive offsite recharge contributing to Horseshoe Lake as well. Potential water quality influence to Horseshoe Lake was examined conservatively as though treated stormwater released to shallow infiltration from Basins 1 through 3 was instead piped directly to Horseshoe Lake. This conservative approach was taken for two reasons. First, if no adverse impacts are found from this method, then actual impacts are certain to be less because of the actual infiltration pathway. Second, the thin shallow aquifer is conveyed in coarse sediments that do not offer as much filtration benefit as usually occurs. For that reason, the project also proposes to mitigate Horseshoe Lake water quality by avoiding shallow infiltration of stormwater originating on pollution generating surfaces within ¼ mile of offsite Horseshoe Lake. That stormwater is conveyed south to Pond 3, which does not infiltrate to groundwater that recharges Horseshoe Lake.

The results of the quantitative forecast for the Proposed Action show that treated stormwater discharge to shallow infiltration on site would have water quality very similar to existing water quality in Horseshoe Lake for all constituents except total phosphorus and fecal coliforms. Horseshoe Lake is not listed as sensitive to phosphorus loading, and infiltration of stormwater

greater than ¼ mile from receiving water bodies is considered a best management practice to avoid phosphorus impact on lakes. Phosphorus binds readily to aluminum and iron that naturally occur in soils, so phosphorus would be reduced during subsurface transit to and in the shallow aquifer. All parameters are predicted to be within state water quality standards, including fecal coliforms. No adverse water quality changes or impacts to Horseshoe Lake are reasonably predicted even under the conservative evaluation method employed for this project, which overestimates impacts.

Crisp Creek and Green River Confluence

Crisp Creek is recharged from the pre-Olympian Aquifer near it's confluence with the Green River. Some of the recharge to the pre-Olympian Aquifer originates on site; much of it originates offsite and from Horseshoe Lake as described by Associated Earth Sciences, Inc. (2008). This analysis as reflected in Table 3-18 conservatively examines treated stormwater discharge from the Proposed Action at the point of infiltration to the pre-Olympian Aquifer, before any attenuation of stormwater constituents by subsurface travel (both saturated and

Table 3-17. Basin 1 through 3 Shallow Infiltration Recharging Horseshoe Lake

Parameter	Units	Storm Water Quality at Infiltration	Background Water Quality *(average from Table 2-13)*	Water Quality Standards (a)
		Basins 1-3	**Horseshoe Lake**	**Horseshoe Lake**
Dissolved Copper	µg/L	0.6	1.0	2.5 (b)
Dissolved Zinc	µg/L	6.9	6.0	23.3 (b)
Dissolved Lead	µg/L	0.21	0.24	0.35 (b)
Total Ammonia-N	mg/L	0.04	<0.005	2.30 (c)
Nitrate + Nitrite-N	mg/L	0.21	0.33	n/a
Total Phosphorus	mg/L	0.066	<0.005	n/a
Turbidity	NTU	2.7	1.2	<5 over background
Total Suspended Solids	mg/L	3.6	2.0	n/a
Fecal Coliforms	CFU/100 mL	41	12	<50 geometric mean
Total Petroleum Hydrocarbons	mg/L	0.2	not measured	no sheen
Oil and Grease	mg/L	0.5	0.23	

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
To calculate background averages, values below detection are estimated at ½ of the detection level.
(a) Chapter 173-201A WAC.
(b) Dissolved metal chronic standard at average hardness (67 mg/L).
(c) Total ammonia criterion for 15°C and pH of 7.0.

unsaturated flow), before any dilution or mixing in the pre-Olympian Aquifer which extends well offsite, or before any dilution or mixing in Crisp Creek and the Green River. In essence, the analysis examines water quality impacts as though treated stormwater from Ponds 3 and 4 was piped to discharge to Crisp Creek or the Green River. This extremely conservative approach was taken because if no adverse impacts are seen by this method, then there is a very reliable

conclusion of no adverse impact to water quality beneficial uses in Crisp Creek or the Green River downstream. Actual impacts would be less than those shown in Table 3-18 for the reasons described above.

Table 3-18. Basins 1 - 4 and Ponds 3 & 4 Infiltration to the Shallow and Pre-Olympia Aquifers Recharging Crisp Creek and the Green River

Parameter	Units	Stormwater Infiltration after Treatment	Background Water Quality *(averages from Tables 2-11 & 2-12)*		Water Quality Standards (a)	
		Basins 1-4; Ponds 3 &4	Crisp Ck.	Green R.	Crisp Ck.	Green R.
Dissolved Copper	µg/L	1.2	0.20	0.22	5.64 (b)	3.34 (c)
Dissolved Zinc	µg/L	5.5	0.23	<0.5	52.2 (b)	31.1 (c)
Dissolved Lead	µg/L	0.17	0.01	<0.2	1.02 (b)	0.51 (c)
Total Ammonia-N	mg/L	0.05	0.07	0.01	2.30 (d)	2.30 (d)
Nitrate + Nitrite-N	mg/L	0.30	0.74	0.22	n/a	n/a
Total Phosphorus	mg/L	0.053	0.048	0.020	n/a	n/a
Turbidity	NTU	1.9	1.9	17.1	<5 over background	<5 over background
Total Suspended Solids	mg/L	6.2	7.4	23.1	n/a	n/a
Fecal Coliforms	CFU/100 mL	40	47 geometric mean	5 geometric mean	<100 geometric mean	<100 geometric mean
Total Petroleum Hydrocarbons	mg/L	0.2	not measured	not measured	no sheen	no sheen
Oil and Grease	mg/L	0.3	not measured	not measured	no sheen	no sheen

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
To calculate background averages, values below detection are estimated at ½ of the detection level.
(a) Chapter 173-201A WAC.
(b) Dissolved metal chronic standard at average hardness (44 mg/L).
(c) Dissolved metal chronic standard at average hardness (24 mg/L).
(d) Total ammonia criterion for 15oC and pH of 7.0.

Even without allowance for attenuation due to (1) infiltration (filtration and chemical binding); (2) duration of travel to recharge at Crisp Creek; or (3) mixing in the pre-Olympian Aquifer, Crisp Creek, or the Green River; stormwater at infiltration from the proposed project would meet all water quality standards in Crisp Creek and in the Green River, as shown in Table 3-18. Metals concentrations at infiltration would be higher than background in Crisp Creek and the Green River.

More realistically, the closest point of infiltration is about 0.9 miles from Crisp Creek. Time of transit from the site infiltration points to Crisp Creek is on the order of 1 to 10 years (the average expected duration is about 5 years), from which point the recharged water to Crisp Creek would be conveyed to the Green River. Particles such as fecal coliforms and positively charged particles such as dissolved metals move more slowly than the water because of filtration (depending on the coarseness of the aquifer material) and because of electric attraction to soil particles. Over the subsurface transit distance, heavy metals would be attenuated, because

they are relatively immobile wherever they would encounter finer-grained material. Total phosphorus would be reduced by attraction to and mineralization with naturally occurring iron and aluminum. Over a one year or more span of time none of the fecal coliforms predicted in Table 3-8 would survive.

It is reasonably concluded that background water quality conditions in Crisp Creek and the Green River would not measurably change or be degraded as a result of the Proposed Action.

Basin 7 Shallow Aquifer and Ravensdale Creek

Stormwater from Basin 7 North (7N) would infiltrate after treatment to the Shallow Aquifer near the point that the aquifer recharges Ravensdale Creek. Stormwater from Basin 7 South (7S) would discharge to the buffer of Wetland B4 which has no open water component and is drained offsite to a ditched infiltration trench, also located offsite, which recharges the Shallow Aquifer near the point that the aquifer recharges Ravensdale Creek. For both basins, transit through the Shallow Aquifer is through very coarse material lacking fines. For the purposes of this water quality analysis, the transit is considered equivalent to piped conveyance in that it would lack attenuating features commonly attributed to subsurface passage. Some attenuation of treated stormwater constituents would occur in passage through the finer-grained soils of Wetland B4 and its buffer after discharge, most notably for metals, fecal coliforms; and ammonia, nitrate- and nitrite-nitrogen would attenuate through denitrification, plant uptake, and volatilization losses at various points in the natural nitrogen cycle in the wetland soils and biota. These attenuating effects are not included in the results shown in Table 3-19, which means the forecast conservatively overestimates impacts. Since there are no wells or beneficial uses of groundwater between the points of infiltration (both on and offsite) and Ravensdale Creek nearby where the shallow aquifer completely discharges (the infiltrated water would not move past Ravensdale Creek), impacts to groundwater are considered, but beneficial uses of groundwater could not be adversely affected.

Table 3-19. Basin 7N and 7S Infiltration to the Shallow Aquifer which Recharges Ravensdale Creek

Parameter	Units	Stormwater Infiltration after Treatment	Background Water Quality *(averages from Tables 2-14 & 2-7)*		Water Quality Standards	
		Basins 7N & 7S	Shallow Aquifer	Ravensdale Creek	Shallow Aquifer (a)	Ravensdale Creek (b)
Dissolved Copper	µg/L	1.4	2.5	<1	1,000 (b)	5.41 (c)
Dissolved Zinc	µg/L	9.2	12	7	5,000 (b)	50.1 (c)
Dissolved Lead	µg/L	0.32	<1	<1	50 (b)	0.97 (c)
Total Ammonia-N	mg/L	0.10	not measured	0.02	n/a	2.30 (d)
Nitrate + Nitrite-N	mg/L	0.37	not measured	0.80	10.0	n/a
Total Phosphorus	mg/L	0.055	<0.005	0.012	n/a	n/a
Turbidity	NTU	2.0	no reliable measure	no reliable measure	1	<5 over background
Total Suspended Solids	mg/L	2.4	not measured	2.1	500 for total dissolved solids	n/a

Fecal Coliforms	CFU/100 mL	80	<1	1 geometric mean	<1	<50 geometric mean
Total Petroleum Hydrocarbons	mg/L	0.1	not measured	<1	Volatile organic standards are listed by compound	no sheen
Oil and Grease	mg/L	0.4	not measured	2.1		no sheen

NTU – Nephelometric turbidity units *n/a – not applicable or no numeric standard*
CFU – Colony-forming units
To calculate background averages, values below detection are estimated at ½ of the detection level.
(a) Chapter 246-290-310 WAC
(b) Chapter 173-201A WAC.
(c) Dissolved metal chronic standard at average hardness (42 mg/L).
(d) Total ammonia criterion for 15oC and pH of 7.0.

For groundwater, all stormwater constituents at the two points of discharge would meet groundwater quality standards with the potential exception of fecal coliforms (Table 3-19). The drinking water standard for fecal coliforms is less than 1 CFU/100 mL, or 1 CFU/100 mL for groundwater quality standards. Groundwater between the points of infiltration to the Shallow Aquifer and its discharge about ¼ mile away would see a rise in fecal coliforms above these criteria intended to be protective of drinking water beneficial use, but there are no drinking water wells in this location and potential for this type of use in this specific area is considered negligible.

For Ravensdale Creek, all stormwater constituents at the points of infiltration would meet surface water quality standards prior to any mixing or dilution in the Shallow Aquifer that discharges to Ravensdale Creek, with the possible exception of fecal coliforms. Most constituents would be near background levels in Ravensdale Creek. Peaks of up to 80 CFU/100 mL are forecast from Basins 7N and 7S. These peaks are less than maximum of 100 mg/L allowed under the state standard for measures comprising the geometric mean, but greater than the maximum geometric mean of 50 CFU/100 mL allowed under the standard. Given the intermittent nature of stormwater runoff and the fact that some fecal coliforms would be attenuated after dispersion from Basin 7S, compliance with the geometric mean state standard of 50 CFU/100 mL is likely, given the background Shallow Aquifer concentration of <1 that was measured by Golder Associates. The background would be indicative of the between-storm recharge condition that would also comprise the condition measured for the geometric mean. 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 basic wet pond and basic sand filter would remove more fecal coliforms than a large sand filter alone. Biofiltration swales and sand filters in combination would further lower fecal coliforms to the extent they are feasible to construct in Basin 7N at this location. Biofiltration swale and sand filter combinations remove about 85 percent of fecal coliforms (A.C. Kindig & Co. 2008), compared to the efficiency of 67 percent for the basic wet pond and sand filter combination assessed in Table 3-19. If Basin 7N employed biofiltration swales and sand filter combinations, the model predicts the combined Basin 7N and 7S discharge to infiltration would have a peak fecal coliform concentration of 53 CFU/100 mL, which would maintain surface water quality standards in Ravensdale Creek and Lake Sawyer downstream with greater certainty. Since there is no reasonably anticipated adverse impact to beneficial uses, including recreation in Lake Sawyer downstream, from this stormwater discharge, use of biofiltration and

sand filters in Basin 7N would be in the category of "should be considered if feasible" but not "essential mitigation to avoid adverse impact."

Phosphorus loading impacts to Lake Sawyer are discussed in Section 3.2.6.3 above.

3.2.7.1 Water Quality Impact Conclusion for the Proposed Action

Under the Proposed Action, with the exception of zones of groundwater fecal coliform impact to groundwater along the western boundary of Basins 1 through 4 and in zones around points of infiltration from Ponds 3 and 4 discussed in Section 3.2.7, beneficial uses of the direct and indirect receiving waters will be protected and water quality standards will be met. This includes phosphorus protection for Lake Sawyer, as described above in Section 3.2.6.3. Although not necessary to avoid or minimize adverse impact, it is recommended that a biofiltration swale and basic sand filter combination be considered for treatment of stormwater in Basin 7N to the extent it is feasible.

3.2.8 Water Quality under No Action Alternative

It is reasonable to assume that development under the No Action Alternative would occur in conformance with the 2005 Ecology Manual as for the Proposed Action. Even under this assumption, greater water quality impacts are likely to occur under No Action relative to the Proposed Action for several reasons. First, No Action would have less open space than the Proposed Action, because the MPD standards require The Villages MPD to provide a total of 486 acres of open space. The MPD standards would not apply under the No Action Alternative. Less open space under the No Action Alternative would reduce the water quality benefits of preserving natural drainage pathways, preserving natural recharge to summer baseflows, and undisturbed native vegetation. Second, more office/light industrial development may occur than under the proposed action, because the zoning designations on the main property are assumed to be business park/light industrial, light industrial, mixed use, and medium density residential absent a MPD, and zoning in Basin 7 is assumed to be business park/light industrial. Although the No Action Alternative for The Villages MPD has not yet been defined by the city, it is reasonably expected a higher intensity land use could occur under this zoning than under a MPD. These categories of land use generate more fecal coliforms than other types of land use, which would increase potential for recreation use impacts and groundwater impacts downstream. These categories of land use also generate more phosphorus than other types of land use, which would increase potential for interference with TMDL efforts to control eutrophication in Lake Sawyer from Basins 5, 6, and 7 of The Villages (the other basins are not in the Lake Sawyer watershed). Third, the No Action Alternative could have more medium density single family residences than under the Proposed Action, 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, where homeowner education is more feasibly coordinated Fourth, the stormwater facilities would not be organized on a regional basis as buildout occurs on individual properties through 2025, 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.

3.2.9 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. Associated Earth Sciences (2008) evaluated the potential for added impervious surfaces under the Proposed Action to reduce groundwater recharge that could affect base flows. Associate Earth Sciences, Inc. assessment concluded no reductions in base flow to Rock Creek, Ravensdale Creek, Stream 4, Horseshoe Lake, Black Diamond Lake, Crisp Creek or the Green River would occur as a result of the Proposed Action. Recharge to Black Diamond Lake and Horseshoe Lake would be balanced by design of the stormwater system to avoid increasing inflow to those water bodies. Otherwise, groundwater recharge over non-till soils is expected to increase as a result of development under the Proposed Action due to clearing (reducing evapotranspiration losses of water from vegetation) and infiltration of all stormwater on those portions of the site. No adverse changes to summer baseflows that could affect water quality are reasonably expected to occur under either action alternative.

The Proposed Action is a clustered MDP. The No Action Alternative would likely have more office-industrial and less preserved open space than the Proposed Action. The No Action Alternative would not be clustered, but would avoid critical areas and their buffers to the extent feasible (and require specific local, state, and possibly federal permits where impacts were proposed) as would also occur under the Proposed Action. It would be more difficult to coordinate a stormwater system that balanced water recharging Horseshoe Lake and Black Diamond Lake under the No Action Alternative, relative to the Proposed Action, which could have adverse impacts on Horseshoe Lake water levels or adverse impacts to the Black Diamond Lake bog, which is sensitive to water volumes which pass through it.

3.2.10 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 Villages project would maximize infiltration and proposes to use the 2005 Ecology Manual for storm management under the Proposed Action in Basins 1, 2, 3, 4, and 7. The Villages MPD 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 Villages MPD include the following:

- Bioretention and Biofiltration swale treatment associated with discharge infiltration in the basins 1 through 4 and 7 North;
- Direct infiltration of roofs and non-pollution generating surfaces in Basins 7 through 4 and 7 as feasible by infiltrative soils after grading,
- Pervious/porous hard surface treatments such as porous pavers that infiltrate directly 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 Villages would narrow roadways below typically applied standards as feasible for public safety and other concerns, and as approved by the City. Another example employed by The Villages is clustering under the MPD and the provision of MPD required open space, 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 Villages Proposed Action 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 The Villages that (a) preserves about 37 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 has large areas where soils with infiltration potential exist and LID facilities for stormwater treatment and infiltration are proposed (Basins 1 through 4 and 7). LID treatments such as porous pavement or other semi-permeable treatments are not required to further mitigate water quality, and have very little benefit over till soils where surface discharge basins exist. Nonetheless, to the extent that porous pavements or other semi-permeable treatments are feasible and employed, they would reduce stormwater generation in Basins 5 and 6 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 from Basins 5, 6, and 7. These are beneficial results even if the realized benefits are modest or small.

Under the No Action Alternative, 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 and the Lawson Hills MPD. Lawson Hills MPD has draft technical reports for a future DEIS prepared which defines that proposal. Only Basins 5 and 6 of The Villages site in the Rock Creek basin and Basins 7 North and South have any potential for cumulative water quality effects with Lawson Hills MPD, because they have no other shared watershed drainages. The remainder of The Villages site infiltrates to groundwater flowing away from Rock Creek and Lake Sawyer (recharging Horseshoe Lake, Crisp Creek, and the Green River). The cumulative impacts of Lawson Hills and The Villages would manifest at Jones Lake, in Rock Creek below Ginder Creek, and at Ravensdale Creek near it's mouth at Lake Sawyer for all three projects.

The 2005 Ecology Manual is proposed for stormwater management at Lawson Hills and for The Villages. A portion of The Villages site drains to Black Diamond Lake, which contributes headwaters to Rock Creek via tributary 09-0085A (Associated Earth Sciences 2000), but a negligible, if any, portion of that stormwater would be treated water from pollution generating surfaces released to non-bog wetlands above Black Diamond Lake. The conceptual plan is to balance stormwater recharge to Black Diamond Lake to the existing condition using runoff from non-pollution generating surfaces. Lawson Hills has no connection to Black Diamond Lake, so there are no potential cumulative impacts in that watershed.

During construction, the BMPs described in Section 3.1 of this report for The Villages are proposed for Lawson Hills, except that Lawson Hills included more slope-related BMPs due to its higher incidence of moderate to steep slopes. If 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.

For long term stormwater discharge, Lawson Hills stormwater analysis shows it would not have any adverse water quality impacts that would reduce beneficial uses, and that the Lawson Hills proposal would be consistent with the Lake Sawyer Management Plan to protect the lake from increased eutrophication. Where there is overlap in the Rock Creek and Ravensdale Creek basins, all stormwater constituent concentrations for Lawson Hills are reasonably expected to be within applicable state water quality standards with the mitigation measures proposed, as they are for The Villages project listed in Section 3.4 below. On a concentration basis, it is expected that The Villages and Lawson Hills 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 listed in Section 3.2.6.3. Since both projects propose to follow those recommendations germane to stormwater runoff in equivalent fashion, then unanticipated changes in phosphorus impacts to Lake Sawyer would be avoided and the Lake Sawyer Management Plan recommendations are reasonably expected to control adverse impacts.

3.4 Mitigating Measures

Proposed 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 3.1.8 from the 2005 Ecology Manual;
- Construction mitigation measures for drainage described in Section 3.1.6 designed to avoid impacts to the Black Diamond Lake Bog;
- 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 phosphorus, fecal coliforms, and storm runoff volumes by use of LID methods described in Section 3.2.10 as feasible;
- Minimizing phosphorus loading impacts through use of the Lake Sawyer Management Plan recommendation measures described in Section 3.2.6.3; and
- Minimizing storm runoff through preservation of open space under the MPD provisions, including preservation of sensitive areas and buffers as required by the City of Black Diamond.
- To mitigate any impact from fecal coliforms to groundwater from Pond 3 or 4 discharge, an easement would be acquired from the affected offsite property owner(s) to include 75 feet around the infiltration structure that would prevent the drilling of wells.

Potential suggested mitigation measures for water quality include the following:

- Although not necessary to avoid or minimize adverse impact, it is recommended that a biofiltration swale and basic sand filter combination be considered for treatment of stormwater in Basin 7N to the extent it is feasible.

3.5 Matching the Pace of Mitigation to Impacts Through 2025 Buildout

For stormwater quality, as the site is stabilized and converted from construction discharge permit coverage under the Construction NPDES permit to long term coverage, requirements of the City's drainage code would be required for stormwater management, which as described previously are expected to be equivalent to the 2005 Ecology Manual. Therefore, completion of each project portion and its occupancy requires that the stormwater infrastructure be constructed and completed for that project portion in tandem with other project construction. Water quality facilities and related infrastructure would be constructed in equal pace with other project features that they serve and would become operational as the project features they serve are completed. This would include homeowner education measures provided to new homeowners and all other mitigating measures described in Section 3.4.

3.6 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 surface or groundwater reasonably expected.

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