3-L
PRELIMINARY WORKING DRAFT FACILITIES PLAN

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

King County Brightwater TREATMENT SYSTEM

Appendix 3-L

Preliminary Working Draft Facilities Plan

May 2003

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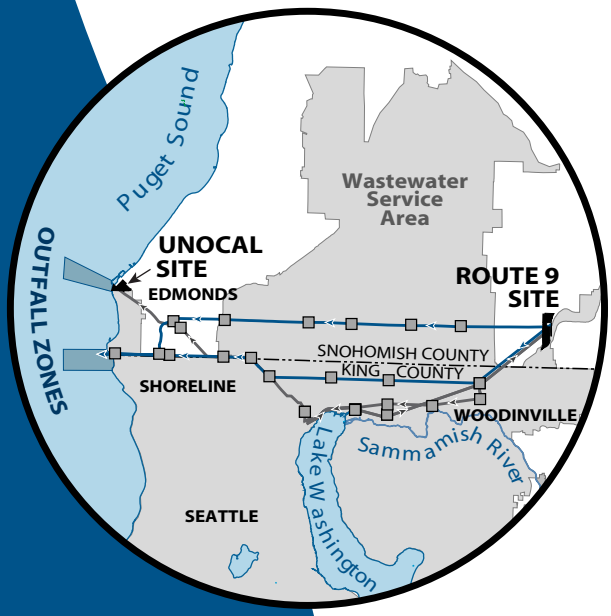
King County
Department of Natural Resources and Parks
Wastewater Treatment Division

PRELIMINARY WORKING DRAFT

FACILITIES PLAN

Brightwater Regional Wastewater Treatment System

May 2003



Brightwater
TREATMENT SYSTEM

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Preliminary Working Draft
Facilities Plan

Brightwater Regional Wastewater Treatment System

King County Department of Natural Resources and Parks
Wastewater Treatment Division

May 2003

Prepared in compliance with the Washington Department of Ecology, Requirements for Engineering Reports, WAC 173-240-060.

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Acronyms and Abbreviations

AAF	average annual flow
Ac	acre
ACH	air changes per hour
ADWF	average dry weather flow
AKART	All known, available, and reasonable methods of prevention, control, and treatment
ATAD	autothermal thermophilic aerobic digestion
AWT	advanced wastewater treatment
AWWF	average wet weather flow
BACT	best available control technology
BAF	biological aerated filters
bgs	below ground surface
BMP	best management practice
BNAs	Base neutral acid extractables
BNSF	Burlington Northern-Santa Fe (Railroad)
BOD_5	5-day biochemical oxygen demand
BPC	ballasted primary clarification
°C	degree centigrade
C3	utility water, non-potable, disinfected effluent
CAO	Critical Area Ordinance
CAS	conventional activated sludge
CATAD	computer augmented treatment and disposal system
CBOD	carbonaceous biochemical oxygen demand
CCTV	cable connected television camera
CEPC	chemically enhanced primary clarification
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
City Light	Seattle City Light
Cl_2	chlorine
CO	carbon monoxide
COD	chemical oxygen demand
CPC	conventional primary clarification
CPPs	Countywide Planning Policies
CSI	conveyance system improvements
CSO	combined sewer overflow
CUP	conditional use permit
CWA	Clean Water Act (federal)
CZMA	Coastal Zone Management Act

DAFT	dissolved air flotation thickener
dBA	decibel, A-weighted
DEQs	Detailed Evaluation Questions
DNR	Department of Natural Resources (Washington State)
DO	dissolved oxygen
DOH	Department of Health (Washington State)
D/T	dilution to threshold
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPF	Essential Public Facility
ESA	Endangered Species Act
ESI	Eastside interceptor
ETS	effluent transfer system
°F	degree Fahrenheit
FERC	Federal Energy Regulatory Commission
FPA	Forest Practices Act
FSS	fixed suspended solids
ft^3	cubic foot, cubic feet
FWPCA	Federal Water Pollution Control Act
F/M	food to microorganism ratio
gal	gallon, gallons
GBT	gravity belt thickener
gfd	gallons per square foot per day
GIS	geographic information system
GMA	Growth Management Act (Washington State)
gpad	gallons per acre per day
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
H_2S	hydrogen sulfide
HAP	hazardous air pollutant
HCP	Habitat Conservation Plan
HMP	Habitat Management Plan
hp	horsepower
HPO	high purity oxygen
hr	hour
I/I	infiltration/inflow
in.	inches

kW	kilowatt
kWh	kilowatt-hour
L	liter
lb	pound, pounds
lb/d	pounds per day
MBR	membrane bioreactor
MCRT	mean cell residence time
Metro	Municipality of Metropolitan Seattle or King County Department of Metropolitan Services
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MG	million gallons
mgd	millions gallons per day
MLLW	mean lower low water
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MOSS	Marine Outfall Siting Study
MPA	Marine Protected Area
MTCA	Model Toxics Control Act
MW	megawatts
MWWF	maximum wet weather flow
N	nitrogen
NA	not applicable, not analyzed
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O&M	operation and maintenance
OHW	ordinary high water mark
Ortho-P	orthophosphorus (PO_4)
P	phosphorus
PAC	powdered activated carbon
PAH	polycyclic aromatic hydrocarbon
PC	pollutant concentrations
PCB	polychlorinated biphenyl
PFRP	process to further reduce pathogens
PM	particulate matter
PSA	Portal Siting Area
PSAMP	Puget Sound Ambient Monitoring Program
PSCAA	Puget Sound Clean Air Agency
psi	pounds per square inch

PSRC	Puget Sound Regional Council
PSRP	process to significantly reduce pathogens
PSE	Puget Sound Energy
PUD	Public Utility District
PWWF	peak wet weather flow
Q	flow
RAS	return activated sludge
RCW	Revised Code of Washington
RM	river mile
ROV	remotely operated vehicle
RWSP	Regional Wastewater Services Plan
$SBOD_5$	soluble 5-day biochemical oxygen demand
scf	standard cubic feet
scfm	standard cubic feet per minute
scf/d	standard cubic feet per day
SCS	Soil Conservation Service
SEPA	State Environmental Policy Act
SIP	State Implementation Plan
SMA	Shoreline Management Act
SMS	Sediment Management Standards
SO_2	sulfur dioxide
SR	State Route
SS	suspended solids
SSO	sanitary sewer overflow
TAZ	Transportation Analysis Zone
TBM	tunnel boring machine
TDH	total dynamic head
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily loading
TS	total solids
TSS	total suspended solids
TWAS	thickened waste activated sludge
UBC	Uniform Building Code
UFC	Uniform Fire Code
UGA	Urban Growth Area
UGB	Urban Growth Boundary
USGS	U.S. Geological Survey
UV	ultraviolet (light)
VERTAD	vertical shaft thermophilic aerobic digestion

VOC	volatile organic compound
VS	volatile solids
VSS	volatile suspended solids
WAC	Washington Administrative Code
WAS	waste activated sludge
WDFW	Washington Department of Fish and Wildlife
WIFZ	Whidbey Island Fault Zone
WISHA	Washington Industrial Safety and Health Act
WLA	wasteload allocation
WRIA	Water Resource Inventory Area
ZID	zone of initial dilution

Executive Summary

Note to Reviewers of Facilities Plan: This Executive Summary is substantially complete except for presentation of the revised project cost estimate and the associated financial evaluation. The revised project cost estimate will be developed concurrent with preparation of the Final EIS, and the financial evaluation will be finalized following completion of the revised project cost estimate.

ES.1 Introduction

This Facilities Plan describes the existing and future wastewater service needs of north King County and south Snohomish County and how a recommended system of conveyance, treatment, and effluent management facilities (preferred alternative) has been developed. The new facilities, collectively referred to as the Brightwater Regional Wastewater Treatment System (Brightwater), will be owned and operated by King County Department of Natural Resources and Parks, Wastewater Treatment Division. Brightwater is scheduled to begin operation during 2010.

This Facilities Plan is prepared in accordance with Washington State Department of Ecology and federal requirements. A Department of Ecology Facilities Plan Checklist is included in Appendix A, providing a cross reference to all required information within this report.

The *Regional Wastewater Services Plan* (RWSP), adopted by the King County Council under Ordinance 13680 in November 1999, identifies the need for King County to construct a new 36- to 54-million gallon-per-day (mgd) treatment plant in north King County or south Snohomish County by 2010, and thus establishes the basis for this Facilities Plan. Brightwater is necessitated by a wide range of factors, including population growth and economic development, requirements for urban services, environmental and public health protection, constraints on expansion of the County's existing treatment plants and conveyance facilities, and goals to produce reclaimed water to augment the regional water supply. Flows from the King County wastewater service area will exhaust the capacity of existing treatment plants by 2010. In addition, restrictions in conveyance capacity may result in overflows of raw sewage unless the Brightwater treatment and conveyance facilities are brought on-line by 2010.

The environmental effects of Brightwater are being evaluated through a concurrent Environmental Impact Statement (EIS). The Draft EIS, published on November 6, 2002, presents comprehensive information related to the environmental setting of the project as well as potential environmental impacts of the alternative projects and proposed mitigation measures. The Final EIS, due to be published in late 2003, will evaluate the preferred alternative based on public and agency comments. The Facilities Plan reader is referred to the Draft and Final EIS for further detail on related subjects.

Wastewater from the King County service area is currently treated at the West Point, South, and Vashon Treatment Plants. Under the proposed plan, conveyance improvements will intercept flows within the Brightwater Service Area and deliver them to the new Brightwater treatment facilities. Brightwater will thus serve to off-load a portion of the wastewater flows currently treated at other facilities, as well as provide increased treatment capacity within the overall King County system. Figure ES-1 shows the relationship between treatment capacity and projected wastewater flows for the King County wastewater system over the planning period. Figure ES-2 shows the existing service areas for the West Point and South Treatment Plants, and how they would be modified once Brightwater is in service.

ES.2 Wastewater Flows

ES.2.1 Population and Flow Projections

Figure ES-2 shows the potential tributary areas that could contribute wastewater to Brightwater (Brightwater Service Area). Population, flow, and load projections were developed for the Brightwater Service Area based on a 50-year planning horizon extending from Year 2000 through Year 2050. The Year 2000 sewered population in the Brightwater Service Area was estimated at approximately 352,000, contributing approximately 28.8 million gallons per day (mgd) average wet weather flow (AWWF) to the existing West Point and South Treatment Plants. A portion of the Brightwater Service Area flows will continue to be treated at West Point and South Treatment Plants, but the majority will be conveyed to Brightwater. Table ES-1 summarizes the projected population and wastewater flows that will be treated by Brightwater during the planning period.

Table ES-1. Projected Population and Wastewater Flows for the Brightwater Service Area

Year	Sewered Population	Average Dry Weather Flow[a]	Average Wet Weather Flow[a]	Peak Hour Flow[a]
2010	256,000	17.6	22.2	83
2020	408,000	27.8	35.0	129
2030	415,000	27.4	34.4	123
2050/Ultimate	690,000	43.9	53.0	170

[a] Brightwater Service Area flows decrease slightly between Year 2020 and 2030 due to flow transfers accomplished within King County conveyance system, managing capacity between Brightwater, South Treatment Plant, and West Point Treatment Plant. Reference Section 3.2.1 of this Facilities Plan for detailed description of flow management.

Based on the projected rates of growth, the Brightwater treatment facilities would be initially sized for a Phase 1 AWWF of 36 mgd with a Phase 2 expansion to 54 mgd AWWF anticipated by 2040. The Phase 1 and 2 design flows are rounded upward from the values

developed in the flow projections. The Phase 2 expansion would enable Brightwater to meet the service area needs through 2050, based on a projection of saturation development. Once Brightwater is in service, King County will have a unique capability for managing and transferring flows between three treatment plants, maximizing the value and longevity of existing infrastructure and enhancing the reliability of the wastewater system.

ES.2.2 Infiltration/Inflow

King County is presently completing a 6-year, $41.5 million Regional Infiltration/Inflow (I/I) Control Program to reduce I/I that flows into the county's wastewater facilities and the local agency collection systems. The program is designed to quantify and locate systemwide I/I; conduct pilot I/I control projects to identify cost-effective removal techniques; develop model design standards to reduce I/I; and evaluate alternative billing structures, incentive programs, surcharges, and variable billing rates for systems with excessive I/I. The program will culminate in the development of a long-term I/I control program for both local agency and King County conveyance systems.

Pilot demonstration projects will be used to evaluate the effectiveness of various rehabilitation techniques in reducing I/I. Successful technologies can then be used as models for future remediation projects. The Regional I/I Control Program plans to perform 10 pilot projects with $13.2 million allocated for project design and construction. The selected pilot projects include three projects each in the north, east, and south regions of the King County service area plus a regional manhole rehabilitation effort involving three agencies. Pilot project construction will be initiated during 2003.

The Regional I/I Control Program is a complex project involving both technical and policy actions that will evolve over several years. The project is proceeding on schedule and will culminate in the King County Executive submitting an I/I control plan to the Regional Water Quality Committee and King County Council during 2005. As opportunities for cost effective I/I remediation are quantified, they will be considered in the county’s plans for implementation and phasing of the Brightwater facilities.

ES.3 Alternative Analysis: Siting and Candidate System Development

ES.3.1 Siting Study

The Brightwater alternative analysis began with a comprehensive siting study that identified and screened potential sites, evaluated associated conveyance systems, and investigated potential marine outfall locations. The siting process was a complex undertaking involving extensive research, geographical information system analysis, field investigations, public

involvement and stakeholder input, and consultation with local municipalities. The general sequence and phasing of siting activities is depicted in Figure ES-3.

As the siting study advanced, the evaluation of potential sites became progressively more detailed. As candidate systems were identified, they were evaluated with respect to a wide range of technical and policy criteria and total life cycle cost. Ultimately, the evaluations narrowed a list of 95 potential treatment plant sites to four candidate systems, each consisting of a treatment plant site with near-surface and deep tunnel conveyance options and one or more outfall zones.

Upon review of the four candidate systems, the King County Executive found that the Unocal and Route 9 alternatives best met the policy siting criteria and broader goals and policies of the region. Subsequent analyses of conveyance options identified two viable corridors for Route 9 conveyance—one along 228th Street and one along 195th Street, and one corridor for Unocal conveyance, as shown in the System Alternatives figure located at the back of this Facilities Plan. Based on these findings, the following alternatives were advanced into the EIS process for environmental review:

- Route 9–195th Street System
- Route 9–228th Street System
- Unocal System
- No Action Alternative

In August 2002 the King County Executive identified the Route 9–195th Street system (see System Alternatives figure at the end of this Facilities Plan) as the preferred alternative because of the relative efficiencies and flexibility it would provide. The King County Executive also preferred construction of tunnels for placement of conveyance pipelines rather than near-surface/open cut construction because of the lower overall impacts and lower operation and maintenance (O&M) costs. Outfall Zones 7S was preferred because of excellent mixing, constructability, and potential to avoid or minimize impacts on the sensitive nearshore habitat.

The Route 9–195th Street system is considered the preferred alternative for purposes of this Facilities Plan. As such, treatment process evaluations have been structured around the Route 9 site. However, the treatment technologies discussed herein would be appropriate for the Unocal site, if selected. Although the Route 9–195th Street system is the Executive's preferred alternative, each of the action alternatives analyzed in the Draft EIS and this Facilities Plan are viable options. The final alternative will be selected after the Final EIS is issued. In selecting a final alternative, the King County Executive will consider information presented in the Final EIS; comments from the public and local, state, and federal agencies; input from tribal governments; and factors such as cost and regional policies.

The Final EIS is scheduled for publication in late 2003, approximately 7 months after the initial submittal of this Facilities Plan. Thus, this Facilities Plan may require revisions or supplements to address issues identified during preparation of the Final EIS.

ES.3.2 Treatment Process Alternative Analyses

The alternative analyses considered a wide range of liquids and solids processes for potential application at Brightwater. Alternatives were based on treating an average wet weather flow of 36 mgd and a peak hour flow of 170 mgd. Effluent limitations were based on secondary treatment requirements for biochemical oxygen demand (BOD_5) and total suspended solids (TSS) of 30 milligrams per liter (mg/L), fecal coliform bacteria of 200/100 milliliters, and 85 percent removal of influent BOD_5 and TSS on a monthly basis. Water quality-based effluent limitations are not anticipated due to the high degree of mixing and dilution offered by the marine outfall. Up to 5 mgd of effluent would be treated for use as a Class A reclaimed water under the Washington *Water Reclamation and Reuse Standards.*

The screening of potential treatment technologies identified two preferred options for the main liquid treatment process—conventional activated sludge (CAS) and membrane bioreactor (MBR). In comparing the CAS and MBR processes, it was recognized that the MBR would produce far better effluent quality than CAS (typically 2 mg/L BOD_5 and TSS for MBR as opposed to 20 to 30 mg/L for CAS), benefiting the environment through a substantially lower discharge of pollutants to Puget Sound. However, the MBR technology is more expensive than CAS on a unit flow basis. Configuring an MBR to accept peak flows and loads would render it infeasible due to high cost. Therefore, the concept of a split flow MBR system was developed, in which the MBR process would be configured to accommodate a daily flow in excess of the AWWF, but below the peak day flow. Flow in excess of a split flow threshold would be routed around secondary treatment and recombined with MBR effluent through ballasted primary clarification, a process uniquely configured to provide enhanced sedimentation of high wet weather flows.

Alternative analyses evaluated various thresholds for initiating split flow treatment and found a feasible balance of cost and performance with an MBR sized to accept a 38-mgd flow (average flow over a 24-hour period). The analyses concluded that the 38-mgd split flow MBR would produce much higher effluent quality than a CAS process sized to treat the entire Brightwater flow. On an average annual basis, the discharge of BOD_5 and TSS from the split flow MBR would be 75 to 80 percent lower than the corresponding discharge from CAS. Split flow events are projected to occur an average of 25 times per year, and would not jeopardize compliance with anticipated National Pollutant Discharge Elimination System (NPDES) Permit limits. The MBR process would offer further benefits with respect to ammonia removal, a toxic pollutant under the State Water Quality Criteria. It is anticipated that the average total ammonia nitrogen in the MBR effluent would be less than 1 mg/L, compared to 20 mg/L or greater for a typical CAS effluent without nitrification.

Relative comparisons indicate that split flow MBR offers a lower capital cost than CAS ($531 million versus $566 million). However, split flow MBR is projected to have higher

annual O&M costs. Overall, the comparative present worth of alternatives differs by only a few percent, within the accuracy of the cost estimates. Based on the combined evaluations of cost and non-cost factors, and considering the significant reduction in discharge of pollutants offered by split flow MBR, the split flow MBR process was selected as the preferred alternative for secondary treatment.

ES.4 Preferred Alternative: Treatment Facilities

The proposed treatment system involves an MBR process that will produce extremely high quality effluent. The preferred alternative incorporates split flow treatment, in which flows above a split stream threshold of 38 mgd receive advanced primary treatment and are recombined with the MBR flows. The split stream threshold represents the *average* flow that can be routed to the MBR process over a 24-hour period; diurnal peaks of up to approximately 56 mgd could be accommodated by the MBR during a given 24-hour period. The flow split will be located upstream of the conventional primary clarifiers.

The split stream flows will receive ballasted primary clarification, with an estimated frequency of 25 split flow events per year under Phase 1 design/Year 2040 conditions. The effluent from the MBR and ballasted primary clarification processes is combined and disinfected prior to discharge, and the resultant annual mass discharge of pollutants is far less than the discharge that would result from a full flow secondary treatment process such as CAS.

ES.4.1 Liquid Treatment Process

A process schematic for the proposed treatment system is presented in Figure ES-4. Incoming flows will receive preliminary treatment at the headworks area though screening followed by aerated or vortex grit removal. Following preliminary treatment, the flow will enter a flow split structure, which will direct average daily flows in excess of 38 mgd to the ballasted clarification process. An average of 25 split flow events are anticipated annually.

Flows below the split stream threshold will receive primary clarification and fine screening followed by biological treatment in the MBR process. The MBR will have two major groups of process tanks—the aeration basins, which act as bioreactors, and the membrane tanks, in which the membranes that effect liquid/solid separation will be located. The MBR process will be designed to operate at elevated mixed liquor concentrations on the order of 8,000 mg/L at a sludge age of approximately 15 days, providing complete nitrification year round. The BOD_5 and TSS in the MBR effluent will average approximately 2 mg/L, with ammonia nitrogen typically 1 mg/L or less.

A portion of the MBR effluent, initially up to 5 mgd, may be withdrawn for disinfection, distribution, and reuse as a Class A reclaimed water. MBR effluent that is not directed to reuse will be combined with the periodic flow from the split stream/ballasted primary clarification process, disinfected with sodium hypochlorite, and directed to the effluent conveyance system. Dechlorination will be accomplished by adding sodium bisulfite, as required, in the downstream conveyance system.

Effluent would be transported from the Route 9 site to the marine outfall by an effluent conveyance system along the 195th Street corridor. The configuration of the effluent conveyance facilities is being established through ongoing preliminary design activities. Initial findings indicate that gravity conveyance appears feasible; thus, effluent pumping may not be required. In the event that effluent pumping is found to be necessary, space has been reserved for an effluent pump station in the preliminary site plan.

ES.4.2 Solids Processing and Biosolids Management

Brightwater will include a complete solids handling train, incorporating thickening, stabilization, liquid biosolids storage, and dewatering. The stabilized, dewatered biosolids will be hauled off-site and beneficially used along with biosolids from the West Point and South Treatment Plants. It is anticipated that the majority of the biosolids will be managed by land application, with composting providing an alternative means of biosolids management during periods of extended inclement weather, or when market conditions dictate.

Gravity belt thickeners have been shown to be the most cost-effective method of raw sludge thickening and will be used to co-thicken primary and MBR waste activated sludge. The fine screens used to protect the ballasted clarification and membrane equipment will remove oversize materials from the raw sludge, reducing the potential for obstruction of downstream equipment and improving biosolids quality.

The co-thickened sludge will receive a minimum of Class B stabilization through mesophilic anaerobic digestion. Alternately, King County may elect to install a batch feed thermophilic–mesophilic anaerobic digestion system to produce Class A biosolids. The evaluation of Class A versus Class B biosolids treatment is still in progress and a final process determination will be made during preliminary design. Should King County proceed with Class B mesophilic anaerobic digestion, the digester complex would be configured so that it can be upgraded to a Class A thermophilic–mesophilic anaerobic digestion process in the future.

ES.4.3 Preliminary Site Plan and Facility Layout

A preliminary site plan for the Brightwater facilities is presented in Figure ES-5. The site plan is developed into a conceptual rendering in Figure ES-6. The site plan reflects initial input from the Brightwater architectural team, and seeks to retain much of the site for environmental mitigation and enhancement features. The site plan and rendering show the

anticipated arrangement of the proposed Phase 1 facilities, along with areas set aside for the Phase 2 expansion. The site plan and rendering also show a reserved area that could be used for construction of secondary clarifiers if the MBR process fails to perform as anticipated, allowing conversion to a conventional activated sludge process.

ES.4.4 Odor Control

Odor control will be of paramount importance to the Brightwater facilities. Odor control systems will involve covering process units to contain foul air and treating foul air through multi-stage odor control facilities. The proposed odor control system involves three stage chemical scrubbers using sodium hypochlorite, sodium hydroxide, and potentially sulfuric acid. The air from the chemical scrubbers will be treated using carbon adsorption polishing prior to discharge. Odor control chemicals will be delivered by truck and stored on-site in bulk storage tanks, with containment and safety provisions meeting the requirements of the Uniform Fire Code and local jurisdictions.

ES.4.5 Reuse

Brightwater is proposed to produce up to 5 mgd of Class A reclaimed water upon completion of the Phase 1 facilities. Reclamation facilities at the Brightwater site will be sized for substantial expansion. Area will be reserved for a minimum of 54 mgd of future reclamation capacity.

It is anticipated that the reclaimed water will be withdrawn from the MBR effluent flow, disinfected, and conveyed to various reuse sites. King County communications with potential reuse customers indicate a preference for ultraviolet (UV) disinfection. Hence, a UV system is proposed for disinfection of reuse flows. Reuse facilities will be configured to comply with the Washington State *Water Reclamation and Reuse Standards*. Since the identified irrigation demands are seasonal, the reuse system may be operated for only a portion of the year, typically from May through September.

Within the project area, King County has identified 19 potential reuse sites where Class A water could be utilized for irrigation, with peak day demands estimated at 50 mgd or greater. User interest must be established through further study, and reuse agreements must be developed and implemented prior to initiating reclamation. King County will pursue these activities concurrent with design so that reuse agreements will be in place when the reclamation facilities are placed in service. Potential reuse sites are discussed in greater detail in Section 4.3.6 and Appendix F of this Facilities Plan.

ES.5 Preferred Alternative: Conveyance Facilities

The King County Executive's preferred alternative for Brightwater conveyance is the Route 9–195th Street system, as shown in the System Alternatives figure located at the back of this Facilities Plan. Key features of the conveyance system are summarized in Table ES-2, based on preliminary design activities completed to date:.

Table ES-2. Summary of Executive's Preferred Alternative Conveyance System

Parameter	Influent Corridor	Effluent Corridor
Conveyance Length	7.4 miles	12.7 miles
Anticipated Tunnel Inside Diameter	10 to 11 feet	8 to 12 feet
New Pump Stations Along Conveyance System	None	None
Portal Siting Areas	Portal 11–NE 175th St & 68th Ave NE Portal 34–NE Bothell Way & 80th Ave NE Portal 41–NE 195th St & 120th Ave NE	Portal 41–NE 195th St & 120th Ave NE Portal 44–NE 195th St & 80th Ave NE Portal 45–NE 195th St & 58th Ave NE Portal 7–Ballinger Way NE & 25th Ave NE Portal 27–NE 205th St & 1st Ave NE Portal 23–NW 205th St & Firdale Ave Portal 19–NW 205th St & Richmond Beach Dr NW
Method of Conveyance	Gravity flow to influent pump station	Gravity pressurized flow for entire length

The conveyance system continues to evolve through ongoing preliminary design. Near-term activities will focus on defining issues critical to systemwide permitting such as portal locations and potential impacts to wetlands and other aquatic resources, air handling and odor control strategies, connections between influent conveyance and existing King County facilities, emergency flow management, and construction methods.

ES.6 Preferred Alternative: Marine Outfall Facilities

As shown in Figure ES-7, the preferred alternative involves construction of the marine outfall in Zone 7S, adjacent to Point Wells. The outfall will originate from the conveyance pipeline terminus at Portal Siting Area 19. Microtunneling and trenched construction will be

evaluated for outfall pipeline installation at the shoreline and through the nearshore region. The outfall alignment, outfall construction methods, segment lengths, and other outfall installation details will be determined during preliminary and final design.

Diffuser locations in Zone 7S will be located beyond 4,000 feet offshore at water depths between 650 and 700 feet below mean low low water. The final diffuser configuration will be designed to function properly at both low flow and peak flow periods. Water quality and dilution zone analyses have shown that diffusers meet all applicable water quality criteria within the range of lengths and diffuser port configurations analyzed.

Outfall preliminary design activities will focus on establishing the final outfall pipeline alignment, optimum number and diameter of outfall pipelines, diffuser configuration and location, offshore and nearshore construction methods, and construction materials.

ES.7 Estimated Cost of the Brightwater Regional Wastewater Treatment System

The projected capital, O&M, and present value life cycle costs for the preferred alternative are summarized in Table ES-3.

Insert revised cost estimate, to be completed during Final EIS

ES.8 User Fees and Project Financing

Insert summary of Chapter 6 once the user fee and financing analysis has been updated per the revised cost estimate, to be completed during Final EIS

LIST OF FIGURES

Figure ES-1	Projected Treatment Plant Needs for West Point, East, and Brightwater Service Areas
Figure ES-2	Brightwater Service Area
Figure ES-3	Brightwater Siting Analysis Flow Chart
Figure ES-4	Treatment Process Schematic
Figure ES-5	Preliminary Site Plan, Brightwater Treatment Facilities
Figure ES-6	Conceptual Rendering, Brightwater Treatment Facilities
Figure ES-7	Route 9–195th Street System Alternative

Chapter 1 Introduction

1.0 Introduction

This Facilities Plan for the Brightwater Regional Wastewater Treatment System (Brightwater) describes the existing and future wastewater service needs of north King County and south Snohomish County and how a recommended system of conveyance, treatment, and effluent management facilities has been developed. The new facilities will be owned and operated by King County Department of Natural Resources and Parks, Wastewater Treatment Division. Brightwater is scheduled to begin operation in 2010.

This Facilities Plan is prepared as an Engineering Report under the requirements of Washington Administrative Code (WAC) 173-240-060 and Code of Federal Regulations (CFR) 40 CFR Part 35. A Washington Department of Ecology (Ecology) Facilities Plan Checklist is included as Appendix A. The checklist cross-references the location of each required item of information within this report. Additional supporting information is contained in the reference documents listed at the end of each chapter, as well the *Brightwater Draft Environmental Impact Statement* (Draft EIS) referenced in the report text.

1.1 Project Background and Related Studies

Brightwater is a key element in implementing the *Regional Wastewater Services Plan* (RWSP), which was adopted by the King County Council under Ordinance 13680 in November 1999 (King County, 1998). Under Ordinance 13680, King County set forth a series of policy directives to implement the RWSP, and to guide the management of treatment plant, conveyance, infiltration/inflow, combined sewer overflow, biosolids, water reuse, wastewater service, water quality protection, wastewater planning, environmental mitigation, public involvement, and financial issues.

The RWSP describes how wastewater infrastructure will be provided throughout the King County wastewater service area consistent with the Washington State Growth Management Act (GMA). It establishes the need for King County to construct a new 36- to 54-million-gallon-per-day (mgd) treatment plant in north King County or south Snohomish County by 2010, and therefore establishes a basis for this Facilities Plan. The RWSP supplements King County's *Comprehensive Water Pollution Abatement Plan,* and has been approved by Ecology as the General Sewer Plan for King County.

The environmental effects of Brightwater on the project area are being evaluated through a concurrent EIS developed in accordance with the State Environmental Policy Act (SEPA), Revised Code of Washington (RCW) 43.21C. The EIS is part of an environmental review process that began in spring 2002 with a public and agency scoping period to solicit comments on the proposed project. The recommended alternative presented in Chapter 5 of this Facilities Plan incorporates initial feedback provided by government agencies and the public during the SEPA process.

The Draft EIS, published on November 6, 2002, presents information related to the environmental setting of the project as well as potential environmental impacts of the alternative projects and proposed mitigation. The Draft EIS and this Facilities Plan are integral to one another, and the Facilities Plan reader is referred to the Draft EIS for further detail on related subjects. The Final EIS, which will include responses to public and agency comments on the Draft EIS, is scheduled for publication in late 2003.

1.2 Service Area

King County currently provides wastewater service to much of King County as well as portions of south Snohomish County and a small portion of north Pierce County, as shown in Figure 1-1. The boundary of the King County wastewater service area would not change under the Brightwater project; however, conveyance of flows to the existing East and West Service Areas will be modified as wastewater is redirected to the new Brightwater Service Area. The existing conveyance system and service areas are described in Chapter 2. Conveyance system modifications required to convey flows to Brightwater are discussed in Chapter 4 and Appendix C.

1.3 Facilities Plan Overview

This Facilities Plan describes how King County proposes to implement new wastewater management facilities to meet the growing needs of its wastewater service area as projected through Year 2050. Sewered development within these areas is currently served by King County-operated facilities, with flows treated at the West Point and South Treatment Plants. Under the proposed plan, conveyance improvements will intercept flows within the Brightwater Service Area and deliver them to the new Brightwater treatment facilities. Brightwater will thus serve to off-load a portion of the wastewater flows currently treated at other King County facilities, as well as to provide increased treatment capacity within the overall King County system. The interrelationship of Brightwater and the West Point and South Treatment Plants is described in Chapters 2 and 3.

The Brightwater treatment process will meet Ecology requirements for technology-based effluent limitations and applicable water quality-based effluent limitations. Brightwater is also proposed to initially produce up to 5 mgd of Class A reclaimed water for reuse purposes.

The Brightwater treatment facilities will be designed to accommodate both phased expansion to 54 mgd to serve the growing wastewater needs of the service area as well as liquid and solids stream treatment enhancements. Future liquid stream improvements could include expansion of reclaimed water production and process enhancements to meet more restrictive effluent limitations. Future solids stream improvements could include process enhancements to produce Class A biosolids.

King County is currently seeking ways to evaluate and implement opportunities for enhancing the Brightwater system to provide recreational, educational, and environmental benefits to the communities served by the system.

1.4 Planning Period

Population, flow, and load projections are based on a 50-year planning horizon extending from Year 2000 through Year 2050. Brightwater is proposed to be placed in service in 2010. Year 2050 conditions represent assumed full build-out of the present Brightwater Service Area.

It is proposed that construction of Brightwater treatment facilities will be phased; however, the influent and effluent conveyance facilities will be sized to convey the Year 2050 projected peak hour flows (170 mgd). Based on the assumed rates of growth, the Brightwater treatment facilities would be sized for an initial Phase 1 capacity of 36 mgd average wet weather flow (AWWF) with a Phase 2 expansion to 54 mgd AWWF anticipated by 2040. The Phase 2/Year 2040 expansion would enable Brightwater to meet the service area needs through 2050.

1.5 Need for the Brightwater System

The need for Brightwater is driven by a wide range of factors, including population growth and economic development, requirements for urban services, environmental and public health protection, constraints on expansion of King County's West Point and South Treatment Plants and associated conveyance facilities, and goals for production of reclaimed water to augment the regional water supply. These issues are briefly discussed below:

- **Population Growth and Economic Development.** The sewered population of the Brightwater Service Area is projected by King County to grow from approximately 352,000 in 2000 to 690,000 in 2050. During this period, average wet weather wastewater flow is projected to increase from approximately 21 mgd to 54 mgd. The Brightwater flows, combined with flows from new development in other portions of the King County wastewater service area, will exhaust the capacity of existing treatment plants by 2010. Restrictions in conveyance capacity will result in overflows of raw sewage.

- **Requirements for Urban Services.** The state Growth Management Act requires that urban services, including sewers and wastewater treatment, be provided to serve planned growth in Urban Growth Areas. Further, as a wholesale provider, King County is contractually committed to have capacity in place to accept wastewater from agencies that provide local sewer service in the Brightwater Service Area and other portions of the King County wastewater service area.

- **Environmental and Public Health Protection.** The Brightwater facilities will ensure the continued protection of water quality by providing appropriate facilities to convey and treat wastewater produced by the growing population of King and Snohomish Counties. The potential release of untreated sewage during sanitary sewer overflows (SSOs) from a system operating above its hydraulic capacity represents a significant public health risk. King County's level of service objective of no SSOs for wet weather influenced flows for a 20-year rainfall event will be compromised if the current regional system is not relieved by 2010.

- **Constraints at Existing South and West Point Treatment Plants.** The RWSP analyzed a comprehensive group of options to meet the increasing demand for regional wastewater treatment capacity. Alternatives included expansion of either the South Treatment Plant and/or the West Point Treatment Plant to accommodate projected growth. Expansion of existing treatment facilities would be constrained by available space at the treatment plant sites and terms of the West Point Settlement Agreement, and would offer less flexibility than construction of a third plant. Further, conveyance system limitations would complicate the conveyance of wastewater from north King and south Snohomish Counties to the existing treatment facilities. Thus, King County determined that a new regional facility is necessary. The RWSP proposed to locate the new plant close to or within the area experiencing the most growth.

- **Production of Reclaimed Water to Augment the Regional Water Supply.** A key aspect of Brightwater is the production of highly treated reclaimed water. This reclaimed water will serve as a new water resource to help meet the growing regional demand as well as to protect aquatic resources. As currently proposed, Brightwater will initially be capable of producing up to 5 mgd of reclaimed water. Space will be reserved on-site to expand reuse facilities in the future as the need arises.

1.6 Public, Agency, and Tribal Involvement

In 2000, King County developed a public involvement program for the Brightwater project. This flexible and far-reaching program was designed around project milestones and adjusts as circumstances change. Elements of the public involvement program, which has been updated throughout the siting process, include:

- Regular consultation with tribal governments
- Opinion leader interviews and briefings to elected officials and other regional community, business, and environmental leaders
- Executive Advisory Committee
- Community site nomination process
- Newsletters, videos, displays in public areas
- Web site that includes opportunities to comment on the project
- Focus groups (2000 and 2001)
- Media outreach
- Speakers bureau and special events like booths at fairs
- Workshops for regional stakeholders (August 2000, May 2001)
- Public meetings throughout the siting area (June 2000, April 2001, October 2001)
- Toll-free phone line and timely response to citizen correspondence
- Technical information made available on CDs, at libraries, and on the Web page
- Two community task forces based around the potential plant sites (2002)
- Scoping meetings for the Draft EIS (June 2002)
- Design guidelines workshops for communities near potential plant sites (Summer 2002)
- Conveyance workshops for communities near potential conveyance routes (Summer 2002)
- Technology seminar on treatment plant processes, geology and groundwater issues, and odor prevention and control (October 2002)
- Draft EIS public hearings (December 2002)

A series of technical seminars is scheduled for summer 2003 to provide revised and new information to the public and offer an opportunity for input. Seminar topics will focus on marine outfall, treatment plant, and conveyance updates, including issues such as engineering design and odor prevention, and special topics such as geology, surface water, groundwater, noise, and traffic.

Members of the public have had opportunities to:

- Nominate sites for consideration
- Help develop the policy criteria by which sites would be evaluated
- Comment on candidate sites before specific ones were selected for evaluation in the Draft EIS
- Help develop guidelines for architects designing the facilities
- Comment on the scope of the Draft EIS
- Comment on the Draft EIS

1.7 Regulations

The following sections provide an overview of the major federal, state, and local water quality regulations that impact planning of the Brightwater system. A discussion of other relevant permits and approvals is presented in Chapter 5 of this Facilities Plan.

1.7.1 Federal

King County is permitted to operate wastewater treatment plants that discharge effluent to surface waters of the state and nation under the National Pollutant Discharge Elimination System (NPDES). The NPDES program provides a permitting and regulatory framework for ensuring that wastewater treatment facilities are planned, operated, and maintained consistent with the federal Clean Water Act of 1972 and subsequent amendments. NPDES regulations are codified under 40 CFR Part 122, and Chapter 173-220 et. seq. Washington Administrative Code (WAC). NPDES permits typically place limits on the quantity and concentration of pollutants that may be discharged, and in most cases are issued for a 5-year period. A new NPDES permit will be required for any discharge resulting from the Brightwater facilities. Authority for NPDES permit issuance and enforcement was delegated by EPA to Ecology in 1973. The responsibility for review and approval of wastewater facility plans was similarly delegated by EPA to Ecology.

In addition to NPDES permitting, it is anticipated that Brightwater will require a Clean Water Act, Section 404 Permit (404 Permit) from the U.S. Army Corps of Engineers. The 404 Permit will trigger consultation by the U.S. Fish and Wildlife Service and National Marine Fisheries Service under the Endangered Species Act. This process will impact the design, construction, and operation of the Brightwater facilities as they affect listed and threatened species.

1.7.2 State

The Brightwater facilities will be subject to the specific environmental, habitat, and water quality regulations of state agencies, including Ecology, Washington Department of Natural Resources, Washington Department of Fish and Wildlife, and the State Department of Health (DOH). Ecology is responsible for review of this Facilities Plan. The purpose of this review is to ascertain that the proposed facilities will protect public health and water quality and not violate State Water Quality Standards, as contained in Chapter 173-201A WAC. The policies for providing this protection are established in Chapters 90.48, 90.52, and 90.54 RCW. Ecology will also be responsible for issuing and administering any NPDES permits required for the project, consistent with Chapter 173-220 WAC. DOH has a review role related to wastewater reclamation and reuse in ensuring compliance with the Reclaimed Water Act, Chapter 90.46 RCW.

Ecology has published a planning and design guide, *Criteria for Sewage Works Design,* known as the "Orange Book" (Ecology, 1998). The Orange Book presents best design practices for wastewater conveyance and treatment facilities "to ensure that the design of sewage collection and treatment facilities is consistent with the public health and water quality objectives of the State of Washington." Where Facilities Plan recommendations deviate from the Orange Book guidelines, supporting information is required to justify the proposed configuration. In the case of Brightwater, management of peak wet weather treatment by the proposed split flow treatment process would deviate from the Orange Book**.** Information supporting the split flow strategy is presented in Chapters 4 and 5 of this Facilities Plan.

1.7.3 Local

The Municipality of Metropolitan Seattle (Metro) was created in 1958, by a public vote, to exercise the powers allowed under RCW 35.58 related to water pollution control (King County, 1999). Metro was given responsibility for developing and implementing a *Comprehensive Water Pollution Abatement Plan* for the Seattle metropolitan area. A primary focus of the plan was to restore water quality in the Lake Washington watershed, which had become badly degraded by wastewater discharges and combined sewer overflow (CSO). The Metro water pollution control authority was subsequently transferred to King County when Metro merged into the county government structure in 1994.

The initial *Comprehensive Water Pollution Abatement Plan* and its subsequent amendments have become the core planning document for providing wastewater conveyance and treatment in the Lake Washington watershed, including tributary areas that lie in Snohomish County. Chapter 365-195-340 WAC and Chapters 36.70A.200 and 35.58.200 RCW give King County the authority to site essential public facilities for wastewater management throughout the Lake Washington watershed, including areas of south Snohomish County that lie in the Brightwater Service Area.

The Brightwater facilities will be subject to the specific environmental, land use, zoning, and building regulations of local jurisdictions in which project elements are located.

1.8 Facilities Plan Organization

This document has been organized and prepared to meet Ecology requirements for a wastewater facilities plan. It contains the following major elements:

Chapter 1, Introduction, discusses the need for Brightwater, including a summary of the planning work that established the general configuration of the major components of the Brightwater system.

Chapter 2, Background Information, presents environmental, demographic, and technical data on the project area to provide a context and framework for evaluating the proposed project. Chapter 2 discusses existing wastewater flows within the Brightwater Service Area, as well as observations on present levels of infiltration and inflow (I/I) and reuse program.

Chapter 3, Future Conditions, presents projections of future demographics and waste loads for the Brightwater Service Area. Chapter 3 also establishes the relationship of Brightwater to the proposed expansion of other King County wastewater treatment facilities.

Chapter 4, Alternative Analysis, describes how alternative sites for Brightwater and respective influent and effluent conveyance systems were identified, evaluated, and ranked. Chapter 4 describes potential effluent management options, including alternative marine outfall locations, upland discharge options, and effluent reuse. The alternative analysis presents design criteria for wastewater treatment process options and provides relative comparisons of technologies to identify a recommended alternative.

Chapter 5, Recommended Alternative, presents the technical details and projected costs of the recommended alternative, including influent conveyance, treatment processes, effluent conveyance, and water reuse.

Chapter 6, Financial Evaluation, develops capital and operations and maintenance costs into financial information, including implementation costs of the preferred alternative, customer service charges, new customer fees, and funding sources.

Appendices present technical documentation and other information that support the main body of the text.

Supplement, consisting of the Brightwater Predesign, Phase 1, Task 1.03 Treatment Plant Process Engineering Technical Memorandum, presents detailed information on the screening and evaluation of treatment processes considered for the Brightwater facilities.

1.9 Reference Documents

King County has prepared a wide range of documents that provide background for or supplement the alternative analyses presented in this Facilities Plan. These include investigations of Puget Sound performed under the Marine Outfall Siting Study (MOSS); technical documents and mapping prepared for treatment facility and conveyance system siting; technical memoranda related to conveyance, treatment process selection, and effluent management facilities; and the Draft EIS and associated studies required for environmental permitting. These documents are excerpted and referenced in subsequent sections of this Facilities Plan. A list of references is provided at the end of each chapter.

1.10 References

Brown and Caldwell, 1958. *Metropolitan Seattle Sewerage and Drainage Survey*, Seattle, WA.

King County, 1998. *Regional Wastewater Services Plan,* Seattle, WA.

King County, November 23, 1999, Ordinance 13680.

Washington Department of Ecology, 1998. *Criteria for Sewage Works Design,* Publication # 98-37 WQ, Olympia, WA.

LIST OF FIGURES

Figure 1-1 Brightwater Service Area

Chapter 2 Background Information

2.1 Introduction

The Draft EIS for the Brightwater regional wastewater treatment system describes the existing environmental setting of the Brightwater project area and presents detailed information related to potential environmental impacts at the preferred treatment plant, conveyance, and outfall sites. This chapter summarizes the information presented in the Draft EIS to provide background for the alternative analyses presented in Chapter 4 of this Facilities Plan. In addition, this chapter presents information on potential receiving waters, demographics, current wastewater flows and loads, existing wastewater facilities, I/I, CSO and SSO, and unsewered areas to fulfill the requirements of the Department of Ecology State Revolving Fund Facilities Plan Checklist (included as Appendix A).

All figures cited within this chapter are provided at the end of the chapter.

2.2 Existing Environment

This section describes the existing environmental setting of the Brightwater project area, with an emphasis on surface water quality. The reader is referred to Chapters 4, 6, and 7 of the Draft EIS for information on plants and animals; endangered species; and habitat, wetlands, and other sensitive areas.

2.2.1 Water Resources

The Brightwater project area includes a wide range of surface water resources, including both fresh and marine water bodies, and is underlain by a complex hydrogeologic environment. An evaluation of the suitability of these water bodies as potential receiving waters is presented in Chapter 4 of this Facilities Plan.

2.2.1.1 Surface Water Resources: Streams, Rivers, Lakes

Surface water resources in the Brightwater project area are shown in Figure 2-1. The majority of the project area lies in the 692-square-mile Cedar River-Sammamish watershed, designated as Water Resource Inventory Area (WRIA) 8 by Ecology. WRIA 8 includes areas within King and Snohomish Counties. Land use consists of forest (45 percent), urban areas (31 percent), surface waters (15 percent), range lands (5 percent),

agriculture (1 percent), and other miscellaneous uses (3 percent) (Ecology, 2002b). Surface water quantities are seasonally limited, and Ecology indicates that the basin suffers from over-appropriation of surface water rights. According to the 1998 Department of Ecology 303(d) List of Impaired and Threatened Water Bodies, nine streams and lakes in the watershed have been identified for total maximum daily loads (TMDLs) to mitigate water quality impairment. None of the rivers or streams within the Brightwater project area are designated as wild and scenic rivers under the federal Wild and Scenic Rivers Act, or as outstanding resource waters under the State Water Quality Standards (WAC 173-201A).

The Lake Washington/Sammamish River system is a major component of the WRIA 8 system. The eastern portion of the project area is located in several basins tributary to this drainage, including Little Bear Creek, North Creek, Swamp Creek, East Lake Washington, Lyon Creek, and McAleer Creek. The western portion of the project area includes several small streams that drain directly into Puget Sound. King County has designated this drainage as the Middle Puget Sound Basin. Major surface water resources within the basin include Willow Creek and its tributary, Shelleberger Creek, located near Edmonds.

The following sections of this chapter summarize major surface water features. For additional information, the reader is referred to the Draft EIS, which presents detailed descriptions of all study area surface water resources and surface water quality.

Surface Water Resources of the Lake Washington/Sammamish River System

Little Bear Creek

Little Bear Creek is approximately 7.4 miles long and drains a basin of 15 square miles. It begins southeast of the City of Everett, flows south near State Route (SR) 9 through the City of Woodinville, and discharges into the Sammamish River at river mile (RM) 5.4. Flow in Little Bear Creek varies widely; the stream is highly influenced by stormwater runoff from developed areas within the basin. Gaging conducted near the mouth of Little Bear Creek from 1979 through 1999 recorded flows from 2.68 to 260 cubic feet per second (cfs), with a mean annual value of 19.69 cfs (King County, 2002a).

Snohomish County, which rates fish-bearing streams according to Washington State Department of Natural Resources (DNR) guidelines, rates Little Bear Creek as a DNR Type 1 water from the mouth to SR 522, and a Type 2 water from SR 522 to its headwaters. A Type 1 rating indicates that it is a shoreline of statewide significance, and a Type 2 rating indicates it is a stream 20 feet or greater in width and is used by a substantial number of anadromous or resident fish (WAC 222-16-030). As a feeder stream to a Lake Class water (Lake Washington), Little Bear Creek is designated Class AA extraordinary quality water under the State Water Quality Standards.

King County has collected water quality data from 12 locations in the Little Bear Creek watershed since 1971 (King County, 2002a). King County has conducted water quality monitoring at the mouth of Little Bear Creek on an approximate monthly basis since 1979 and in Little Bear Creek upstream of SR 9 since early 2002. Snohomish County has monitored Little Bear Creek at two locations for the past 10 years.

Monitoring has indicated that portions of Little Bear Creek periodically fail to meet State Water Quality Criteria for bacteriological quality. Concentrations of fecal coliform bacteria have shown a decreasing trend over time, but still experience periodic criteria exceedances. Likely sources of fecal coliform bacteria are related to the rural nature of the watershed (animal waste) and effects of urbanization. The decrease in fecal coliform levels is believed to be a result of a decrease in livestock and hobby farms in the watershed. Temperature has increased over time, likely due to the effects of urbanization and impacts to the stream corridor. Dissolved oxygen (DO) levels also periodically fail to meet State Water Quality Criteria, consistent with elevated water temperatures, which reduce DO concentrations.

Since Little Bear Creek periodically fails to meet State Water Quality Criteria for fecal coliform bacteria, it has been placed on the 1998 303(d) List. At present, a TMDL has not been initiated.

North Creek

North Creek originates in the City of Everett near the Everett Mall, flows south through unincorporated Snohomish County and the City of Mill Creek, and enters the Sammamish River at RM 4.4 near the City of Bothell. The main stem of the creek is 12.6 miles long. Snohomish County classifies North Creek as a DNR Type 1 water from the mouth to the confluence of Silver Creek, and as a DNR Type 2 water from Silver Creek upstream. North Creek is a Class AA water under the State Water Quality Standards.

For water years 1995 through 2001, the average wet-season flow of North Creek at the Snohomish-King County line was 82.3 cfs, and the corresponding average dry-season flow was 21.6 cfs (Snohomish County, 2002a).

King County has collected monthly water quality samples in North Creek upstream of SR 522 since 1971, and near the bridge at NE 205th Street since early 2002, with intermittent data collection at NE 205th Street since 1973. Based on samples collected by King and Snohomish Counties, the waters of North Creek are generally cool and slightly turbid, with periodic high fecal coliform bacteria concentrations (King County, 2002a; Snohomish County, 2002a). King County water quality data are summarized in the Surface Water Appendix of the Draft EIS, along with additional water quality data for North Creek. Low DO concentrations have been measured in the upper basin. While water quality in North Creek has been characterized as generally good by King County (Metro, 1989, 1990, 1991, and 1994; King County, 2002b), temperature, turbidity, and pH periodically fail to meet Class AA criteria.

North Creek is on the 1998 303(d) List for DO and fecal coliform bacteria. Because of the bacteriological impairment, a TMDL report has been developed and is proceeding to implementation (Ecology, 2001a, 2002a). The TMDL also recognizes impairment of DO levels, and proposes a range of actions to improve water quality, including source inventories and mapping, implementation of best management practices (BMPs), public education, habitat restoration/improvement, and watershed stewardship and volunteer programs.

Swamp Creek

Swamp Creek originates in the City of Everett at the outlet of Lake Stickney, southeast of Paine Field. The creek flows south through the Cities of Lynnwood, Brier, Mountlake Terrace, and Bothell, entering the Sammamish River at RM 0.6 near the City of Kenmore. The main stem of the creek is 10.9 miles long. Snohomish County classifies Swamp Creek as a DNR Type 1 water from the mouth to the confluence with Scriber Creek, and as a DNR Type 2 water from Scriber Creek upstream. Swamp Creek is a Class AA water under the State Water Quality Standards.

For water years 1995 through 2001, the average wet-season discharge at a site just upstream of Interstate 405 (I-405) was 22.4 cfs, and the average dry-season discharge was 3.0 cfs (Snohomish County, 2002a).

Monitoring performed by King and Snohomish Counties has shown that Swamp Creek experiences periodic water quality impairment due to elevated temperature, low DO, and elevated levels of fecal coliform bacteria. On occasion, turbidity and pH also failed to meet Class AA criteria (King County, 2002a; Snohomish County, 2002a). Swamp Creek water quality has been characterized as poor by King County (King County, 2002d). Dissolved oxygen was low in the upper basin, with concentrations meeting the Class AA criterion about one-half of the time. Fecal coliform bacteria concentrations met the Class AA criterion only one-third of the time at King County sampling stations (King County, 2002a). Ecology has therefore placed Swamp Creek on the 1998 303(d) List for DO and fecal coliform bacteria. At present, a TMDL has not been initiated for Swamp Creek.

Sammamish River

The Sammamish River is approximately 13.8 miles long. It flows west and northwest from Lake Sammamish to enter Lake Washington at the City of Kenmore. Water quality data have been collected in the Sammamish River at Bothell by Ecology (1959 to 1999) and at Kenmore by King County (1979 to 1999). The Sammamish River is a Class AA water under State Water Quality Standards.

The U.S. Geologic Survey (USGS) previously maintained gaging station 12126500 on the Sammamish River at Bothell. For the period of 1939 to 1986, the mean annual stream flow was 367 cfs and the peak recorded instantaneous flow was 1,910 cfs (in January 1956).

Water quality in the Sammamish River is impaired by elevated temperatures, fecal coliform bacteria, turbidity and total suspended solids (TSS), and low DO. Urbanization and loss of riparian vegetation have contributed to the deterioration of water quality. The Sammamish River has been placed on the 1998 303(d) List for fecal coliform bacteria, DO, pH, and temperature. At present, a TMDL has not been initiated for the Sammamish River.

McAleer Creek

McAleer Creek originates from Lake Ballinger, a 100-acre water body located in the Cities of Mountlake Terrace and Edmonds. Historic water quality problems in the lake have included severe algal blooms, oxygen-depleted bottom waters, and bacterial contamination (Mountlake Terrace, 1993). Lake Ballinger is considered eutrophic. Hall Creek, which originates at the outlet of Hall Lake in the City of Lynnwood, is the major surface water inflow to Lake Ballinger. The Hall Creek watershed is highly urbanized and receives runoff from industrial areas, highways, and freeways.

McAleer Creek flows south from Lake Ballinger through the Cities of Mountlake Terrace and Shoreline and unincorporated King County to enter Lake Washington near Lake Forest Park. For water years 1992 through 1994 and for 2001, the average wet-season flow in McAleer Creek was 13.0 cfs and the average dry-season flow was 7.0 cfs (King County, 2002b).

The City of Shoreline classifies McAleer Creek as a Type 2 water (mean annual flow less than 20 cfs and documented salmonid use). The Cities of Mountlake Terrace and Lake Forest Park do not classify streams under the DNR typing system. The McAleer Creek/Lake Ballinger/Hall Creek system is a Class AA water under State Water Quality Standards.

On the basis of monthly monitoring by King County (King County, 2002b), McAleer Creek is generally cool and well-oxygenated, with periodically elevated temperature, TSS/turbidity, nitrate-nitrogen, ammonia, and fecal coliform bacteria. On occasion, DO does not meet Class AA criteria. The Class AA criterion for fecal coliform bacteria was met only 23 percent of the time. McAleer Creek has been included in the 1998 303(d) List for fecal coliform bacteria. At present, a TMDL has not been initiated within the McAleer Basin.

Lake Washington

Lake Washington is the largest lake in King County. It has a drainage area of approximately 472 square miles and a surface area of approximately 21,500 acres. The overall water quality of Lake Washington is good, and the lake is characterized as mesotrophic, having moderate transparency and moderate levels of nutrients and algae (King County, 2002c). As discussed in the Draft EIS, public concern over water quality

degradation in Lake Washington led to the formation of Metro, the forerunner of King County's current Wastewater Treatment Division.

King County collects data at several Lake Washington water quality stations, including one located in the City of Kenmore near the mouth of the Sammamish River. Recent data (http://dnr.metrokc.goc/wlr; King County, 2002c) indicate that water quality is typically compliant with State Water Quality Criteria at that station, with moderate levels of nutrients that are similar to other areas of the lake. Although parts of Lake Washington are on the 1998 303(d) List for fecal coliform bacteria, the Kenmore station meets State Water Quality Criteria for fecal coliform bacteria.

Surface Water Resources of the Middle Puget Sound Basin

Willow Creek

Willow Creek originates from springs in the City of Woodway, flowing northwesterly approximately 1.5 miles before entering Edmonds Marsh and the Puget Sound. The creek supplies water to the Deer Creek Hatchery. The Willow Creek watershed includes areas of residential development, and portions of the creek have been routed through culverts and linear, excavated ditches. Willow Creek is a Class AA water under State Water Quality Standards.

Limited flow data are available for Willow Creek. During May and June 1990, flow ranged from 0.5 to 1.7 cfs near the outlet of Edmonds Marsh (R.W. Beck, 1991). These data were subsequently used in a water resources study, which projected a 100-year storm flow of 56 cfs.

Water quality in Willow Creek is variable, reflecting the impacts of stream channel modifications and development in the watershed. Limited water quality sampling indicates that pH, temperature, and fecal coliform bacteria periodically fail to meet Class AA water quality criteria (CH2M HILL, 1998); however, the creek has not been included on the 1998 303(d) List and a TMDL has not been initiated. The Willow Creek/Edmonds Marsh system is discussed further in Chapters 6 and 7 of the Draft EIS.

Shelleberger Creek

Shelleberger Creek originates in a wetland in south Edmonds and flows northwesterly into Willow Creek near the Edmonds Marsh. The Shelleberger Creek watershed is characterized by dense residential development. Like Willow Creek, it is a Class AA water under State Water Quality Standards. No data are available for stream flow or water quality in Shelleberger Creek.

2.2.1.2 Surface Water Resources: Flooding and Flood Plains

Flood plains occur in low-lying areas along the Sammamish River, North Creek, and Swamp Creek, as shown in Figure 2-2. The main risk results from rising floods, caused by extended periods of heavy rainfall, snowmelt, and combinations of both conditions. Flood events in February 1996, November 1995, April 1991, and November 1990 had major regional impacts, resulting in large-scale property damage and federally declared disaster conditions.

According to *Flood Hazard Management Issues in Snohomish County* (Snohomish County, 2001), flood flows in North Creek and Swamp Creek have significantly increased due to the effects of urbanization. Floods in these watersheds are caused primarily by heavy rainfall. Along Lower North Creek in Bothell, in the vicinity of the I-405/SR 522 interchange, a system of levees has been constructed to protect business parks and other development.

Where Brightwater facilities involve work in and around floodplains, design and construction activities will require careful coordination with King and Snohomish County surface water management agencies.

2.2.1.3 Marine Water Resources: Puget Sound

As part of the Brightwater program, King County initiated a comprehensive study of existing conditions in Puget Sound to evaluate ocean discharge alternatives. Termed the Marine Outfall Siting Study, it evaluated seabed geology and sediments, currents, marine life, and chemical and bacteriological conditions in potential receiving water areas.

This section of Chapter 2 summarizes the MOSS investigations. For additional information, the reader is referred to the Draft EIS and MOSS documents. A list of reports and other documents produced by the MOSS program is presented in the References section at the end of this chapter. The MOSS reports were electronically distributed on compact disk accompanying the Draft EIS.

General Description and Circulation Patterns

Puget Sound is a deep, glacially carved fjord estuary that connects to the Strait of Juan de Fuca through Admiralty Inlet and Deception Pass. Puget Sound is characterized by a series of relatively deep basins separated by shallower sills. The Brightwater project area lies adjacent to a region of Puget Sound called the Triple Junction. Here, Admiralty Inlet and Possession Sound join the Central Basin at the southern end of Whidbey Island. The portions of Puget Sound and Possession Sound in the vicinity of the Brightwater project area are considered Class AA marine waters under State Water Quality Standards.

General features and circulation patterns of Puget Sound are shown in Figure 2-3. Currents in the Triple Junction are affected by a number of factors, including tidal exchange, freshwater input from river inflow, winds, and bathymetry. During incoming tides, water flows through Admiralty Inlet to the Central Basin and Possession Sound offshore of Edmonds; during outgoing tides, currents from the Central Basin and Possession Sound converge as they enter Admiralty Inlet. The complex and irregular topography of the seafloor in this area creates more intensified flood (inflowing) currents along the western shore along Kingston and north Kitsap Peninsula, and more intensified ebb (outflowing) currents between Richmond Beach and Edmonds.

In addition to tidal currents, Puget Sound exhibits typical estuarine circulation, with the inflow of more dense saline water at depth and outflow of less dense brackish water at the surface. The depth at which this transition of flow occurs depends on numerous factors, including the amount of freshwater runoff. Brackish water is formed at the surface as rivers discharge fresh water to Puget Sound. The area's three largest rivers—the Skagit, Snohomish, and Stillaguamish—all empty into the Whidbey Basin, creating a strong surface outflow from Possession Sound. The rivers in South Puget Sound and the Central Basin also create a brackish, outflowing surface layer. However, the South Puget Sound surface layer is less energetic and deeper than the flow out of Possession Sound.

Saline ocean water enters Puget Sound over shallow sills in Admiralty Inlet, then flows south through the Central Basin and north through Possession Sound into Whidbey Basin. Combined with the tidal currents, this inflowing water forms a mean southward current along the western shore that extends from near the surface to the bottom and to the south below 360 feet in depth. An outflowing layer exists along the eastern side of the Central Basin, with the net current to the north from the surface to approximately 360 feet in depth.

In the Triple Junction, winds create complex current patterns because they reinforce surface flow in some locations and oppose it in others. A wind blowing from the north reinforces the surface water flowing south out of Possession Sound while retarding water flowing north from the Central Basin. Similarly, a wind blowing from the south retards the surface outflow from Possession Sound while reinforcing outflow from the Central Basin. The wind-induced surface currents can create an opposing current at depth; a wind blowing from the south induces a northward flow at the surface and a southward flow at depth.

Tidal movements and currents are discussed in more detail in the *Brightwater Marine Outfall – Puget Sound Physical Oceanography Related to the Triple Junction Region* (Ebbesmeyer et al., 2002).

MOSS Field Studies Summary

As part of the MOSS effort, an enhanced marine water quality monitoring program was conducted during 1999, 2000, and 2001. The program included sampling and analysis of

beach, nearshore and offshore water, sediment, shellfish tissue, and macroalgae. The study area incorporated the Central Basin of Puget Sound from the southern end of Whidbey Island in the north to Shilshole Bay in the south. Parts of Admiralty Inlet and Possession Sound were also included in the study area. Water column sampling and characterization were used to confirm the accuracy of oceanographic circulation models, screen alternative outfall zones, and assess potential impacts to human health, aquatic life, and wildlife. Marine water quality monitoring stations are shown in Figure 2-4.

Water samples were analyzed for physical properties, nutrients, DO, chlorophyll, photosynthetically active radiation, and bacteria. Organic compounds and metals were monitored in beach, nearshore, and offshore sediments. Conventional parameters were analyzed for nearshore and offshore sediments. Conventional parameters—excluding sulfides, ammonia-nitrogen, and total volatile solids—were also measured in beach sediments. Organic compounds and metals were monitored in shellfish tissues and metals were monitored in macroalgae samples.

Water quality studies were conducted by King County as part of the MOSS program. The results of these studies are presented in the *Water Quality Status Report for Marine* Waters, 1999-2000 (King County, 2001a) and *Water Quality Status Report for Marine Waters, 2001* (King County, 2002g). These water quality studies are summarized in the following section.

Marine Water Quality: General

During the MOSS investigations, salinity, temperature, and depth transects across Puget Sound were conducted monthly at three locations in 1999 and at six locations in 2000. Data collected also included DO and chlorophyll-*a*. Temperature, salinity, and density data indicated typical seasonal patterns, with the water column warming in June. Salinities near the surface of the Possession Sound transect were lower than other areas due to the freshwater input of the Snohomish River. Overall, transect data indicated patterns consistent with observed and suspected circulation patterns of the Central Basin and Possession Sound.

DO concentrations were above 5 milligrams/liter (mg/L) at all stations in the vicinity of the Brightwater project area. Class AA water quality criteria indicate that DO concentrations should be above 7 mg/L, but acknowledge that natural conditions, such as the upwelling that occurs in Puget Sound, can cause concentrations to fall below these levels. When naturally low DO concentrations occur, human activities must not cause dissolved oxygen to drop by more than 0.2 mg/L (WAC 173-201 A-030[1][B][ii][B]).

Concentrations of nutrients, such as ammonia and nitrate + nitrite-nitrogen, were similar for both 1999 and 2000. Ammonia was highest in the summer and nitrate + nitrite-nitrogen was most abundant in winter. All ammonia concentrations for beach and offshore stations, including those located near potential outfall zones, were well below the Class AA ammonia criteria for marine waters.

Marine Water Quality: Bacteria

All offshore stations met the Class AA marine water criteria for fecal coliform bacteria. At intertidal stations, however, the influence of freshwater runoff from the surrounding watersheds was evident. The number of intertidal stations exceeding the Class AA criteria for fecal coliform bacteria increased during the high rainfall months and at stations closer to freshwater inflows. *Enterococcus* bacteria concentrations in the offshore samples were low, when detected. *Enterococcus* levels at beach stations varied among stations and months, and did not correlate with fecal coliform bacteria counts.

Marine Water Quality: Metals and Organics

Total and dissolved metals were measured in marine waters at both offshore and intertidal stations within the MOSS area. Organic compounds, including base neutral acid extractables (BNAs), chlorinated pesticides, polychlorinated biphenyls (PCBs), chlorinated herbicides, and organophosphorus pesticides, were also measured in marine offshore and intertidal areas within the study area. All results for metals were below applicable acute and chronic Washington State Water Quality Criteria. A total of 20 organic compounds out of 108 measured were detected, all of which were BNAs. At present, Ecology has not promulgated water quality criteria for any of the detected BNA compounds.

2.2.1.4 Groundwater Resources

The regional groundwater regime of the project area is highly complex and includes both confined and unconfined aquifers at varying depths. Groundwater movement is generally controlled by groundwater recharge/discharge relationships and the glacial stratigraphy of the area. In general, groundwater recharge occurs in the higher topographical areas. As the groundwater migrates downgradient, it typically discharges in lower-lying areas, and ultimately into surface water bodies of the Lake Washington–Sammamish River system and Puget Sound. Generalized hydrogeologic regimes and regional groundwater flow trends are shown in Figure 2-5. A conceptual hydrogeological model showing typical patterns of groundwater flow toward inland water bodies and Puget Sound is shown in Figure 2-6.

The complex glacial stratigraphy in the project area has a strong influence on groundwater flow. The direction of flow is generally vertical/downward in recharge areas, and the amount of downward flow is controlled in part by the permeability of the deposits. Groundwater that infiltrates from precipitation into coarse-grained, high-permeability deposits typically flows under unconfined conditions. Groundwater flow in such deposits is often perched on top of a low-permeability unit, such as glacial till. Where a perching low-permeability stratum is absent, most of the flow is typically downward.

As vertical flow encounters low-permeability materials, movement becomes predominantly lateral and the groundwater may discharge at springs on hillsides, and at contacts along water courses. A portion of the flow will percolate downward to underlying granular outwash or lacustrine deposits. Through much of King and Snohomish Counties, groundwater flow beneath low-permeability units is under confined (pressurized) conditions. At deeper depths beneath these zones, groundwater includes regional flows from the Cascade Mountains that ultimately discharge into Puget Sound.

The Vashon Advance Outwash sand unit, located in the northeast portion of the project area, comprises an important groundwater resource known as the Cross Valley Aquifer, which provides water to the Cross Valley Water District. The Cross Valley Aquifer was designated as a sole source aquifer by EPA in 1987. Major features of the Cross Valley Aquifer are shown in Figure 2-7. Groundwater flow in the main body of the aquifer is generally to the south. Around the perimeter, however, flow is toward the edge of the aquifer.

2.2.2 Topography, Geography, and Geology

This section provides an overview of the topography, geography, and geology of the Brightwater project area. Geological information specific to proposed project elements is presented in Chapter 4 of the Draft EIS, including information on site-specific geological hazards.

The Brightwater project area is located in the central portion of the Puget Sound Lowland, an elongated topographic and structural depression bordered by the Cascade Mountains on the east and the Olympic Mountains on the west. It is characterized by rolling terrain with broad valleys. In general, the ground surface elevation of the Puget Lowland area is within 500 feet of sea level. Surficial geology of the project area is shown in Figure 2-8.

The Puget Sound Lowland was filled to significant depths by glacial and non-glacial sediments during the Pleistocene Epoch. Bedrock outcrops are present in only a few locations in the greater Seattle area—at Alki Point in West Seattle, in the Duwamish Valley near Boeing Field along I-5, and in the southern portion of Rainier Valley and Seward Park in southeastern Seattle. Near the project area, bedrock outcrops occur along the Snohomish River Valley. Elsewhere in the King and Snohomish County area, the bedrock is deeply buried by Pleistocene and Holocene sediments. The contact between the bedrock and overlying sediments in the project area has been interpreted to dip to the west, with bedrock occurring a few hundred feet below ground surface (bgs) along the eastern portion of the project area. Based on deep drill holes and seismic profiling, the typical depth to bedrock in the Seattle area is believed to be in the range of 2,400 to 2,700 feet bgs.

Geologists generally agree that the Puget Sound area was subjected to four to six major glaciation periods during the Pleistocene Epoch. Ice for these glacial events originated in

the coastal mountains and the Vancouver Range of British Columbia. The maximum southward advance of the ice was about halfway between Olympia and Centralia. During the most recent glaciation, the thickness of ice was about 3,000 feet in the project area. The last ice covering the project area receded about 13,500 years ago.

The stratigraphic record in the central Puget Sound Lowland is a complex sequence of glacially derived and interglacial sediments (sediments that accumulated in between glacial periods). Complete or partial erosion of some deposits, as well as local deposition of lake, river, and ocean sediments, further complicates the geologic setting.

2.2.2.1 Regional Seismicity

The project area is situated near the leading edge of a subduction zone, a region where two tectonic plates collide, resulting in one plate overriding the second. While not yet fully understood, the tectonics and seismicity of the area are dominated by the convergence and subduction of the western oceanic Juan de Fuca plate beneath the eastern continental North American Plate.

Known faults and other major geological structural features are shown in Figure 2-9. The nearest active fault to the project area is the South Whidbey Island Fault Zone, located approximately 2 or more miles north of the project area. The South Whidbey Island Fault Zone is estimated to be 4 to 7 miles wide, dipping steeply to the north. It has been mapped along the southern edge of Whidbey Island, and extends southeast across Puget Sound. An onshore extension of the fault has been postulated as extending south eastward across Snohomish County. South of the project area, along the I-90 corridor, lies the Seattle Fault, which is also considered to be active.

Seismic events in the Puget Sound area are generally believed to result from three source mechanisms: (1) the very large Cascadia source (magnitude 8.5+) off the coast of Washington; (2) the intraplate source (up to magnitude 7.5) occurring 18.5 to 43.5 miles beneath Puget Sound; and (3) random crustal events (up to magnitude 7+) that could occur in the upper 20 miles anywhere in the region. The 1949 Olympia earthquake (magnitude 7.1), the 1965 Sea-Tac earthquake (magnitude 6.5), and the 2001 Nisqually earthquake (magnitude 6.8) are recent events associated with the intraplate fault mechanism.

The project is located in an area that has experienced earthquakes in the past and can be expected to experience earthquakes in the future. The project area has been designated as a Seismic Zone 3 (moderate to high seismic risk) under the 1997 Uniform Building Code (International Conference of Building Officials, 1997), and Brightwater facilities would be designed accordingly.

2.2.2.2 Other Geologic Hazards

Geologic hazards such as high erosion potential, landslide, and liquefaction hazards are identified and mapped as part of county and local critical area regulations. Each of these geologic hazards occurs to some degree in the Brightwater project area. Geological hazards in the vicinity of major elements of the Brightwater system are discussed in Chapter 4 of the Draft EIS.

2.2.3 Climate

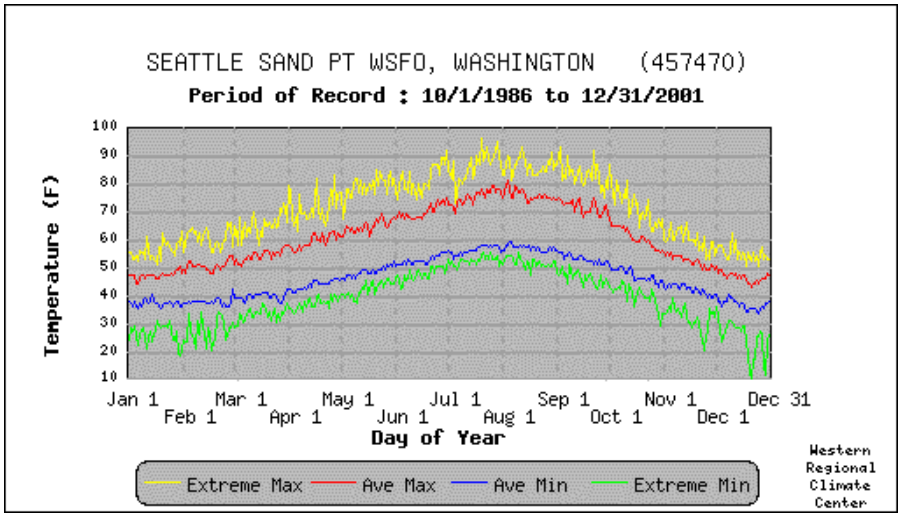
As described in Chapter 5 of the Draft EIS, the Brightwater project area has a mild climate, influenced by its coastal location, and the semi-permanent high- and low-pressure areas located over the north Pacific Ocean. These factors produce significant variations in weather conditions over short distances. Variations in temperature, length of the growing season, fog, rainfall, and snowfall are influenced by distance from Puget Sound, topography, and air from the ocean moving through the Strait of Juan de Fuca and the Chehalis River Valley. Occasionally, in the winter season, cold air from the interior of Canada flows southward across the project area.

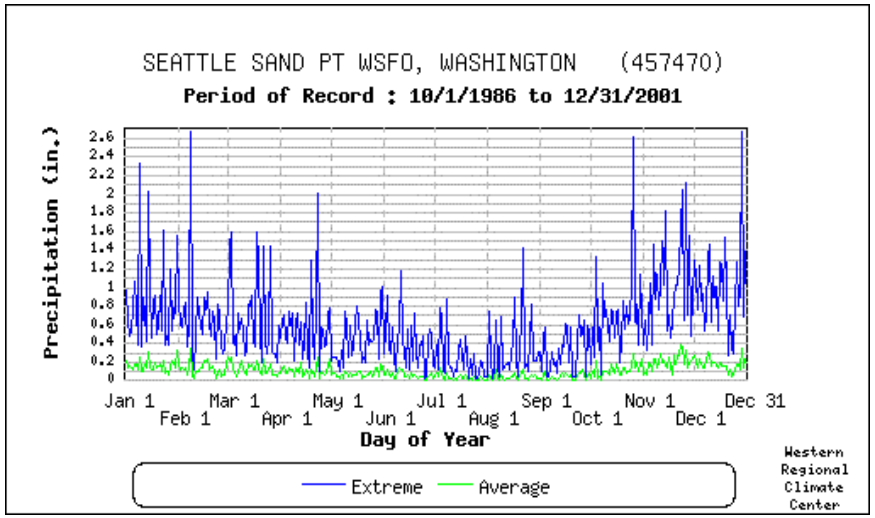
Table 2-1 summarizes representative temperature, precipitation, and snowfall data for the project area. The data were collected by the National Oceanic and Atmospheric Administration weather station at Sand Point in northeast Seattle, the nearest weather station to the Brightwater project area with long-term records.

The prevailing wind direction is south or southwest during the winter and north or northwest during the summer. Occasional severe winter storms produce strong northerly winds. The summer months are characterized by moderate temperatures and light, variable winds that tend to blow from the north. The highest recorded winds in the area are associated with strong storms that cross the state from the southwest in the fall and winter. The Olympic Mountains buffer the Puget Sound Lowland from the weather that arrives from the Pacific Ocean. The Cascade Mountains and Puget Sound also buffer the area from weather systems moving into the area. The result is mild, wet, and cloudy winters and cool summers. Summer weather is often dominated by persistent high-pressure cells that create stagnant air conditions. This weather pattern can contribute to the formation of photochemical smog, as indicated by ozone concentrations downwind from urban centers.

Table 2-1. Climatological Summary, Sand Point Weather Station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	47.0	50.6	54.3	59.5	64.8	69.8	74.9	75.7	71.7	61.0	52.1	46.2	60.6
Average Minimum Temperature (°F)	36.8	37.6	39.4	43.8	48.7	52.6	56.0	56.7	52.9	47.0	41.7	36.6	45.8
Average Total Precipitation (in.)	4.74	3.24	3.86	3.18	2.19	2.51	0.92	0.97	1.27	3.08	5.35	5.14	35.45
Average Total Snowfall (in.)	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.9





a. Data Source: National Oceanic and Atmospheric Administration, Western Regional Climate Center (http://www.wrcc.dri.edu).

b. Data for Sand Point Weather Station, Station ID 457470, Seattle, Washington. Period of record: October 1, 1986 to December 31, 2001.

2.2.4 Air Quality

In the Puget Sound area, the main source of air pollution is internal combustion engines, wood burning stoves, road dust, and industrial emissions. The Brightwater project area is currently a maintenance area under the EPA classifications (Puget Sound Clean Air Agency, 2002). The standards for carbon monoxide and ozone were violated in the past, but are now being met and closely monitored under a State Implementation Plan (SIP) for attainment of air quality standards.

The Brightwater facilities lie within the carbon monoxide and ozone maintenance areas and thus are subject to the requirements of the SIP. Detailed evaluations of potential emissions from the Brightwater facilities are presented in Chapter 5 of the Draft EIS.

The average wind velocity within the Puget Sound Lowland is less than 10 miles per hour. Although the Puget Sound Lowland area is the most densely populated and industrialized area in Washington, there is sufficient wind most of the year to disperse air pollutants released into the atmosphere. Air pollution is usually most noticeable in the late fall and winter seasons, under conditions of clear skies, light wind, and a sharp temperature inversion. Temperature inversions occur when cold air is trapped under warm air, preventing vertical mixing in the atmosphere. Inversions can last several days and can prevent pollutants from being dispersed by the wind. Inversions are most likely to occur during October, November, December, January, and February. If poor dispersion persists for more than 24 hours, it can result in the declaration of an "air pollution episode" or local "impaired air quality" by the Puget Sound Clean Air Agency (PSCAA). PSCAA has not declared an air pollution episode in the last 3 years.

2.3 Land Use, Demography, and Wastewater Flows

The Brightwater project area includes portions of north King County and south Snohomish County. Project area demography and land use are described in the current King County and Snohomish County Comprehensive Plans (King County, 2000a; Snohomish County, 2002c) and the reader is referenced to these documents for additional information. Based on these documents, land use in north King and south Snohomish Counties is shown in Figures 2-10 and 2-11, respectively. Within the Brightwater project area, land use varies extensively, ranging from built-out areas with complete urban services to less developed areas that are presently unsewered.

Those portions of the overall Brightwater project area that will be served by the Brightwater facilities are referred to as the Brightwater Service Area. The Brightwater Service Area was identified by projecting overall flows for the King County wastewater system; establishing system-wide needs for capacity; investigating capacity limitations of

existing treatment and conveyance facilities; and identifying basins that could be routed to Brightwater to relieve the treatment and conveyance limitations. The relationship of Brightwater to existing King County facilities is discussed in Section 3.2.1 of this Facilities Plan.

Current population and wastewater projections for the Brightwater Service Area are described in the following sections of this chapter. Future population and wastewater projections are presented in Chapter 3 of this Facilities Plan.

2.3.1 Service Area Population and Wastewater Flows

As shown in Figure 1-1, Brightwater will serve areas extending from the Sammamish Plateau on the south, to Lake Forest Park on the west, to Bear Creek/south Snohomish County on the north. Wastewater from existing development within the Brightwater Service Area enters the King County system through a large number of trunk and interceptor sewers and pump station/force main systems. Many of these facilities are unmetered; thus, a direct measurement of wastewater flows is not possible. Current wastewater flows and loads have therefore been estimated using demographic data and unit generation rates.

During preparation of the *Regional Wastewater Services Plan*, King County estimated the population of the Brightwater Service Area and projected wastewater flows and loads using the following methodology. This approach has been used to project wastewater flows and loads for the Brightwater Service Area.

1. Existing residential population, commercial employment, and industrial employment figures were developed for each service area basin. The population and employment figures were taken from the Puget Sound Regional Council (PSRC) Transportation Analysis Zone (FAZ) 1995 forecasts for Year 2000. Population estimates were limited to areas within the King County and Snohomish County Urban Growth Areas.

2. Residential average base sanitary flow was estimated for each basin by multiplying the residential population by a unit flow of 60 gallons per capita per day (gpcd). Nonresidential average base sanitary flow was estimated by multiplying the employment population by 35 gpcd for commercial users and 75 gpcd for industrial users. These factors are the result of calibration of observed unit flows within the South Treatment Plant and West Point Treatment Plant tributary areas.

3. Infiltration/inflow factors were applied to basins within the service area to account for average dry weather I/I, average wet weather I/I, and peak wet weather I/I. Allowances for average dry weather and average wet weather I/I were estimated from King County flow monitoring data and assigned to tributary

basins. I/I allowances were added to the base sanitary flows to derive average dry weather flow (ADWF) and average wet weather flow (AWWF). Peak wet weather flow (PWWF) was derived by fitting the King County I/I model to available flow monitoring or pump station flow records. The calibrated I/I model was then used to simulate more than 40 years of rainfall record, and the peak flows from this exercise were used to develop a peak flow versus return period relationship. The peak flow with an estimated average recurrence of once in 20 years was selected as the peak wet weather design flow. Where flow records did not exist, peak I/I values on an area basis (flow per acre) were chosen from nearby basins with similar characteristics.

Year 2000 data are used to establish the current population and wastewater flows for the Brightwater Service Area, as presented in Table 2-2. A similar approach has been used to project future population and flows, as discussed in Chapter 3 of this Facilities Plan.

2.4 Existing Water Systems

The Brightwater project area is served by a wide variety of water systems ranging from individual private wells to large public systems operated by municipalities. Table 2-3 summarizes the major public water systems in the Brightwater project area. Figure 2-12 shows the general service areas of these entities. Water sources include treated surface water delivered from the City of Everett and Seattle Public Utilities systems, and groundwater withdrawn from local wells. The majority of project area residents are supplied with treated surface water.

2.5 Existing Treatment and Conveyance Facilities

The existing King County wastewater system serves a 420-square-mile area of King, south Snohomish, and north Pierce Counties. King County provides wholesale wastewater services to these customers, operating large-diameter trunk and interceptor pipelines, pump stations, and force mains; CSO facilities; and wastewater treatment plants. Figure 2-13 shows the major components of the King County wastewater system.

Local components of the system, consisting of collection facilities operated by 33 cities and districts throughout the King County wastewater service area, are referred to as “local agencies.” The local agencies that may eventually be served all or in part by Brightwater include the following entities:

- Alderwood Water and Sewer District
- City of Bothell
- City of Brier
- Cross Valley Water District

Table 2-2. Brightwater Service Area Population, Flow, and Load Projections by Basin for Current Condition (Year 2000)

Basin	Land Area (acre)		% Res. Pop. Sewered	Sewered Res. Pop.	Commer-cial Pop.	Indus-trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Lake Forest	1,294	7,722	100%	7,722	2,021	67	9,810	99	1,281	0.54	0.14	0.33	0.68	0.87
McAleer & Lyon	2,085	14,647	98%	14,333	4,066	53	18,453	91	1,897	1.01	0.20	0.49	1.21	1.49
Hollywood - Snohomish Co.	4,556	2,869	0%	0	304	118	422	0	0	0.02	0.00	0.00	0.02	0.02
Bear Creek - Snohomish Co.	8,614	11,570	0%	0	1,706	1,035	2,741	0	0	0.14	0.00	0.00	0.14	0.14
North Creek - Snohomish Co.	16,329	70,353	60%	42,249	8,858	5,072	56,178	46	7,511	3.23	0.81	1.93	4.03	5.15
Swamp Creek - Snohomish Co.	7,929	44,977	57%	25,461	8,369	2,889	36,718	42	3,330	2.04	0.36	0.85	2.39	2.89
Lake Forest - Snohomish Co.	943	5,523	87%	4,790	505	209	5,505	54	509	0.32	0.05	0.13	0.38	0.45
Lyon	473	2,857	87%	2,471	291	116	2,878	70	331	0.17	0.04	0.08	0.20	0.25
Kenmore - Snohomish Co. Subtotal	38,844	138,149	54%	74,971	20,033	9,437	104,442	30	11,682	5.91	1.25	2.99	7.16	8.90
Swamp Ck - King Co.	718	3,695	95%	3,520	832	76	4,428	91	653	0.25	0.07	0.17	0.32	0.41
Bothell	2,252	11,039	97%	10,672	4,519	816	16,007	78	1,757	0.86	0.19	0.45	1.05	1.31
Kenmore Sect. 5	1,327	4,500	83%	3,750	1,129	118	4,996	70	929	0.27	0.10	0.24	0.37	0.51
North Creek - King Co.	1,084	3,504	97%	3,382	1,957	330	5,670	61	661	0.30	0.07	0.17	0.37	0.47
Bear Creek - King Co.	1,466	6,401	83%	5,296	3,062	753	9,111	71	1,041	0.48	0.11	0.27	0.59	0.75
Woodinville East	870	4,194	33%	1,398	1,963	506	3,867	33	287	0.19	0.03	0.07	0.22	0.26
Woodinville	1,085	2,916	98%	2,872	782	205	3,859	93	1,009	0.22	0.11	0.26	0.32	0.47
Inglewood	1,250	6,566	97%	6,339	1,437	125	7,901	99	1,238	0.44	0.13	0.32	0.57	0.76
Kenmore-King Co. Subtotal	10,052	42,816	87%	37,229	15,681	2,927	55,837	75	7,575	3.00	0.81	1.94	3.81	4.94
Redmond North	1,934	8,991	97%	8,713	3,488	1,117	13,318	61	1,180	0.73	0.13	0.30	0.86	1.03
Redmond East	4,922	21,455	96%	20,684	7,819	2,233	30,737	68	3,347	1.68	0.36	0.86	2.04	2.54
Redmond South	2,755	20,163	98%	19,853	20,526	4,034	44,413	94	2,590	2.21	0.28	0.66	2.49	2.88
Hol-Lake Hills	1,510	11,143	100%	11,134	5,515	545	17,193	96	1,450	0.90	0.16	0.37	1.06	1.27
Blakely/North Ridge	1,296	2,041	100%	2,041	657	0	2,698	50	648	0.15	0.07	0.17	0.21	0.31
Northeast Sammamish	2,804	13,202	100%	13,194	746	23	13,963	79	2,215	0.82	0.24	0.57	1.06	1.39
Hollywood Pump Station Basin Subtotal	15,221	76,994	98%	75,619	38,751	7,953	122,322	75	11,429	6.49	1.23	2.93	7.72	9.42
Lake Ballinger (Edmonds East)	4,128	32,195	99%	31,915	8,837	462	41,214	90	3,715	2.26	0.40	0.95	2.66	3.21
Total	**71,624**	**312,522**	**NA**	**241,789**	**89,388**	**20,900**	**352,077**	**NA**	**37,579**	**19.2**	**4.0**	**9.6**	**23.2**	**28.8**

Table 2-3. Major Public Water Systems in Brightwater Project Area

Name	Areas Served	Number of Connections	Approximate Population Served	Main Sources of Water
Cross Valley Water District	Unincorporated Snohomish and King Counties	5,230	13,670	Groundwater from local wells, treated surface water from Everett
Woodinville Water District	Unincorporated King County	11,680	40,000	Treated surface water from Seattle Public Utilities
City of Bothell	Bothell	3,090	11,800	Treated surface water from Seattle Public Utilities
Northshore Utility District	Kenmore, Unincorporated King County	19,580	67,000	Treated surface water from Seattle Public Utilities
Alderwood Water & Sewer District	Lynnwood, Brier, Unincorporated Snohomish County	33,570	107,400	Treated surface water from Everett
City of Lynnwood	Lynnwood	7,850	32,300	Treated surface water from Everett, delivered through Alderwood Water & Sewer District
Lake Forest Park Water District	Lake Forest Park	850	2,600	Groundwater from local wells
Shoreline Utility District	Shoreline	7,840	30,400	Treated surface water from Seattle Public Utilities
City of Mountlake Terrace	Mountlake Terrace	5,270	20,400	Treated surface water from Everett, delivered through Alderwood Water & Sewer District
Olympic View Water District	Woodway area and unincorporated Snohomish County	4,450	15,200	Treated surface water from Seattle Public Utilities, treated surface water from Deer Creek.
City of Edmonds	Edmonds	9,420	31,300	Treated surface water from Everett and Seattle Public Utilities

Source: Washington State Department of Health, Drinking Water Program, Group A Public Water System Database

- City of Lake Forest Park
- Northeast Sammamish Sewer and Water District
- Northshore Utility District
- City of Redmond
- Sammamish Plateau Water and Sewer District
- Shoreline/Ronald Wastewater District
- Woodinville Water and Sewer District

2.5.1 Existing Wastewater Treatment Plant Summary

King County operates three wastewater treatment plants and two CSO treatment plants. Table 2-4 summarizes information on each treatment plant, including the service area, the year the facility was initially placed into service, when it was upgraded or expanded, its capacity in mgd AWWF/PWWF, and the type of treatment it provides.

Table 2-4. King County Wastewater Treatment Plant Summary

Treatment Plant	Areas Served	Year Placed into Service	Year(s) Upgraded	Capacity, AWWF/ PWWF (mgd)	Type of Treatment
West Point	West Service Area	1965	1996	133/440[a]	Secondary[b]
South	East Service Area	1965	1974, 1985, 1993, 1999	115/325[c]	Secondary[d]
Vashon Island	Northeast Vashon Island	1957	2003	0.26[e]	Secondary
Alki	CSO flows from West Seattle	1958	1987, 1997	45 to 67[f]	CSO
Carkeek Park	CSO flows from Blue Ridge, Carkeek Park and Bitter Lake areas of North Seattle	1962	1994	20	CSO

[a] The West Point Treatment Plant has an AWWF capacity of 133 mgd and a peak flow capacity of 440 mgd.

[b] Flows up to 300 mgd receive secondary treatment in a pure oxygen activated sludge process. Incremental flows between 300 and 440 mgd receive primary treatment and disinfection.

[c] The South Treatment Plant has an AWWF capacity of 115 mgd and a peak flow capacity of 325 mgd.

[d] Flows up to 209 mgd receive secondary treatment in an air activated sludge process. Incremental flows between 209 and 325 mgd receive primary treatment and disinfection.

[e] The Vashon Island Treatment Plant will undergo expansion to 0.52 mgd AWWF during 2003/2005.

[f] Because of outfall hydraulic restrictions, the Alki plant capacity ranges between 45 and 67 mgd, depending on tidal conditions.

[g] Table lists mechanical treatment plants only, and does not include details of the Buehla Park and Cove recirculating septic/sand filter systems.

This section provides an overview of the two existing treatment plants that will be impacted by construction of Brightwater—the West Point Treatment Plant and the South Treatment Plant. The Vashon Island Treatment Plant will not be impacted by Brightwater, and therefore is not addressed in this Facilities Plan. Chapter 3 of this report, which presents future flow and load projections, provides further discussion of how implementation of Brightwater will allow King County to manage flows and loads to existing treatment facilities.

2.5.2 Conveyance System Summary

The King County conveyance system consists of approximately 330 miles of pipelines and tunnels, 43 pump stations, CSO regulator stations, CSO outfalls, and other conveyance facilities. The system transports raw wastewater to the treatment plants. After treatment, effluent is conveyed through five outfall pipelines to Puget Sound.

2.5.2.1 Pipelines

King County operates a network of pipelines throughout its service area. Local agencies own and operate smaller pipelines from individual homes and businesses that connect to King County's pipelines. King County's pipelines consist of force mains (pressurized sewers), trunk sewers, and interceptors. King County trunk sewers pick up flows from the local agencies' pipelines and convey them to large-diameter interceptors that transport flow to the treatment facilities. Whenever possible, wastewater is conveyed by gravity. Where necessary, the wastewater is pumped through force mains. Pump stations associated with the conveyance system force mains are referred to as "off-site" pump stations to distinguish them from influent pumping systems at the treatment plants. Force mains comprise approximately 17 miles of the King County conveyance system.

The majority of King County's combined sewage travels to the West Point Treatment Plant. The combined flows are conveyed primarily by way of the North Interceptor, the West Duwamish Interceptor, and the Elliott Bay Interceptor.

2.5.2.2 Off-Site Pump Stations

King County's 45 off-site pump stations are located throughout its service area, as shown in Figure 2-13. Installed capacities range from less than 1 mgd to about 130 mgd.

Within the Brightwater Service Area, the existing Kenmore, North Creek, and York Pump Stations may be used to convey flows to the Brightwater Treatment Plant. The recently constructed North Creek Pump Station and York Pump Station are currently used to divert flows from the West Point tributary area to the South Treatment Plant, offloading the West Point Treatment Plant during the peak flow season. The role of these

facilities in Brightwater conveyance is discussed in Chapters 4 and 5 of this Facilities Plan.

2.5.2.3 Combined Sewer Overflows

King County uses regulator stations to maximize the storage capability of large-diameter trunk sewers. Figure 2-14 presents a schematic drawing of a regulator. Regulators operate by modulating the flow to the downstream interceptors during conditions of high storm flow and utilizing trunk sewers for storage. During low flow periods, when the interceptor flows are below a specified set point, the flow from the trunk sewer passes through the regulator and into the interceptor. As flows in the interceptor increase, the regulator gate begins to close, and the wastewater begins backing up in the trunk. When the trunk reaches its specified storage capacity, an overflow gate is opened and the trunk flows are released as combined sewer overflow. The King County conveyance system includes 37 CSO locations as shown in Figure 2-15.

As shown in Figures 1-1 and 2-13, portions of the Brightwater Service Area are currently tributary to the West Point Treatment Plant. Flows are conveyed via the Kenmore Pump Station and downstream Kenmore Interceptor to the Matthews Park Pump Station and then via the Lake City Tunnel and North Interceptor to the West Point Treatment Plant. Along this reach, CSOs are located at Canal Street and 3rd Avenue West. The diversion of Brightwater flows away from the West Service Area will avoid future increases in CSOs in this area that would otherwise result from increasing development in the Brightwater Service Area. No new CSOs are proposed within the Brightwater Service Area.

2.5.2.4 Sanitary Sewer Overflows

When King County adopted the RWSP under Ordinance 13680, it was accompanied by a series of conveyance policies that guide how improvements to the wastewater conveyance system will be accomplished. Conveyance Policy 1 states that "…King County shall plan, design, and construct county wastewater facilities to avoid sanitary sewer overflows." At that time, hydraulic capacity to convey a 20-year storm was adopted as the design standard for separated portions of the King County conveyance system.

King County reports all sanitary sewer overflows to Ecology. Within the Brightwater Service Area, SSOs have historically occurred at the north end of Lake Washington in the Kenmore area, primarily during major storm events. Four SSOs were reported at Kenmore Pump Station from the period of 1997 through 2002, with one additional suspected overflow from the downstream Kenmore Interceptor (Lake Line reach). In addition, two overflows were reported during this period at the York Pump Station, due to a mechanical failure and a pipeline failure.

The routing of flows to Brightwater is anticipated to control future SSOs in the Kenmore area. In the interim period before Brightwater is constructed, King County has proposed to implement the following improvements to reduce SSOs:

- Constructing 6 million gallons of storage at North Creek Pump Station.
- Developing an emergency response plan for the north Lake Washington area conveyance facilities.
- Installing, where feasible, alarms and flow meters at critical points on the Kenmore Interceptor.
- Increasing pump station capacities to handle the 20-year design storm flow.
- Ensuring that emergency power systems at the Kenmore and Matthews Park Pump Stations are sufficient to power all pumps in the event of a power outage.

SSOs may also occur within local agency collection systems. Reported overflows from local agency facilities are available in Ecology's records.

2.5.3 West Point Treatment Plant

The West Point Treatment Plant serves King County's West Service Area, as shown in Figure 2-13. Placed into service in 1965, the West Point Treatment Plant was originally constructed as a primary treatment facility. The West Service Area includes separate sewers as well as large areas of combined sewers. During rainfall events, when stormwater is being conveyed, flow coming into the plant increases significantly.

The original primary treatment plant design capacity was 125 mgd ADWF and 320 mgd peak flow. The West Point Treatment Plant was upgraded in 1996 to provide secondary treatment for an AWWF of 133 mgd and a peak secondary flow of 300 mgd. Secondary treatment is provided by a pure oxygen activated sludge process. An aerial photograph of the West Point Treatment Plant is shown in Figure 2-16, and a conceptual process schematic is provided in Figure 2-17.

During the West Point Treatment Plant secondary upgrade, primary treatment facilities were expanded to provide additional wet weather capacity to reduce CSOs. The peak primary treatment capacity of 440 mgd is significantly greater than the peak secondary treatment capacity of 300 mgd. Flows between 300 and 440 mgd are provided with primary treatment, diverted around the secondary process, and disinfected prior to discharge. Effluent is discharged though a marine outfall extending off West Point to a depth of 240 feet.

Brightwater will allow King County to divert flows away from the West Point Treatment Plant that would otherwise exceed its capacity by 2013. The North Creek Pump Station is already used to transfer flows from the West Service Area to the South Service Area via

the York Pump Station to reduce peak wet weather loading of the West Point Treatment Plant. By 2010, the North Creek flows along with other wastewater from north King and south Snohomish Counties will be directed to Brightwater. Under this scenario the West Point Treatment Plant is projected to have adequate capacity through year 2050, and it is not proposed for expansion during the planning period.

Brightwater will also give King County the ability to shift flow between the three plants as needed to control loading or for emergency or special operational needs. Thus, flows may be shifted from the Brightwater Service Area to the West Point Treatment Plant and vice versa, as capacity is available. This capability will help King County maintain the West Point Treatment Plant, South Treatment Plant, and Brightwater within their rated capacities, and maximize the efficiency of treatment at the three facilities.

2.5.4 South Treatment Plant

King County's South Treatment Plant is located in Renton and began operation in 1965. It provides secondary treatment for King County's East Service Area as shown in Figure 2-13. The East Service Area collection system is substantially separated, and as a result, the South Treatment Plant experiences less wet weather peaking than the West Point Treatment Plant. The original treatment plant had a secondary treatment capacity of 24 mgd ADWF, with effluent discharged into the Duwamish River. The plant has undergone three expansions to its current capacity of 115 mgd AWWF. Current planning includes a provision for expansion of the South Treatment Plant to 135 mgd by 2029. Secondary treatment is provided by an air activated sludge process. An anaerobic selector is used to maintain a well settling activated sludge to enhance performance of the secondary clarifiers. An aerial photograph of the South Treatment Plant is shown in Figure 2-18, and a conceptual process schematic is provided in Figure 2-19.

Effluent from the plant is discharged to Puget Sound through the effluent transfer system (ETS). The ETS consists of an effluent pump station located at the South Treatment Plant, a 12-mile-long force main along the Duwamish River to Elliott Bay, and a 9,500-foot-long submarine outfall into Puget Sound. Discharge from the outfall is at a depth of 610 feet. The ETS was completed in 1987 and eliminated the daily discharge to the Duwamish River, although periodic maintenance and peak flow discharges are allowed under the current NPDES permit. The ETS has a current capacity of approximately 325 mgd. Flows in excess of 325 mgd are discharged to the Duwamish River; however, there have been no such events for over 5 years.

As with the West Point Treatment Plant, Brightwater will enable King County to divert flows away from the South Treatment Plant to facilitate management of future flows and loads.

2.5.5 Current Flows and Loads and Treatment Performance

Table 2-5 summarizes recent influent flows and loads to the West Point and South Treatment Plants and compares these data to the plant design criteria. Presently, the West Point Treatment Plant receives influent flows and loads that exceed design criteria for average annual and peak day 5-day biochemical oxygen demand (BOD_5) and average annual TSS. However, sustained peak influent conditions as represented by maximum month flow, BOD_5, and TSS are well within design criteria.

Table 2-5. West Point and South Treatment Plants, Influent Loadings Compared to Design Criteria, 1999 through 2001

Parameter	Design Value	1999	2000	2001	1999-2001 Average	Average as Percent of Design Criterion
West Point Treatment Plant						
Flow (mgd)						
Average Annual	142	129	111	118	119	84
ADWF	110	102	105	104	104	95
AWWF (Non-Storm)	133	158[a]	117[a]	133[a]	136[a]	Note a
Maximum Month	215	122	104	109	111	52
Peak Day	440	356	268	354	326	74
BOD_5 (1,000 lb/day)						
Average Annual	168	179	168	180	176	105
Maximum Month	254	197	194	213	201	79
Peak Day	352	393	354	353	367	113
TSS (1,000 lb/day)						
Average Annual	181	187	180	198	189	104
Maximum Month	274	197	194	213	201	73
Peak Day	543	393	354	353	367	68
South Treatment Plant						
Flow (mgd)						
Average Annual	108	88	80	70	80	74
ADWF	96	70	71	61	68	71
AWWF	115	111	87	87	95	83
PWWF	325	250	265	319	287	88
BOD_5 (1,000 lb/day)						
Average Annual	220	132	145	128	135	61

Table 2-5. West Point and South Treatment Plants, Influent Loadings Compared to Design Criteria, 1999 through 2001

Parameter	Design Value	1999	2000	2001	1999-2001 Average	Average as Percent of Design Criterion
Maximum Month	251	177	187	160	174	69
Peak Day	355	316	336	226	293	83
TSS (1,000 lb/day)						
Average Annual	201	143	145	136	142	71
Maximum Month	235	174	170	170	172	73
Peak Day	343	349	278	296	308	90

a. Design criterion is for AWWF, non-storm. Data are for AWWF including storm events

The South Treatment Plant is less heavily loaded relative to its design criteria, with no parameter exceeding its design value. Maximum month loadings of BOD_5 and TSS are 69 and 73 percent of respective design values, while influent flows range from 71 to 88 percent of design capacity.

Table 2-6 summarizes recent performance of the West Point and South Treatment Plants. The summary was assembled using 3 years of daily data from January 1999 through December 2001. The data indicate that average effluent BOD_5 and TSS concentrations are essentially equal at both plants, with the treatment processes providing over 90 percent removal of both constituents. These are typical expected performance levels for high purity oxygen and conventional activated sludge processes.

Table 2-6. Average Influent and Effluent Concentrations at South and West Point Treatment Plants

Parameter (mg/L unless noted)	West Point Treatment Plant[a]	South Treatment Plant[a]
Influent Average		
BOD_5	190	211
TSS	200	222
Total Kjeldahl nitrogen	28	37
Total phosphorus	2.8[b]	6.5
Effluent Average		
BOD_5	15	15
TSS	12	12
Total Kjeldahl nitrogen	NA[c]	28
Total phosphorus	NA[c]	2.3
Average Percent Removal, BOD_5 and TSS		

Table 2-6. Average Influent and Effluent Concentrations at South and West Point Treatment Plants

Parameter (mg/L unless noted)	West Point Treatment Plant[a]	South Treatment Plant[a]
BOD_5	92 %	93 %
TSS	94 %	95 %

[a] Period of record: 1999 through 2001.

[b] Orthophosphate only.

[c] NA = Not analyzed.

Average influent concentrations of both BOD_5 and TSS are higher at the South Treatment Plant than at the West Point Treatment Plant. This is attributed to the higher industrial loading received at the South Treatment Plant, and the diluting effect from combined sewer flows in the West Service Area.

Statistical characterizations of influent wastewater characteristics and treatment performance are presented in Appendix B. The BOD_5 removal probability distributions in Appendix B show that the 50th percentile for the final effluent at the West Point Treatment Plant is 22 mg/L, rising to 41 mg/L at the 95th percentile level. A higher level of performance is achieved at the South Treatment Plant, where equivalent percentile concentrations were 12 mg/L and 27 mg/L, respectively. Based on these data, typical technology-based monthly effluent limitations of 30 mg/L BOD_5 and 30 mg/L TSS should be readily achieved with a conventional activated sludge system at Brightwater.

Brightwater will reduce future flows and loads that would otherwise be conveyed to the West Point and South Treatment Plants. Chapter 3 discusses how future flows and loads will be managed between these two existing plants and the Brightwater facilities. Currently, flow transfers from the York and North Creek drainages to the South Treatment Plant occur only during wet weather winter months. However, these flow transfers will become year-round, which will increase loadings at the South Plant.

2.5.6 Current Biosolids Management Summary

King County's biosolids management program reflects a long-adopted policy of 100 percent beneficial use, either as a directly applied soil amendment or as a compost feedstock. The biosolids produced at the West Point and South Treatment Plants are treated to meet Class B pathogen reduction using mesophilic anaerobic digestion, an approved process to significantly reduce pathogens under EPA 40 CFR Part 503 (503 Regulations). The digested biosolids are dewatered and then trucked off site. A projected 135,000 wet tons of dewatered biosolids will be generated during 2003 for the combined West Point and South Treatment Plants (King County, 2003).

Since 1972, King County biosolids have been used in numerous land application, reclamation, and research projects within Washington. King County has supported important scientific research on the environmental effects of biosolids recycling that has demonstrated the value and safety of land application. The current biosolids beneficial use program has been designed to provide reliability thorough the establishment of several market outlets and geographic diversity.

The biosolids processing facilities for Brightwater will be designed for continued compatibility with beneficial use practices, producing a Class B or higher quality product.

2.5.6.1 Biosolids Quality: Pathogens and Vector Attraction Reduction

Biosolids quality standards for beneficial use have been set by EPA based on extensive risk analysis. The quality standards are published in Subpart D of the 503 Regulations. These standards address pathogen reduction, vector attraction, and quality requirements based on specific metals concentration limits.

The pathogen reduction requirements are divided into two categories: Class A and Class B. For the land application of Class B biosolids, the regulations place certain site access restrictions to allow time for reduction in pathogen levels. As noted, King County currently produces a Class B biosolids product at its treatment plants.

The vector attraction reduction requirement is a measure of the biological stability of the biosolids product. The 503 Regulations require a minimum volatile solids reduction of 38 percent. King County meets the vector attraction requirements through mesophilic anaerobic digestion processes. Typical volatile solids reduction averages 55 to 60 percent at both the West Point and South Treatment Plants, well above the minimum level required by the 503 Regulations (King County, 2003).

2.5.6.2 Biosolids Quality: Metals

Biosolids quality is also regulated on the basis of concentrations of nine metals. In order to be suitable for land application, metals must be below the Ceiling Concentrations (milligrams/kilogram [mg/kg] dry weight) listed in 40 CFR 503.13(b)(1), Table 1:

Arsenic (As) – 75 Cadmium (Cd) – 85 Copper (Cu) – 4,300 Lead (Pb) – 840 Mercury (Hg) – 57
Molybdenum (Mo) – 75 Nickel (Ni) – 420 Selenium (Se) – 100 Zinc (Zn) – 7,500

If any of biosolids metals concentrations exceed these limitations, the biosolids cannot be land applied. Biosolids from the West Point and South Treatment Plants consistently meet the Ceiling Concentration requirements, and are therefore suitable for land application.

If the metals concentrations are below the pollutant concentrations (PC) listed in 40 CFR 503.13(b)(3), Table 3, the material is considered an even higher quality "clean" (or PC) biosolids, and may be land applied without monitoring of cumulative metal loadings. The PC limits (mg/kg dry weight) are:

As – 41	Cd – 39	Cu – 1,500	Pb – 300
Hg – 17	Ni – 420	Se – 100	Zn – 2,800

As a result of a successful pretreatment program and efforts to control the corrosivity of the regional potable water supply, King County meets the PC standard as summarized in Table 2-7. The differences between the West Point and South Treatment Plants may in part be explained by the predominance of older galvanized and lead jointed water piping in the West Service Area as compared to the predominance of newer copper water piping and fewer lead jointed water pipes in the East Service Area. Brightwater biosolids are expected to have similar characteristics to the South Treatment Plant biosolids, and should be suitable for land application and other forms of beneficial use.

Table 2-7. Comparison of King County Biosolids Quality to EPA Standards

	EPA Regulations, 40 CFR Part 503.13, Table 3	2001 Mean Concentration (mg/kg[a, b])		2001 Max Concentration (mg/kg[a, b])	
Metal	**Pollutant Concentrations**	**South Treatment Plant**	**West Point Treatment Plant**	**South Treatment Plant**	**West Point Treatment Plant**
Arsenic	41	7.62	6.45	8.7	7.28
Cadmium	39	3.98	5.31	5.68	15.19
Copper	1,500	610	548	653	638
Lead	300	47.4	133	56.8	159
Mercury	17	2.51	2.35	3.72	3.14
Nickel	420	21.5	33.1	27.5	38.7
Selenium	100	6.42	6.04	7.91	7.3
Zinc	2,800	762	830	880	980

[a] Dry-weight basis

[b] Data Source: King County, Wastewater Treatment Division, 2003.

2.5.6.3 Biosolids Management Practices

King County's current program serves three markets: eastern Washington agriculture, western Washington silviculture, and feed stock for a local commercial composter. Dewatered biosolids are transported from the West Point and South Treatment Plants using contract drivers operating King County-owned covered trucks and trailers. Trailer storage space at the South Treatment Plant and at a local offsite staging area provides

flexibility to handle extreme weather road conditions. Application flexibility is provided by delivering biosolids for composting at times when land application is problematic, such as extended periods of inclement weather.

Eastern Washington Agriculture

Biosolids are shipped to two private operators for agricultural land application. Boulder Park, a contractor in Douglas County, utilizes biosolids on dryland wheat. Natural Selection Farms applies biosolids to land for hop production in Yakima County. The arid climate at these locations facilitates near-continuous application, year round. The two operations handle approximately 70 percent of King County's biosolids production. Haul distance is approximately 150 miles one-way.

Western Washington Silviculture

Approximately 25 percent of King County biosolids are land applied on forest land used for silviculture. This program has been developed over many years and is supported by numerous research studies conducted by the University of Washington. The silvicultural program includes the Weyerhaeuser Snoqualmie Forest, and state-owned lands managed by the Department of Natural Resources. King County supports the I-90 corridor "Greenway Trust" by both silvicultural application and reclamation of logging roads.

Composting

GroCo, a King County commercial topsoil manufacturer, produces Class A biosolids compost for local commercial and retail sale as a soil amendment. In a typical year, GroCo receives between 5 and 10 percent of the dewatered Class B biosolids production from the West Point and South Treatment Plants. Biosolids are typically provided to GroCo during the winter months, when hauling to eastern Washington is impacted by inclement weather. Biosolids are composted using a non-aerated static pile process with a sawdust-bulking agent.

Biosolids Management Costs

Overall, the biosolids utilization program costs approximately $27/wet ton (approximately $120/dry ton) of biosolids on a weighted average basis (King County, 2003). A breakdown of current distribution and costs for the program components is shown in Table 2-8.

Table 2-8. Current King County Biosolids Management Costs[a]

Management Practice	Projected 2003 Quantity (wet tons)[b]	2003 Haul Cost ($/wet ton)	2003 Application Cost ($/wet ton)
Boulder Park, Land Application (Douglas County)	60,000	22.00	4.50
Natural Selection Farms, Land Application (Green Valley, Yakima County)	35,000	20.00	8.50
Silviculture (Western Washington)	30,000	18.00	8.00
GroCo Composting	10,000	5.00	38.00[c]
Total	**135,000**		

a Costs are for handling digested, dewatered cake. Costs do not include upstream processing—dewatering, digestion, and thickening.

b Source: King County, 2003.

c Tipping fee.

2.5.7 Water Reuse Program

King County has established a Water Reuse Program to pursue opportunities for using reclaimed water to help satisfy regional water resource needs. The Water Reuse Program also supports state agency goals of reducing reliance on marine discharges. A 5-year water reuse work plan was transmitted to the King County Council in December 2000 and two primary implementation efforts have been initiated: a water reuse technology demonstration project and a satellite water reclamation facility located in the Sammamish Valley.

2.5.7.1 Water Reuse Technology Demonstration Project

King County began operating a water reuse technology demonstration facility at the West Point Treatment Plant in June 2001. This ongoing project is evaluating the effectiveness, operability, and cost of seven advanced wastewater treatment technologies. The goal of this program was to identify technologies that could:

- Minimize the size of a satellite treatment facility.
- Reduce the costs and potential impacts of producing reclaimed water at small, upstream satellite plants for commercial and irrigation uses.

- Cost-effectively remove nutrients, pathogens, organics, and other contaminants from wastewater as may be necessary to make reclaimed water suitable for discharge to freshwater to supplement surface water supplies.

The demonstration facility combined several treatment technologies into small-scale operational process systems to assess their ability to meet process objectives. For example, one of the first technologies operated was a Fuzzy Filter, which is a column containing tightly packed compressible filter media typically used for tertiary treatment. King County also evaluated this technology for its ability to provide primary treatment by decompressing the media and reducing flow through the column. A membrane bioreactor (MBR) was also operated under the demonstration program. The MBR process combines a biological reactor to provide secondary treatment with membrane filters that screen particles larger than one-tenth of a micron, providing an effluent suitable for a wide range of reuse applications. The MBR technology has the potential to eliminate the need for secondary clarification and tertiary filtration when applied to a full-scale treatment facility.

2.5.7.2 Sammamish Valley Reclaimed Water Production Facility

As part of the RWSP, King County adopted water reuse policies, including one to implement pilot and demonstration projects. King County worked with a Stakeholder Task Force to solicit and rank nominations from public and private parties interested in partnering to implement water reuse demonstration projects. In all, King County received 11 nominations representing 13 projects.

Each of these projects was ranked based on a set of criteria developed jointly with the Stakeholder Task Force. The criteria evaluated factors such as cost per unit of reclaimed water, regulatory issues, community impacts and support, and integration with other King County projects. The Sammamish Valley Reclaimed Water Production Facility, which will produce between 1 and 3 mgd of water for irrigation, ranked favorably on all the criteria and therefore received the highest overall ranking. Accordingly, this project was selected for implementation and is currently under design. The facility should be operational in 2005 or 2006.

2.5.8 Water Conservation Program

In adopting the RWSP, the King County Council implemented a water conservation program. Policy calls for King County, through public education campaigns, to encourage water purveyors to participate in pilot projects that support homeowner water conservation, emphasizing strategies and technologies that reduce wastewater. King County has allocated $300,000 per year for a 5-year water conservation program that was initiated in 2001. Projects completed to date are summarized in the following paragraphs.

The impacts of water conservation on projected Brightwater Service Area flows are discussed in Section 3.3 of this Facilities Plan.

2.5.8.1 King County Housing Authority

King County Department of Natural Resources and Parks partnered with the King County Housing Authority and Seattle Public Utilities to replace washing machines and toilets at low-income housing facilities administered by the King County Housing Authority. King County spent approximate $275,000 for new washing machines and toilets under this program, with an estimated reduction of 14 million gallons of water use and wastewater production annually.

2.5.8.2 King County Department of Community and Human Services

King County Department of Natural Resources and Parks partnered with King County Department of Community and Human Services to spend $10,000 to replace toilets, showerheads, and faucet aerators at low-income housing units. These improvements are expected to reduce water use and wastewater production by 220,000 gallons per year.

2.5.8.3 Public Outreach and Education

King County, through the Wastewater Treatment Division, initially allocated over $15,000 to develop improved public awareness messages about reducing the amount of material disposed of in the wastewater system that is more appropriately disposed of as solid waste. This currently ongoing program will reduce both water use and wastewater production, as well as energy used in wastewater treatment.

2.5.8.4 Water Audits and Retrofits of King County Facilities

King County is partnering with local utilities to audit county-owned facilities that have high indoor water use, including the Courthouse, the Yesler Building, swimming pools, and park restrooms. Retrofits will provide both water savings as well as educational opportunities for the general public. The 2002 budget for water audits and retrofits was $296,000.

2.6 Infiltration and Inflow

This section discusses I/I within the Brightwater Service Area and describes the ongoing King County Regional Infiltration and Inflow Control Program, which will provide further definition of I/I during 2003 through 2005.

King County is responsible for transporting and treating wastewater collected by local agencies that provide sewer service to residential, commercial, and industrial users. The local agencies own and operate independent collection systems that convey wastewater to the King County system. Approximately 65 percent of the City of Seattle collection system is a combined sewer system. The remainder of the local agency collection systems are designed as separated systems and do not intentionally convey stormwater.

While the majority of local agency sewer systems are separated, they may still convey significant extraneous flows in the form of I/I. Infiltration and inflow consists of stormwater and groundwater that enters the collection system through various means, including cracked pipes, damaged pipe joints, manhole covers, improperly connected drains and downspouts, improperly connected storm drains, illicitly connected downspouts, and other defects.

When King County developed Ordinance 13680 for implementation of the RWSP, it included a series of I/I policies that "guide the County in working cooperatively with component (local) agencies to reduce the amount of I/I that flows into the component agencies' local collection systems." This program, based on long-term King County and local agency partnerships, is designed to determine where I/I comes from, establish whether it is cost effective to remove I/I, and recommend actions to actively control I/I in the future.

2.6.1 Regulatory Requirements

EPA, through Public Law 92-500 (the Clean Water Act of 1972) as amended, and Ecology have both issued regulations intended to limit the adverse effects of I/I, as described in the following sections.

2.6.1.1 Environmental Protection Agency Regulations

Federal regulations related to I/I are listed in 40 CFR Section 35-2005, Definitions, and 35-2120, Infiltration/Inflow, as amended November 1985. For a wastewater project to receive EPA funds, an analysis is required to determine whether it is more cost effective to remove all or part of the I/I or to provide capacity to convey and treat the I/I. EPA has defined net threshold values below which I/I levels are considered reasonable and acceptable. Where per capita levels exceed the EPA thresholds, the wastewater agency is

required to undertake an analysis to evaluate the cost effectiveness of I/I removal. The threshold for non-storm infiltration under high groundwater conditions is 120 gpcd. Above this threshold, the wastewater agency may be required to perform a sewer system assessment to determine the quantity of excessive infiltration and propose a rehabilitation program to reduce I/I. The threshold value for storm-influenced I/I is 275 gpcd or "chronic operational problems during storm events." High groundwater non-storm conditions are based on maximum month non-storm flows and the storm-influenced conditions are based on the peak flow 20-year occurrence value.

2.6.1.2 Washington Department of Ecology Requirements

State regulations are encompassed in WAC 173-240-050, General Sewer Plan; WAC 173-240-060, Engineering Report; and WAC 173-245-040, CSO Reduction Plan. State guidelines are presented in Chapter 30, Infiltration/Inflow Correction, and Section C1-3.3.3, "Infiltration/Inflow," of the *Criteria for Sewage Works Design* (Ecology, 1998).

The state requires removal of I/I under the following conditions:

- If excessive I/I is causing overflows or bypassing of treatment facilities.
- If I/I removal is more cost effective than expanding the treatment plant.
- If excessive I/I is causing NPDES permit violations (influent dilution results in the 85 percent removal requirement not being met).

2.6.2 King County Regional I/I Control Program

The King County Regional I/I Control Program is a 6-year, $42 million program designed to:

- Quantify and locate I/I in separated portions of the region's conveyance system through a comprehensive flow monitoring program.
- Conduct pilot I/I control projects to identify cost effective I/I removal techniques.
- Develop model design standards for use in local agency collection systems to reduce I/I within their facilities.
- Evaluate solutions and financial options, including alternative billing structures, incentive programs, surcharges, or variable billing rates for systems with excessive I/I.
- Develop a regional I/I control plan with recommended I/I reduction levels in the local agency collection systems and long-term measures to meet those targets.

Additional information on the program is available on the King County web site at http://dnr.metrokc.gov/wtd/i-i.

Flow monitoring provides the technical framework upon which the Regional I/I Control Program will be based. Over 800 flow meters have been used to identify I/I in the King County interceptor system and in tributary basins within the local agency systems. Flow meter installation began in winter 2000-2001; however, below-normal precipitation necessitated additional flow monitoring during winter 2001-2002. The flow monitoring data are currently under analysis, and will be incorporated into the Brightwater flow projections during 2003.

Pilot demonstration projects will be used to evaluate the effectiveness of various rehabilitation techniques in reducing I/I. Successful technologies can then be used as models for future remediation projects. The Regional I/I Control Program plans to perform 10 pilot projects with $13.2 million allocated for project design and construction. The selected pilot projects include three projects each in the north, east, and south regions of the King County service area plus a regional manhole rehabilitation effort involving three agencies. Pilot project construction will be initiated during 2003.

The Regional I/I Control Program is a complex project involving both technical and policy actions that will evolve over several years. The project is proceeding on schedule and will culminate in the King County Executive submitting a Regional I/I Control Program to the Regional Water Quality Committee and King County Council during 2005.

2.6.3 Observed I/I in the Brightwater Service Area

The Regional I/I Control Program will develop detailed assessments of I/I throughout the King County service area. Completion of flow monitoring was delayed by drought conditions, when accurate flow monitoring data could not be obtained, and these assessments have not been completed as of the date of publication of this Draft Facilities Plan. However, preliminary indications are that I/I levels are similar to those assumed in the RWSP. The RWSP I/I evaluations are preliminary in nature, and will be superseded by data developed during the Regional I/I Control Program.

King County has delineated its wastewater service area into sewer basins. In many cases, these basins cross the boundaries of the local agencies. Figure 2-20 shows the sewer basin and local agency boundaries in the Brightwater Service Area. Table 2-9 cross-references the sewer basins with the contributing local agencies. The land area, population, and estimated flows for Year 2000/current condition are shown for each of the sewer basins in the Brightwater Service Area in Table 2-10.

Table 2-9. Sewer Basins in the Brightwater Service Area and Contributing Local Agencies

Basin Designation	Local Agencies
Lake Forest	Lake Forest Park Northshore Utility District
Lake Forest – Snohomish County	Alderwood Water and Sewer District Brier
McAleer and Lyon	Lake Forest Park Ronald Wastewater District
Hollywood – Snohomish County	Cross Valley Water District
Bear Creek – King County	Woodinville Water and Sewer District
Bear Creek – Snohomish County	Alderwood Water and Sewer District
North Creek – King County	Bothell
North Creek – Snohomish County	Alderwood Water and Sewer District Silver Lake Sewer District
Swamp Creek – Snohomish County	Alderwood Water and Sewer District Brier
Swamp Creek – King County	Northshore Utility District
Lyon	Brier Mountlake Terrace
Bothell	Bothell Northshore Utility District Woodinville Water and Sewer District
Kenmore Section 5	Bothell Northshore Utility District
Woodinville East	Woodinville Water and Sewer District
Woodinville	Woodinville Water and Sewer District
Inglewood	Northshore Utility District
Redmond North	Redmond
Redmond East	Redmond
Redmond South	Redmond
Hollywood – Lake Hills	Redmond Bellevue
Blakely/North Ridge	Redmond
Northeast Sammamish	Northeast Sammamish Sewer and Water District Sammamish Plateau Water and Sewer District

Table 2-10. Sewer Basin Areas, Populations, and Projected Total Flows for Current Condition (Year 2000)

Basin	Land Area (acre)	Sewered		Base Flow (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
		Res. Pop.	Area (ac)				
Lake Forest	1,294	7,722	1,281	0.54	0.68	0.87	4.20
McAleer & Lyon	2,085	14,333	1,897	1.01	1.21	1.49	6.20
Hollywood -– Snohomish Co.	4,556	0	3	0.02	0.02	0.02	0.02
Bear Creek – Snohomish Co.	8,614	0	0	0.14	0.14	0.14	0.14
North Creek – Snohomish Co.	16,329	42,249	7,511	3.23	4.03	5.15	16.08
Swamp Creek – Snohomish Co.	7,929	25,461	3,330	2.04	2.39	2.89	9.61
Lake Forest – Snohomish Co.	943	4,790	509	0.32	0.38	0.45	1.19
Lyon	473	2,471	331	0.17	0.20	0.25	0.73
Kenmore - Snohomish Co. Subtotal	**38,844**	**74,971**	**11,682**	**5.91**	**7.16**	**8.90**	**27.78**
Swamp Ck – King Co.	718	3,520	653	0.25	0.32	0.41	1.73
Bothell	2,252	10,672	1,757	0.86	1.05	1.31	3.87
Kenmore Sect. 5	1,327	3,750	929	0.27	0.37	0.51	1.86
North Creek – King Co.	1,084	3,382	661	0.30	0.37	0.47	1.43
Bear Creek – King Co.	1,466	5,296	1041	0.48	0.59	0.75	2.26
Woodinville East	870	1,398	287	0.19	0.22	0.26	0.68
Woodinville	1,085	2,872	1,009	0.22	0.32	0.47	2.37
Inglewood	1,250	6,339	1,238	0.44	0.57	0.76	2.56
Kenmore – King Co. Subtotal	**10,052**	**37,229**	**7,575**	**3.00**	**3.81**	**4.94**	**16.77**
Redmond North	1,934	8713	1,180	0.73	0.86	1.03	3.25
Redmond East	4,922	20,684	3,347	1.68	2.04	2.54	8.84
Redmond South	2,755	19,853	2,590	2.21	2.49	2.88	7.75
Hollywood – Lake Hills	1,510	11,134	1,450	0.90	1.06	1.27	4.00
Blakely/North Ridge	1,296	2,041	648	0.15	0.21	0.31	1.53
Northeast Sammamish	2,804	13,194	2,215	0.82	1.06	1.39	5.56
Hollywood Pump Station Basin Subtotal	**15,221**	**75,619**	**11,429**	**6.49**	**7.72**	**9.42**	**30.95**
Lake Ballinger (Edmonds East)	4,128	31,915	3,715	2.26	2.66	3.21	11.30
Total	**71,624**	**241,789**	**37,579**	**19**	**23**	**29**	**97**

Table 2-11 presents the corresponding Year 2000/current condition I/I values and relates the preliminary estimates of I/I to population (gallons per capita per day) and sewered area (gallons per acre per day). These preliminary data suggest that many basins exhibit I/I that exceeds the EPA peak flow threshold of 275 gpcd for detailed cost-effectiveness analysis; however, only two basins exhibited average wet weather I/I that exceeds the EPA 120 gpcd threshold for groundwater influence.

As King County completes more accurate estimates of I/I under the Regional I/I Control Program, it will evaluate the cost effectiveness of I/I remediation. The Regional I/I Control Plan is scheduled for completion in 2005 and will develop recommendations for I/I control in regional and local systems. The program will develop alternative/options identifying funding mechanisms, cost sharing alternatives, management options, and schedules. The Regional I/I Control Program will also evaluate the I/I characteristics of each local agency, and means for addressing systems with excessive levels of I/I. As opportunities for cost effective I/I remediation are quantified, they will be considered in the county's plans for implementation and phasing of the Brightwater facilities.

Table 2-11. Sewer Basin I/I Per Capita and Per Acre for Current Condition (Year 2000)

Basin	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	Per Capita I/I (gpcd)		PWWF I/I (gpad)[b]
				PWWF	Max. Month[a]	
Lake Forest	0.14	0.33	3.66	474	65	2,857
McAleer and Lyon	0.20	0.49	5.19	362	52	2,735
Hollywood – Snohomish Co.	0.00	0.00	0.00	--	--	--
Bear Creek - Snohomish Co.	0.00	0.00	0.00	--	--	--
North Creek - Snohomish Co.	0.81	1.93	12.86	304	70	1,712
Swamp Creek - Snohomish Co.	0.36	0.85	7.57	297	52	2,274
Lake Forest - Snohomish Co.	0.05	0.13	0.87	182	42	1,712
Lyon	0.04	0.08	0.57	229	53	1,712
Kenmore - Snohomish Co. Subtotal	**1.25**	**2.99**	**21.87**	**292**	**62**	**1,872**
Swamp Creek – King Co.	0.07	0.17	1.49	422	73	2,274
Bothell	0.19	0.45	3.01	282	65	1,712
Kenmore Sect. 5	0.10	0.24	1.59	424	98	1,712
North Creek – King Co.	0.07	0.17	1.13	335	77	1,712
Bear Creek – King Co.	0.11	0.27	1.78	336	78	1,712
Woodinville East	0.03	0.07	0.49	352	81	1,712
Woodinville	0.11	0.26	2.16	752	139	2,140
Inglewood	0.13	0.32	2.12	334	77	1,712
Kenmore – King Co. Subtotal	**0.81**	**1.94**	**13.77**	**370**	**80**	**1,817**

Table 2-11. Sewer Basin I/I Per Capita and Per Acre for Current Condition (Year 2000)

Basin	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	Per Capita I/I (gpcd)		PWWF I/I (gpad)[b]
				PWWF	Max. Month[a]	
Redmond North	0.13	0.30	2.52	290	53	2,140
Redmond East	0.36	0.86	7.16	346	64	2,140
Redmond South	0.28	0.66	5.54	279	51	2,140
Hollywood – Lake Hills	0.16	0.37	3.10	279	51	2,140
Blakely/North Ridge	0.07	0.17	1.39	679	125	2,140
Northeast Sammamish	0.24	0.57	4.74	359	66	2,140
Hollywood Pump Station Basin Subtotal	**1.23**	**2.93**	**24.46**	**323**	**60**	**2,140**
Lake Ballinger (Edmonds East)	0.40	0.95	9.04	283	46	2,434
Total (Flow) or Average (I/I Values)	**3.83**	**9.63**	**78.0**	**323**	**61**	**2,075**

[a] Maximum Month I/I values are assumed to be 154 percent of average wet weather flow values based on analyses conducted for the Renton III Enlargement project.

[b] Basins exhibiting the same I/I rate were analyzed together at a common downstream flow measurement point. The values shown are the average for these basins.

2.7 Unsewered Areas

Flow projections for Year 2000/Current Conditions in the Brightwater Service Area consider only those flows from existing, sewered development. Estimates of flows that will result from future sewering of presently unsewered or undeveloped areas are presented in Chapter 3.

2.7.1 Performance of Existing On-Site Treatment Systems

Brightwater is necessitated by growth and capacity limitations at existing King County treatment and conveyance facilities, as opposed to water quality problems or public health risks associated with on-site (septic) treatment systems. Within the Brightwater Service Area, there are no identified areas of persistent failure of on-site treatment systems, and no health emergencies or advisories have occurred because of such problems (Snohomish County, 2002b). As described in Section 2.2.1, Water Resources, surface water quality degradation in the project area has been attributed primarily to

stream channel modifications, loss of riparian vegetation, surface runoff from local development, and fecal contamination from domestic pets and livestock. On-site treatment systems have not been identified as a major contributor to water quality problems in the Brightwater Service Area.

When existing on-site treatment systems fail within an unsewered area, the homeowner is required to work with Snohomish County Health District staff or King County Health Department, as applicable, and an approved on-site system designer to develop an acceptable replacement system or alternative system solution. Where sewer service is available, homeowners may elect to connect to the system and abandon their on-site treatment.

Within the Brightwater Service Area, it is anticipated that on-site treatment systems will be gradually replaced as sewers are extended through the Urban Growth Area. Anticipated scenarios for sewering of the Brightwater Service Area are described in Chapter 3 of this report.

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Chapter 3 Future Conditions

3.1 Introduction

As part of the *Regional Wastewater Services Plan* and subsequent planning activities, King County prepared estimates of the population and wastewater production within the Brightwater Service Area. This chapter presents projections of population, wastewater flows, and wastewater loads for the Brightwater Service Area under future conditions, and discusses how the projections were developed.

3.2 Demography, Land Use, and Wastewater Projections

Chapter 2, Section 2.3 of this Facilities Plan introduces the methodology used to estimate current population, wastewater flows, and wastewater loads for the Brightwater Service Area. To facilitate long-term system-wide planning, King County projected service area conditions for a planning period extending from Year 2000 through Year 2050.

Future projections for the Brightwater Service Area were based on the following methodology:

1. Future residential population, commercial employment, and industrial employment figures were developed for each service area basin. The population and employment figures were taken from the PSRC TAZ 1995 forecasts, which project population and employment through Year 2020. King County extended these projections beyond Year 2020, assuming straight-line growth to achieve full build-out (saturation conditions) in Year 2050. The straight-line projection method was independently adopted during the development of the RWSP.

2. Areas which are presently unsewered were assumed to be sewered by Year 2020. This is conservative in that some development is likely to continue with on-site treatment beyond Year 2020; however, this assumption will help ensure that adequate treatment capacity is available when needed.

3. It was assumed all lands within the sewer basins would be sewered without regard to parks and other areas set aside from development.

4. Population estimates were limited to areas within the existing King County and Snohomish County Urban Growth Areas. It was assumed that development outside present Urban Growth Areas would remain unsewered for the planning horizon.

Flows shown from unsewered basins beyond the Urban Growth Area (e.g., Hollywood Snohomish, Bear Creek Snohomish) are from existing small commercial or industrial areas that are assumed to be sewered and served by Brightwater.

5. Residential average base sanitary flow was estimated for each basin by multiplying the residential population by a unit flow of 60 gpcd. Nonresidential average base sanitary flow was estimated by multiplying the employment population by 35 gpcd for commercial employees and 75 gpcd for industrial employees. These factors are the result of calibration of observed unit flows within the South Treatment Plant and West Point Treatment Plant tributary areas.

6. I/I factors were applied to basins within the service area to account for average dry weather I/I, average wet weather I/I, and peak wet weather I/I. Allowances for average dry weather and average wet weather I/I were estimated from King County flow monitoring data and assigned to tributary basins. I/I allowances were added to the base sanitary flows to derive ADWF and AWWF. PWWF was derived by fitting the King County I/I model to available flow monitoring or pump station flow records. The calibrated I/I model was then used to simulate more than 40 years of rainfall record, and the peak flows from this exercise were used to develop a peak flow versus return period relationship. The peak flow with an estimated average recurrence of once in 20 years was selected as the peak wet weather design flow. Where flow records did not exist, peak I/I values on an area basis (flow per acre) were chosen from nearby basins with similar characteristics.

7. All sewers were assumed to degrade with age, resulting in an increase in I/I. Based on earlier work, King County assumed that the peak I/I would increase at a non-compounded rate of 7 percent per decade to a maximum 28 percent increase. In other words, if the Year 1990 peak 20-year I/I rate was 2,400 gallons per acre per day (gpad), it was assumed that the rate would increase by 168 gpad (2,400 gpad x 0.07) every 10 years until it reaches 3,072 gpad in Year 2030. Degradation beyond Year 2030 was assumed to be negligible. This and other I/I assumptions will be reexamined as the Regional I/I Control Program completes further data analysis.

8. Areas sewered after Year 1990 were assumed to have the same I/I characteristics as the 1990 condition. Thus, new sewered areas would contribute I/I at the same rate as the older sewers in that general area, also subject to the degradation described above.

Tables 3-1 through 3-5 summarize the total population and flow for the Brightwater Service Area for current/Year 2000 through Year 2050 conditions, and identify the portion of the flow that will be treated at Brightwater. Service area flows that are not treated at Brightwater will be conveyed to either the West Point or South Treatment Plants.

Based on these projections, King County proposes to construct Brightwater with an initial treatment capacity of 36 mgd AWWF (rounded from Year 2020/2030 flow projections) and a peak hydraulic capacity of 170 mgd (based on Year 2050 PWWF). This hydraulic capacity is anticipated to suffice beyond Year 2030. The capacity of Brightwater would then be

Table 3-1. Basin Information for Brightwater Service Area - Year 2000

Basin	Land Area (acre)	Residen -tial Pop.	% Res. Pop. Sewered	Sewered Res. Pop.	Commer- cial Pop.	Indus- trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
Lake Forest	1,294	7,722	100%	7,722	2,021	67	9,810	99	1,281	0.54	0.14	0.33	3.66	0.68	0.87	4.20
McAleer and Lyon	2,085	14,647	98%	14,333	4,066	53	18,453	91	1,897	1.01	0.20	0.49	5.19	1.21	1.49	6.20
Hollywood - Snohomish Co.	4,556	2,869	0%	0	304	118	422	0	3	0.02	0.00	0.00	0.00	0.02	0.02	0.02
Bear Creek - Snohomish Co.	8,614	11,570	0%	0	1,706	1,035	2,741	0	0	0.14	0.00	0.00	0.00	0.14	0.14	0.14
North Creek - Snohomish Co.	16,329	70,353	60%	42,249	8,858	5,072	56,178	46	7,511	3.23	0.81	1.93	12.86	4.03	5.15	16.08
Swamp Creek - Snohomish Co.	7,929	44,977	57%	25,461	8,369	2,889	36,718	42	3,330	2.04	0.36	0.85	7.57	2.39	2.89	9.61
Lake Forest - Snohomish Co.	943	5,523	87%	4,790	505	209	5,505	54	509	0.32	0.05	0.13	0.87	0.38	0.45	1.19
Lyon	473	2,857	87%	2,471	291	116	2,878	70	331	0.17	0.04	0.08	0.57	0.20	0.25	0.73
Kenmore - Snohomish Co. Subtotal	**38,844**	**138,149**	**54%**	**74,971**	**20,033**	**9,437**	**104,442**	**30**	**11,682**	**5.91**	**1.25**	**2.99**	**21.87**	**7.16**	**8.90**	**27.78**
Swamp Creek - King Co.	718	3,695	95%	3,520	832	76	4,428	91	653	0.25	0.07	0.17	1.49	0.32	0.41	1.73
Bothell	2,252	11,039	97%	10,672	4,519	816	16,007	78	1,757	0.86	0.19	0.45	3.01	1.05	1.31	3.87
Kenmore Sect. 5	1,327	4,500	83%	3,750	1,129	118	4,996	70	929	0.27	0.10	0.24	1.59	0.37	0.51	1.86
North Creek - King Co.	1,084	3,504	97%	3,382	1,957	330	5,670	61	661	0.30	0.07	0.17	1.13	0.37	0.47	1.43
Bear Creek - King Co.	1,466	6,401	83%	5,296	3,062	753	9,111	71	1,041	0.48	0.11	0.27	1.78	0.59	0.75	2.26
Woodinville East	870	4,194	33%	1,398	1,963	506	3,867	33	287	0.19	0.03	0.07	0.49	0.22	0.26	0.68
Woodinville	1,085	2,916	98%	2,872	782	205	3,859	93	1,009	0.22	0.11	0.26	2.16	0.32	0.47	2.37
Inglewood	1,250	6,566	97%	6,339	1,437	125	7,901	99	1,238	0.44	0.13	0.32	2.12	0.57	0.76	2.56
Kenmore - King Subtotal	**10,052**	**42,816**	**87%**	**37,229**	**15,681**	**2,927**	**55,837**	**75**	**7,575**	**3.00**	**0.81**	**1.94**	**13.77**	**3.81**	**4.94**	**16.77**
Redmond North	1,934	8,991	97%	8,713	3,488	1,117	13,318	61	1,180	0.73	0.13	0.30	2.52	0.86	1.03	3.25
Redmond East	4,922	21,455	96%	20,684	7,819	2,233	30,737	68	3,347	1.68	0.36	0.86	7.16	2.04	2.54	8.84
Redmond South	2,755	20,163	98%	19,853	20,526	4,034	44,413	94	2,590	2.21	0.28	0.66	5.54	2.49	2.88	7.75
Hollywood - Lake Hills	1,510	11,143	100%	11,134	5,515	545	17,193	96	1,450	0.90	0.16	0.37	3.10	1.06	1.27	4.00
Blakely/North Ridge	1,296	2,041	100%	2,041	657	0	2,698	50	648	0.15	0.07	0.17	1.39	0.21	0.31	1.53
Northeast Sammamish	2,804	13,202	100%	13,194	746	23	13,963	79	2,215	0.82	0.24	0.57	4.74	1.06	1.39	5.56
Hollywood Pump Station Basin Subtotal	**15,221**	**76,994**	**98%**	**75,619**	**38,751**	**7,953**	**122,322**	**75**	**11,429**	**6.49**	**1.23**	**2.93**	**24.46**	**7.72**	**9.42**	**30.95**
Lake Ballinger (Edmonds East)	4,128	32,195	99%	31,915	8,837	462	41,214	90	3,715	2.26	0.40	0.95	9.04	2.66	3.21	11.30
Total	**71,624**	**312,522**	**NA**	**241,789**	**89,388**	**20,900**	**352,077**	**NA**	**37,579**	**19.20**	**4.03**	**9.63**	**77.99**	**23.24**	**28.84**	**97.19**

Table 3-2. Basin Information for Brightwater Service Area - Year 2010

Basin	Land Area (acre)	Residen -tial Pop.	% Res. Pop. Sewered	Sewered Res. Pop.	Commer- cial Pop.	Indus- trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
Lake Forest	1,294	7,935	100%	7,935	2,148	72	10,155	100	1,294	0.56	0.14	0.33	3.64	0.70	0.89	4.20
McAleer and Lyon	2,085	14,900	99%	14,740	4,362	46	19,148	96	2,002	1.04	0.21	0.51	5.16	1.26	1.55	6.20
Hollywood - Snohomish Co.	4,556	3,616	0%	0	354	130	484	0	0	0.02	0.00	0.00	0.00	0.02	0.02	0.02
Bear Creek - Snohomish Co.	8,614	14,257	0%	0	2,151	1,064	3,214	9	775	0.16	0.08	0.20	1.61	0.24	0.35	1.76
North Creek - Snohomish Co.	16,329	87,761	80%	70,232	12,431	5,133	87,796	71	11,594	5.03	1.24	2.97	23.79	6.28	8.01	28.82
Swamp Creek - Snohomish Co.	7,929	57,072	78%	44,690	11,733	2,986	59,409	69	5,471	3.32	0.59	1.40	13.25	3.90	4.72	16.57
Lake Forest - Snohomish Co.	943	6,638	93%	6,197	612	191	7,000	77	726	0.41	0.08	0.19	1.49	0.49	0.59	1.90
Lyon	473	3,404	93%	3,175	339	105	3,619	85	402	0.21	0.04	0.10	0.83	0.25	0.31	1.04
Kenmore - Snohomish Co. Subtotal	**38,844**	**172,748**	**72%**	**124,294**	**27,620**	**9,609**	**161,523**	**49**	**18,968**	**9.14**	**2.04**	**4.86**	**40.97**	**11.18**	**14.01**	**50.11**
Swamp Creek - King Co.	718	3,698	98%	3,610	820	83	4,513	95	682	0.25	0.07	0.17	1.65	0.32	0.43	1.90
Bothell	2,252	11,611	98%	11,418	4806	822	17,045	89	2,004	0.91	0.22	0.51	4.11	1.13	1.43	5.03
Kenmore Sect. 5	1,327	5,226	92%	4,790	1296	144	6,230	85	1,128	0.34	0.12	0.29	2.31	0.46	0.63	2.66
North Creek - King Co.	1,084	4,141	98%	4,069	2450	387	6,906	80	867	0.36	0.09	0.22	1.78	0.45	0.58	2.14
Bear Creek - King Co.	1,466	7,821	91%	7,146	3543	808	11,497	85	1,246	0.61	0.13	0.32	2.56	0.75	0.93	3.17
Woodinville East	870	5,089	67%	3,393	2208	532	6,133	67	583	0.32	0.06	0.15	1.20	0.38	0.47	1.52
Woodinville	1,085	3,358	99%	3,333	871	217	4,421	97	1,052	0.25	0.11	0.27	2.40	0.36	0.52	2.65
Inglewood	1,250	6,567	98%	6,453	1425	137	8,016	100	1,250	0.45	0.13	0.32	2.57	0.58	0.77	3.01
Kenmore - King Co. Subtotal	**10,052**	**47,511**	**93%**	**44,212**	**17,420**	**3,129**	**64,762**	**88**	**8,813**	**3.50**	**0.95**	**2.26**	**18.58**	**4.44**	**5.76**	**22.07**
Redmond North	1,934	11,822	98%	11,639	5655	1,576	18,870	80	1,547	0.75	0.17	0.40	3.77	0.92	1.15	4.52
Redmond East	4,922	25,953	98%	25,486	11007	2,691	39,184	84	4,134	1.62	0.44	1.06	10.06	2.07	2.68	11.69
Redmond South	2,755	24,043	99%	23,859	24833	4,115	52,807	93	2,562	1.58	0.27	0.66	6.24	1.85	2.23	7.81
Hollywood - Lake Hills	1,510	11,214	100%	11,210	6249	527	17,985	97	1,465	0.69	0.16	0.38	3.57	0.85	1.07	4.26
Blakely/North Ridge	1,296	4,082	100%	4,082	657	0	4,739	100	1,296	0.24	0.14	0.33	3.15	0.38	0.58	3.40
Northeast Sammamish	2,804	15,396	100%	15,391	1047	34	16,472	90	2,524	0.92	0.27	0.65	6.14	1.20	1.57	7.07
Hollywood P.S. Basin Subtotal	**15,221**	**92,510**	**99%**	**91,667**	**49,447**	**8,944**	**150,058**	**89**	**13,528**	**5.81**	**1.45**	**3.47**	**32.93**	**7.26**	**9.28**	**38.75**
Lake Ballinger (Edmonds East)	4,128	36,114	100%	35,957	9,384	412	45,753	92	3,798	2.52	0.41	0.97	8.78	2.92	3.49	11.30
Total	71,624	371,718		318,806	110,382	22,212	451,399		48,402	23	5.19	12.41	110.06	27.76	34.98	132.63
Total to Brightwater [a]	**52,275**	**243,094**	**NA**	**191,181**	**51,551**	**12,856**	**255,588**	**NA**	**31,077**	**14.24**	**3.3**	**8.0**	**68.3**	**17.6**	**22.2**	**82.6**

[a] Total to Brightwater reflects rounded values.

Table 3-3. Basin Information for Brightwater Service Area - Year 2020

Basin	Land Area (acre)	Residen-tial Pop.	% Res. Pop. Sewered	Sewered Res. Pop.	Commer-cial Pop.	Indus-trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
Lake Forest	1,294	8,458	100%	8,458	2,235	66	10,760	100	1,294	0.59	0.15	0.35	3.61	0.74	0.94	4.20
McAleer and Lyon	2,085	15,482	100%	15,482	4,502	38	20,022	100	2,085	1.09	0.24	0.57	5.11	1.33	1.66	6.20
Hollywood	4,556	4,884	0%	0	380	104	484	0	0	0.02	0.00	0.00	0.00	0.02	0.02	0.02
Bear Creek - Snohomish Co.	8,614	18,130	0%	0	2,557	914	3,472	9	775	0.16	0.09	0.21	1.71	0.25	0.37	1.86
North Creek - Snohomish Co.	16,329	101,935	100%	101,935	14,606	5,661	122,202	95	15,513	7.05	1.77	4.22	33.79	8.82	11.27	40.84
Swamp Creek - Snohomish Co.	7,929	66,917	100%	66,917	14,166	3,032	84,115	95	7,533	4.74	0.86	2.05	19.37	5.60	6.79	24.11
Lake Forest - Snohomish Co.	943	7,687	100%	7,687	676	159	8,522	100	943	0.50	0.11	0.26	2.05	0.60	0.75	2.55
Lyon	473	3,938	100%	3,938	374	87	4,399	100	473	0.26	0.05	0.13	1.03	0.31	0.38	1.29
Kenmore - Snohomish Co. Subtotal	**38,844**	**203,491**	**89%**	**180,477**	**32,760**	**9,956**	**223,193**	**65**	**25,236**	**12.72**	**2.87**	**6.87**	**57.94**	**15.60**	**19.59**	**70.67**
Swamp Creek - King Co.	718	3,951	100%	3,951	829	75	4,855	100	718	0.27	0.08	0.20	1.85	0.35	0.47	2.12
Bothell	2,252	11,841	100%	11,841	5,012	634	17,486	100	2,252	0.93	0.26	0.61	4.90	1.19	1.55	5.84
Kenmore Sect. 5	1,327	6,401	100%	6,401	1,510	141	8,052	100	1,327	0.45	0.15	0.36	2.89	0.60	0.81	3.34
North Creek - King Co.	1,084	4,736	100%	4,736	3,017	338	8,091	100	1,084	0.42	0.12	0.29	2.36	0.54	0.71	2.78
Bear Creek - King Co.	1,466	9,776	100%	9,776	3,772	873	14,420	100	1,466	0.78	0.17	0.40	3.19	0.95	1.18	3.98
Woodinville East	870	6,379	100%	6,379	2,247	584	9,211	100	870	0.51	0.10	0.24	1.89	0.60	0.74	2.40
Woodinville	1,085	3,801	100%	3,801	906	212	4,918	100	1,085	0.28	0.12	0.30	2.63	0.40	0.57	2.90
Inglewood	1,250	7,019	100%	7,019	1,445	124	8,588	100	1,250	0.48	0.14	0.34	2.72	0.62	0.82	3.20
Kenmore - King Co. Subtotal	**10,052**	**53,902**	**100%**	**53,902**	**18,738**	**2,981**	**75,621**	**100**	**10,052**	**4.11**	**1.14**	**2.73**	**22.44**	**5.26**	**6.85**	**26.55**
Redmond North	1,934	14,348	100%	14,348	7,931	1,838	24,116	100	1,934	1.28	0.22	0.53	4.68	1.50	1.80	5.96
Redmond East	4,922	29,539	100%	29,539	13,640	2,663	45,843	100	4,922	2.45	0.56	1.34	11.91	3.01	3.79	14.36
Redmond South	2,755	26,645	100%	26,645	28,793	3,673	59,111	100	2,755	2.88	0.31	0.75	6.67	3.20	3.63	9.55
Hollywood - Lake Hills	1,510	11,552	100%	11,552	7,110	452	19,113	100	1,510	0.98	0.17	0.41	3.65	1.15	1.39	4.63
Blakely/North Ridge	1,296	4,082	100%	4,082	657	0	4,739	100	1,296	0.27	0.15	0.35	3.14	0.42	0.62	3.40
Northeast Sammamish	2,804	16,252	100%	16,252	1,258	36	17,546	100	2,804	1.02	0.32	0.76	6.79	1.34	1.78	7.81
Hollywood Pump Station Basin Subtotal	**15,221**	**102,418**	**100%**	**102,418**	**59,389**	**8,662**	**170,469**	**100**	**15,221**	**8.87**	**1.73**	**4.14**	**36.83**	**10.61**	**13.01**	**45.71**
Edmonds East	4,128	38,765	100%	38,765	10,151	361	49,277	94	3,880	2.71	0.44	1.06	9.39	3.15	3.76	12.10
Total	71,624	422,517		399,503	127,775	22,065	549,342		57,769	30.10	6.58	15.72	135.33	36.68	45.81	165.42
Total to Brightwater[a]	**59,300**	**328,603**	**NA**	**305,590**	**85,645**	**17,040**	**408,274**	**NA**	**45,692**	**22.61**	**5.2**	**12.4**	**106**	**27.8**	**35.0**	**129**

[a] Total to Brightwater reflects rounded values.

Table 3-4. Basin Information for Brightwater Service Area - Year 2030

Basin	Land Area (acre)	Residen -tial Pop.	% Res. Pop. Sewered	Sewered Res. Pop.	Commer- cial Pop.	Indus- trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
Lake Forest	1,294	8,775	100%	8,775	2,349	68	11,192	100	1,294	0.61	0.16	0.37	3.59	0.77	0.99	4.20
McAleer and Lyon	2,085	15,845	100%	15,845	4,745	31	20,621	100	2,085	1.12	0.25	0.60	5.08	1.37	1.72	6.20
Hollywood	4,556	5,804	0%	0	422	103	525	0	0	0.02	0.00	0.00	0.00	0.02	0.02	0.02
Bear Creek - Snohomish Co.	8,614	21,213	0%	0	2,989	884	3,873	9	775	0.17	0.09	0.22	1.80	0.26	0.39	1.97
North Creek - Snohomish Co.	16,329	118,265	100%	118,265	17,713	5878	141,855	95	15,513	8.16	1.87	4.46	35.74	10.03	12.62	43.90
Swamp Creek - Snohomish Co.	7,929	78,263	100%	78,263	17,219	3112	98,594	95	7,533	5.53	0.91	2.17	20.49	6.44	7.70	26.02
Lake Forest - Snohomish Co.	943	8,780	100%	8,780	769	136	9,685	100	943	0.56	0.11	0.27	2.17	0.68	0.84	2.74
Lyon	473	4,481	100%	4,481	418	74	4,973	100	473	0.29	0.06	0.14	1.09	0.35	0.43	1.38
Kenmore - Snohomish Co. Subtotal	**38,844**	**236,805**	**89%**	**209,788**	**39,531**	**10,187**	**259,505**	**65**	**25,236**	**14.73**	**3.04**	**7.26**	**56.75**	**17.78**	**22.00**	**76.03**
Swamp Creek - King Co.	718	3,963	100%	3,963	813	75	4,852	100	718	0.27	0.09	0.21	1.95	0.36	0.48	2.22
Bothell	2,252	12,128	100%	12,128	5,099	578	17,805	100	2,252	0.95	0.27	0.65	5.19	1.22	1.60	6.14
Kenmore Sect. 5	1,327	7,405	100%	7,405	1,709	160	9,274	100	1,327	0.52	0.16	0.38	3.06	0.68	0.90	3.57
North Creek - King Co.	1,084	5,435	100%	5,435	3,627	355	9,417	100	1,084	0.48	0.13	0.31	2.50	0.61	0.79	2.98
Bear Creek - King	1,466	11,406	100%	11,406	4,208	929	16,542	100	1,466	0.90	0.18	0.42	3.38	1.08	1.32	4.28
Woodinville East	870	7,405	100%	7,405	2,424	620	10,449	100	870	0.58	0.10	0.25	2.00	0.68	0.83	2.58
Woodinville	1,085	4,243	100%	4,243	977	218	5,438	100	1,085	0.31	0.13	0.31	2.78	0.44	0.62	3.08
Inglewood	1,250	7,054	100%	7,054	1,425	125	8,604	100	1,250	0.48	0.15	0.36	2.88	0.63	0.84	3.36
Kenmore - King Co. Subtotal	**10,052**	**59,038**	**100%**	**59,038**	**20,283**	**3,060**	**82,381**	**100**	**10,052**	**4.48**	**1.21**	**2.89**	**21.62**	**5.69**	**7.37**	**28.22**
Redmond North	1,934	17,556	100%	17,556	10,621	2,305	30,482	100	1,934	1.60	0.23	0.56	4.95	1.83	2.15	6.55
Redmond East	4,922	33,733	100%	33,733	16,643	2,903	53,279	100	4,922	2.82	0.59	1.42	12.60	3.42	4.24	15.42
Redmond South	2,755	29,414	100%	29,414	32,370	3,478	65,261	100	2,755	3.16	0.33	0.79	7.05	3.49	3.95	10.21
Hol - Lake Hills	1,510	11,712	100%	11,712	7,887	414	20,013	100	1,510	1.01	0.18	0.43	3.87	1.19	1.44	4.88
Blakely/North Ridge	1,296	4,082	100%	4,082	657	0	4,739	100	1,296	0.27	0.16	0.37	3.32	0.42	0.64	3.59
Northeast Sammamish	2,804	11,699	100%	11,699	987	28	12,715	100	2,804	0.74	0.34	0.81	7.18	1.08	1.55	7.92
Hollywood P.S. Basin Subtotal	**15,221**	**108,196**	**100%**	**108,196**	**69,164**	**9,129**	**186,490**	**100**	**15,221**	**9.60**	**1.83**	**4.38**	**38.97**	**11.43**	**13.98**	**48.56**
Edmonds East	4,128	42,262	100%	42,262	10,772	310	53,344	96	3,963	2.94	0.48	1.14	10.14	3.41	4.08	13.08
Total	71,624	470,922		443,905	146,844	22,785	613,534		57,851	33.48	6.97	16.65	136.15	40.45	50.13	176.30
Total to Brightwater [a]	**54,772**	**312,517**	**NA**	**285,500**	**110,571**	**19,054**	**415,125**	**NA**	**41,561**	**22.43**	**5.0**	**12.0**	**100**	**27.4**	**34.4**	**123**

[a] Total to Brightwater reflects rounded values.

Table 3-5. Basin Information for Brightwater Service Area - Year 2050/Assumed Saturation

Basin	Land Area (acre)	Residen-tial Pop.	% Res. Pop. Sewered	Sewered Res. Pop.	Commer-cial Pop.	Indus-trial Pop.	Total Sewered Pop.	% Land Sewered	Sewered Area (ac)	Base Flow (mgd)	ADWF I/I (mgd)	AWWF I/I (mgd)	PWWF I/I (mgd)	ADWF (mgd)	AWWF (mgd)	PWWF (mgd)
Lake Forest	1,294	9,511	100%	9,511	2,564	67	12,142	100.00	1,294	0.67	0.16	0.37	3.53	0.82	1.04	4.20
McAleer and Lyon	2,085	16,681	100%	16,681	5,180	16	21,877	100.00	2,085	1.18	0.25	0.60	5.02	1.43	1.78	6.20
Hollywood - Snohomish Co.	4,556	7,819	0%	0	422	89	511	0.00	0	0.02	0.00	0.00	0.00	0.02	0.02	0.02
Bear Creek - Snohomish Co.	8,614	27,773	0%	0	3,719	763	4,482	9.00	775	0.19	0.09	0.22	1.80	0.28	0.41	1.99
North Creek - Snohomish Co.	16,329	149,847	100%	149,847	23,460	6,467	179,774	95.00	15,513	10.30	1.87	4.46	35.74	12.17	14.76	46.04
Swamp Creek - Snohomish Co.	7,929	100,204	100%	100,204	23,016	3,255	126,475	95.00	7,533	7.06	0.91	2.17	20.49	7.97	9.23	27.55
Lake Forest - Snohomish Co.	943	10,943	100%	10,943	940	86	11,969	100.00	943	0.70	0.11	0.27	2.17	0.81	0.97	2.87
Lyon	473	5,561	100%	5,561	501	46	6,109	100.00	473	0.35	0.06	0.14	1.09	0.41	0.49	1.44
Kenmore - Snohomish Co.	38,844	302,148	88%	266,555	52,058	10,706	329,319	65	25,236	18.62	3.04	7.26	61.30	21.66	25.88	79.91
Swamp Creek - King Co.	718	4,540	100%	4,540	886	81	5,507	100.00	718	0.31	0.09	0.21	1.95	0.40	0.52	2.26
Bothell	2,252	13,848	100%	13,848	6,058	497	20,402	100.00	2252	1.08	0.27	0.65	5.19	1.35	1.73	6.27
Kenmore Sect. 5	1,327	8,466	100%	8,466	1,893	166	10,525	100.00	1327	0.59	0.16	0.38	3.06	0.75	0.97	3.64
North Creek - King Co.	1,084	6,013	100%	6,013	4,353	292	10,659	100.00	1084	0.54	0.13	0.31	2.50	0.67	0.85	3.03
Bear Creek - King Co.	1,466	14,508	100%	14,508	4,778	1,019	20,306	100.00	1466	1.11	0.18	0.42	3.38	1.29	1.54	4.49
Woodinville East	870	9,590	100%	9,590	2,708	698	12,996	100.00	870	0.72	0.10	0.25	2.00	0.83	0.97	2.73
Woodinville	1,085	5,127	100%	5,127	1,101	225	6,454	100.00	1085	0.36	0.13	0.31	2.78	0.49	0.68	3.14
Inglewood	1,250	8,016	100%	8,016	1,553	135	9,704	100.00	1250	0.55	0.15	0.36	2.56	0.70	0.91	3.11
Kenmore - King	10,052	70,109	100%	70,109	23,330	3,114	96,554	100	10052	5.26	1.21	2.89	23.42	6.47	8.15	28.67
Redmond North	1,934	21,664	100%	21,664	14,749	2,870	39,283	100.00	1934	2.03	0.23	0.56	4.95	2.26	2.59	6.98
Redmond East	4,922	41,818	100%	41,818	22,463	3,153	67,434	100.00	4922	3.53	0.59	1.42	12.60	4.12	4.95	16.13
Redmond South	2,755	37,097	100%	37,097	40,902	3,265	81,264	100.00	2755	3.90	0.33	0.79	7.05	4.23	4.70	10.96
Hollywood - Lake Hills	1,510	12,121	100%	12,121	9,482	321	21,924	100.00	1510	1.08	0.18	0.43	3.87	1.27	1.52	4.95
Blakely/North Ridge	1,296	4,082	100%	4,082	657	0	4,739	100.00	1296	0.27	0.16	0.37	3.32	0.42	0.64	3.59
Northeast Sammamish	2,804	14,165	100%	14,165	1,345	37	15,547	100.00	2804	0.90	0.34	0.81	7.18	1.24	1.71	8.08
Hollywood Pump Station Basin Subtotal	15,221	130,947	100%	130,947	89,598	9,647	230,192	100	15221	11.72	1.83	4.38	38.97	13.55	16.10	50.68
Edmonds East	4,128	48,833	100%	48,833	12,086	209	61,128	96	3,963	3.37	0.48	1.14	10.14	3.85	4.51	13.51
Total	71,624	578,228		542,635	184,818	23,760	751,213		57,851	40.81	6.97	16.65	142.37	47.78	57.46	183.18
Total to Brightwater [a]	**67,496**	**529,395**	**NA**	**493,803**	**172,731**	**23,550**	**690,084**	**NA**	**53,888**	**37.4**	**6.5**	**15.5**	**132**	**43.9**	**53.0**	**170**

[a] Total to Brightwater reflects rounded values.

expanded from 36 mgd to approximately 54 mgd in Year 2040 to meet the AWWF projected by Year 2050.

As King County develops additional information on I/I within the Brightwater Service Area, the I/I assumptions will be checked and flow projections updated where required.

3.2.1 Management of Flows between Brightwater and Existing Treatment Facilities

Under the RWSP, King County proposes to meet long-term needs for increased treatment capacity through the construction of Brightwater and a future expansion of the South Treatment Plant. Due to space limitations and other constraints, expansion of the West Point Treatment Plant is not proposed. To maximize the life of all three wastewater treatment plants and most efficiently use available capacity, King County plans to convey some of the Brightwater Service Area flows to its other plants at various times in the planning period. Table 3-6 presents a planning scenario illustrating how flows from the Brightwater Service Area may be managed between the West Point Treatment Plant, South Treatment Plant, and Brightwater facilities.

Figure 3-1 provides a graphical summary of the total projected flows to the King County West, East, and Brightwater Service Areas for the planning period. It illustrates how system-wide Year 2050 treatment needs for 332 mgd AWWF will be met by:

- Utilizing existing capacity of 248 mgd AWWF
- Constructing Brightwater with an initial capacity of 36 mgd AWWF (Brightwater Phase 1)
- Expanding the South Plant by 20 mgd AWWF by Year 2030
- Expanding Brightwater by 18 mgd AWWF by Year 2040 (Brightwater Phase 2)

3.2.2 Influent Wastewater Loads and Design Conditions Summary

Influent wastewater loads were estimated using monitoring records from the South Treatment Plant. South Treatment Plant data were selected over West Point data since the tributary area is a substantially separated system and most similar to Brightwater. The last 5 years of monitoring data for influent flow, BOD_5, TSS, nitrogen, and phosphorus were imported into a database and ratios developed relating the average dry weather, average wet weather, maximum 30-day, maximum 7-day, and maximum day mass loads to the average annual averages. The ratios were then used to estimate the BOD_5, TSS, nitrogen, and phosphorus from the projected Brightwater Service Area flows. Anticipated

Table 3-6. Average Wet Weather Flows (mgd) to Brightwater, South Treatment Plant, and West Point Treatment Plant

			Before Brightwater			After Brightwater											
Brightwater Service Area	**2000**		**2010**			**2010**			**2020**			**2030**			**2050/Assumed Saturation**		
Basin Name	**West Point**	**South**	**West Point**	**South**	**Brightwater**	**West Point**	**South**	**Brightwater**	**West Point**	**South**	**Brightwater**	**West Point**	**South**	**Brightwater**	**West Point**	**South**	**Brightwater**
Hollywood - Snohomish Co.		0.0		0.0				0.0			0.0			0.0			0.0
Woodinville East		0.3		0.5				0.5			0.7			0.8			1.0
Woodinville		0.5		0.5				0.5			0.6			0.6			0.7
Bear Creek - Snohomish Co.		0.1		0.4				0.4			0.4			0.4			0.4
Bear Creek - King Co.		0.7		0.9				0.9			1.2			1.3			1.5
North Creek - Snohomish Co.		5.2		8.0				8.0			11.3			12.6			14.8
North Creek - King Co.		0.5	0.6					0.6			0.7			0.8			0.8
Bothell	1.3		1.4					1.4			1.5			1.6			1.7
Kenmore Section 5	0.5		0.6					0.6			0.8			0.9			1.0
Inglewood	0.8		0.8					0.8			0.8			0.8			0.9
Swamp Creek - Snohomish Co.	2.9		4.7					4.7			6.8	7.7					9.2
Swamp Creek - King Co.	0.4		0.4					0.4			0.5			0.5			0.52
Lake Forest - Snohomish Co.	0.5		0.6					0.6			0.8	0.8					1.0
Lake Forest - King Co.	0.9		0.9					0.9			0.9	1.0					1.0
Lyon - Snohomish Co.	0.3		0.3					0.3			0.4	0.4					0.5
McAleer & Lyon	1.5		1.6					1.6			1.7	1.7					1.8
Lake Ballinger	3.2		3.5			3.5			3.8			4.1			4.5		
Subtotal	12.2	7.3	15.4	10.3		3.5		22.2	3.8		29.0	15.7	0.0	20.4	4.5	0.0	36.9
Hollywood Pump Station		9.4		11.4			11.4			7.0	6.0			14.0			16.1
Brightwater Total								22.2			35.1			34.4			53.0
West Point and South Plant Capacity Management																	
RWSP Flow Projections	119.8	92.4	132.3	105.1		132.3	105.1		144.8	121.2		153.6	129.7		169.5	142.9	
North Creek Pump Station[a]	-7.3	7.3	-10.3	10.3		-22.2			-29.0			-20.4			-36.9		
Hollywood Pump Station[b]										-6.0			-14.0			-16.1	
AWWF (Total by Facility, Rounded)	**113**	**100**	**122**	**115**	**0**	**110**	**105**	**22**	**116**	**115**	**35**	**133**	**116**	**34**	**133**	**127**	**53**
AWWF (Total for Service Areas)	**212**		**237**			**237**			**266**			**283**			**312**		

[a] Transfers flow from West Service Area/West Point to East Service Area/South Plant until Brightwater placed in service. Transfers flow to Brightwater once Brightwater is in service.

[b] Transfers flow from East Service Area/South Plant to Brightwater.

wastewater temperature was projected based on South Treatment Plant influent characteristics. The projected influent flows and loads are summarized in Table 3-7.

Table 3-7. Brightwater Flow and Load Summary

	Value for Condition						
Parameter by Year	**Average Annual**	**Average Dry Weather**	**Average Wet Weather**	**Maximum 30-Day**	**Maximum 7-Day**	**Maximum Day**	**Peak Hour**
Flow rate (mgd)							
2000	17.9	15.2	20.5	29.0	40.7	56.2	64.6
Brightwater Design, Phase 1	31.3	26.7	36.0	50.8	71.4	98.7	129.0
2010	20.0	17.1	23.0	32.5	45.6	63.0	-
2020	31.3	26.7	36.0	50.8	71.4	98.7	-
2030	31.3	26.7	36.0	50.8	71.4	98.7	-
2040	31.3	26.7	36.0	50.8	71.4	98.7	-
Ultimate/2050, Phase 2	47.0	43.9	54.0	76.2	107.2	148.0	170.0
Total BOD_5 (lb/day)							
2000	34,200	34,216	34,196	44,787	53,178	110,227	
Brightwater Design, Phase 1	60,000	60,028	59,994	78,573	93,294	193,381	-
2010	38,333	38,351	38,329	50,200	59,605	123,549	-
2020	60,000	60,028	59,994	78,573	93,294	193,381	-
2030	60,000	60,028	59,994	78,573	93,294	193,381	-
2040	60,000	60,028	59,994	78,573	93,294	193,381	-
Ultimate/2050, Phase 2	90,000	90,041	89,991	117,860	139,941	290,072	-
Soluble BOD_5 (lb/day)							
2000	13,467	13,857	13,187	18,213	27,346	28,519	
Brightwater Design, Phase 1	23,626	24,311	23,136	31,953	47,976	50,033	-
2010	15,094	15,532	14,781	20,415	30,651	31,966	-
2020	23,626	24,311	23,136	31,953	47,976	50,033	-
2030	23,626	24,311	23,136	31,953	47,976	50,033	-
2040	23,626	24,311	23,136	31,953	47,976	50,033	-
Ultimate/2050, Phase 2	35,439	36,466	34,704	47,930	71,964	75,050	-
Total Suspended Solids (lb/day)							
2000	35,720	36,018	35,469	43,476	51,921	95,738	
Brightwater Design, Phase 1	62,667	63,189	62,227	76,274	91,089	167,962	-
2010	40,037	40,371	39,756	48,731	58,196	107,309	-
2020	62,667	63,189	62,227	76,274	91,089	167,962	-
2030	62,667	63,189	62,227	76,274	91,089	167,962	-
2040	62,667	63,189	62,227	76,274	91,089	167,962	-
Ultimate/2050, Phase 2	94,000	94,783	93,340	114,411	136,633	251,942	-
Minimum Temperature (C^c)							
Brightwater Design[b]	16.0	18.0	14.0	11.8	10.6	10.0	-

Table 3-7. Brightwater Flow and Load Summary

	Value for Condition						
Parameter by Year	**Average Annual**	**Average Dry Weather**	**Average Wet Weather**	**Maximum 30-Day**	**Maximum 7-Day**	**Maximum Day**	**Peak Hour**
Maximum Temperature (C[c])							
Brightwater Design[b]	16.0	18.0	14.0	20.2	20.1	21.1	-
Ammonia-N (lb/day)							
2000	3,255	3,232	3,282	3,879	4,930	6,695	
Brightwater Design, Phase 1	5,710	5,671	5,758	6,805	8,649	11,746	-
2010	3,648	3,623	3,679	4,347	5,526	7,504	-
2020	5,710	5,671	5,758	6,805	8,649	11,746	-
2030	5,710	5,671	5,758	6,805	8,649	11,746	-
2040	5,710	5,671	5,758	6,805	8,649	11,746	-
Ultimate/2050, Phase 2	8,565	8,506	8,637	10,207	12,974	17,619	-
TKN (lb/day)							
2000	5,992	5,948	6,046	7,182	8,215	12,335	
Brightwater Design, Phase 1	10,513	10,435	10,607	12,600	14,413	21,640	-
2010	6,716	6,667	6,776	8,050	9,208	13,826	-
2020	10,513	10,435	10,607	12,600	14,413	21,640	-
2030	10,513	10,435	10,607	12,600	14,413	21,640	-
2040	10,513	10,435	10,607	12,600	14,413	21,640	-
Ultimate/2050, Phase 2	15,769	15,653	15,910	18,901	21,620	32,460	-
Total Phosphorus (lb/day)							
2000	1,104	1,062	1,137	1,545	1,826	2,357	
Brightwater Design, Phase 1	1,937	1,864	1,995	2,711	3,204	4,136	-
2010	1,237	1,191	1,274	1,732	2,047	2,642	-
2020	1,937	1,864	1,995	2,711	3,204	4,136	-
2030	1,937	1,864	1,995	2,711	3,204	4,136	-
2040	1,937	1,864	1,995	2,711	3,204	4,136	-
Ultimate/2050, Phase 2	2,905	2,796	2,992	4,067	4,807	6,204	-
Soluble Ortho Phosphorus (lb/day)							
2000	596	587	608	994	1,375	1,375	
Brightwater Design, Phase 1	1,046	1,029	1,068	1,744	2,412	2,412	-
2010	668	658	682	1,114	1,541	1,541	-
2020	1,046	1,029	1,068	1,744	2,412	2,412	-
2030	1,046	1,029	1,068	1,744	2,412	2,412	-
2040	1,046	1,029	1,068	1,744	2,412	2,412	-
Ultimate/2050, Phase 2	1,569	1,544	1,601	2,616	3,618	3,619	-

3.3 Wastewater Flow Reduction

This section describes how water conservation has been factored into estimates of base sanitary flows, and how I/I remediation factors into the sizing of facilities and timing of future expansions.

3.3.1 Water Conservation

The quantity of sanitary wastewater discharged to the collection system is a function of the quantity of water that is utilized in the activities that generate the wastewater. For residential and commercial dischargers, the wastewater from toilet flushing, bathing and other personal hygiene, clothes washing, and food preparation are related to the water demands of the specific fixtures and appliances. For industrial dischargers, the quantity of wastewater is a function of the specific wet industrial processes.

In the case of Brightwater, the sizing and phasing of conveyance and treatment elements are driven primarily by peak wet weather conditions that occur during the late fall and winter months. During these events, the wet weather effects are dominant. Base sanitary flows represent less than 20 percent of the peak 20-year storm flow. Water conservation therefore has little effect on the sizing of the proposed conveyance and treatment facilities (King County, 1998; King County, 2003). Nevertheless, the potential benefits of water conservation are acknowledged, and they have been considered in the projection of flows and loads for the Brightwater Service Area.

The quantity of wastewater to be treated can thus be reduced by utilizing low water demand fixtures, appliances, and processes as well as providing financial incentives and enhanced customer awareness. Historically, leadership for water conservation has come from local water purveyors; national codes and standards, such as the Uniform Plumbing Code; plumbing fixture and appliance manufacturers; and the King County Wastewater Treatment Division. Within King County, these efforts have seen a historical decrease in average single-family home residential flows from approximately 900 cubic feet per month to approximately 750 cubic feet per month, a reduction of over 15 percent. In considering the future of the Brightwater Service Area, new construction will represent over 40 percent of the total tributary customer base, providing further flow reduction opportunities as new, more efficient fixtures and appliances come into use. Further, plumbing retrofits of existing homes are anticipated to occur as a result of water purveyor incentives and residential remodeling work. These activities will help sustain historic water conservation achievements and could potentially reduce potable water demands and base sanitary wastewater flows by a further 10 to 18 percent. While this reduction seems significant, it would provide a reduction of only 2 to 4 percent of the Year 2020 peak 20-year storm flow (King County, 2003).

The projections of base sanitary flows for the Brightwater Service Area are reflective of water conservation achieved to date within the King County wastewater system. The King County residential wastewater production rate of 60 gpcd is lower than typical national values of 70 to 80 gpcd (Metcalf and Eddy, 1991). The 60 gpcd rate has also been found to be reasonable for current levels of wet weather water use by Seattle Public Utilities' customers. King County will continue to monitor trends in sanitary wastewater production, and will adjust future flow projections as water conservation results may dictate.

3.3.2 Infiltration/Inflow

Chapter 2 of this Facilities Plan provides an overview of the King County Regional I/I Control Program, and discussed how the project will develop information on the costs, feasibility, and effectiveness of I/I removal from the King County and local agency collection systems.

The potential for reducing the size of wastewater conveyance and treatment facilities through I/I remediation depends on the magnitude of the I/I problem. For example, consider Year 2000 conditions in the Brightwater Service Area. Under this scenario, average wet weather I/I represents 34 percent of the total AWWF and peak wet weather I/I represents 80 percent of the total PWWF. A 10 percent reduction in I/I from current levels would allow the hydraulic capacity of facilities to be reduced by 7 percent for AWWF conditions and 2 percent for PWWF conditions. Such a reduction of I/I could be used to extend the design life of the Brightwater facilities by postponing the Brightwater Year 2040/Phase 2 expansion by approximately 8 years, as well as potentially reducing the AWWF sizing of the Phase 2 expansion by 4 mgd. However, reductions in I/I will not postpone the Phase 2 expansion of Brightwater solids handling facilities.

King County's approach to determining the cost effectiveness of I/I removal is discussed in Section 2.6 of this Facilities Plan. At this time, there is inadequate information to estimate what levels of I/I removal might be achieved in the Brightwater Service Area or the cost of remediation. As the Regional I/I Control Program develops additional information in this regard, the cost effectiveness of I/I removal will be investigated, and Brightwater Service Area flow projections will be revisited and adjusted where required.

3.4 References

King County, 1998, Regional Wastewater Services Plan, Final Environmental Impact Statement, Seattle, WA.

King County, 2003. Fact Sheet, King County Wastewater Flow Projections, Seattle, WA.

Metcalf and Eddy, 1991, *Wastewater Engineering. Treatment, Disposal, Reuse*, Third Edition, New York, New York.

LIST OF FIGURES

Figure 3-1	Projected Treatment Plant Needs for West, East and Brightwater Service Area
Figure 3-2	Projected Average Dry Weather, Average Wet Weather, and Peak Wet Weather Flow to Brightwater Facilities
Figure 3-3	Projected Annual Average Brightwater BOD_5 and TSS Load to Brightwater Facilities

Chapter 4 Alternative Analysis

Note to Reviewers of Preliminary Working Draft Facilities Plan: Chapter 4 is intended to be viewed in conjunction with the Phase 1 Task 1.03 Treatment Plant Process Engineering Technical Memorandum (Task 1.03 Technical Memorandum), which is included as a supplement to this document. The Task 1.03 Technical Memorandum presents extensive and detailed evaluations of potential treatment technologies that are summarized in this chapter. In addition, detailed evaluations of conveyance, marine discharge/outfall, disinfection, and effluent reuse are presented in Appendices C, D, E, and F, respectively.

Cost estimates presented in this chapter provide relative comparisons of options used in the alternative analyses, developed as part of the Task 1.03 Technical Memorandum. Overall costs for the Brightwater Regional Wastewater Treatment System will be revised during preparation of the Final EIS, and will be presented in a future supplement to this document.

4.1 Introduction

This chapter summarizes the extensive investigations that King County has undertaken to identify and analyze potential sites for the Brightwater facilities, and describes the alternative analyses performed on the various treatment, conveyance, and effluent management options. The recommended alternative for the Brightwater facilities is then described in Chapter 5.

4.1.1 Background Studies and Concurrent Investigations

The need for the Brightwater project was analyzed extensively in the *Regional Wastewater Services Plan* (King County, 1997), *Final Environmental Impact Statement* (King County, 1998), and supporting studies completed under the county's Wastewater 2020 Plus planning project. The RWSP evaluated a range of service strategies for providing necessary improvements to the King County wastewater system. In developing service strategies, the RWSP considered options for secondary treatment with a marine discharge to Puget Sound, as well as advanced treatment with discharge of highly treated reclaimed water at Hiram Chittenden Locks or upstream waters of the Lake Washington system. The RWSP established the basic need to construct a new treatment plant in north King County or south Snohomish County by 2010, coupled with a phased expansion of the South Treatment Plant. The recommended service strategy identified the following major elements that would compose the Brightwater system:

- A new secondary treatment plant with an initial capacity of approximately 36 mgd AWWF, and the capability to treat a portion of the wastewater to meet Class A reclaimed water standards.
- Influent conveyance facilities to deliver raw wastewater to the treatment plant.
- Effluent conveyance facilities to deliver treated effluent to Puget Sound.
- A new outfall located in north King County or south Snohomish County for marine discharge of effluent.

The RWSP was adopted by the King County Council under Ordinance 13680 in November 1999. Following its adoption, King County initiated a series of studies and preliminary design activities to evaluate potential sites for Brightwater, refine the overall concept for the Brightwater system, and evaluate environmental impacts of the project alternatives. These investigations, briefly summarized below, culminated in the *Draft Environmental Impact Statement, Brightwater Regional Wastewater Treatment System*, which was published in November 2002.

Marine Outfall Siting Study, a comprehensive investigation of the physical and biological conditions in and around potential receiving water areas of Puget Sound. The MOSS provided information necessary to evaluate marine discharge of treated effluent and included analysis of outfall zones and potential construction methods. Eight potential marine outfall zones were identified during the MOSS. Appendix D of this report summarizes the outfall alternative analysis undertaken as part of the MOSS program.

Brightwater Treatment System, Siting Project Phase 1, a study that utilized geographical information system analysis, land search, and community nomination processes to identify potential sites for the Brightwater treatment facilities. Through these evaluations, 95 potential treatment plant sites were identified. They were subsequently screened to 38 sites and then from 38 to 6 sites through further analysis.

Brightwater Treatment System, Siting Project Phase 2, a detailed evaluation process that further screened the potential sites from six to two locations. Two conveyance corridors with two alternative configurations were identified. Conveyance configurations included a near surface, open cut pumped alternative and a deep tunnel gravity flow alternative for each corridor. The Siting Project Phase 2 developed conceptual “candidate systems” that included two treatment facility sites with general layouts, two conveyance options, and candidate marine outfall zones.

King County, Conveyance System Improvements (CSI), a multi-year, multi-disciplinary effort to upgrade and improve King County’s conveyance system and plan for future needs. The CSI project refined the conveyance options developed under the Siting Project Phase 2 and evaluated alternative corridors for delivering raw wastewater to Brightwater and for conveying treated effluent to the point of discharge. Appendix C of this report presents a summary of the CSI Brightwater conveyance analyses.

Phase I Engineering Services for the Brightwater Treatment Plant, which provided preliminary design engineering to evaluate treatment technologies, refine treatment facility layouts, and support the Draft EIS.

Brightwater Treatment System, Siting Project Phase 3, Draft EIS, the environmental review and concurrent engineering, geotechnical, cost analysis, and community/public involvement program. Phase 3 included the issuance of the Draft EIS, which provided a comparison of the Brightwater system alternatives, along with an evaluation of environmental impacts in accordance with Washington SEPA requirements. The Draft EIS identified a preferred alternative for Brightwater, the 195th Street system, as described in this chapter.

Brightwater Conveyance Predesign and Geotechnical Investigations, initiated during late 2002. These two concurrent efforts will refine the conveyance and outfall concepts, ultimately determining whether conveyance will be accomplished by gravity tunnels or pumped systems, and whether the outfall will be constructed using tunneled or trenched methods.

4.1.2 Alternative Analysis Approach and Cost Evaluation Methodology

This chapter summarizes the wide range of alternative analyses that were undertaken during the MOSS program; Brightwater Phase 1, 2, and 3 Siting Projects; and Brightwater Phase 1 Engineering Services. The alternative analyses present relative comparisons of options based on present-value cost analyses and non-cost factors related to process, operation and maintenance, and environmental/community impact considerations. Based on the alternative analyses, recommended configurations are established for the major components of the Brightwater system. The recommended alternative is given further definition in Chapter 5, and financial analysis in Chapter 6, wherein capital and operation and maintenance (O&M) costs are translated into user fees.

Relative cost comparisons utilized in siting investigations and relative comparison of treatment process options should be considered as a planning or reconnaissance level, having a –25 to + 40 percent level of accuracy, and incorporate the following cost factors and allowances:

> **Mitigation Allowance:** 10 percent of base construction cost, including sales tax and allied costs. Contingency, art allowance, and land/right-of-way costs are excluded from the mitigation allowance calculation.
>
> **Art Allowance:** 1 percent of adjusted base cost of construction, including contingency at 10 percent of adjusted base construction cost and allied costs. Adjusted base of construction excludes demolition, hazardous materials removal, underground pipelines, and shaft/portal construction.

Construction Contingency Allowance: 25 percent of treatment plant cost.

Sales Tax: 8.9 percent.

Engineering, Administration, Legal, and other Allied Costs: 35 percent of the sum of the base construction cost, construction contingency, and sales tax.

Life Cycle Cost Period: 20 years.

Discount Rate for Present Worth Analysis: 3 percent.

Operations and Maintenance Staff Salary with Benefits: $43.00/hour average rate.

Chemicals, Solid Waste, and Biosolids Management: Chemical costs based on average wet weather flow conditions, and vendor's estimated costs for chemicals delivered to site. Biosolids management and solid waste disposal costs are based on unit cost per mgd of flow at the West Point and South Treatment Plants.

Electrical Power Cost: $0.05 per kilowatt-hour.

4.2 Brightwater Siting Studies and Draft Environmental Impact Statement

This section describes how alternative sites were identified for the Brightwater facilities, and how preferred locations for treatment, conveyance, and outfall elements (together comprising the Brightwater Regional Wastewater Treatment System) were selected as presented in the Draft EIS.

The primary objectives of the siting analysis were to: 1) determine the best treatment plant site(s), conveyance routes, and outfall zones based on community, environmental, engineering, land acquisition, and financial considerations; 2) meet the site selection criteria policies set forth in King County Council Ordinance 14107; and 3) comply with the requirements of SEPA. The siting analysis was formulated around the following basic assumptions:

- Sites must accommodate projected average wet weather wastewater flows of 50 to 60 mgd with room for future expansion.
- Sites should be capable of serving north King County and south Snohomish County.
- Sites would be located within existing Urban Growth Areas in King and Snohomish Counties.

4.2.1 Siting Process

The Brightwater project team developed a three-phase siting process, based on a systematic approach to narrowing the number of sites under consideration. The general sequence of siting process activities is depicted in Figure 4-1. As the phases of the siting study advanced, the evaluation of potential sites became progressively more detailed.

4.2.1.1 Phase 1: Identification of Potential Treatment Plant Sites

From November 1999 through May 2001, King County performed Phase 1 of the Siting Project. Phase 1 was designed to identify suitable new treatment plant sites, and to investigate Puget Sound to determine potential locations for a marine discharge.

Phase 1 began with an inventory of land in King and Snohomish Counties to develop a list of potential sites for evaluation. The lands inventory was created using real estate surveys, King County and Snohomish County tax assessors' data, geographic information system (GIS) data, digital aerial photographs, and digital assessor parcel information. Sites that would occupy existing developed parks, schools, cemeteries, airport fly zones, zoos, and golf courses were eliminated from further consideration. King County also requested nominations of potential sites from the public and retained a commercial real estate broker to search for possible sites in commercial and industrial areas.

The study area included north King County and south Snohomish County. Mountlake Terrace was the approximate center of the study area. The southern boundary of the study area was the City of Redmond and the northern boundary was the City of Everett. The study area and the 95 potential treatment plant sites identified during Phase 1 are shown in Figure 4-2.

Phase 1 conveyance evaluations were performed under the King County CSI program and proceeded in parallel with the treatment plant siting study. Initial evaluations identified conceptual corridors for transporting raw wastewater to each of the potential treatment plant sites and for conveying effluent to potential outfall zones. The evaluations included preliminary investigations of vertical profiles for deep tunnel and near surface conveyance (cut and cover construction) options. As the siting work progressed, conveyance evaluations became progressively more detailed, as described in Appendix C.

During Phase 1, the MOSS program developed background information and initiated screening investigations related to the potential siting of a marine discharge in Puget Sound. A detailed discussion of the MOSS investigations is presented in Appendix D.

4.2.1.2 Phases 1a, 1b, and 2: Criteria for Evaluating Alternative Treatment Plant Sites and Results of Screening Evaluations

Phase 1a: Initial Screening

The 95 sites identified during Phase 1 were evaluated and screened for engineering and environmental (E & E) constraints that would make the site unfavorable for location of a treatment plant. The presence of any one of 13 constraints, based on a defined threshold, precluded the site from further consideration. Only sites that did not have E & E constraints were evaluated in subsequent screening. The E & E constraints included:

- Size less than 25 acres
- Shape with a length-to-width ratio greater than 10 to 1, or an irregular shape incompatible with treatment facility layout
- Location within 0.5 kilometer from a documented fault zone
- Slopes greater than 30 percent
- Known landslides and high potential for instability
- Location within a zone of liquefiable soils and deep lateral spreading
- Presence of Class 1 wetlands
- Location in a 100-year flood plain
- Presence of a Superfund site
- Location near an airport or airport clear zone
- Presence of designated agricultural or forest land or land held in trust
- Presence of a designated wildlife preserve or conservation land
- Presence of park with officially designated habitat/natural areas

The E & E constraints eliminated 57 sites, leaving 38 sites to advance into Phase 1b, Refined Screening. The 38 sites are shown in Figure 4-3.

Under the MOSS program, potential outfall zones were identified and screened for general suitability. Outfall zones were eliminated from further consideration if certain critical constraints were apparent, including presence of a Superfund site, presence of ship anchorage zones, and shallow depth incompatible with anticipated diffuser requirements (100-foot depth was the assumed minimum necessary to meet dilution

requirements). Potential outfall zones were then evaluated and ranked relative to geophysical constraints, biological resource issues, and shoreline public use considerations. The most favorable outfall zones were designated as “more flexible,” while the less favorable zones were designated as “less flexible.” Ten outfall zones (eight zones with two zones divided into north and south areas) emerged from this analysis, as shown in Figure 4-4.

Phase 1b: Refined Screening

Based on public comments, the King and Snohomish County Executives developed draft policy site screening criteria that were refined by advisory, policy, and technical committees involved with the siting process. The King County Council reviewed and revised the policy site screening criteria, and adopted them under Ordinance 14043 in February 2001. The remaining 38 sites were analyzed during Phase 1b using the policy site screening criteria, reducing the number of sites from 38 to seven.

The seven candidate sites were designated as Edmonds Unocal (later designated Unocal), Point Wells, Gun Range, Gravel Quarry, Thrashers Corner, Woodinville, and Route 9. Under Ordinance 14107, adopted by the King County Council during May 2001, the Woodinville site was eliminated from further consideration. The six remaining treatment plant sites and 10 Phase 1a marine outfall zones were chosen for evaluation under a refined set of policy site selection criteria. The sites and outfall zones are shown in Figure 4-4. The policy site selection criteria were then applied in the Phase 2 screening evaluation to determine the most suitable candidate systems.

Phase 2: Screening Evaluation

Phase 2 of the siting process took place from June 2001 through December 2001 and involved the development and analysis of conceptual candidate systems that included treatment plant sites with a general facility layout, two conveyance options, and a marine outfall. The two conveyance options included a near surface configuration consisting primarily of underground pipelines installed close to the surface (primarily with cut and cover construction) and a deep tunnel with deep tunnel pipelines. The conceptual systems were developed to allow consistent, comparative analysis of options, particularly with respect to project costs and impacts. The Phase 2 candidate systems are summarized in Table 4-1.

Table 4-1. Phase 2 Candidate Systems

Plant Sites		Conveyance Options		Marine Outfall Options	
Point Wells					
Unocal				Zone 1	Zone 5
Gravel Quarry		Near-Surface Pipeline		Zone 2	Zone 6
Route 9	+	Deep Tunnel	+	Zone 3	Zone 7
Gun Range				Zone 4	Zone 8
Thrashers Corner					

Detailed Evaluation Questions

To systematically apply the policy site selection criteria, the project team developed a set of Detailed Evaluation Questions (DEQs) – measurable questions to help evaluate how well each system would meet the policy criteria. The DEQs focused on both project constraints and opportunities. In Phase 2, the DEQs addressed engineering and land acquisition issues, environmental considerations, community impacts, and financial policy considerations. For each policy criterion, one or more DEQs were applied to the six candidate systems. For most questions, a qualitative scale of high, medium, and low was used to assess the relative constraints and opportunities of each site. Quantitative information was used for those questions where such information was available. The DEQs were posed in a manner that could be answered through interpretation of aerial photos and GIS data, preliminary plant layouts, conveyance corridor routing, parcel maps, limited on-site reconnaissance, and from physical, natural, and community resources that were readily available.

A total of 91 DEQs were developed for the sites and systems under consideration. Eighteen of the questions were designed to evaluate community constraints and opportunities, 12 questions to evaluate environmental constraints, 37 questions to evaluate technical constraints, and 2 questions to address financial constraints in terms of life cycle cost and King County's financial security and bonding capability. Twenty-two questions were provided by the MOSS team to evaluate the biological, oceanographic, and geophysical characteristics of Puget Sound, community and human values, and the engineering design and construction requirements for potential marine outfalls.

Data gathered through the DEQ process were processed using Criterion Decision Plus® software, which facilitated the relative comparison of sites.

Key Siting Factors

The project team, based on experience and professional judgement, determined that certain DEQs represented "Key Factors," which should be given more emphasis in the evaluation. The basis for selecting the Key Factors included:

- Importance – factors that were most important in determining system suitability
- Discrimination – factors that clearly distinguished between systems
- Independence – factors that were unique measures of suitability
- Significance – factors that represented constraints that would be difficult to mitigate
- Available Data – factors than could be clearly determined at this level of analysis

Emphasis on the Key Factors focused the evaluation on the most significant considerations that were supported by reliable data. While the Key Factors were given emphasis in the analysis, all DEQs were considered in evaluation of the systems. The Key Factors are listed in Table 4-2.

Table 4-2. Siting Project, Phase 2 Key Factors

Engineering
Useable area
Buffer zone
Potential upgrade/expansion area
Shape
Average energy consumption
Number of conveyance portals (for tunnel components)
Total conveyance length
Flow management flexibility
Land Acquisition
Legal restrictions on title
Complexity of relocations
Total private property acquisition – conveyance corridor
Community
Opportunity for on-site mitigation
Vehicle access
Traffic disruption – construction
Alternative access
Public safety training for law enforcement
Existing land use change
Environmental Factors
Endangered Species Act compliance – Site
Endangered Species Act compliance – Conveyance
Wetlands
Permitability
Financial-Cost
Life cycle cost

The MOSS program conducted a parallel evaluation of the potential outfall zones using a set of primary factors and secondary factors, as summarized in Appendix D.

Policy Site Selection Criteria

The Phase 2 evaluation concluded that of the six systems, four systems met the policy site selection criteria. Development of the Gun Range site would displace an existing use that supports public safety and law enforcement training, and relocation would not be possible within a reasonable time frame or within reasonable geographic proximity. The Thrashers Corner site was found to have significant constraints because of extensive wetlands that would limit and fragment the useable area. As a result, the Gun Range and Thrashers Corner sites/systems were removed from further consideration.

System ratings for the Key Factors are shown in Table 4-3. Narrative descriptions of the advantages and constraints observed for each candidate system are presented in Table 4-4.

Phase 2 Preliminary Cost Estimates

Preliminary cost estimates were prepared during Phase 2 to help decision-makers evaluate the proposed candidate systems and provide a preliminary budget range for the various Brightwater options. The Phase 2 cost estimates were developed using planning-level schematic drawings and conceptual information on sizing of facilities. Site-specific geotechnical information was not available for use in preparing the estimates.

Estimates were developed for present value total life cycle cost. Capital costs were based on a new 36-mgd activated sludge secondary treatment plant with solids handling and administrative and maintenance facilities located on-site, conveyance systems to transport a peak flow of 170 mgd to the plant and effluent to Puget Sound, and a new marine outfall for discharge of the effluent. Capital cost estimates included site acquisition, permits, mitigation, engineering, and construction of the plant, conveyance system, and marine outfall. Operations and maintenance costs included labor, energy, materials, and equipment repair over a 20-year life cycle period. The cost estimates are summarized by system in Table 4-5.

The capital costs for the alternative systems ranged from $948 million for the Point Wells system with deep tunnel conveyance to $1.37 billion for Route 9 system with near-surface conveyance. The Point Wells system had been used in the RWSP for cost estimating purposes. The Phase 2 cost estimates reflected an approximate 12 percent increase over the RWSP costs, largely due to a rapid rise in the cost of land and the addition of advanced odor control facilities.

Table 4-3. Phase 2 Key Factor Summary for Candidate Site/Systems

Key Factor		Point Wells		Unocal		Gravel Quarry		Route 9	
	Code	Surface	Tunnel	Surface	Tunnel	Surface	Tunnel	Surface	Tunnel
TECHNICAL									
Useable Area	ENGR-Config2b	Medium		Medium		Medium		Low	
Buffer Zone	ENGR-Config3b	Low		Medium		Low		Low	
Potential Upgrade Area	ENGR-Config4b	Medium		Medium		Medium		Low	
Shape	ENGR-Config5b	Low		Medium		Medium		Low	
Total Length	ENGR-Conv1b	Low	Low	Low	Low	Medium	Medium	**HIGH**	**HIGH**
Average Energy Consumption	ENGR-Conv4b	Medium	Low	Medium	Low	Medium	Medium	**HIGH**	Low
Number of Portals	ENGR-Conv7b	Medium	**HIGH**	**HIGH**	**HIGH**	Low	**HIGH**	Medium	**HIGH**
Number of Pump Stations	ENGR-Conv8b	**HIGH**	Medium	**HIGH**	Medium	Medium	Low	**HIGH**	Low
Flow Management – Flexibility	ENGR-Sys4b	Medium	Medium	Medium	Medium	Medium	Medium	**HIGH**	Low
Legal Restrictions on Title	LAND-Time3b	Low		Low		Low		Medium	
Complexity of Relocations	LAND-Time5b	**HIGH**		Low		Medium		**HIGH**	
Private Property – Conveyance	LAND-Time7b	Medium	Low	Medium	Medium	Low	**Medium**	Medium	**HIGH**
ENVIRONMENTAL									
Endangered Species Compliance Act – Site	Bio2b	Low		Low		Low		Low	
Endangered Species Act – Conveyance	Bio7b	Medium	Low	Medium	Low	**HIGH**	Low	**HIGH**	Low
Wetlands – Site	Bio4b	Medium		Medium		Medium		No	
Permitability – Resource Permits	PE2b	**HIGH**		**HIGH**		Low		Medium	
COMMUNITY									
Compatibility with Surrounding Land Use	LU2b	Low		Low		**HIGH**		Low	
Traffic Disruption – Construction Site	Acc2b	Medium		Medium		Medium		**HIGH**	
Public Safety Training for Law Enforcement	ENVR-PS1b	No		No		No		No	
Vehicle Access	ENGR-Acc1b	**HIGH**		Medium		Low		Medium	
Alternative Access	ENGR-Acc2b	Low		Low		HIGH		Medium	
Community Compatibility (*Opportunity*)	COMM-Benfit1b	**HIGH opportunity**		Low		Medium		**HIGH opportunity**	
FINANCIAL									
Life cycle Cost	FIN-Sys2b	Low	Low	**HIGH**	Medium	Medium	Medium	**HIGH**	Medium

Note:
Low = Desirable
High = Less Desirable

Table 4-4. Summary of System Characteristics

Point Wells	Unocal	Gravel Quarry	Route 9
ENGINEERING *Advantages*			
• Excellent buffer around majority of site. • Sufficient area for treatment facilities and upgrades. • Flat site; minimal cut and fill required. • No retaining walls required. • Shortest conveyance length. • Moderate opportunity for water reuse. • Both near-surface and tunnel conveyance systems have flexibility for flow management during emergencies.	• Sufficient area for treatment facilities and upgrades. • Edmonds WWTP provides opportunity to consolidate operations. • Second shortest conveyance length. • Moderate opportunity for water reuse. • Both near-surface and tunnel conveyance systems have flexibility for flow management during emergencies.	• Sufficient area to provide a 200-foot buffer around majority of treatment units. • Sufficient area for treatment facilities and upgrades. • Minimal or no groundwater or liquefaction expected. • Centrally located in service area and in proximity to existing infrastructure. • Moderate conveyance length. • Moderate opportunity for water reuse. • Both near-surface and tunnel conveyance systems have flexibility for flow management during emergencies.	• Site adequate in size to provide minimum of a 200-foot buffer on all sides with railroad and Highway 522 on east side of site providing an additional buffer. • Large area and shape allows flexibility in design of treatment facilities and space for future upgrades. • Site has minimal slope and does not require retaining walls. • Minimal or no liquefaction expected. • Moderate to high opportunity for water reuse. • Tunnel conveyance system has a relatively low energy requirement. • Tunnel conveyance system has the most flexibility to provide flow management during emergencies.

Table 4-4. Summary of System Characteristics

Point Wells	Unocal	Gravel Quarry	Route 9
ENGINEERING *Constraints*			
• High groundwater levels may complicate construction. • Foundation stabilization is required west of the railroad tracks due to liquefiable soils and lateral spreading. • Vehicular traffic limited to existing access through Richmond Beach. Construction of alternate access via new road down hillside would be complicated by steep slopes, heavily wooded area, and drainages.	• Potential co-use with Edmonds Crossing multi-modal transportation facility project could limit flexibility and complicate the schedule. • Achieving odor control goals may be more expensive. • High groundwater levels may complicate construction. • Extensive site preparation required, including major retaining walls.	• Shape of the useable area with narrow connection between quarry and DNR property constrains layout. • Elevation highest of sites being considered, which results in moderate to high energy requirement. • Presence of steep slopes requires hillside excavation and major retaining walls.	• Longest conveyance length increases uncertainty and risk. • Near-surface conveyance system has relatively high energy requirements. • Artesian groundwater conditions on site may complicate construction and operation. • Near-surface conveyance system has limited flexibility to provide flow management during emergencies.
LAND ACQUISITION *Advantages*			
• Negotiations with one owner. • One parcel. • Combined site and outfall location reduces total land acquisition required for system.	• Negotiations with one or two (Edmonds) owners. • Comparatively minor relocation issues anticipated. • Combined site and outfall location reduces total land acquisition required for system.	• Negotiations with few owners.	• Industrial property zone. • Valuation is straightforward.
LAND ACQUISITION *Constraints*			
• Relocation complexity may be significant due to unique site requirements (deep-water port) and broad impacts of existing use. • The extent of hazardous contamination on the site poses an increased risk of acquisition complexity.	• Hazardous materials contamination on much of the site may affect acquisition complexity.	• Possible hazardous materials contamination (fill) on portion of site may increase acquisition complexity. • Washington State/DNR ownership of a portion of the site may increase acquisition complexity.	• Negotiations with many owners. • Relocations may be complex due to number and business type of existing uses. • Possible hazardous materials contamination on a portion of the site may increase acquisition complexity.

Table 4-4. Summary of System Characteristics

Point Wells	Unocal	Gravel Quarry	Route 9
ENVIRONMENTAL *Advantages*			
• Because lower portion of site is highly disturbed, there will be minimal disruption of natural resources, including wetlands. • Opportunities for stream enhancement at site by daylighting existing piped streams. • Opportunity to expedite cleanup of contaminated soils on-site.	• Most of site is highly developed as an industrial site. • Opportunity to enhance stream/riparian buffer and wetland buffer on-site. • Opportunity to expedite cleanup of contaminated soils on-site.	• Minimal regulated natural resources on active gravel quarry area. • No documented contamination on site. • Few streams or wetlands on site.	• Development of treatment plant affects few natural resources. • Piped streams on site offer enhancement potential; possible enhancement options. • Opportunity to enhance Little Bear Creek.
ENVIRONMENTAL *Constraints*			
• Near shore demolition may trigger shoreline permit; shoreline is of statewide significance. • Identified bald eagle nest on upper terrace may affect construction schedule. • In-water improvements to the existing pier would require an individual Corps permit. • Contaminated soils and groundwater at site will require time-consuming remediation.	• Extent and proximity of on-site wetland will result in difficulty in avoiding impacts to the wetland buffer. • Heron rookery along Willow Creek could limit mitigation options and affect construction schedule. • Shoreline permit may be required; shoreline is of statewide significance. • In-water improvements to the pier may require an individual Corps permit.	• Upland terrace is vegetated with a mature forest that provides high quality habitat; forested area would be largely removed. • On-site streams are tributary to Crystal Creek, which is a tributary to Swamp Creek. • Historic land uses indicate a possibility of contamination; additional study needed to determine contamination potential at site.	• Site is tributary to Little Bear Creek across SR 9, a stream of high sensitivity and development constraints. • Site is bordered by areas containing wetlands, which site design would need to avoid. • Historic land uses on a portion of the site may have caused soil or groundwater contamination.

Table 4-4. Summary of System Characteristics

Point Wells	Unocal	Gravel Quarry	Route 9
COMMUNITY *Advantages*			
• Topography allows visual screening from residential areas above site. • Opportunities for community enhancement on upper portion of site. • Opportunity to restore natural shoreline for public use, and restore views of natural setting from shoreline area south of site. • Opportunities for community enhancement and public access from neighborhoods north and south of site along shoreline. • Location near rail line and shoreline provides options for barge and rail access during construction. • Existing industrial character of site would lessen land use transition issues associated with conversion to treatment facility.	• Location near rail line and shoreline provides options for rail and barge access for construction traffic. • Existing industrial site character would lessen land use transition issues associated with conversion to treatment facility. • Opportunity for partnership with Edmonds Crossing multi-modal transportation facility. • Opportunity for community enhancement associated with site facility design.	• Major local access road to treatment plant site has recently been upgraded. • Moderate level of potential opportunities for community enhancement. • Low probability for cultural resources on site. • Parts of site are not highly visible; could be effectively screened. Existing trees could remain in the buffer area.	• Location near rail line provides options for rail access during construction. • Existing industrial site character would lessen land use transition issues associated with conversion to treatment facility. • Large site size provides flexibility in community enhancement options. • Potential partnership opportunity with Northshore School District. • Opportunity to reduce truck traffic from current conditions.
COMMUNITY *Constraints*			
• Access to site (approximately 1/2 mile in length) is a narrow two-lane roadway through residential neighborhood along shoreline access to site. • Potentially high likelihood of cultural resources in shoreline area. • Site is highly visible from the shoreline and offshore areas.	• Highly visible site will require design mitigation. • Documented federally protected cultural resources in stream corridor.	• Majority of site is surrounded by residential development; shift from undeveloped forest to wastewater treatment plant site represents substantial land use change.	• Site is surrounded by roadways/intersections with identified capacity problems. • Potential for cultural resources within site area.

Table 4-4. Summary of System Characteristics

Point Wells	Unocal	Gravel Quarry	Route 9
COST IMPLICATIONS			
• Low capital and life cycle cost. • Soil and groundwater remediation, groundwater, and liquefaction could increase site preparation costs. • If new access roadway provided, cost could increase. • Tunnel conveyance less expensive than near-surface conveyance. • Risk of significant increase in relocation costs.	• Capital and life cycle cost in low to middle of the range. • Soil and groundwater remediation, groundwater, and liquefaction could increase site preparation costs. • Site layout provides room for Edmonds Crossing project but cost estimate excludes the additional structural support needed for that project. • Tunnel conveyance less expensive than near-surface conveyance.	• Capital and life cycle cost in middle to high end of the range. • Middle of cost range for energy requirement due to elevation of site; increases in energy costs would increase annual O & M costs to a greater extent than at the sites with lower energy consumption. • Near-surface conveyance less expensive than tunnel conveyance.	• Highest capital and life cycle cost. • Highest up-front capital cost due to full investment in longest conveyance length. • Tunnel conveyance less expensive than near-surface conveyance. • Potentially least cost site for water reuse.

Table 4-5. Phase 2 Estimated Costs for Brightwater Systems (Millions of Dollars)

Systems (with conveyance options)	Capital Cost [a]	O&M Cost	RWSP Index [b]	Range of Life Cycle Cost	
				Total –25%	Total +40%
Unocal (surface)	$1,120	$172	1.32	$969	$1,809
Unocal (tunnel)	$997	$148	1.17	$859	$1,603
Route 9 (surface)	$1,373	$198	1.61	$1,178	$2,199
Route 9 (tunnel)	$1,333	$174	1.57	$1,130	$2,109
Point Wells (surface)	$1,055	$167	1.24	$917	$1,711
Point Wells (tunnel)	$948	$144	1.11	$819	$1,529
Gravel Quarry (surface)	$1,126	$182	1.32	$981	$1,831
Gravel Quarry (tunnel)	$1,168	$174	1.37	$1,006	$1,878

Note: All costs are in midpoint 2001 dollars.

[a] Contingency for construction has been included using the following percentages: treatment plant at 25%, conveyance at 30%, and marine outfall at 35%.

[b] RWSP Index compares original *Regional Wastewater Services Plan* capital cost estimates with current capital cost estimates.

Final Candidate Systems Identification

Each of the four remaining systems offered opportunities and challenges relative to development as part of Brightwater. The King County Executive found that the Unocal and Route 9 sites best met the policy siting criteria and the broader goals and policies of the region. These two systems offered significant opportunities for intergovernmental partnerships to benefit the surrounding communities and were compatible with regional goals related to land use, environmental protection, and provision of affordable multi-modal transportation. With the approval of the King County Council, the Unocal and Route 9 systems were advanced to a Phase 3 evaluation.

All eight potential outfall zones were found to be suitable; however, only outfall zones 5, 6, 7 north, and 7 south were situated sufficiently close to the Unocal and Route 9 systems to warrant further consideration.

The Phase 3 systems are summarized in Table 4-6.

Table 4-6. Phase 3, Proposed Final Candidate Systems

Plant Sites		Conveyance Options		Marine Outfall Options
Unocal Route 9	+	Near-Surface Pipeline Deep Tunnel	+	Zone 5 Zone 6 Zone 7 north Zone 7 south

4.2.1.3 Phase 3 Conveyance Evaluations

Concurrent with the Siting Project Phase 3, the CSI team re-examined the basic conveyance concepts developed in Phase 2 for the Unocal and Route 9 systems, as detailed in Appendix C. The goal of this work was to identify conveyance options to be evaluated in the EIS.

For each candidate system, the team investigated a number of conveyance corridors; evaluated construction methods; and analyzed hydraulic regimes for tying into the existing wastewater conveyance system, delivering influent to the new treatment plant, and conveying effluent to the outfall zones. The conveyance systems were divided into segments to facilitate detailed analysis and evaluated using the following guiding principles:

- Intercept influent wastewater flows from the defined Brightwater Service Area as efficiently as possible to convey to the new plant.
- Minimize the total length of new conveyance to reduce project costs and environmental and community impacts.
- Minimize the number of pump stations to reduce system complexity and future operational costs.
- Route conveyance so that suitable land is available as required to site the pump stations and tunnel portals and to optimize use of public land.
- Design tunnels to be built at depths where high groundwater pressures can be avoided.
- Design tunnel portals to be as shallow as possible to minimize construction impacts, risks, and costs.
- Develop surface conveyance alternative(s) where there are concerns about the feasibility of deep tunnel construction.

- Route conveyance to avoid or minimize environmental impacts to wetlands and streams to the greatest extent possible; minimize any potential impacts by using non-disruptive construction methods.
- Place the conveyance system within public rights-of-way, where possible, to limit the number of easements and property acquisitions.
- Avoid, where possible, routing the conveyance system along major regional traffic corridors; if a major transportation arterial cannot be avoided, minimize the impacts to the extent possible.

Tunnels were favored over cut and cover options because they would minimize or avoid surface environmental impacts and traffic disruption. This was particularly important for the Route 9 system, which has the longest conveyance corridors. As a result of these evaluations, three conveyance corridors were identified for inclusion in the EIS.

Route 9 System Conveyance

For the Route 9 influent conveyance system, only the Route 9 influent – deep tunnel option was advanced into the EIS. The deep tunnel influent conveyance option follows a cross-country route (i.e., not in public right-of-way) northeasterly from the existing Kenmore Pump Station to near the North Creek Pump Station and then to the Route 9 site. Within this corridor and subject to engineering and environmental considerations, sub-options are possible, including microtunneling at a shallow depth and various alignments.

For the Route 9 effluent conveyance system, deep tunnels along 228th Street and 195th Street were favored because of the potential for gravity flow, amount of corridor within public right-of-way, geotechnical and environmental considerations, and, in the case of 195th Street, potential for a portion of the influent conveyance to fall in the same corridor as effluent conveyance. Both corridors were advanced to the EIS for further review.

Unocal System Conveyance

For the Unocal system, the deep tunnel was favored over the other Unocal influent conveyance system alternatives and advanced into the EIS. Two construction sub-options were identified for further analysis: a deep tunnel conveying flow by gravity and a shallower tunnel with flow pumped through force mains from an off-site pump station.

4.2.2 Phase 3: SEPA Process and EIS

Phase 3 initiated the SEPA environmental review process and Draft and Final EIS preparation; continued engineering and geotechnical analysis of treatment plant,

conveyance, and outfall elements; cost estimating; and continued community involvement and public comment. Phase 3 siting evaluations began in January 2002 and are anticipated to continue through 2003 in association with the EIS.

As part of the SEPA process, a Draft EIS was issued in November 2002 that evaluated the following alternatives:

- Route 9 – 195th Street System
- Route 9 – 228th Street System
- Unocal System
- No Action Alternative

Both Route 9 alternatives were configured to include outfall zone 7 south, while the Unocal alternative was configured to include outfall zone 6 on the basis of proximity considerations. Outfall zone 5 was eliminated from further consideration as it was located farthest from the effluent conveyance corridors and offered no significant advantages over zones 7 south and 6.

Major components of the action alternatives are shown on the oversized System Alternatives map located at the back of this Facilities Plan. Table 4-7 presents a summary comparison of the key features of the three action alternatives. For additional information, the reader is referred to the Draft EIS.

Table 4-7. Comparison of Key Features of the Brightwater Alternatives

Features	Route 9 – 195th Street System	Route 9 – 228th Street System	Unocal System
Affected jurisdictions	Cities of Woodinville, Bothell, Kenmore, Lake Forest Park, Shoreline, Mountlake Terrace, and Edmonds Town of Woodway Unincorporated King and Snohomish Counties	Cities of Bothell, Brier, Mountlake Terrace, Edmonds, Shoreline, Woodinville, Kenmore, and Lake Forest Park Town of Woodway Unincorporated King and Snohomish Counties	Cities of Edmonds, Mountlake Terrace, Shoreline, Lake Forest Park, Kenmore, and Bothell Town of Woodway Unincorporated King and Snohomish Counties
Treatment plant capacity	36 mgd in 2010 54 mgd in 2040	36 mgd in 2010 54 mgd in 2040	36 mgd in 2010 54 mgd in 2040 72 mgd in 2040 (if Edmonds and Lynnwood contribute flow)
Total conveyance corridor lengths	7.8 miles – influent 12.5 miles – effluent	7.8 miles – influent 12.9 miles – effluent	11.6 miles – influent

Table 4-7. Comparison of Key Features of the Brightwater Alternatives

Features	Route 9 – 195th Street System	Route 9 – 228th Street System	Unocal System
New pump stations along conveyance route	None	None	One off-site at Portal Siting Area 11 (if the force main-gravity option is selected)
Pump stations at treatment plant	One influent One effluent (if the force main-gravity option is selected); no effluent pump station if gravity deep tunnel effluent option is selected	One influent One effluent (if the force main-gravity option is selected); no effluent pump station if gravity deep tunnel effluent option is selected	One influent One effluent
Total number portal siting areas along conveyance route	10[a]	12	7 (8 if the force main-gravity option is selected)
Outfall zone	zone 7S	Zone 7S	Zone 6

[a] Only 10 portal siting areas would be required for 11 portals because two portals would be constructed at Portal Siting Area 41. An additional portal also may be constructed at Portal Siting Area 19 for construction of the outfall.

4.2.2.1 Preferred Alternative for Brightwater Regional Wastewater Treatment System

In August 2002 the King County Executive identified the Route 9 – 195th Street system as the preferred alternative. As shown on the oversized System Alternatives map, the Route 9 – 195th Street system consists of the following major elements:

- Influent conveyance extending eastward from Ballinger Way NE along NE Bothell Way, then northeasterly toward the North Creek Pump Station to the Route 9 site. Influent conveyance would consist of a gravity system, delivering raw wastewater to an influent pump station located at the Route 9 site.
- Wastewater treatment facilities located at the Route 9 site.
- Effluent conveyance sharing a common corridor with influent conveyance from the Route 9 site to the 195th Street right-of-way. The effluent conveyance would then diverge, proceeding westerly along the 195th Street right-of-way to the Lake Ballinger Way/NW 205th Street corridor. Effluent would be conveyed through either a deep gravity tunnel or a combination of pumped and gravity flow in a tunnel.
- Marine outfall located at Zone 7S, in the vicinity of Point Wells.

The Route 9 – 195th Street system was identified as the preferred alternative because of the relative efficiencies and flexibility it would provide. For example, the Route 9 site is twice the size of the Unocal site, facilitating the layout, design, and construction of the treatment plant. The larger site would also provide more room for a landscaped buffer. The Route 9 conveyance system and the manner in which it would connect to existing King County facilities would also provide more flexibility for sending flows to the West Point or South Treatment Plants during emergencies. The Route 9 – 195th Street system also offers excellent opportunities to deliver reclaimed water to users near the plant and along the effluent conveyance corridor. The King County Executive also identified as a preferred alternative the construction of tunnels for conveyance rather than near-surface/open cut construction because of the lower overall impacts, lower capital cost, and lower operations and maintenance costs. Outfall zone 7S was preferred because of excellent mixing, constructability, and potential to avoid or minimize impacts on the sensitive nearshore habitat.

Based on the King County Executive's determination, the Route 9 – 195th Street system is considered the preferred alternative for purposes of this Facilities Plan. As such, treatment process evaluations are structured around the Route 9 site. However, while the Route 9 – 195th Street system is the Executive’s preferred alternative, each of the action alternatives analyzed in the Draft EIS are viable options. The preferred alternative will be further evaluated in the Final EIS. Following publication of the Final EIS, the King County Executive will select an alternative based on the results of the Draft and Final EIS; comments from the public and local, state, and federal entities; input from tribal governments; and factors such as cost and regional policies.

Preliminary design level treatment process evaluations and site layout have proceeded on the preferred alternative. The results of this preliminary work are summarized in the following sections of this chapter.

In December 2002, King County initiated preliminary design of the Brightwater conveyance system and marine outfall (conveyance system predesign). The conveyance system predesign will establish the configuration of the Brightwater influent and effluent conveyance systems and marine outfall, detail connections to the existing King County conveyance system, determine conveyance pumping requirements, and determine the number of tunnel portals and their locations.

The conveyance system predesign was initiated approximately 7 months after treatment-related preliminary design work; therefore, conveyance facilities are currently defined in less detail than treatment processes. The conveyance system predesign will proceed through 2003. Chapter 5 summarizes the conveyance system predesign activities.

4.3 Treatment Process Alternative Analysis

This section of the Facilities Plan summarizes the alternative analysis performed to evaluate and select treatment processes for the Brightwater Treatment Plant. Details of the alternative analysis are presented in the Task 1.03 Technical Memorandum, which is included as a supplement to this Facilities Plan. Fact sheets describing each of the technologies considered in the alternative analysis are presented in Section 3 of the Task 1.03 Technical Memorandum.

4.3.1 General Design Criteria and Treatment Requirements

Chapter 3 of this Facilities Plan describes the methods used to develop wastewater flow and load projections for the Brightwater Service Area, and presents influent flows and loads through Year 2050. This section briefly summarizes the design influent flows and loads, and describes how the Brightwater treatment facilities will be configured for expansion to accommodate future flows and loads.

Table 4-8 summarizes the design flows and loads for the Brightwater facilities under average annual, average wet weather, and peak month conditions, and lists the peak hourly flow for hydraulic design. Design conditions are listed for Brightwater Phase 1, which extends from initial startup in 2010 to 2040, and for Brightwater Phase 2, which will involve an expansion (anticipated completion by 2040) to accommodate ultimate build-out of the service area.

Table 4-8. Estimated Design Flow and Load Summary

Parameter[a]	Units	Brightwater Phase 1[b] (2010 through 2040)	Brightwater Phase 2[b] (After Year 2040)
Average Annual Conditions			
– Flow	mgd	31	47
– BOD_5	lb/d	60,000	90,000
– Soluble BOD_5	lb/d	24,000	35,000
– TSS	lb/d	63,000	94,000
– NH_3-N	lb/d	5,700	8,600
– TKN	lb/d	11,000	16,000
– Total P	lb/d	1,900	2,900
– Temperature, avg.	°C	16.0	16.0

Table 4-8. Estimated Design Flow and Load Summary

Parameter[a]	Units	Brightwater Phase 1[b] (2010 through 2040)	Brightwater Phase 2[b] (After Year 2040)
Average Wet Weather Conditions			
– Flow	mgd	36	54
– BOD_5	lb/d	60,000	90,000
– Soluble BOD_5	lb/d	23,000	35,000
– TSS	lb/d	62,000	93,000
– NH_3-N	lb/d	5,800	8,600
– TKN	lb/d	10,600	16,000
– Total P	lb/d	2,000	3,000
– Temperature, avg.	°C	14.0	14.0
Peak Month (Maximum 30-Day) Conditions			
– Flow	mgd	51	76
– BOD_5	lb/d	79,000	118,000
– Soluble BOD_5	lb/d	32,000	48,000
– TSS	lb/d	76,000	114,000
– NH_3-N	lb/d	6,800	10,000
– TKN	lb/d	13,000	19,000
– Total P	lb/d	2,700	4,100
– Temperature, min.	°C	11.8	11.8
Peak Day Conditions			
– Flow	mgd	99	148
– BOD_5	lb/d	193,000	290,000
– Soluble BOD_5	lb/d	50,000	75,000
– TSS	lb/d	168,000	252,000
– NH_3-N	lb/d	12,000	18,000
– TKN	lb/d	22,000	32,000
– Total P	lb/d	4,100	6,200
– Temperature, min.	°C	10.0	10.0
Peak Hour Flow			
– Flow	mgd	130	170

[a] Abbreviations: BOD_5 – Biochemical oxygen demand; °C – Degrees Celsius; NH_3-N – Ammonia + ammonium nitrogen; TKN – Total Kjeldahl nitrogen; Total P – Total phosphorus; TSS – Total suspended solids

[b] Values are rounded from detailed projections presented in Chapter 3.

4.3.1.1 Future Expansion of Brightwater: Brightwater Phase 2

While this Facilities Plan is intended to describe the Brightwater Phase 1 facilities as required for Department of Ecology approval, Phase 2 facilities are also considered in portions of the alternative analysis to ensure that adequate area is reserved to accommodate the future Brightwater Phase 2 expansion.

As described in Chapter 3, King County plans to meet future needs of its overall wastewater service area through staged expansions of the South Treatment Plant and Brightwater. Brightwater will be designed with a Phase 1 capacity of 36 mgd average wet weather flow and configured to accommodate a Phase 2 expansion to 54 mgd AWWF. The Brightwater site plan will include dedicated areas reserved for the Phase 2 expansion.

To accommodate increased future flows, Brightwater will incorporate the following hydraulic design features:

- The influent and effluent conveyance pipelines and tunnels and critical treatment plant hydraulic structures will be designed for the Year 2050 peak hour flow of 170 mgd.
- Influent and effluent pump stations will be designed with a Phase 1 firm capacity (capacity with largest unit out of service) of 140 mgd. Phase 2 firm capacity would increase to 170 mgd.
- In addition, sufficient hydraulic capacity will be provided within the plant and effluent conveyance system to pass the Phase 2 firm capacity of 170 mgd under gravity pressurized conditions.

4.3.1.2 Treatment Requirements and Anticipated Effluent Limitations for Marine Discharge

The RWSP established that Brightwater would involve a secondary treatment plant with a marine discharge to Puget Sound. As part of the Brightwater Marine Outfall Siting Study, King County performed a reasonable potential analysis of the likelihood for Brightwater discharge to cause a violation of State Water Quality Standards. The reasonable potential analysis is presented in Appendix D of this report.

The analysis concluded that the marine discharge would offer excellent dilution, and that no reasonable potential exists for water quality standard violations. Therefore, technology-based effluent limitations appear appropriate for the Brightwater discharge, as opposed to more restrictive water quality-based effluent limitations.

Technology-based effluent limitations establish the minimum level of treatment that must be provided by a municipal wastewater treatment plant regardless of receiving water

quality and available dilution. Technology-based effluent limitations are promulgated at a federal level in 40 CFR Part 133, *Secondary Treatment Regulation*, and established in Chapter 173-221 WAC, *Discharge Standards and Effluent Limitations for Domestic Wastewater Facilities.* Table 4-9 summarizes the requirements of Chapter 173-221 WAC, which constitute the anticipated effluent limitations for the Brightwater marine discharge. Effluent limitations will ultimately be established through an NPDES Permit, administered by Ecology.

Table 4-9. Anticipated Effluent Limitations for Brightwater Marine Discharge Under 173-221 WAC

Parameter[a]	Units	Requirement
30-Day Effluent Average		
– BOD_5	mg/L	30 maximum
– TSS	mg/L	30 maximum
– BOD_5 Removal, as Percent of Influent Concentration	%	85 minimum
– TSS Removal, as Percent of Influent Concentration	%	85 minimum
7-Day Effluent Average		
– BOD_5	mg/L	45
– TSS	mg/L	45
Effluent Bacteriological Quality		
– Fecal coliform bacteria, monthly geometric mean	#/100 mL	200 maximum
– Fecal coliform bacteria, weekly geometric mean	#/100 mL	400 maximum
Effluent pH		
– Effluent pH	pH units	6.0 to 9.0

[a] Effluent requirements may also be expressed in terms of carbonaceous BOD_5 removal.

It is also anticipated that the Brightwater discharge, if disinfected with chlorine, would be required to meet a total residual chlorine limit prior to discharge. The residual chlorine limit would be established as a water quality-based effluent limit, considering effluent characteristics, receiving water parameters, and dilution.

Under the requirements of the State NPDES Permit Program, Chapter 173-220 WAC, wastewater dischargers are required to apply “all known, available, and reasonable methods of prevention, control, and treatment” (AKART). The secondary treatment requirements summarized in Table 4-9 are considered as AKART for marine discharges of municipal wastewater that do not require water quality based effluent limitations.

4.3.1.3 Treatment Requirements for Effluent Reuse

While Brightwater will include a marine discharge, King County also proposes to configure the plant to produce initially up to 5 mgd of Class A reclaimed water for reuse.

Space will be reserved on-site for additional reuse capacity up to 54 mgd. Treatment requirements for production of reclaimed water are determined jointly by Ecology and the Washington Department of Health. In September 1997, these agencies published *Water Reclamation and Reuse Standards* under the authority of RCW 90.46. The regulations define four grades of reclamation water quality—Class A, Class B, Class C, and Class D—which are associated with specific beneficial uses, such as crop and landscape irrigation, impoundments, groundwater recharge, toilet and urinal flushing, and stream flow augmentation. Treatment requirements for the four classes of reclamation water are summarized in Table 4-10.

Table 4-10. Water Reclamation and Reuse Standards Summary

Reclaimed Water Class	Treatment Process Requirements[a]				Allowable Total Coliform Bacteria (#/100 mL)	
	Oxidation	Coagulation	Filtration	Disinfection	Maximum	7-Day Average
Class A	Yes	Yes	Yes	Yes	23	2.2
Class B	Yes	No	No	Yes	23	2.2
Class C	Yes	No	No	Yes	23	240
Class D	Yes	No	No	Yes	Note b	240

Notes:

[a] *Water Reclamation and Reuse Standards* treatment process definitions:

Oxidation: Stabilization of wastewater resulting in BOD_5 and TSS of less than 30 mg/L, non-putrescible conditions, and presence of dissolved oxygen.

Coagulation: Application of chemicals to de-stabilize and agglomerate the fine particulate matter in an oxidized wastewater.

Filtration: Processing of an oxidized, coagulated wastewater through a filter medium to reduce turbidity to less than 2 nephelometric turbidity units (NTU) monthly average, 5 NTU maximum.

Disinfection: Destruction of pathogenic organisms by chemical, physical, or biological means.

[b] No maximum total coliform limit is indicated for Class D waters.

Under the proposed reuse plan, the Brightwater facilities would initially be designed to treat up to 5 mgd of wastewater to meet Class A requirements. By producing a Class A reclaimed water, King County will maximize the potential for effluent reuse, since Class A water is the highest quality reclaimed water, approved for all forms of reuse allowed by the Washington *Water Reclamation and Reuse Standards*. Additional information on the proposed Brightwater reuse program is presented in Appendix F of this report.

4.3.2 Preliminary Treatment Processes

Preliminary treatment includes screening, comminution and grinding, and grit removal processes that remove or transform materials in the influent that may clog or damage

downstream equipment. Preliminary treatment operations would be located at an enclosed headworks area at the influent end of the treatment plant.

For Brightwater, King County has elected to remove coarse solids from the influent wastewater; therefore, comminution and grinding were excluded from the preliminary treatment analysis. As described in Section 3 of the Task 1.03 Technical Memorandum, nine screening and grit removal technologies were evaluated for potential application at Brightwater. Screening alternatives included step screens, perforated plate screens, filter belt screens, and climber screens. Grit removal technologies included aerated grit chambers, rectangular gravity horizontal flow systems, square horizontal flow chambers, vortex grit removal, and an option for no removal of grit.

The preliminary treatment technologies were evaluated jointly by King County and the engineering design team in a workshop setting. Alternatives were compared and contrasted, considering the advantages and disadvantages of each option. For screening, it was decided that climber screens with a bar spacing of no greater than 3/8 inch were appropriate as a preliminary basis of design. Climber screens have been successfully used at King County's West Point and South Treatment Plants, and offer benefits of rugged construction, reliable performance, and equipment standardization.

Grit removal was evaluated in a similar manner to screening, and was determined to be essential for protection of downstream equipment; thus, the no grit removal option was eliminated from further consideration. Of the remaining alternatives, horizontal flow configurations were determined to offer the least effective grit removal. It was also observed that horizontal flow systems have been largely replaced by more effective grit removal technologies. Both aerated and vortex systems would offer acceptable grit removal performance, and were retained for further consideration. Final selection of the grit removal technology will be undertaken during preliminary design.

4.3.3 Primary Treatment Processes

Five primary treatment technologies and the option of no primary treatment option were examined for application at Brightwater. Primary treatment technologies included conventional primary clarification, dissolved air filtration, inclined plate settlers, chemically enhanced primary clarification (metal salts and possibly polymer), and ballasted primary clarification.

Primary treatment processes were evaluated during a technology screening workshop, which is fully described in Section 3 of the Task 1.03 Technical Memorandum. Screening criteria were used to narrow the alternatives to three processes: conventional primary clarification, chemically enhanced primary clarification, and ballasted primary clarification.

Table 4-11 presents preliminary design criteria for the three remaining primary treatment technologies. These criteria were applied in the primary treatment analysis, included in

Section 4 of the Task 1.03 Technical Memorandum. Based on these criteria, it was determined that year-round use of coagulant chemicals would add significant costs for chemical purchase, solids processing, and biosolids management; however, occasional use of coagulants may be cost effective for handling peak flows and loads.

Table 4-11. Primary Treatment, Preliminary Design Criteria

	Typical Design Criteria				Typical Performance (% Removal)	
Process	**Surface Overflow Rate at AWWF (gpd/ft^2)[a]**	**Peak Surface Overflow Rate (gpd/ft^2)[a]**	**Ferric Chloride Dose (mg/L)**	**Polymer Dose (mg/L)**	**TSS**	**BOD_5**
Conventional Primary Clarification	1,500[b]	3,300	Not applicable		50	30
Chemically Enhanced Primary Clarification	2,000	4,000	20	1	60	40
Ballasted Primary Clarification	50,000	80,000	70	1	70	50

[a] Gallons per day per square foot

[b] 1,500 gpd/ft2 at design AWWF of 36 mgd equates to 1,300 gpd/ft2 at design average annual flow of 31.3 mgd

As a result of the analysis, conventional primary clarifiers were selected for treatment of the main flow stream (flow receiving primary and secondary treatment). The primary clarifiers will include chemical feed equipment to improve process reliability under peak flow or emergency conditions. Ballasted primary clarification was retained for further evaluation under a split flow concept (flow receiving only primary treatment) for secondary treatment, as it was found to have significant footprint advantages and potential capital cost advantages.

4.3.4 Secondary Treatment Processes

Sixteen secondary treatment process technologies were considered for application at Brightwater, as shown in Table 4-12. Screening workshops were used to reduce the initial list of processes into smaller groups for further analysis. Details of the secondary treatment process evaluation are presented in the Task 1.03 Technical Memorandum, Section 3.

Table 4-12. Secondary Treatment Process Summary

Treatment Technology	Compatibility with Candidate Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Lagoon Treatment	Incompatible due to large space requirement.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Rarely used for new treatment facilities in excess of 10 mgd.	Eliminated based on screening criteria.
Wetlands	Incompatible due to large space requirement.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Rarely used for new treatment facilities in excess of 10 mgd.	Eliminated based on screening criteria.
Land Treatment	Incompatible due to large space requirement.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Rarely used for new treatment facilities in excess of 10 mgd.	Eliminated based on screening criteria.
Oxidation Ditch	Incompatible due to large space requirement.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Rarely used for new treatment facilities in excess of 10 mgd.	Eliminated based on screening criteria.
Sequencing Batch Reactors	Compatible with Brightwater space requirements.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Eliminates separate secondary clarifiers. Costs for large municipal systems are typically greater than CAS.	Eliminated based on screening criteria.
Conventional Activated Sludge (CAS)	Compatible with Brightwater space requirements.	Yes, used for large and small facilities.	Used successfully at South Treatment Plant.	Considered a baseline secondary treatment process against which to compare other alternatives.	Retained for additional analysis.
High Purity Oxygen Activated Sludge (HPO)	Compatible with Brightwater space requirements.	Yes, used for large facilities.	Used successfully at West Point Treatment Plant.	Total basin and clarifier volume for HPO system with nitrification approximately 3% greater than CAS. HPO requires greater hydraulic head than CAS. HPO typically costs more than CAS.	Eliminated based on subsequent analyses.
Trickling Filters	Compatible with Brightwater space requirements.	Yes, but typically not used for large new facilities.	Not used at West Point or South Treatment Plants.	Trickling filter tower heights may be visually obtrusive.	Eliminated based on screening criteria.
Rotating Biological Contactors	Compatible with Brightwater space requirements.	Yes, but is currently not used for large new facilities.	Not used at West Point or South Treatment Plants.	Current design criteria require high energy input.	Eliminated based on screening criteria.
Trickling Filter-Solids Contact Process	Compatible with Brightwater space requirements.	Yes, used for large facilities.	Not used at West Point or South Treatment Plants.	Considered for South Treatment Plant, but not selected because of obtrusive tower heights. Add-on nitrification process would be costly.	Eliminated based on screening criteria.
Hybrid Processes	Compatible with Brightwater space requirements.	Developing. Some hybrid processes are used for small facilities.	Not used at West Point or South Treatment Plants.	Some hybrid processes require chemical treatment or solids contact to control effluent quality.	Eliminated based on screening criteria.

Table 4-12. Secondary Treatment Process Summary

Treatment Technology	Compatibility with Candidate Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Biological Aerated Filters (BAF)	Compatible with Brightwater space requirements.	Yes, proven in Europe. Only one facility greater than 14 mgd in U.S.	Not used at West Point or South Treatment Plants.	Has larger footprint than MBR. Produces more sludge as ballasted primary treatment required upstream of process. Cannot produce reclaimed water for reuse.	Eliminated based on subsequent analyses.
Membrane Bioreactors (MBR)	Compatible with Brightwater space requirements.	Yes, but only two large municipal facilities in Europe. Operating facilities in U.S. limited to less than 10 mgd.	Not used at West Point or South Treatment Plants.	Eliminates secondary clarifiers. Requires small footprint. Produces high quality effluent. Improves disinfection potential. Applicable for reclaimed water	Retained for additional analysis.
Powdered Activated Carbon (PAC) Activated Sludge	Compatible with Brightwater space requirements.	Yes, but no longer used for large municipal facilities.	Not used at West Point or South Treatment Plants.	Wet air oxidation, which is costly and a potential source of odors, is required for recovery of PAC.	Eliminated based on screening criteria.
Biological Fluidized Bed	Compatible with Brightwater space requirements.	No. Only large municipal application failed.	Not used at West Point or South Treatment Plants.		Eliminated based on screening criteria.
Deep Shaft Process	Compatible with Brightwater space requirements.	Yes, proven for small facilities. Only one large operating municipal facility	Not used at West Point or South Treatment Plants.	Plant in Manitoba reverted back to CAS due to operational problems. Requires large clarifiers. Foaming problems can result when air releases from solution	Eliminated based on screening criteria.
Physical Chemical Treatment	Compatible with Brightwater space requirements.	Yes, but not currently used for new municipal secondary treatment facilities.	Not used at West Point or South Treatment Plants.	High chemical cost. High sludge production. High operational costs	Eliminated based on screening criteria.

Initial screening identified four alternatives for further consideration, including conventional activated sludge (CAS), high purity oxygen activated sludge (HPO), biological aerated filters (BAF), and membrane bioreactors (MBR).

Preliminary analysis of the four alternatives determined that HPO was typically more expensive than CAS and would require more space to be set aside for potential nitrification requirements. The analyses also determined that the MBR process has significant advantages over BAF, including capital cost, small space requirement (footprint), and high effluent quality. Based on these analyses, which are fully discussed in Sections 4 and 5 of the Task 1.03 Technical Memorandum, HPO and BAF were eliminated from further consideration.

Preliminary design and performance criteria were established for the MBR, CAS, and BAF alternatives, as summarized in Table 4-13. Subsequent screening analyses concluded that the BAF process offered no advantages over the CAS and MBR processes. Thus, the BAF process was removed from further consideration and final secondary process evaluation focused on a comparison of the CAS and MBR technologies.

Table 4-13. Secondary Treatment Process Technology Design and Performance Criteria

	Typical Design Criteria						Typical Effluent Quality	
Secondary Treatment Process	**MLSS (mg/L)**	**F/M (day^{-1})**	**SRT (days)**	**Hydraulic Loading Rate**	**BOD_5 Loading Rate**	**TSS Loading Rate**	**BOD_5 (mg/L)**	**TSS (mg/L)**
Conventional Activated Sludge	3,000	0.3	3.5	1,400[a]	N/A	N/A	20	20
Membrane Bioreactor	8,000	0.06	16	15[b]	N/A	N/A	2	2
Biological Aerated Filter	N/A	N/A	N/A	4[c]	175[d]	125[e]	20	25

Abbreviations: N/A – parameter is not applicable to process; MLSS – mixed liquor suspended solids; F/M – food to microorganism ratio; SRT – solids residence time

[a] Hydraulic loading rate for conventional activated sludge is the maximum allowable surface overflow rate of the secondary clarifiers at the peak hour flow, gallons per day per square foot (gpd/ft^2).

[b] Hydraulic loading rate for membrane bioreactor is the maximum flux rate through the membranes at the peak hour flow (gpm/ft^2).

[c] Hydraulic loading rate for biological aerated filter is the maximum allowable flow per filter area at the peak hour flow, gallons per minute per square foot (gpm/ft^2).

[d] BOD_5 loading rate for biological aerated filter is the maximum allowable BOD_5 loading per filter area at the peak month load, pounds per day per 1,000 square feet (lb/d/1000 ft^2).

[e] TSS loading rate for biological aerated filter is the maximum allowable TSS loading per filter area at the peak month load (lb/d/1000 ft^2).

4.3.4.1 Analysis of Conventional Activated Sludge and Membrane Bioreactor Processes: Development of the Split Flow Treatment Concept

In comparing the CAS and MBR processes, it was recognized that the MBR would produce far better effluent quality than CAS, benefiting the environment through a substantially lower discharge of pollutants to Puget Sound. However, the MBR technology is significantly more expensive than CAS on a unit flow basis. Configuring an MBR to accept peak flows and loads would render it infeasible due to high cost. Therefore, the concept of a split flow MBR system was developed, in which the MBR process would be configured to accommodate a daily flow in excess of the AWWF, but below the peak day flow. The maximum capacity that could be treated by the MBR is termed the secondary treatment, or split stream, threshold. Flows in excess of the secondary treatment threshold constitute a split stream that would be routed around the MBR. The split stream could potentially be treated using an alternative process better suited to hydraulic peaks, such as ballasted primary clarification. The split stream would be blended with the MBR effluent and disinfected prior to discharge.

The following sections of this report discuss the development of the split flow treatment concept. A complete discussion of split flow treatment and secondary treatment threshold development is provided in Section 11 of the Task 1.03 Technical Memorandum.

Split Flow Treatment Analysis

The objective of split flow treatment is to produce a high quality effluent that matches or exceeds the performance of existing King County conventional activated sludge treatment facilities; satisfy state requirements for AKART and protect water quality; meet anticipated NPDES permit requirements; reduce the size of the facility to improve opportunities for expansion, mitigation, and environmental enhancement; and provide the most cost-effective methodology for wastewater treatment.

As discussed in the Task 1.03 Technical Memorandum, a range of split flow treatment alternatives were considered in initial evaluations, including systems based on CAS and MBR secondary treatment processes. From this analysis, three MBR-based split flow treatment alternatives were selected for detailed analysis. The alternatives are illustrated in Figure 4-5 and summarized below:

- MBR secondary treatment, with all flow receiving conventional primary clarification (CPC). Flow split is located after primary clarification, with split stream directed around the secondary process.
- MBR secondary treatment, with all flow receives chemically enhanced primary clarification (CEPC). Flow split is located after primary clarification, with split stream directed around the secondary process.

- MBR secondary treatment with flow split located ahead of conventional primary clarification. Split stream receives ballasted primary clarification (BPC)

The BPC process involves flocculant chemical addition and seeding of the split stream with sand or return sludge to increase the removal of BOD_5 and TSS. Ballasted clarification can operate at high surface loading rates—up to about 80,000 gallons per day per square foot (gpd/ft^2) for some systems—thus requiring a small footprint. BOD_5 removals of 50 percent or greater, and TSS removals of 80 percent or greater have been achieved though ballasted clarification processes. Additional information on the ballasted clarification process is presented in Appendix G of this Facilities Plan.

Evaluation of Split Flow Alternatives

The analysis of split flow treatment was conducted by performing iterative mass balance calculations on effluent quality until the blended effluent met anticipated NPDES Permit requirements for BOD_5 and TSS. The design capacity of the secondary treatment facilities (split stream threshold) for each alternative was determined based on conservative assumptions that were intended to assure compliance with potential NPDES permit requirements. Peak month BOD_5 and TSS were limited to 30 mg/L or less, minimum removal of BOD_5 and TSS was established at 85 percent, and peak week BOD_5 and TSS were limited to 45 mg/L or less.

Projected effluent concentrations, mass discharges, and recurrence frequencies of split stream events were then estimated. The split stream recurrences and volume were generated from a 51-year simulation of wastewater flows from the Brightwater Service Area, extrapolated to the Phase 1 average wet weather design flow. The results of the analysis show that the MBR process is capable of achieving a low split stream threshold due to the significantly lower effluent BOD_5 and TSS in the MBR effluent. The addition of ballasted primary clarification for split stream treatment drops the threshold further due to the reduced BOD_5 and TSS in the split stream effluent.

The projected split stream thresholds, split stream frequencies, and blended effluent quality for typical split flow performance are shown in Table 4-14. Based on projected effluent quality, process space/footprint requirements, flexibility to accept peak wet weather flows, and cost considerations, the MBR/ballasted primary clarification split flow alternative was advanced for further comparison against a base case of full flow CAS.

Table 4-14. Summary of Split Flow Treatment and Split Steam Frequencies

Parameter	MBR/CPC	MBR/CEPC	MBR/BPC
Split Stream Threshold to ADWF Ratio	1.64	1.51	1.40
Split Stream Threshold (mgd) [a]	44	41	38
Peak Hour Split Stream Flow (mgd)	86	89	92
Peak Hour Flow (mgd)	130	130	130
Average Split Flow Frequency (days/yr)	11	16	25
Maximum Month Conditions			
– Blended Effluent BOD_5 (mg/L)	27	27	27
– Blended Effluent TSS (mg/L)	19	18	16
– BOD_5 Removal Efficiency (%)[b]	85	85	85
– TSS Removal Efficiency (%)[b]	89	90	91
Maximum Week Conditions			
– Blended Effluent BOD_5 (mg/L)	43	41	38
– Blended Effluent TSS (mg/L)	30	27	23

Abbreviations: ADWF – Average Dry Weather Flow; BPC – Ballasted Primary Clarification; CEPC – Chemically Enhanced Primary Clarification; CPC – Conventional Primary Clarification

[a] Nominal daily capacity of secondary process. Diurnal peak flow exceeds this value without causing a flow split event

[b] Maximum month removal efficiencies are presented to demonstrate compliance with state and federal requirements for 85 percent removal of BOD_5 and TSS on a monthly basis..

Projected Effluent Quality and Mass Discharge of BOD_5 and TSS

Split flow MBR treatment is projected to produce much higher effluent quality than full flow CAS treatment. On an average annual basis, the BOD_5 discharge from the split flow MBR is only 25 percent of full flow CAS and the average annual MBR TSS discharge is only 20 percent of full flow CAS. Even in the extreme year, the MBR system is still projected to achieve lower annual BOD_5 and TSS discharges than full flow CAS treatment. Only in the extreme month from 51 years of flow data does the projected MBR BOD_5 discharge exceed full flow CAS, and even under this event, the TSS discharge from MBR is still projected to be 45 percent lower than full flow CAS. The projected BOD_5 and TSS discharge that would result from the Brightwater Phase 1 facilities is presented in Figures 4-6 and 4-7, comparing a base case of full flow conventional activated sludge to split flow MBR.

Nitrification and Discharge of Ammonia Nitrogen

The MBR process would offer further benefits with respect to ammonia removal, a toxic pollutant under the State Water Quality Criteria due to its adverse effects on marine and

aquatic life. The split flow MBR would significantly reduce the ammonia discharge since the MBR system would be designed for complete nitrification, year round. It is anticipated that the average total ammonia nitrogen in the MBR effluent would be less than 1.0 mg/L, compared to 15 mg/L or greater for a typical CAS effluent without nitrification.

Comparative Costs of Secondary Treatment Alternatives

As detailed in Section 7 of the Task 1.03 Technical Memorandum, comparative cost estimates were developed to aid in selecting a recommended secondary treatment alternative. These estimates, presented in Table 4-15, represent relative capital costs for full flow CAS and split flow MBR. The cost estimates reflect complete liquid and solids process trains, site development, and allied costs, allowing review of overall treatment costs.

Table 4-15. Comparative Capital Cost Estimates for Brightwater Phase 1 Full Flow CAS and Split Flow MBR at Route 9 Site

	Cost by Process, Millions of Dollars	
Item	**Full Flow Conventional Activated Sludge[a]**	**Split Flow Membrane Bioreactor**
Influent Pump Station	$58.7	$58.7
Headworks	$3.2	$3.2
Grit Removal	$5.7	$5.7
Primary Clarification	$14.0	$6.6
Ballasted Primary Clarification		$3.2
Ferric Chloride Feed System	$0.4	$0.5
Fine Screening of Flow to MBR		$2.5
Secondary Biological Treatment (CAS)	$25.5	
Secondary Biological Treatment (MBR)		$45.6
Secondary Clarification	$20.5	
Disinfection	$13.8	$13.8
5 mgd Water Reuse Facility[b]	$19.5	$12.4
Thickening/Dewatering	$17.0	$16.1
Anaerobic Digestion	$14.1	$13.0
Maintenance Building	$2.1	$2.1
Administration Building	$6.6	$6.6
Electrical Substation	$8.0	$8.4
Effluent Pump Station	$21.7	$21.7
Stormwater Management	$4.4	$4.0
Subtotal	**$235.3**	**$224.3**

Table 4-15. Comparative Capital Cost Estimates for Brightwater Phase 1 Full Flow CAS and Split Flow MBR at Route 9 Site

Item	Cost by Process, Millions of Dollars	
	Full Flow Conventional Activated Sludge[a]	Split Flow Membrane Bioreactor
Site Preparation		
Hazardous Material Removal	$1.7	$1.7
Site Demolition and Prep	$3.8	$3.8
Mass Site Excavation	$6.7	$5.5
Imported Fill on Site	$1.6	$1.2
Rock Piling Site Stabilization	$0.0	$0.0
Retaining Walls	$0.6	$0.6
New Elevated Roadway or Bridge	$0.0	$0.0
Site Improvements	$4.8	$5.2
Subtotal	**$19.2**	**$18.0**
Basic Plant Subtotals	**$254.5**	**$242.3**
Site Mitigation	$46.2	$46.2
Art	$0.9	$0.9
Odor Control	$29.8	$21.1
Subtotal	**$76.9**	**$68.2**
Contingency	$70.3	$65.8
Sales Tax	$31.1	$29.2
Allied Costs	$133.9	$125.4
Subtotal	**$235.3**	**$220.4**
TOTALS	**$566.7**	**$530.9**

[a] Adjusted from URS cost estimate dated 6/30/02 for an activated sludge process with an initial capacity of 36 mgd.

[b] Based on URS cost estimate dated 6/30/02 for a 5 mgd effluent reuse facility (filtration/chlorination) with 25% contingency, 8.9% sales tax, and 35% allied costs removed.

The capital cost for full flow CAS was estimated at approximately $567 million. Split flow MBR has an estimated capital cost of approximately $531 million.

Note to Reviewers of Preliminary Working Draft Facilities Plan: Project costs will be updated with a revised cost estimate prepared concurrent with the Final EIS.

Annual operation and maintenance costs are detailed in Section 7 of the Task 1.03 Technical Memorandum. The annual operation and maintenance cost for full flow CAS is approximately $4.5 million, with a present value cost of approximately $66.2 million. The annual operation and maintenance cost for split flow MBR is approximately $6.7 million, with a present value cost of approximately $99.8 million. Combining capital

and operation and maintenance costs, full flow CAS would have a total present value cost of approximately $633 million, and split flow MBR would have a total present value cost of $631 million. The total present value cost for these two alternatives is effectively equal considering the accuracy of the estimates.

Non-cost evaluations are discussed in detail in Sections 5 and 8 of the Task 1.03 Technical Memorandum. Overall, MBR was rated 7 percent higher than CAS based on the numerical evaluation criteria.

Based on the combined evaluations of cost and non-cost factors, and considering the significant reduction in discharge of pollutants offered by split flow MBR, the split flow MBR process with split stream treatment using ballasted clarification was selected as the preferred alternative for secondary treatment. The split flow MBR process will be configured to facilitate future expansion by reserving space for the 18 mgd AWWF Brightwater Phase 2 expansion. In addition, to help ensure system reliability, Brightwater will be configured with a reserved area for installation of secondary clarifiers should the MBR process fail to perform as anticipated. The clarifiers would allow the secondary process to be converted to CAS while retaining use of the MBR aeration basins. A conceptual site plan showing the Phase 1 process train, Phase 2 expansion area, and reserve area for secondary clarifiers is presented in Chapter 5.

4.3.5 Disinfection Processes

The disinfection process analysis for the marine discharge considered the major technologies currently used at large wastewater treatment plants in North America, including chlorine gas, liquid chlorine disinfection using sodium hypochlorite (generated on-site or delivered to the site in bulk liquid form), ozone, and ultraviolet (UV) light using either low pressure-high intensity or medium pressure-high intensity lamps.

As described in Section 3 and subsequent parts of the Task 1.03 Technical Memorandum, disinfection processes were first evaluated in relationship to screening criteria in a workshop setting. Chlorine gas disinfection was eliminated from further consideration, primarily on the basis of health and safety risks in the event of a chlorine gas leak. Ozone disinfection was eliminated from further consideration due to concerns about reliability, effectiveness, and cost. On-site generation of sodium hypochlorite was determined to be infeasible primarily due to cost, but bulk-delivered sodium hypochlorite was retained for further analysis. UV disinfection was retained for further evaluation, and UV treatment analyses were undertaken using the South Treatment Plant effluent as a surrogate for the Brightwater effluent to further investigate the feasibility of UV technology.

Chlorine disinfection using bulk-delivered sodium hypochlorite and UV disinfection proceeded to a more detailed analysis, summarized in the Disinfection Process Evaluation included as Appendix E of this Facilities Plan. The Disinfection Process Evaluation assessed the disinfection alternatives for application to the split flow MBR process that was identified as the recommended means of secondary treatment.

A supplemental analysis was performed to evaluate disinfection alternatives for reuse, presented in the Brightwater Predesign Technical Memorandum, Reuse, presented in Appendix F of this Facilities Plan.

4.3.5.1 Evaluation of Disinfection Alternatives for Marine Discharge

Figure 4-8 shows process schematics for the sodium hypochlorite and UV processes considered in the alternative analysis. These include:

- Bulk sodium hypochlorite delivered to the treatment plant, added to the combined MBR effluent and BPC split stream effluent, using the Brightwater effluent conveyance system to provide contact time. Dechlorination would be provided by adding sodium bisulfite to the downstream end of the effluent conveyance system.
- UV disinfection with separate UV systems treating the MBR effluent and BPC split stream effluent. By providing two separate UV systems, the disinfection processes can be designed to account for differing effluent quality in the two effluent streams.
- UV disinfection using a single system to treat the combined MBR and BPC split stream effluent.
- Combined UV disinfection of the MBR effluent and sodium hypochlorite disinfection of the BPC split stream effluent. The Brightwater effluent conveyance system would be used to provide contact time. Dechlorination would be provided by adding sodium bisulfite to the downstream end of the effluent conveyance system.

While the alternative analyses make provision for the addition of sodium bisulfite for dechlorination, dechlorination may only be required under certain periodic conditions of flow and chlorine dose since the 12 plus mile-long effluent conveyance system should provide adequate decay of chlorine. At the South Treatment Plant, for example, King County relies on the 12-mile-long effluent transfer system to reduce chlorine residuals to an acceptable level. For Brightwater, the sodium bisulfite addition would be located on the Brightwater effluent conveyance system, at Portal 41 or at a site closer to the Puget Sound. Further definition of dechlorination requirements will be developed during preliminary design.

4.3.5.2 Disinfection System: Preliminary Design Criteria for Marine Discharge

The disinfection analysis evaluated alternatives on the basis of Brightwater Phase 1 flows and projected effluent quality from upstream treatment processes. Table 4-16 summarizes

the general design criteria for the disinfection alternatives. Additional details of the preliminary design criteria are presented in Appendix E of this Facilities Plan.

Table 4-16. Preliminary Design Criteria for Marine Discharge Disinfection Alternatives

Parameter	Units	Value
Design Influent Flow Rates		
– Average Annual Influent Flow	mgd	31 mgd
– Peak Hour Influent Flow	mgd	130 mgd
Average Annual Design Flows to Disinfection		
– MBR Effluent	mgd	31
– Ballasted Clarification Effluent	mgd	0
Peak Wet Weather Design Flows to Disinfection		
– MBR Effluent	mgd	38
– Ballasted Clarification Effluent	mgd	92
UV Transmittance		
– MBR Effluent	%	65
– Ballasted Clarification Effluent	%	42
Sodium Hypochlorite Disinfection		
– Sodium Hypochlorite Solution Strength	%	12.5
– Available Chlorine from Sodium Hypochlorite Solution	lb/gal	1.0
– Average Chlorine Dose to MBR Effluent	mg/L	2. 0
– Average Chlorine Dose to Ballasted Clarification Effluent	mg/L	10.0
– Minimum Contact Time at Annual Average Flow	minutes	60
– Minimum Contact Time at Peak Hour Flow	minutes	20
– Sodium Bisulfite Dose (if required)	mg/L	1.0
Ultraviolet Disinfection		
– UV Dose, Low Pressure, High Intensity Lamps	mW-sec/cm^2	35
– UV Dose, Medium Pressure, High Intensity Lamps	mW-sec/cm^2	28

4.3.5.3 Disinfection Alternative Analysis for Marine Discharge

The capital, annual operation and maintenance, and total present value life cycle costs were estimated for each disinfection alternative. Capital costs were based on vendor information, preliminary layouts of disinfection facilities, and construction cost data for similar facilities. Annual costs included labor, electrical energy, chemical purchase, and equipment replacement. The comparative costs of the disinfection alternatives are presented in Table 4-17.

Table 4-17. Comparative Cost of Marine Discharge Disinfection Alternatives

Item	Sodium Hypo-chlorite	Separate UV Disinfection of MBR and BPC Effluent		Combined UV Disinfection of MBR and BPC Effluent		Combined UV + Sodium Hypo-chlorite
		Low Pressure High Intensity	Medium Pressure High Intensity	Low Pressure High Intensity	Medium Pressure High Intensity	
Capital cost	$2,849,000	$6,869,000	$6,795,000	$6,298,000	$5,883,000	$4,836,000
Annual cost	$217,000	$156,000	$171,000	$192,000	$210,000	$142,000
Present value of annual cost	$3,229,000	$2,321,000	$2,544,000	$2,857,000	$3,125,000	$2,113,000
Total Present Value[a]	$6,078,000	$9,190,000	$9.339,000	$9,155,000	$9,008,000	$6,949,000

[a] Present value analysis period of 20 years at 3 percent, resulting present value factor = 14.88.

This analysis indicated that sodium hypochlorite disinfection offered the lowest capital cost and lowest present value cost. An evaluation of non-cost factors, as presented in Appendix E, revealed no fatal flaws to sodium hypochlorite disinfection. Based on these considerations, sodium hypochlorite was selected as the recommended disinfection alternative for the marine discharge.

4.3.5.4 Disinfection Alternative Analysis for Reuse

Disinfection options for the Brightwater reuse facilities were evaluated through a supplemental alternative analysis, presented in Appendix F of this Facilities Plan. Based on communications with potential reuse customers, King County identified a user preference for UV disinfection. Hence, UV was selected for disinfection of reclaimed water flows. Key features of the system are as follows:

- Reuse disinfection facilities would be configured to achieve total coliform levels of 2.2 total coliform/100 mL, 7-day average, 23 total coliform/100 mL maximum, in accordance with the State of Washington, *Water Reclamation and Reuse Standards* (Ecology, 1997) standards for Class A reclaimed water.

- The system would be sized and configured in accordance with National Water Research Institute (NWRI), *Ultraviolet Disinfection, Guidelines for Drinking Water and Water Reuse* (NWRI, 2000).

- Reclaimed water would be withdrawn from the MBR effluent flow, with BOD_5 and TSS of 2 mg/L and a UV transmittance of 65 percent. A UV dose of 80

mJ/cm^2 is assumed for planning purposes, to be verified during preliminary design.

The proposed reuse disinfection facilities are described in further detail in Chapter 5 of this Facilities Plan.

4.3.6 Uplands Discharge and Reuse

The RWSP evaluated options for an inland discharge to the Lake Washington basin as well as a marine discharge to Puget Sound, and concluded that a marine outfall was the preferred means of effluent management for the Brightwater system. Since publication of the RWSP, King County has undertaken further evaluations to investigate whether alternative means of effluent management could preclude the need for a marine outfall. The investigations are presented in documents included in Appendix F of this Facilities Plan entitled Technical Memorandum, Uplands Discharge, and Technical Memorandum, Reuse, and in a separate document entitled *Indirect Potable Reuse of Reclaimed Water at Lake Washington from the Route 9 Site* (King County, 2002c). These documents evaluated the following alternative means of effluent management:

- Reclamation and reuse for irrigation and industrial processes
- Potential discharge of highly treated effluent into Lake Washington to create opportunities for additional withdrawals from the lake
- Injection of highly treated effluent into groundwater
- Use of highly treated effluent for stream flow augmentation

These investigations are summarized in the following sections of this Facilities Plan.

4.3.6.1 Effluent Reuse for Irrigation and Industrial Processes

As described in the Technical Memorandum, Reuse, King County has evaluated potential opportunities to utilize reclaimed water for both irrigation and industrial uses in the project area. Through these analyses, the county identified a number of potential users of reclaimed water for irrigation, as summarized in Table 4-18 and shown in Figure 4-9. No significant industrial users were identified.

Table 4-18. Potential Water Reuse Opportunities in the Brightwater Project Area

	Estimated Acreage		Estimated Water Demand		
Water Reuse Opportunities	Total[a]	Irrigable[b]	Average Seasonal (mgd)[c]	Peak Day (mgd)[d]	Water Right, Application, or Claim (mgd)
Wellington Hills Golf Course	80	80	0.45	0.7	None identified

Table 4-18. Potential Water Reuse Opportunities in the Brightwater Project Area

Water Reuse Opportunities	Estimated Acreage		Estimated Water Demand		
	Total[a]	Irrigable[b]	Average Seasonal (mgd)[c]	Peak Day (mgd)[d]	Water Right, Application, or Claim (mgd)
Echo Falls Country Club	161	161	0.59	1.0[f]	None identified
Flower World Nursery	80	80	0.60	1.0[f]	None identified
Abbey View Cemetery	74	74	0.21	1.1[f]	1.1
Ballinger Park Golf Course	48	48	0.26	0.4[f]	None identified
Holyrood Cemetery	76	76	0.21	0.3	0.5
Nile Temple Golf Course	112	112	0.45	0.7	0.5
Standard Oil of California		Not known		0.4[e]	0.4
Edmonds Memorial Cemetery		Not known		0.2[e]	0.2
Restlawn Memorial Gardens.		Not known		0.3[e]	0.3
Highlands, Inc.		Not known		0.3[e]	0.3
Jackson Park Golf Course	160	160	0.52	0.8	None identified
Seattle Golf and Country Club	138	138	1.14	1.8	1.3
Lynnwood Municipal Golf Course	36	36	0.39	0.6	0.4
Yost Memorial Park		Not known		0.3[f]	None identified
Edmonds Community College		Not known		0.2[f]	None identified
Agricultural sites	1,000	1,000	6.5	10.0[f]	To be determined
Agricultural sites and Bob Heirman Wildlife Park	8,493	8,493	19.54	33.3[g]	None identified
Total				**53.4**	

[a] Estimated total acreage determined from available GIS mapping.

[b] Irrigable acreage based upon field estimate or following estimation: 25% total acreage = irrigable acreage in parks; 100% total acreage = irrigable acreage in golf courses, cemeteries, and agricultural land based on previous studies performed by King County.

[c] Estimated seasonal water demand calculated from information in *Identification of Potential Satellite Projects for Direct Non-Potable Uses – Summary Report (King County,* 2000a).

[d] Peak-day demands of non-agricultural uses are based on information furnished by King County.

[e] Based on water right, application, or claim data provided by King County.

[f] Based on data provided by King County.

[g] Water demand for agricultural areas estimated based on water demand for alfalfa in the Seattle area, per *State of Washington Irrigation Guide* (Washington State University, 1990).

The potential sites represent reuse opportunities, but do not reflect a commitment by potential users to utilize reclaimed water. Nevertheless, King County has determined that there is a significant market for reclaimed water in the vicinity of the proposed Brightwater facilities. King County has elected to initially produce up to 5 mgd of reclaimed water and to reserve space on-site for up to 54 mgd of production, should the demand grow.

While irrigation may reduce the amount of effluent discharged through the marine outfall, it represents a seasonal demand for reclaimed water, typically extending from May through September. As such, reclamation would not be a viable replacement for marine discharge.

4.3.6.2 Potential Discharge to Lake Washington

Options for discharge to Lake Washington were evaluated in the RWSP and in the subsequent report entitled *Indirect Potable Reuse of Reclaimed Water at Lake Washington from the Route 9 Site*, (King County, 2002c). The report revisited the potential to discharge highly treated effluent into Lake Washington, which could create opportunities for additional withdrawals from the lake and reduce the length and cost of effluent conveyance facilities. However, any discharge to Lake Washington would require advanced treatment beyond the MBR process proposed for Brightwater, including additional nutrient removal and seasonal cooling of effluent to avoid adverse receiving water impacts.

Because of permitting uncertainties, the high cost of additional advanced treatment, and adverse public perception, the Lake Washington discharge was not considered a feasible alternative to a marine discharge. It was therefore eliminated from further consideration in the facilities planning process.

4.3.6.3 Groundwater Injection

Groundwater injection would involve artificial recharge of Brightwater effluent into the aquifers that underlie the project area. Since effluent management alternatives must provide certain long-term performance, the groundwater injection investigation was based on managing the projected Year 2040/Brightwater Phase 2 flows of 54 mgd AWWF, 170 mgd peak hour.

Based on available information, recharge of treated effluent into shallow geologic units, consisting of recessional glacial outwash, does not appear feasible. The recessional outwash generally consists of localized deposits of sand and gravel overlying low permeability Vashon till. The deposits are relatively thin and discontinuous, and due to their limited extent, have limited storage capacity. Where underlain by till, deeper vertical groundwater movement is limited, resulting in shallow perched groundwater zones within the unit. Recharge of effluent into these isolated deposits would likely result in significant groundwater mounding with rapid radial flow away from each recharge well; this would result in substantial groundwater discharge along the perimeter of the deposits at ground surface.

Injecting treated effluent into the deeper advance outwash may be technically feasible, subject to further verification through site-specific hydrogeological investigations. An injection system would require perhaps 500 recharge wells, each with a recharge rate of

250 gpm to accept the 170-mgd peak hour flow. Alternately, a system of approximately 150 wells could be used to recharge the 54-mgd AWWF, coupled with approximately 2,500 acre-feet of storage to attenuate peak flows.

Because study area aquifers are used as a source of drinking water, the treated effluent would be required to meet State Drinking Water Quality Standards (WAC 173-200), likely requiring reverse osmosis treatment. An Underground Injection Permit would be required under WAC 173-218. If the water is to be stored and recovered later, a Reservoir Permit and other related permits associated with WAC 173-157 would be necessary. If the water is to be recovered via aquifer storage and recovery, a valid water right to utilize the recharge water would be necessary.

The complexities and uncertainties of this alternative lead to high costs. Groundwater injection without storage may cost on the order of $330 million, plus land, advanced treatment, and O&M costs. Groundwater injection with storage may cost on the order of $800 million plus land, advanced treatment, and O&M costs. Reverse osmosis treatment could add an additional $800 million or more to the cost of these alternatives.

Because of the high costs, adverse public perception surrounding effluent injection into a potable water aquifer, and uncertainties associated with technical feasibility and permitting, groundwater recharge was removed from further consideration in the facilities planning process.

4.3.6.4 Stream Flow Augmentation

Stream flow augmentation would involve discharge of highly treated effluent into three creeks in the vicinity of the Route 9 site: North Creek, Swamp Creek, and Little Bear Creek. As with the Lake Washington discharge alternatives, the project is anticipated to require additional advanced treatment beyond the proposed MBR system, including nutrient removal and seasonal effluent cooling. Because of limited dilution, effluent would likely be required to meet State Water Quality Criteria prior to discharge, which could necessitate reverse osmosis treatment for removal of trace constituents.

A critical step in evaluating the feasibility of stream flow augmentation is to estimate the amount of flow that could be added to these creeks without causing adverse impacts such as erosion and flooding. The threshold for stream flow augmentation was estimated for each creek based on 50 percent of the 2-year pre-developed stream flow—Ecology’s general criterion for avoiding bank erosion. This flow rate was then compared to the daily flows for each creek to estimate the available capacity to accept Brightwater flows without causing bank erosion. Simulated daily Brightwater discharges were then compared to the daily creek flows in order to estimate the storage volume that would be required to discharge all of the Brightwater flows without exceeding the bank erosion threshold flow rate.

Management of effluent by stream flow augmentation would require significant effluent storage to avoid adverse impacts to the creeks during the wet weather, high flow season. If effluent is distributed to the three creeks, an estimated 3,070 acre-feet (1 billion gallons) of storage would be required. If effluent is managed through discharge to only one creek, storage volumes would increase substantially. Providing the requisite storage volume in open impoundments and a conveyance system would cost on the order of $325 million in capital cost, not including land, additional advanced treatment, and operation and maintenance costs. Effluent cooling and enhanced nutrient removal could increase Brightwater treatment capital costs by roughly $340 million.

Because of high cost, difficulty of obtaining large tracts of land for storage, and treatment and NPDES permitting uncertainties, stream flow augmentation was removed from further consideration in the facilities planning process.

4.3.7 Solids Handling Facilities

This section evaluates solids handling alternatives for Brightwater, including thickening, stabilization, and dewatering/drying processes. In configuring the Brightwater facilities, King County established a requirement that biosolids must be suitable for beneficial use and compatible with the county's current biosolids management program. Therefore, solids handling facilities must produce a minimum of Class B biosolids. To maintain long-term flexibility, King County has established that Class B stabilization processes must accommodate a future upgrade to produce Class A biosolids.

4.3.7.1 Preliminary Mass Balance

As part of the solids handling alternative analysis, preliminary mass balances were developed for the CAS and MBR alternatives, as presented in Section 6 of the Task 1.03 Technical Memorandum. Table 4-19 summarizes the preliminary mass balances for average annual and peak month conditions, showing comparative solids production for full flow CAS and split flow MBR with ballasted primary clarification of the split stream.

Table 4-19. Preliminary Mass Balance Summary

Parameter	Solids Production, lb/d Total Solids by Loading Condition	
	Average Annual[a]	Peak Month[a]
Full Flow Conventional Activated Sludge Alternative		
Primary Solids to Thickening	31,000 TS 25,000 VS	38,000 TS 30,000 VS
Waste Activated Sludge to Thickening	40,000 TS 33,000 VS	51,000 TS 43,000 VS
Thickened Solids to Anaerobic Digestion	66,000 TS 54,000 VS	83,000 TS 68,000 VS

Table 4-19. Preliminary Mass Balance Summary

Parameter	Solids Production, lb/d Total Solids by Loading Condition	
	Average Annual[a]	Peak Month[a]
Anaerobically Digested Biosolids to Dewatering	35,000 TS 23,000 VS	43,000 TS 29,000 VS
Dewatered Biosolids Production	33,000 TS 21,000 VS	41,000 TS 27,000 VS
Split Flow Membrane Bioreactor Alternative		
Primary Solids to Thickening	31,000 TS 25,000 VS	49,000 TS 33,000 VS
Waste Activated Sludge to Thickening	33,000 TS 26,000 VS	32,000 TS 25,000 VS
Thickened Solids to Anaerobic Digestion	59,000 TS 47,000 VS	75,000 TS 53,000 VS
Anaerobically Digested Biosolids to Dewatering	32,000 TS 20,000 VS	44,000 TS 22,000 VS
Dewatered Biosolids Production	30,000 TS 19,000 VS	42,000 TS 21,000 VS

[a] TS indicates total solids, VS indicates volatile solids

4.3.7.2 Solids Handling Alternative Analysis

Twenty-eight solids handling technologies were evaluated for potential application at Brightwater. The solids handling processes fell into three distinct categories, including thickening, stabilization, and dewatering/drying. As with other process evaluations, screening criteria were used to identify appropriate technologies for further analysis. The screening process is described in Section 3 of the Task 1.03 Technical Memorandum. Table 4-20 lists the solids handling technologies and summarizes the findings of the screening evaluation.

Of the 28 technologies, all but five were eliminated from further consideration through the screening evaluation. The technologies that remained for further consideration included:

- Thickening: Dissolved air flotation thickener (DAFT) and gravity belt thickener (GBT)
- Stabilization: Conventional mesophilic anaerobic digestion and thermophilic-mesophilic digestion
- Dewatering: Centrifuges

Table 4-20. Solids Handling Technologies Summary

Solids Handling Technology	Compatibility with Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Thickening Processes					
Source Thickening (thickening in clarifiers)	Adverse impact on site layout since process requires reduction of clarifier overflow rates.	Yes, for primary solids.	Not used at West Point or South Treatment Plants.	Offers no benefit over other thickening options. Deeper tankage may complicate foundation design. May increase odor potential.	Eliminated based on screening criteria.
Gravity Thickeners	Compatible with Brightwater space requirements.	Yes, for primary solids.	Not used at West Point or South Treatment Plants.	Considered and rejected for implementation at both West Point and South Treatment Plants. Relatively high odor potential.	Eliminated based on screening criteria.
Gravity Belt Thickeners (GBTs)	Compatible with Brightwater space requirements.	Yes, for primary solids waste activated sludge, (WAS), and co-thickened solids.	Successfully used at West Point Treatment Plant for co-thickening WAS and primary solids.	Hydraulically limited. Not suitable for primary scum thickening.	Retained for additional analysis.
Rotary Drum Thickeners	Compatible with Brightwater space requirements.	Yes, but used for small facilities with fibrous sludge.	Not used at West Point or South Treatment Plants.	Success with municipal WAS is variable.	Eliminated based on screening criteria.
Dissolved Air Flotation Thickeners (DAFTs)	Compatible with Brightwater space requirements only if footprint savings can be found in other facilities.	Yes, used for primary solids, WAS, and co-thickened solids.	Successfully used at the South Treatment Plant for co-thickening WAS and primary solids.	DAFTs provide grit removal and can handle primary and secondary scum. DAFTs are easily automated. King County experience shows DAFTs more costly to operate than GBTs.	Retained for additional analysis.
Centrifuge Thickeners	Compatible with Brightwater space requirements.	Yes, used for primary solids, WAS, and co-thickened solids.	Not used at West Point or South Treatment Plants.	King County investigated centrifuge thickening for West Point, rejected technology because of high energy costs.	Eliminated based on screening criteria.
Stabilization Processes					
Mesophilic Anaerobic Digestion	Compatible with Brightwater space requirements.	Yes, used for large facilities.	Successfully used at West Point and South Treatment Plants.	Proven process, commonly used at treatment plants of all sizes	Retained for additional analysis.
Thermophilic Anaerobic Digestion	Compatible with Brightwater space requirements.	Emerging, used for five large North American facilities.	Not used at West Point or South Treatment Plants. However, similar mesophilic anaerobic digestion process used at both plants.	Biosolids odors may be stronger than typical odors from mesophilic anaerobic digested sludge.	Eliminated based on screening criteria.

Table 4-20. Solids Handling Technologies Summary

Solids Handling Technology	Compatibility with Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Thermophilic-Mesophilic Anaerobic Digestion	Compatible with Brightwater space requirements.	Emerging, used at more than 10 plants in North America.	Not used at West Point or South Treatment Plants. However, similar mesophilic anaerobic digestion process used at both plants.	Studies for implementation at both South and West Point Treatment Plants show comparable costs to mesophilic digestion. Product may meet Class A requirements for pathogen reduction and vector attraction reduction, but batch feeding required to satisfy process definition for Class A/Process to Further Reduce Pathogens	Retained for additional analysis.
Acid/Gas Anaerobic Digestion	Compatible with Brightwater space requirements.	Emerging, used at about 5 plants in North America.	Not used at West Point or South Treatment Plants.	Only one plant with long history of operation digests only WAS. Acid digestion gas can contain 10,000 ppm of H_2S and is extremely odorous.	Eliminated based on screening criteria.
Recuperative Thickening Anaerobic Digestion	Compatible with Brightwater space requirements.	Developing, less than two plants larger than 10 mgd have successfully operated for extended periods of time.	Not used at South Treatment Plant. West Point has recuperative thickening centrifuges but does not use them.	Many design questions have not been answered, including digestion loading limitations, effect of thicker solids on mixing and heating. Technology holds promise and space should be allocated for future facilities.	Eliminated based on screening criteria.
Facultative Sludge Lagoons	Incompatible due to large space requirements.	Yes, typically for small facilities.	Not used at West Point or South Treatment Plants.	Rarely used for new treatment facilities in excess of 10 mgd.	Eliminated based on screening criteria.
Thermal Hydrolysis Anaerobic Digestion	Compatible with Brightwater space requirements.	Emerging. Only two facilities greater than 10 mgd exist, both are in Europe.	Not used at West Point or South Treatment Plants.	European plants have not performed consistently and have had maintenance problems. Produces Class A biosolids. May become viable alternative at plant expansion, assuming further advances in technology.	Eliminated based on screening criteria.
Autothermal Thermophilic Aerobic Digestion (ATAD) (including Vertical Shaft ATAD, or VERTAD, process)	Compatible with Brightwater space requirements.	ATAD-Yes, but typically at facilities smaller than 10 mgd. There are no known VERTAD installations.	Not used at West Point or South Treatment Plants.	South Plant piloted VERTAD and achieved only 46% volatile solids reduction. ATADs are associated with difficult to contain odors. ATADs require substantial power inputs. ATADs typically have higher operations and maintenance costs than anaerobic digestion.	Eliminated based on screening criteria.

Table 4-20. Solids Handling Technologies Summary

Solids Handling Technology	Compatibility with Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Dual Digestion with ATAD or VERTAD process	Compatible with Brightwater space requirements.	Yes, but no new dual digestion facilities currently being constructed for plants larger than 10 mgd.	Not used at West Point or South Treatment Plants.	Dual digestion does not significantly increase volatile solids destruction or reduce digestion footprint. VERTAD dual digestion may be proven in future years and used for future expansions.	Eliminated based on screening criteria.
Alkaline Stabilization	Compatible with Brightwater space requirements.	Yes, used for large and small facilities across North America.	Not used at West Point or South Treatment Plants.	Biosolids may release strong ammonia odors. Product becomes unstable as pH drops. Significant change in biosolids product compared to South and West Point Treatment Plants.	Eliminated based on screening criteria.
On-Site Composting	Incompatible due to large space requirement.	Yes, used for large and small facilities across North America.	Not used at West Point or South Treatment Plants. However, a portion of West Point and South Treatment Plant biosolids product are composted off-site.	Process has a significant odor potential that is difficult to contain.	Eliminated based on screening criteria.
Thermal Destruction	Compatible with Brightwater space requirements.	Yes, used for large facilities across North America.	Not used at West Point or South Treatment Plants.	Air emissions from these processes are highly regulated. A permit could not be obtained within the required timeframe. Product is inconsistent with King County Policy promoting beneficial reuse of biosolids.	Eliminated based on screening criteria.
Dewatering/Drying Processes					
Belt Filter Press Dewatering	Compatible with Brightwater space requirements.	Yes, used for large and small facilities across North America.	Successfully used at the South Treatment Plant, but currently being replaced with centrifuges.	Achieves only 15 to 20% cake solids compared to 25% from centrifuges. Costs of trucking and application of biosolids driving conversion to centrifuges at South Treatment Plant.	Eliminated based on screening criteria.
Centrifuge Dewatering	Compatible with Brightwater space requirements.	Yes, used for large and small facilities across North America.	Successfully used at West Point Treatment Plant. South Treatment Plant is in the process of converting to centrifuge dewatering.		Retained for additional analysis.
Screw Press Dewatering	Compatible with Brightwater space requirements.	Yes, but used primarily in the pulp and paper industry.	Not used at West Point or South Treatment Plants.	Typically not marketed to the municipal wastewater industry.	Eliminated based on screening criteria.
Rotary Press Dewatering	Compatible with Brightwater space requirements.	Emerging, used primarily in small facilities.	Not used at West Point or South Treatment Plants.	Piloted at South Treatment Plant without success. However, pilot testing was brief and failure could have resulted from limited time for optimization.	Eliminated based on screening criteria.

Table 4-20. Solids Handling Technologies Summary

Solids Handling Technology	Compatibility with Brightwater Sites	Proven Technology?	Process Standardization Considerations	Screening Observations/Comments	Screening Status
Pressure Filters	Compatible with Brightwater space requirements.	Yes, but no longer used for sludge dewatering for land application.	Not used at West Point or South Treatment Plants.	More expensive than other dewatering technologies in terms of capital and O&M. Operator attention required to scrape cake from filters.	Eliminated based on screening criteria.
Second Stage Dewatering	Compatible with Brightwater space requirements.	Developing, marketed on limited basis by two companies.	Not used at West Point or South Treatment Plants.	No known installations greater than 10 mgd with two years of operating history. Second stage dewatering facility will significantly increase capital costs.	Eliminated based on screening criteria.
Thermal Drying	Compatible with Brightwater space requirements.	Yes, used for large and small facilities. Majority of installations on stabilized biosolids product.	Not used at West Point or South Treatment Plants.	Unsuccessful operation of raw sludge drying at West Point Treatment Plant. Raw solids may release odors. Requires high energy input. Typically, biosolids haul and disposal costs must be greater than $60 per wet ton to justify drying.	Eliminated based on screening criteria.
Drying Beds	Incompatible due to large space requirements.	Yes, but use restricted primarily to hot arid climates.	Not used at West Point or South Treatment Plants.	Odor releases cannot be contained. Poor visual aesthetics.	Eliminated based on screening criteria.

Thickening Process Evaluation

Thickening is used to concentrate primary and waste activated sludge prior to stabilization. The thickening process evaluation considered the two technologies that were identified for further analysis in the initial screening—GBT and DAFT—applied to the split flow MBR liquid treatment process. For Brightwater, the GBT and DAFT processes would be configured to co-thicken primary solids from the conventional primary clarifiers, primary solids from the split stream ballasted clarification process, and waste activated sludge from the MBR process. Table 4-21 summarizes the thickening process alternative analysis.

The GBT process was selected as the recommended thickening alternative on the basis of lower life cycle cost and performance advantages. The gravity belt thickener installation will be configured to accommodate future expansion through addition of a fourth duty GBT unit as part of the Brightwater Phase 2 expansion.

Stabilization Process Evaluation

The stabilization process evaluation compared three anaerobic digestion configurations for potential application at Brightwater:

- Conventional mesophilic digestion producing Class B biosolids
- Continuous feed thermophilic-mesophilic digestion producing Class B biosolids
- Batch feed thermophilic-mesophilic digestion for producing Class A biosolids

Table 4-22 summarizes the preliminary design criteria for the stabilization processes. In all cases, it is assumed that anaerobic digesters will utilize fixed covers as opposed to floating covers as an odor control measure. Carbon scrubbers will be located at the digester pressure relief vents to treat the digester gas in case of an emergency digester gas release to the atmosphere. To enhance solids process flexibility, King County may consider also construction of a biosolids storage tank for holding liquid biosolids prior to dewatering. A decision on whether or not to provide the biosolids storage tank will be made during preliminary design.

Life cycle cost analyses indicated that mesophilic anaerobic digestion would have an estimated capital cost of $33.9 million and a total annual O&M cost of $1.3 million, yielding a total present value cost of $53.2 million. Continuous feed thermophilic-mesophilic digestion would have an estimated capital cost of $35.1 million, an annual O&M cost of $1.2 million, and a total present value cost of $53.0 million. Batch feed thermophilic-mesophilic anaerobic digestion would have an estimated capital cost of $39.7 million, an annual O&M cost of $1.2 million, and a total present value cost of $57.5 million.

Table 4-21. Thickening Process Preliminary Design Criteria and Alternative Analysis Summary

Parameter	Units	Value
Gravity Belt Thickening		
Preliminary Design Criteria and Alternative Analysis Summary:		
– Maximum hydraulic loading	gpm/m	200
– Maximum solids loading	lb/m/hr	1,000
– Belt width	m	2
– Number of duty units	–	2
– Number of standby units	–	1
– Estimated capital cost		$8,640,000
– Estimated present value, O&M cost		$2,850,000
– Net present value		$11,490,000
Advantages (relative to DAFT):		• Smaller footprint/space requirement • Lower capital cost and energy use • Higher thickened solids concentration
Disadvantages (relative to DAFT):		• Hydraulic load limitations • Requires building • Washwater flow/return stream • Higher operator attention
Dissolved Air Flotation Thickening		
Preliminary Design Criteria and Alternative Analysis Summary:		
– Maximum solids loading	lb/sf/d	36
– Diameter	ft	46
– Depth	ft	11
– Number of duty units	–	2
– Number of standby units	–	1
– Estimated capital cost		$9,780,000
– Estimated present value, O&M cost		$2,090,000
– Net present value		$11,870,000
Advantages (relative to GBT)		• Accepts higher hydraulic loads • Concentrates scum • Removes grit though bottom sludge • Reduces soluble BOD_5
Disadvantages (relative to GBT)		• Greater footprint/space requirement • Higher capital cost • Higher energy use • Lower thickened solids concentration

Abbreviations: gpm/m – gallons per minute per meter; lb/m/hr – pounds per meter per hour; lb/sf/d – pounds per square foot per day

Table 4-22. Stabilization Process Preliminary Design Criteria

Parameter	Units	Mesophilic Anaerobic Digestion	Continuous Feed Thermophilic-Mesophilic Anaerobic Digestion	Batch Feed Thermophilic-Mesophilic Anaerobic Digestion
Biosolids Quality	–	Class B	Class B	Class A
Number of Batch Feed Tanks	#	0	0	4
Batch Feed Tank Volume	MG	–	–	0.19
Number of Digesters	#	4	4	4
Digester Volume (ea)	MG	1.0	1.0	1.0
Minimum Process Hydraulic Detention Time, Thermophilic Stage[a]	Days	–	8	8
Recommended Hydraulic Detention Time, Thermophilic Stage[a]	Days	–	10[c]	10[c]
Minimum Process Hydraulic Detention Time, Mesophilic Stage[b]	Days	20	8	8
Recommended Hydraulic Detention Time, Mesophilic Stage[b]	Days	20	10[c]	10[c]
Volatile Solids Destruction	%	58	65	66
Number of Digested Biosolids Storage Tanks	#	1	1	1
Digester Biosolids Storage Tank Volume	MG	1.0	1.0	1.0

[a] Detention time under peak month conditions, at 55°C average temperature

[b] Detention time under peak month conditions, at 55°C average temperature

[c] Thermophilic-mesophilic recommended hydraulic detention times allow interchangeable operation between thermophilic-mesophilic and mesophilic

As of publication of this Facilities Plan, King County has not reached a final decision on whether to proceed with a Class B or Class A stabilization process. For purposes of this Facilities Plan, it is assumed that solids stabilization would make use of mesophilic anaerobic digestion. The Brightwater site plan will be configured with reserved area for two future anaerobic digesters to facilitate expansion. The system will be configured to

facilitate future upgrade to a thermophilic/mesophilic anaerobic digestion to produce a Class A biosolids product.

Dewatering Evaluation

Centrifuges offer benefits related to equipment standardization and dewatering performance that were unmatched by other alternatives. Centrifuge dewatering is used at the West Point Treatment Plant, and the South Treatment Plant is currently being converted from belt press dewatering to centrifuge dewatering. Centrifuge dewatering therefore emerged from initial screening as the preferred dewatering technology.

Preliminary design criteria for the centrifuge dewatering system are summarized in Table 4-23.

Table 4-23. Preliminary Design Criteria for Centrifuge Dewatering

Parameter	Units	Value/Comments
Number of Centrifuges Installed	—	3
- Duty Centrifuges	—	2
- Standby Centrifuges	—	1
Maximum month loading per centrifuge	gpm	150
Solids capture	%	90
Cake solids, minimum	% total solids	25
Cake handling system	—	Enclosed screw conveyors feeding storage hopper

The solids processing building will be configured to facilitate future expansion through the addition of a third duty centrifuge.

4.4 Treatment Process Odor Control Evaluation

Odor control will be of paramount importance to the Brightwater facilities. King County has established a goal of preventing and controlling odors so there are no perceptible odors off-site. All liquid processes will be covered and vented to odor control units. The solids processing building will have odor control to treat the process air generated by thickening, dewatering, and cake handling equipment. The anaerobic digesters will have odor control on the digester pressure relief vents to treat digester gas in the event of a release. Ventilation rates will be established based on process air volumes and the intensity of odors. Processes that have high odor potential will have redundant odor control units. The liquid processes will also have maintenance odor control units to treat

the air in an empty basin should a facility be drained for access. To provide a high degree of odor containment and treatment, the Brightwater facilities will include multiple stages of odor control.

The vapor phase odor control analysis considered a broad range of potential technologies for treatment of foul air, including:

- Chemical scrubbers: Packed towers and atomized mist configurations
- Biological processes: Biofilters, bioscrubbers/biotrickling towers, and return of foul air to aeration basins for treatment
- Adsorption processes: Activated carbon
- Thermal oxidation
- Masking agents
- Counteractants
- Ozone
- Ionization

Based on an initial screening of alternatives, four odor control technologies were found to offer the most proven performance and were retained for further analysis, including chemical scrubbers, biofilters, bioscrubbers, and activated carbon adsorption. Biofilters and bioscrubbers were considered for potential future use as one stage of a multi-stage odor control system. The preferred system consists of three-stage chemical scrubbing with potential addition of activated carbon polishing.

For liquid phase odor control, the following chemicals were evaluated:

- Precipitation: Iron salts (ferrous chloride, ferric chloride, ferrous sulfate, and similar compounds)
- Inhibition: Anthraquinone, calcium nitrate (Bioxide™)
- Augmentation: Organisms and enzymes
- pH control: Caustic soda, lime, magnesium oxides/hydroxides
- Oxidation: Chlorine compounds, air/oxygen, hydrogen peroxide, ozone, potassium permanganate

Based on performance, cost, safety, and materials handling considerations, three odor control chemicals were retained for further evaluation: iron salts, sodium hypochlorite,

and calcium nitrate. It is noted that King County may investigate the use of other odor control chemicals as actual operating conditions dictate.

4.4.1 Odor Control System Sizing Criteria

The sizing of vapor phase odor control systems is based on ventilation rates and anticipated concentrations of odorous compounds. Annual costs are derived from loading rates to the odor control units. Ventilation rates used in the analysis of vapor phase odor control technologies are shown in Table 4-24. This table does not include the emergency digester vent scrubbers or the biosolids truck scrubbers that will be used while the trucks are in the staging area on-site.

Table 4-24. Preliminary Ventilation Rates by Unit Process for 36 mgd Plant

Odor Source	Air changes per hour	Ventilation Rate[a] (cfm[b])
Influent Pump Station Wet Well	Max Fill at peak hr + 10% to maintain negative pressure	61,800
Headworks Building	12	42,600
Headworks (Truck Loading)	20	41,700
Headworks (Screening/Grit Removal)	20	23,300
Primary Clarifiers	20	17,400
Ballasted Primary Clarifiers (Split Flow)	20	2,600
Fine Screening Building	20	3,000
Aeration Basins	6 plus aeration air	36,700
Membrane Bioreactor Tanks	6 plus aeration air	30,000
Raw Sludge Blend Tank	6	2,100
Gravity Belt Thickeners (GBTs)	20	4,000
Thickened Sludge Blend Tank	6	2,000
Anaerobic Digesters	Provide carbon canisters on pressure relief assemblies	To be determined during design
Centrifuges	12 for room 1,000 cfm/centrate line 300 cfm/discharge chute 6 above hoppers	9,500
Cake Handling Conveyors	35 cfm/linear foot	10,500
Biosolids Truck Loading Area	20	32,000
Polymer Storage	12	11,000
Polymer Feed	12	25,600

Odor Source	Air changes per hour	Ventilation Rate[a] (cfm[b])
Centrate Tanks	6	3,000
Total		**358,800**

[a] Ventilation rates based on the preliminary sizing of membrane bioreactor (MBR) alternative. Maintenance air and redundancy not included.

[b] cfm = cubic feet per minute

The odor control system will be designed for peak odor and will use chemicals in the influent conveyance system and at the influent pump station during the summer, when odors are most significant. To establish loadings to the odor control system, assumptions were developed for odor characteristics of the various foul air streams. These assumptions, based on King County data and experience at other treatment facilities, are shown in Table 4-25. The assumptions are based on upstream chemical addition to provide liquid phase odor control.

Table 4-25. Assumed Hydrogen Sulfide, Ammonia, and Odor Loadings at the Plant (with liquid phase treatment)

Odor Source	Hydrogen Sulfide		Ammonia		Odor	
	Peak ppmV	Average ppmV	Peak ppmV	Average ppmV	Peak D/T	Average D/T
Influent Pump Station Wet Well	50	10	30	6	1,500	300
Headworks Building	10	5	10	5	500	250
Headworks (Truck Loading)	10	5	25	13	250	125
Headworks (Screening/Grit)	35	18	50	25	500	250
Primary Clarifiers	25	13	50	25	1,000	500
Aeration Basins Anoxic Zone	15	8	100	50	500	250
Aeration Basins Aerobic Zone and Membrane Tanks	10	5	100	50	500	250
Centrifuges	25	13	50	25	3,000	1,500
Conveyors	25	13	50	25	3,000	1,500
Biosolids Truck Loading	25	13	5	3	500	250
Gravity Belt Thickeners	25	13	30	15	1,000	500
Thickened Sludge Blend Tank	100	50	100	50	10,000	5,000
Raw Sludge Blend Tank	100	50	100	50	10,000	5,000
Polymer Storage Room	0.1	0.05	15	8	300	150
Polymer Feed Room	0.1	0.05	15	8	300	150
Centrate Tanks	25	13	250	125	3,000	1,500

Abbreviations: ppmV – parts per million by volume; D/T – dilutions to threshold

4.4.2 Evaluation of Odor Control Alternatives

After initial screening, the liquid and vapor phase technologies were rated with respect to process factors, O&M considerations, and environmental and community issues, as summarized in Table 4-26.

Table 4-26. Ratings by Non-Monetary Evaluation

Criterion	Weight	Nitrate	Iron Salts	Sodium Hypo-chlorite	Chemical Scrubber	Biofilter	Bio-scrubber	Carbon
		Liquid Phase Treatment			Vapor Phase Treatment			
Process Considerations								
Appropriate technology	3	5	5	5	5	4	3	5
Reliability	5	3	4	4	2	4	4	4
Robustness	4	3	3	3	3	3	3	3
Process standard-ization	2	5	3	5	4	1	1	5
Process flexibility	4	1	1	1	5	2	3	3
Ease of construction	2	5	5	5	4	2	4	4
Subtotal	*20*	22	21	23	23	16	18	24
O & M Considerations								
Operator safety	4	4	2	2	2	5	4	4
Ease of maintenance	4	4	2	2	2	4	3	3
Ease of operation	4	4	3	2	3	5	4	4
Operating flexibility	4	5	5	5	5	2	2	3
Operating environment	4	4	4	2	3	3	3	3
Subtotal	*20*	21	16	13	15	19	16	17
Environmental and Community Considerations								
Public safety and security	4	4	3	3	3	5	4	4
Exhaust air quality	4	3	3	2	3	4	4	3
Site utilization	3	5	5	5	5	1	4	4

Table 4-26. Ratings by Non-Monetary Evaluation

Criterion	Weight	Nitrate	Iron Salts	Sodium Hypo-chlorite	Chemical Scrubber	Biofilter	Bio-scrubber	Carbon
Construction impacts	3	5	5	5	4	2	4	4
Sustainability	2	4	3	3	2	5	4	4
Operational impacts	4	5	5	5	2	4	2	3
Subtotal	*20*	26	24	23	19	21	22	22
Total		69	61	59	57	56	56	63
Weighted Total		**236**	**211**	**199**	**196**	**205**	**199**	**217**

The odor control technologies were then ranked according to the overall weighted score. The higher the overall score, the higher the ranking. Liquid and vapor phase technologies were ranked independently as shown in Table 4-27.

Table 4-27. Ranking of Technologies

Technology	Ranking
Liquid Phase Treatment	
Nitrate	1
Iron salts	2
Sodium hypochlorite	3
Vapor Phase Treatment	
Carbon	1
Biofilter	2
Bioscrubber	3
Chemical scrubber	4
Biofilter	2
Bioscrubber	3

Based on the rankings, capital, annual O&M, and present value life cycle costs were then developed for two levels of vapor phase odor control. The first alternative would use three-stage chemical scrubbers. The second alternative would use three-stage chemical scrubbers with carbon adsorption polishing. Capital costs were based on vendor information, actual construction costs for similar facilities, and engineering judgment. Annual costs reflect chemical purchase, labor, electricity, chemicals, carbon, and equipment replacement.

The capital, first year O&M, and life cycle costs are summarized for two alternatives in Table 4-28.

Table 4-28. Cost Estimates for Odor Control Systems for MBR Plant

Odor Control Alternative	Capital Cost	Annual Cost	Present Value Life Cycle Cost
Liquid process fully covered, liquid phase treatment, 3-stage chemical scrubbers, carbon adsorption polishing	$46.4M	$3.8M	$102.3M
Liquid process fully covered, liquid phase treatment, 3-stage chemical scrubbers	$38.4M	$3.5M	$90.2M

4.4.3 Recommended Odor Control Alternative

The recommended odor control alternative consists of chemical scrubbing and carbon polishing with liquid phase treatment upstream in the collection system and at the influent pump station. Space will be reserved for biotechnology (either biofiltration for polishing or a bioscrubber for first-stage roughing) to retrofit either one of the chemical stages or the carbon stage. These technologies are familiar to King County and are proven to meet the demands of a rigorous odor control system such as the one envisioned for Brightwater.

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Chapter 5 Preferred Alternative

Note to Reviewers of Preliminary Working Draft Facilities Plan: A revised cost estimate for the preferred Route 9-195th Street System will be developed concurrent with preparation of the Final EIS, and presented as a future supplement to this Facilities Plan.

Treatment plant layouts presented in this chapter are based on the Route 9 site, which was identified as the preferred alternative in the Draft EIS. Figures showing the potential arrangement of the treatment facilities at the Unocal site will be presented in the final EIS.

5.1 Introduction

This chapter further defines the preferred alternative (Route 9 – 195th Street system) and describes the proposed treatment facilities. It reflects refinement of the preferred treatment process alternative, as developed through preliminary design activities conducted after the alternative analysis described in Chapter 4. Thus, the description the preferred treatment process in this chapter may differ from comparative presentation of alternatives contained in Chapter 4.

5.2 Flow and Load Summary

Brightwater is proposed to be constructed in two phases. Phase 1 includes plant operation in 2010 with a capacity of 36 mgd AWWF. Phase 2 would involve an 18 mgd expansion, which would bring the Brightwater facility to a total capacity of 54 mgd AWWF, anticipated to be required by 2040. While this Facilities Plan is intended to address only the Brightwater Phase 1 project, information on Phase 2 flows and loads and plant layouts have also been analyzed so that the Phase 1 facilities can be configured accommodate future expansion.

As discussed in Chapters 2 and 3, the influent flows and loads will be determined by the tributary drainage basins routed to Brightwater, the phasing of drainage basin additions to the Brightwater Service Area, and growth within the basins. Projected design flows and influent loads of BOD_5, TSS, and other key parameters are developed in Chapter 3 of this Facilities Plan. Key design parameters are summarized in Table 5-1.

Table 5-1. Influent Design Flow and Load Summary

Parameter[a]	Units	Brightwater Phase 1[b] (2010 through 2040)	Brightwater Phase 2[b] (After Year 2040)
Average Annual Conditions			
– Flow	mgd	31.3	47.0
– BOD_5	lb/d	60,000	90,000
– Soluble BOD_5	lb/d	24,000	35,000
– TSS	lb/d	63,000	94,000
– NH_3-N	lb/d	5,700	8,600
– TKN	lb/d	11,000	16,000
– Total P	lb/d	1,900	2,900
– Temperature (avg.)	°C	16.0	16.0
Average Wet Weather Conditions			
– Flow	mgd	36.0	54.0
– BOD_5	lb/d	60,000	90,000
– Soluble BOD_5	lb/d	23,000	35,000
– TSS	lb/d	62,000	93,000
– NH_3-N	lb/d	5,800	8,600
– TKN	lb/d	10,600	16,000
– Total P	lb/d	2,000	3,000
– Temperature (avg.)	°C	14.0	14.0
Maximum 30 Day (Peak Month) Conditions			
– Flow	mgd	50.8	76.2
– BOD_5	lb/d	79,000	118,000
– Soluble BOD_5	lb/d	32,000	48,000
– TSS	lb/d	76,000	114,000
– NH_3-N	lb/d	6,800	10,000
– TKN	lb/d	13,000	19,000
– Total P	lb/d	2,700	4,100
– Temperature (min.)	°C	11.8	11.8
Peak 7 Day (Peak Week) Conditions			
– Flow	mgd	71.4	107
– BOD_5	lb/d	93,000	140,000
– Soluble BOD_5	lb/d	48,000	72,000
– TSS	lb/d	91,000	137,000
– NH_3-N	lb/d	8,700	13,000
– TKN	lb/d	14,000	22,000
– Total P	lb/d	3,200	4,800

Table 5-1. Influent Design Flow and Load Summary

Parameter[a]	Units	Brightwater Phase 1[b] (2010 through 2040)	Brightwater Phase 2[b] (After Year 2040)
– Temperature (min.)	°C	10.6	10.6
Peak Day Conditions			
– Flow	mgd	99	148
– BOD_5	lb/d	193,000	290,000
– Soluble BOD_5	lb/d	50,000	75,000
– TSS	lb/d	168,000	252,000
– NH_3-N	lb/d	12,000	18,000
– TKN	lb/d	22,000	32,000
– Total P	lb/d	4,100	6,200
– Temperature (min.)	°C	10.0	10.0
Peak Hour Flow			
– Flow	mgd	130	170

[a] Abbreviations: BOD_5 – Biochemical oxygen demand; °C – Degrees Celsius; NH_3-N – Ammonia + ammonium nitrogen; TKN – Total Kjeldahl nitrogen; Total P – Total phosphorus; TSS – Total suspended solids

5.3 Wastewater Treatment Facilities

Table 5-1 indicates that the peak hour influent flow exceeds the average annual flow by a factor of over four to one. Sizing the liquid stream process to treat the peak hour flow, which has a 1 in 20-year recurrence, would require construction of treatment units that would see limited use. Alternately, sizing the liquid stream process for highly efficient treatment of typical flows and providing another means of treatment for storm-influenced flows offers opportunities to reduce capital and O&M costs without compromising the ability to meet projected NPDES Permit requirements. This concept, referred to as split flow treatment, allows MBR technology to be applied to Brightwater, reducing the annual discharge of pollutants by 75 percent or more when compared to a conventional activated sludge process. Split flow treatment offers further benefits, producing a reclamation quality effluent that will facilitate reuse. The process will also occupy less land than conventional activated sludge, thereby increasing the area available for mitigation and environmental enhancement at the treatment plant site.

As discussed in Chapter 4 of this Facilities Plan, the split flow treatment evaluation identified an optimum combination of a 38 mgd MBR system (allowable peak diurnal flow of 56 mgd) with ballasted primary clarification split stream treatment sized for 92 mgd, based on Brightwater Phase 1 design conditions.

The proposed treatment system involves an MBR process that will produce extremely high quality effluent, with typical BOD_5 and TSS averaging approximately 2.0 mg/L and ammonia nitrogen typically below 1.0 mg/L. The recommended alternative incorporates split flow treatment, in which flows above a split stream threshold of 38 mgd are routed around the secondary process. The split stream threshold represents the *average* flow that can be routed to the MBR process over a 24-hour period; diurnal peaks of up to approximately 56 mgd could be accommodated by the MBR during a given 24-hour period. The flow split will be located upstream of the conventional primary clarifiers.

The split stream flows will receive ballasted primary clarification, with an estimated frequency of 25 split flow events per year under Phase 1 design/Year 2040 conditions. The effluent from the MBR and ballasted primary clarification processes is combined and disinfected prior to discharge, and the resultant annual mass discharge of pollutants is far less than the discharge that would result from a full flow secondary treatment process such as conventional activated sludge.

5.3.1 Liquid Treatment Process Summary

A process schematic for the recommended treatment system is presented in Figure 5-1. All flow will enter the plant though an influent pump station, and then be pumped to the headworks area. The influent pump station structure is anticipated to be constructed as a large cylindrical concrete shaft, approximately 110 feet in diameter, with the bottom of the facility about 260 feet below the ground surface. Details of the influent pump station construction will be further defined through geotechnical investigations and structural evaluations conducted during preliminary design. The influent pump station is proposed to utilize pumps paired in series to generate the require total dynamic head in excess of 200 feet. The discharge of each influent pump will be equipped with a magnetic flow meter to measure influent flow.

The influent pump station will discharge to the headworks area, where the incoming wastewater will receive preliminary treatment through screening and vortex or aerated grit removal. While the initial alternative analysis selected mechanically raked climber screens, subsequent evaluations have recommended a 9 millimeter (mm) maximum opening perforated plate screen to protect the downstream ballasted clarification process. Thus, the preliminary design criteria presented in this chapter reflect a perforated plate screen system. In addition to protecting downstream equipment, the 9 mm influent screen will remove oversized, undesirable debris from the raw sludge, improving the quality of the biosolids product. Final selection of the grit removal process will be made during preliminary design, based on a comparative analysis of technical and operational considerations.

Following preliminary treatment, the flow will enter a flow split structure that will direct average daily flows in excess of 38 mgd to the ballasted clarification process. As described in Chapter 4, an average of 25 split flow events are anticipated annually under

Brightwater Phase 1 design conditions. Flows below the split stream threshold will receive conventional primary clarification.

Primary effluent will receive fine screening followed by biological treatment in the MBR process. Fine screening is proposed to utilize internal feed band type screens, with 2 mm round openings. The fine screens will protect the membranes from damage by oversized materials, and will further improve the quality of the biosolids by removing debris from the raw biological solids.

The MBR will have two major groups of process tanks—the aeration basins, which act as bioreactors, and the membrane tanks, in which the membranes that effect liquid/solid separation will be located. The MBR process will be designed to operate at elevated mixed liquor suspended solids (MLSS) concentrations of 6,000 to 8,000 mg/L or higher and at a sludge age ranging from 8 to 16 days, providing complete nitrification year round. Aeration calculations are adjusted for the high MLSS conditions by using an average alpha factor (relative rate of oxygen transfer in wastewater compared to water) of 0.5 for the aeration basins.

The membranes, with a pore size of 0.04 to 0.4 micron depending on the equipment provided, will be immersed in the mixed liquor. The permeability of the membranes will be maintained through routine automated processes and periodic in situ cleaning operations. Typical cleaning regimens vary by manufacturer and may involve air scour, membrane relaxation, membrane backpulsing with permeate, membrane backpulsing with sodium hypochlorite solution, and immersion in sodium hypochlorite solution. MBR equipment is available from several major manufacturers, and a detailed evaluation will be completed during preliminary design to select a final MBR configuration. Membrane flux rates ranging from 10 to 15 gallons per square foot per day are under consideration and will be refined during preliminary design with input from membrane manufacturers.

A portion of the MBR effluent, initially up to 5 mgd, may be withdrawn for UV disinfection, distribution, and reuse as a Class A reclaimed water. MBR effluent that is not directed to reuse will be combined with the periodic flow from the split stream/ballasted primary clarification process, disinfected with sodium hypochlorite, and directed to the effluent conveyance system. Dechlorination, as required, will be accomplished by addition of sodium bisulfite in the downstream conveyance system. It is anticipated that the dechlorination facility would be located at Portal 41 (see System Alternatives map located at the end of this report for Portal 41 location) or at a location closer to Puget Sound. The need for dechlorination will be further established during preliminary design.

Effluent will be transported from the Route 9 site to the marine outfall by an effluent conveyance system along the 195th Street corridor, as shown in the System Alternatives map included at the back of this Facilities Plan. The configuration of the effluent conveyance facilities is being established through ongoing preliminary design activities. Initial findings indicate that gravity conveyance is feasible; hence, effluent pumping is not proposed.

5.3.2 Solids Processing and Biosolids Management

Brightwater will include a complete solids handling train, incorporating thickening, stabilization, and dewatering. The stabilized, dewatered biosolids will be hauled off-site and beneficially used along with biosolids from the West Point and South Treatment Plants. As described in Chapter 2 of this report, King County manages biosolids through land application to agriculture and silviculture and by processing biosolids into a compost product (performed by a private contractor, GroCo). It is anticipated that the majority of the biosolids will be managed by land application, with composting providing an alternative means of biosolids management during periods of extended inclement weather, or when market conditions dictate.

Gravity belt thickeners have been shown to be the most cost-effective method of raw sludge thickening and will be used to co-thicken primary (including ballasted clarification) and waste activated sludge. Gravity belt thickeners cannot handle primary scum; thus, scum from the conventional and ballasted primary processes will be concentrated, bypassed around the gravity belt thickeners, mixed with the thickened sludge, and fed to the anaerobic digesters. Strategies for handling peak day ballasted sludge production will be refined during preliminary design, and may involve co-settling of ballasted primary solids in the conventional primary clarifiers.

The co-thickened sludge will receive a minimum of Class B stabilization through mesophilic anaerobic digestion, followed by centrifuge dewatering. Alternately, King County may elect to install a batch feed thermophilic-mesophilic anaerobic digestion system to produce Class A biosolids. The evaluation of Class A versus Class B biosolids treatment is still in progress, and final process determination will be made during preliminary design. Should King County proceed with Class B mesophilic anaerobic digestion, the digester complex would be configured so that it can be upgraded to a Class A thermophilic-mesophilic anaerobic digestion process in the future.

During preliminary design, King County will evaluate the need for a digested biosolids storage tank. If constructed at a nominal volume of 1.1 million gallons (to match the adjacent anaerobic digesters), the biosolids storage tank would provide an estimated 9.2 days of storage under average annual design conditions. Biosolids would be withdrawn from the storage tank and pumped to high solids centrifuges for dewatering. An enclosed truck bay will be provided for loading the dewatered biosolids into hauling vehicles.

5.3.3 Management of Other Residual Solids

Residual solids produced in screening and grit removal processes will be managed through landfill disposal in accordance with applicable regulations. Screenings will be removed at two locations—headworks and primary effluent areas—and washed and compacted prior to disposal.

5.3.4 Preliminary Flow and Mass Balances

Preliminary flow and mass balance calculations for the split flow MBR process are presented in Section 6 of the Task 1.03 Technical Memorandum. Flow and mass balances have been developed for average annual, peak month, and peak week flow conditions, and consider the impacts of return streams on the liquid process. In the absence of an existing wastewater treatment facility, key assumptions were made for typical removals and yields observed at other treatment plants. The flow and mass balance assumptions are summarized in Table 5-2.

Table 5-2. Key Assumptions for Split Flow MBR Flow and Mass Balances

Unit Process/Parameter	Assumption
Headworks Screens (9 mm)	
BOD_5 Removal	0.5%
TSS Removal	0.5%
Grit Removal	
BOD_5 Removal	0.5%
TSS Removal	0.5%
MBR Flow Conventional Primary Clarification	
BOD_5 Removal	30%
TSS Removal	50%
Split Stream Ballasted Primary Clarification	
BOD_5 Removal	50%
TSS Removal	70%
Chemical Dose	70 mg/L ferric chloride
Fine Screens (2 mm, for flow to MBR)	
BOD_5 Removal	5%
TSS Removal	10%
Aeration Basins	
Biomass Yield	0.8 lb/lb BOD_5 removed
Membrane Tank	
Effluent BOD_5	2 mg/L
Effluent TSS	2 mg/L
Raw Sludge Concentrations	
Conventional Primary Sludge	1.5%
Ballasted Primary Sludge	5%
Waste Activated Sludge	1%
Primary Sludge Screening	
BOD_5 Removal	2%
TSS Removal	5%
Sludge Thickening	
Thickened Sludge Concentration	6%
Solids Capture	95%

Table 5-2. Key Assumptions for Split Flow MBR Flow and Mass Balances

Unit Process/Parameter	Assumption
Anaerobic Digestion	
Volatile Solids Destruction	58%
BOD_5 Destruction	58%
Centrifuge Dewatering	
Cake Concentration	25%
Solids Capture	95%

The flow and mass balance results are summarized in Table 5-3 and presented graphically in Figures 5-2, 5-3, and 5-4. The mass balance figures reflect raw sludge screening, a process that may be unnecessary due to the fine screening of raw wastewater and primary effluent. The mass balance diagrams will be updated during preliminary design, as process details are further defined.

Table 5-3. Summary of Preliminary Flow and Mass Balance Results, Split Flow MBR

Mass Balance Inputs and Outputs	Average Annual Flow	Maximum Month Flow	Peak Week Flow
Influent Wastewater			
Flow (mgd)	31.3	50.8	71.4
BOD_5 (1,000 lb/d)	60	79	93
TSS (1,000 lb/d)	63	76	91
VSS (1,000 lb/d)	50	61	73
FSS (1,000 lb/d)	13	15	18
Ferric Chloride Added to Split Stream			
FSS, 1,000 lb/d	0	8	19
Final Effluent			
Flow (mgd)	31.3	50.8	71.4
BOD_5 (1,000 lb/d)	0.5	11	22
TSS (1,000 lb/d)	0.5	6.4	13
VSS (1,000 lb/d)	0.4	5.1	11
FSS (1,000 lb/d)	0.1	1.3	2.0
Dewatered Biosolids Production			
Production (yd^3/day)	72	99	134
TS (1,000 lb/d, dry weight)	30	42	56
VS (1,000 lb/d, dry weight)	19	21	23
FS (1,000 lb/d, dry weight)	11	21	33

Table 5-3. Summary of Preliminary Flow and Mass Balance Results, Split Flow MBR

Mass Balance Inputs and Outputs	Average Annual Flow	Maximum Month Flow	Peak Week Flow
Screenings and Grit to Landfill			
Production (yd^3/day)	5.5	5.6	7.4
TS (1,000 lb/d, dry weight)	5.3	6.0	7.0
VS (1,000 lb/d, dry weight)	4.4	5.1	5.9
FS (1,000 lb/d, dry weight)	0.9	0.9	1.1

Abbreviations: TSS – total suspended solids; FSS – fixed suspended solids; VSS – volatile suspended solids; TS – total solids; FS – fixed solids; VS – volatile solids; yd^3/day – cubic yards per day

5.3.5 Recommended Treatment Facilities

Unit processes and treatment facilities have been sized based on influent flow and load data, results of the split flow treatment evaluation, preliminary flow and mass balances, and established design criteria, including Ecology's *Criteria for Sewage Works Design* (Ecology, 1998). Preliminary design criteria and proposed unit process sizing for major components of Brightwater are summarized in Table 5-4, accompanied by comments on the general configuration of processes and equipment, and how critical process units meet Ecology requirements for redundancy. The individual treatment processes are described in further detail in the Task 1.03 Technical Memorandum. Fact sheets describing the proposed unit processes are presented in Appendix G of this Facilities Plan.

Certain items shown in the treatment process schematic—including the raw sludge blending tank and circulation pumps, thickened sludge tank and circulation pumps, digester feed pumps, and centrate sump/centrate pumps—have not been sized as of publication of this Facilities Plan. Sizing of these elements will be determined during preliminary design.

5.3.6 Preliminary Site Plan and Facility Layout

The Route 9 site comprises an area of approximately 106 acres, bounded by SR 522 and the BNSF Railroad on the east and south, SR 9 on the west, and private property on the north. The site slopes from east to west and provides approximately 79 acres of useable area for the Brightwater facilities. The site is presently occupied by a lumber yard, construction contractors, and an automobile parts business. The adjacent state highways and railroad right-of-way provide significant buffering of the site, and the establishment of on-site mitigation and buffering areas will provide further separation of the facility from residents and businesses in the project vicinity. The site would be accessed at several points along the SR 9 frontage.

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Influent Pump Station			
Approximate facility footprint (ft x ft)	130 x 130	130 x 130	Two enclosed bays, grit/screenings truck loading
Influent pump type	Centrifugal non-clog	Centrifugal non-clog	Variable speed, VFD drive
Total number of influent pumps	10	12	Two pumps in series
Number of pumping systems	5	6	Each system consists of two pumps in series
Pump capacity, each pump/system, mgd	35	34	
Total dynamic head (TDH) each system (ft)	250-270	250-270	125 to 135 ft TDH per stage, to be refined during preliminary design
Number of stages	2	2	Two pumps in series
Firm capacity (one pumping system out of service) (mgd)	140	170	Meets Ecology reliability criteria to pump peak flow with one system out of service
Maximum capacity, all pumps in service (mgd)	170	210	
Influent flow meter type	Magnetic	Magnetic	One meter located on each pump discharge
Minimum caisson diameter for pump station structure (ft)	110	110	
Headworks Building (Influent Screening and Grit Removal)			
Approximate facility footprint (ft x ft)	130 x 92	130 x 92	Two enclosed bays for disposal truck loading
Influent Screens			
Number of units	4 + 2 standby	6 + 1 standby	Meets Ecology reliability criteria through provision of standby screen
Screen type	Perforated plate	Perforated plate	System includes washing and compaction
Sidewater depth approaching screens (ft)	10	10	Approximate dimensions, to be confirmed during preliminary design
Screen channel width (ft)	6	6	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Perforation size (mm)	9	9	
Grit Removal			
Number of units	3	4	
Type	Vortex	Vortex	Vortex assumed. Final determination to be made during preliminary design. Grit handling includes classification and washing
Diameter (ft)	24	24	
Sidewater depth (ft)	8	8	
Grit pumps, type	Centrifugal recessed impeller	Centrifugal recessed impeller	
Number of grit pumps	3 + 3 standby	4 + 4 standby	
Grit pump capacity, each (gpm)	120	120	
Grit pump TDH (ft)	30	30	
Flow Split Structure			
Approximate facility footprint (ft x ft)	15 x 12	15 x 12	
Flow control	Magnetic flow meters + weirs or flow control valves	Magnetic flow meters + weirs or flow control valves	Splits flow between conventional primary clarification/MBR (38 mgd, Phase 1; 56 mgd, Phase 2) and ballasted clarification
Primary Clarification (Conventional)			
Basin dimensions, length x width (ft)	200 x 20	200 x 20	Rectangular units, covered, with chain/flight sludge collectors. Gallery areas house appurtenant equipment
Sidewater depth, average (ft)	12	12	
Number of units	6	9	
Operating overflow rates:			

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Overflow rate at peak flow, set by split stream threshold: 38.0 mgd Phase 1; 56.0 mgd Phase 2 (gpd/ft^2)	1,580 2,370 at diurnal peak	1,560 2,340 at diurnal peak	Well below allowable peak overflow rates in *Criteria for Sewage Works Design*; average overflow rates control
At 31.3 mgd average annual flow, Phase 1; 47.0 mgd average annual flow, Phase 2 (gpd/ft^2)	1,330	1,330	
BOD_5 removal (%)	30	30	
TSS removal (%)	50	50	
Primary sludge pumps (type)	Progressive cavity	Progressive cavity	Constant speed
Typical sludge concentration (%)	1.0 – 2.0	1.0 – 2.0	
Number of primary sludge pumps	6 + 3 standby	9 + 5 standby	
Pump capacity, each (gpm)	100	100	
Pump TDH (ft)	75	75	
Ballasted Primary Clarification Facility (Split Stream Component)			
Ballasted primary clarification facility approximate footprint size (ft x ft)	90 x 70	140 x 115	
BOD_5 removal (%)	50	50	Assumes polymer and ferric chloride or alum addition, typical dose of 70 mg/L
TSS removal (%)	70	70	
Number of units	2	3	
Injection tanks			
Length x width (ft x ft)	18 x 18	18 x 18	
Sidewater depth (ft)	26	26	
Maturation tanks			
Length x width (ft x ft)	22 x 35	22 x 35	
Sidewater Depth (ft)	26	26	
Est. Peak Day Sludge - Phase 1 (ppd)	107,000	161,000	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Average Sludge TS (%)	5	5	
Minimum Sludge TS (%)	2.5	2.5	
Ballasted clarification sludge pumps (type)	Progressive cavity	Progressive cavity	Constant speed
Number of pumps	2 + 1	3 + 1	
Typical sludge concentration (%)	5.0	5.0	
Pump capacity (gpm)	175	175	
Pump TDH (ft)	100	100	
Settling tanks			
Length x width (ft x ft)	30 x 30	30 x 30	
Sidewater depth (ft)	26	26	
Maximum allowable overflow rate (gpd/ft^2)	80,000	80,000	
Overflow rate at peak hour flow: 92 mgd, Phase 1; 114 mgd, Phase 2 (gpd/ft^2)	73,600	60,800	
Fine Screening Facility			
Fine screening facility footprint (ft x ft)	90 x 90	90 x 90	Includes enclosed truck loading bays
Number of screens	3 + 1 standby	4 + 1 standby	Nominal capacity of 20 mgd each
Type	Perforated plate/band center feed	Perforated plate/band, center feed	Screenings treatment, including washing and compaction anticipated to be provided at centralized facility at headworks
Sidewater depth approaching screens (ft)	14	14	
Screen channel width (ft)	4	4	
Screen perforation (mm)	2	2	2 mm represents maximum anticipated perforation size. Finer screens may be considered in preliminary design

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
MBR System			
Aeration Basins			
Approximate facility footprint (ft x ft)	130 x 450	190 x 450	Includes gallery along centerline of complex and ends of tanks
Configuration	Plug flow with anoxic selectors	Plug flow with anoxic selectors	Covered basins
Number of aeration basins	4	6	
Basin dimensions (ft x ft)	400 x 23	400 x 23	
Sidewater depth (ft)	25	25	
Total basin volume (ft^3)	920,000	1,380,000	
Typical MLSS (mg/L)	8,000	8,000	
Yield, lb biomass/lb BOD_5 removed	0.8	0.8	
F/M ratio	0.06	0.06	
Design sludge retention time (days)	8 to 16	8 to 16	
Aeration system diffuser type	Fine bubble, flexible disk	Fine bubble, flexible disk	
Number of blowers	4+1 standby	6+1 standby	Meets Ecology reliability criteria through provision of standby blower
Blower type	Centrifugal	Centrifugal	
Airflow, per blower (scfm)	15,000	15,000	
Blower discharge pressure (psi)	12	12	
Membrane Basin Feed (Intermediate Lift) Pumps			
Pump type	Mixed flow	Mixed flow	Variable speed with VFD drive
Design return rate (% of AWWF)	400	400	Pumps pump incoming flow plus return flow; return is by gravity flow to aeration basins
Number of pumps	4 + 1 standby	6 + 1 standby	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Pump capacity, each (mgd)	38	38	
Pump TDH (ft)	15	15	
Membrane Basins			
Number of membrane basins	12	18	
Membrane basin dimensions (ft x ft)	121 x 10	121 x10	Covered tanks
Sidewater Depth (ft)	12	12	
Membrane Basin Air Scour Blowers			
Number of blowers	6 + 1 standby	9 + 1 standby	
Blower type	Centrifugal	Centrifugal	
Airflow, per blower (scfm)	15,400	15,400	Membrane basin air scour blowers provide a portion of the total process air requirement
Blower discharge pressure (psi)	6	6	
MBR Support Building			
Approximate facility footprint (ft x ft)	200 x 100	300 x 100	To be refined during preliminary design
WAS Pumps			
WAS pump type	Screw centrifugal	Screw centrifugal	Variable speed with VFD drive
WAS concentration from aeration basin (mg/L)	8,000	8,000	
WAS concentration from RAS system (mg/L)	8,000 - 10,000	8,000 - 10,000	
Number of WAS pumps	1 + 1 standby	2 + 1 standby	
WAS pump capacity, each (gpm)	400	400	
WAS pump TDH (ft)	50	50	
Permeate Pumps			
Permeate pump type	Horizontal end suction	Horizontal end suction	Variable speed with VFD drive
Number of permeate pumps	12 + 2 standby	18 + 2 standby	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Permeate pump capacity, each (gpm)	3,960	3,960	
Permeate pump TDH (ft)	30	30	
Chemical Backpulse Pumps			
Backpulse pump type	Horizontal end suction	Horizontal end suction	Variable speed with VFD drive
Number of backpulse pumps	9	14	
Backpulse pump capacity, each (gpm)	To be determined	To be determined	
Backpulse pump TDH (ft)	To be determined	To be determined	
Disinfection System for Marine Discharge			
Chemical type	Sodium hypochlorite	Sodium hypochlorite	System will be provided with standby metering pumps to meet Ecology requirements for reliability
Disinfection requirement, fecal coliform bacteria (number/100 mL)	200	200	
Dose (mg/L chlorine)	2.0 to 10.0	2.0 to 10.0	Peak dose represents disinfection of combined MBR and split stream effluent during split flow event. Low dose represents MBR effluent
Minimum contact time at average annual flow (min)	60	60	Provided in effluent conveyance system between Brightwater and conveyance Portal 41. Reference Technical Memorandum, Disinfection, included in Appendix E
Minimum contact time at peak hour flow (min)	20	20	
Dechlorination, Portal 41 or Location Closer to Puget Sound			Note: Location of facility to be established during preliminary design.
Chemical type	Sodium bisulfite	Sodium bisulfite	System will be provided with standby metering pumps to meet Ecology requirements for reliability

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Dose (mg/L)	2.0 to 15.0	2.0 to 15.0	Peak dose represents disinfection of combined MBR and split stream effluent during split flow event. Low dose represents MBR effluent
Minimum contact time at average annual flow (min)	20	20	Provided in effluent conveyance system, downstream of Portal 41. Reference Technical Memorandum, Disinfection, included in Appendix E
Minimum contact time at peak hour flow (min)	10	10	
Disinfection System for Reuse			
Approximate facility footprint (ft x ft)	100 x 140	100 x 325	
Disinfection type	UV	UV	
UV transmittance (%)	65	65	
Anticipated UV dose, mJ/cm^2	80	80	Per NWRI guidelines, to be determined during preliminary design
Disinfection requirement, total coliform bacteria (number/100 mL)	2.2	2.2	
Flow (mgd)	5	Up to 54	
Number of units	2	10	
Reuse Water Pump Station			
Approximate facility footprint (ft x ft)	100 x 100	100 x 100	
Facility capacity (mgd)	5	Up to 54	
Reuse water pump type	Vertical turbine	Vertical turbine	
Number of reuse water pumps	3 + 1 standby	To be determined	
Capacity, each (gpm)	1,180	To be determined	
Total Dynamic Head (ft)	300	To be determined	TDH allowance. Value will be ascertained as design progresses

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Gravity Belt Thickeners			Located in Solids Handling Building
Typical feed concentration (% total solids)	1.0 – 2.0	1.0 – 2.0	
Design feed concentration (% total solids)	1.0	1.0	
Design thickened solids concentration (% total solids)	6.0	6.0	
Feed solids load at average annual (lb/d)	62,000	93,000	
Feed solids load at max. month (lb/d)	79,000	118,500	
Feed solids load at peak week - design condition (lb/d)	97,000	145,500	
Feed solids load at peak week - design condition (gpm)	444	666	
Number of meters/unit	2	2	3 meter units may be evaluated during preliminary design
Maximum hydraulic loading (gpm/m)	250	250	
Maximum solids loading (lb/hr/m)	1,000	1,000	
Number of units	3 + 1 standby	4 + 1 standby	Reflects dedicated unit for handling ballasted primary sludge flows, as requested by operations staff
Number of units operational 24/7 at average annual condition	1.3	1.9	
GBT Feed Pumps			
GBT feed pump type	Screw centrifugal	Screw centrifugal	Variable speed, VFD drive
Number of GBT feed pumps	3 + 1 standby	4 + 1 standby	
GBT feed pumps (capacity per unit)	550	550	
GBT feed pumps, TDH (ft)	40	40	
Thickened Sludge Pumps			
Thickened sludge pump type	Progressive cavity	Progressive cavity	Variable speed, VFD drive
Number of thickened sludge pumps	3 + 1 standby	3 + 1 standby	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Thickened sludge pumps (capacity per unit)	80	80	
Thickened sludge pumps, TDH (ft)	200	200	
GBT Sludge Conditioning System			
Chemical type	Polymer	Polymer	Polymer feed system configuration to be established during preliminary design
Anaerobic Digestion (Assumes Class B process)			
Process type	Class B process. High-rate, mesophilic, 95-100º F	Class B process. High-rate. mesophilic, 95-100º F	Facility configured for future upgrade to Class A process. Heating provide by boiler system, alternately by waste heat from cogeneration if system is constructed
Typical feed sludge concentration (% total solids)	6.0	6.0	
Feed sludge flow at average flow (mgd)	0.12	0.18	
Feed sludge flow at peak month (mgd)	0.15	0.22	
Feed sludge flow at peak week (mgd)	0.19	0.28	
Design detention time (days)	20, minimum at peak month	20, minimum at peak month	Exceeds Ecology's minimum requirements for detention time
Number of digester tanks	4	6	
Volume per digester (MG)	1.1	1.1	Includes storage volume in digester process tankage. Final volume to be determined during preliminary design, considering volume separate storage tank if provided.
Diameter (ft)	55	55	
Sidewater depth (ft)	60	60	
Operating detention time, days			
At average flow	37	To be determined	Based on 1.1 MG digesters described above
At peak month	29	To be determined	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
At peak week	24	To be determined	
Digested Biosolids Storage			Need for digested biosolids storage to be determined during preliminary design
Number of storage tanks	1	1	
Volume per tank (MG)	1.1	1.1	
Diameter (ft)	55	55	
Sidewater depth (ft)	60	60	
Operating detention time (days, average annual)	9.2	To be determined	
Digester Mixing System			
Type	Draft tube or pumped	Draft tube or pumped	
Number of units	3 per tank	3 per tank	Assumes draft tube mixing
Flow per unit (gpm)	To be determined	To be determined	
Centrifuge Dewatering (in Solids Handling Building)			
Typical feed concentration (% total solids)	3.0 – 3.5	3.0 – 3.5	
Feed flow at average flow (mgd)	0.12	0.18	
Feed flow at peak month (mgd)	0.15	0.22	Design condition
Feed flow at peak week (mgd)	0.19	0.28	
Design hydraulic loading at peak month (gpm/unit)	150	150	
Design solids loading at peak month (lb/hr/unit)	2,250	2,250	
Hours of operation per week	120	120	168 hours are available per week. Sizing allows peak week solids production to be dewatered in 5 days/week at 24 hours per day
Number of units required at peak week	1.2	1.8	

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Number of units installed	2 + 1 standby	3 + 1 standby	Meets Ecology requirements for reliability by providing standby unit
Capture (%)	95	95	
Dewatered cake concentration (% total solids)	25	25	
Dewatered cake production, average annual (yd^3/d)	73	110	
Dewatered cake production, peak week (yd^3/d)	134	200	
Cake handling system	Enclosed bins discharging into haul trucks	Enclosed bins discharging into haul trucks	
Centrifuge Feed Pumps			
Centrifuge feed pump type	Progressive cavity	Progressive cavity	Variable speed, VFD drive
Number of centrifuge feed pumps	2 + 1 standby	3 + 1 standby	
Centrifuge feed pumps (capacity per unit)	175	175	
Centrifuge feed pumps, TDH (ft)	60	60	
Centrifuge Solids Conditioning System			
Chemical type	Polymer	Polymer	Polymer feed system configuration to be established during preliminary design
Odor Control Systems			
Number of stages	4	4	Three-stage packed tower chemical scrubbers with carbon polishing
Chemical types	Sulfuric acid, sodium hypochlorite, sodium hydroxide	Sulfuric acid, sodium hypochlorite, sodium hydroxide	
Capacity per scrubber (cfm)	25,000 to 40,000	25,000 to 40,000	
Number of scrubbers by area:			

Table 5-4. Preliminary Design Criteria

Facility and Equipment Description	Phase 1	Phase 2	Comments
Influent pump station	3 + 1 standby	3 + 1 standby	
Headworks and primary treatment	5 + 1 standby	5 + 1 standby	
Secondary treatment	4 + 1 standby	5 + 1 standby	
Solids handling	3 + 1 standby	3 + 1 standby	
Predicted ventilation rates of entire system (cfm)	360,000	415,000	
Electrical and Cogeneration Facilities			
Approximate footprint, Electrical Substation (ft x ft)	120 x 80	To be determined	
Approximate footprint, Cogeneration (ft x ft)	150 x 100	To be determined	
Cogeneration capacity (MW)	4 to 6	To be determined	Cogeneration is optional facility to be evaluated during preliminary design
Fuel type	Digester gas/natural gas	Digester gas/natural gas	
Prime mover	Gas turbine	Gas turbine	
Number of units	1	To be determined	
Available heat (MMBTU/hr)	Up to 16	To be determined	
Approximate Footprints of Other Buildings (ft x ft)			
Chemical Building	105 x 200	105 x 200	
Solids Handling (Thickening/Dewatering)	175 x 105	175 x 105	
Maintenance Building	200 x 100	200 x 100	
Administration Building	200 x 100	200 x 100	

5.3.6.1 Zoning and Mitigation Considerations

The site is located entirely within unincorporated Snohomish County, and over half of the site lies within identified Urban Growth Areas. Portions of the site within Urban Growth Areas are zoned as Light Industrial, Heavy Industrial, and Freeway Service (King County, 2001). Areas outside of the Urban Growth Areas are zoned Rural 5-Acre. The Brightwater facilities are proposed to lie entirely within the Urban Growth Areas, and wastewater treatment facilities are an approved land use in the Light and Heavy Industrial Zones. There will be no Brightwater-related construction on the portions of the site that are zoned Rural 5-Acre, and outside of the Urban Growth Areas. Further detail on land use, zoning, and site development standards is presented in Chapter 11 of the Draft EIS.

While King County will configure the Brightwater facilities to minimize environmental impacts, a number of existing surface water resources and wetlands will be impacted by construction. King County proposes to mitigate the impacts by establishing mitigation and buffer areas at the site, and by relocating and restoring several watercourses that have been routed through culverts and channels by existing development. The existing environment of the site and potential impacts from treatment plant construction are discussed in Chapters 6 and 7 of the Draft EIS. A conceptual mitigation plan for the Route 9 site is presented in Figure 7-7 of the Draft EIS. The mitigation plan will be finalized through the EIS process, and incorporated into the site layout and design.

5.3.6.2 Preliminary Site Plan

A preliminary site plan for the Brightwater facilities is presented in Figure 5-5. The site plan is developed into a conceptual rendering in Figure 5-6, based on the preliminary sizing of treatment process units presented in Table 5-4. The site plan and rendering reflect initial input from the Brightwater architectural team, and seek to retain much of the western portion of the site for environmental mitigation and enhancement features. The site plan and rendering show the anticipated arrangement of the proposed Phase 1 facilities, along with the area set aside for the Phase 2 expansion. The site plan and rendering also show a reserved area that could be used for construction of secondary clarifiers (8 circular footprint areas at northern end of facilities), should the MBR process fail to perform as anticipated, allowing conversion to a conventional activated sludge process.

5.3.7 Preliminary Hydraulic Profile

Figure 5-7 presents a preliminary hydraulic profile for the Brightwater facilities, reflecting the Phase 2 peak flow of 210 mgd (Year 2050 condition with all influent pumps operating at maximum capacity) and the Phase 2 AWWF of 54 mgd. The preliminary hydraulic profile considers the Phase 2 flows to ensure that future hydraulic

requirements can be met. The hydraulic profile will be developed in further detail as the Brightwater design progresses, considering the full range of Phase 1 and Phase 2 flow conditions.

5.3.8 Emergency Flow Management

As described in Chapter 4, Section 4.3 of this Facilities Plan and Section 11 of the Task 1.03 Technical Memorandum, preliminary design investigations explored potential use of the influent conveyance facilities to attenuate peak flows to Brightwater. The storage volume could also be used to enhance overall reliability of the Brightwater system by providing emergency storage. Emergency storage would reduce the potential for conveyance system overflows in the event of short-term power outages or equipment malfunctions. King County has elected to retain the influent storage capability for emergency storage rather than utilize storage for peak flow attenuation.

As discussed in Chapters 2 and 3, existing conveyance infrastructure is used to deliver current flows from the Brightwater Service Area to the South and West Point Treatment Plants. Of particular importance are the Kenmore Pump Station, which conveys flow via the Kenmore Interceptor to the West Point Treatment Plant, and the North Creek and York Pump Stations, which transfer flows to the Eastside Interceptor for conveyance to the South Treatment Plant. This infrastructure will remain in service as part of the Brightwater conveyance system, providing King County with the ability to manage the Brightwater Service Area flows between three treatment plants, providing flexibility in emergency flow management.

When all of the factors that impact emergency flow management are viewed as a system—emergency storage, standby power, mechanical redundancy, and flow transfer capabilities in the conveyance system—the projected frequency of an emergency overflow is less than one event per 100 years.

5.3.9 Standby Power and Energy Self Generation

With a deep marine outfall, it is anticipated that Brightwater will be required to meet Ecology requirements for Class II reliability. As a Class II facility, Brightwater would require standby power "sufficient to operate all vital components and critical lighting and ventilation during peak wastewater flow conditions…except that vital components used to support the secondary processes need not be operable to full levels of treatment, but shall be sufficient to maintain the biota" (Ecology, 1998). The proposed standby power system is intended to provide reliability at or above Class II requirements. Ecology further requires "two separate and independent sources of electrical power … from two separate utility substations" or a generator system based at the plant (*Criteria for Sewage Works Design*, Section G2-8.3).

Brightwater will be served by dual utility feeds from the Snohomish County Public Utility District (Snohomish County PUD). Although several substations in the area are available to supply the two utility feeds, the Route 9 site is located close to the principal regional transmission level substation (SnoKing) operated by the Bonneville Power Authority (BPA), which feeds the other substations in the region. Therefore, a higher level of reliability can be provided by dual feeds from the SnoKing substation than by providing feeds through two other local area substations.

Snohomish County PUD has indicated that it can provide service to the Brightwater facility via two 115 thousand volt (kV) transmission lines from the SnoKing substation. Snohomish County PUD owns the outbound transmission lines starting from the dead-end towers in the substation. The two lines would be extended to the plant and looped through at the plant via a main-tie-main 115 kV switching arrangement such that power can be supplied to the plant by either transmission line independently.

The SnoKing substation has 115 kV to 230 kV lines serving it from BPA, Seattle City Light (SCL), and Puget Sound Energy (PSE). According to Snohomish County PUD, these lines will be upgraded to four 230 kV lines and one 500 kV line within the next few years. As a transmission level substation, the SnoKing substation will offer an extremely high level of reliability. The multiple incoming main transmission services are connected to the high voltage buses via individual substation transformers. A sectionalizing switch currently allows segregation of the incoming service bus into two sections in the event that one of the services is faulted. In addition, both the high side and low side buses in the substation have auxiliary buses. Tie breakers and sectionalizing switches allow the auxiliary buses to back up the main buses. In the near future, and prior to Brightwater construction, the SnoKing substation will be upgraded such that the high side main bus will have two sectionalizing breakers to split it into three buses and the low side bus will have a circuit breaker to split the main bus into two sections. The two transmission lines that would serve the Brightwater plant will be the Parkridge and Clearview lines. These are located at opposite ends of the substation low (distribution side) bus, configured in a way that they will be segregated by the new sectionalizing breaker.

It is important to note that the level of reliability provided by two utility feeds directly from the SnoKing substation is at such a high level that any service from other locations would degrade service reliability to Brightwater, since the exposure of the transmission lines over longer distances and additional switch gear in series with SnoKing would necessarily lower the reliability. In summary, independent transmission lines from the SnoKing substation in conjunction with the sectionalizing improvements will have an extremely higher level of reliability than providing service from other available substations.

King County is considering a further enhancement of the Brightwater electrical power system, involving optional standby power in the form of an energy self generation system (cogeneration). The purposes of the cogeneration system are to beneficially utilize digester gas as a fuel source, provide sufficient energy to heat the anaerobic digesters and plant spaces through heat recovery from the cogeneration system, provide on-site power

generation for additional redundancy in the standby power system (i.e., provide standby power if both utility feeds fail), and provide cost-effective energy during periods of energy price fluctuations. The cogeneration system would have the capability to burn both digester gas, available at a rate of approximately 1.5 megawatts (MW), and natural gas. The system would be sized to handle average plant power demands and be capable of pumping higher flows into the plant at reduced levels of treatment. The initial estimate of the size of the system is between 4 and 6 MW of generating capacity. Final sizing will be conducted in preliminary design.

5.3.10 Ancillary Facilities and Support Systems

5.3.10.1 Administration Building

The administration building is anticipated to be a two-story structure housing the administrative offices, laboratory, conference room, operations and process control center, restrooms, lockers, visitor reception area, lunchroom, archive and equipment storage areas, document production facilities, and library.

The laboratory will include bench space, fume hoods, refrigerators, scales, sinks, emergency eyewash and shower, ovens, and equipment for sample storage and routine sample analysis. It is intended that the laboratory be equipped and staffed to perform analyses required for routine process control and monthly discharge monitoring reports as required under the plant NPDES Permit. Special testing, such as periodic analyses of biosolids metals and effluent priority pollutants, will be performed off-site at the King County Wastewater Treatment Division Water Quality Laboratory.

The operations and process control center will be the main location from which operations staff monitor and control the treatment processes via the plant supervisory control and data acquisition system.

5.3.10.2 Maintenance Building

The maintenance building will serve as a centralized location for performing major repairs that cannot be performed on in-place equipment. It is anticipated to be a two-story structure housing repair facilities, spare parts storage, and maintenance staff offices. The building is anticipated to have drive-in truck maintenance bays to facilitate loading and unloading of equipment.

5.3.10.3 Chemical Building

The chemical building will be used to store and meter sodium hypochlorite to the effluent disinfection system (for marine discharge) and to feed chemicals to the odor control systems. Odor control chemicals will include sodium hypochlorite, sodium hydroxide, and potentially sulfuric acid. Chemicals will be delivered by truck and stored on-site in bulk storage tanks, with containment and safety provisions meeting the requirements of the Uniform Fire Code (International Fire Code Institute, 1998) and local jurisdictions. The building will be sized to meet both Phase 1 and Phase 2 chemical handling requirements.

Ballasted primary clarification chemicals will include iron salts (such as ferric chloride) or alum and polymer, which may be fed from the chemical building, or from a separate chemical area at the ballasted clarification process. Polymer may be delivered in bulk liquid or dry form, and diluted into solution on-site.

5.3.10.4 Stormwater Management

The majority of the Route 9 site south of 228th Street has been previously developed and consists largely of impervious surfaces. Existing stormwater management facilities were installed during previous site development, and have involved routing natural surface drainages into culverts and ditches. The proposed Brightwater facilities will involve approximately 30 acres of impervious surfaces for paved roads and parking, treatment process units, and other structures. The resultant stormwater will be managed by collection, detention, treatment, and discharge to surface waters, including Little Bear Creek. Stormwater management facilities will be designed in accordance with Snohomish County requirements and the *Stormwater Management Manual for Western Washington* (Ecology, 2001a), and will evolve through the design process.

Low impact development concepts will be utilized where possible to minimize runoff volumes and provide environmentally sound stormwater management. The objective is to keep stormwater management on-site. Potential low impact development methods include green (vegetated) roofs, pervious pavement, amended soils for the pervious areas, and local bioretention. Furthermore, rain that falls on covered process tanks may be allowed to drain into the liquid process, reducing stormwater volumes. Runoff originating from off site would be routed around the Brightwater facilities.

Detention facilities will be sized using Ecology's Western Washington Hydrological Model (Ecology, 2001b) and other appropriate modeling tools. Assuming that the pre-development condition was a forested site, up to 25 acre-feet of detention volume and 7 acre-feet of stormwater treatment volume could be required to simulate how the stormwater would be detained on a natural, forested site (predevelopment condition).

Ecology requires that runoff from industrial sites be given enhanced treatment. This is necessary since runoff from industrial areas can contain contaminants related to the

nature of site operations, and enhanced treatment is needed to reduce suspended solids and other contaminants prior to discharge to inland surface waters. For Brightwater, contaminated runoff could occur at certain process locations, including chemical storage areas, chemical transfer locations, biosolids truck loading areas, and truck parking or maintenance areas. It is proposed that these areas be hydraulically isolated so that stormwater does not mix with stormwater from other portions of the site. Stormwater from areas with potential of contamination will be returned to the treatment process. Therefore, no special or enhanced stormwater treatment is proposed for these flows.

It is anticipated that stormwater will be collected and conveyed to one or more low-lying areas such as the buffer zone along Route 9. After detention and treatment, stormwater will discharge under Route 9 and into Little Bear Creek.

5.3.11 Operations and Maintenance and Staffing

Preliminary estimates of staffing were developed during the Draft EIS as part of an effort to define environmental impacts from the Brightwater project. The estimates indicated that Brightwater would require a total staff of approximately 48 persons, including administrative and management functions, operations staff, process control and laboratory staff, mechanics, electricians, instrument technicians, and building and grounds maintenance. Actual staffing requirements will be influenced by the number of off-site conveyance facilities that are assigned to the Brightwater for operation and maintenance, as well as the level of automation that will be achieved through the instrumentation and process control systems; thus, staffing will be further evaluated during preliminary design.

5.4 Reuse

The basis of the Brightwater reuse program is presented in Chapter 4 of this Facilities Plan and in the Technical Memorandum, Task 1.06 – *Reclaimed Water Technology Review; Evaluation of Potential Water Reuse Opportunities*, presented in Appendix F. Brightwater is proposed to initially produce up to 5 mgd of Class A reclaimed water upon completion of the Phase 1 facilities. Space will be reserved on-site for future production of up to 54 mgd of reclaimed water. It is anticipated that the reclaimed water will be withdrawn from the MBR effluent flow upstream of blending with the periodic split flows, disinfected, and conveyed to various reuse sites. Through communications with potential reuse customers, King County has identified a user preference for UV disinfection. Thus, reuse flows will receive UV disinfection.

Since the identified irrigation demands are seasonal, it is anticipated that the reuse system will operate for only a portion of the year, typically from May through September. Reuse facilities will be configured to comply with the Washington State *Water Reclamation and Reuse Standards* (Ecology, 1997).

King County has identified a number of potential opportunities within the project area to reuse Class A water for irrigation. Potential reuse sites are shown in Figure 5-8. Site characteristics and potential water demands are summarized in Table 4-18 in Chapter 4.

The potential sites represent reuse opportunities, but do not reflect a commitment by potential users to utilize reclaimed water. User interest must be established through further study, and reuse agreements must be developed and implemented prior to initiating reuse. King County will refine the reuse program plans concurrent with the Brightwater design and construction so that reuse agreements will be in place when the reclamation facilities are placed in service.

Preliminary estimates of capital and O&M costs for the reuse facilities, including estimates of the unit cost of reclaimed water production, are presented in Appendix F. As the reuse program is further defined, and specific users and conveyance methods identified, the cost estimates will be refined.

5.5 Recommended Conveyance Facilities

The preferred alternative for Brightwater conveyance, as identified by the King County Executive, is the Route 9 – 195th Street System, as shown in the System Alternatives map located at the back of this Facilities Plan. Key features of the conveyance system are summarized in Table 5-5.

Table 5-5. Summary of Executive's Preferred Alternative Conveyance System

Parameter	Influent Corridor	Effluent Corridor
Conveyance Length	7.4 miles	12.7 miles
Anticipated Tunnel Inside Diameter	10 to 11 feet	8 to 12 feet
New Pump Stations Along Conveyance System	None	None
Portal Siting Areas	Portal 11—NE 175th St & 68th Ave NE Portal 34—NE Bothell Way & 80th Ave NE Portal 41—NE 195th St & 120th Ave NE	Portal 41—NE 195th St & 120th Ave NE Portal 44—NE 195th St & 80th Ave NE Portal 45—NE 195th St & 58th Ave NE Portal 7—Ballinger Way NE & 25th Ave NE Portal 27—NE 205th St & 1st Ave NE Portal 23—NW 205th St & Firdale Ave Portal 19—NW 205th St & Richmond Beach Dr NW

Table 5-5. Summary of Executive's Preferred Alternative Conveyance System

Parameter	Influent Corridor	Effluent Corridor
Method of Conveyance	Gravity flow to influent pump station	Gravity pressurized flow for entire length

The conveyance system is currently under preliminary design. Near-term activities are focusing on defining issues critical to systemwide permitting, such as portal locations and potential impacts to wetlands and other aquatic resources. Investigations are also in progress to evaluate potential impacts from conveyance and treatment plant construction on groundwater resources. Key preliminary design activities include the following issues:

- **Portal locations within siting areas.** The preliminary design process will determine the final location of the 1 to 2 acres required for portal construction within each of the 72-acre areas identified for general portal siting.
- **Number of portals needed along influent and effluent tunnels.** The preliminary design will determine if the potential exists to reduce the number of portals needed for tunnel construction.
- **Tunnel alignment and depth.** The preliminary design process will optimize the horizontal alignment and vertical profile to minimize capital and operational costs, balanced against construction risks. Vertical profile evaluations will be established so that effluent can be conveyed from Brightwater to the outfall by gravity flow.
- **Air handling odor control strategies.** The preliminary design will evaluate where to site odor control facilities and identify appropriate odor control facilities.
- **Connections between influent conveyance and existing King County facilities.** The preliminary design will select the alignment, depths, and construction methods for connections to existing King County interceptors and pump stations to route wastewater to Brightwater.
- **Emergency flow management.** The preliminary design will make determinations regarding influent flow routing, emergency flow transfer capabilities, and the location of a safety relief point.

5.6 Recommended Marine Outfall Facilities

As shown in the System Alternatives map located at the back of this Facilities Plan, the recommended alternative involves construction of the marine outfall in zone 7S. The

outfall will originate from the conveyance pipeline terminus at Portal Siting Area 19. Microtunneling and trenched construction will be evaluated for outfall pipeline installation at the shoreline and through the nearshore region. The outfall alignment, outfall construction methods, segment lengths, and other outfall installation details will be determined during preliminary and final design based on site-specific information and further analyses discussed in this section.

Diffuser locations in zone 7S will be located beyond 4,000 feet offshore at water depths between 650 and 700 feet below mean low low water. The final diffuser configuration will be designed to function properly at both low flow and peak flow periods. As discussed in Appendix D of this Facilities Plan, water quality and dilution zone analyses have shown that diffusers meet all applicable water quality criteria within the range of lengths and diffuser port configurations analyzed.

Outfall preliminary design activities will focus on addressing the following issues:

- **Outfall pipeline alignment.** A favorable pipeline alignment will be selected based on site-specific bathymetric survey and geotechnical borings. The selected alignment will facilitate outfall construction by avoiding subsurface conditions adverse to tunneling and potentially unstable surface soils.

- **Outfall construction method.** Feasibility analysis of tunneling construction methods will be based on geotechnical borings completed at the shoreline and in the nearshore region. Construction safety issues and the risks inherent to each construction method will also influence outfall construction method selection.

- **Outfall pipeline number and diameter.** Outfall pipeline requirements will be refined to establish the optimum number and diameter of pipelines. The final selection of the pipeline design criteria will be based on an iterative process involving allowable span lengths, pipe diameter, and pipe wall thickness.

- **Diffuser configuration and location.** The diffuser will be designed to function properly within the range of minimum and maximum Brightwater flows as predicted by modeling and potential water reuse. Diffuser length and location will be based on the availability of suitable diffuser sites (slope less than 2 percent) identified during alignment-specific bathymetric surveys.

- **Construction materials.** Pipeline materials and the potential use of flexible joints will be based on stress analysis of pipeline span lengths for the selected outfall alignment.

Preliminary design activities will also include engineering analyses to determine the range of potential structural, hydraulic performance, and installation factors for outfall alternatives presented in this Facilities Plan. Results of these analyses will support the selection of final outfall design and installation details. Activities, analyses, and studies performed during predesign and final design will provide a properly functioning outfall over its design life while minimizing costs and environmental impacts.

5.7 Permits and Approvals

The Brightwater Regional Wastewater Treatment System includes influent conveyance facilities, a new treatment plant, effluent conveyance facilities, reuse facilities, and a marine outfall in Puget Sound. Project components are located in two counties and in several local jurisdictions. As such, numerous federal, tribal, state, county, and local agencies will participate in the permitting process. King County has initiated the permitting process through introductory communications and pre-application meetings with the jurisdictions involved in the permitting process, and has conducted periodic workshops to provide project updates to the regulatory community.

A master list of permits and approvals that must be secured for the project is presented in Appendix H of this Facilities Plan. Major permits and approvals are summarized as follows:

- Permits and Approvals initiated under the Joint Aquatic Resources Permits Application process: U.S. Army Corps of Engineers Section 404 Permitting, Ecology Section 401 Water Quality Certification

- Consultation by the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries (formerly National Marine Fisheries Service) under Section 7 of the Endangered Species Act

- Washington Department of Ecology: NPDES Stormwater Discharge Permit for construction

- Permits and approvals from local jurisdictions, including Snohomish County, King County, City of Bothell, City of Kenmore, City of Lake Forest Park, City of Shoreline, City of Mountlake Terrace: Anticipated permits and approvals vary by jurisdiction, and include Conditional Use Permits, Special Use Permits, Essential Public Facilities Process, Clearing and Grading Permits, Building and Demolition Permits, and Shoreline Substantial Development Permits. The list of permits and approvals from local jurisdictions will be refined as additional information is gathered during preliminary design

- Washington Department of Natural Resources: Lands/Aquatic Lease for Marine Outfall and Stream/River Crossings

- Puget Sound Clean Air Agency: Notice of Construction and possible Title V Operating Permit

- Washington Department of Fish and Wildlife: Hydraulic Project Approval for marine and freshwater construction impacts

- Washington Department of Ecology: NPDES Permits for effluent and stormwater discharge, Model Toxics Control Act and associated hazardous waste remediation approvals, and coastal shore management

5.8 Cost Estimate for Recommended Alternative

Overall costs for the Route 9 – 195th Street system are presented in Tables 5-7 and 5-8. The estimates include costs for raw wastewater conveyance, treatment at the Route 9 site, and effluent conveyance/discharge through the marine outfall, but do not reflect the costs of distributing reclaimed water to potential reuse sites. Reuse program costs will be finalized at a later date when further specifics on reuse opportunities have been established.

Insert Tables 5-7 (Capital Cost Estimate) and 5-8 (Present Worth Cost Estimate) from updated project cost estimate, to be developed concurrent with Final EIS.

The cost estimate serves as the basis of the financial and rate analysis presented in Chapter 6 of this Facilities Plan. The estimate is anticipated to have an accuracy of –10 to +15 percent, and is based on the following assumptions and allowances:

Mitigation Allowance: 10% of base construction cost, including sales tax and allied costs. Contingency, art allowance, and land/right-of-way costs are excluded from the mitigation allowance calculation.

Art Allowance: 1% of adjusted base cost of construction including contingency at 10% of adjusted base construction cost and allied costs. Adjusted base of construction excludes demolition, hazardous materials removal, underground pipelines, and shaft/portal construction.

Construction Contingency Allowance: 20% for treatment plant, 30% for land conveyance and outfall, applied to base construction cost.

Sales Tax: 8.9%.

Engineering, Administration, Legal, and other Allied Costs: 35% of the sum of the base construction cost, construction contingency, and sales tax.

Life Cycle Cost Period: 20 years.

Discount Rate: 3%.

Operations and Maintenance Staff Salary with Benefits: $43/hour average rate, with 260 workdays per year. 10% overtime assumed at average rate of $55.90/hour.

Equipment Repair and Replacement: Assumption is that 1/20 of capital cost of mechanical, electrical, instrumentation, and control systems is budgeted for replacement each year. Boilers, tanks, covers, ductwork, and wiring are excluded from the replacement calculation.

Chemicals, Solid Waste, and Biosolids Management: Chemical costs based on average wet weather flow conditions and vendors' estimated costs for chemicals delivered to site. Biosolids management and solid waste disposal costs are based on unit cost per mgd of flow at West Point and South Plants.

Electrical Power Cost: $0.05 per kilowatt-hour.

5.9 References

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Chapter 6 Financial Evaluation

Note to Reviewers of Preliminary Working Draft Facilities Plan: This chapter presents a draft financial analysis for the Brightwater Regional Wastewater Treatment System based on the Brightwater Regional Wastewater Treatment System, Draft EIS Estimates published November 27, 2002. The draft financial analysis is based on the full flow CAS system alternative included in the cost estimate. The financial analysis will be updated following completion of revised project cost estimates, which will be developed during preparation of the Final EIS.

6.1 Introduction

This chapter discusses the capital and operational costs for implementing the recommended Brightwater Regional Wastewater Treatment System and describes the financing plan for funding capital costs. This chapter also discusses customer wholesale wastewater service rates and new customer service connection fees required to support the financing plan and ongoing operational costs.

6.2 Capital Costs

The estimated capital cost of the Brightwater facilities, in 2002 dollars, is presented in Table 6-1. The costs presented are total project costs, including construction, contingency, allowance for host community mitigation, project art, sales tax, and site/right-of-way procurement, as well as project allied costs related to engineering, environmental evaluation, permitting, and King County management. The actual implementation cost will be a function of construction timing of the particular project elements. A proposed implementation schedule is presented in Figure 6-1.

Assuming capital cost annual inflation of 3 percent per year, the annual cash flow required to implement the program is presented in Table 6-2. The sum of the annual dollars results in an adjusted-for-inflation total project cost of approximately $1.349 billion (2002 dollars), which includes conveyance, treatment, and marine outfall components.

6.3 Operations and Maintenance Costs

The estimated annual O&M costs of the Brightwater facilities are summarized in Table 6-3. The costs are presented by the major cost categories, including labor, energy,

chemicals, solid waste, and replacement parts. The actual net increase to King County Wastewater Treatment Division operational budget is less than this amount because some cost savings will be achieved at the county's other regional plants as a result of diverting flows to Brightwater that are presently tributary to the West Point and South Treatment Plants. The net additional annual cost assumed for the rate impact analysis is approximately $18.4 million (2002 dollars).

6.4 Project Financing

For purposes of initial analysis, rate and financing evaluations are based on a preliminary cost estimate developed during November 2002 for the Brightwater Regional Wastewater Treatment System (King County, 2002). These initial analyses will be revised when an updated cost estimate for the recommended alternative is issued later in 2003.

In adopting the *Regional Wastewater Services Plan*, the King County Council included recommendations that defined the Brightwater program and specific policies related to financing. The policies that apply to the funding of Brightwater were originally outlined in King County Ordinance No. 13680, Section 16, and amended by King County Ordinance No. 14219, Section 3. With respect to the RWSP, the essence of these policies is that "growth should pay for growth." Through these policies, customers representing new connections to the wastewater system will pay for the cost of expanding capacity through the combined revenues of their monthly sewer rate and capacity charge. The capacity charge is a fee that is assessed to all newly connecting customers—residential, commercial, and industrial—to the King County wastewater system. Newly connecting customers have the option to pay King County a bi-annual fee over 15 years or to pay an upfront charge that represents a discounted value (currently 8 percent) of the 15 years of bi-annual payments.

Because the Brightwater facilities are being sized to serve long-term service area growth through Year 2030, by definition the accumulation capacity charge fees will not be adequate within the construction time frame to fully fund the Year 2010 facilities construction. King County therefore proposes to fund the capital portion of the cost through a combination of capacity charges, a portion of the annual revenue from the monthly sewer service rate, the sale of new revenue bonds, and the potential use of State Revolving Fund low interest loans.

The ongoing costs of operating and maintaining the new facilities will be fully funded by the monthly wholesale user rate.

6.5 Service Fees and Capacity Charges

King County's capacity and service charges are based on the equal benefit theory, namely equivalent customer categories are assessed the same fee regardless of their location

within the service area or which facility actually treats their wastewater. The capacity charges reflect the projected capital cost for serving new customers through 2030. The calculation of capacity charges includes the costs of Brightwater as well as other capital facilities required to serve new customers tributary to the West Point and South Treatment Plants. The current capacity charge for single-family or single-family residential equivalent customer (residential equivalent of 750 cubic feet per month of winter water consumption) is $17.20 per month. Preliminary estimates indicate the capacity charge could increase to as much as $36.60 to support the Brightwater project, or a total accumulated amount over 15 years equivalent to $6,588.

The projected single-family residential equivalent service fee to cover the debt service and O&M costs for the entire King County wastewater system are summarized below:

Average Rate 2002-2030[a]	**Capacity Charge 2004[b]**	**Lump-sum with Discount[c]**	**Full-term[d]**
$23.87	$39.10	$3,984	$7,038

[a] Average rate adjusted for inflation, 2002 dollars

[b] Assumes charge increases at 3 percent per year from this base.

[c] If charge is paid in full at outset, includes 8% discount.

[d] Sum of payments over full 15-year term.

The preliminary rate projections reflect an assumed annual inflation of 3 percent on operational costs and the recommended implementation program as described in Chapter 5 and illustrated in Figure 6-1.

6.6 References

King County, 1997. *Regional Wastewater Services Plan*, Seattle, WA.

King County, 2002. *Brightwater Regional Wastewater Treatment System, Draft EIS Estimates, November 27, 2002.* Seattle, WA.

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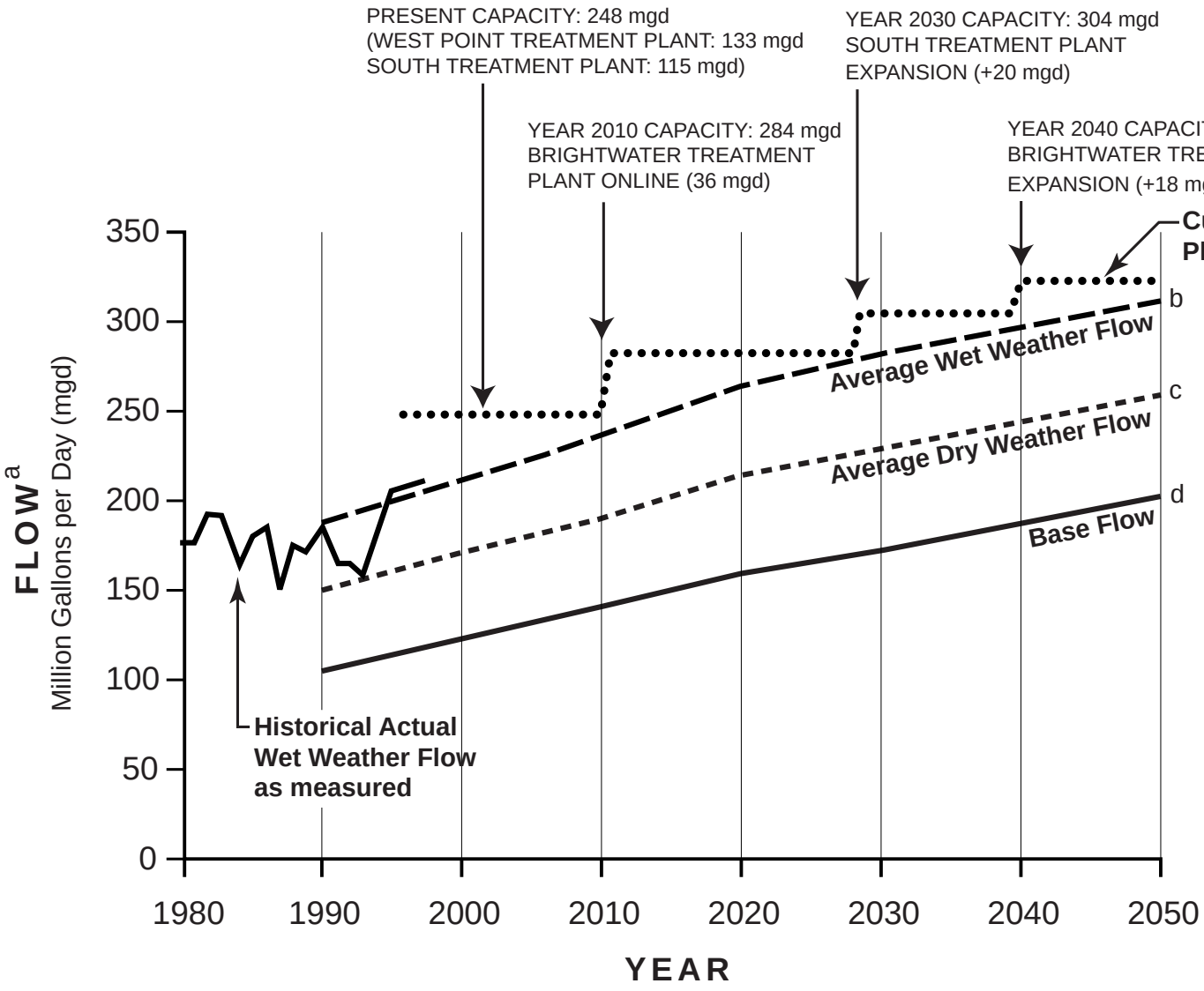
6-1 Brightwater Implementation Schedule



Notes:

a. Flow represents total to West Point, South, and Brightwater Treatment Plants.

b. AWWF is the average wet-weather flow during the relatively wet months of November through April.

c. Average dry weather flow (ADWF) is the average non-storm flow for the relatively dry months of May through October.

d. Base flow is wastewater flow that does not include inflow and infiltration.

e. Treatment plant capacities expressed as AWWF.

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Figure ES-1

Projected Treatment Plant Needs for West, East, and Brightwater Service Areas

BRIGHTWATER FACILITIES PLAN

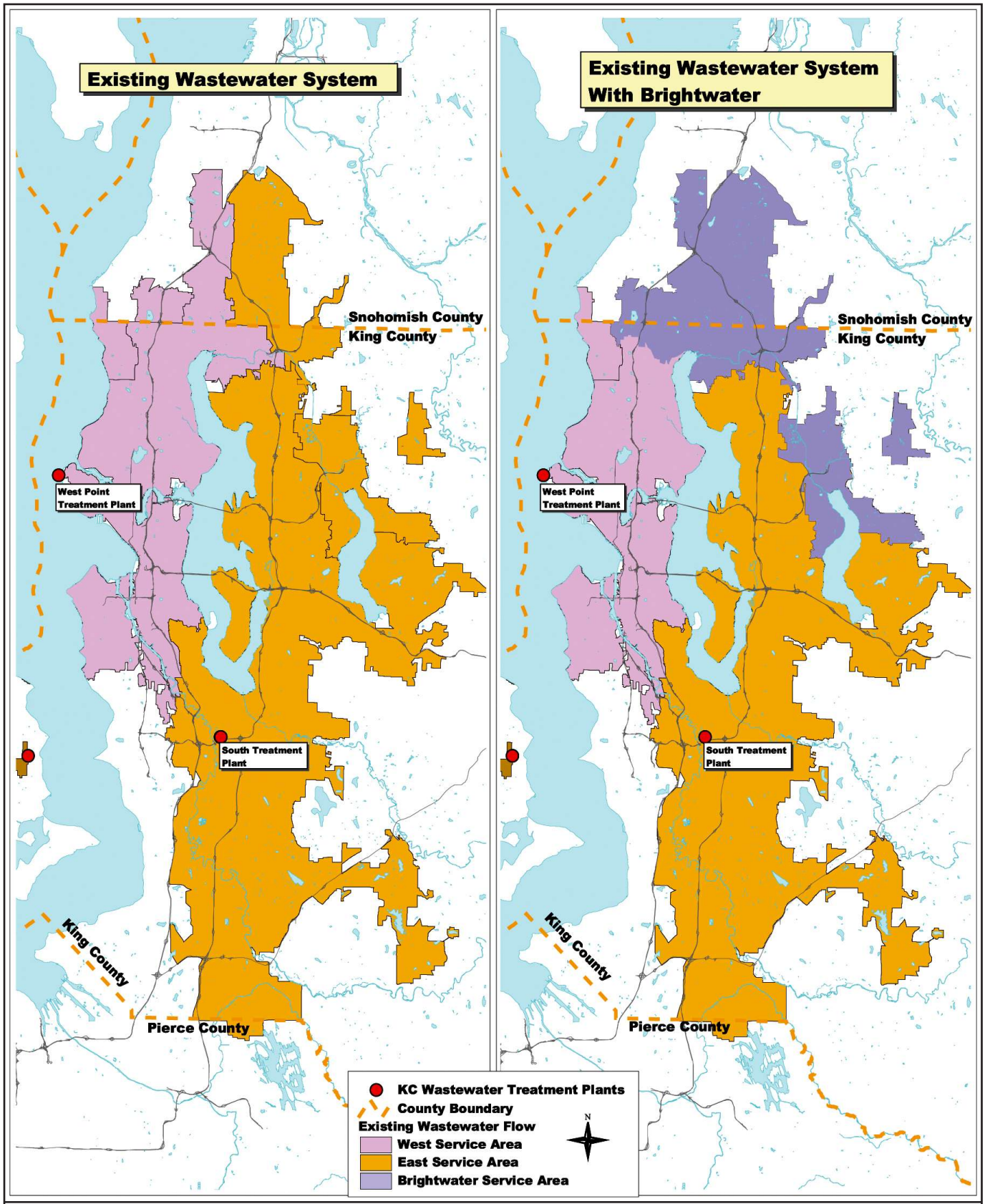

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Figure ES-2
Brightwater Service Area

BRIGHTWATER FACILITIES PLAN

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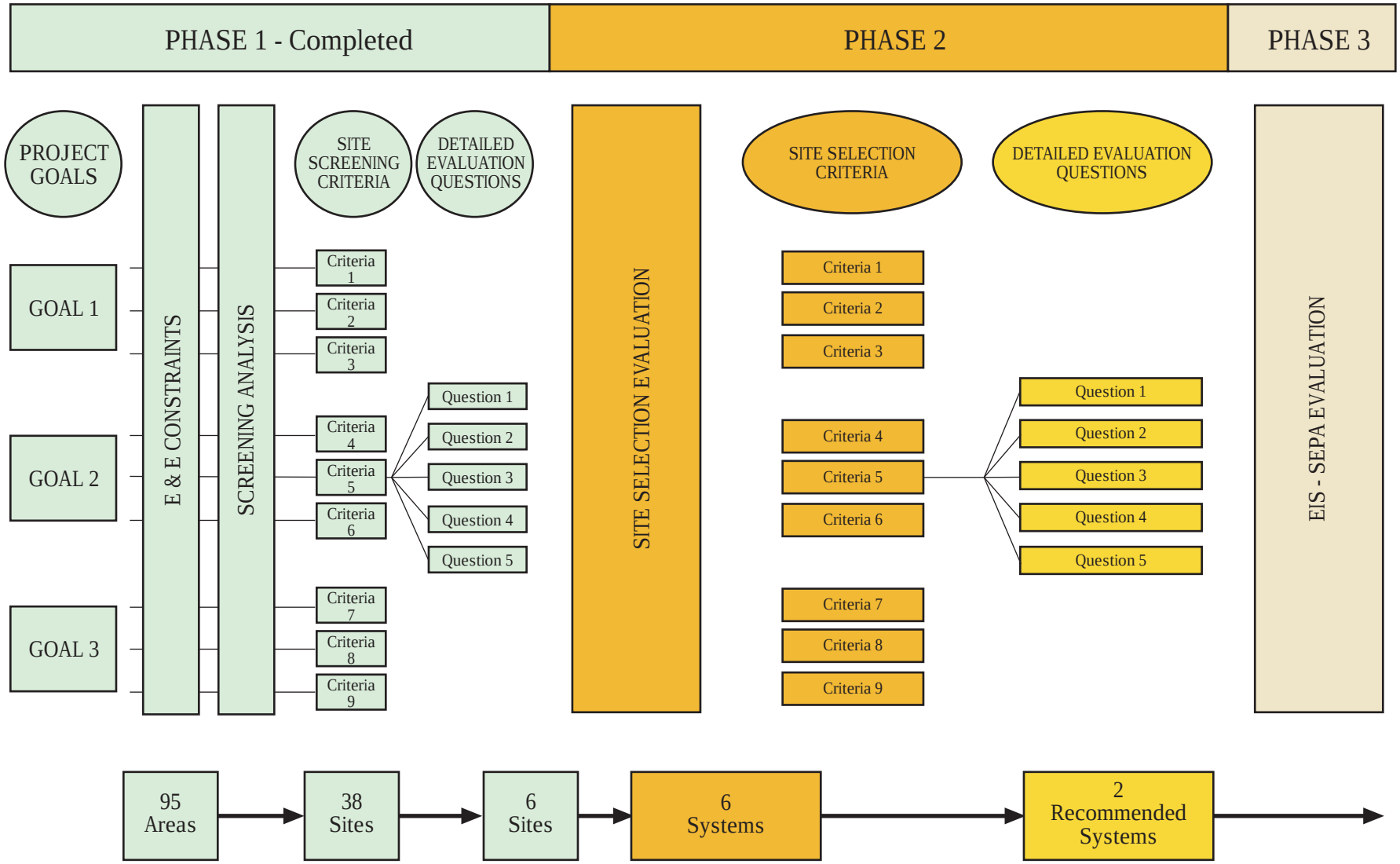

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File Name: 173243.16.01_W012003016SEA • FIG ES-3_Brightwater Siting Analysis Flow Chart • 04/22/03 • dk

Figure ES-3
Brightwater Siting Analysis Flow Chart

BRIGHTWATER FACILITIES PLAN

NOTES:

1. ODOR CONTROL NOT SHOWN IN PROCESS SCHEMATIC.
2. SEE PRELIMINARY DESIGN CRITERIA TABLE FOR EQUIPMENT SIZING.
3. SODIUM HYPOCHLORITE ADDED ON -SITE FOR DISINFECTION. CONTACT TIME PROVIDED IN EFFLUENT CONVEYANCE LINE.
4. VALVES, GATES, AND OTHER FLOW CONTROL APPURTENANCES NOT SHOWN.

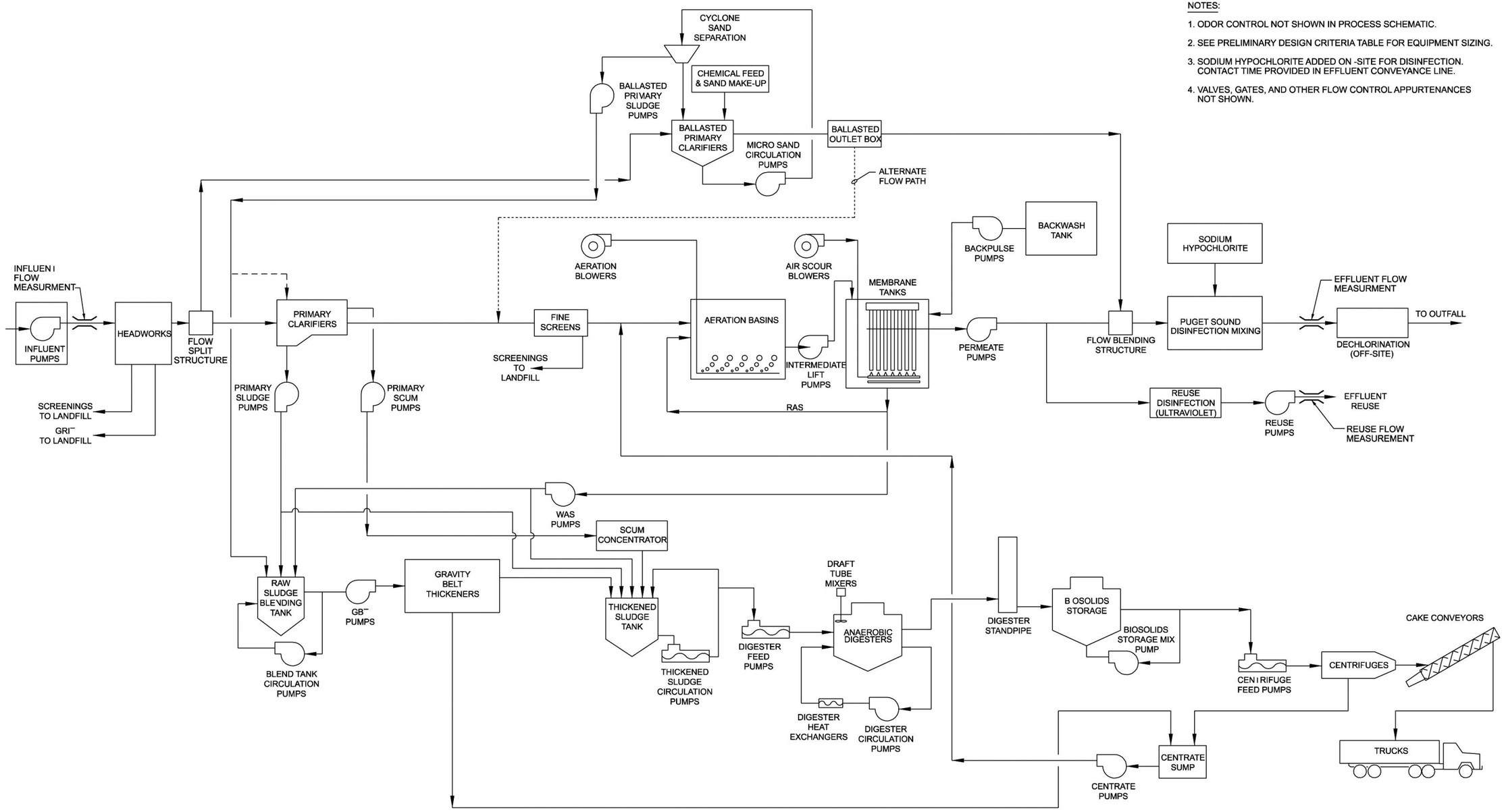

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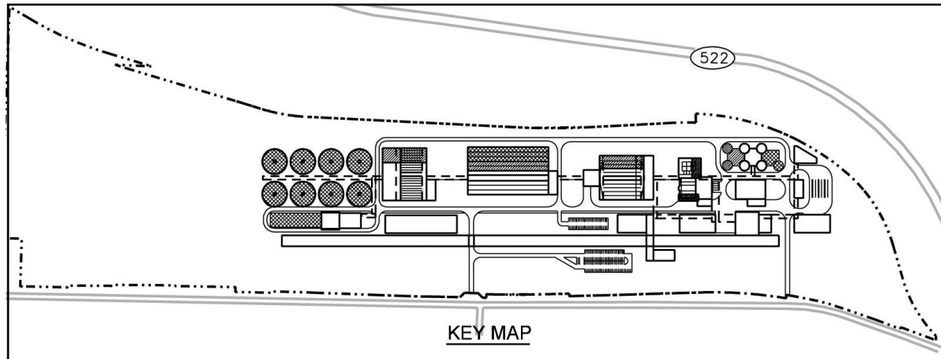
Figure ES-4
Treatment Process Schematic

BRIGHTWATER FACILITIES PLAN



KEY MAP

Legend

- 36 MGD FACILITIES
- ADDITIONAL FACILITIES FOR EXPANSION TO 54 MGD
- POTENTIAL ADDITIONAL FACILITIES
- ODOR CONTROL
- (X) FACILITY NUMBER

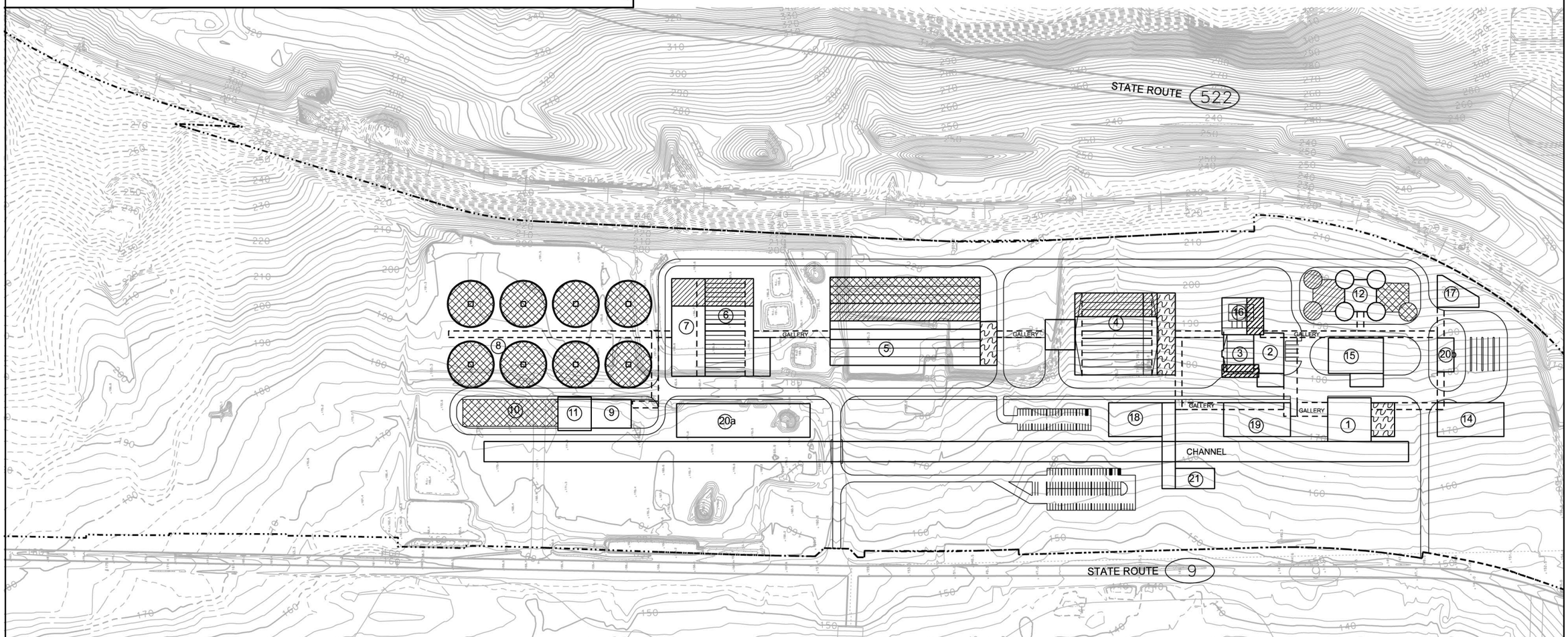
NO.	FACILITY	NO.	FACILITY
1	Influent Pump Station	11	Reuse Water Pump Station
2	Headworks Building	12	Anaerobic Digesters
3	Grit Removal (Aerated or Vortex)	13	Effluent Pump Station (if required)
4	Primary Clarification	14	Chemical Building
5	Aeration Basins	15	Thickening/Dewatering
6	Membrane Tanks	16	Ballasted Clarification (for Split Flow)
7	Membrane Support Building	17	Cogeneration
8	Secondary Clarifiers (if required)	18	Administration Building
9	Disinfection, Reuse, 5 mgd	19	Maintenance Building
10	Future Disinfection, 56 mgd	20	Electrical Substation
		21	Education Building

NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL.
2. THE FOLLOWING FACILITIES ARE NOT SHOWN ON THIS SITE PLAN:
   -EFFLUENT PUMP STATION

N

0 150 300 450
Scale In Feet



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File Name: 173243.16.01_W012003016SEA • FIG ES-5_Preliminary Site Plan • 04/22/03 • dk

Figure ES-5
Preliminary Site Plan, Brightwater Treatment Facilities

BRIGHTWATER FACILITIES PLAN

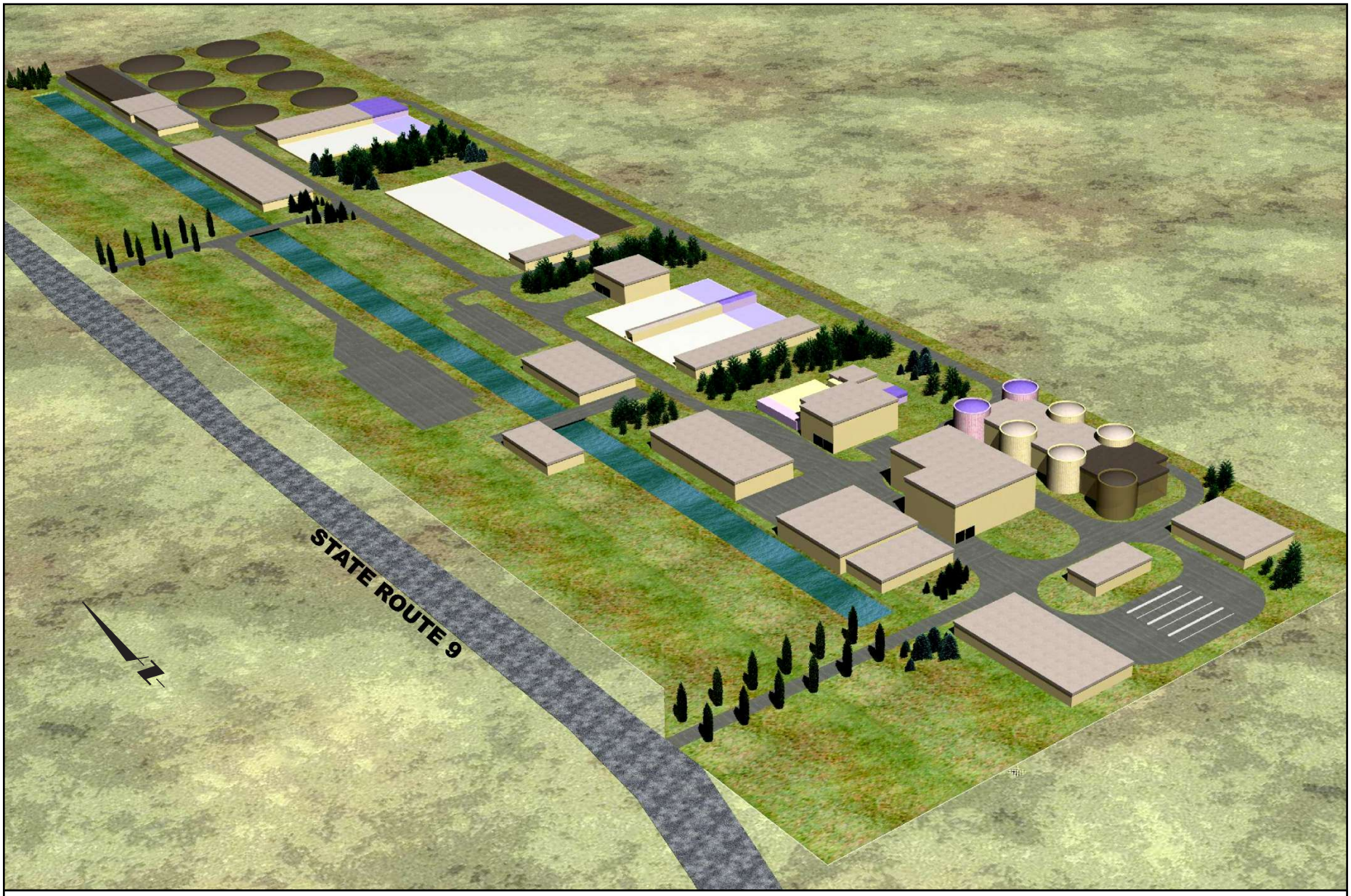

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Figure ES-6
Conceptual Rendering, Brightwater Treatment Facilities

BRIGHTWATER FACILITIES PLAN

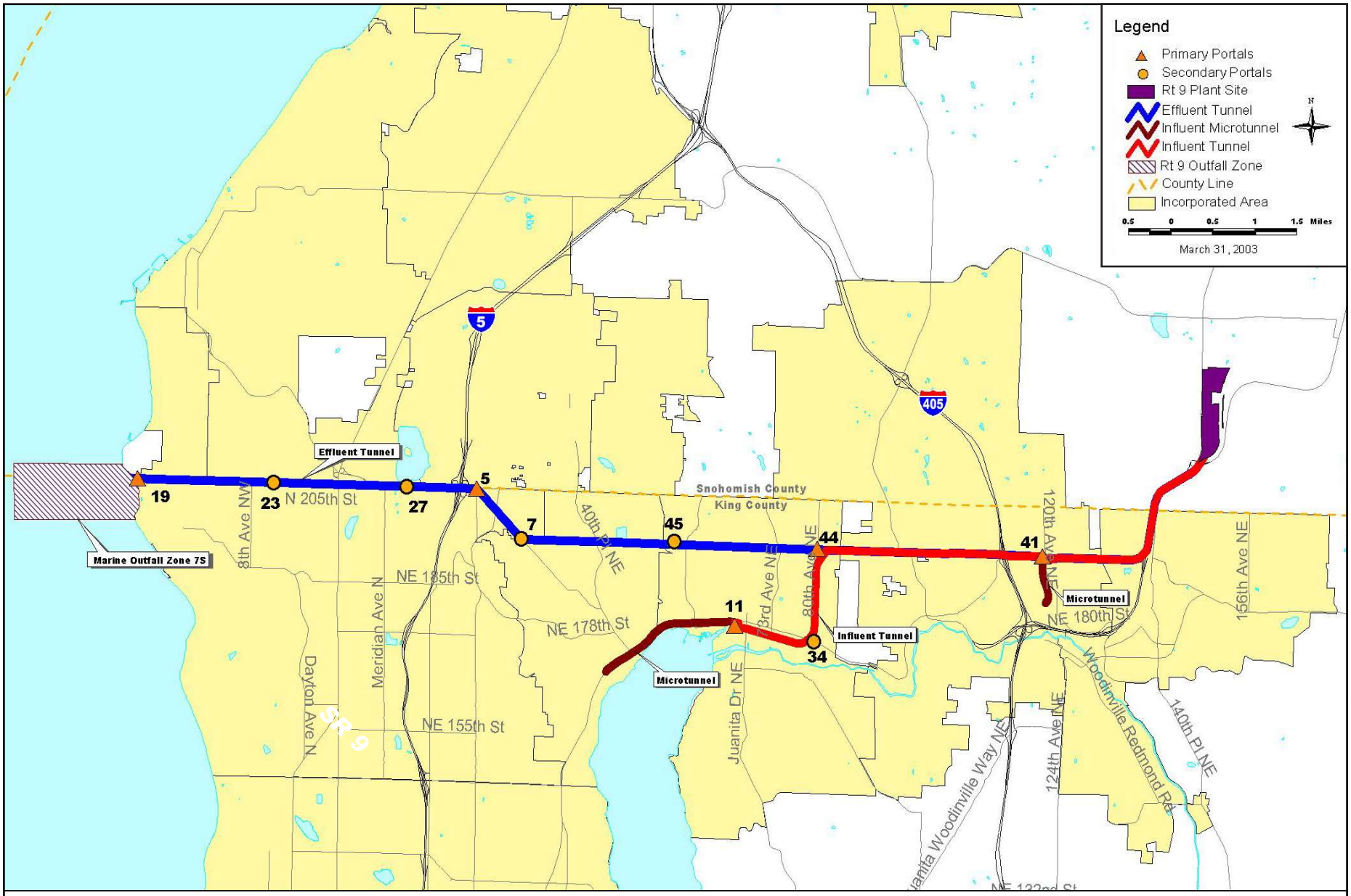

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Figure ES-7
Route 9 - 195th Street System Alternative

BRIGHTWATER FACILITIES PLAN

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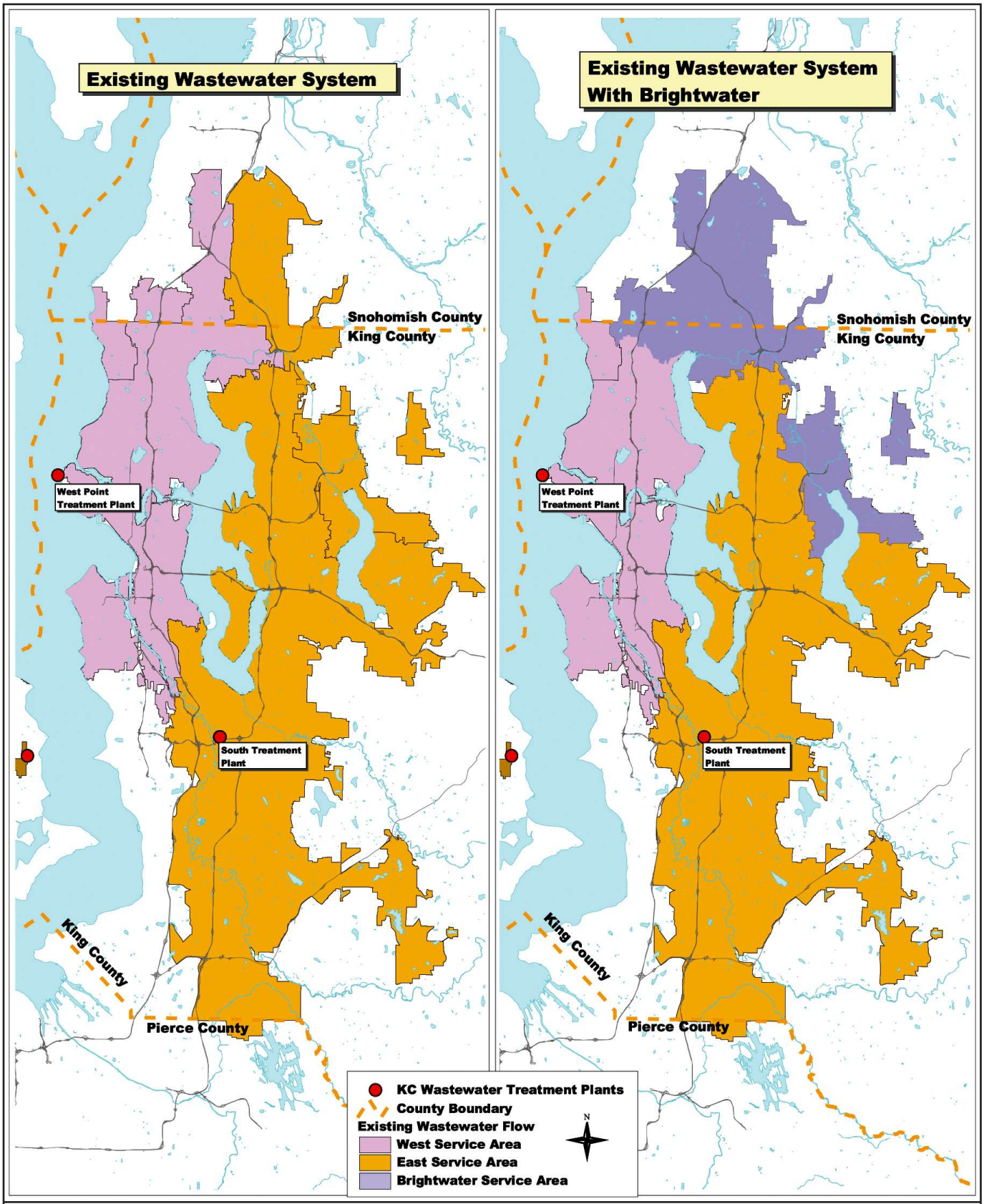

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Figure 1-1
Brightwater Service Area

BRIGHTWATER FACILITIES PLAN

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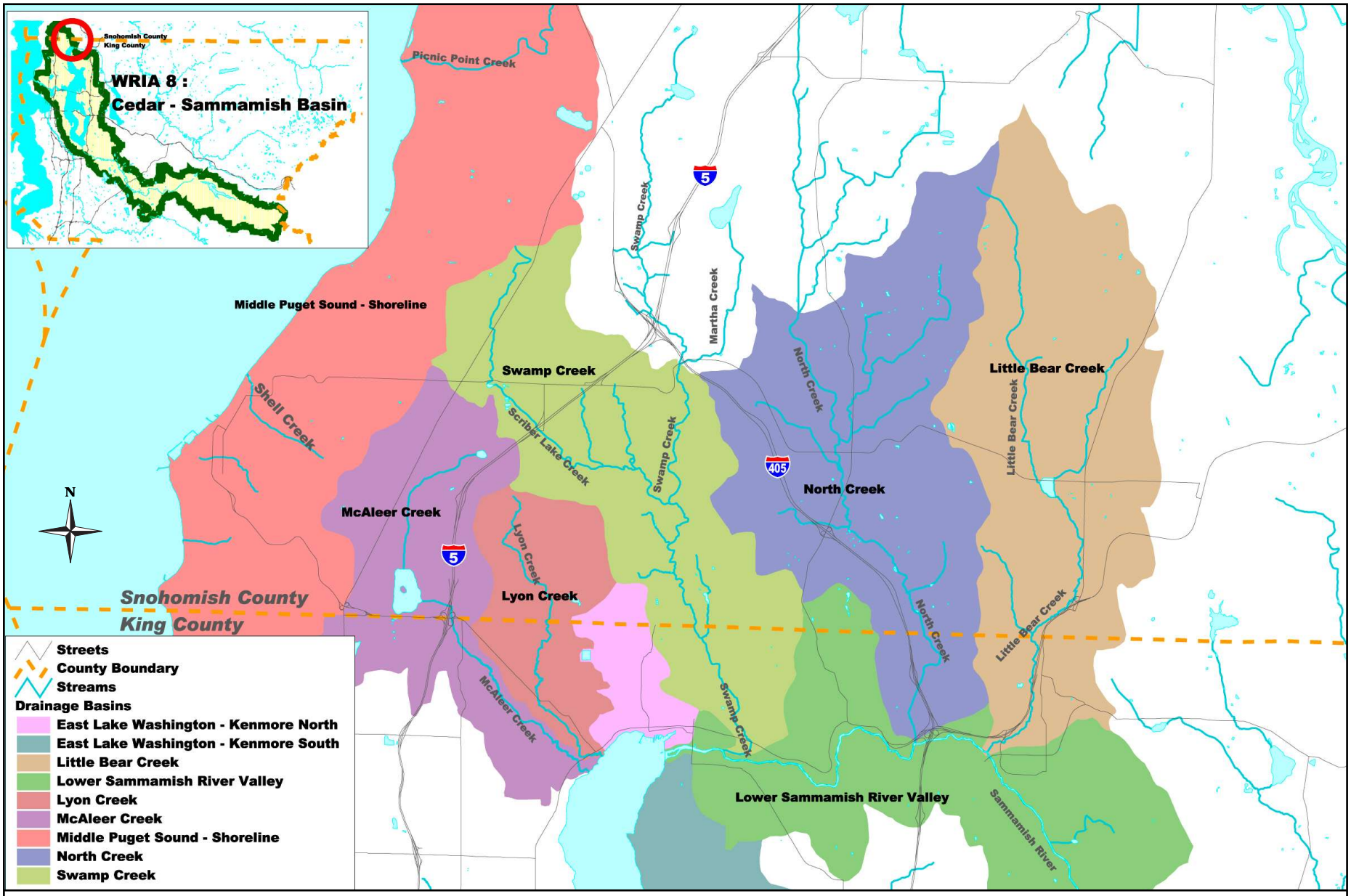

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Figure 2-1
Surface Water Resources in Brightwater Project Area

BRIGHTWATER FACILITIES PLAN

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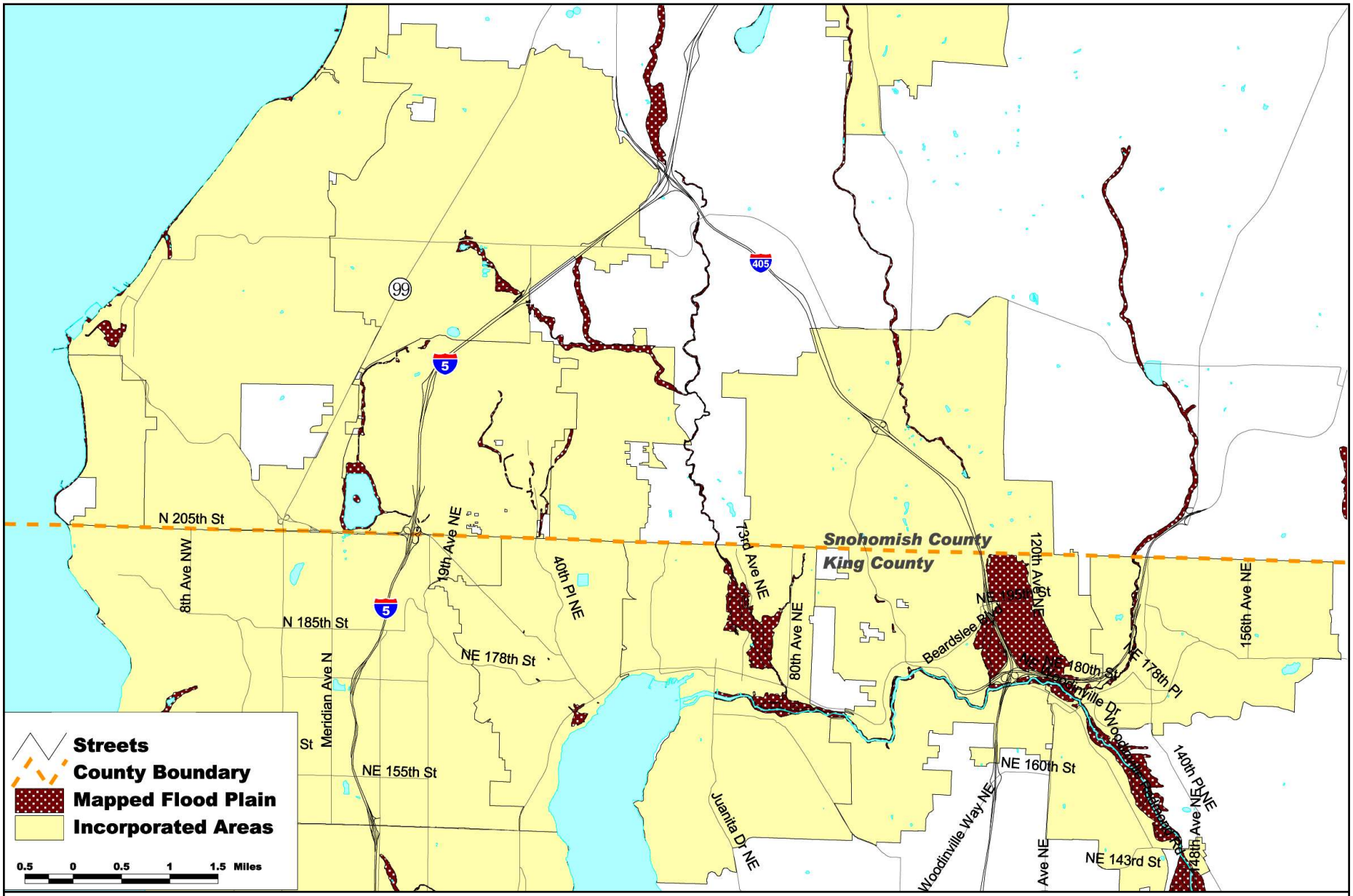

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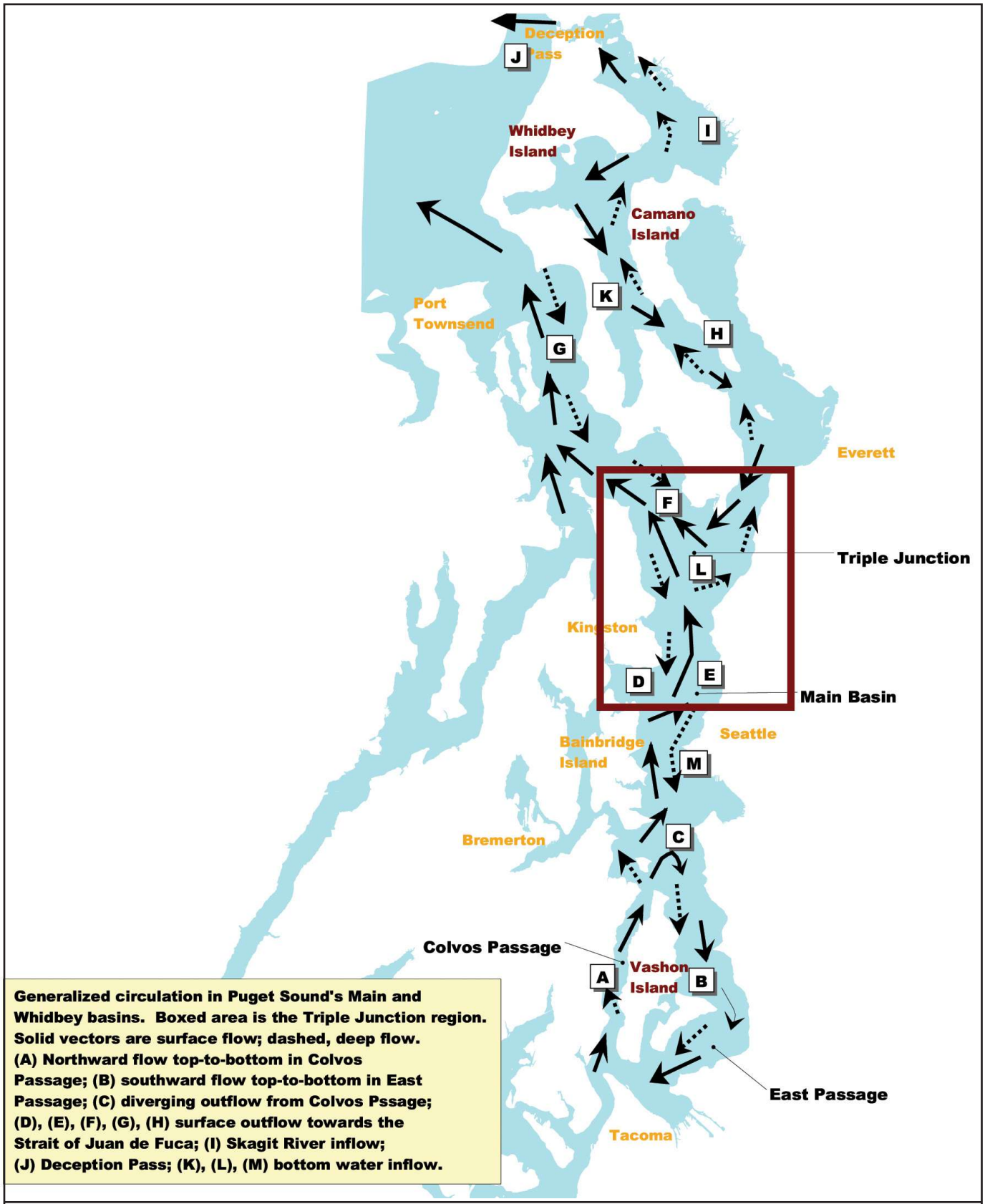
Figure 2-2
Flood Plains in the Project Area

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-2_Flood Plains in the Project Area • 04/17/03 • gm/dk



Generalized circulation in Puget Sound's Main and Whidbey basins. Boxed area is the Triple Junction region. Solid vectors are surface flow; dashed, deep flow. (A) Northward flow top-to-bottom in Colvos Passage; (B) southward flow top-to-bottom in East Passage; (C) diverging outflow from Colvos Pssage; (D), (E), (F), (G), (H) surface outflow towards the Strait of Juan de Fuca; (I) Skagit River inflow; (J) Deception Pass; (K), (L), (M) bottom water inflow.

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File Name: 173243.16.01_W012003016SEA • FIG 2-3_Vicinity Map & Circulation • 04/17/03 • gm/dk

Figure 2-3
Vicinity Map and Schematic Circulation in Puget Sound

BRIGHTWATER FACILITIES PLAN

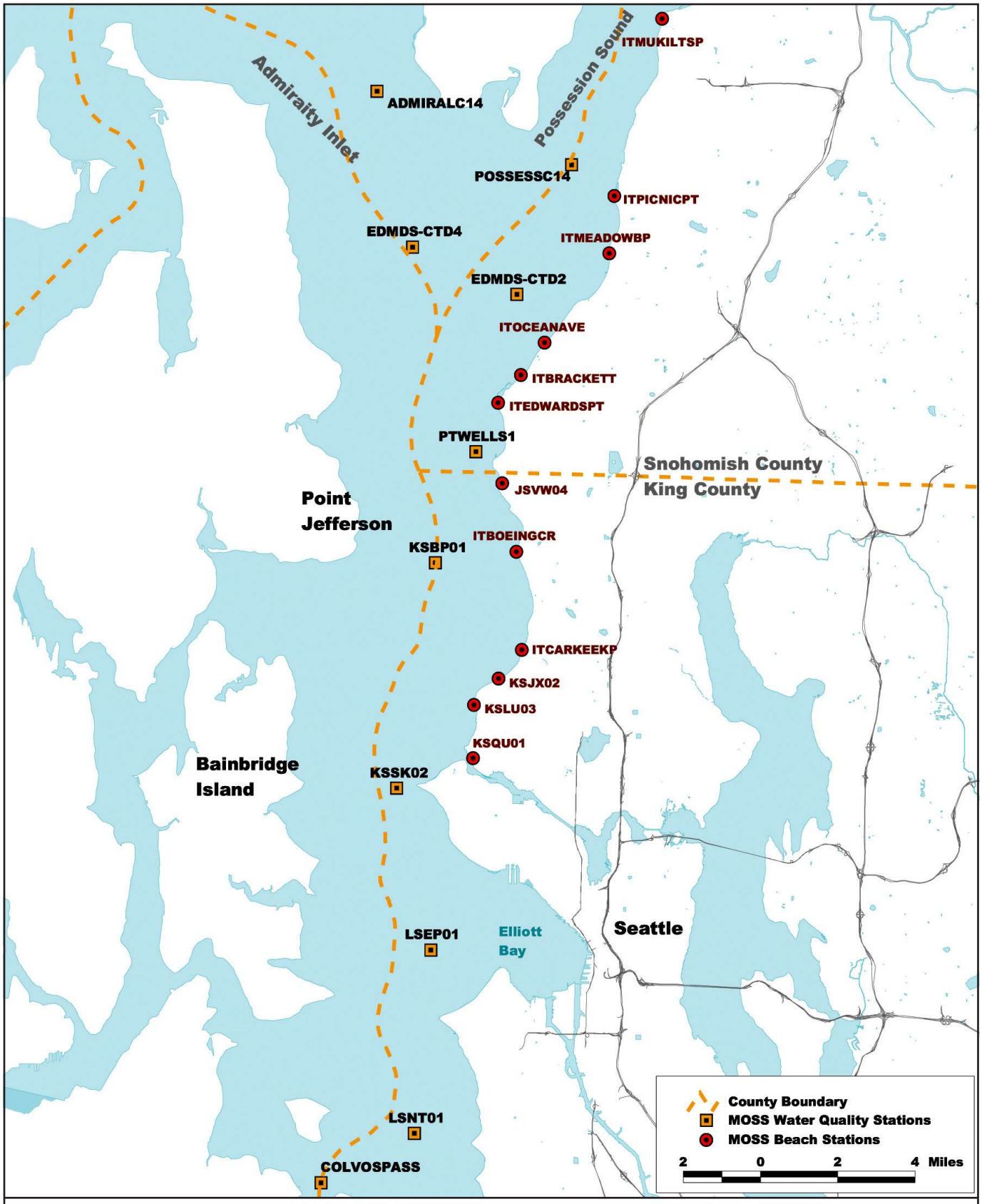

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Figure 2-4
Puget Sound Water Quality Sampling Stations

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-4_Puget Sound Water Sampling Stations • 04/17/03 • gm/dk

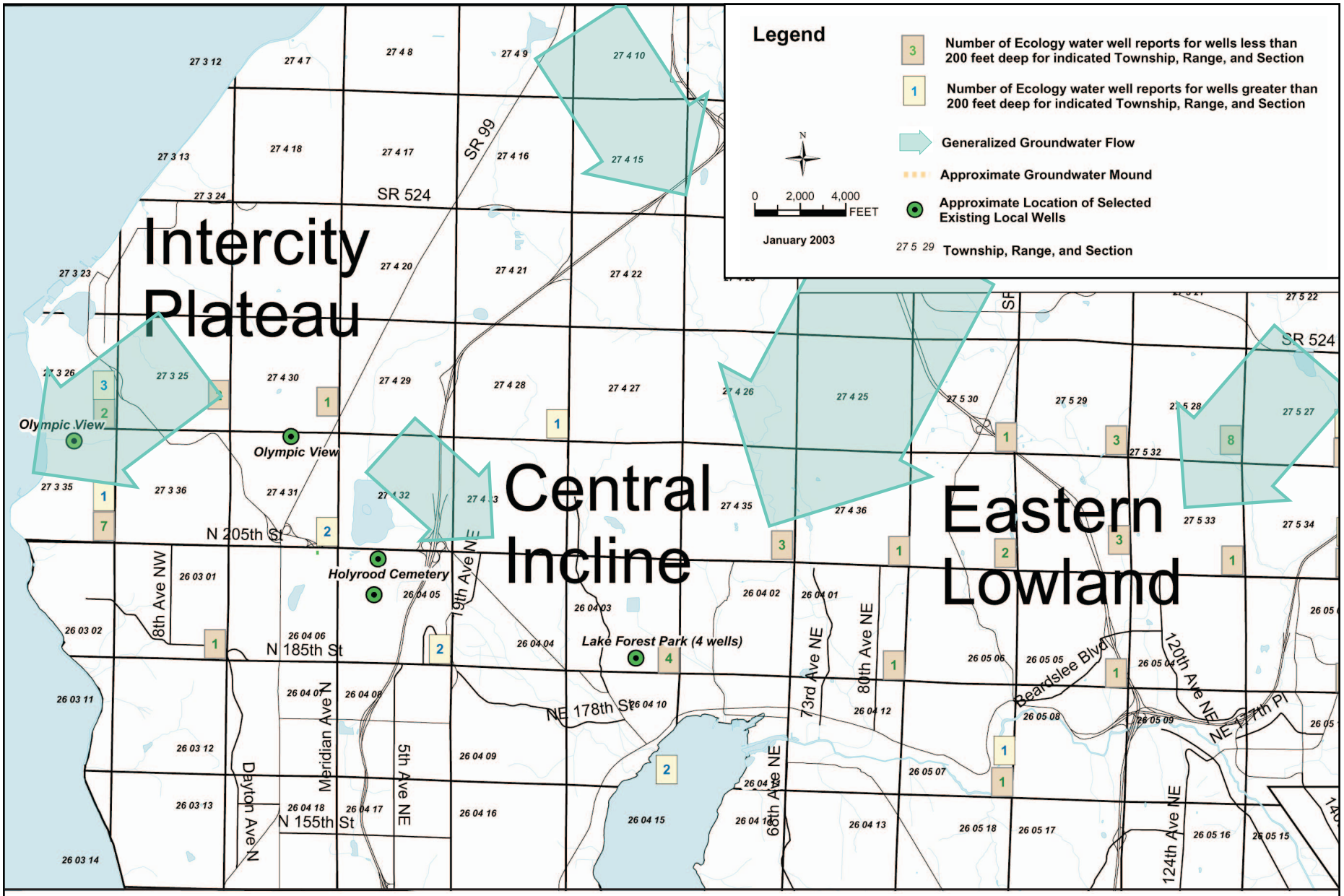

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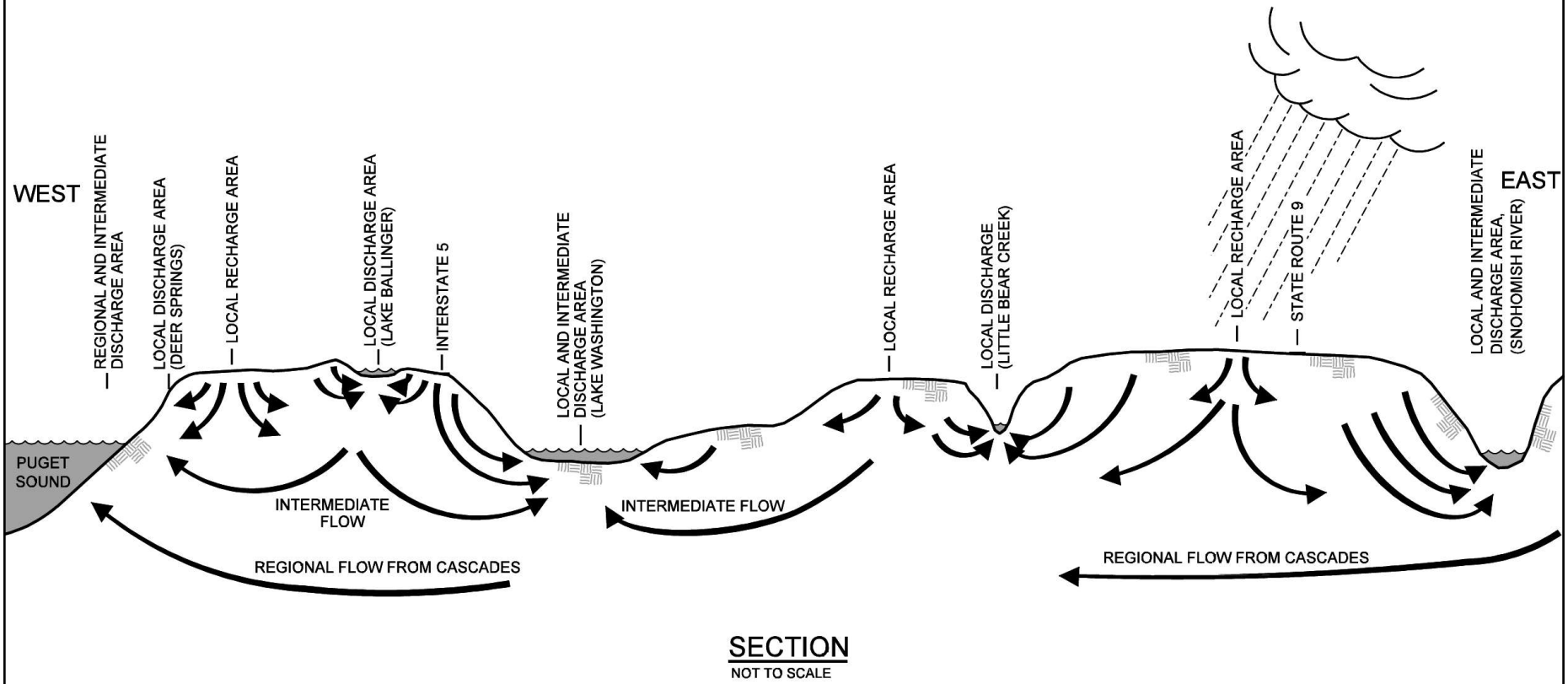
Figure 2-5
Groundwater Features in the Project Area

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-5_Groundwater Features • 04/17/03 • gm/dk



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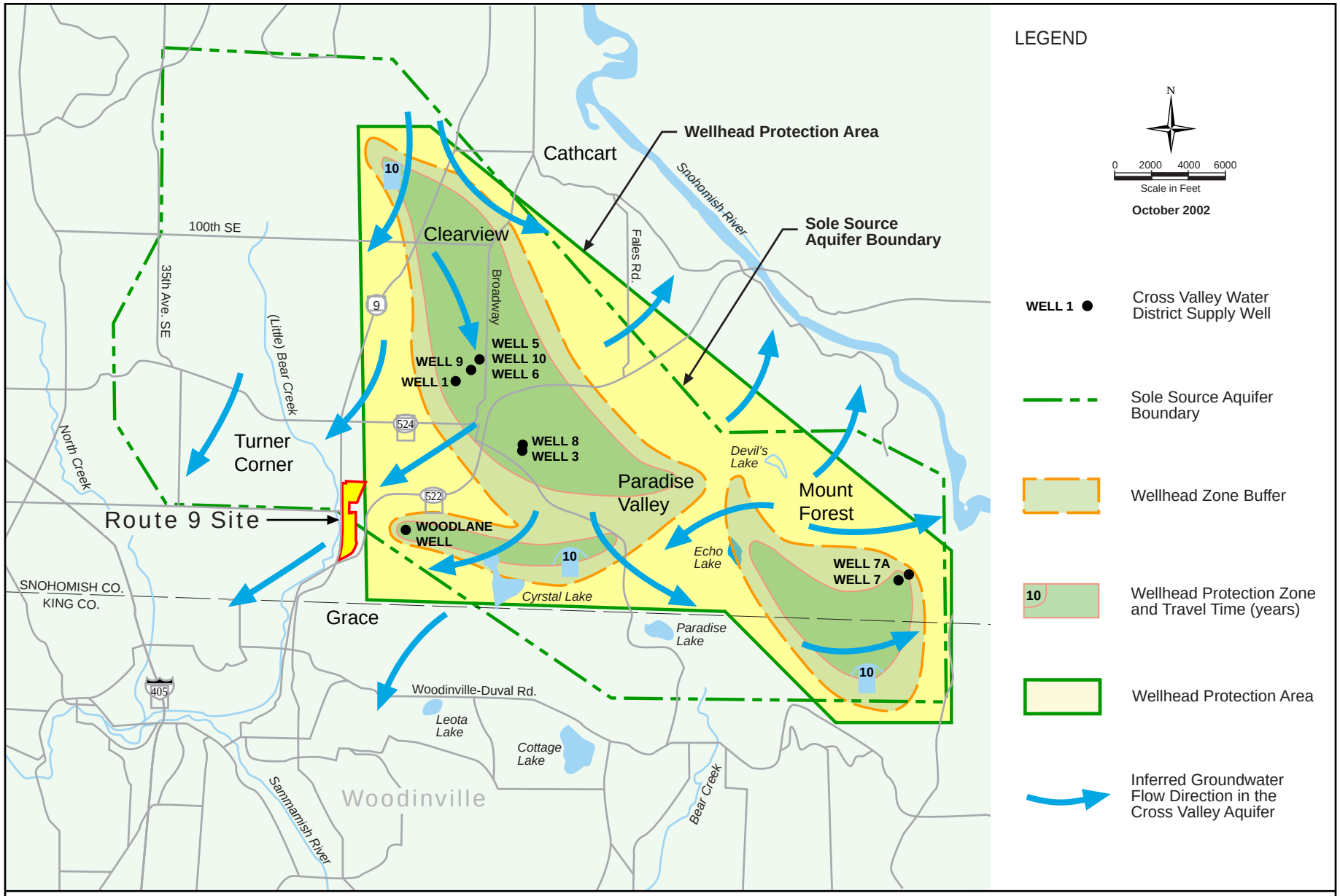
File Name: 173243.16.01_W012003016SEA • FIG 2-6_Conceptual Hydrogeological Flow Model • 04/18/03 • dk

Figure 2-6
Conceptual Hydrogeological Flow Model

BRIGHTWATER FACILITIES PLAN



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Data Sources: Cross Valley Water District **Prepared by:** CH2M HILL

File Name: 157689.P3.EP.31_W082002002SEA • EARTH • FIG 04-06_Cross_Valley_Aquifer_Protection_Area_v2 • 10/20/02 • dk/mm

Figure 2-7
Cross Valley Aquifer

BRIGHTWATER DRAFT EIS

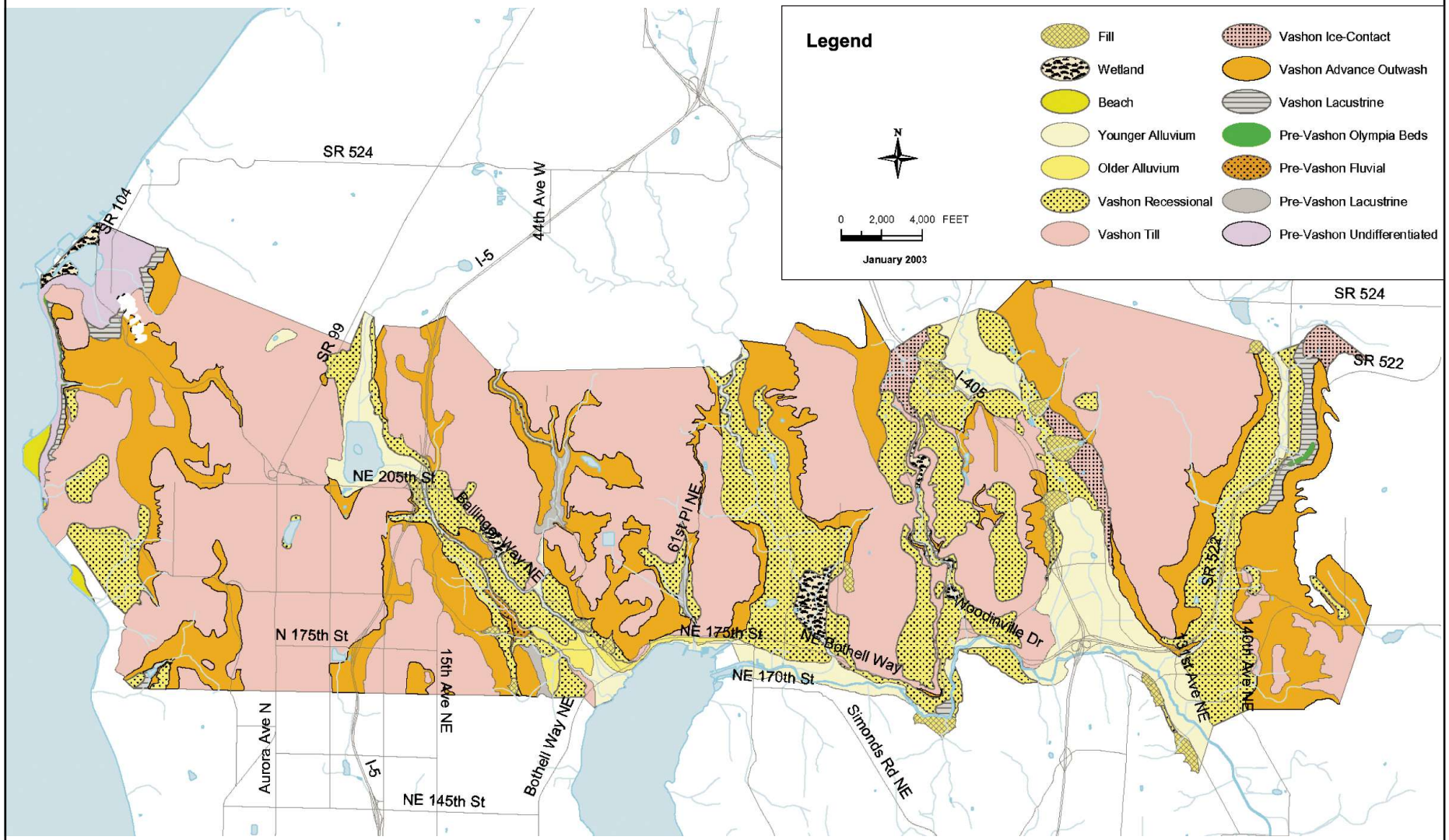

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Figure 2-8
Surficial Geology in the Project Area

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-8_Surficial Geology in the Project Area • 04/17/03 • gm/dk

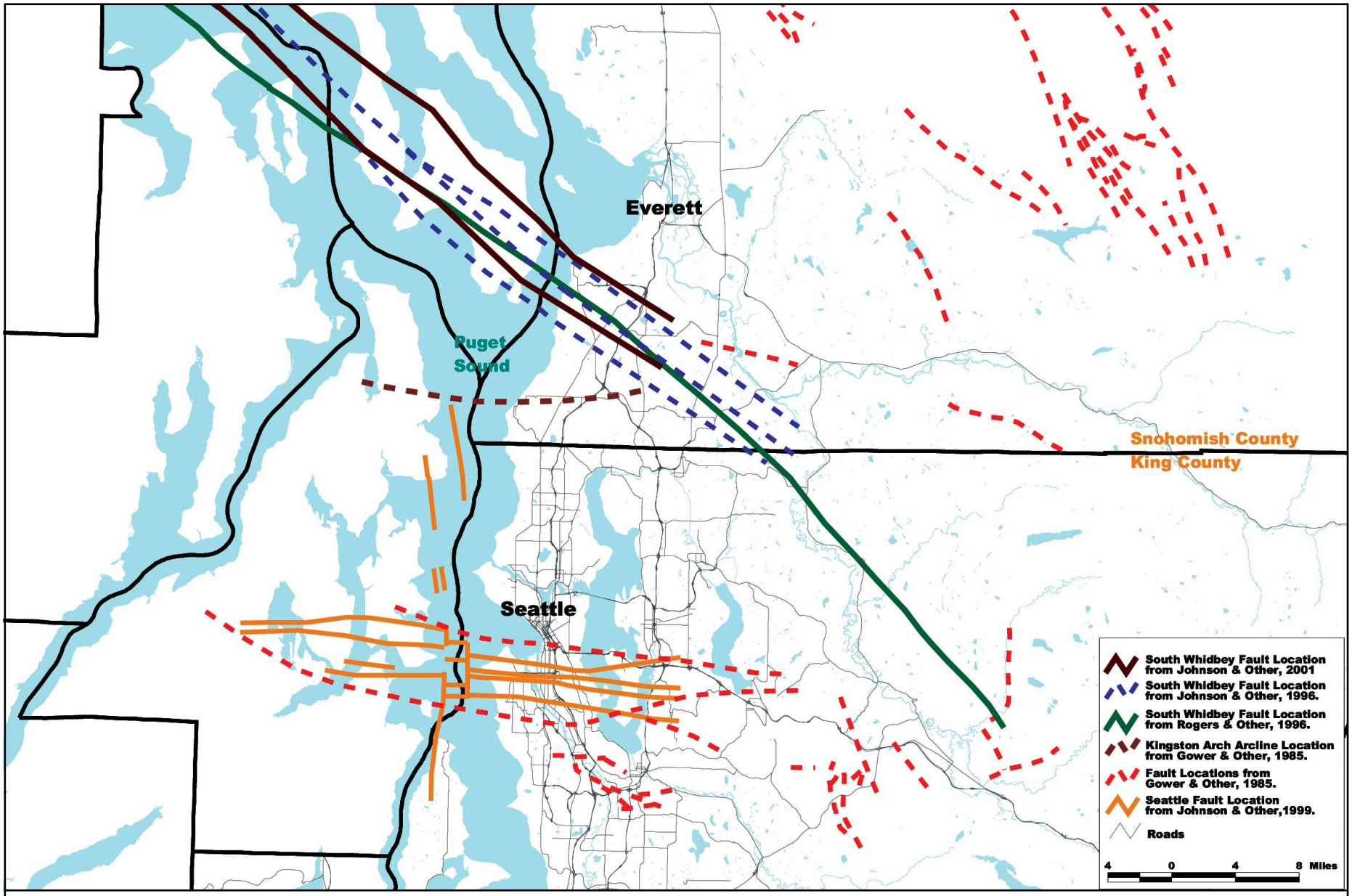

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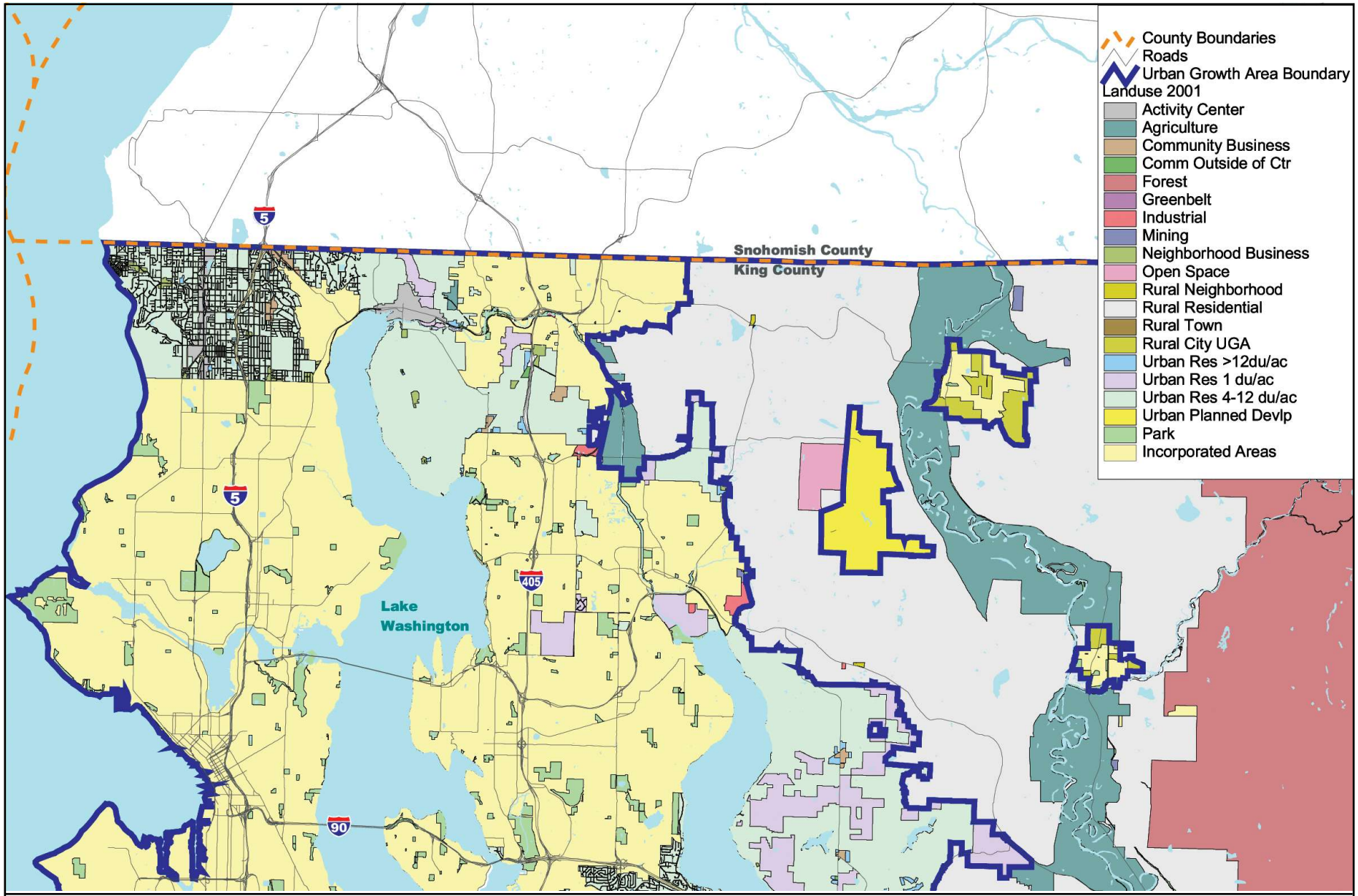
Figure 2-9
Major Geologic Structural Feature Locations in the Project Vicinity

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-9_Major Geologic Structural Features • 04/17/03 • gm/dk



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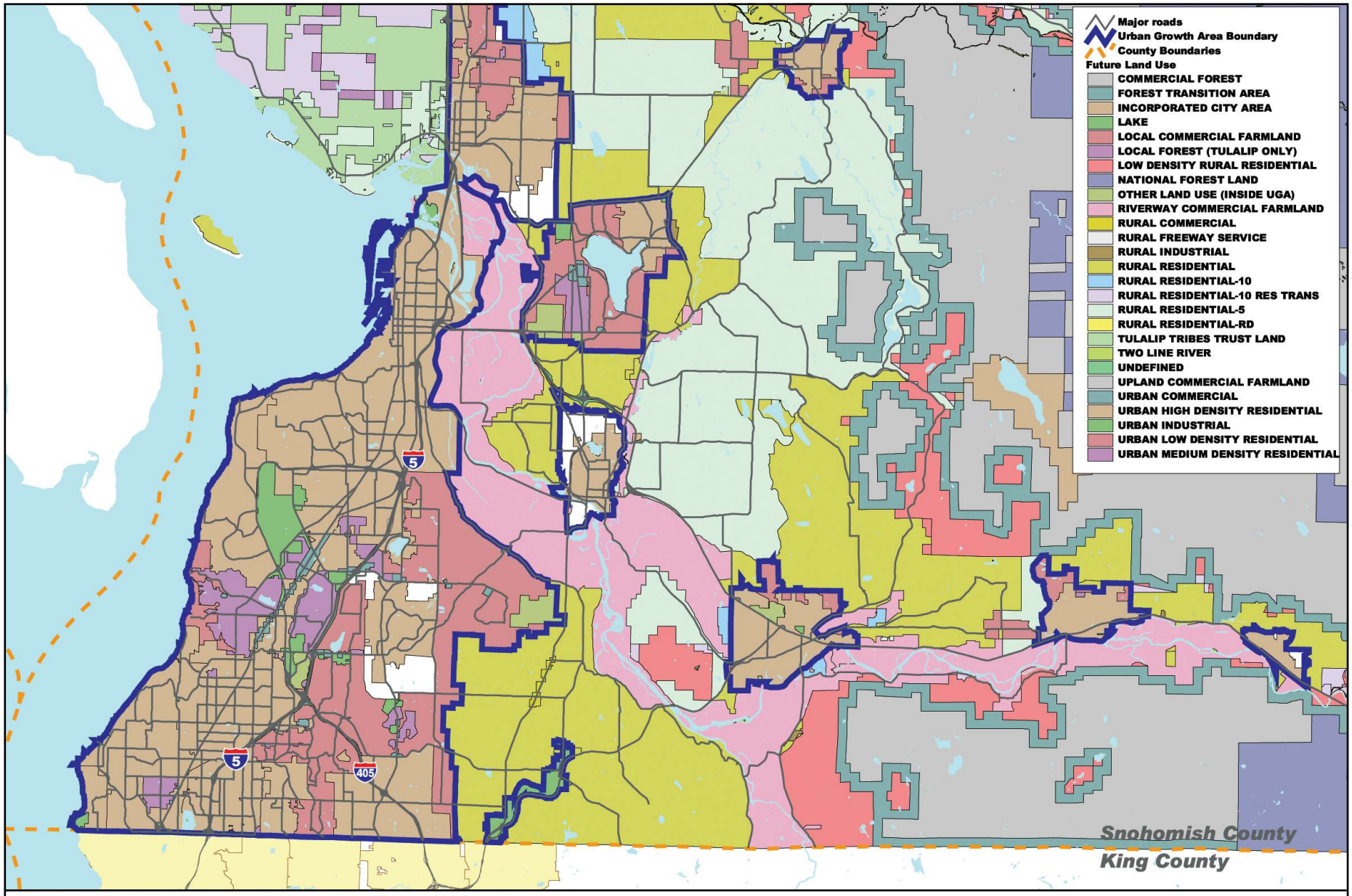
N

1 0 1 2 3 Miles

Figure 2-10
North King County Land Use

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-10_North King County Land Use • 04/18/03 • gm/dk



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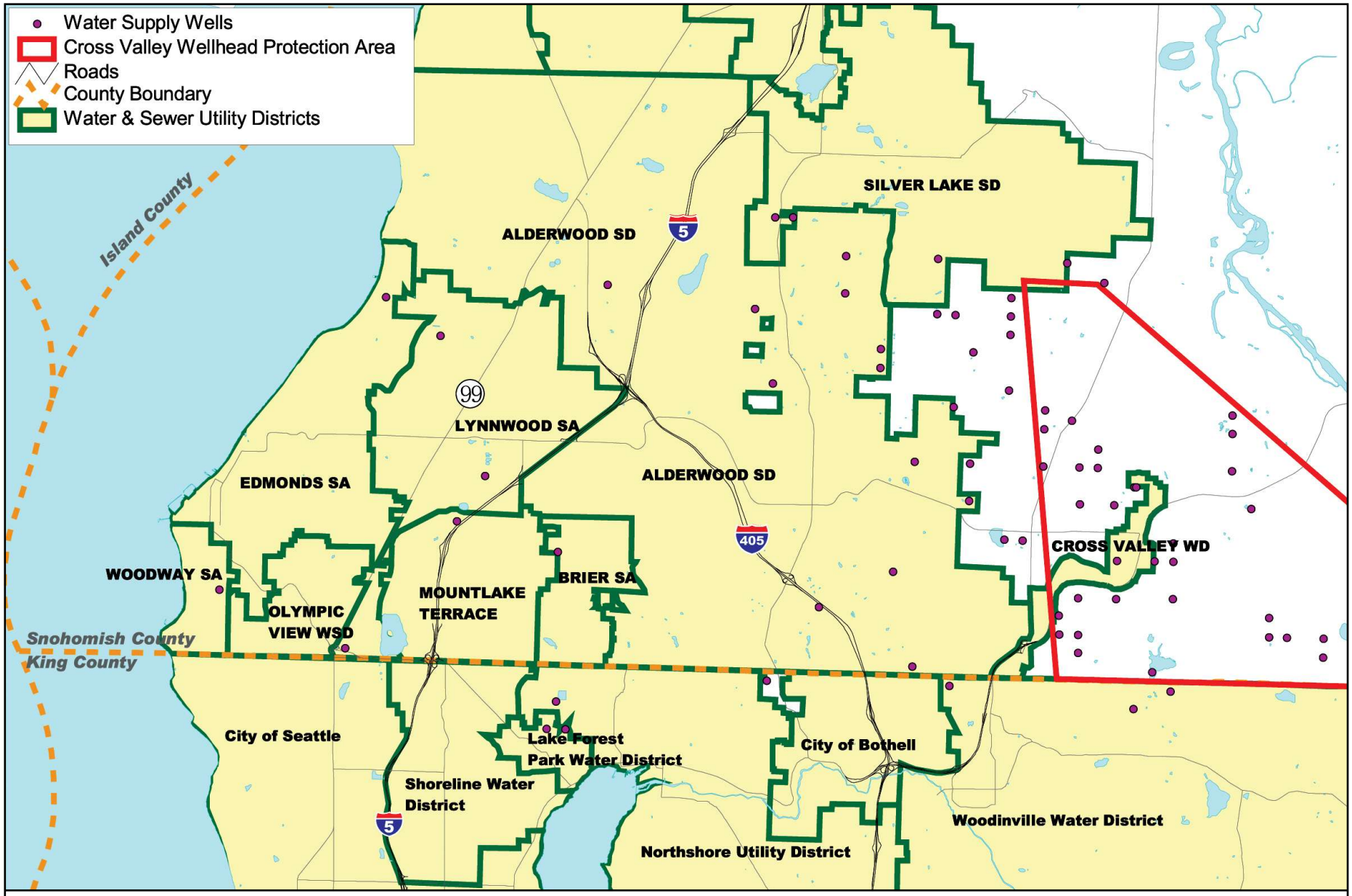
N

1 0 1 2 Miles

Figure 2-11
South Snohomish County Land Use

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-11_South Snohomish County Land Use • 04/18/03 • gm/dk



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N

1 0 1 2 Miles

Figure 2-12
Major Public Water Systems

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-12_Major Public Water Systems • 04/18/03 • gm/dk

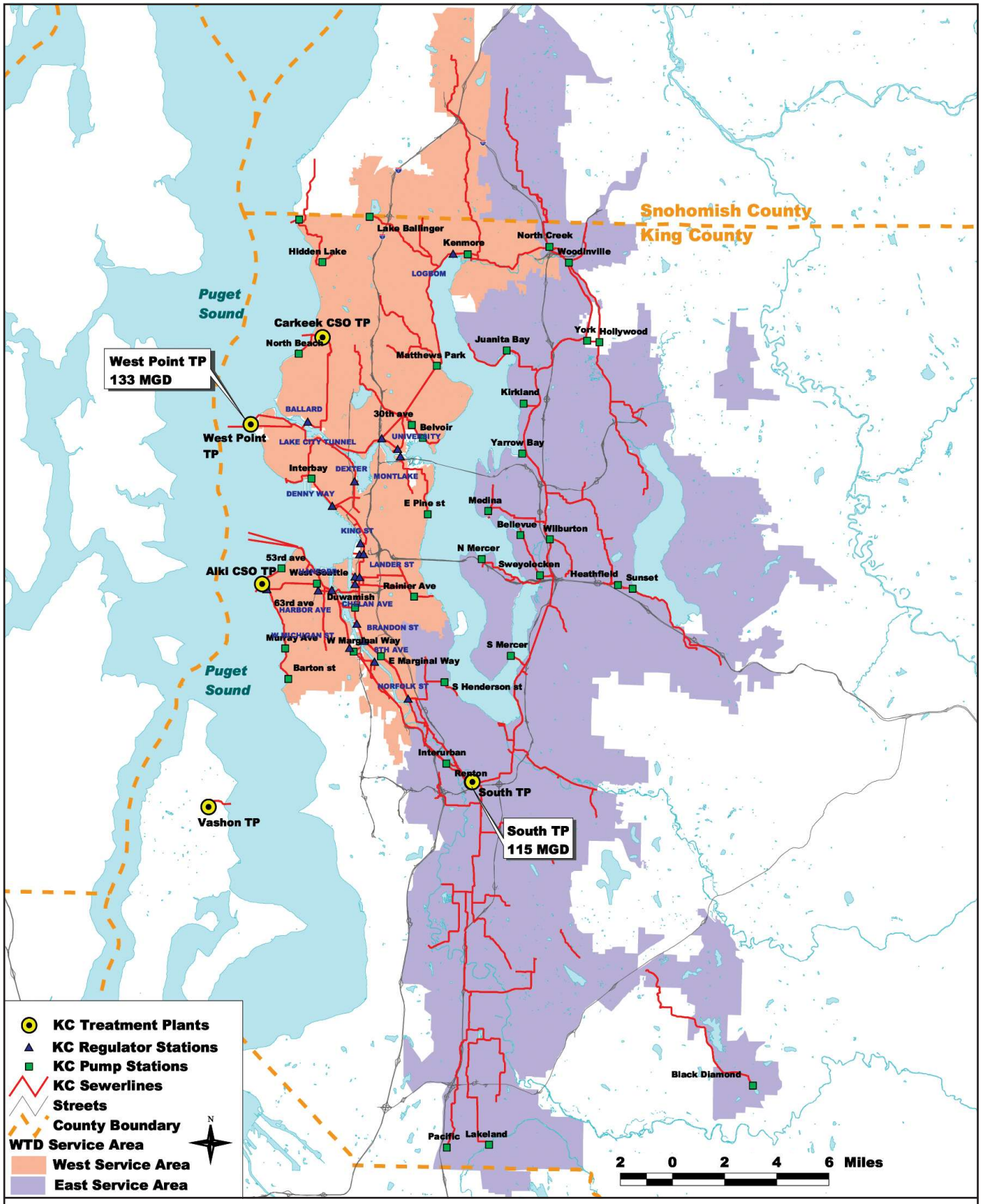

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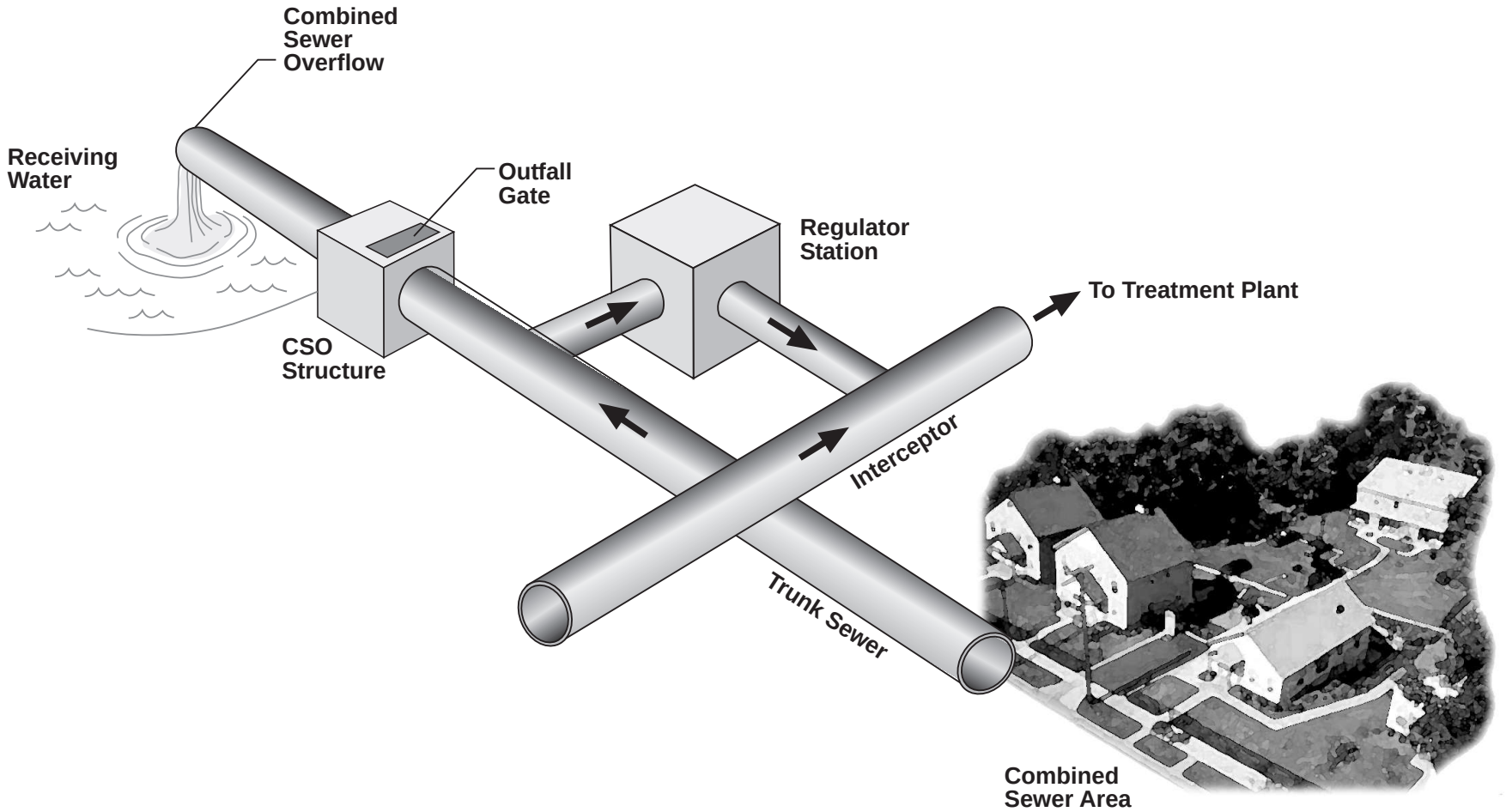
Figure 2-13
Existing Wastewater System

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-13_Existing Wastewater System • 04/18/03 • gm/dk



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File Name: 173243.16.01_W012003016SEA • FIG 2-14_Schematic of Typical Regulator Station • 04/18/03 • dk

Figure 2-14
Schematic Drawing of Typical Regulator Station

BRIGHTWATER FACILITIES PLAN

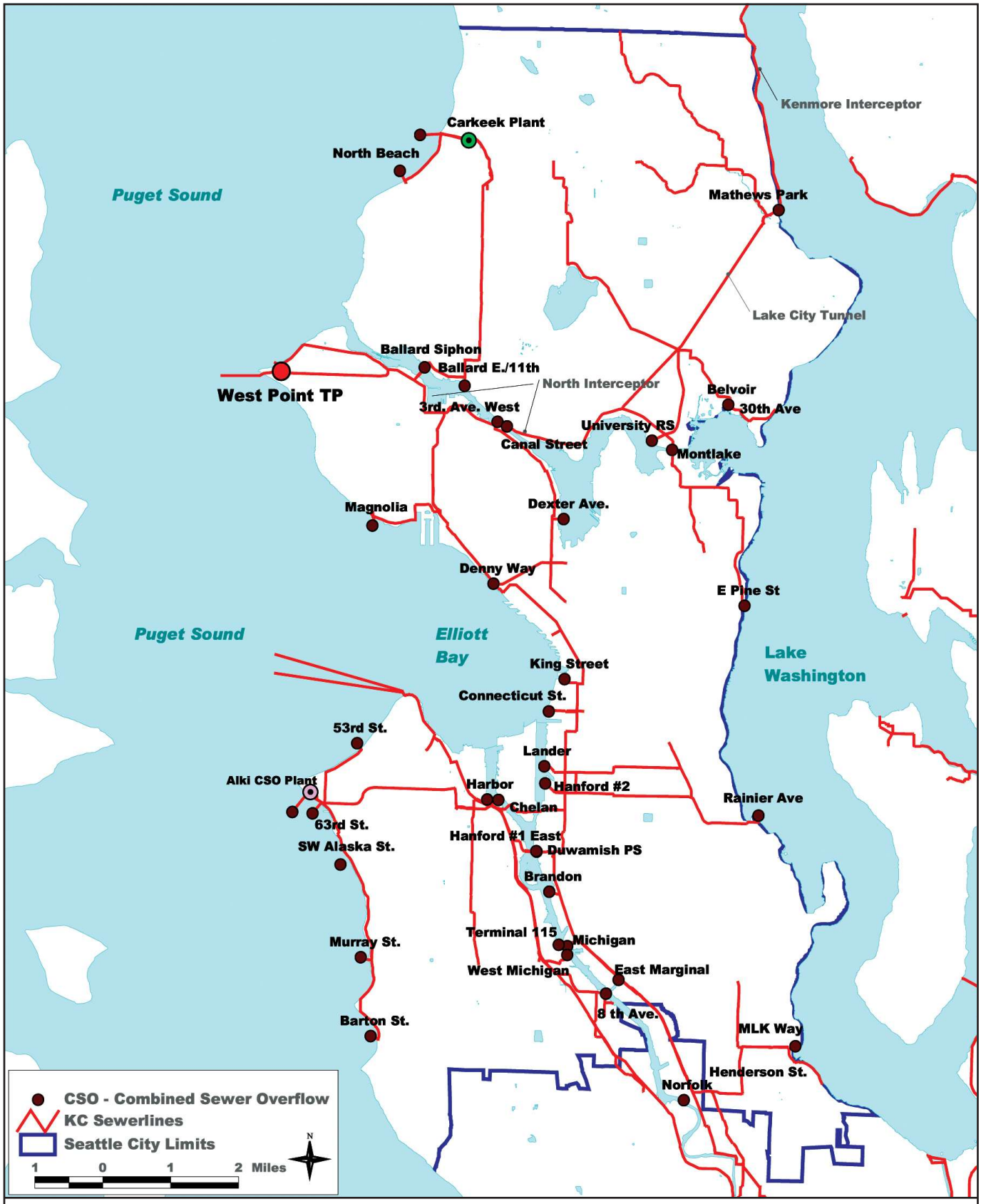

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Figure 2-15
Combined Sewer Overflow Locations

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-15_Combined Sewer Overflow Locations • 04/18/03 • gm/dk

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File Name: 173243.16.01_W012003016SEA • FIG 2-16_West Point Treatment Plant • 05/1/03 • dk

Figure 2-16
West Point Treatment Plant, Aerial Photograph

BRIGHTWATER FACILITIES PLAN

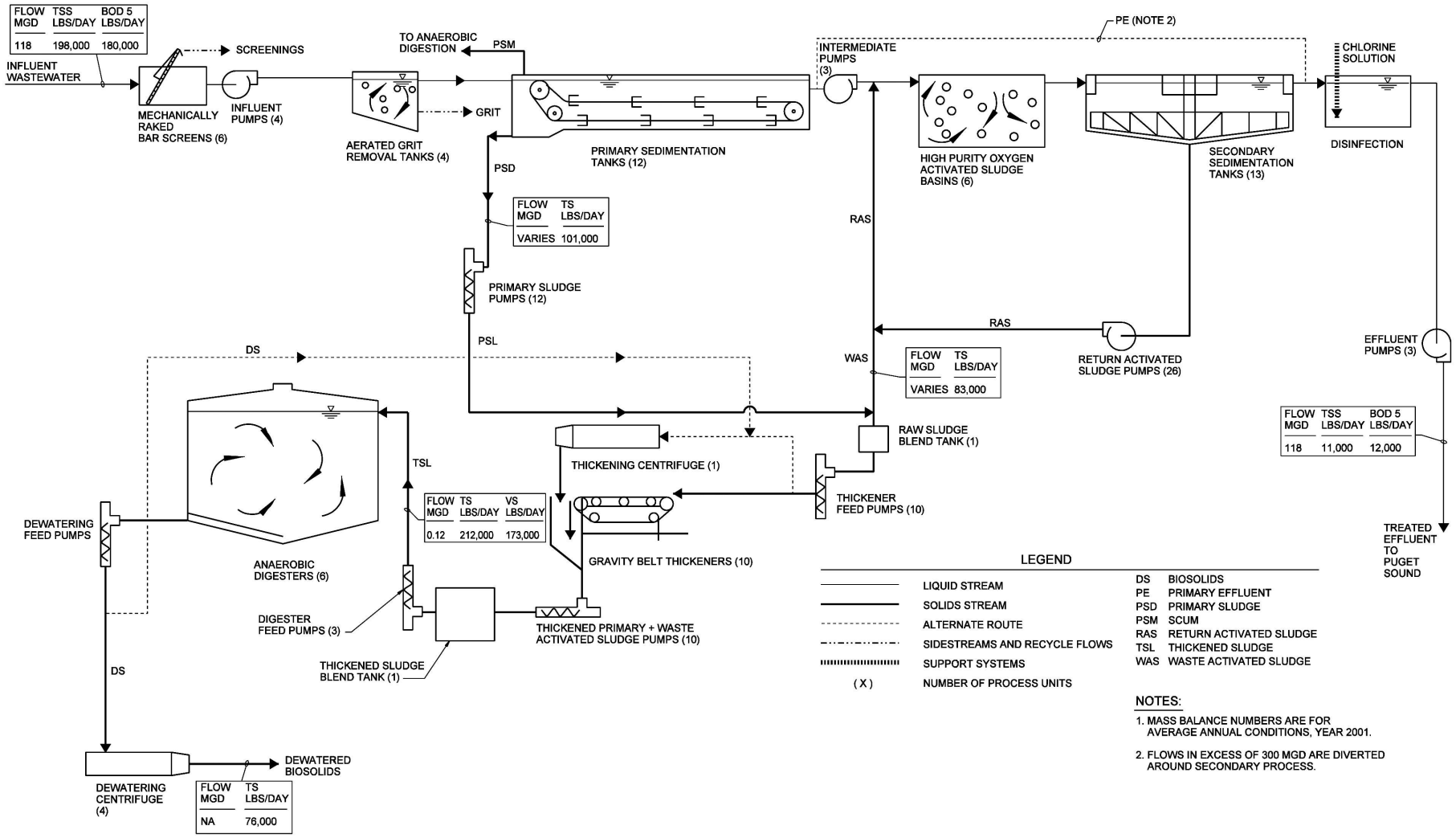

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Figure 2-17
West Point Treatment Plant
Liquid and Solids Process Schematic

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-17_West Pt. Liquid & Solids Process Schematic • 04/18/03 • dk

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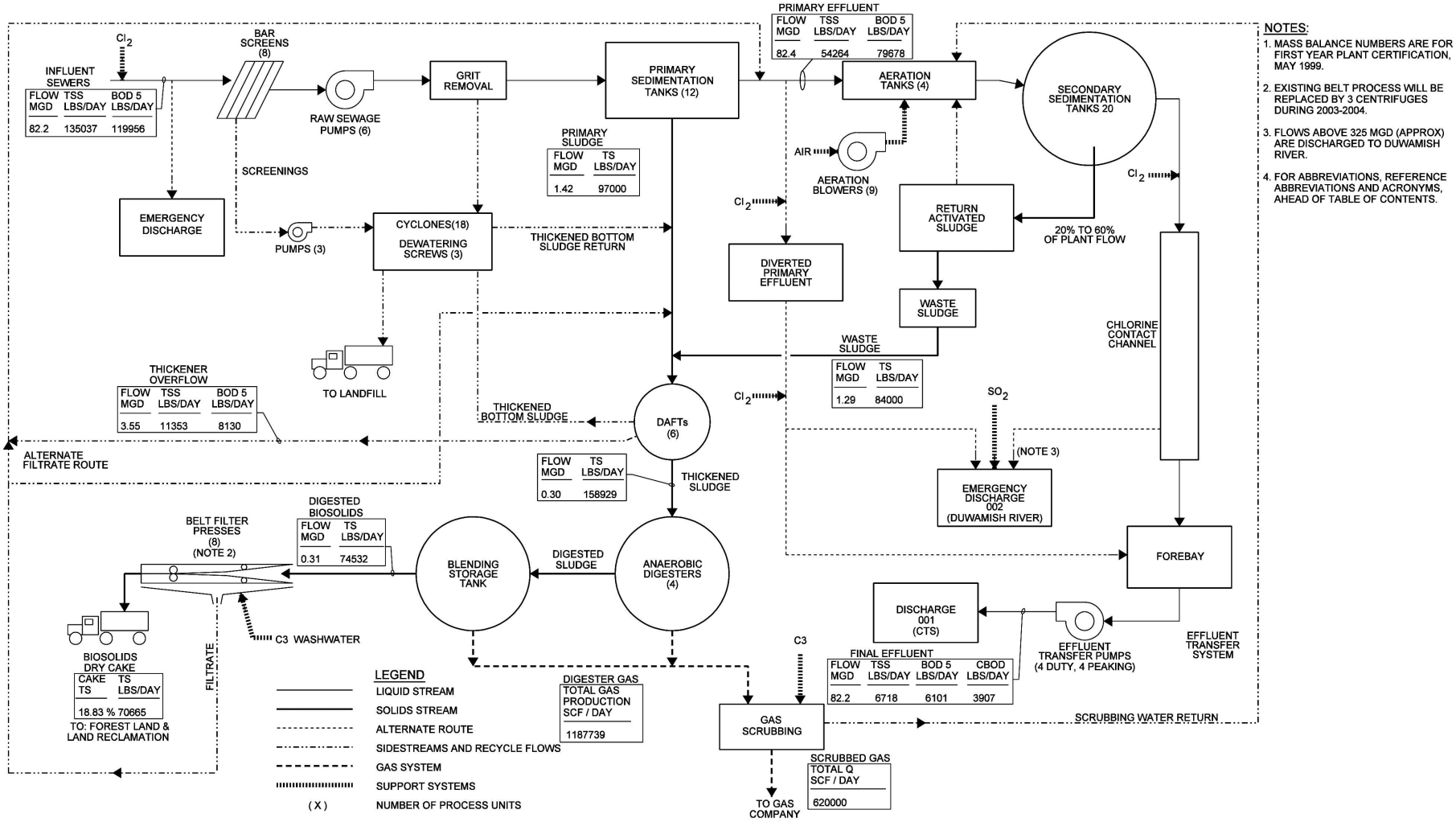
File Name: 173243.16.01_W012003016SEA • FIG 2-18_South Treatment Plant • 05/1/03 • dk

Figure 2-18
South Treatment Plant, Aerial Photograph

BRIGHTWATER FACILITIES PLAN



NOTES:

1. MASS BALANCE NUMBERS ARE FOR FIRST YEAR PLANT CERTIFICATION, MAY 1999.
2. EXISTING BELT PROCESS WILL BE REPLACED BY 3 CENTRIFUGES DURING 2003-2004.
3. FLOWS ABOVE 325 MGD (APPROX) ARE DISCHARGED TO DUWAMISH RIVER.
4. FOR ABBREVIATIONS, REFERENCE ABBREVIATIONS AND ACRONYMS, AHEAD OF TABLE OF CONTENTS.

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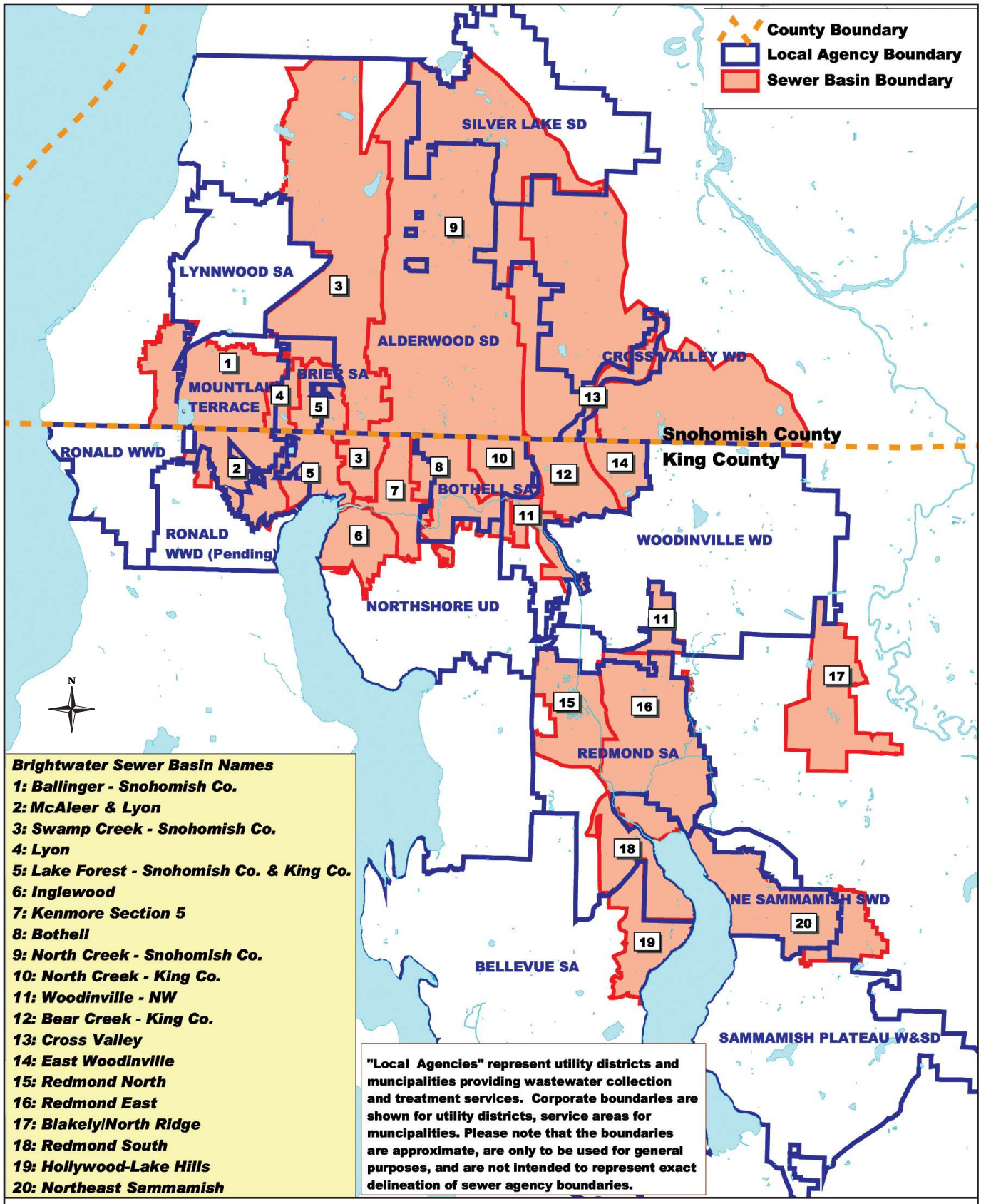
Figure 2-19
South Treatment Plant
Liquid and Solids Process Schematic

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-19_So. Treatment Plant Liquid & Solids Process Schematic • 04/18/03 • dk



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1 0 1 2 Miles

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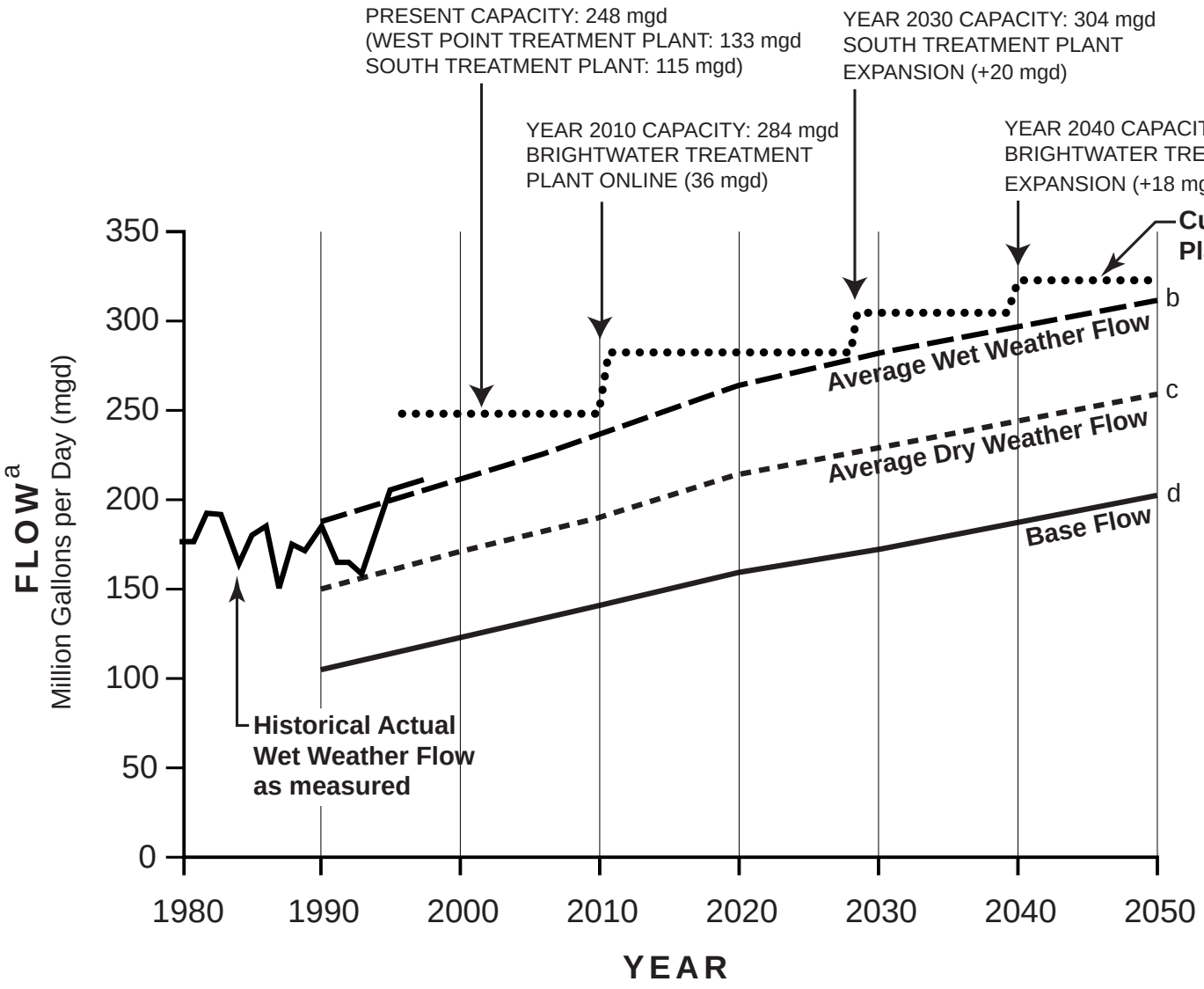
Figure 2-20
Sewer Basins Within the Brightwater Service Area and Local Agency Boundaries
BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 2-20_Sewer Basins in Brightwater Service Area • 04/18/03 • gm/dk



Notes:

a. Flow represents total to West Point, South, and Brightwater Treatment Plants.

b. AWWF is the average wet-weather flow during the relatively wet months of November through April.

c. Average dry weather flow (ADWF) is the average non-storm flow for the relatively dry months of May through October.

d. Base flow is wastewater flow that does not include inflow and infiltration.

e. Treatment plant capacities expressed as AWWF.

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File Name: 173243.16.01_W012003016SEA • FIG 3-1_Projected Needs Graph • 04/18/03 • dk

Figure 3-1

Projected Treatment Plant Needs for West, East, and Brightwater Service Areas

BRIGHTWATER FACILITIES PLAN

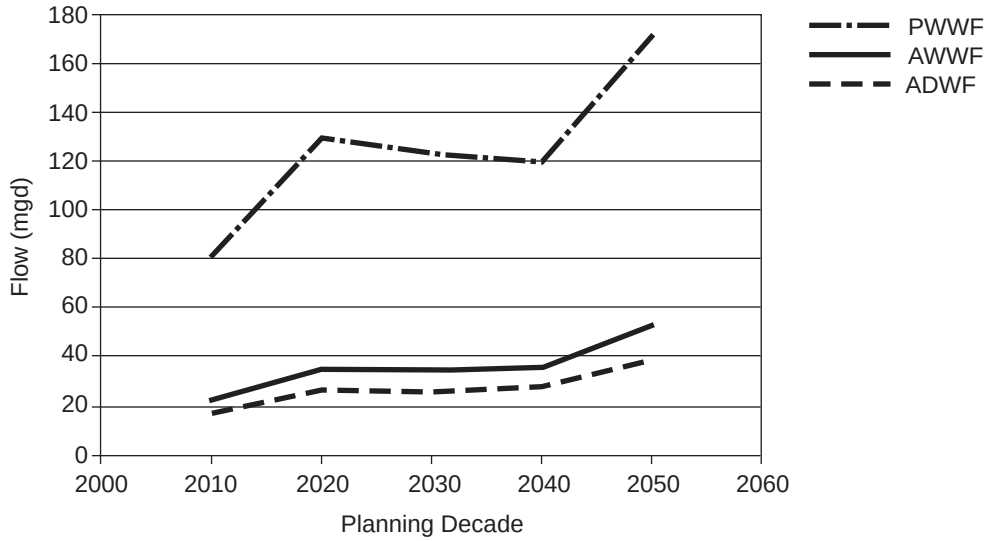


Figure 3-2

Projected Average Dry Weather, Average Wet Weather, and Peak Wet Weather Flow to Brightwater Facilities

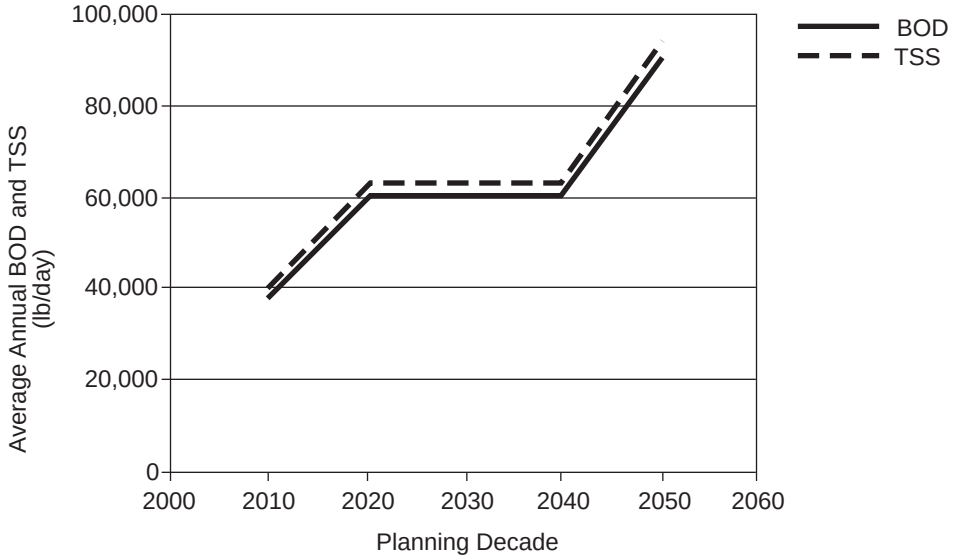
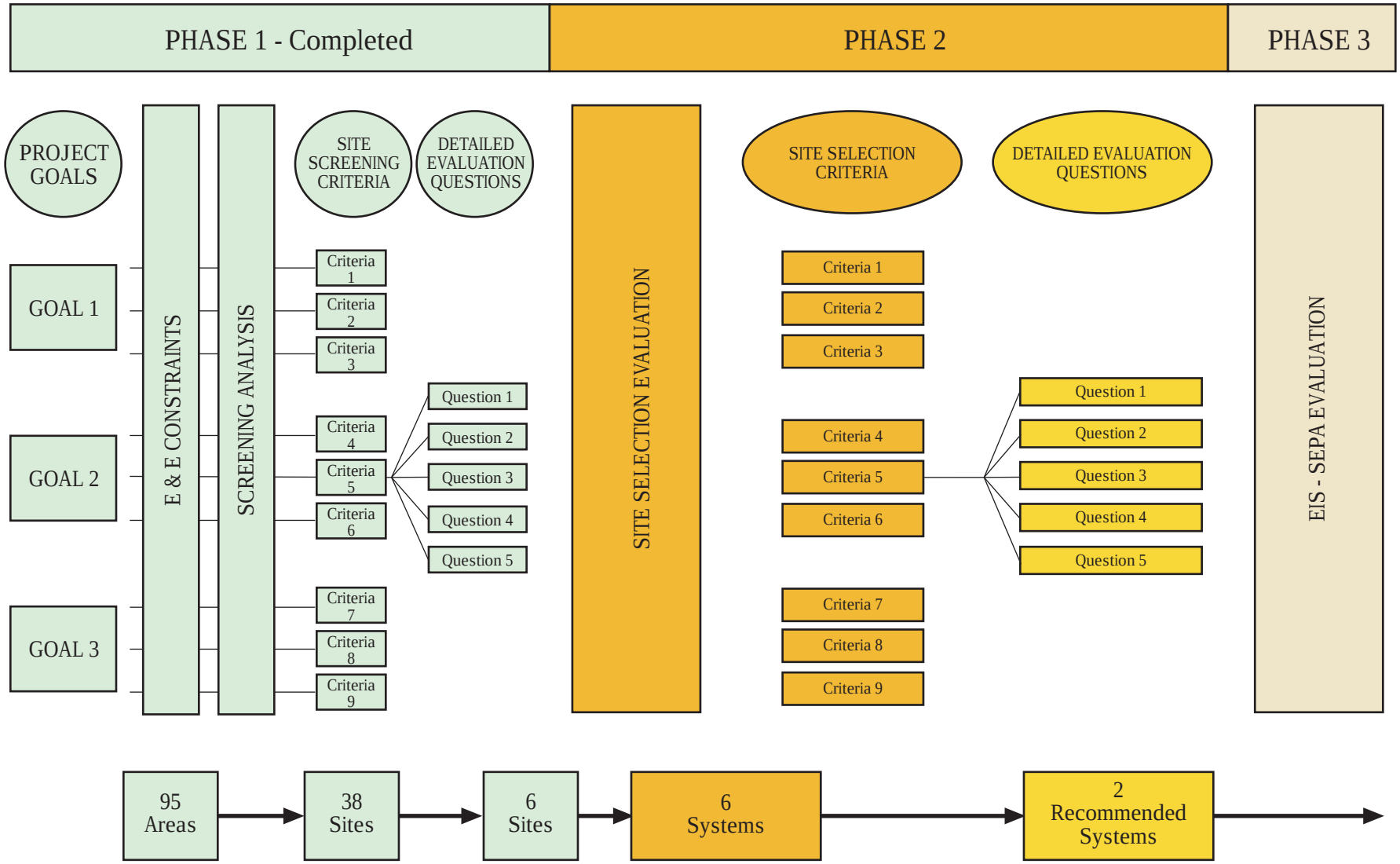


Figure 3-3

Projected Annual Average Brightwater BOD and TSS Load to Brightwater Facilities



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File Name: 173243.16.01_W012003016SEA • FIG 4-1_Brightwater Siting Analysis Flow Chart • 04/22/03 • dk

Figure 4-1
Brightwater Siting Analysis Flow Chart

BRIGHTWATER FACILITIES PLAN

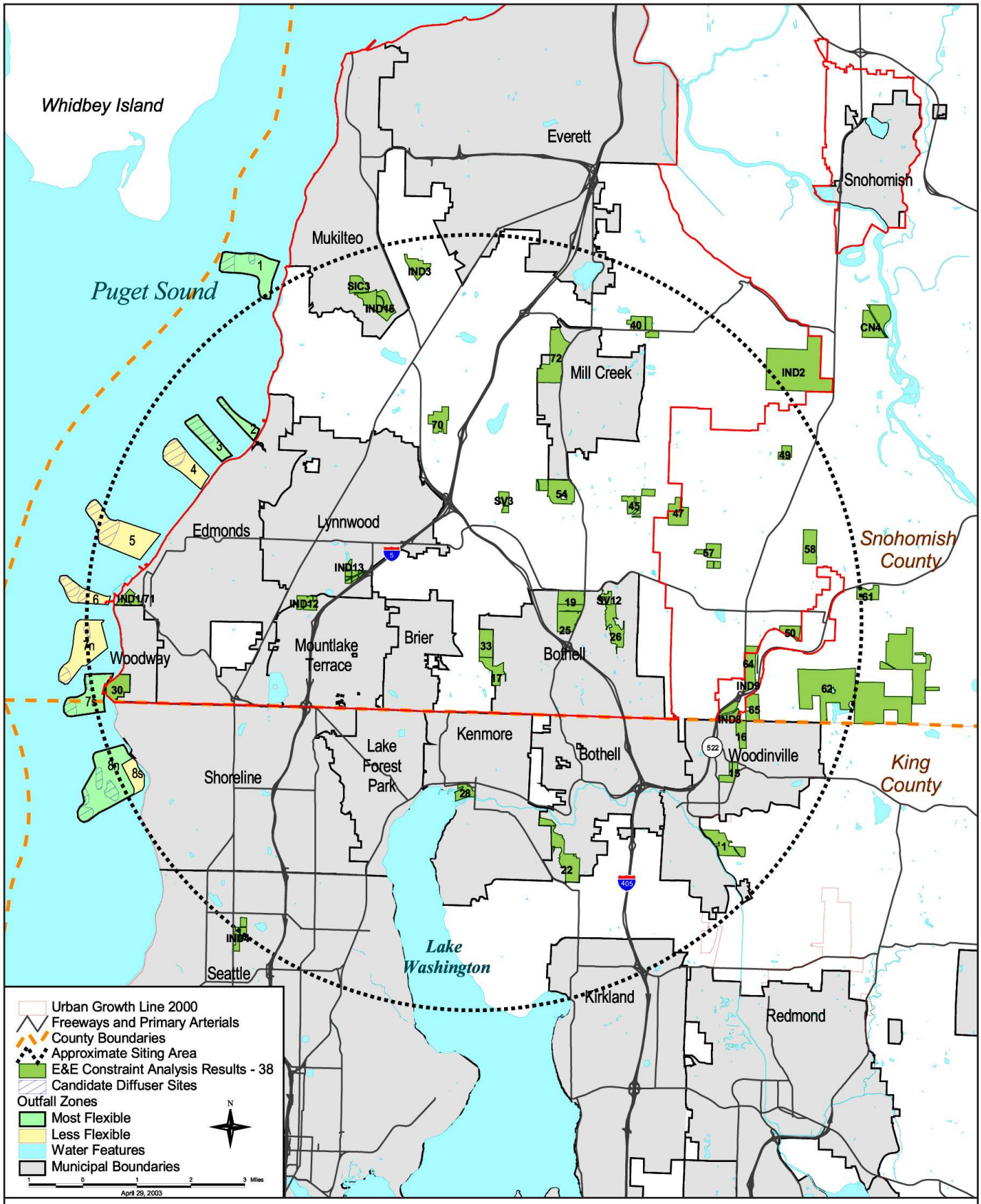

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Figure 4-3

Study Area and 38 Potential Treatment Plant Sites Evaluated in Phase 1b – Refined Screening

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-3_Study Area - 38 Potential Sites • 04/24/03 • dk

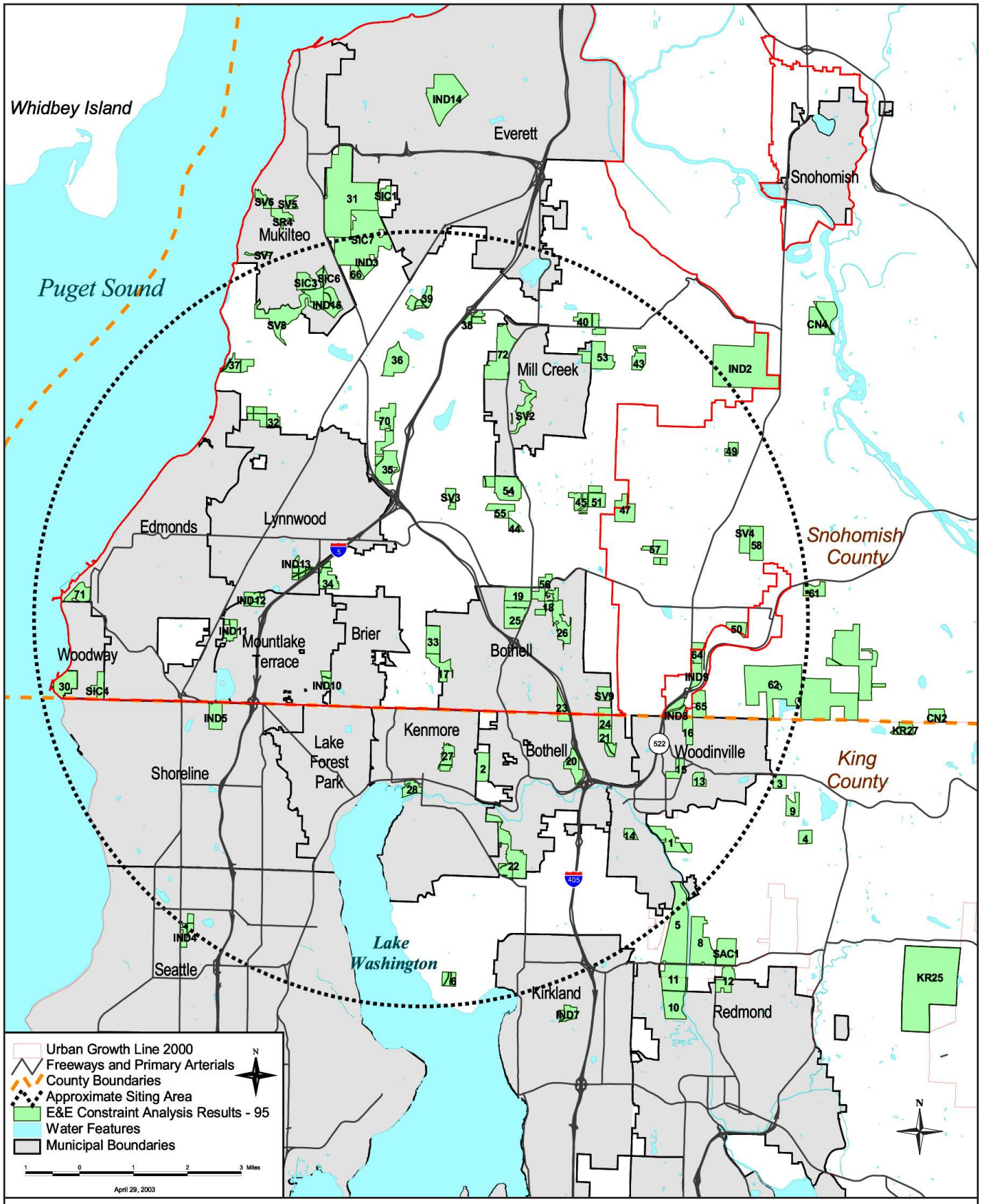

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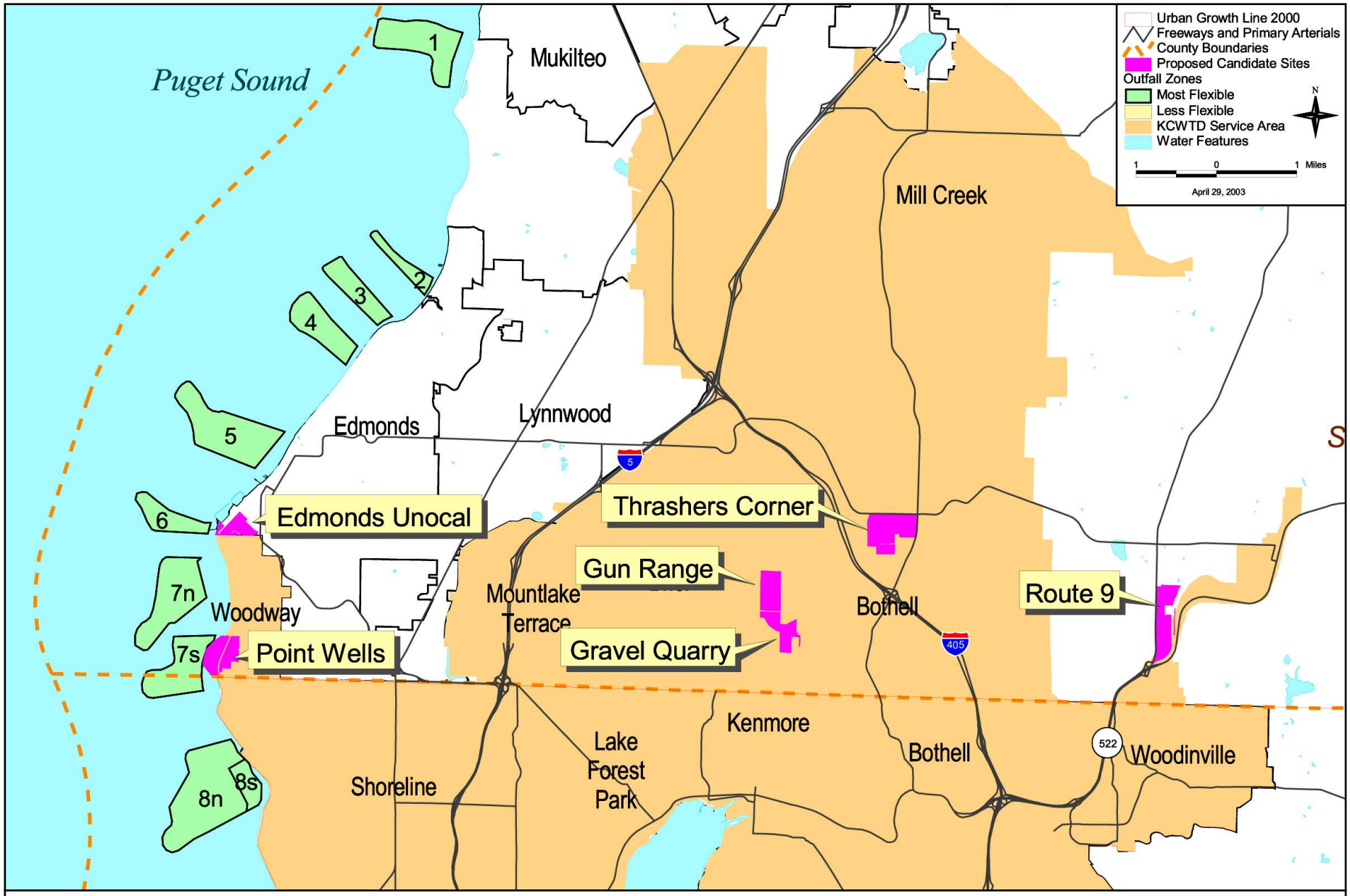
Figure 4-2

Study Area and 95 Potential Treatment Plant Sites Evaluated in Phase 1 – Initial Screening

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-2_Study Area - 95 Potential Sites • 04/24/03 • dk



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N

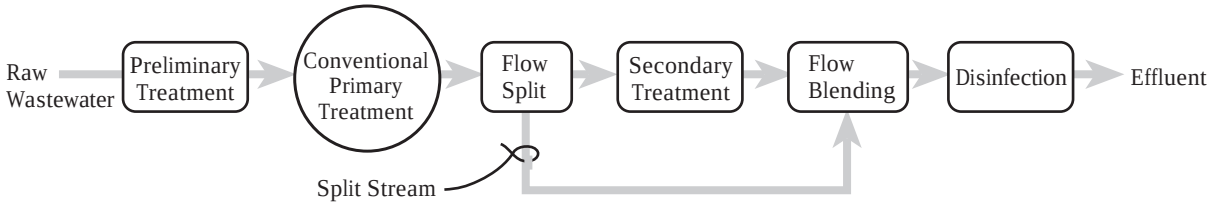
0.5 0 0.5 1 1.5 2 2.5 Miles

Figure 4-4

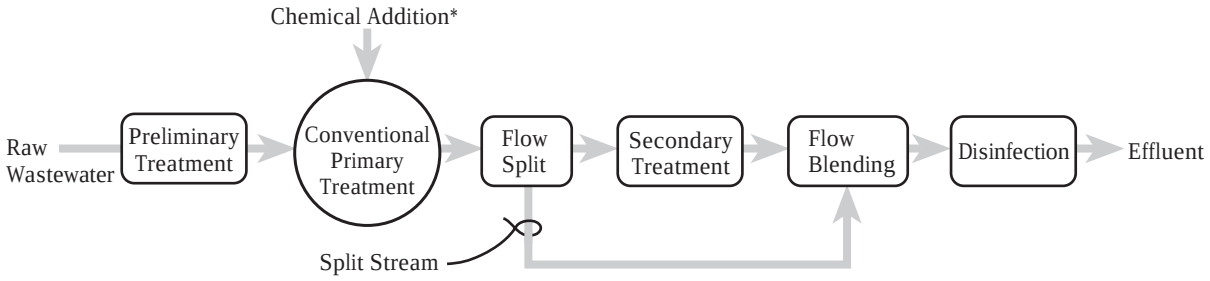
Six Potential Treatment Plant Sites and Ten Outfall Zones Evaluated in Phase 2

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-4_Six Sites and Ten Outfall Zones • 04/24/03 • dk

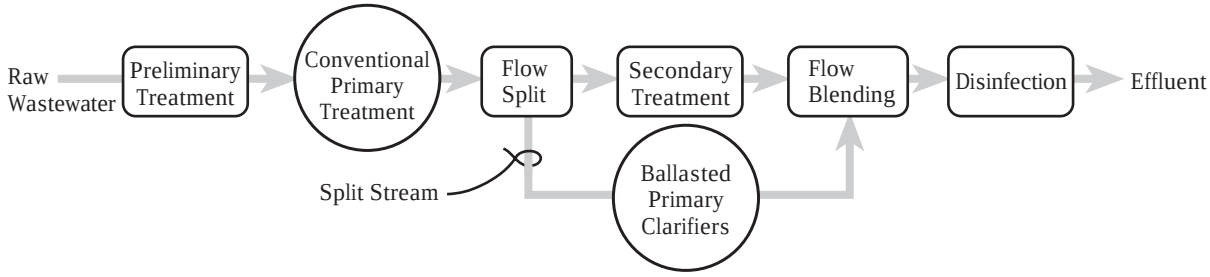


MBR with Conventional Primary Clarification



*Chemical addition required only when flow splitting

MBR with Chemically Enhanced Primary Clarification



MBR with Ballasted Primary Clarification

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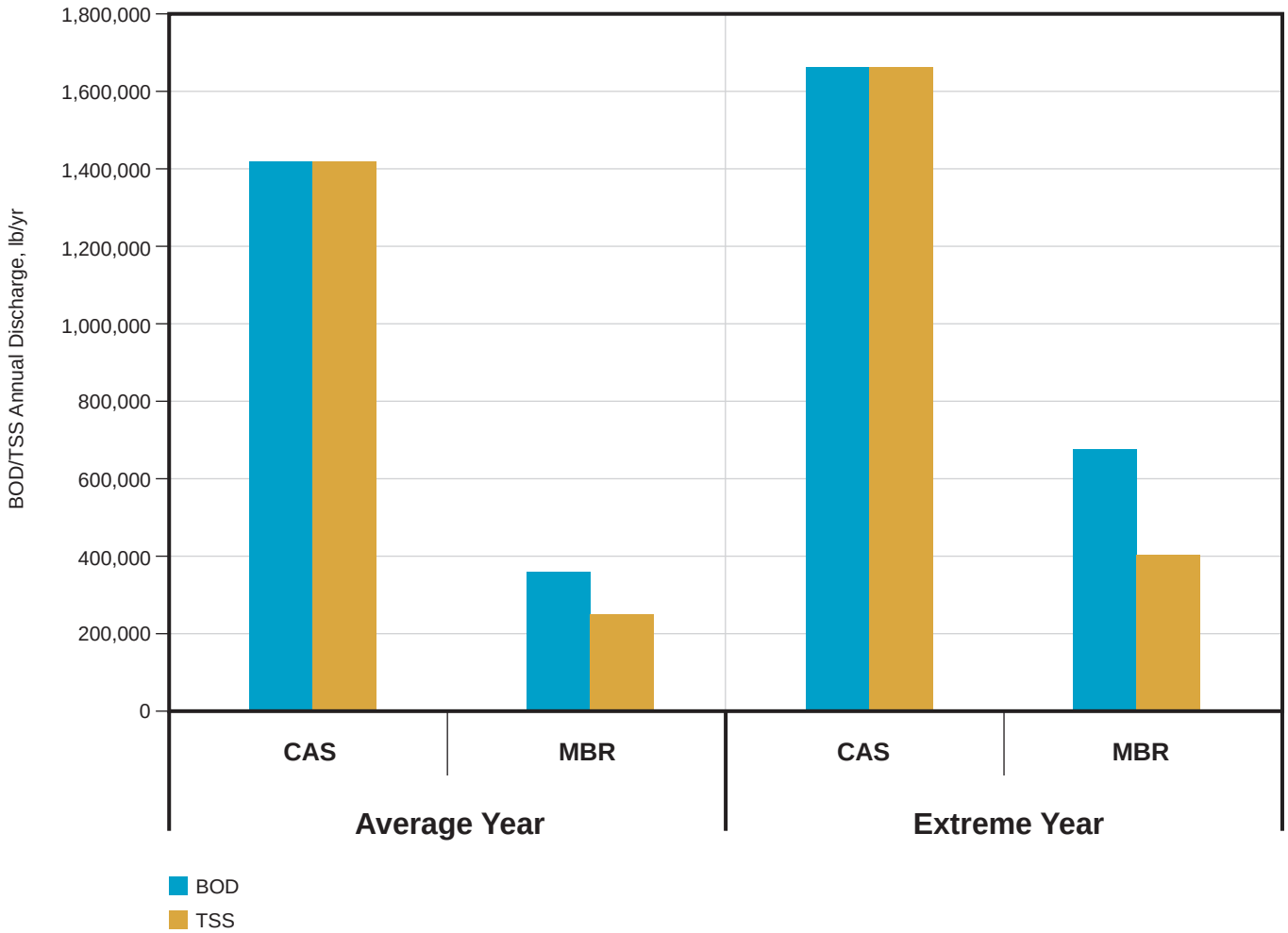
Figure 4-5
Split Flow Treatment Process Schematics

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-5_Split Flow Schematics • 04/22/03 • gm/dk



CAS – Full blow conventional activated sludge

MBR – Membrane bioreactor with split stream treatment using ballasted primary clarification

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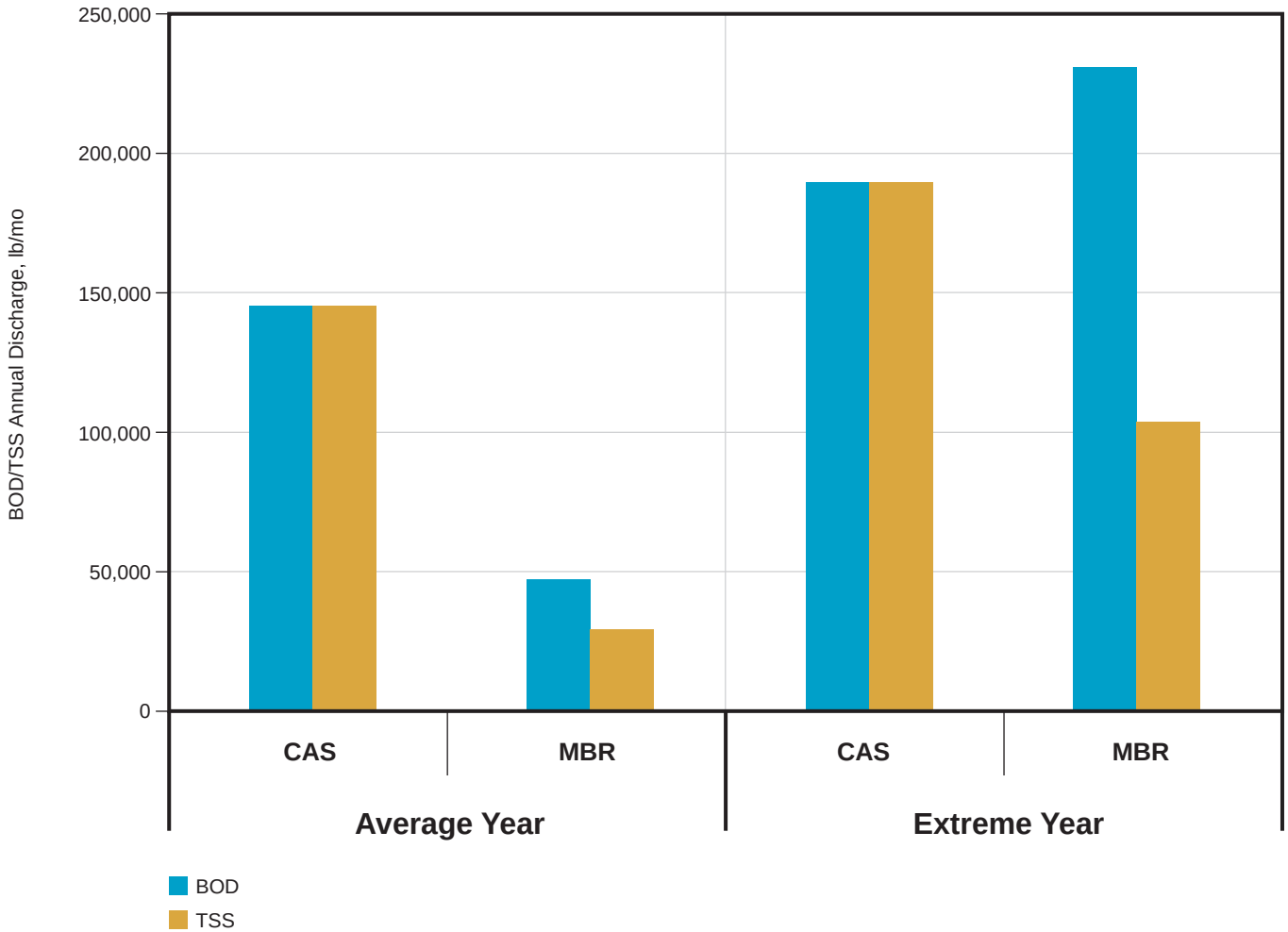
File Name: 173243.16.01_W012003016SEA • FIG 4-6_Comparison of Annual Effluent BOD • 04/22/03 • dk

Figure 4-6

Comparison of Annual Effluent BOD_5 and TSS for Full Flow Conventional Activated Sludge and Split Flow MBR Using Ballasted Primary Clarification

BRIGHTWATER FACILITIES PLAN



CAS – Full blow conventional activated sludge

MBR – Membrane bioreactor with split stream treatment using ballasted primary clarification

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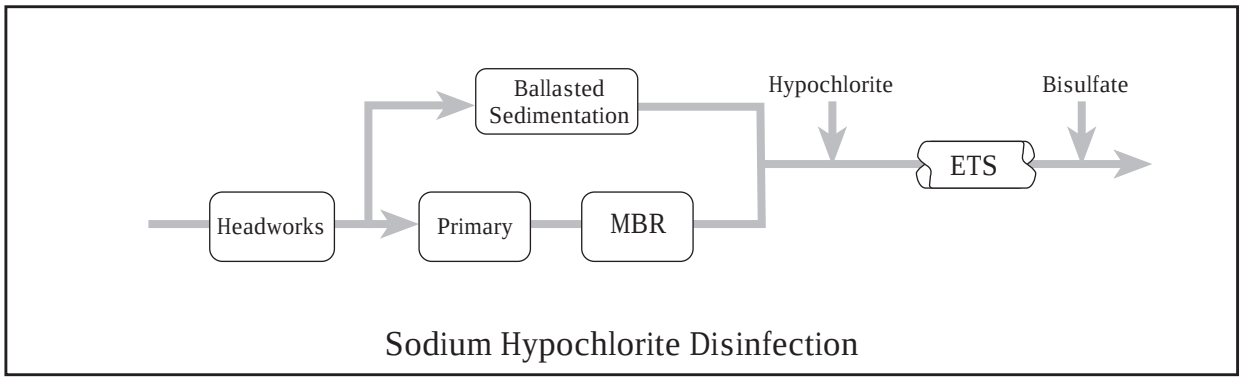
File Name: 173243.16.01_W012003016SEA • FIG 4-7_Comparison of Max. Month Effluent BOD • 04/22/03 • dk

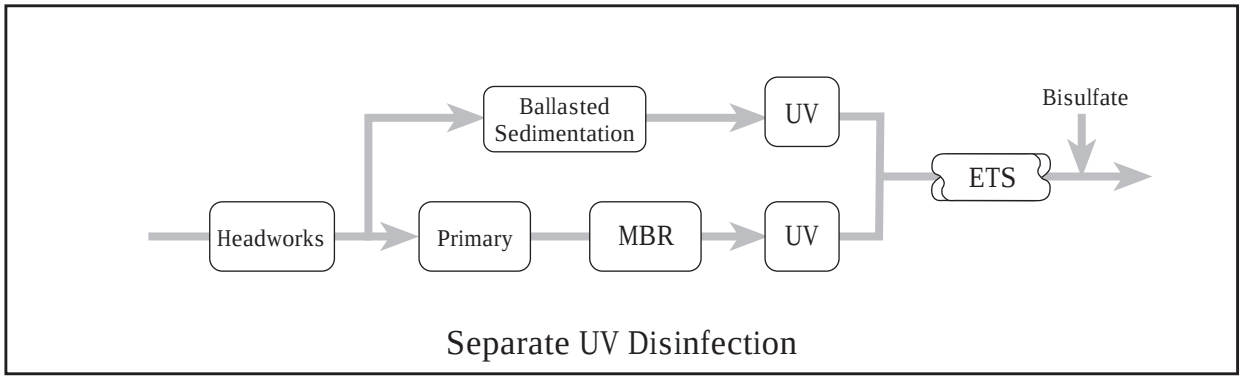
Figure 4-7

Comparison of Maximum Month Effluent BOD_5 and TSS for Full Flow Conventional Activated Sludge and Split Flow MBR Using Ballasted Primary Clarification

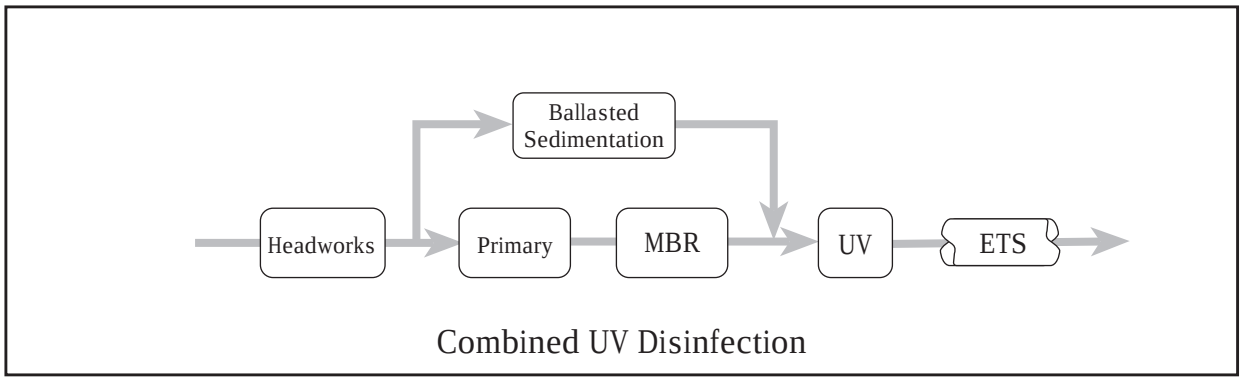
BRIGHTWATER FACILITIES PLAN



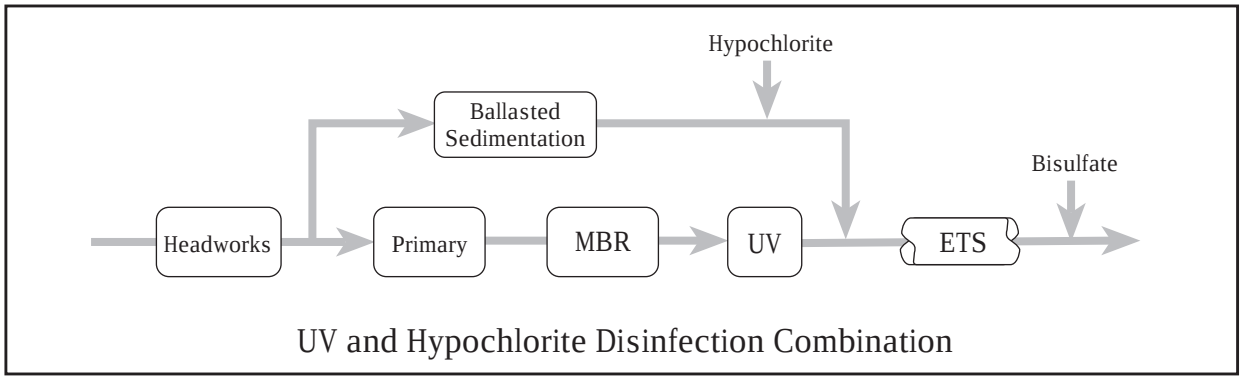
Sodium Hypochlorite Disinfection



Separate UV Disinfection



Combined UV Disinfection



UV and Hypochlorite Disinfection Combination

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Figure 4-8
Process Schematics for Disinfection Alternatives

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-8_Disinfection Schematics • 04/23/03 • gm/dk

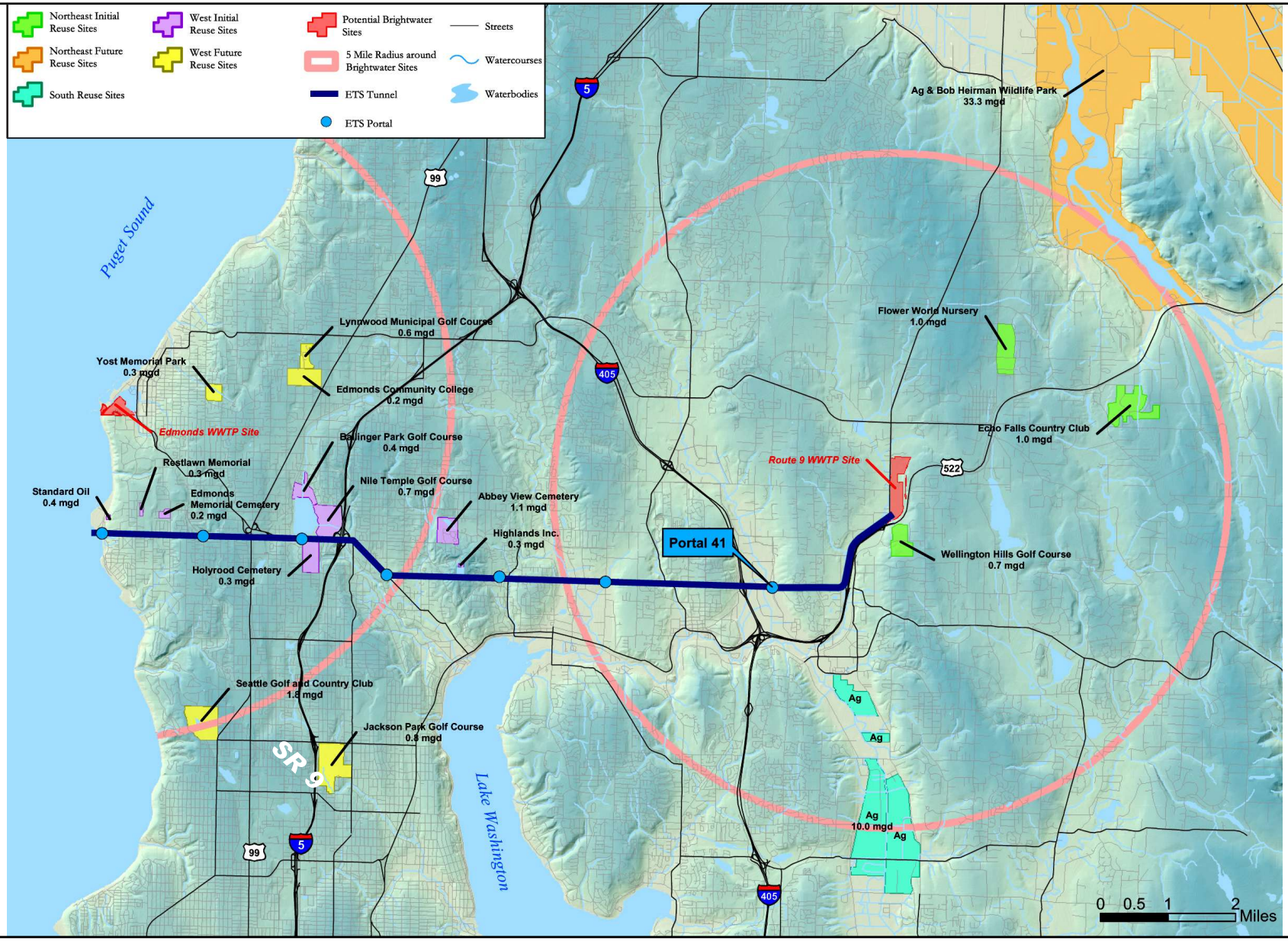

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Figure 4-9
Potential Water Reuse Sites

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 4-9_Potential Water Reuse Sites • 04/24/03 • dk

NOTES:

1. ODOR CONTROL NOT SHOWN IN PROCESS SCHEMATIC.
2. SEE PRELIMINARY DESIGN CRITERIA TABLE FOR EQUIPMENT SIZING.
3. SODIUM HYPOCHLORITE ADDED ON -SITE FOR DISINFECTION. CONTACT TIME PROVIDED IN EFFLUENT CONVEYANCE LINE.
4. VALVES, GATES, AND OTHER FLOW CONTROL APPURTENANCES NOT SHOWN.

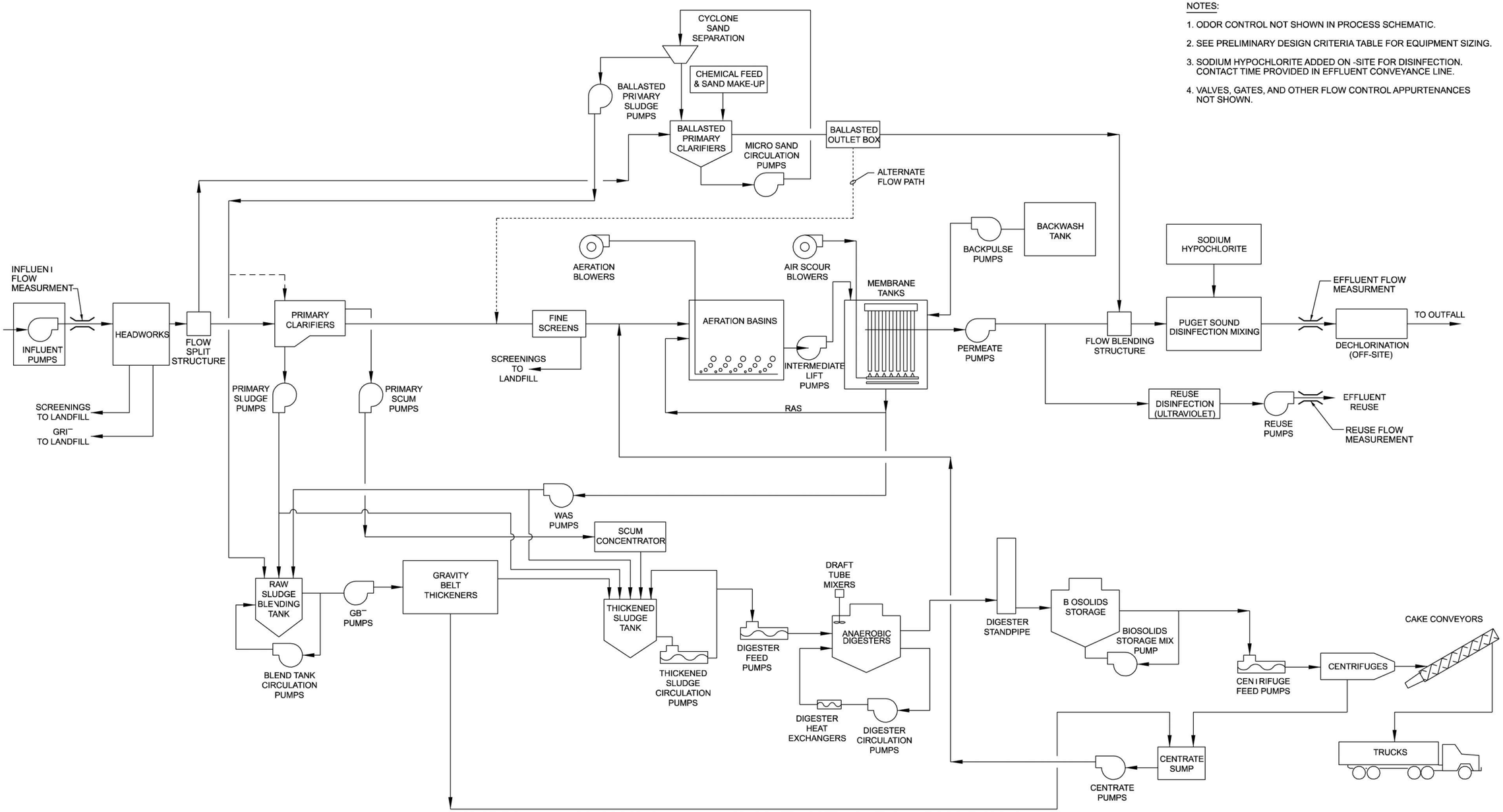

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Figure 5-1
Treatment Process Schematic

BRIGHTWATER FACILITIES PLAN

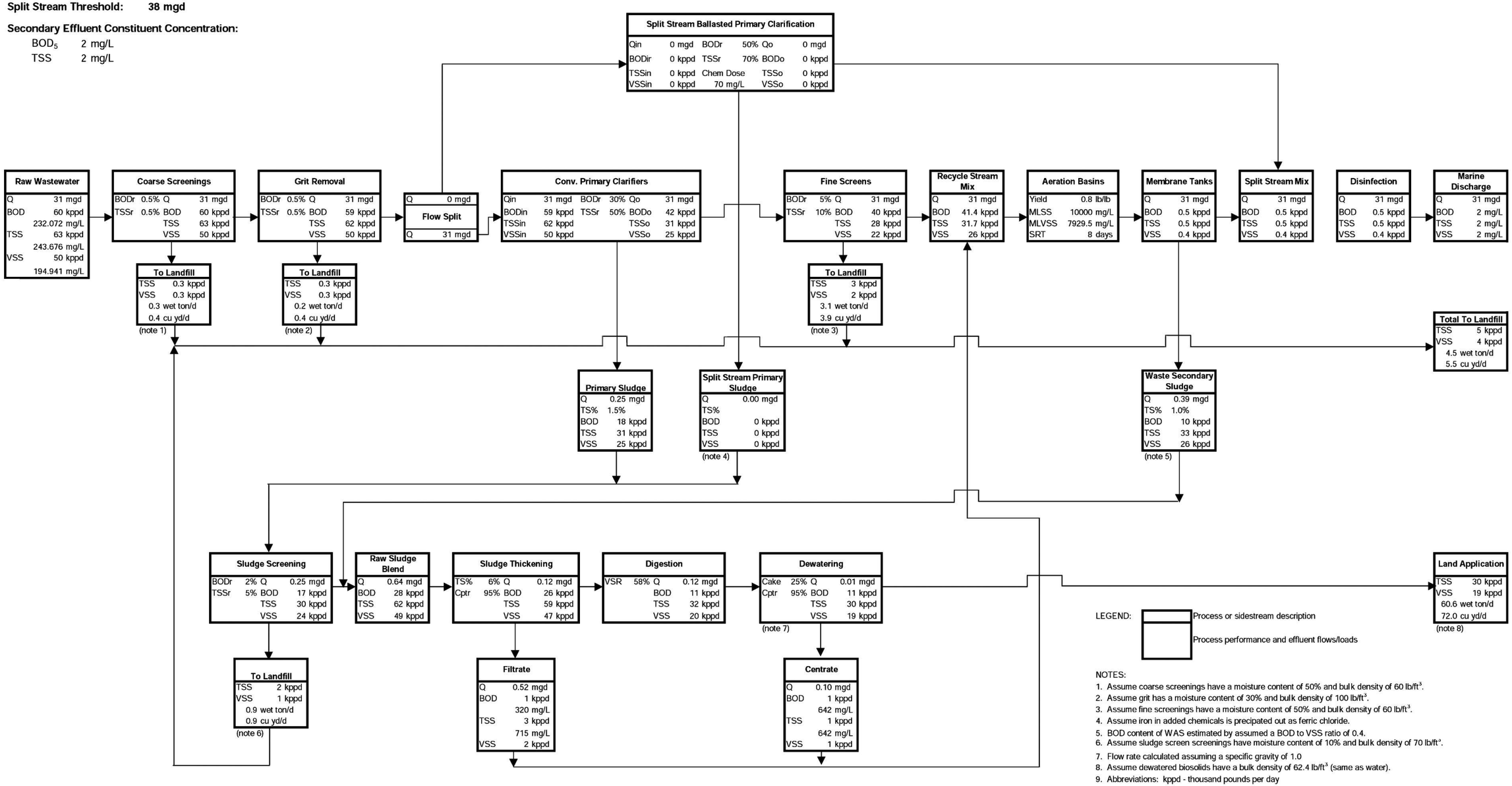
File Name: 173243.16.01_W012003016SEA • FIG 5-1_Treatment Process Schematic • 05/1/03 • dk

Assumptions:

Split Stream Threshold: **38 mgd**

Secondary Effluent Constituent Concentration:

BOD_5 2 mg/L
TSS 2 mg/L



NOTES:

1. Assume coarse screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
2. Assume grit has a moisture content of 30% and bulk density of 100 lb/ft^3.
3. Assume fine screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
4. Assume iron in added chemicals is precipated out as ferric chloride.
5. BOD content of WAS estimated by assumed a BOD to VSS ratio of 0.4.
6. Assume sludge screen screenings have moisture content of 10% and bulk density of 70 lb/ft^3.
7. Flow rate calculated assuming a specific gravity of 1.0
8. Assume dewatered biosolids have a bulk density of 62.4 lb/ft^3 (same as water).
9. Abbreviations: kppd - thousand pounds per day

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Figure 5-2
Flow and Mass Balance
Average Annual Condition

BRIGHTWATER FACILITIES PLAN

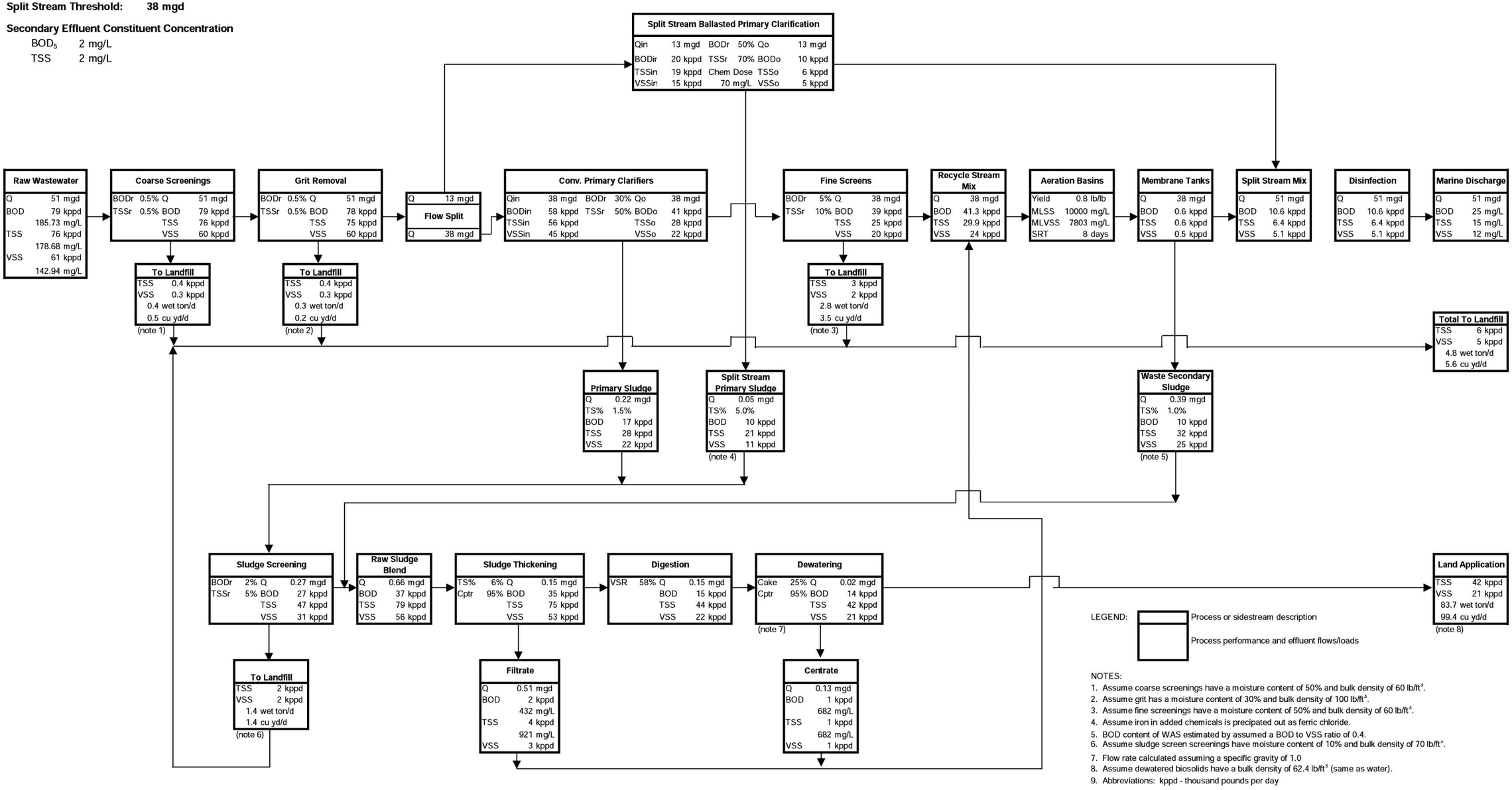
File Name: 173243.16.01_W012003016SEA • FIG 5-2_Flow and Mass Balance, Avg. Annual Cond. • 04/24/03 • dk

Assumptions:

Split Stream Threshold: **38 mgd**

Secondary Effluent Constituent Concentration

BOD_5	2 mg/L
TSS	2 mg/L



NOTES:

1. Assume coarse screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
2. Assume grit has a moisture content of 30% and bulk density of 100 lb/ft^3.
3. Assume fine screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
4. Assume iron in added chemicals is precipated out as ferric chloride.
5. BOD content of WAS estimated by assumed a BOD to VSS ratio of 0.4.
6. Assume sludge screen screenings have moisture content of 10% and bulk density of 70 lb/ft^3.
7. Flow rate calculated assuming a specific gravity of 1.0
8. Assume dewatered biosolids have a bulk density of 62.4 lb/ft^3 (same as water).
9. Abbreviations: kppd - thousand pounds per day

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Figure 5-3
Flow and Mass Balance
Peak Month Condition

BRIGHTWATER FACILITIES PLAN

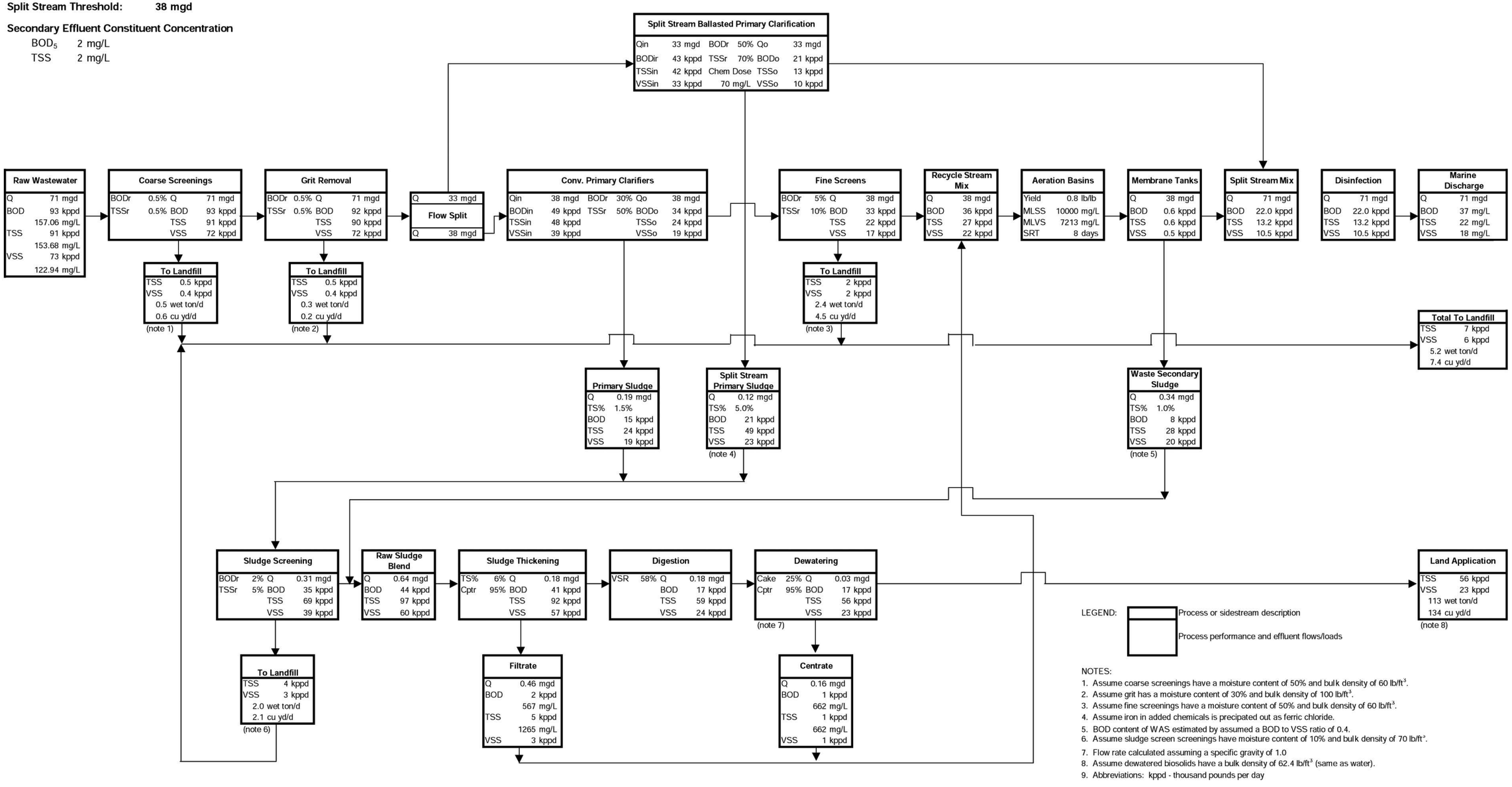
File Name: 173243.16.01_W012003016SEA • FIG 5-2_Flow and Mass Balance, Peak Month Cond. • 04/24/03 • dk

Assumptions:

Split Stream Threshold: **38 mgd**

Secondary Effluent Constituent Concentration

BOD_5 2 mg/L
TSS 2 mg/L



NOTES:

1. Assume coarse screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
2. Assume grit has a moisture content of 30% and bulk density of 100 lb/ft^3.
3. Assume fine screenings have a moisture content of 50% and bulk density of 60 lb/ft^3.
4. Assume iron in added chemicals is precipated out as ferric chloride.
5. BOD content of WAS estimated by assumed a BOD to VSS ratio of 0.4.
6. Assume sludge screen screenings have moisture content of 10% and bulk density of 70 lb/ft^3.
7. Flow rate calculated assuming a specific gravity of 1.0
8. Assume dewatered biosolids have a bulk density of 62.4 lb/ft^3 (same as water).
9. Abbreviations: kppd - thousand pounds per day

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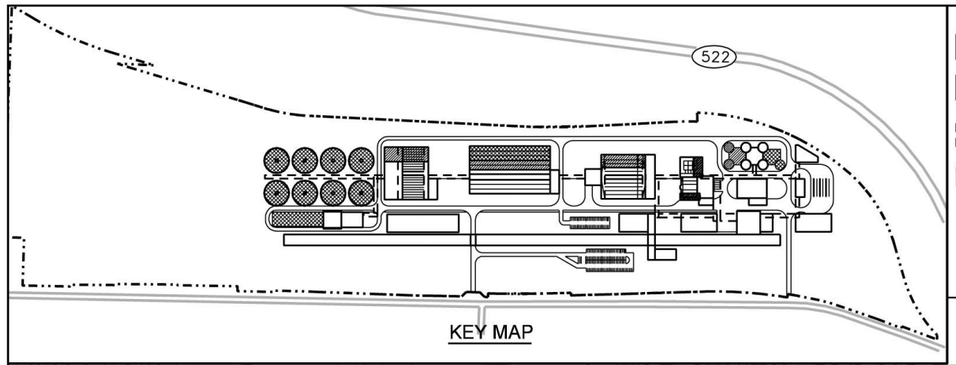
Wastewater Treatment Division

Figure 5-4
Flow and Mass Balance
Peak Week Condition

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 5-2_Flow and Mass Balance, Peak Week Cond. • 04/24/03 • dk



Legend

- 36 MGD FACILITIES
- ADDITIONAL FACILITIES FOR EXPANSION TO 54 MGD
- POTENTIAL ADDITIONAL FACILITIES
- ODOR CONTROL
- (X) FACILITY NUMBER

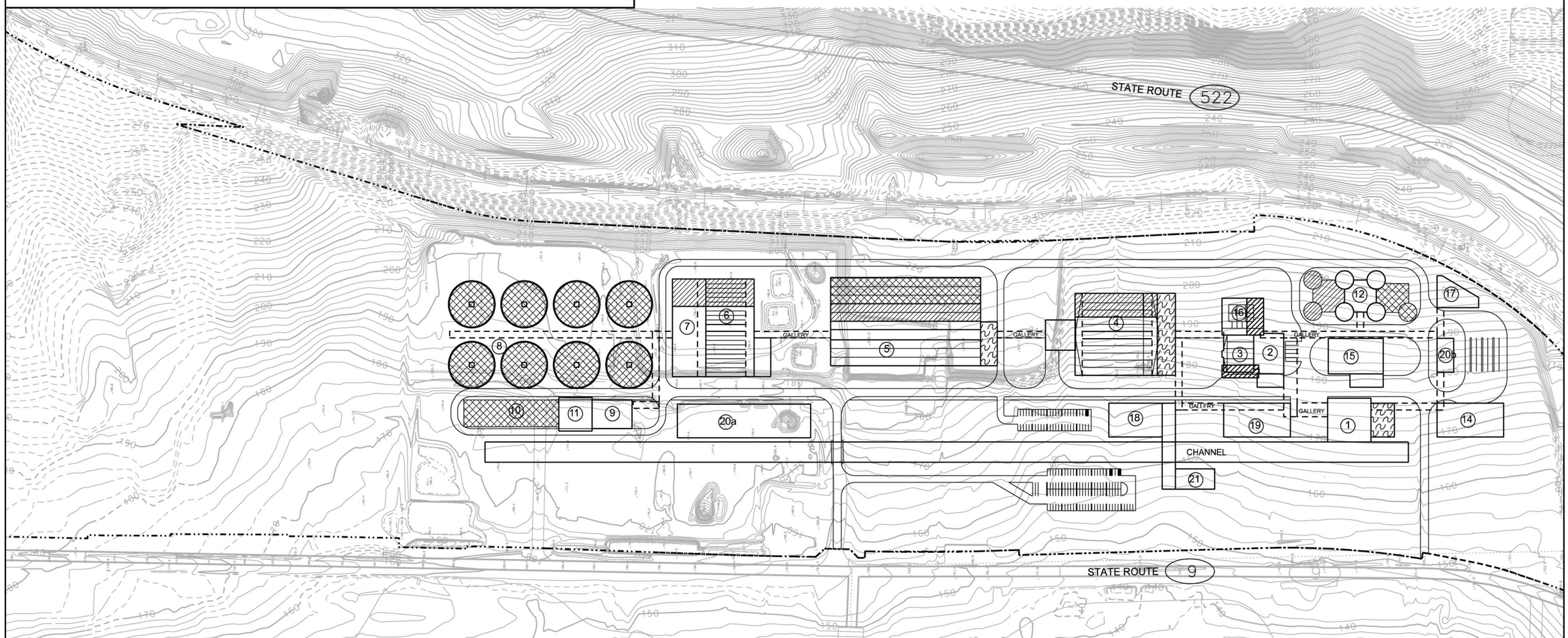
NO.	FACILITY	NO.	FACILITY
1	Influent Pump Station	11	Reuse Water Pump Station
2	Headworks Building	12	Anaerobic Digesters
3	Grit Removal (Aerated or Vortex)	13	Effluent Pump Station (if required)
4	Primary Clarification	14	Chemical Building
5	Aeration Basins	15	Thickening/Dewatering
6	Membrane Tanks	16	Ballasted Clarification (for Split Flow)
7	Membrane Support Building	17	Cogeneration
8	Secondary Clarifiers (if required)	18	Administration Building
9	Disinfection, Reuse, 5 mgd	19	Maintenance Building
10	Future Disinfection, 56 mgd	20	Electrical Substation
		21	Education Building

NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL.
2. THE FOLLOWING FACILITIES ARE NOT SHOWN ON THIS SITE PLAN:
   -EFFLUENT PUMP STATION

N

0 150 300 450
Scale In Feet



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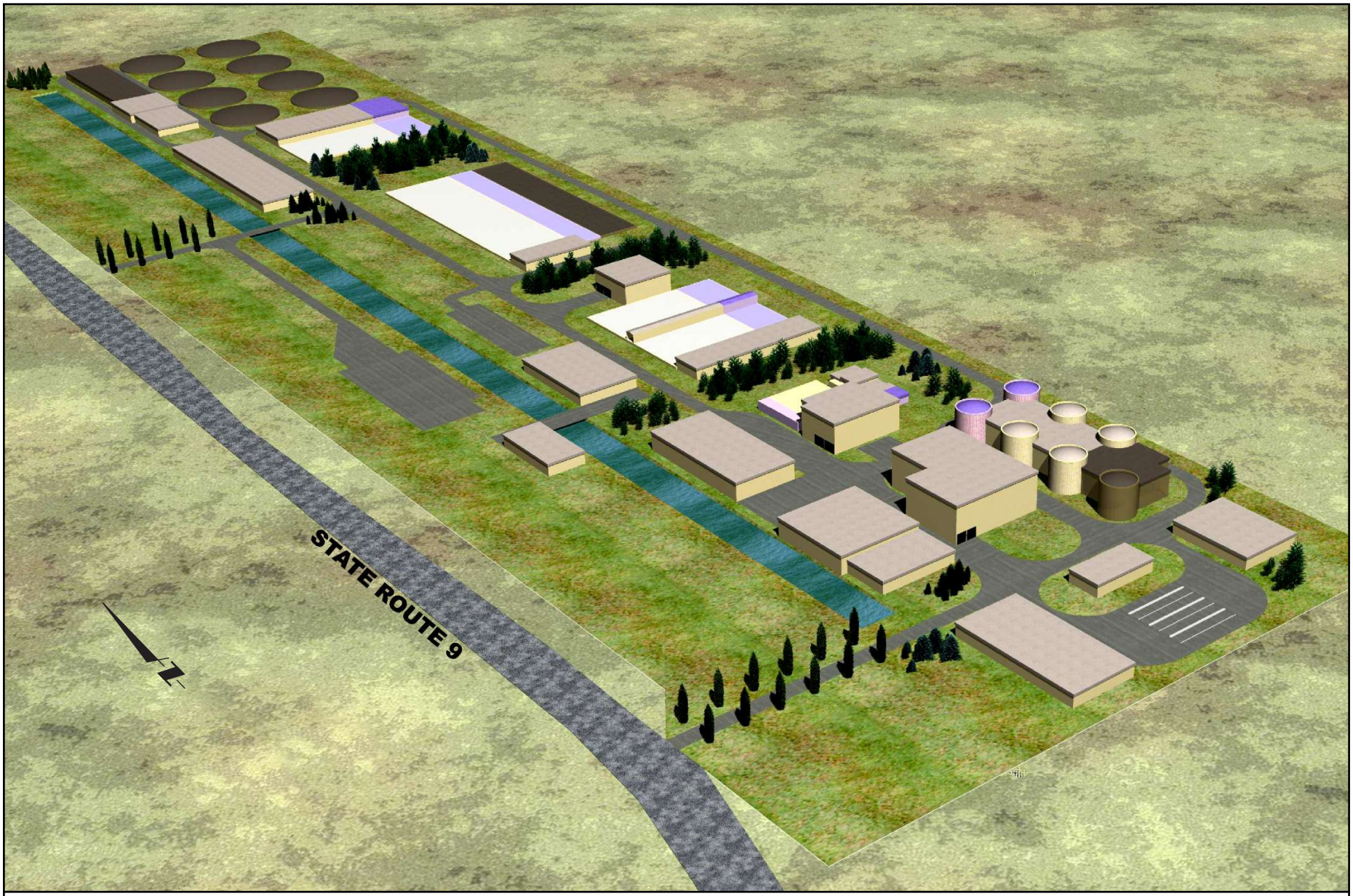
File Name: 173243.16.01_W012003016SEA • FIG 5-5_Preliminary Site Plan • 05/1/03 • dk

Figure 5-5
Preliminary Site Plan
Brightwater Treatment Facilities

BRIGHTWATER FACILITIES PLAN



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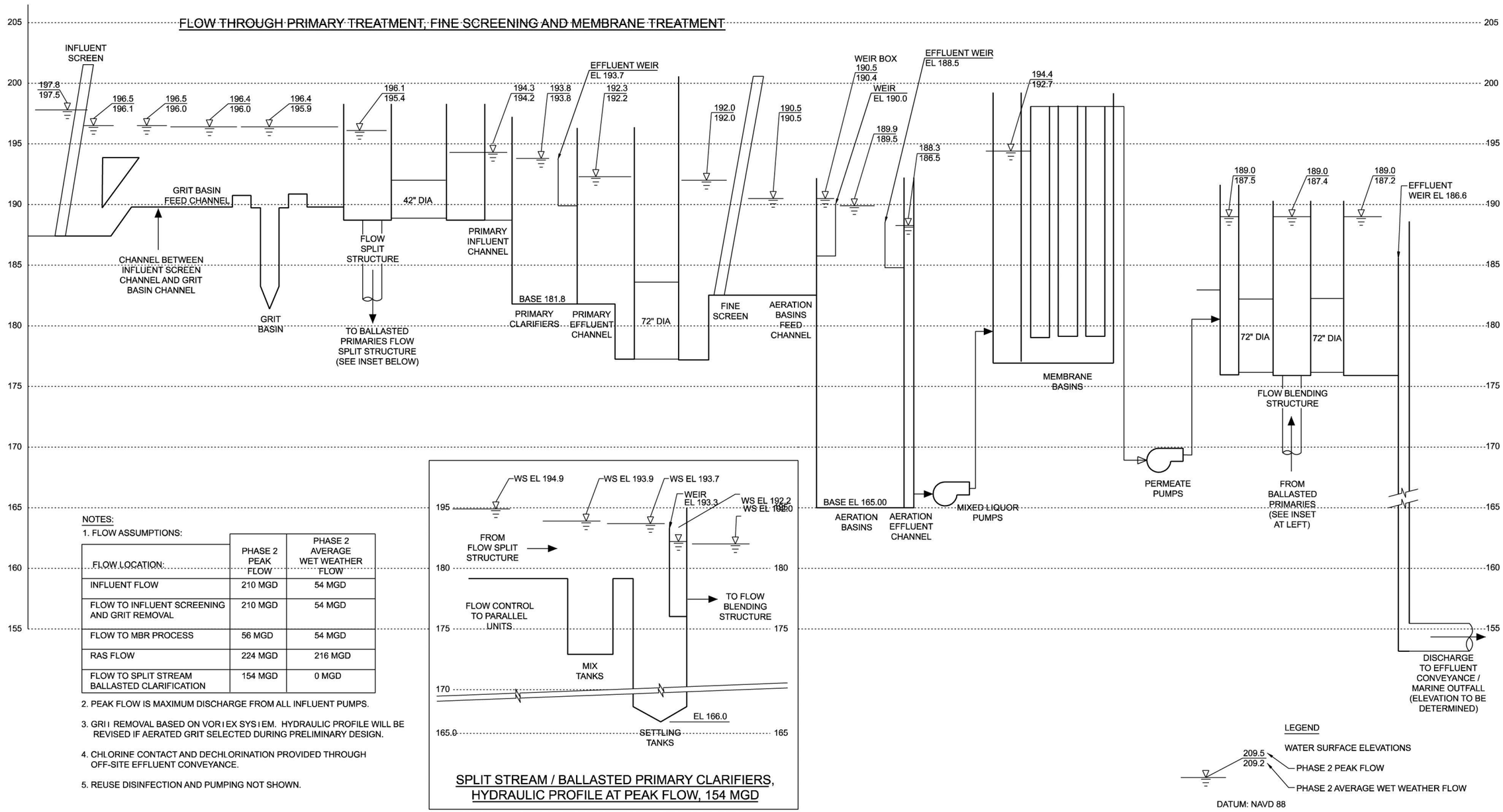
File Name: 173243.16.01_W012003016SEA • FIG 5-6_Conceptual Rendering • 04/22/03 • dk

Figure 5-6
Conceptual Rendering, Brightwater Treatment Facilities

BRIGHTWATER FACILITIES PLAN



NOTES:

1. FLOW ASSUMPTIONS:

FLOW LOCATION:	PHASE 2 PEAK FLOW	PHASE 2 AVERAGE WET WEATHER FLOW
INFLUENT FLOW	210 MGD	54 MGD
FLOW TO INFLUENT SCREENING AND GRIT REMOVAL	210 MGD	54 MGD
FLOW TO MBR PROCESS	56 MGD	54 MGD
RAS FLOW	224 MGD	216 MGD
FLOW TO SPLIT STREAM BALLASTED CLARIFICATION	154 MGD	0 MGD

2. PEAK FLOW IS MAXIMUM DISCHARGE FROM ALL INFLUENT PUMPS.

3. GRIT REMOVAL BASED ON VORTEX SYSTEM. HYDRAULIC PROFILE WILL BE REVISED IF AERATED GRIT SELECTED DURING PRELIMINARY DESIGN.

4. CHLORINE CONTACT AND DECHLORINATION PROVIDED THROUGH OFF-SITE EFFLUENT CONVEYANCE.

5. REUSE DISINFECTION AND PUMPING NOT SHOWN.

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File Name: 173243.16.01_W012003016SEA • FIG 5-7_Conceptual Hydraulic Profile for Split Flow MBR • 05/1/03 • dk

Figure 5-7
Conceptual Hydraulic Profile for Split Flow MBR

BRIGHTWATER FACILITIES PLAN

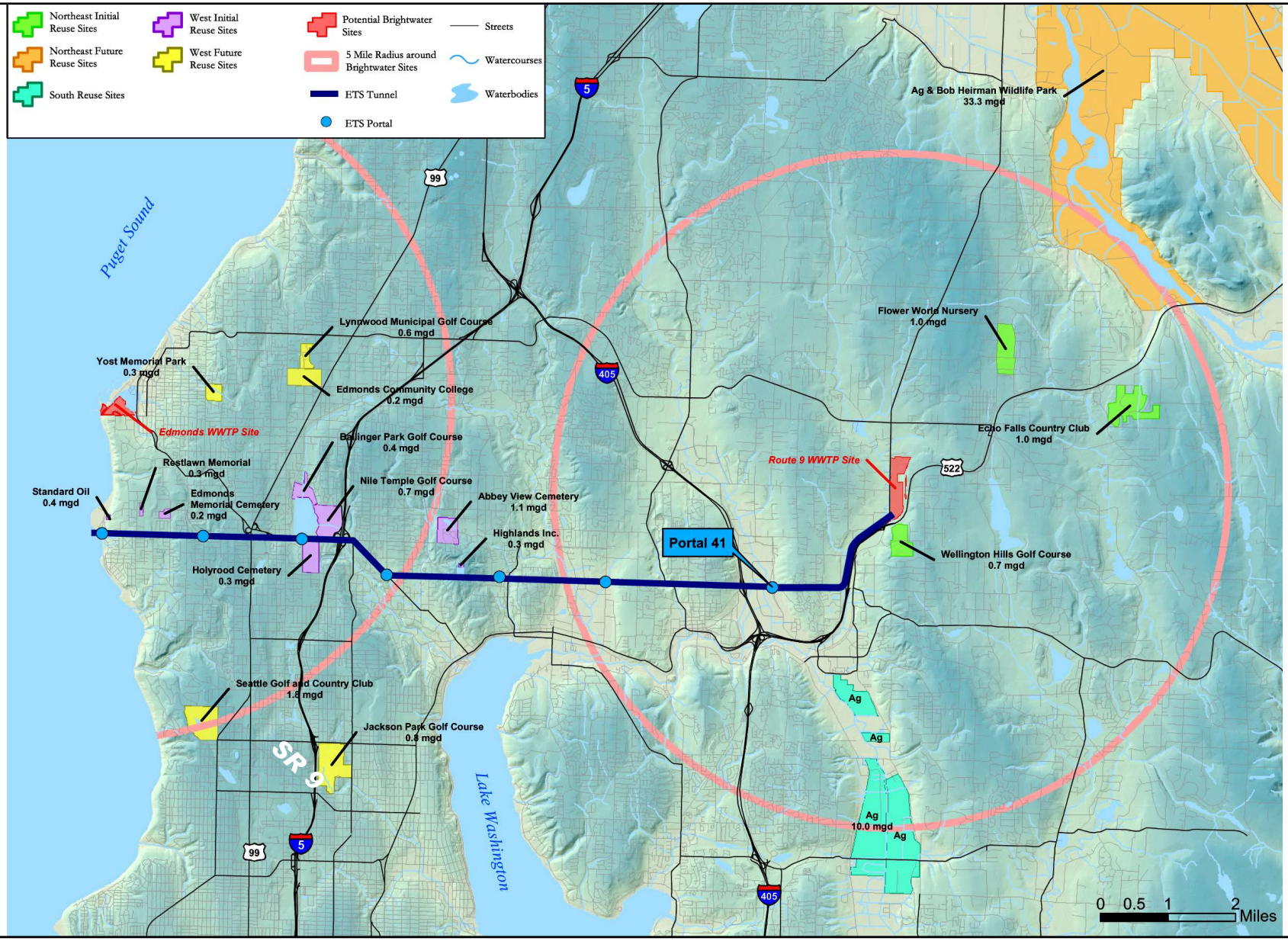

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Figure 5-8
Potential Water Reuse Sites

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 5-8_Potential Water Reuse Sites • 04/24/03 • dk

ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ESTIMATED COST
Brightwater System			
Land Acquisition	11/01/02	12/31/04	147,600,000
Brightwater Plant			
Demo/Remediation	10/01/04	06/30/05	7,200,000
Site Preparation	07/01/05	06/30/06	18,300,000
Pump Stations	01/02/06	12/31/07	76,000,000
Liquid Stream	07/03/06	06/30/09	87,900,000
Solids Stream	01/02/07	12/31/09	100,600,000
Administration & Maintenance Building	07/03/06	12/31/09	13,600,000
Landscape/Final Cleanup	01/04/10	06/30/11	18,800,000
Art & Mitigation Costs	01/03/05	06/30/11	40,600,000
Allied Costs	11/01/02	06/30/11	112,900,000
Conveyance System			
Marine Outfall Construction	01/02/08	12/07/09	38,200,000
Eff. 19 to 23 Portal 19 @ 60'	07/03/05	11/17/05	2,300,000
Eff. 19 to 23 TBM Procurement	07/03/05	07/02/06	4,200,000
Eff. 19 to 23 Portal 23 @ 200'	03/22/06	03/24/07	14,200,000
Eff. 19 to 23 Tunneling & Cleanup (8,255 LF)	07/03/06	07/26/07	22,200,000
Eff. 27 to 23 TBM Procurement	01/02/08	12/31/08	4,200,000
Eff. 27 to 23 Tunneling & Cleanup (7,675 LF)	01/02/09	12/28/09	20,700,000
Eff. 44 to 41b Portal 44 @ 50'	10/01/05	02/16/06	2,200,000
Eff. 44 to 41b TBM Procurement	07/01/05	06/30/06	4,200,000
Eff. 44 to 41b Tunneling & Cleanup (12,750 LF)	07/03/06	02/25/08	34,400,000
Eff. 44 to 45 TBM Procurement	12/05/07	12/04/08	4,200,000
Eff. 44 to 45 Portal 45 @ 150'	10/06/08	08/07/09	9,300,000
Eff. 44 to 45 Tunneling & Cleanup (8,300 LF)	12/05/08	12/31/09	22,300,000
Eff. 7 to 27 Portal 7 @ 50'	07/05/05	11/18/05	2,200,000
Eff. 7 to 27 TBM Procurement	07/05/05	07/03/06	4,200,000
Eff. 7 to 27 Portal 27 @ 50'	11/19/06	04/06/07	2,200,000
Eff. 7 to 27 Tunneling & Cleanup (7,775 LF)	07/05/06	11/27/07	20,900,000

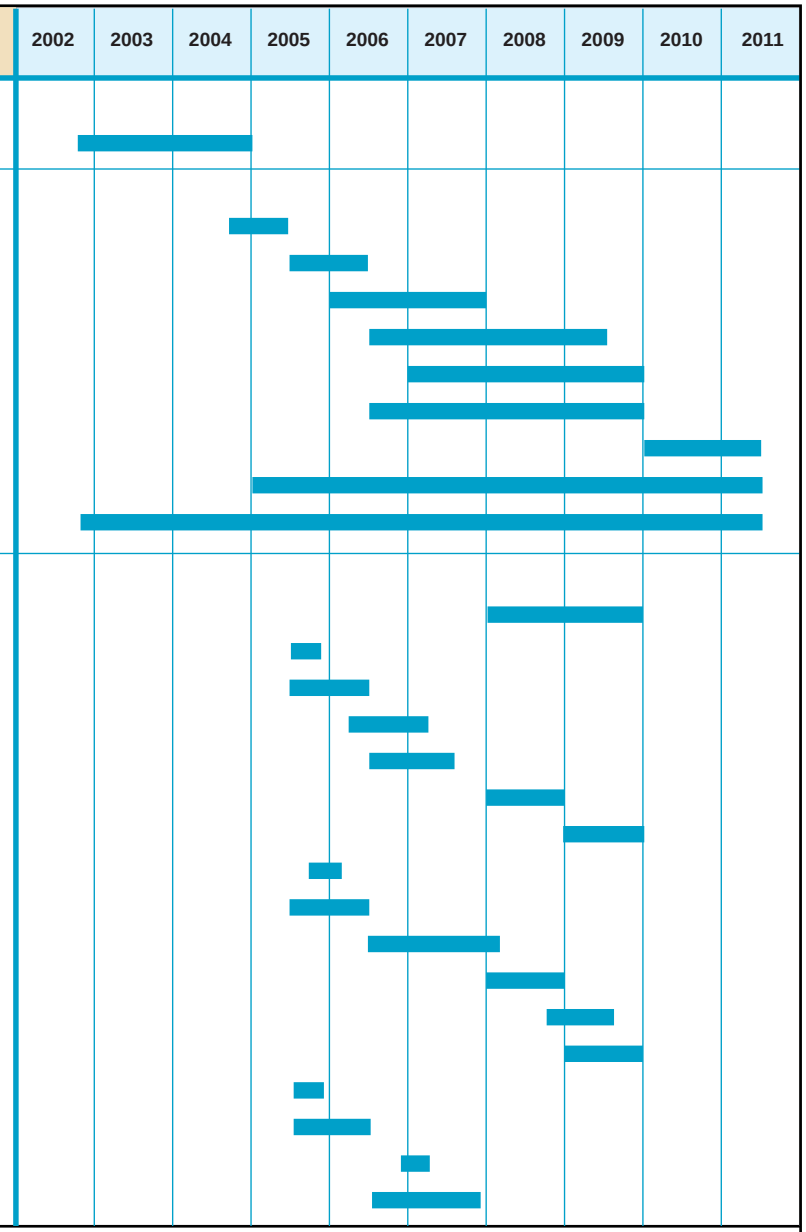

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Figure 6-1
Brightwater Implementation Schedule

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG 6-1_Implementation Schedule • 04/23/03 • rd

Appendix A

Washington Department of Ecology Facilities Plan Checklist

Brightwater Regional Wastewater Treatment System

TOPIC	SECTION IN REPORT/COMMENTS
I. General Information	
A. Project Description	1.1, 1.3
B. Location Map	1.2; Figure 1-1; System Alternatives Map at end of report
C. Sewer Service Area Map	Figure 1-1
D. Level of Treatment, Required Copy of Current Permit or Draft Permit for New Discharge, Compliance in Order	4.3.1.3. The project involves a new treatment facility and thus there is no existing NPDES Permit or compliance issues. NPDES permitting for the new facility will be initiated through the Department of Ecology following review and acceptance of the Facilities Plan.
II. Background Information	
A. Existing Environment	Chapters 4, 5, 6, 7, and 11 of the Draft EIS supplement information presented in the Facilities Plan
1. Water	2.2.1
2. Air	2.2.4
3. Land	2.2.2
4. Sensitive areas	Chapters 4, 6, 7, and 11 of the Draft EIS
5. Endangered species/habitat	Chapter 7 of Draft EIS

TOPIC	SECTION IN REPORT/COMMENTS
6. Public health	2.7
B. Demography and Land Use	2.3; Chapter 11 of Draft EIS
1. Current population	2.3.1
2. Current land use zoning	2.3; Figures 2-10, 2-11
3. Current zoning map	Figures 2-10, 2-11
C. Current Wastewater Treatment	2.5
1. Describe current treatment process	2.5
a. Location of STP(s), biosolids disposal, pump stations, and collection systems	2.5; 2.5.6-Biosolids; Figure 2-13 (pump stations and collection systems)
b. Existing design capacity & wastewater flows and characteristics	Table 2-5
c. Developed areas within services area that are currently on on-site system	Various tracts of unsewered development occur within Brightwater Service Area. Reference section 2.7. Sewered versus unsewered development is considered in existing population and flow projections (Table 2-2) and future projections (Tables 3-1 through 3-5).
d. STP performance compared to permit limits	2.5.5; Table 2-6
e. Current O&M program for plant and collection system	Staffing plan and O&M for Brightwater facilities is discussed in 5.3.11
2. Plant flow diagram	Figures 2-17, 2-19
3. Site layout map	Aerial photographs, Figures 2-16, 2-18
4. Current plant loading (tables of at least 1 year of data)	Table 2-5
5. Current biosolids disposal methods	2.5.6
6. Locations & waste characteristics of current industrial dischargers.	Reported to Ecology by King County's Industrial Waste Section
7. Sources of plant loadings	
a. Industrial	Table 2-2

TOPIC	SECTION IN REPORT/COMMENTS
b. Commercial	Table 2-2
c. Domestic	Table 2-2
d. Infiltration	2.6; Tables 2-2, 2-11
e. Inflow	2.6; Tables 2-2, 2-11
8. Seasonal loading variations	Table 2-2
9. Flow meter accuracy checked	Not applicable to Brightwater as it is a proposed facility
10. Lab analysis checked for accuracy by state certified lab	Existing King County laboratories are in compliance
11. Plant bypasses	2.5.3; 2.5.4
D. Receiving Water Evaluations	
1. AWT need evaluated	4.3.1.3; Appendix D
2. Water quality analyzed	Appendix D
3. Dilution zone analysis	Appendix D
4. Toxics in effluent	Appendix D
5. Nutrient impacts/bacteria impacts	Appendix D
6. Are water quality standards being met now?	Appendix D
7. Receiving water flows	Not applicable to marine discharge
E. I/I Studies	
1. Degree in collection system	2.6
a. Methods used and data adequate to support excessive or non-excessive I/I determination	2.6
b. Non-excessive I/I determined and used as part of base flow in design	2.6; Table 2-11
c. Schedule for sewer rehab including where rehabilitation is proposed and amount of correction	2.6

TOPIC	SECTION IN REPORT/COMMENTS
from rehabilitation is realistic	
2. Sewer overflows?	2.5.2.4
a. Fixes recommended	2.5.2.4
3. Combined sewer overflows	2.5.2.3; also reference King County CSO Control Plan
a. Fixes evaluated	Reference King County CSO Control Plan
4. CSO report approved?	Yes
5. Map locating CSOs and SSOs	Figure 2-15
6. Discussion of frequency and volume of overflow	Reference King County CSO Control Plan
7. Impacts of overflow on receiving water	Reference King County CSO Control Plan
F. Unsewered Communities	2.7
1. Health emergency	2.7.1
2. Sanitary survey conducted	Not performed as part of Brightwater, as project is not the result of on-site treatment system failure
3. Statistics/data on total on-site systems and number of failures	Table 2-2 indicates sewered versus unsewered development. No statistics available for on-site treatment system failure
4. Local Health Dept/Dept of Health involved	2.7.1
5. Reasons for failures	2.7.1
III. Future Conditions	
A. Demography or Land Use	
1. Population projections based on appropriate data source	3.2
2. Future land use changes/zoning densities	Figures 2-10, 2-11
3. Future service area	Figure 1-1; Tables 3-6 and 3-7
4. Recreation and open space alternatives	Considered in siting evaluation and site plan development
B. Waste Load	

TOPIC	SECTION IN REPORT/COMMENTS
1. Future flows & loadings	
a. Domestic	Tables 3-1 through 3-5
b. Commercial	Tables 3-1 through 3-5
c. Industrial	Tables 3-1 through 3-5
d. I/I	
2. Continued use of existing on-site wastewater systems possible?	Yes. May/will be connected to sewers in accordance with policies of local jurisdictions.
IV. Alternatives	
A. Locations	4.2
1. Alternative sites	4.2
2. Proximity of residences or developed areas	Considered in siting process. Reference Table 4-3
3. 25-year & 100-yr floodways and floodplains	4.2; Figure 2-2
4. Adequacy of site soils to support the facility	Initial geotechnical investigations indicate favorable conditions at Route 9 site. Geotechnical investigations proceeding on deep structures.
5. Site difficulties	Table 4-3
6. Location of wells: domestic, agricultural, and industrial	Figures 2-5, 2-7 and 2-12
B. Design Criteria	
1. Design population	Tables 3-1 through 3-5
2. Design flow conditions (peak, average, wet, & dry weather)	Table 3-7
3. BOD, TSS nutrients	Table 3-7
4. Recycle streams	Reflected in preliminary mass balances, Figures 5-2, 5-3, and 5-4
5. Special handling for industrial wastes	
a. Treatability in STP	Not anticipated as problem

TOPIC	SECTION IN REPORT/COMMENTS
b. Pretreatment needs	In accordance with King County Industrial Waste Program
C. Types of Systems Evaluated (i.e., all practicable waste treatment technologies)	
1. Fixed growth	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.4; Table 4-12
2. Suspended growth	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.4; Table 4-12
3. Land treatment	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.4; Table 4-12
4. Lagoons	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.4; Table 4-12
5. Operational improvements	Not applicable since new facility
6. Innovative or alternative	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.4; Table 4-12
7. Revenue producing capabilities	Reclaimed water may offer partial cost recovery potential. Reference Technical Memorandum, Reuse, Appendix F
D. Types of Collection Systems Evaluated	Local collection system issues not typically applicable to regional conveyance system addressed in the Facilities Plan. Reference 4.2.1.3 and Appendix C for conveyance alternative analysis
E. Sludge Treat/Disposal Alternative	
1. Aerobic	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.7; Table 4-20
2. Anaerobic	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.7; Table 4-20
3. Composting	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.7; Table 4-20
4. Land disposal	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.7; Table 4-20

TOPIC	SECTION IN REPORT/COMMENTS
5. Utilization	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3.7; Table 4-20
F. Effects of Flow Reduction Measures	2.5.8; 2.6
G. Evaluate & Rank Alternatives	
1. Criteria	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables
a. Total capital costs	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables
b. Environmental impacts	Reference Draft EIS
c. Public acceptability	Reference Draft EIS/SEPA process
d. Meet effluent limits	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3; Table 4-14
e. Ease of maintenance	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables
f. Present worth (including O & M)	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables; Table 4-15
2. I/A technology	
a. Considered Yes__X___ No _____	Split flow MBR
H. Select Final Alternatives to Further Evaluate and Rank	
1. Evaluate and rank final alternatives	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables
2. Select recommended alternative	Technical Memorandum Task 1.03, Treatment Plant Process Engineering which supplements Facilities Plan; 4.3 and associated tables
V. Final Recommended/Selected Alternatives	
A. Site Layout	Figure 5-5
B. Flow Diagram	Figure 5-1

TOPIC	SECTION IN REPORT/COMMENTS
C. Hydraulic Profiles (peak plant flow high receiving water flow or elevation)	Figure 5-7
D. Follows Recommendations in Criteria Manual	Table 5-4
E. Design Criteria for Each Process Unit	Table 5-4
F. Sizing Calculations for Each Process Unit	Sizing criteria listed in Table 5-4
G. Age and Adequacy of Existing Process	Not applicable
H. Units to be Retained	Not applicable
I. Solids Treatment	5.3.2; Table 5-4
J. Recycle Flow Accounted for?	Mass and flow balances, Figures 5-2, 5-3, 5-4.
K. Site Specific Outfall Analysis	Appendix D
L. Sizing Calculations Included	Sizing criteria listed in Table 5-4
M. Biosolids Disposal Plan	
1. Description of plan	
2. Action required to implement	
N. Ability to Expand Treatment Plant	Table 5-4; Figure 5-5
O. Ability to Expand Collection System	Appendix C
P. O&M Staffing Requirements	5.3.11
Q. Lab Staffing Requirements	5.3.11
R. Solid Mass Balance	Figures 5-2, 5-3, 5-4
VI. Financial	
A. Capital, O&M, Costs of Selected Alternative	
B. User Charges for Selected Alternative With Loan & Without Loan	

TOPIC	SECTION IN REPORT/COMMENTS
C. Funding of Project	
1. Possible funding sources identified	Chapter 6
2. Effects of possible funding sources on project and user costs evaluated	Chapter 6
VII. Other Requirements	
A. WQMP Conformance	
B. SEPA Compliance Achieved	
1. SERP compliance	
2. Projects identified in a:	
(a) General sewer plan	Reference King County *Regional Wastewater Services Plan,* as approved by the Department of Ecology
(b) Capital improvement plan	Yes
3. Public participation	Ongoing, coordinated with SEPA process
C. List of Needed Permit Approvals for Recommended Alternative	Appendix H
D. Review of Existing Sewer Use System & User Charges	Chapter 6
E. O&M for Collection System, Treatment Plants, On-site Systems	5.3.11
F. Implementation	Chapter 6
G. Financial Aspects (Capital Financing Plan)	Chapter 6
H. Legal and Administration	Allowances included in cost estimates
I. Staffing & Management	5.3.11
J. Value Engineering Required? Yes ____ No ____	

Appendix B

Performance Data and Influent Wastewater Characteristics

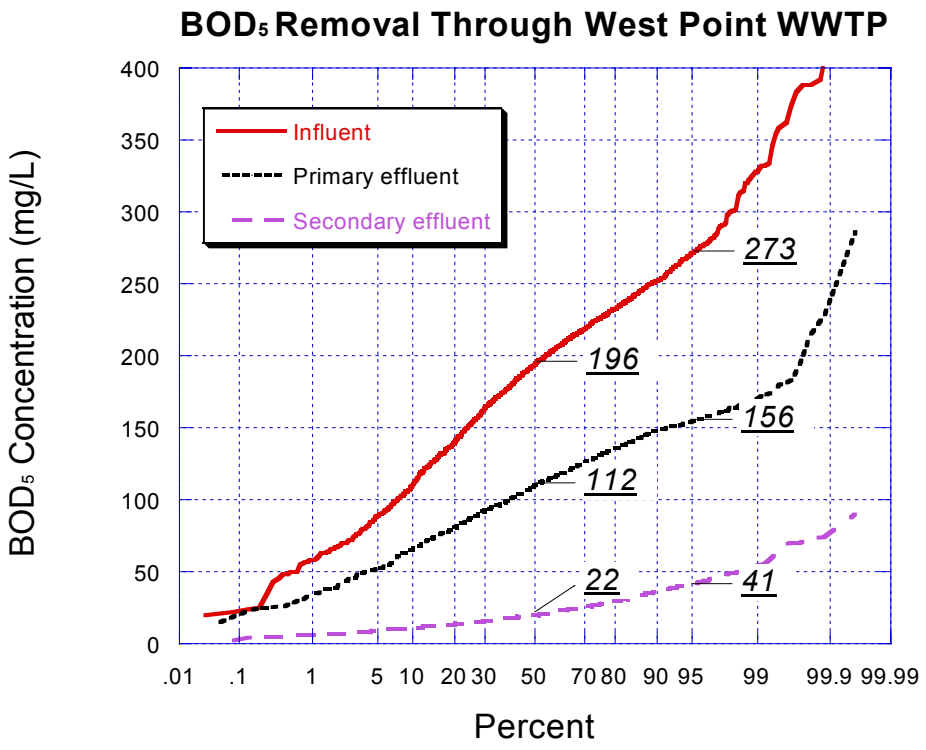
West Point and South Treatment Plants

LIST OF FIGURES

Figure B-1	BOD_5 Removal, West Point and South Treatment Plants
Figure B-2	TSS and BOD_5 Influent Mass Loadings, West Point and South Treatment Plants
Figure B-3	TSS and BOD_5 Influent Variability, West Point and South Treatment Plants
Figure B-4	Influent Flow and Temperature Variability, West Point and South Treatment Plants

Note: Data are presented as exceedance plots, based on period of record from January 1997 through December 2001.

Figure B-1
BOD_5 Removal, West Point and South Treatment Plants



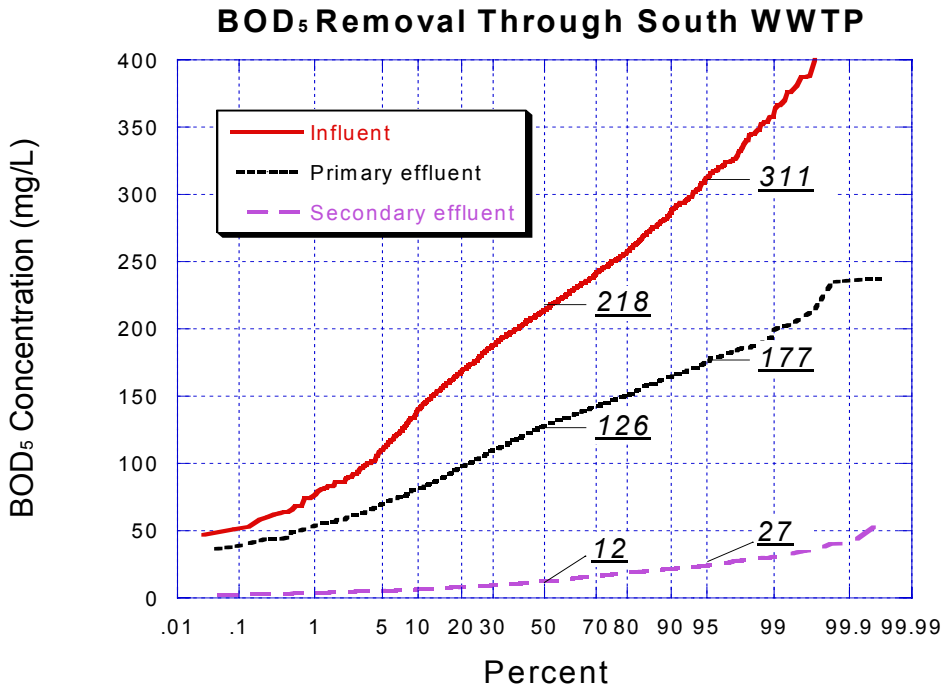
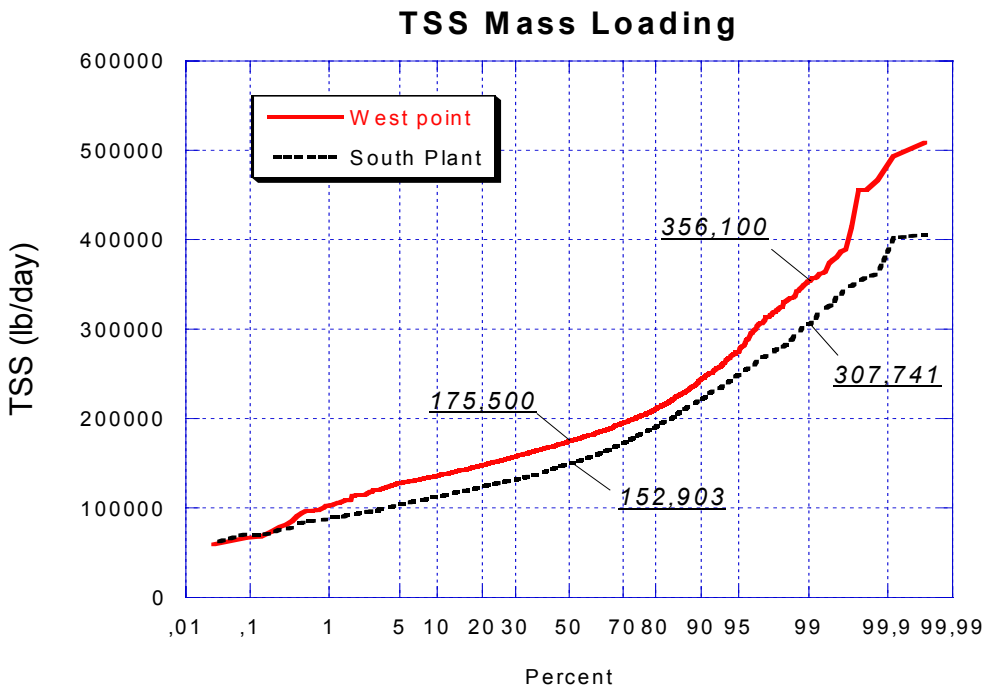


Figure B-2
TSS and BOD_5 Influent Mass Loadings, West Point and South Treatment Plants



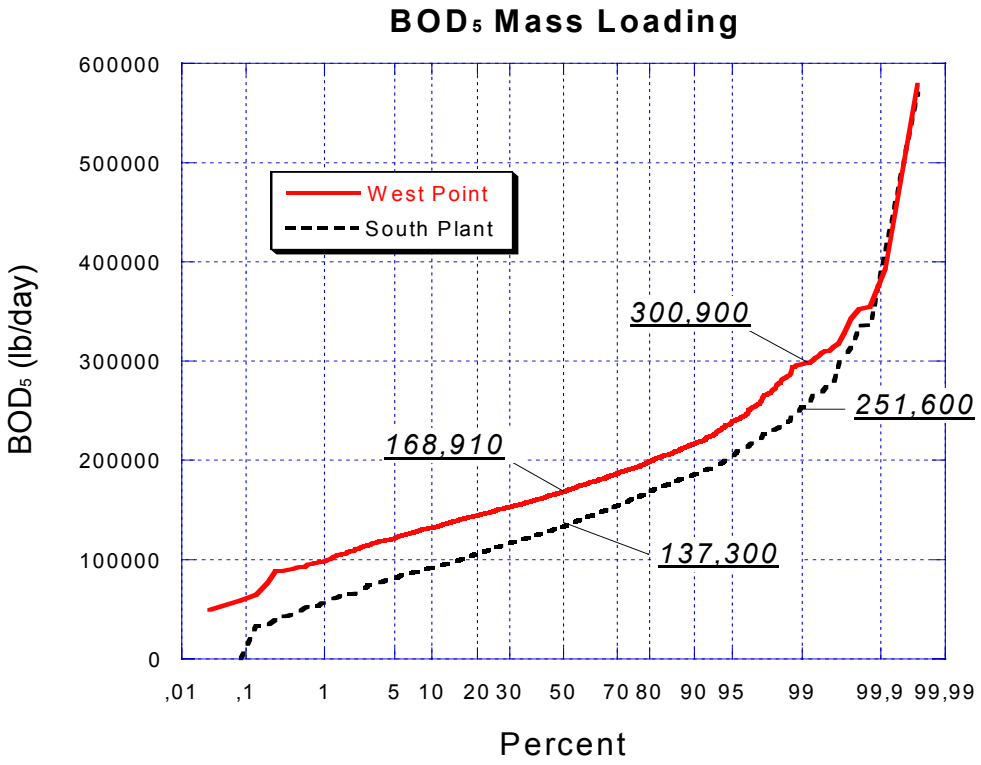
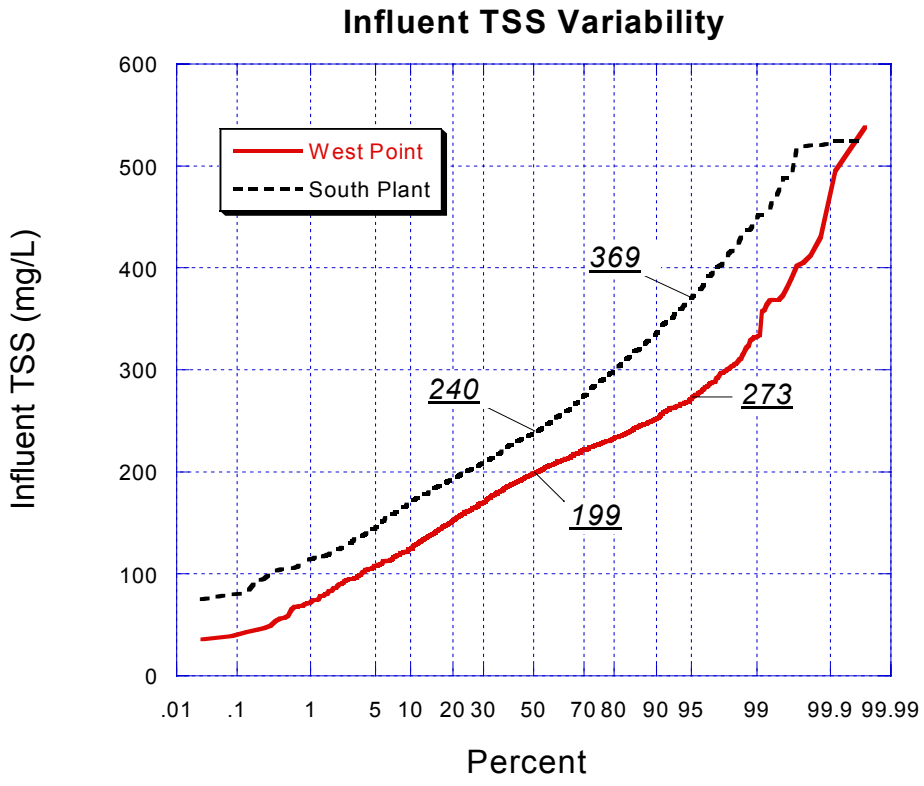


Figure B-3
TSS and BOD_5 Influent Variability, West Point and South Treatment Plants



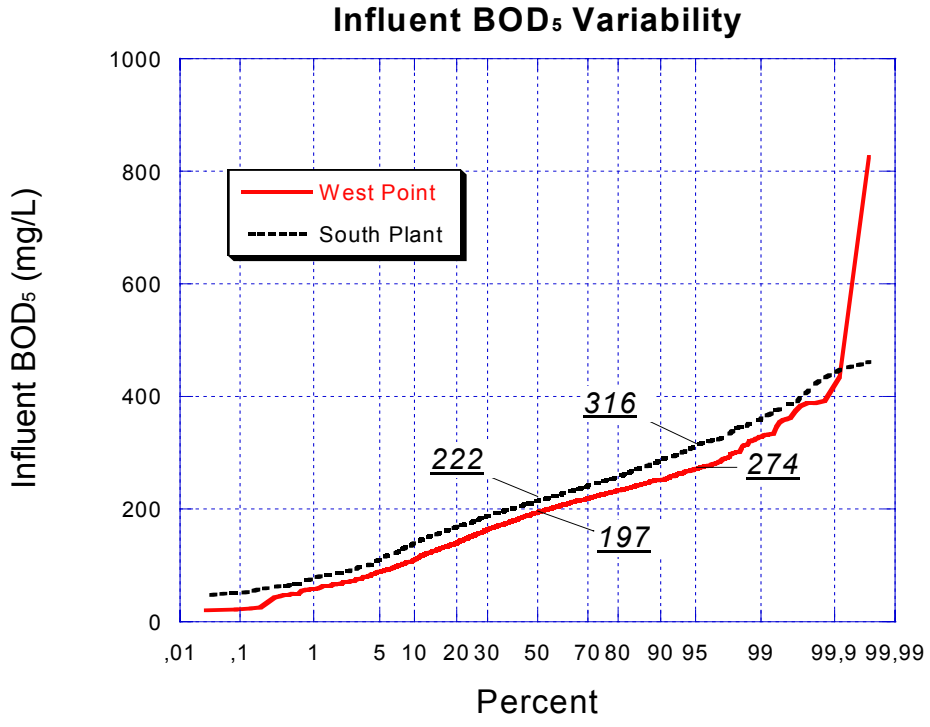
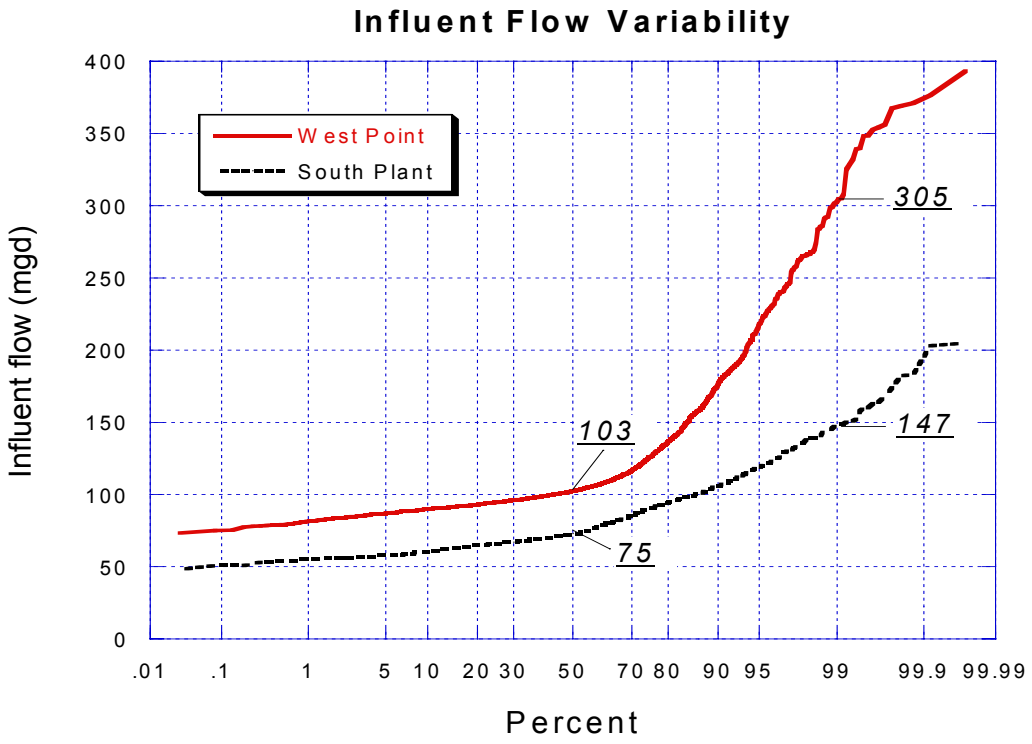
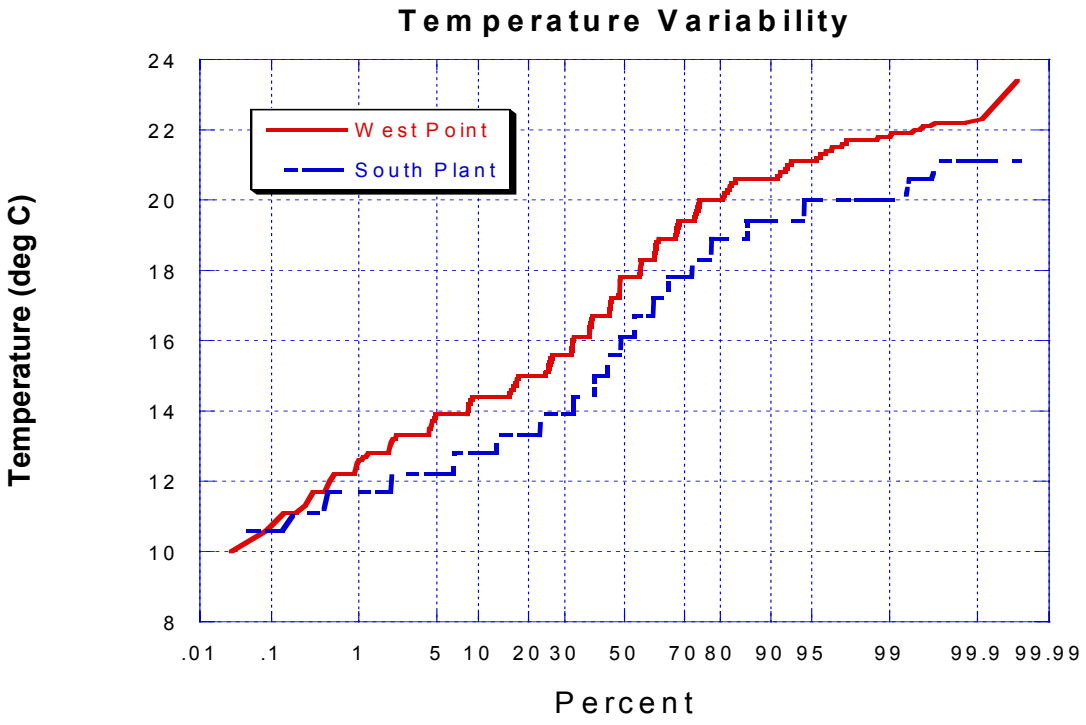


Figure B-4
Influent Flow and Temperature Variability, West Point and South Treatment Plants





Appendix C
Conveyance System Alternative Analysis

Note to Ecology: This appendix presents the alternatives analysis performed to determine the two conveyance corridors documented in the Draft Environmental Impact Statement. Predesign investigations are underway to refine the alignments for the Final EIS and will be transmitted to Ecology under separate cover.

C.1 Introduction

This appendix describes the alternative analysis performed on the Brightwater conveyance system—those components of the project that will convey raw wastewater to the treatment plant and treated effluent to the marine outfall. In particular, discussions focus on work that was performed concurrent with the Brightwater Siting Project Phase 3, after treatment plant site alternatives had been narrowed to the Route 9 and Unocal options.

Working as part of the King County Conveyance System Improvement (CSI) Program, the conveyance team reexamined the conveyance concepts developed during the Siting Project Phase 2. For both the Route 9 and Unocal sites, the team identified a number of potentially feasible conveyance corridors; evaluated vertical profiles; investigated potential construction methods; and analyzed pumping regimes that would tie into the existing King County conveyance system, deliver influent to Brightwater, and convey effluent to several possible outfall zones in the Puget Sound.

C.2 Preliminary Route 9 Conveyance Alternatives

Four influent systems and 22 effluent systems were initially developed for the Route 9 site. The preliminary Route 9 alternatives are listed in Tables C-1 and C-2 and shown in Figure C- 1. Alternative alignments were developed for each probable conveyance terminus and alternative construction methods (near surface/open cut microtunneling, and conventional tunneling/deep tunnel). Alignments were also divided into sub-elements, or segments, to facilitate analysis. The influent systems were developed to connect existing King County conveyance pipelines to the proposed treatment plant location. Each of the

Route 9 effluent systems connected the treatment plant to one of the proposed outfall locations. Those segments without corridor designations and names were eliminated from consideration after the first round of screening and were not assigned to corridor designations.

Table C-1. Preliminary Route 9 Influent Conveyance Corridors

Segment	Construction	Corridor Identification
R9I-T1	Deep Tunnel	Eliminated in first screening round
R9I-T2	Deep Tunnel	Eliminated in first screening round
R9I-T3	Deep Tunnel	K – Rt 9 Influent Deep Tunnel
R9I-S1	Near Surface	Eliminated in first screening round

Table C-2. Preliminary Route 9 Effluent Conveyance Corridors

Segment	Construction	Corridor Identification
R9E-T1	Deep Tunnel	F – Rt 9 - 228th Deep Tunnel
R9E-T2	Deep Tunnel	F – Rt 9 - 228th Deep Tunnel
R9E-T3	Deep Tunnel	H – Rt 9 County Line Deep Tunnel
R9E-T4	Deep Tunnel	H – Rt 9 County Line Deep Tunnel
R9E-T5	Deep Tunnel	Eliminated in first screening round
R9E-T6	Deep Tunnel	Eliminated in first screening round
R9E-T7	Deep Tunnel	H – Rt 9 County Line Deep Tunnel
R9E-T8	Deep Tunnel	H – Rt 9 County Line Deep Tunnel
R9E-T9	Deep Tunnel	I – Rt 9 South Deep Tunnel
R9E-T10	Deep Tunnel	I – Rt 9 South Deep Tunnel
R9E-T11	Deep Tunnel	J – Rt 9 195th Deep Tunnel
R9E-T12	Deep Tunnel	J – Rt 9 195th Deep Tunnel
R9E-S1	Near Surface	E – Rt 9 228^{h} Near Surface
R9E-S2	Near Surface	E – Rt 9 228^{h} Near Surface
R9E-S3	Near Surface	G – Rt 9 County Line Near Surface
R9E-S4	Near Surface	G – Rt 9 County Line Near Surface
R9E-S5	Near Surface	Eliminated in first screening round
R9E-S6	Near Surface	Eliminated in first screening round
R9E-S7	Near Surface	Eliminated in first screening round
R9E-S8	Near Surface	Eliminated in first screening round
R9E-S9	Near Surface	Eliminated in first screening round
R9E-S10	Near Surface	Eliminated in first screening round

C.3 Preliminary Unocal Conveyance Alternatives

For the Unocal system, analyses focused on raw wastewater influent corridors because the facility would not require an effluent conveyance system due to its proximity to an outfall zone. The Unocal preliminary influent corridors are listed in Table C- 3 and shown in Figure C-2. Fourteen preliminary influent conveyance system segments were identified for the treatment plant location at Unocal, divided into 4 segments east of the existing Kenmore Pump Station and 10 west of the pump station.

Table C-3. Preliminary Unocal Influent Conveyance Corridors

Segment	Construction	Segment/Route	Corridor	Corridor Name
Eastern Section – Between North Creek and Kenmore				
EDI-ES1	Near Surface	SR 522	A	Unocal South Near Surface
EDI-ES2	Near Surface	Residential ROW[a]		
EDI-ET1	Deep Tunnel	Cross-Country Non-ROW	B, C	Unocal South Deep Tunnel
EDI-ET2	Deep Tunnel	195th	D	Unocal 195th Deep Tunnel
Western Section – Between Kenmore and Unocal				
EDI-WS1	Near Surface	Ballinger – N 205th – 100th W	A	Unocal South Near Surface
EDI-WS2	Near Surface	Residential ROW		
EDI-WS3	Near Surface	Ballinger – N 205th – SR 104	A	Unocal South Near Surface
EDI-WT1	Deep Tunnel	Ballinger – N 205th – 100th W	B	Unocal South Deep Tunnel
EDI-WT2	Deep Tunnel	Cross Country – Non-ROW	C	Unocal North Deep Tunnel
EDI-WT3	Deep Tunnel	Ballinger – N 205th – SR 104	B	Unocal South Deep Tunnel
EDI-WT4	Deep Tunnel	Ballinger – N 205th – 100th W	B	Unocal South Deep Tunnel
EDI-WT5	Deep Tunnel	Ballinger – N 205th – SR 104	B	Unocal South Deep Tunnel
EDI-WT6	Deep Tunnel	195th - Ballinger – N 205th – 100th W	D	Unocal 195th Deep Tunnel
EDI-WT7	Deep Tunnel	195th - Ballinger - N 205th – SR 104	D	Unocal 195th Deep Tunnel

Notes:
[a] Right-of-way

The number of alternatives was reduced through two rounds of screening evaluations as summarized in this section. The reader is referred to the *Brightwater Phase 3 Pre-Scoping Conveyance Evaluation Summary* and *Brightwater Phase 3 Pre-Draft EIS Conveyance Evaluation Summary* (King County, 2002a; King County, 2002b) for additional information regarding the screening evaluations.

C.4 Screening of Alternatives for Environmental Impact Statement Scoping Notice

The number of alternatives was first reduced prior to public distribution of the Environmental Impact Statement (EIS) scoping notice as described in this section.

C.4.1 Criteria for Evaluating Conveyance Alternatives

The conveyance team worked collectively to develop a comprehensive list of conveyance evaluation factors. The factors were selected to test the relative suitability of proposed alternatives and were based on measurable physical properties and characteristics. Alternatives were evaluated against the factors using a tiered approach: 1) two factors were identified as threshold (pass/fail) factors that all the alternatives had to satisfy before being considered for further evaluation, 2) a set of 21 factors was selected for the scoping round of evaluation to determine relative suitability, and. 3) a subset of 10 of these 21 factors were given priority in determining the overall ranking of alternatives.

Each of the 21 factors was posed as an evaluative question, similar to the Detailed Evaluation Questions used in treatment plant siting. For example, steep slopes were identified as an evaluation factor with the following question: "What is the extent of potential pump station and portal areas with slopes greater than 30 degrees?" To establish a systematic response that would allow comparison among alternatives, a rating scale was developed. With respect to slopes, for example, the scale included: High - greater than 20% of the total area has slopes more than 30 degrees; Medium - less than 20% of the total area has slopes more than 30 degrees; Low – none of the area has slopes greater than 30 degrees. The factor questions, scales, and ratings were compiled into evaluation tables found in Appendix A of *Brightwater Phase 3 Pre-Scoping Conveyance Evaluation Summary* (King County, 2002a).

After completion of the evaluation tables, the ratings were entered into a numerical decision model that was used to evaluate the relative ranking and performance of alternatives. The model was also used to establish balance in the relative contribution of factors from technical/engineering, environmental/community, and land acquisition considerations.

Ten of the factors were classified as "priority" and were modeled separately and in combination with the entire set of 21 factors. The priority factors included total number of tunnel portals, number of portals deeper than 200 feet, total conveyance length, number of pump stations, number of wetland crossings, number of stream crossings,

dewatering volume for disposal, construction impact on roads, total surface disruption, and surface private property acquisition. Table C-4 lists the evaluation factors by key words, and identifies threshold factors (TF) or priority factors (PF).

Table C-4. Evaluation Factors for Scoping Notice

Component[a]	Importance[b]	Deep Tunnel	Near Surface	Key Words
Engineering				
ROUTE	PF	•		Total Number of Portals
ROUTE		•		Average Depth of Potential Deep Tunnel Portals
ROUTE	PF	•		Number of Portals Deeper than 200 feet
ROUTE		•		Groundwater Head on Tunnel
ROUTE		•	•	Proximity to Fault
ROUTE	PF	•	•	Total Conveyance Length
ROUTE	PF		•	Number of Pump Stations
PS/PORT			•	Landslide Potential
PS/PORT			•	Steep Slopes Greater than 30%
PS/PORT		•		Depth of Dewatering
CONV SYS		•		Total Length of Tunneling
CONV SYS			•	Total Length of Microtunneling
CONV SYS			•	Total Length of Cut and Cover

Table C-4. Evaluation Factors for Scoping Notice

Component[a]	Importance[b]	Deep Tunnel	Near Surface	Key Words
Community/Environmental				
PS/PORT	TF			Availability of Buildable Land
CONV SYS	TF			Excluded Land Uses for Surface Facilities
ROUTE			•	Endangered Species Act Compliance
ROUTE	PF		•	Number of Wetland Crossings
ROUTE		•	•	Drinking Water Wells
ROUTE	PF		•	Number of Stream Crossings
ROUTE		•	•	Presence of Contamination
ROUTE	PF	•		Dewatering Volume for Disposal
ROUTE	PF		•	Construction Impacts on Roads
CONV SYS	PF		•	Total Surface Disruption (PS/PT area + (corridor length x 40' width))
Land Acquisition				
ROUTE	PF		•	Surface Private Property Acquisition (PS/PT + Cross-Country)
ROUTE		•	•	Surface & Subsurface Private Property Acquisition (Above + Subsurface Tunnel)

[a] Indicates project component to which factor most applies. Route indicates conveyance system routing. Conveyance indicates uniform applicability to conveyance system. PS/PORT indicates pump stations/portals.

[b] PF indicates priority factor. TF indicates threshold factor

C.4.2 First Screening Evaluation

The evaluation model indicated that the corridors with the shorter conveyance lengths, lower amounts of surface disruption, shallower tunnels, and less impact to streams and wetlands should be retained. Corridors were established as 1,000-foot-wide zones in which more precisely located tunnel or pipeline alignments would be established during subsequent analyses. For tunnel corridors, portal siting areas (PSAs) were established as 72-acre circles in which 1- to 2-acre portals would be located. The number and location of portals would be established following technical analyses to establish allowable portal spacings, geotechnical investigations, and a portal siting process.

As a result, one Route 9 influent corridor and six effluent corridors were retained for consideration in the EIS Scoping Notice, as follows:

- Route 9 Effluent 228th St SW– Near Surface (Corridor E)
- Route 9 Effluent 228th St SW– Deep Tunnel (Corridor F)
- Route 9 Effluent County Line – Near Surface (Corridor G)
- Route 9 Effluent County Line – Deep Tunnel (Corridor H)
- Route 9 Effluent South Corridor (Kenmore/Ballinger Way NE) – Deep Tunnel (Corridor I)
- Route 9 Effluent 195th – Deep Tunnel (Corridor J)
- Route 9 Influent – Deep Tunnel (Corridor K)

The Route 9 corridors are shown in Figure C-3.

For the Unocal system, the following four influent corridors were retained for consideration:

- Unocal South Influent – Near Surface (Corridor A)
- Unocal South Influent – Deep Tunnel (Corridor B)
- Unocal North Influent – Deep Tunnel (Corridor C)
- Unocal 195th Influent – Deep Tunnel (Corridor D)

The Unocal corridors are shown in Figure C-4.

C.4.3 Second Screening Evaluation

A second round of evaluations was conducted on the conveyance system alternatives included in the EIS Scoping Notice to further reduce the number of alternatives that would be included in the Draft EIS.

In the second round of screening, the number of evaluation factors was expanded from 22 to 47. The additional 25 key factors, summarized in Table C-5, addressed new issues or examined topics at a greater level of detail. The conveyance team determined that 6 of the 25 new key factors should be deferred to the Final EIS analysis when more specific information on portal and pump station locations is available. These six factors were excluded from the relative rankings and, in total, 41 key factors were retained in the second round of evaluation.

Table C-5. Additional Factors Used in Pre-DEIS Evaluation of Conveyance Alternatives

	Code		Key Words	Description
	ENGINEERING			
1	ENGR-Util3c		Existing Utility Congestion	Measure of relocations and conflicts with underground utilities
2	ENGR-Acc1c	●	Construction & Maintenance Access	Proximity to major roadways
3	ENGR-Geo3c	●	Soil Liquefaction	Number of PT/PS in areas of soil liquefaction
4	ENGR-Conv4c		Energy Consumption	Average annual energy consumption
5	ENGR-Sys4c		Flow Management Flexibility	Ability to handle prolonged rain and/or multiple equipment failures
6	OUTFALL		Outfall Location	Conveyance connects directly to preferred outfall zones
	ENVIRONMENTAL / COMMUNITY			
7	ENVR-LU2b		Compatibility with Surrounding Land Uses	Relative density of development in PT/PS areas
8	ENVR-CR3c	●	Archeological & Historic Resources	Likely presence of cultural resources at PT/PS
9	ENVR-CR5c	●	Archeological & Historic Resources	Likely presence of cultural resources along conveyance
10	ENVR-Hazm4c		Presence of Contamination	Known documented contamination at PT/PS
11	ENVR-Bio2c		Endangered Species Act Compliance	Unavoidable disruption of special status species habitat at PT/PS
12	ENVR-Bio7c		Endangered Species Act Compliance	Unavoidable disruption of special status species habitat along route
13	ENVR-Bio4c		Wetlands Impacts	Unavoidable impacts to wetlands and their buffers at PT/PS
14	ENVR-Hydro4d		Drinking Water Wells	Potential intersection with travel zone of Group A water supply system
15	ENVR-Hydro2c		Stream Impacts	Direct impacts to streams or their buffers at PT/PS
16	ENVR-Acc3c	●	Traffic Disruption - Roads & Streets	Extent of roadway traffic disruption from construction of PT/PS
17	ENVR-LU4c		Land Use	Relative percentages of land uses crossed by conveyance
18	ENVR-Acc4c	♦	Traffic Disruption - Residential Access	Extent of residential access disruption from conveyance construction
19	ENVR-Acc5c	♦	Traffic Disruption - Commercial Access	Extent of commercial access disruption from conveyance construction
	LAND ACQUISITION			
20	LAND-Time9c		Relative Number of Acquisition Parcels	Estimated number of acquisition parcels along conveyance
21	LAND-Time 8c		Number of Relocations- Permanent	Estimated number of relocations along conveyance
22	LAND-Time10c		Relative Level of Upland Development	Extent of construction impacts to existing and pending development
23	LAND-Time3c	●	Legal Restrictions on Title	Title restrictions that limit available useable area
24	LAND-Time5c		Complexity of Relocations	Difficulty of relocating occupants at PT/PS
	FINANCIAL			
25	FINAN-Sys3d		Lifecycle Costs	Estimated 50-year present work lifecycle costs

PT/PS = Portals and Pump Stations

● *Factor deferred to Final EIS when site-specific information is available*

♦ *Factor given twice the weight of other factors to address public concerns about construction affecting commute routes and business access*

During the second screening evaluation, two categories were added to the screening criteria groups–Financial and Outfall. Financial considerations in the prior evaluation were accounted for with engineering surrogates such as conveyance length, number of pump stations, and number of portals. Cost was explicitly considered in the second evaluation as the cost estimates, which were being developed during the pre-scoping evaluation, were now available. The outfall factor was a result of the finalization of the marine outfall siting study (MOSS). Details of the outfall-related screening evaluations are presented in Appendix D, and are not discussed in further detail in this appendix.

As with previous evaluations, the ratings for each of the factors were loaded into a numerical decision model used to compile the overall relative performance of alternatives. Two of these factors, Traffic Disruption – Residential and Traffic Disruption – Commercial, were considered to be sufficiently important to receive twice the weight of the other factors. King County used the model results, along with public and agency input received during the scoping process, to determine which options were less feasible and which options should advance to full EIS analysis.

C.4.3.1 Screening Evaluation Summary

The analysis concluded that tunnel options were preferable over cut and cover options because they would minimize or avoid surface environmental impacts and traffic disruption. This is particularly important for the Route 9 system, which is located approximately 13 miles inland from Puget Sound and has the longest conveyance corridors.

For the Route 9 influent conveyance system, only the Route 9 Influent – Deep Tunnel (Corridor K) was advanced from preliminary screening. The deep tunnel influent conveyance along this corridor follows a cross-country route (i.e., not in public right-of-way) northeasterly from the existing Kenmore Pump Station to near the North Creek Pump Station and then to the Route 9 site. Within this corridor and subject to engineering and environmental considerations, sub-options are possible, including microtunneling at a shallow depth and various alignments.

For the Route 9 effluent conveyance system, deep tunnels along 228th Street (Corridor F) and 195th Street (Corridor J) were clearly favored by the analysis because of the potential for gravity flow, amount of corridor within public right-of-way, geotechnical and environmental considerations, and, in the case of 195th Street, potential for a portion of the influent conveyance to fall in the same corridor as effluent conveyance. Both corridors were recommended for additional analysis in the Draft EIS. The advantages and disadvantages of these two effluent corridors are summarized in Table C-6.

Table C-6. Comparison of Recommended Route 9 Effluent Conveyance Corridors

Parameter	Summary by Corridor	
	228th Street (Corridor F)	**195th Street (Corridor J)**
Advantages	• Deep tunnel avoids crossing nearly 40 stream/wetland systems • Density of population lower and parcel size larger in eastern part of corridor; relatively more undeveloped land available for portal locations.	• Corridor shares portion of alignment with influent corridor – reduces overall impact. • Corridor shares a portion of alignment with a utility corridor – should make tunnel acquisitions less complex because of limited surface uses. • Can use a large amount of public right-of-way.
Disadvantages	• Affects 228th Street SE - recently improved after years of construction. • Portal locations adjacent to salmonid streams.	• Longer than Corridor F by 1 mile. • Greater number of wetlands/streams affected than 228th St. corridor. • Avoids disruption of major roadways including 228th St. • Construction access on local roads could have a more disruptive effect on neighborhoods.

For the Unocal system, the Deep Tunnel (Corridor B) was favored over the other Unocal influent conveyance system alternatives. Two construction sub-options were evaluated along Corridor B: a deep tunnel conveying flow by gravity and a shallower tunnel with flow pumped through force mains. The pre-EIS screening evaluation indicated that the sub-options performed equally well and it was therefore recommended that both be analyzed and presented in the Draft EIS.

C.5 Description of Brightwater Conveyance Facilities

The Brightwater conveyance system would include a system of influent and effluent pipelines primarily constructed in tunnels. The system would also include tunnel construction and maintenance access points (portals), odor control and/or ventilation facilities, potential new pumping facilities depending on the selected profile of the system, and the marine outfall.

The conveyance pipelines would be constructed using a variety of methods. Most of the conveyance pipes would be constructed in tunnels (for diameters greater than 8 feet) using tunnel boring machines (TBMs) and microtunnels (for diameters less than 8 feet) using microtunneling machines. However, other construction methods would be used for connecting new tunnels and pump stations to existing facilities. For these connections, open-cut construction would likely be used. In places where connections would cross streams, wetlands, high traffic roadways, or other sensitive features, methods such as microtunneling or jack and bore could be used to avoid surface disturbances.

The tunnels could be as shallow as 30 feet or as deep as 455 feet below the ground surface. The pipes would either be gravity sewers or force mains, as dictated by the selected vertical profile. Gravity pipelines would range between 5 and 14 feet in diameter. Force mains would be placed within a 14-foot-diameter tunnel and would consist of 54-inch- and 48-inch-diameter parallel pipelines. Microtunnels could range between 5 and 8 feet in diameter.

The conveyance pipes would be routed within 1,000-foot-wide corridors that show the general path that a conveyance pipeline may follow. The corridors are much wider than the actual utility easement that would eventually be required for pipeline construction and maintenance (estimated to be between 20 and 100 feet wide). The wide corridor provides flexibility to accommodate site-specific conditions when selecting final alignments. It also facilitates future evaluation of the relative impacts and mitigation associated with alignment sub-alternatives.

Portal siting areas have been identified along each corridor at intervals of approximately 10,000 feet. PSAs are 2,000-foot-diameter (72-acre) circles within which 1 to 2 acres would be selected for portal siting. In a few areas, two portals may be co-located, requiring up to 4 acres for construction. Portals would serve as access points for tunnel

construction. Portals would typically require 50-foot-diameter vertical shafts that are excavated to provide access for launching and/or retrieving the tunneling equipment and installing pipes. If a force main is selected, pump stations may be constructed for either the Route 9 or Unocal systems. For the Route 9 system, an influent pump station, and potentially an effluent pump station, may be constructed at the treatment plant site. For the Unocal system, the pump station would be constructed in Kenmore, near the existing King County Kenmore Pump Station.

After construction is complete, most of the portal sites could be restored to pre-construction conditions, with a concrete pad as small as 10 by 10 feet. Other areas may have an above-ground structure for housing ventilation and/or odor control equipment with approximate dimensions of 40 by 50 feet. A pump station, if needed, would take an approximate 90- by 160-foot space above ground. Dechlorination facilities could be located at one of the PSAs on the western end of the effluent tunnel for the Route 9 alternatives. In all locations, above-ground structures would be architecturally finished to blend into the local landscape.

C.5.1 Design Flows

The Brightwater flow projections are detailed in Chapters 2 and 3 of this Facilities Plan. Briefly summarized, the Brightwater conveyance system would be designed to convey peak flows that would occur at full service area buildout. Peak flow is defined as the flows resulting from a 24-hour rainfall event with an intensity and duration that has the probability of occurring once every 20 years in this region. Flow projections are based on population and employment forecasts, long-term rainfall data, and a calibrated flow simulation from a design storm.

The resulting estimated 20-year peak flow for the year 2050 is 170 million gallons per day (mgd), which will be revisited as additional information from the Regional Infiltration and Inflow Control Program becomes available.

C.5.2 Tunnel Evaluation

There are several inter-related issues that are being examined in the tunnel evaluation, including: 1) portal siting, 2) tunnel alignment, 3) tunnel profile/grade and depth, and 4) siting of any permanent structures required at the portals. The following sections discuss how these issues will be addressed through ongoing siting and technical evaluations.

C.5.2.1 Portal Siting

The PSAs under consideration in the Draft EIS are currently 72 acres, of which approximately 1 to 2 acres are required for the construction. The area of the PSAs will be

decreased through three levels of siting evaluation, which parallel the siting process used for the Brightwater treatment facilities:

- Level 1 – Exclusion screening
- Level 2 – Candidate screening
- Level 3 – Final selection

Level 1 and 2 siting evaluations involve ongoing work that is incomplete as of the date of publication of this Facilities Plan. These Level 1 and 2 evaluations will be completed by the date of publication of the Final EIS and will consider all three conveyance alternatives—Route 9/195th Street, Route 9/228th Street, and the Unocal system. Level 3 screening will be conducted after publication of the Final EIS and selection of the final treatment plant site and conveyance system alternative.

Level 1 – Exclusion Screening

Level 1 screening consists of identifying and avoiding sensitive lands. This level of screening will be applied to the portals of all three conveyance systems and will be included in the Final EIS. Sensitive areas consist of:

- Wetlands and wetland buffers
- Streams and riparian buffers
- Critical habitat for endangered/threatened/candidate/state priority species
- Occupied cemetery lands
- Areas of known cultural and historical resources

Level 2 – Candidate Screening

The goal of Level 2 Candidate Screening is to identify multiple viable sites for further consideration within the remaining area of the PSAs. In contrast to the Level 1 evaluation, which will identify sensitive areas, Level 2 Candidate Screening focuses on selecting the best areas to locate the 2-acre portal area. Evaluations involve reviews of aerial photographs and field inspections of the portal areas to identify a specific parcel or multiple adjacent parcels that are undeveloped or underdeveloped. If multiple undeveloped and underdeveloped areas cannot be located in a PSA, then the following developed property will be identified as potential areas:

- Publicly owned lands

- Residential land uses
- Commercial/industrial land uses

In the same manner as the evaluation of the conveyance alternatives, data collected from field inspections and aerial photograph reviews are used to answer 22 factors, with answers being either a quantitative value or a qualitative high/medium/low answer. Results of the factors are loaded into the same numerical decision model used in the treatment plant siting and conveyance system analyses to compile the overall relative performance of alternative sites.

Level 3 – Final Selection

During final selection, public comments received during the Draft EIS and other public involvement processes will be factored into the decision process. Final selection will identify specific sites for portal construction from the Level 2 candidate sites at each of the PSAs.

C.5.3 Tunnel Depth and Distance Between Portals

There is a range of feasible depths at which the conveyance system tunnels can be constructed. The Draft EIS shows two alternatives—a shallow option that requires pump stations to assist in conveying flows to and from the treatment plant and a deep tunnel option that uses gravity to convey the flow to the point of delivery. While the deep tunnel option may offer significant cost savings by eliminating the need to construct, operate, and maintain a 170-mgd pump station, costs or delays related to the risk of constructing deep portals and tunnels could negate potential cost savings. This issue primarily affects the two Route 9 effluent corridors and the Unocal influent corridor.

The PSAs are currently set at nominal 10,000-foot intervals under the assumption that this is the maximum reasonable interval between access shafts for the removal of tunnel spoils, ventilation, and TBM maintenance. The assumption is based on construction experience with typical soft ground tunneling. The feasibility of extending the practical distance between portals to up to 20,000 feet or more will be evaluated during 2003 as part of the Brightwater conveyance predesign. Geotechnical investigations are currently being conducted to further define the subsurface environment. The results of this exploratory work will be used to evaluate feasible portal depths and the maximum allowable spacing between portals.

C.5.4 Tunnel Alignment

The Draft EIS describes 1,000-foot-wide tunnel corridors between the PSAs and treatment plant. The actual alignment will typically require a surface right-of-way or an easement that is 20 to 100 feet wide at a location within the 1,000-foot-wide corridor. The final alignment will be determined once the portal construction area in each of the PSAs has been determined. Primary final alignment goals are to stay within public right-of-way or under publicly owned property to the greatest extent possible while minimizing the total length of conveyance.

C.5.5 Permanent Above-Ground Structures

The nature and location of permanent structures at portals along the conveyance system will be finalized in the predesign process after the publication of the Final EIS and selection of the final system configuration. The engineering factors influencing the decision on the number of structure types and locations are related to mitigating odor and corrosion issues in the influent system, and tunnel access for future inspection and/or maintenance.

C.5.6 Local Connections

Local connections to the existing conveyance system would be required to tie in to the influent tunnel at the Kenmore and North Creek Pump Stations. Diversion structures would be constructed below ground at both pump stations, adjacent to existing facilities.

New pipelines constructed by open cut and/or jack-and-bore or microtunnel construction methods would be required between the diversion structures and the portal site. Additional drop structures within the portal may be needed depending on the depth of the tunnel and location of the portal site.

C.5.7 Open Cut and Microtunneling Evaluation

The local connections between the existing conveyance system and the new influent tunnels will be installed using open cut, jack-and-bore, and/or microtunneling methods. It is expected that microtunneling or jack-and-bore methods would be used to cross sensitive areas or busy roadways that cannot be open cut. Open cut may be a faster and less expensive method of construction, while jack-and-bore and microtunneling generally have less surface disruption. Final evaluation of construction methods for making local connections will be conducted during predesign.

C.5.8 Storage Considerations

Minimum tunnel diameters are determined based upon the room needed for tunnel construction activities. Therefore, the influent tunnels are larger than necessary for conveying wastewater to the treatment plant. The additional volume in the tunnels is to be used for wastewater storage to reduce peak flow volumes entering the treatment plant and provide storage during emergency events. The Route 9 influent system is proposed to be either a 60-inch microtunnel or 14-foot outside-diameter tunnel from Lake Forest Park to Kenmore and a 14-foot outside-diameter tunnel from Kenmore to the Route 9 site. The feasibility of tunneling versus microtunneling from Lake Forest Park to Kenmore will be evaluated during predesign.

The inside diameter of the tunnel will range from 11 to 12 feet, depending on whether the tunnel is lined with sacrificial cement-concrete or a PVC membrane liner. The influent tunnel would provide up to approximately 25 million gallons of storage, assuming that the influent system is tunneled between Lake Forest Park and Kenmore and is comprised of a 12-foot inside-diameter tunnel with PVC liner.

C.5.9 Safety Relief Point

Safety relief requirements for both the Route 9 and Unocal influent conveyance systems are being evaluated as a part of predesign. If included, the safety relief point would only be used during extreme emergency conditions and only after all other emergency flow management procedures have been implemented. The proposed location of the safety relief structure outfall is in Kenmore, between a zone starting immediately upstream of the 68th Ave NE bridge on the Sammamish River and extending to Lake Washington at Tracy Owens (Log Boom) Park to the west. The outfall from the relief structure would discharge to either the Sammamish River or the northern end of Lake Washington. The final location of the structure and outfall will be decided in the predesign process.

C.6 Preferred Alternative Conveyance System Summary

The Draft EIS presents the Route 9 195th Street system as the preferred alternative. Figure C- 5 shows the preferred alternative. Key features of the system are summarized in Table C-7.

Table C-7. Preferred Alternative Conveyance System

Parameter	Influent Corridor	Effluent Corridor
Conveyance Length	7.8 miles	12.5 miles
New Pump Stations Along Conveyance System	None	None
Portal Siting Areas	Portal 10—NE 178th St & 44th Ave NE Portal 11—NE 175th St & 68th Ave NE Portal 34—NE Bothell Way & 80th Ave NE Portal 41—NE 195th St & 120th Ave NE	Portal 41—NE 195th St & 120th Ave NE Portal 44—NE 195th St & 80th Ave NE Portal 45—NE 195th St & 58th Ave NE Portal 7—Ballinger Way NE & 25th Ave NE Portal 27—NE 205th St & 1st Ave NE Portal 23—NW 205th St & Firdale Ave Portal 19—NW 205th St & Richmond Beach Dr NW
Conveyance Option	Gravity flow for entire length	Gravity/pressure pipe flow for entire length, or Combination of force main flow (from the treatment plant site to Portal 27) and gravity flow (from Portal 27 to Portal 19)

Preliminary design of the conveyance system is now underway. During this phase of the project, the conveyance team will focus on addressing the following issues:

- Microtunneling versus tunneling from Lake Forest Park to Kenmore – the predesign process will determine which construction method is more appropriate from cost, schedule, impacts, and flow management viewpoints.
- Refine portal location within siting areas – the location of the 1 to 2 acres needed for construction within each of the 72-acre PSAs described in the Draft EIS will be determined.
- Portal spacing and number of portals needed along influent and effluent tunnels – work is needed to determine if the potential exists to reduce the number of portals needed for tunnel construction.
- Tunnel alignment and depth – the predesign process will optimize the horizontal and vertical alignments to minimize capital and operational costs while maintaining low construction risks.

- Air handling odor control strategies – an evaluation will be conducted on where to site odor control facilities and which odor control technologies may be used.
- Local connections to influent tunnel – predesign will select the alignment, depths, and construction methods for installing the pipes connecting existing King County trunks to the new influent tunnel.
- Flow management – decisions will need to be made regarding the use of extra tunnel volume for either peak shaving or emergency storage, flow diversion scenarios, peak flow rates, and the location of the safety relief point.

Preliminary design efforts to date have been based on risk management and responses to the Draft EIS, and have resulted in enhancements to the 195th Street conveyance system. These enhancements include:

- The horizontal alignment has been modified to minimize the number of private property easements. The modified alignment is shown in Figure C-6.
- The effluent pump station has been eliminated by modifying the pipeline depth.
- The tunnel drive length has been increased from 10,000 to 20,000 feet, which allows some of the portals to serve as secondary portals. Secondary portals would be reserved and used only if geotechnical investigations reveal that a shorter tunnel drive length is needed.
- The segment of tunnel between Portals 10 and 11 was determined to be unnecessary based on updated flow routing within the existing system. However, a 24-inch-diameter local connection to the Lake Forest Park area in the vicinity of 66th Avenue will be needed in the future. This connection would be added by open cut construction or microtunneling.

C.7 References

King County, 2002a. Brightwater Phase 3 Pre-Scoping Conveyance Evaluation Summary Seattle, WA.

King County, 2002b. Brightwater Phase 3 Pre-Draft EIS Conveyance Evaluation Summary Seattle, WA.

LIST OF FIGURES

Figure C-1 Route 9 System, Map of Preliminary Influent and Effluent Segments

Figure C-2 Unocal System, Map of Preliminary Influent and Effluent Segments

Figure C-3 EIS Scoping Notice, Map Showing Potential Route 9 Corridors

Figure C-4 EIS Scoping Notice, Map Showing Potential Unocal Corridors

Figure C-5 Route 9, 195th Street System Alternative

Figure C-6 Route 9 195th Street System (Preferred)

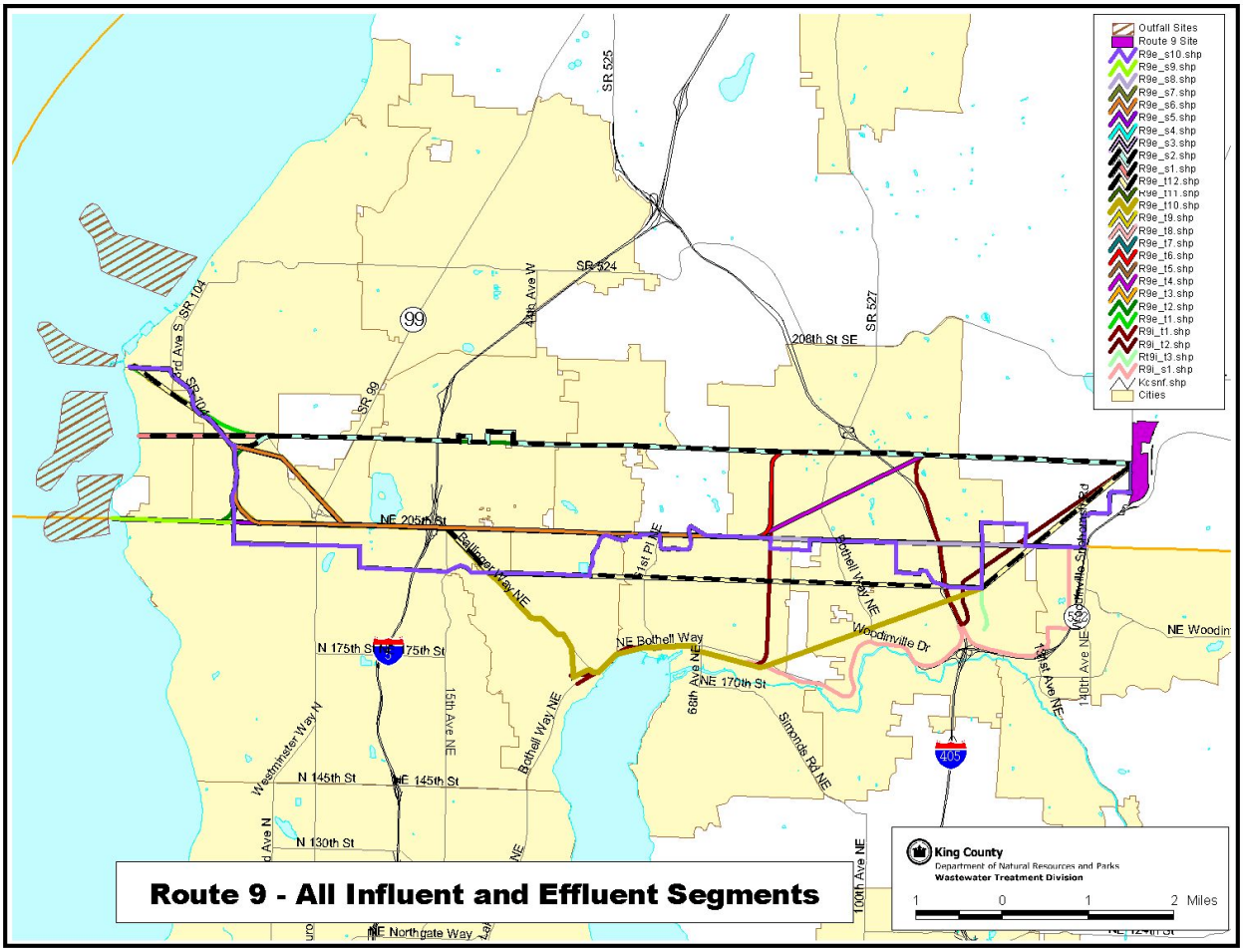


Figure C-1

Route 9 System, Map of Preliminary Influent and Effluent Segments

BRIGHTWATER FACILITIES PLAN

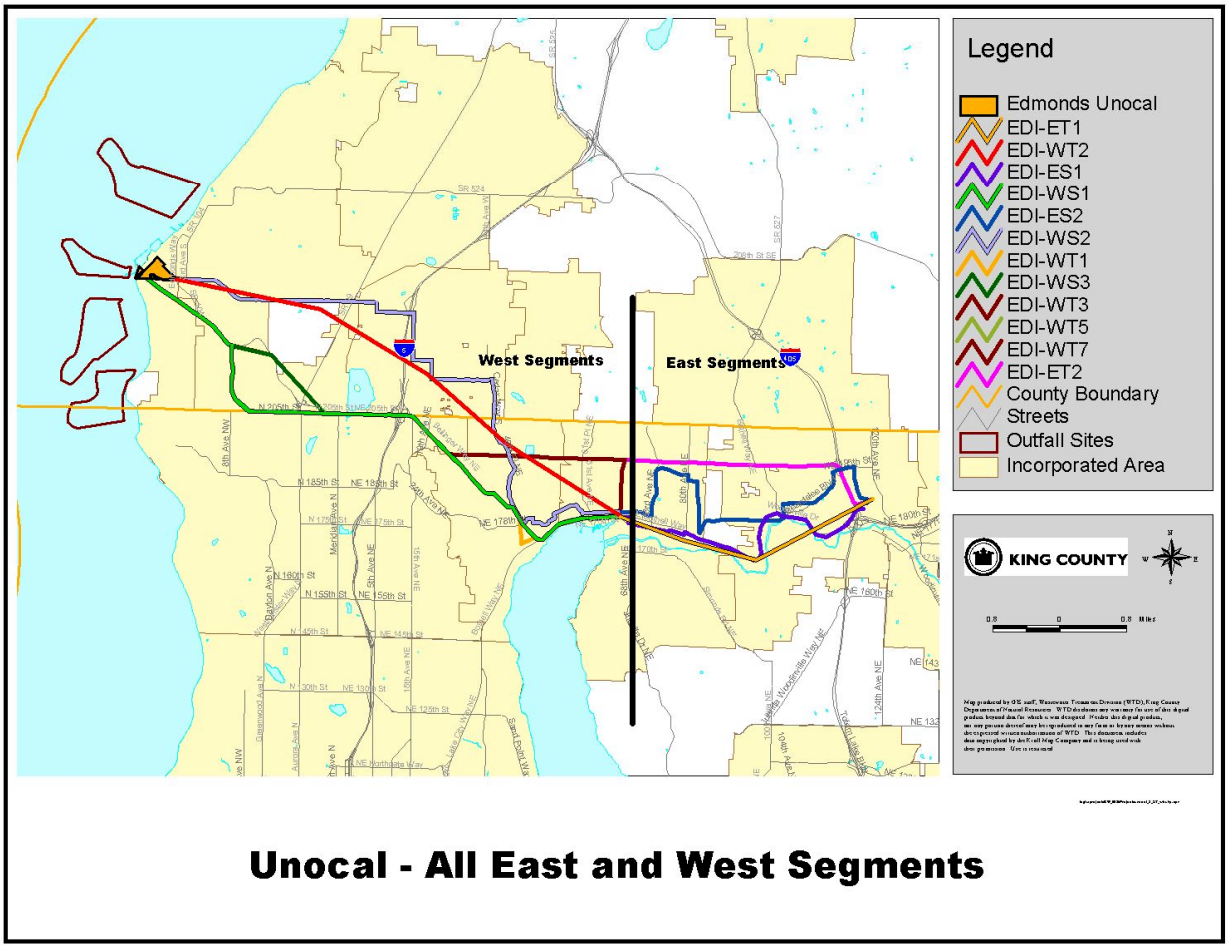


Figure C-2

Unocal System, Map of Preliminary Influent and Effluent Segments

BRIGHTWATER FACILITIES PLAN

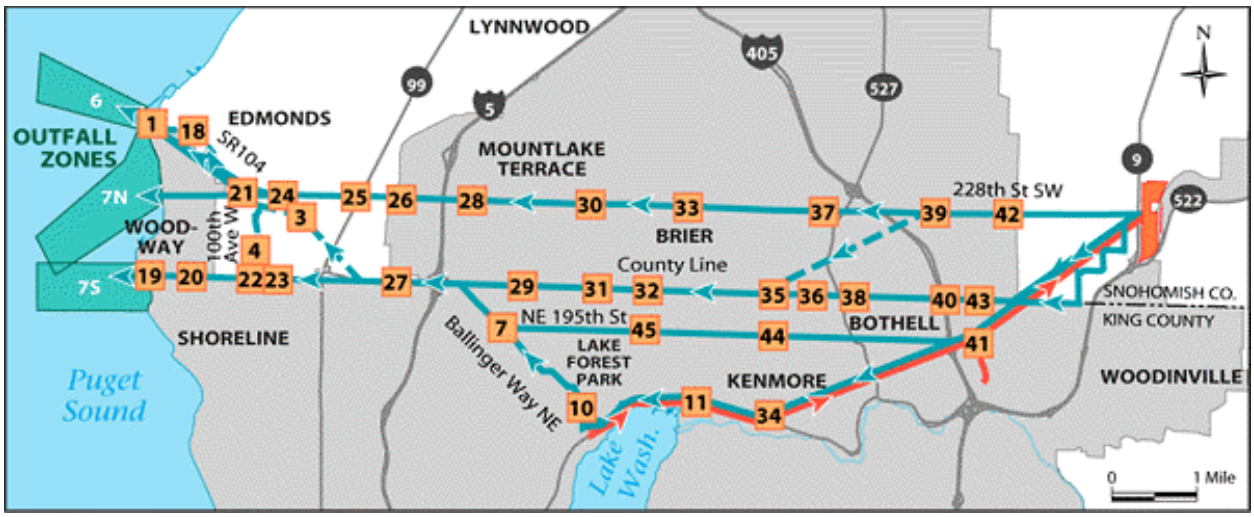


Figure C-3

EIS Scoping Notice, Map Showing Potential Route 9 Corridors

BRIGHTWATER FACILITIES PLAN

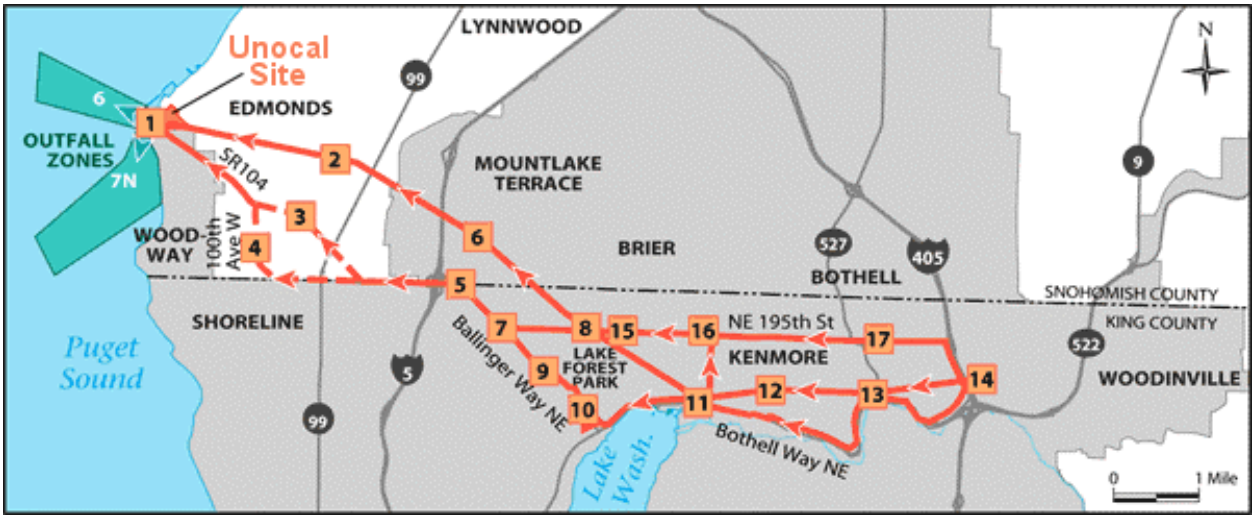
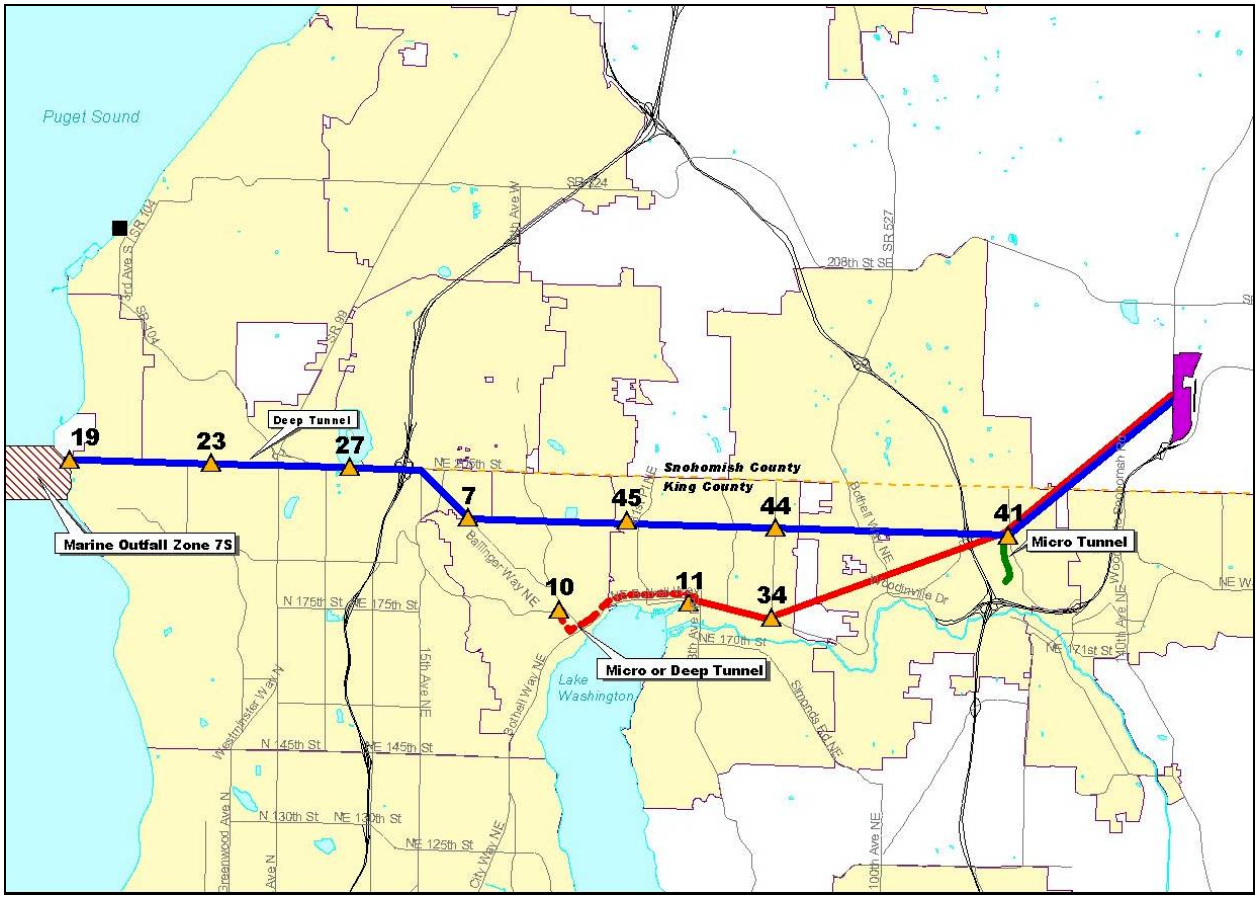
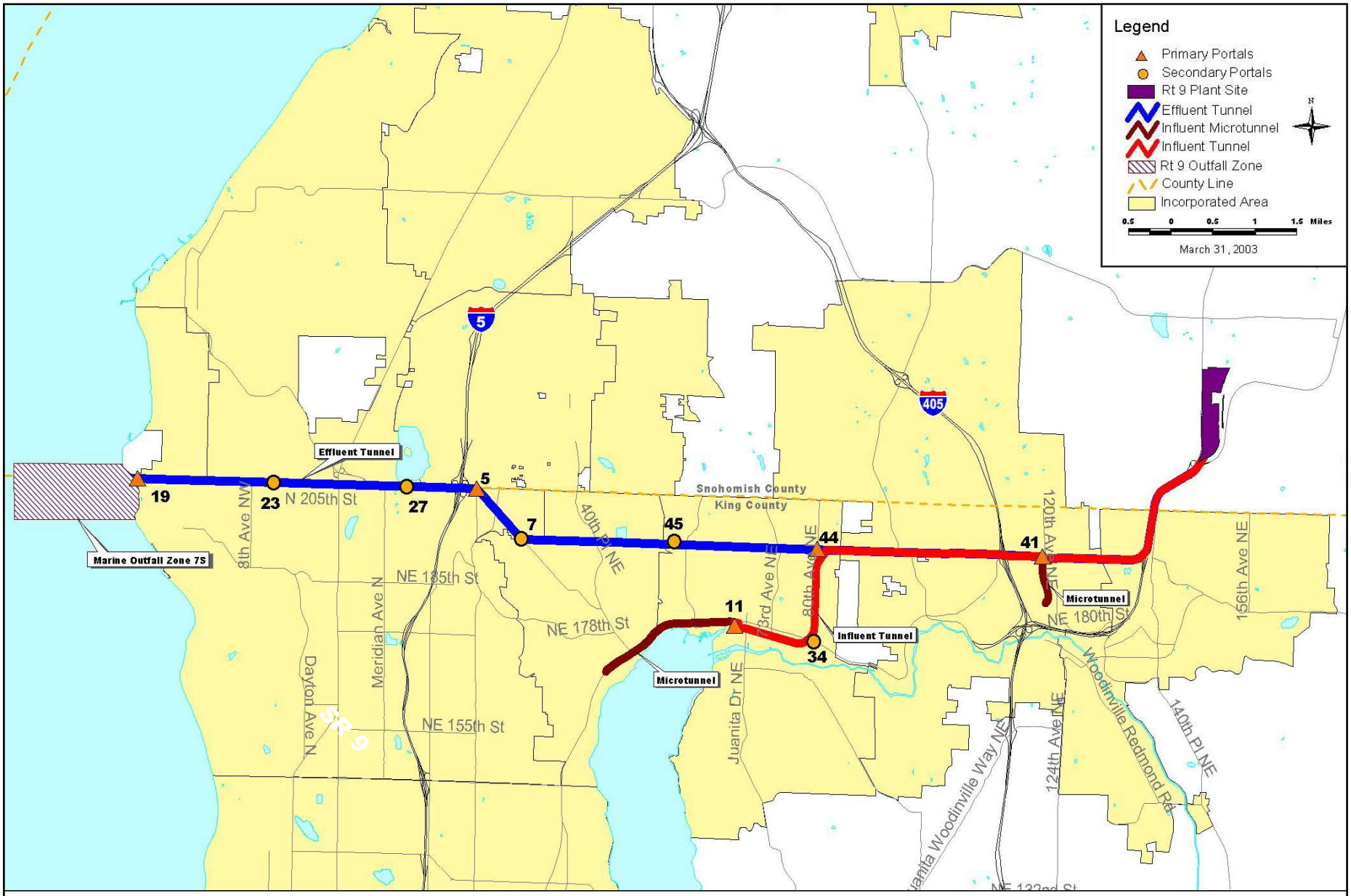


Figure C-4

EIS Scoping Notice, Map Showing Potential Unocal Corridors

BRIGHTWATER FACILITIES PLAN


Puget Sound
19
23
27
Deep Tunnel
Marine Outfall Zone 7S
7
45
44
41
Snohomish County
King County
Micro Tunnel
10
11
34
Micro or Deep Tunnel
Lake Washington
Bothell Way NE
Bothell Way NE
Bothell Way NE



King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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Data Sources: King County dataset
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Prepared by: King County WTD GIS

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Figure C-6
Route 9 - 195th Street System Alternative

BRIGHTWATER FACILITIES PLAN

File Name: 173243.16.01_W012003016SEA • FIG C-6_Rt. 9 - 195th St. System Alternative • 04/24/03 • dk

Appendix D
Marine Outfall Alternative Analysis

D.1 Introduction

This appendix evaluates the management of Brightwater effluent through use of a marine outfall discharging to Puget Sound. Effluent management alternatives have been evaluated through the *Regional Wastewater Services Plan* (RWSP) and subsequent Brightwater studies, in accordance with Washington State Department of Ecology (Ecology) guidelines provided in *Criteria for Sewage Works Design* (Ecology, 1998). Typically, the closest suitable receiving water in which water quality standards can be met with known, available, and reasonable methods of control and treatment is evaluated for effluent discharge. However, Ecology has historically discouraged discharge of effluent to lakes and their tributaries when a marine discharge is possible.

Potential receiving waters in the Brightwater project area include Puget Sound, Lake Washington, Sammamish River, and numerous smaller tributaries of the Lake Washington–Sammamish River system. Only in Puget Sound can water quality criteria and Ecology guidelines be met consistently and economically. Therefore, a marine discharge to the Puget Sound was determined to be the preferred option for effluent management under the RWSP.

This appendix provides further definition of the Brightwater marine discharge, describing how the marine outfall will be configured to optimize dilution of effluent while minimizing environmental and societal impacts. Safety relief outfalls that would be used only under extreme emergency conditions such as pump station failure or extraordinary wet weather events may be located in water bodies other than Puget Sound. Safety relief outfalls are discussed in Appendix C of this Facilities Plan.

D.2 Marine Discharge

Many issues must be accounted for in the design, construction and operation of a marine outfall. Siting of the outfall should avoid areas with unstable or irregular seafloor slopes. Outfall siting should be protective of marine plant and animal life, human health, and water quality standards and minimize impacts to surrounding land use, recreation, and public services. Once a suitable location has been selected, design should focus on the materials, construction methods, and hydraulic performance for a properly functioning

marine outfall. Treatment requirements and the outfall siting process are described in subsequent sections of this appendix.

D.2.1 Treatment Requirements for Ocean Discharge

In accordance with the Clean Water Act, the State of Washington has set water quality standards to protect the beneficial uses of surface waters. The standards vary with classification of the surface water body (Chapter 173-201A WAC). Ecology assigns the classifications, which include AA (extraordinary), A (excellent), B (good), C (fair), and Lake Class. Water quality standards reflect the state's desired level of water quality, but not necessarily water quality conditions. Class AA waters support desired beneficial uses, including but not limited to water supply, stock watering, fish and wildlife habitat, recreation, commerce, and navigation.

The portions of Puget Sound in the vicinity of potential outfall zones are designated as Class AA marine waters under the State Water Quality Standards. For Class AA marine waters, water quality criteria have been established for fecal coliform bacteria (an indicator of fecal contamination from wastewater and other sources), dissolved oxygen (DO), total dissolved gas, temperature, pH, turbidity, aesthetics, and toxic, radioactive, and deleterious toxic materials (including metals and ammonia). Narrative and numeric requirements for Class AA marine waters are presented in Table D-1.

Table D-1. Washington State Water Quality Standards for Class AA Marine Waters (WAC 173-201[A])

Narrative Water Quality Parameter	Numeric Water Quality Parameter
Water quality of this class shall markedly and uniformly exceed the requirements for all or substantially all uses. Characteristic uses shall include: • Water supply (domestic, industrial, and agricultural) • Stock watering • Fish and shellfish • Wildlife habitat • Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment) • Commerce and navigation Toxic, radioactive, or deleterious material concentrations shall be below those that have the potential, either singularly or cumulatively, to adversely affect characteristics uses, adversely affect public health, or cause acute or chronic conditions to the most sensitive biota dependent upon those waters.	Fecal Coliform Bacteria: • Shall both not exceed a geometric mean value of 14 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean exceeding 43 colonies/100 mL. Dissolved Oxygen: • Shall exceed 7.0 mg/L except when natural phenomenon such as upwelling occurs, causing the DO to be depressed near or below 7.0 mg/L. Natural dissolved oxygen levels may be degraded by up to 0.2 mg/L by human-caused activities. Temperatures: • Shall not exceed 13.0°C due to human activities. • When natural conditions exceed 13.0°C, no temperature increases will be allowed that will raise the receiving water temperature by greater than 0.3°C.

Table D-1. Washington State Water Quality Standards for Class AA Marine Waters (WAC 173-201[A])

Narrative Water Quality Parameter	Numeric Water Quality Parameter
Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.	• Incremental temperature increases resulting from point source activities shall not, at any time, exceed at the mixing zone boundary, 8 ÷ (background temperature -4°C). pH: • Shall be within the range of 7.0 to 8.5 units with a human-caused variation within a range of less than 0.2 units. Turbidity: Human caused variation 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.

D.2.1.1 Technology-Based Effluent Limitations

Technology-based effluent limitations establish the minimum level of treatment that must be provided by a municipal wastewater treatment plant regardless of receiving water quality and available dilution. Where receiving water fails to meet water quality criteria, or where a discharge has a reasonable potential to cause a violation of State Water Quality Standards, the treatment facility may be required to meet more restrictive water quality based limitations. Technology-based effluent limitations require municipal dischargers to provide a minimum of secondary treatment. As a general rule, most marine discharges that achieve a high level of mixing and dilution are permitted under technology-based effluent limitations.

Federal technology-based effluent limitations are found in 40 CFR Part 133, *Secondary Treatment Regulation.* State technology-based effluent limitations are established in WAC 173-221*, Discharge Standards and Effluent Limitations for Domestic Wastewater Facilities.* Table D-2 summarizes the requirements of 173-221 WAC.

Table D-2. WAC 173-221 Discharge Requirements Summary

Parameter[a]	Units	Requirement
30-Day Effluent Average		
– BOD_5	mg/L	30 maximum
– TSS	mg/L	30 maximum
– BOD_5 Removal, as Percent of Influent Concentration	%	85 minimum

Table D-2. WAC 173-221 Discharge Requirements Summary

Parameter[a]	Units	Requirement
– TSS Removal, as Percent of Influent Concentration	%	85 minimum
7-Day Effluent Average		
– BOD_5	mg/L	45
– TSS	mg/L	45
Effluent Bacteriological Quality		
– Fecal coliform bacteria, monthly geometric mean	#/100 mL	200 maximum
– Fecal coliform bacteria, weekly geometric mean	#/100 mL	400 maximum
Effluent pH		
– Effluent pH	pH units	6.0 to 9.0

[a] Effluent requirements may also be expressed in terms of carbonaceous BOD_5 removal.

Discharges must not cause water quality violations outside of an approved mixing zone; otherwise more stringent effluent limitations may be imposed. Section D.10 of this appendix presents an initial analysis of the potential of the Brightwater marine discharge, which shows that there is no reasonable potential to violate State Water Quality Criteria. Thus, the technology-based effluent limitations summarized in Table D-2 appear appropriate for the Brightwater facilities.

D.2.1.2 Dilution and Mixing Zone Considerations

A mixing zone is that portion of a water body adjacent to discharge where mixing results in the dilution of the effluent with the receiving water. The points of compliance for acute and chronic numeric water quality criteria (such as for ammonia, chlorine, and metals) are allowable acute and chronic mixing zone boundaries as defined by WAC 173-201(A)-100. The size and distance to acute and chronic mixing zone boundaries will differ for each outfall alignment and diffuser configuration.

Marine outfalls typically terminate in multiport diffusers that promote rapid dilution of effluent with ambient marine waters. Dilution modeling is used to assess the degree of mixing of effluent and receiving waters. Upon discharge, the momentum of effluent exiting a diffuser structure results in vigorous mixing with ambient seawater. As this momentum starts to dissipate, the effluent buoyancy provides further mixing as the plume rises through the water column due to a difference in plume and receiving water density. When the receiving water column is density stratified, sufficient dilution may occur at depth such that the diluted effluent becomes denser than the overlying surface water and is trapped below the surface. When the plume traps, initial mixing is completed. The diluted effluent then forms a waste field around this trapping depth, which is then spread and advected laterally by currents and eddies generated by wind, tides, estuarine transport mechanisms, and bathymetric features.

In the analysis completed for Phase 3 evaluation and conceptual design, the primary objective of dilution modeling was to meet the following siting objectives and design parameters as stated in the *Criteria for Sewage Works Design* (Ecology, 1998):

- Achieve 100:1 initial dilution for effluent discharged from the Brightwater outfall into Puget Sound.
- Minimize surfacing of the effluent plume.
- Optimize far-field dilution.

Results of the Phase 3 dilution analysis from *Phase 3 Initial Dilution Assessment of Potential Diffuser Zones – MOSS Plume Modeling: Continuous Discharges to Puget Sound* (King County, 2002d) are summarized in subsequent portions of this appendix.

D.3 Identification and Screening of Potential Outfall Sites

In Phase 1 of the Marine Outfall Siting Study (MOSS), three constraints were identified that, if present, would seriously limit construction or operation of the marine outfall. These constraints included presence of a Superfund site (designated under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]), presence of anchor zones, and minimum required diffuser depth. No Superfund sites or anchor zones were identified in the MOSS study area, which extended from Mukilteo State Park to Shilshole Bay. The minimum diffuser depth required to meet regulatory dilution standards was assumed to be 100 feet.

After initial identification of unconstrained sites, the MOSS team determined the presence of geophysical constraints such as steep slopes; presence of submarine canyons, ridges, and slides; and unsuitable substrate for tunneling. Next, the MOSS team examined nearshore biological, shoreline public use, and hazardous materials constraints in those areas not already constrained by geophysical issues. After compiling all the information, eight unconstrained preliminary outfall zones were identified in Phase 1, two of which have both north and south subareas, yielding a total of 10 areas evaluated and ranked. Five areas (1, 2, 3, 7S, and 8N) were designated as “flexible” and the other five areas (4, 5, 6, 7N, and 8S) were designated as “less flexible.” In general, a site was classified as less flexible if one or more of the biological, shoreline public use, or hazardous materials features were present. A map of potential outfall zones is shown in Figure D-1. A complete description of the methodology used in applying the MOSS site screening criteria can be found in *Detailed Evaluation Questions, Marine Outfall Siting Study* (King County, 2001a).

D.3.1 Outfall Site Descriptions

As part of the Phase 1 MOSS evaluation, a preliminary geophysical investigation of Puget Sound was conducted in water depths between 10 and 600 feet, a distance of up to 5,000 feet offshore. The objective of the geophysical survey was to provide detailed characterization of the physical features of the seafloor and the subsurface geology.

Bathymetry characteristics of the study area include a relatively flat shelf extending approximately 700 to 3,000 feet from the shoreline to water depths of 40 to 80 feet. Beyond the shelf, the seabed slope increases, reaching down to the moderately sloped main channel seabed of Puget Sound. The main channel seabed has ground slopes of less than 5 percent and is generally located more than 4,000 feet offshore.

Nearshore soil is characterized by 10 to 100 feet of medium-grained sediment covering semi-consolidated glacial material. Offshore slope soils consist of semi-consolidated glacial material with very little sediment cover. Sediment cover at the diffuser sites is composed of up to 50 feet of fine-grained material.

Table D-3 presents summary information for the areas surveyed in the preliminary geophysical investigation. The full report is presented in *Marine Geophysical Investigation: Marine Outfall Siting Study* (King County, 2001f).

Table D-3. Geophysical Investigation Summary

Outfall Location	Bathymetry[1]	Diffuser Site	Geophysics/Geology
1	Depth 10 to 600 feet, fairly consistent slope (16%), several minor slope changes	Slope <1% at 4,000 feet offshore, 20 to 50 feet of fine-grained sediment	5 to 10 feet fine to medium-grained sediment on upper slope, no faulting or slides
2	Depth 10 to 525 feet, regular and consistent contours (15%)	Slope <1% at 2,000 feet offshore, 20 to 30 feet of fine-grained sediment	10 feet medium-grained sediment on slope, no slump features or faults
3	Depth 10 to 525 feet, slope varies, max slope of 20%	Slope <1.5% at 4,000 feet offshore, 10 to 15 feet of fine-grained sediment	10 to 15 feet medium-grained sediment on upper slope, 10 to 15 feet fine-grained sediment on lower slope
4	Depth 10 to 475 feet, regular and consistent contours (20%)	Slope <1.5% at 3,500 feet offshore, 10 to 15 feet of fine-grained sediment	10 to 15 feet medium-grained sediment on upper/mid slope, 10 to 20 feet fine-grained sediment on lower slope
5	Depth 10 to 420 feet, broad shelf, consistent slope (22%)	Slope <2% at 4,000 feet offshore, 20 feet of fine-grained sediment	15 to 20 medium-grained sediment on shelf, glacial sediment on slope
6	Depth 10 to 570 feet, regular and consistent contours (20%)	Slope <2% at 3,000 feet offshore, 15 to 20 feet of fine-grained sediment	30 to 50 feet medium-grained sediment on shelf, 5 to 10 feet on upper, mid and lower slope
7N (A)	Depth 10 to 120 feet, broad shelf, regular contours (5%)	Slope <3% at 1,700 feet offshore, medium-grained sediment	Less than 5 feet medium-grained sediment

Table D-3. Geophysical Investigation Summary

Outfall Location	Bathymetry[1]	Diffuser Site	Geophysics/Geology
7N (B)	Depth 10 to 600 feet, regular and consistent contours (15%)	Slope <1% at 4,300 feet offshore, 15 feet of fine-grained sediment	20 to 40 feet medium-grained sediment on upper slope
7S (A)	Depth 10 to 280 feet, broad shelf, regular and consistent contours (13%)	Slope <3% at 2,500 feet offshore, 5 feet of fine to medium-grained sediment	10 to 20 feet sediment on mid slope
7S (B)	Depth 10 to 600 feet, relatively steep, but consistent contours (22%)	Slope <2% at 3,200 feet offshore, 10 to 15 feet of fine-grained sediment	10 to 20 feet medium-grained sediment on upper and mid slope
8N	Depth 10 to 400 feet, gradual upper slope, steeper lower slope (18%)	Slope <1% at 3,000 feet offshore, medium-grained sediment	20 feet medium-grained sediment on upper slope
8S	Depth 75 to 600 feet, gradual upper slope, steeper lower slope (16%)	Slope <1% at 2,500 and 5,500 feet offshore, 20 to 40 feet of fine grained sediment	10 to 20 feet sediment on upper slope

1. Percent slope values presented in Table D-2 are averaged over relatively large areas of the seafloor. Later, more detailed bathymetry investigations indicated some small areas with slopes approaching 35%. Slopes between 20 and 25 percent are typical of many of the areas beyond the nearshore shelf.

D.3.2 Criteria for Evaluating Alternative Sites

In Phase 2, the detailed evaluation questions (DEQs) developed to evaluate outfall alternatives addressed engineering, environmental, community (neighborhood effects), and financial policy considerations. The methodology and results of the Phase 2 evaluation are presented in *Phase 2 Detailed Evaluation Questions* (King County, 2001b) and *Application of Phase 2 Detailed Evaluation Questions* (King County, 2001c). All eight outfall zones identified in Phase 1 were found to be suitable. However, Zones 1 through 4 and Zone 8 (along with their associated diffuser sites) were eliminated from further consideration based on the geographic distance between these zones and the proposed land-based treatment facility and conveyance routes. These geographically distant outfall zones would be burdened with the additional costs of a longer conveyance route without providing substantial benefits in terms of outfall and diffuser characteristics.

Five diffuser sites in four candidate outfall zones (Zones 5, 6, 7N, and 7S) were evaluated further in Phase 3. The Phase 3 evaluation was supported by updated plume modeling and water quality analyses, workshops assessing outfall construction methods and potential construction risks, and conceptual level outfall design. Conceptual level design led to the development of conceptual outfall alignments for each of five candidate diffuser sites and potential methods of outfall pipeline construction.

The outfall alignments developed during conceptual design represent feasible pipeline alignments and provide the basis for estimating pipe length, potential slope conditions,

and other design parameters. The outfall alignments are differentiated by two general construction methods for crossing the nearshore area, tunnel and trench. Evaluation of tunnel construction methods was further divided by the potential tunnel terminus point, either at an offshore access portal or directly at the seafloor sideslope.

The conceptual outfall alignments and construction methods were evaluated using a matrix of 29 factors developed by King County and the Project Team and documented in *Brightwater Phase 3 DEIS Conveyance Evaluation Summary* (King County, 2002f). These factors addressed scientific, engineering, and societal concerns involving the construction and operation of a marine outfall in Puget Sound. Seven of the 29 factors used in this analysis were identified as primary factors. These primary factors represent issues that, if realized, would have the greatest effect on the construction and/or operation of the outfall or would result in a substantial community impact. The seven primary factors included:

- Staging Factors (size/access)
- Location of Staging Area
- Shaft Proximity to Shoreline
- Outfall Pipeline Length
- Ferry Traffic Disruption
- Net Currents
- Tidal Current Direction

The result of this final phase of analysis, was the selection of three outfall zones (Zones 6, 7N, and 7S) and the selection of construction methods that were presented as alternatives in the State Environmental Policy Act (SEPA) Scoping Notice. Using the Brightwater policy site selection criteria adopted by the King County Council in 2001, King County selected three treatment systems (plant, conveyance, and outfall) for inclusion in the Brightwater Draft EIS. The three treatment systems terminate with an outfall in one of two zones, Zones 6 and 7S

D.3.3 Screening Evaluations Summary

Summary results of the Phase 3 screening evaluation are presented in Tables D-4 and D-5 for the outfall zones evaluated for the Route 9 and Unocal alternatives, respectively. For the Route 9 site, all five outfall zones were evaluated. Only Zones 5, 6, and 7N were evaluated for the Unocal site. Although all of the candidate outfall zones are viable alternatives, the evaluation indicated that some outfall zones presented a more practical

Table D-4

ALTERNATIVE	Staging Factors (size/access)	Location of Staging Area	Shaft Proximity to Shoreline	Outfall Pipeline Length	Ferry Traffic Disruption	Net Currents	Tidal Current Direction	Nearshore Obstructions	Nearshore Outfall Segment Length	Nearshore Water Access	Mitigation	Construction Schedule Delays	Commercial/Maritime Traffic Disruption	Contaminated Sediment Concerns	Local Park Access	Commercial Disruption	Tribal Concerns	Cultural Resources Concerns	Residential Concerns	Geoduck Concerns	Eelgrass Concerns	Marina Access	Bathymetry / Soil Stability	Baitfish Concerns	Marine Sanctuary Concerns	Aquatic Life Protection	Water Quality Standards	Is 100:1 Dilution Achievable?	Human Health Protection
ZONE 5																													
Tunnel-1	◉	◉	◉	◉	◉	◉	●	○	◉	◉	○	◉	○	○	●	◉	○	○	○	○	○	○	○	○	◉	○	○	○	○
Tunnel-2	◉	◉	◉	◉	◉	◉	●	○	◉	◉	○	◉	○	○	●	◉	○	○	○	◉	○	○	○	○	◉	○	○	○	○
Tunnel-3	●	●	◉	◉	◉	◉	●	●	◉	◉	○	◉	○	○	◉	◉	○	○	●	◉	○	○	○	○	◉	○	○	○	○
Trench	●	●	○	◉	◉	◉	●	●	◉	◉	●	◉	○	○	◉	◉	○	○	●	◉	●	○	○	◉	◉	●	○	○	○
ZONE 6																													
Tunnel-1	○	◉	◉	○	○	●	○	◉	○	○	○	○	○	◉	◉	◉	○	○	○	○	○	○	◉	○	◉	○	○	○	○
Tunnel-2	○	◉	◉	○	○	●	○	◉	○	○	○	○	○	◉	◉	◉	○	○	○	◉	○	○	◉	○	◉	○	○	○	○
Trench	○	◉	○	○	○	●	○	◉	○	○	◉	◉	○	◉	◉	◉	○	○	○	◉	◉	○	◉	◉	◉	◉	○	○	○
ZONE 7N																													
Tunnel-1	○	◉	◉	●	○	○	○	◉	●	◉	○	◉	○	◉	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○
Tunnel-2	○	◉	◉	●	○	○	○	◉	●	◉	○	◉	○	◉	◉	◉	○	○	○	◉	○	○	○	○	○	○	○	○	○
Trench	○	◉	○	●	○	○	○	◉	●	●	●	●	○	◉	◉	◉	○	○	○	◉	●	○	○	◉	○	●	○	○	○
ZONE 7S (Mid-Depth)																													
Trench	◉	○	○	○	○	●	○	◉	○	◉	●	◉	◉	●	○	◉	○	○	○	●	◉	○	◉	◉	○	●	○	○	●
ZONE 7S (Deep)																													
Tunnel-1	◉	○	◉	○	○	○	○	○	○	◉	○	◉	◉	●	○	◉	○	○	◉	○	○	○	◉	○	○	○	○	○	○
Tunnel-2	◉	○	◉	○	○	○	○	○	○	◉	○	◉	◉	●	○	◉	○	○	◉	◉	○	○	◉	○	○	○	○	○	○
Trench	◉	○	○	◉	○	○	○	◉	○	◉	◉	◉	◉	●	○	◉	○	○	◉	◉	◉	○	◉	◉	○	◉	○	○	○
Rich. Beach Tunnel 1	○	○	◉	○	○	○	○	○	○	◉	○	◉	◉	○	○	○	○	○	◉	○	○	○	◉	○	○	○	○	○	○
Rich. Beach Tunnel 2	○	○	◉	○	○	○	○	○	○	◉	○	◉	◉	○	○	○	○	○	◉	◉	○	○	◉	○	○	○	○	○	○
Rich. Beach Trench	○	○	○	○	○	○	○	○	○	◉	●	◉	◉	○	○	○	○	○	◉	◉	●	○	◉	◉	○	●	○	○	○

Primary Factors (Staging Factors (size/access) – Tidal Current Direction)

Secondary Factors (Nearshore Obstructions – Human Health Protection)

Key:
- ○ Relatively little/no risk or effect
- ◉ Moderate risk or effect
- ● Relatively high risk or effect

Table D-5

ALTERNATIVE	Staging Factors (size/access)	Location of Staging Area	Shaft Proximity to Shoreline	Pipeline Length	Ferry Traffic Impacts	Net Currents	Tidal Current Direction	Nearshore Obstructions	Segment Length	Nearshore Water Access	Mitigation	Construction Schedule Impacts	Commercial/Maritime Traffic Impacts	Contaminated Sediment Concerns	Park Access	Commerical Disruption	Tribal Concerns	Cultural Resources	Residential Concerns	Geoduck Concerns	EelGrass Concerns	Marina Access	Bathymetry / Soil Stability	Baitfish Concerns	Marine Sanctuary Impacts	Aquatic Life Protection	Water Quality Standards	100:1 Dilution	Human Health Protection
Zone 5																													
Tunnel-1	⊙	⊙	⊙	●	●	⊙	●	○	●	⊙	○	⊙	○	○	●	⊙	○	○	○	○	○	⊙	○	○	⊙	○	○	○	○
Tunnel-2	⊙	⊙	⊙	●	●	⊙	●	○	●	⊙	○	⊙	○	○	●	⊙	○	○	○	⊙	○	⊙	○	○	⊙	○	○	○	○
Trench	⊙	⊙	○	●	●	⊙	●	●	●	⊙	●	⊙	○	○	●	⊙	○	○	○	⊙	●	⊙	○	⊙	⊙	●	○	○	○
Zone 6																													
Tunnel-1	○	○	○	○	○	●	○	○	○	○	○	○	○	⊙	○	○	○	○	○	○	○	○	⊙	○	⊙	○	○	○	○
Tunnel-2	○	○	○	○	○	●	○	○	○	○	○	○	○	⊙	○	○	○	○	○	⊙	○	○	⊙	○	⊙	○	○	○	○
Trench	○	○	○	○	○	●	○	⊙	○	○	⊙	○	○	⊙	⊙	○	○	○	○	⊙	⊙	○	⊙	⊙	⊙	⊙	○	○	○
Zone 7N																													
Tunnel-1	○	○	○	●	○	○	○	○	●	⊙	○	⊙	○	⊙	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Trench	○	○	○	●	○	○	○	⊙	●	●	●	●	○	⊙	⊙	○	○	○	○	⊙	●	○	○	⊙	⊙	●	○	○	○

Primary Factors: (Staging Factors (size/access) – Tidal Current Direction)

Secondary Factors: (Nearshore Obstructions – Human Health Protection)

Key:

○ Relatively little/no risk or effect

⊙ Moderate risk or effect

● Relatively high risk or effect

alternative relative to others. Differences among zones are related to the amount of land available for construction and the amount of disruption that would result from the construction and operation of the outfall. These include possible disruptions to commercial activity and the biological resources of Puget Sound.

Zone 5 presents increased potential for impacts relative to the other zones due to the direction of the tidal and net currents, increased length of onshore construction, disruption of local park access (Brackets Landing), and conflicts with Washington State Ferry operations at the Edmonds terminal. All of the conceptual outfall alignments for Zone 5 would require coordination with the ferry traffic, potentially increasing the duration of construction. Additionally, the net and tidal current regime in the water around Zone 5 is less conducive to the mixing and advection of the effluent relative to the other zones.

Zone 7S, Diffuser Site A also has a less conducive regime of net currents. Additionally, the steeper slope of the diffuser site would hinder construction and operation of the diffuser. The depth and anticipated effluent plume movement would likely result in a large and costly regulatory shellfish closure zone due to the proximity of the plume to the resources (not because of water quality issues).

The screening evaluation confirmed Zones 6, Zone 7N, and Zone 7S Diffuser Site B as strong alternatives for the outfall and diffuser. Each of the alternatives has adequate on-land area for the staging of the nearshore construction, and these locations should have minimal effect on the quality of life for area residents and commercial enterprises. The magnitude and direction of both the tidal and net currents are parallel to the shoreline and should provide strong mixing and dilution of the effluent plume with the surrounding water. The screening evaluation indicated that there were no benefits in pursuing Zone 5 or Zone 7S Diffuser Site A because alternatives were available that did not have the potential hindrances associated with these sites.

D.4 Outfall Alternative Analysis

D.4.1 General Performance Objectives

General performance objectives for marine outfalls as stated in Ecology's *Criteria for Sewage Works Design* (Ecology, 1998) include the following:

- Optimize far-field dilution
- Minimize the potential for reflux
- Minimize contact with humans
- Minimize contact with fisheries and other aquatic habitat

- Minimize contact with the shoreline
- Minimize potential of net sediment deposition
- Minimize potential for effluent pooling
- Minimize surfacing of effluent plume
- Minimize navigational hazards
- Facilitate ease of access

The Phase 1 and 2 DEQ analyses (King County, 2001a, b, and c) addressed these performance objectives in the site selection process. Additional studies and analysis pertaining to the performance objectives are included in the MOSS documents listed in the references section of this appendix, and the reader is referred to these documents for additional information.

D.4.2 Design Flows

Design flows for discharged effluent from the Brightwater treatment plant and outfall have been projected by King County for an array of possible scenarios. Table D-6 lists the projected design flows for Brightwater, and the design flows for the option of including additional flow from the cities of Edmonds and Lynnwood wastewater treatment plant expansion around 2040. In preliminary analyses of outfall Zone 6, Edmonds and Lynnwood flows were considered as part of the total Brightwater flow as an option for Unocal plant site.

Table D-6. Projected Design Flows for Brightwater, City of Edmonds, and Lynnwood Service Areas

Flow Condition	Brightwater (mgd)	Brightwater, Edmonds, and Lynnwood (mgd)
Initial Average Dry Weather Flow	18	18
Initial Average Wet Weather Flow	36	36
Buildout Average Wet Weather Flow	54	72
Peak Flow	170	235

Design flow impacts the number and diameter of pipelines selected to convey the effluent from the shoreline to the diffuser. Pipeline(s) should be selected that limit system head losses at peak flow while minimizing sedimentation at low flows. Minimum flow should be no less than 1.5 feet per second (ft/sec) for secondary effluent, with seasonal sediment scour flows of at least 2 ft/sec (Ecology, 1998). Flow velocities less than 1.5 ft/sec are

likely to occur in large tunnel sections or large diameter single pipelines. However, since the proposed pipeline lengths and diameters are large, rates of sedimentation for secondary effluent are not expected to impact effluent flow to the diffuser. Velocities in excess of 15 ft/sec usually require special consideration of the interior pipe lining material as well as consideration of various energy dissipation measures.

To obtain the desired flow velocities for both initial and peak design flow conditions, dual outfall pipes may be needed. Dual pipelines could be constructed in stages as flows increase over the planning horizon. Table D-7 shows the outfall pipeline velocities that would result from different single- and dual-pipe configurations.

Table D-7. Outfall Pipeline Velocities

Pipes		Daily Flow Rate					
Quantity	Diameter (inches)	18 mgd	36 mgd	54 mgd	72 mgd	170 mgd	235 mgd
		Pipe Velocity (ft/sec)					
1	36	3.94	7.88	11.82	15.76	37.21	51.44
2	36			5.91	7.88	18.61	25.72
1	42	2.89	5.79	8.68	11.58	27.34	37.79
2	42				5.79	13.67	18.9
1	48	2.21	4.43	6.65	8.86	20.93	28.93
2	48					10.47	14.47
1	54	1.75	3.50	5.25	7.00	16.53	22.86
2	54					8.27	11.43
1	60	1.42	2.84	4.26	5.67	13.40	18.52
2	60					6.70	9.26
1	66	1.17	2.34	3.51	4.69	11.07	15.30
1	72	0.99	1.97	2.96	3.94	9.30	12.86

As shown in Table D-7, single-pipe configurations in the of 36- to 48-inch-diameter range result in excessively high pipeline velocities at peak flow conditions of 170 mgd or greater. Single pipeline sizes of 60 to 72 inches in diameter exhibit low velocities, below 1.5 ft/sec, for the initial average dry weather flow (ADWF) condition of 18 mgd.

D.4.3 Preliminary Hydraulic Analysis

Available head will vary with conveyance method and whether or not the effluent is pumped. Head loss calculations assumed 85 feet of available head in order to determine the range of feasible pipeline number, size, and length configurations. Calculated total head loss incorporates extreme high and low tides as well as representative effluent and seawater density head differences. Outfall pipeline and diffuser hydraulic models were

used to determine the hydraulic grade line from the effluent pump station (Unocal site) or conveyance pipeline terminus (Route 9 site) to the end of the outfall and diffuser.

D.4.3.1 Outfall Pipeline

Single- and dual-pipe outfall configurations were evaluated for both the tunnel and trench alternative configurations. Fathom® software (Version 5.0, November 11, 2001) was used to generate solutions to pipe flow head loss calculations. For each segment of pipe analyzed, the following parameters were entered:

- Inside diameter of pipe
- Length of pipe in segment
- Coefficient of roughness
- Pipe elevation
- Minor losses

Tunnel alternatives were evaluated assuming an inside diameter of 96 inches for both the tunnel and offshore access portal. Tunnel segment length varies by outfall zone and alignment. Segment lengths for each tunnel alignment are provided in Section D.7 of this appendix. The depth of the offshore tunnel access portals is assumed to be 70 feet.

Several single- and dual-pipe configurations were evaluated for the remaining offshore outfall pipelines to be installed beyond, or seaward of, the tunnel construction. The single pipe configurations included diameters of 60, 66, and 72 inches. The dual-pipe configurations include twin pipes with diameters of 48, 54, and 60 inches.

Analysis of the trench alternative incorporated the same single- and dual-pipe configurations as evaluated in the tunnel alternative. In the trench alternatives, pipe diameter is assumed to be the same for both nearshore and offshore outfall segments. Segment lengths for each trench alignment are provided in Section D.7 of this appendix.

Appendix C of the *Brightwater Marine Outfall Conceptual Design Report* (Parametrix, 2002a) presents the pipeline hydraulic performance for all tunnel and trench construction methods utilizing both single- and dual-pipeline configurations. Beginning at the conveyance pipeline terminus, calculation of head loss along the outfall pipeline was divided into segments. Segment 1 consists of the nearshore pipeline (tunnel or trench). Head loss in the offshore tunnel access portal, if utilized, is shown as Segment 2. Segment 3 represents the offshore outfall pipeline. Diffuser losses (Segment 4) were calculated separately, as described in the following section.

D.4.3.2 Diffuser

Hydraulic analysis of multiport diffusers was performed using an iterative process developed in *Diffusers for Disposal of Sewage in Sea Water* (Rawn et al., 1960). The diffuser model projects port flow distribution, diffuser head loss, and other operating characteristics. The hydraulic performance of multiport diffuser configurations encompassing single or dual diffuser sections up to lengths of 750 feet was evaluated.

Multiport diffuser configurations developed during final design will be based on the following flow and performance objectives:

- Minimum port velocity of 2 to 3 ft/sec at peak flow.
- Maximum port velocity should rarely exceed 15 ft/sec.
- Across port flow variation of less than 20 percent under normal diffuser operating flow range.
- Total port area between 50 and 75 percent of diffuser pipe area.
- Minimize saltwater intrusion (Froude number greater than 1 for each port).
- Minimize friction head loss.

Two diffuser port configurations (number and spacing of ports) were developed for analysis. The first configuration was based on King County's South Treatment Plant outfall and included 168 4-inch diffuser ports. A second configuration with 50 8-inch ports was also developed to show the possible range in diffuser configurations. Appendix D of the *Brightwater Marine Outfall Conceptual Design Report* (Parametrix, 2002a) presents the design characteristics and performance of each diffuser configuration evaluated for Zones 6 and 7S.

D.5 Water Quality Analysis: Dilution Modeling

The EPA computer model Visual Plumes (Frick et al., 2001) was used to model acute and chronic dilutions for the outfall alternatives. Ecology specifies critical combinations of effluent and ambient conditions in the *NPDES Permit Writer's Manual* (Ecology, 2000). The required oceanographic parameters are current speed and density profiles, which were obtained during field studies between 1999 and 2002 (Ebbesmeyer et al., 2002 and King County, 2001d and 2002b). The effluent design criteria for water quality modeling are maximum day flow for acute conditions and maximum month flow for chronic conditions. Critical current statistics are the 10th and 90th percentile for acute dilution and the median for chronic conditions.

The modeling used slightly different but more conservative assumptions than Ecology recommends. The analysis used the 10th and 90th percentile currents for chronic conditions instead of the median. The maximum 1-hour flow was used for the acute analysis, instead of the maximum day flow recommended by Ecology. Additional detail on the dilution modeling can be found in *Phase 3 Initial Dilution Assessment of Potential Diffuser Zones: MOSS Plume Modeling: Continuous Discharges to Puget Sound* (King County, 2002d). The modeling results are summarized in Table D-8 for effluent design flows corresponding to the initial plant capacity (36 mgd AWWF), the plant capacity after expansion in Year 2040 (54 mgd AWWF), and the predicted capacity if the option to include Edmonds and Lynnwood flows was selected (72 mgd AWWF). The dilution data were used in the reasonable potential analysis presented in this appendix to evaluate compliance with State Water Quality Criteria.

Table D-8. Minimum Acute and Chronic Dilution Ratios as a Function of Average Wet Weather Flow

Outfall Alternative	MLLW Depth	36 mgd AWWF		54 mgd AWWF		72 mgd AWWF	
		Acute[a] 107 mgd	Chronic[b] 45 mgd	Acute[a] 161 mgd	Chronic[b] 68 mgd	Acute[a] 214 mgd	Chronic[b] 90 mgd
Zone 6, 250ft	580 (177)	81	315	47	227	33	230
Zone 6, 500 ft	580 (177)	130	367	84	342	56	274
Zone 6, 750 ft	580 (177)	165	451	118	403	77	325
Zone 7S, 250 ft	660 (201)	93	271	56	272	37	198
Zone 7S, 500 ft	660 (201)	144	367	98	351	64	274
Zone 7S, 750 ft	660 (201)	185	451	133	412	91	325

[a] Peak hour flow

[b] Maximum monthly flow

D.5.1 Mixing Zone Evaluations

State Water Quality Standards allow Ecology to authorize mixing zones around wastewater outfalls that meet secondary treatment requirements. A mixing zone is a volume of water surrounding a discharge in which some or all numerical water quality criteria may legally be exceeded. When a mixing zone is granted, the discharge is required to meet water quality criteria at the boundaries of the mixing zone. For estuary-class mixing zones authorized in WAC 173-201A-100, the requirements are as follows:

- The chronic mixing zone is a radius of 200 feet plus the water depth from the discharge ports, and extends from the surface to the bottom.
- The acute mixing zone is 10 percent of the distance to the chronic mixing zone boundary and also extends from the surface to the bottom.

Table D-9 lists anticipated mixing zone dimensions for characteristic depths in each outfall zone, determined in accordance with Ecology requirements.

Table D-9. Mixing Zone Dimensions

Outfall Alternative	Diffuser Depth (MLLW)	Distance from Any Discharge Port	
		Acute Mixing Zone	Chronic Mixing Zone
Zone 6 (all diffuser lengths)	580 feet (177 m)	780 feet (238 m)	78 feet (24 m)
Zone 7S (all diffuser lengths)	660 feet (201 m)	860 feet (262 m)	86 feet (26 m)

D.6 Outfall Design and Construction

This section discusses outfall design and construction considerations, developed to provide a basis for estimating project costs and to aid in the evaluation of environmental impacts that would result from outfall construction.

D.6.1 Structural Considerations

Structural criteria depend on the outfall alignment, construction alternative, and pipeline materials selected during final design. An additional alignment-specific bathymetry survey and geotechnical investigation performed prior to outfall construction will support development of the structural criteria. Structural considerations to be taken into account during the outfall design include span lengths and support of pipeline installed on the seafloor, and construction, testing, and operational loads.

D.6.1.1 Span and Support Considerations

It is assumed that the offshore pipeline would be laid and supported on the seabed without pre-leveling or trenching. Due to irregular seabed conditions and changes in the seabed over time, uniform support of the pipeline throughout its service life cannot be assumed. Changes in the seabed results from scour, landslide, or differential ground settlement due to earthquakes. These seabed changes may produce additional stresses in the pipeline because of changes in free-span lengths or pipeline curvature.

Analyses performed during final design will help determine the governing pipeline spans, support conditions, and pipe-soil interaction. Final design analysis will be based on subsurface information collected during the final geotechnical investigation and from a detailed outfall zone-specific topographic and bathymetric survey.

D.6.1.2 Construction Loads

In order to maintain the structural integrity of the pipe during its service life, it is necessary to take into consideration any residual construction stresses in the pipe design. It is expected that the most severe stress the pipes would likely experience will be during installation. Construction loads also occur during pipeline shipment. Construction loads that will be analyzed during final design include:

- Self-Weight: Includes pipe material weight, coating, lining, ballast, and fill material.
- Buoyancy: Lighter pipeline materials will be more susceptible to wave forces.
- Handling Stresses: Pipe segments are subjected to stresses resulting from lifting, transportation, storage, and installation method.
- Curvature: Pipe stresses due to ground curvature are directly proportional to the pipe diameter.
- Wave Loads: Wave loads are significant during pipeline installation and may also be significant during pipeline operation.

D.6.1.3 Testing Loads

Testing loads involve internal stresses in the pipeline when subjected to hydrostatic test pressures. This test pressure will be established during final design.

D.6.1.4 Operational Loads

This loading condition corresponds to loads that the completed pipeline would be subjected to during its service life. Effects of buoyancy and pipeline self-weight will be considered. Operational loads that will be analyzed during final design include:

- Operating Pressures: Total pressure will be established when the conveyance method and pump station requirements are determined during final design.
- Earthquake Loads: The outfall pipeline will be located in an active seismic zone with the potential for liquefaction and ground settlement. A design level geotechnical investigation will provide information used to evaluate the effects and significance of these loads.
- Settlement and Landslide Loads: The outfall pipeline may be located in a potential landslide area. The effects and significance of these loads will be evaluated based on the design level geotechnical investigation and recommendations.

- Current Loads: Lateral stresses on the pipeline due to currents will be evaluated as part of final design. Possible scour and vortex shedding effects due to currents should also be considered.
- Other Loads: These include, but are not limited to, thermal effects, pump surge pressures, pipe sag tension, residual stresses, and lateral load due to anchor drag. These loads may be dependent upon conveyance system configuration and pipeline installation method, and should therefore be included in final design.

D.6.2 Construction Alternatives and Materials Selection

D.6.2.1 Construction Alternatives

Construction alternatives presented in this Facilities Plan were developed based in part on input from technical advisors gathered during two workshops held by King County and the Outfall Project Team. The workshops examined the viability and potential risks of both nearshore and offshore construction methods. Two workshop reports, *Nearshore Risk Analysis Technical Report* (King County, 2002g) and *Offshore Construction Methods Workshop Technical Report* (King County, 2002h), summarize the conclusions reached during each workshop. Information collected from the workshops was used to screen and refine viable conceptual outfall alignments and construction methods for further analysis.

Construction activities would originate from a staging area located near the effluent pump station for the proposed Unocal plant site or in close proximity to the terminus of conveyance routes originating from the proposed Route 9 plant site. From the staging area, the outfall pipeline would proceed toward the shoreline and through the nearshore by means of open trench or tunnel construction. One of three potential offshore construction methods—segmental lay, controlled submergence, and bottom pull—could be utilized for installation of the outfall pipeline beyond the trench or tunnel segments. The diffuser will be installed using the same method employed for installation of the offshore pipeline.

Nearshore Construction Methods - Trenching

Trench construction would begin from the on-land staging area, extend on-land to the shoreline, and continue in-water through the nearshore area. Trench construction involves excavating a trench, laying the pipeline and bedding material, then backfilling and restoring the ground surface. It is expected that the in-water nearshore trench excavation would be performed by trestle-mounted and/or barge-mounted equipment. The construction method selected will depend on water depth, land access, and contractor

experience. Both barge and trestle installation methods may utilize trench sheeting in which large interlocking metal sheets, called sheet piles, would be driven into the seafloor up to water depths of approximately -20 feet Mean Low Low Water (MLLW). The sheet piles would prevent surrounding soil and sediment from sliding back into the trench during excavation and minimize the trench width and disturbance to the nearshore habitat. The trench would continue without sheeting to water depths of approximately -50 feet MLLW. The trench would be approximately 12 feet deep in order to allow for pipeline burial and protection. Top width of the trench would depend on the method of construction (trestle or barge), use of single or dual pipelines, and whether trench sheeting is used. Expected top widths of the sheeted trench and unsheeted trench are 25 and 125 feet, respectively. Figure D-2 presents typical cross-sections of sheeted and unsheeted trench construction.

Nearshore Construction Methods - Tunneling

Two variations of tunnel alignments have been evaluated for nearshore construction, both beginning from an access portal located at the on-land staging area. The onshore access portal would be approximately 60 to 100 feet deep with a diameter of approximately 30 to 50 feet. The anticipated outfall internal diameter is 8 feet, but could be as large as 12 feet to accommodate a second pipe for a safety relief outfall from the Unocal site.

The first variation of tunnel construction would terminate at the existing seafloor slope at water depths between -70 and -100 feet MLLW. Termination of tunnel boring at the seafloor slope may require injection of a hardening material into the soil to maintain slope stability at the tunnel boring machine (TBM) exit point. After completion of the tunnel, tunnel equipment would be abandoned in place or recovered using barge-mounted crane equipment and divers. The outfall pipeline would be placed on the seafloor from the end of the tunnel segment to the diffuser section.

The second variation of tunnel construction would terminate at an offshore access portal located at water depths between -20 and -40 feet MLLW. The offshore access portal would be constructed prior to completion of the tunnel and allow recovery of portions of the tunneling machine. The tunnel equipment would be recovered from the portal by barge-mounted crane equipment. The offshore access portal would be approximately 70 feet deep with a diameter of approximately 20 to 30 feet. In addition to recovery of portions of the tunneling machine, the offshore access portal would act as a riser to bring the outfall pipeline tunnel to the seafloor. The outfall pipeline would then continue on the seafloor to the diffuser section. Figure D-3 presents a schematic diagram of potential tunnel variations.

Tunneling under the nearshore could be accomplished by conventional tunneling, microtunneling, or directional drilling methods. Although it is believed that all tunnel methods are viable, the methods involve different risks than those associated with conventional trench excavation and, in pipe diameters over 24 inches, have not been utilized in the glacial type soils encountered in the nearshore areas of Puget Sound.

Detailed safety procedures and worker escape/retrieval systems would be incorporated into the design to help prevent injuries or loss of life. In the event of need to access the tunnel for worker safety or outside equipment repair, the nearshore area of the seabed would be disturbed, potentially negating any benefit gained in protection of the nearshore vegetation by use of the more complex tunneling method of construction.

Tunneling alignments will reduce the construction impact to environmentally sensitive areas in the nearshore region. The impact of weather delays and fish closure periods would also be minimized by the use of tunneling. Despite these advantages, tunneling under Puget Sound has not yet been attempted. Potential risks involved with tunnel construction include subsurface obstructions in the soil that may create a need for access to the TBM head. Excessive ground resistance to pipeline advancement, tunnel flooding, and TBM breakdown (requiring excavation of an access portal for equipment repair) are also of concern. Preliminary geotechnical investigations of the nearshore indicate that the soil is generally well suited for tunneling, but obstacles may be present that could temporarily halt the tunnel construction or possibly require excavation in the overlying seabed.

Current technology in the application of tunnel construction to underwater areas is limited to water depths of -100 to -120 feet by water pressure, or water head, on the TBM. All of the locations being considered for effluent discharge via the outfall pipeline are at water depths greater than -500 feet MLLW. Thus, if tunneling methods are utilized for installation of the outfall pipeline through the nearshore, there must be a transition to another offshore method of pipeline installation.

D.6.2.2 Conventional Tunneling

Conventional tunneling involves the use of a TBM with a cutting mechanism and a shielded work area for the tunnel construction crew. The work area provides for control of the advancing TBM and loading of the cut spoils (soil/earth) onto the transportation system to remove the spoils from the tunnel at an access portal. The transportation system is also utilized to transport tunnel lining material to the shielded area. The lining materials, typically curved concrete cylinder segments, are placed around the perimeter of the tunnel bore to form a closed, circular shell. The lining segments are structurally designed to carry the external soil loading and are sealed to be watertight against the outside water pressure. Once the lining segments are in place, the cutting head is pushed forward or advanced by hydraulic jacks pushing against the newly placed liner segments. Conventional tunneling is a “manned” operation because the tunnel construction crew must have complete access to the work area near the cutting head of the shielded TBM.

D.6.2.3 Microtunneling

Microtunneling is a remotely controlled method of construction that does not require staff within the tunneling machine. The equipment is controlled from outside of the tunnel,

allowing the advancement of the microtunneling machine and concurrent removal of spoils. Hydraulic jacks pushing against the backside of a tunnel access portal move both the pipe and tunneling machine away from the access portal. As the hydraulic jacks reach their maximum displacement, they are withdrawn and another pipe section is set into position. The new section is pushed forward and the process is repeated for the entire length of the tunnel. The tunneling machine, which is attached to the front-most section of the pipe being jacked, completes a bore with a diameter larger than the outside diameter of the jacked pipe. Bentonite clay/water slurry is pumped into the bored opening and, as necessary, the annular space between the jacked pipe and the borehole. The slurry serves two functions. First, it is mixed with the spoils created at the cutter head and serves as a medium to transport the slurry and spoils back to the access portal area, where the mixture is processed to separate the slurry from the spoils. The spoils are hauled away while the cleaned clay slurry is pumped back into the bore. Second, the slurry is used to hold the tunnel bore. This prevents the surrounding soils from settling around the newly installed pipeline, which could possibly prevent the controlled movement of the pipeline with the jacking process.

D.6.2.4 Horizontal Directional Drilling

Horizontal directional drilling (HDD) is another remotely controlled tunnel construction method. Pipeline installation by use of the directional drilling method would utilize a surface or shallow pit launch area. Initially, a smaller pilot bore would be drilled the entire length of the desired alignment. The pilot bore would then be enlarged by a reamer pulled through the pilot bore one or more times to produce the desired hole size. A clay slurry is used to fill the void created by the bore and to prevent collapse prior to pipeline installation. High-density polyethylene (HDPE) or steel pipe would be pulled through the tunnel on the final pass of the reamer. Directional drilling may be appropriate for tunnel installations up to 56 inches in diameter of relatively short lengths (less that 1,000 feet). One potential disadvantage of HDD is that it requires a radiused profile as it enters and emerges from the ground surface, which may be incompatible with adjacent pipeline requirements.

Offshore Construction Methods

Segmental Lay

Pipelines constructed by the segmental lay method require the use of divers and/or robotics to make underwater connections between pipeline segments on the seabed. Several barge-mounted cranes would be used to lower pipeline segments (100 to 500 feet in length) while other barges would supply material to the working barge.

D.6.3 Controlled Submergence

The controlled submergence method involves fabrication of the entire outfall pipeline either onshore or at a convenient offsite location in a sheltered harbor. The pipeline would be floated from land or the sheltered waters and towed into place at the desired outfall zone. Once in place, the pipeline would be lowered (sunk) in a controlled manner while being positioned to settle on the seabed starting from the nearshore and ending at the diffuser. Buoyancy of the outfall pipeline during towing could be accomplished by filling the pipeline with air or by utilizing flotation devices. The floating pipeline could be towed into place by multiple barges (one barge at each end of the pipeline).

D.6.4 Bottom Pull

Bottom pull involves fabrication of long sections of pipeline onshore at the location where the connection will be made with the upland conveyance pipeline. These fabricated sections would be pulled offshore down the existing slope of Puget Sound to the outfall end point in water depths between -500 and -700 feet MLLW. The pull is facilitated by maintaining a small negative buoyancy (5 to 10 pounds per foot) of the pipeline, ensuring that the pipeline rests gently on the seabed. Pulling a fully weighted pipeline along the seabed would abrade the pipeline coatings used for corrosion protection, and impose unnecessary flexing of the pipeline itself due to its own weight.

D.6.4.1 Construction Materials

Pipeline Material Alternatives

Materials that have been considered for construction of the outfall pipeline include welded steel pipe (both concrete coated and bare pipe), prestressed concrete pipe, reinforced concrete pipe, reinforced concrete cylinder pipe (with a steel liner), and HDPE pipe. Selection of the pipeline material will be made during final design based on alignment specific and financial analyses.

Due to the expected service life of the pipeline, its exposure to the marine environment, and high maintenance or replacement costs, it is recommended that the pipe material be well protected from corrosion and material deterioration by appropriate coatings and linings.

D.6.4.2 Steel Pipe

Large-diameter steel pipes may be fabricated either from spiral-welded steel or from longitudinal seam-welded rolled plates. For the spiral-welded pipe, the thickness of the

plate is generally limited to no more than ¾ inch thickness. For the longitudinal seam-welded pipe, plate thickness in excess of 2 inches is generally available. The steel plates are also available in various yield strengths ranging from 36 ksi (thousands of pounds per square inch) through 80 ksi. Pipes with wall thickness less than ¾ inch are produced in Portland by Northwest Pipe Company. The thicker wall pipes are produced in the California plants of Northwest Pipe Company and Ameron, as well as other locations in the United States. Standard shipment lengths are 40 feet, but shorter and/or longer lengths are available.

Steel pipe has been used in numerous marine outfalls despite the corrosion that occurs in the marine environment. To minimize corrosion, a cathodic protection system would be installed and a protective coating is normally applied to the inside and outside of the pipe. Steel pipeline corrosion protection coatings could consist of a mesh-reinforced cement mortar coating over an enamel paint coat on the outer wall or fusion-bonded epoxy covered by a heavy duty urethane abrasion coating. The inner wall of the pipe would be lined with an epoxy system. This protection system would be plant-applied and held back at the ends of the pipe as necessary to facilitate field welding.

It is anticipated that an impressed current cathodic protection system would be used to protect steel pipeline. Impressed current systems are based on an external source of current (cathodic protection rectifier) to reverse corrosion currents. The rectifier is connected to the pipeline as well as a group of buried metal rods, which are sacrificially corroded instead of the pipeline.

D.6.4.3 Prestressed Concrete Pipe

Under plant-controlled conditions, prestressed concrete pipe sections would be produced in a casting bed using pretensioned high-strength steel wire strands for longitudinal reinforcement. These pipes could be manufactured by Concrete Tech in Tacoma, Washington and by Ameron in California, as well as other manufacturers. Production lengths for individual pipe segments could be as long as 180 feet. The length is generally limited by weight limitations and crane capacity to handle the finished pipe segments. The pipe wall thickness would be about 6 inches, and the prestressing strands would be arranged concentrically around the circumference of the pipe.

Due to the reduced cracking strength of concrete pipe sections when conforming to existing ground curvature and large slope changes, it would be necessary to use shorter lengths of pipe at some locations. Lengths of 50 feet or less may be required at these locations. Design would consider the effects of reduced effective prestress force due to applied tension force induced in the pipe by the steepest slopes at the selected outfall zone.

Concrete is resistant to corrosion by sea water or marine organisms. However, it is susceptible to attack by potential acid or sulfur content in wastewater, which can impact

the stability of the material. Protection for concrete pipelines would consist of shop-applied polyurethane coating and polyurethane or coal tar epoxy lining.

D.6.4.4 Reinforced Concrete Pipe and Reinforced Concrete Cylinder Pipe

Reinforced concrete pipe (RCP) is available in lengths ranging from 6 to 32 feet depending on pipe supplier manufacturing procedures and capabilities. Because of the short length of pipe sections, reinforced concrete pipeline would require more individual lengths of pipe and joints, thus lending itself to a segmental lay offshore installation method. The increased number of joints tends to reduce the longitudinal stress in the pipeline that may result from uneven bedding or foundation material and seabed curvature. However, the short lengths of reinforced concrete pipes are most readily installed in shallower water due to the need for diver-assisted placement.

As with prestressed concrete pipe, RCP would be protected with shop-applied polyurethane coating and polyurethane or coal tar epoxy lining.

D.6.4.5 High Density Polyethylene (HDPE) Pipe

HDPE pipe is far more flexible, lighter, and lower strength when compared to steel or concrete pipes. HDPE pipe flexibility facilitates laying the pipeline on an irregular natural seabed and its light weight makes it easy to handle during construction. HDPE pipe is available in 40- to 60-foot lengths that are then connected in the field to form a continuous pipeline. Typical connection methods are butt fusing or flange bolting.

The combined effects of HDPE light weight, material flexibility, and low bending strength require closely spaced weights (10 to 15 feet) in order to offset buoyancy of the pipeline. Potential changes to the seabed due to liquefaction or landslide may cause movement of pipeline anchor weights, damaging the pipeline or allowing pipeline buoyancy.

Corrosion protection would not be required for HDPE pipelines because the material is not affected by sea water or municipal effluent.

Structural Alternatives – Pipe Joints

The number and type of pipe joints would have a direct influence on the structural performance of the pipeline. In conceptual design, rigid (continuous) joints and flexible (ball) joints were considered.

Rigid joints provide inherent strength, better spanning characteristics, and redundancy due to continuity. Flexible joints allow rotational displacement without causing bending

stresses in the pipeline. Flexible joints also allow the pipeline to conform more easily to the natural curvature of the existing seabed and increase the probability of the pipeline withstanding differential displacements without failing due to overstress. Small-diameter pipes may require fewer flexible joints with smaller radius of curvature because they conform more easily to bending and settlement than larger-diameter pipes.

D.6.4.6 Steel Pipe Joints

Three types of steel pipe joining methods were evaluated in conceptual design. Two commonly used rigid connections are welded joints and flange bolted joints. The third connection, while not as commonly used, is the flexible ball joint. It is expected that a series of single ball joints would be placed along pipe strings with fairly uniform and constant slope and that closely spaced double or triple ball joints would be placed where the ground curvature is more extreme. The spacing of the joints would be evaluated based on maximum spanning capacity of the pipe and angle of slope change.

D.6.4.7 Welded Joints

Welded joint connections are suitable for all pipe installation methods. Pipe segments would be field girth welded to form a long pipe string that is then pulled into place, floated and submerged, or laid segmentally.

The length of a pipe string would depend on the size of the available barge and the method of supporting the pipeline. Abutting pipe strings would be welded together to form a continuous all-welded pipeline without using flexible joints. The welds would likely be continuous complete penetration type welds that are designed to develop the required plate material thickness and tested by ultrasonic methods to assure weld quality.

D.6.4.8 Flanged Joints

Flanged joints are similar to welded joints except that at each end of the welded pipe string is a fabricated flange fitting. The flange fitting is a welded fixed flange at one end of the pipe segment and a swivel-type flange at the other end. When the two ends are field bolted, they form a continuous pipeline. Bolting a fixed-end flange to a swivel-end flange provides flexibility and ease of aligning and joining abutting pipe strings. A large number of bolts and flange stiffeners would be required to create continuity between abutting pipe strings. This type of joint connection would not be suitable for bottom pull pipe laying method.

D.6.4.9 Ball Joints

Incorporating ball joints along the pipeline provides tolerance for misaligned pipe and for angular adjustments without causing additional stress in the pipe material. Ball joints can be used to closely conform the pipeline to the seabed profile and to accommodate potential ground settlement due to earthquakes, soil liquefaction, changes in seabed profile due to landslide, and other environmental changes over the service life of the pipeline.

The ball end and casing end of a ball joint are welded to the ends of adjacent pipes and then bolted together after assembly. Ball joints of this type are designed and manufactured by Mobile Pulley and Machine Works in Mobile, Alabama, and Oil States Hydrotech in Houston, Texas.

The ball joint would provide 15 degrees of rotation in any direction off centerline and resist specified tension loads and internal pressure during installation and the service life of the pipeline. Final design would specify the required minimum tension load and pressure for the design of the ball joint.

D.6.4.10 Concrete and CCP Pipe Joints

Flexible joints are desirable in concrete pipes because of the inherent cracking susceptibility of the material. A preferred joint type is the raised bell and spigot with double-gasket joint seals. This joint allows for small angle change between pipe segments. The joint would be restrained from pulling apart by using a minimum of two tie rods located on the spring line at the joint standard bell and spigot ends. On steep slopes similar to those found in the outfall zones, the tie rods would be designed to support the tension exerted by the downhill pipe segments.

D.6.4.11 HDPE Pipe Joints

Typical connection methods are butt fusing or flange bolting. In the latter connection, a pipe section is fitted with a butt-fused stub end and aluminum backup ring. These form the flange assembly. The butt-fusion joining process assures strong, leak-proof joints and can be done at the job site.

Structural Alternatives – Portal Construction

Tunnel alignments would require an onshore access portal to be constructed near the effluent pump station for the Unocal plant site or near the terminus of conveyance lines from the Route 9 plant site. Construction of the onshore access portal would be coordinated with plant and conveyance construction and is discussed in Appendix C. Additionally, an offshore tunnel access portal may be constructed for some tunnel

construction alternatives. Offshore tunnel access portals would be excavated to 70 feet below the existing seabed and would have diameters between 20 and 30 feet. Two options have been evaluated for construction of the offshore tunnel access portals, as described in the following sections.

Wet Sheet Pile Cofferdam

This option would require driving steel box sheet piles (or pile pipes) in a circular pattern to form a cofferdam extending 10 to 20 feet below the bottom of the tunnel. Jetting inside the box piles may be required to allow them to be driven to the required depth. Due to the large water pressure at these depths, the cofferdam would not be dewatered. The soil would be excavated "in the wet" so that the water pressure would be equalized inside and outside of the cofferdam. A steel-lined riser portal would be then lowered into the cofferdam. The annular space between the sheet piles and the riser portal would be filled with lean concrete. The piles at the tunnel opening side of the cofferdam would be extracted while the lean concrete is still fluid. After the lean concrete hardens, the tunnel would be extended into the lean concrete below the riser and a connection made to the riser portal. The cofferdam piles would then be cut off at the ground surface and the offshore pipeline connection made to the top of the riser portal. This wet sheet pile cofferdam option may be impractical due to construction safety concerns.

Augured Casing

The augured casing option would require auguring a receiving portal at least 12 feet in diameter to the required depth and advancing a steel casing of approximately the same diameter concurrently with the auger. Prior to auguring the portal, it may be necessary to pre-inject grout into the soil around the receiving shaft to create an impermeable dense bulb of soil that would eliminate water intrusion as the TBM is advanced into the receiving portal. The grouted bulb of soil, if required, would also allow the steel casing to be socketed and sealed near the top of the bulb to prevent water intrusion from the top. A mined cavern in the bulb would link the casing to the tunnel.

A steel riser shaft liner would be lowered inside the casing and a formed cast-in-place concrete elbow/transition connection would be made between the tunnel and the riser. After the space between the casing and the riser shaft is filled with grout, the portion of the casing above the seabed could then be removed and the top of the riser shaft would then be connected to the remaining offshore outfall pipeline.

D.7 Outfall Alternative Analysis

This section presents the results of further analyses performed on the Zone 6 and Zone 7S outfall sites.

D.7.1 Outfall Zone 6

Zone 6 conceptual outfall alignments are shown in Figure D-4. Zone 6 extends up to 7,500 feet west of the shoreline to water depths of approximately -600 feet MLLW. The northern onshore boundary of the zone generally corresponds with the southern reaches of the Edmonds Marina. The zone's southern onshore boundary is just south of the existing Unocal Pier, now owned by the City of Edmonds.

Along the conceptual alignments in Zone 6, the nearshore shelf extends approximately 1,000 feet offshore. Beyond the shelf, the seafloor is relatively steep with a maximum slope of 25 percent.

The sloped seafloor transitions to the main channel of Puget Sound approximately 4,000 feet offshore at a water depth of approximately -530 feet MLLW. Diffuser locations of less than 2 percent slope would be located beyond 3,000 feet offshore at water depths between -530 and -600 feet MLLW.

Nearshore soils in Zone 6 consist of 90 to 100 feet of medium-grained sediment. Sediment cover on the sloped seafloor decreases from approximately 90 feet at the top of the slope to 15 feet at the middle and lower slope. Potential diffuser locations are covered by 15 to 20 feet of fine-grained material.

D.7.1.1 Alternative Outfall Alignments

The two conceptual outfall alignments, as shown in Figure D-4, represent different methods for crossing the shoreline areas. These alignments are intended to be representative of the range of possible alignments that the outfall will follow. The exact alignment of the outfall pipeline will be determined based on a more thorough evaluation of site-specific conditions during design. For each alignment, both trench and tunnel construction methods are being evaluated for crossing the shoreline area. Trench construction would extend from the Unocal plant effluent pump station by means of trenched pipeline techniques to the shoreline, then continue to water depths of approximately -50 feet MLLW. Trench sheeting may be used from the shoreline to about -20 feet MLLW to mitigate possible environmental impacts associated with unsheeted trench construction. The remaining pipe from about -50 feet MLLW to the diffuser section would be placed directly on the seafloor.

Tunnel construction would begin at the Unocal plant effluent pump station and extend about 1,500 feet to 1,800 feet to either an access shaft or to the existing seafloor side-slope at water depths between about -40 feet MLLW to about -100 feet MLLW. From the offshore tunnel's terminus, the remaining outfall pipeline would be placed on the seafloor to the diffuser section.

The offshore segments for both tunnel and trench alignments would extend at least an additional 2,000 feet from the nearshore segment and up to 6,500 feet. The length of the

offshore section of the outfall pipeline will be determined during pre-design based on bathymetry and water quality considerations at the diffuser site.

Zone 6 conceptual outfall alignments are summarized in Table D-10. The approximate lengths for each section of the Zone 6 conceptual pipeline alignments are presented in Table D-11.

Table D-10. Unocal Outfall Construction Options, Zone 6

Trench	Tunnel
Conventional trenched pipeline from Unocal effluent pump station to -50 feet MLLW	Tunnel from Unocal effluent pump station to between –40 and -100 feet MLLW
Buried pipeline section intersects seabed at about -50 feet MLLW and connects to offshore section of the pipeline	Tunnel connects to outfall pipeline by either an off-shore shaft or by the tunnel intersecting the seabed at about -40 to -100 feet MLLW.
From -50 feet MLLW to end of the diffuser section, direct placement on seafloor.	From tunnel connection to the end of the diffuser section, direct placement on seafloor

Table D-11. Segment Lengths of Unocal Outfall and Diffuser Systems

Unocal Treatment Plant Option Approximate Outfall Segment Lengths				
Alignment	**On-Land (ft)**	**Nearshore (ft)**	**Offshore (ft)**	**Diffuser (ft)**
Trench	1,000-1,500	650	2,100-6,600	250 - 750
Tunnel	1,500-1,800		1,000-5,750	250 - 750

D.7.1.2 Preliminary Hydraulic Grade Line

Hydraulic calculations for the Zone 6 outfall systems are based on a peak flow of 235 mgd, which includes potential contribution from the cities of Edmonds and Lynnwood. Pipeline head losses were calculated for the single- and dual-pipeline alternatives. Diffuser head losses were calculated using King County's South Treatment Plant outfall as a model. The diffuser configuration included 168 evenly spaced 4-inch diffuser ports, based on hydraulic modeling performed as part of the outfall investigations.

For Zone 6, all outfall systems utilizing dual 48-inch-diameter or single 60-inch-diameter offshore pipelines would surpass 85 feet of head loss at peak flow conditions. Some single 66-inch-diameter alignments would also surpass 85 feet of head loss. System head losses for Zone 6 outfall alternatives are presented in Table D-12. These calculations are preliminary in nature and will be refined during subsequent predesign and final design activities.

Table D-12. Zone 6 Total System Head Loss (in Feet)

	Offshore Pipeline Configuration, Number of Pipes x Pipe Diameter (in.)					
Alignment	**2 x48**	**2 x 54**	**2 x 60**	**1 x 60**	**1 x 66**	**1 x 72**
Trench	104	72	55	121	88	68
Tunnel (to –100 ft MLLW)	82	60	49	93	71	58
Tunnel (to –40 ft MLLW)	96	68	55	101	76	62

Outfall alignments with total system head losses greater than 85 feet should not be eliminated from further analysis. More head may potentially be available depending on decisions to be made regarding the conveyance method and effluent pump station characteristics. Hydraulic calculations are preliminary and will be updated during pre-design and final design. Hydraulic head calculations were based on a 500-foot-long diffuser and higher length values in the range of possible offshore pipeline segment lengths (reference Table D-11). Shorter offshore pipeline segments resulting in lower head loss may be selected in pre-design or final design.

D.7.2 Outfall Zone 7S

Zone 7S conceptual outfall alignments are shown in Figure D-5. Zone 7S extends up to 7,500 feet west of the shoreline to water depths of approximately -700 feet MLLW. The northern onshore boundary of the zone generally corresponds with the southern tip of Point Wells. The zone's southern onshore boundary is just south of King County's Richmond Beach Pump Station.

Along the conceptual alignments in Zone 7S, the nearshore shelf extends approximately 1,700 feet offshore. Beyond the shelf, the seafloor is relatively steep with a maximum slope of 30 percent in the northern area of Zone 7S and up to 35 percent in the southern area. The sloped seafloor transitions to the main channel approximately 4,000 feet offshore at a water depth of approximately -650 feet MLLW. Diffuser locations of less than 2 percent slope would be located beyond 3,000 feet offshore at water depths between -650 and -700 feet MLLW.

Nearshore soils in Zone 7S consist of 50 to 70 feet of loose material ranging from fine to coarse sand and some gravel. Approximately 10 to 15 feet of fine- to medium-grained sediment covers the sloped seafloor. Approximately 15 feet of fine-grained material covers potential diffuser locations. Sediments on the lower slope in the main channel seabed have an increased organic content and may contain biogenic gas.

D.7.2.1 Alternative Outfall Alignments

The three conceptual outfall alignments (Point Wells [PW], Point Wells South [PWS], and Richmond Beach [RB]), as shown in Figure D-5, differ by point of origin (based on terminus of the conveyance system) and route the shoreline construction method follows from the terminus of the conveyance system to the shoreline. Trench construction methods could be used for the RB alignment and the PW alignment. Tunnel construction methods could be used for the RB alignment or the PWS alignment. These alignments and shoreline construction methods are intended to be representative of the range of possible alignments that the outfall will follow. The exact alignment of the outfall pipeline will be determined based on a more thorough evaluation of site-specific conditions during construction. Alignments prefaced by "RB" would start from a conveyance terminus near King County's Richmond Beach Pump Station; all others would start from a conveyance terminus near the southern end of the Chevron Point Wells asphalt facility. Only one conveyance terminus-outfall origin will be selected in final design.

Trench construction along the PW alignment would require up to 1,500 feet of pipeline along the shoreline from a possible location for Portal 19 at the southern tip of the Chevron Asphalt facility to the tip of Point Wells. The trench would then continue into Puget Sound to about -50 feet MLLW. Sheeted trench construction techniques may be used from the shoreline to -20 feet MLLW to mitigate possible environmental impacts associated with conventional trench construction methods.

The RB alignment would require about 1,800 feet of conventional trench construction from the shoreline to about -50 feet MLLW. Sheeted trench construction may be used from the shoreline to about -20 feet MLLW to mitigate possible environmental impacts associated with conventional trench construction methods.

Tunnel construction along the PWS and RB alignments would extend west into Puget Sound between about 1,250 and 2,100 feet from Portal 19. The tunnels would terminate underwater at water depths between -40 feet and -100 feet MLLW, either at the existing seafloor side-slope or at an offshore access portal. The offshore access portal would act as a riser to bring the effluent pipeline to the seafloor. In all tunnel alignments, the remaining outfall pipeline would be placed directly on the seafloor to the diffuser section.

The offshore segments for both tunnel and trench alignments would extend at least an additional 1,000 feet from the nearshore segment and up to 6,250 feet. The length of the offshore section of the outfall pipeline will be determined during pre-design based on bathymetry and water quality considerations at the diffuser site.

Table D-13 summarizes conceptual outfall alignments. The approximate lengths for each section of the Zone 6 conceptual pipeline alignments are presented in Table D-14.

Table D-13. Route 9 Outfall Construction Options, Zone 7S

Point Wells (PW) Trench	Richmond Beach (RB) Trench	Point Wells Southern (PWS) Tunnel	Richmond Beach (RB) Tunnel
Conventional trenched pipeline from southern end of Point Wells Chevron Facility to tip of Point Wells, then to -50 feet MLLW	Conventional trenched pipeline from the Richmond Beach Pump Station to -50 feet MLLW	Tunnel from southern end of Point Wells Chevron Facility to between -40 and -100 feet MLLW	Same as trench alignment except point of outfall origin is Richmond Beach Pump Station
Buried pipeline section intersects seabed at about -50 feet MLLW and connects to offshore section of the pipeline	Buried pipeline section intersects seabed at about -50 feet MLLW and connects to offshore section of the pipeline	Tunnel connects to outfall pipeline by either an offshore shaft or by the tunnel intersecting the seabed at about -40 to -100 feet MLLW.	Tunnel connects to outfall pipeline by either an offshore shaft or by the tunnel intersecting the seabed at about -40 to -100 feet MLLW.
From -50 feet MLLW to end of the diffuser section, direct placement on seafloor.	From -50 feet MLLW to end of the diffuser section, direct placement on seafloor.	From tunnel terminus to the end of the diffuser section, direct placement on seafloor	From tunnel terminus to the end of the diffuser section, direct placement on seafloor

Table D-14. Segment Lengths of Route 9 Outfall and Diffuser Systems

Route 9 Treatment Plant Option Approximate Outfall Segment Lengths				
Alignment	**On-Land (ft)**	**Nearshore (ft)**	**Offshore (ft)**	**Diffuser (ft)**
PW (trench)	1,000-1,500	500	1,750-6,250	250–750
RB (trench)	NA	1250	1,500-5,500	250–750
PWS (tunnel)	1,250-1,600		1,500-5,650	250–750
RB (tunnel)	1,700-2,100		1,050-5,550	250–750

D.7.2.2 Hydraulic Gradeline

Hydraulic calculations for the Zone 7S outfall systems are based on a peak flow of 170 mgd. Pipeline head losses were calculated for single- and dual-pipeline alternatives. Diffuser head losses were calculated using King County's South Treatment Plant outfall as a model. The diffuser configuration included 168 evenly spaced 4-inch diffuser ports based on hydraulic modeling performed as part of the outfall investigations.

For all Zone 7S outfall alternatives, the total system head losses are below 85 feet, the anticipated amount of available head. Compared to Zone 6, system head losses are lower for Zone 7S outfall systems, primarily due to a lower peak flow (170 mgd versus 235 mgd) resulting in decreased flow velocities in the outfall and diffuser pipeline. The maximum flow velocity for any Zone 7S pipeline is approximately 13.4 ft/sec. At 235 mgd, maximum flow velocity for any Zone 6 pipeline is approximately 18.5 ft/sec. Hydraulic head calculations were based on a 500-foot diffuser and higher segment lengths in the range of possible offshore pipeline segment lengths. System head losses for Zone 7S outfall alternatives are presented in Table D-15. These hydraulic calculations are preliminary and will be updated during pre-design and final design.

Table D-15. Zone 7S Total System Head Loss (in Feet)

	Offshore Pipeline Configuration, Number of Pipes x Pipe Diameter (in)					
Alignment	**2 x48**	**2 x 54**	**2 x 60**	**1 x 60**	**1 x 66**	**1 x 72**
Point Wells Trench	65	48	39	74	56	46
Point Wells South Tunnel (to –100 ft MLLW)	52	41	35	58	47	40
Point Wells South Tunnel (to –40 ft MLLW)	53	42	36	62	49	42
Richmond Beach Trench	63	47	38	72	55	45
Richmond Beach Tunnel (to –100 ft MLLW)	50	40	35	56	46	40
Richmond Beach Tunnel (to –40 ft MLLW)	53	42	36	62	49	42

D.8 Comparison of Alternatives

This section compares the Zone 6 and 7S outfall locations considering geotechnical and engineering feasibility, constructability, and operations and maintenance issues.

D.8.1 Geotechnical Feasibility

Results of the geotechnical investigations, as they apply to outfall construction, are summarized below. In general, conditions are similar for both Outfall Zones 6 and 7S.

D.8.1.1 Slope Stability and Liquefaction

Loose, granular medium-grained soils were found overlaying denser glacial/interglacial sediment in both alternative outfall zones. The loose upper granular soil zone is

considered susceptible to both liquefaction and seismic induced slope failure during significant seismic events. In general, the borings indicate that the thickness of this zone ranges from less than 5 feet to a maximum of about 10 feet. An apparent slope failure scarp identified in Zone 6 near a relatively steep slope may be an indication of this type of failure. Risks are related to the magnitude of the seismic event, the steepness of the slopes, and the density/thickness ratio of the upper soils. Even relatively flat slopes have some risk of movement due to liquefaction/lateral spreading.

Locating the outfall pipe invert below the loose soil zones can mitigate risk due to slope stability and liquefaction. In deeper waters, where excavation is impractical and where the outfall will be laid at grade, the pipe could be designed to tolerate some slope failures. This can be accomplished by placing the pipe perpendicular to depth contours, adequately strengthening the pipe to bridge unsupported distances, and adding joint flexibility.

D.8.1.2 Trench Conditions

Open cut construction or sheet pile shoring to depths of about 40 feet of water is expected to encounter loose to compact granular soils at the depth of the required excavation (about 12 to 16 feet). These materials should not present any unusual or difficult construction. The composition and density of the materials will impact the stable open cut slopes and the width of the excavation section. Sheet piling and sediment control may be required if fine-grained soils are encountered.

D.8.1.3 Tunneling Conditions

Tunneling methods are well suited to the conditions encountered during the investigation. It is important to collect additional information to adequately characterize the soil conditions and allow selection of a suitable tunnel construction method. The occurrence and frequency of boulders is the primary condition impacting the feasibility of tunneling and the selection of a tunneling method. Therefore, it is critical to assess the probability of encountering boulders, including likely sizes and frequency. Areas with a high probability of encountering cobbles and boulders should be avoided. In addition to boulders, logs and debris can also be a problem. It is possible that the marine soils encountered could contain some buried logs.

Hydrogen sulfide gas (H_2S) was identified at several locations within the dense/stiff interglacial soils. The presence or absence of H_2S can impact the selection of the tunneling equipment. The presence of gas should be determined along the selected outfall alignment.

D.8.1.4 Transition Conditions

In the tunnel method, a transition will be required to an at-grade outfall in deeper waters. Whether by a portal or a transition made in an open cut exposing the end of the tunnel, soils encountered and ease of excavation would be similar. Termination of tunnel boring at the seafloor slope may require injection of a hardening material into the soil to maintain slope stability at the TBM exit point. If cobbles and boulders were prevalent, access portal advancement would be more difficult.

D.8.1.5 Deep Water and Diffuser Conditions

In deep water, beyond the steep side-slopes, the seafloor may be composed of thick, very soft silts and clays with organics. Placing support materials may not be practical at the water depths where the diffuser would be located. Decreasing the weight (buoyancy) of the pipeline would decrease potential settlement.

D.8.1.6 Summary of Site Characteristics

Table D-16 summarizes conditions encountered or inferred from the geophysical and geotechnical investigations at Zones 6 and 7S.

Table D-16. Outfall Sites Geophysical and Geotechnical Conditions Summary

Zone	Characteristic Side-Slope	Diffuser Discharge	Geophysics/ Geology	Main Potential Hazards
6	Consistent, uniform contours. Maximum slope of approximately 25%.	Less than 2 percent, 15-20 feet fine-grained sediment. Located beyond 4,000 feet offshore.	90-100 feet minimum-grained sediment on shelf, 15-90 feet on upper, mid, and lower slope. Overlays interbedded glacial/interglacial silt sand. Evidence of submarine slope failure.	Unstable mid and upper steeps slope areas, particularly along southern area of the site.
7S	Relatively steep slope with maximum slope of approximately 35%.	Less than 1 percent, 15 feet fine-grained sediment. Located beyond 4,000 feet offshore.	50-70 feet medium-grained sediment overlying stiff, interbedded silt.	Relatively steep slopes may indicate higher risk of slope failures along at grade pipeline sections. Boulder encountered at a depth of 26 feet and “boulder-like” drilling conditions between 47-51 foot depths.

D.8.2 Constructability

As determined during the three-phased evaluation of the alternative outfall zones, no major construction constraints were identified at either Outfall Zone 6 or 7S. The constructability analysis for the current level of design focused on pipeline materials and thicknesses, pipe joints, portal construction techniques, and pipe coatings and linings. Analyses of pipeline spans, pipe support, and pipe-soil interactions will be performed for outfall alignment-specific bathymetrics, and geotechnical investigations will be completed during final design.

D.8.3 Operations and Maintenance

The marine outfall and diffuser will be designed for automatic operation. However, outfall pipelines, diffusers, and access portals will require periodic maintenance. Routine inspection of the outfall system will be performed to evaluate its structural integrity and hydraulic performance.

Several components of the marine outfall system will require scheduled inspection and maintenance to ensure safe and reliable operation in conformance with the requirements of an NPDES Permit. These components are discussed below.

D.8.3.1 Cathodic Protection System

If steel pipelines are selected, cathodic protection to prevent corrosion of the pipeline will be required. Two common methods of applying cathodic protection are galvanic anode systems and impressed current systems. Galvanic anode systems consist of buried magnesium or zinc blocks that are connected to the outfall pipe by wires. These materials reverse electrical currents and are sacrificially corroded instead of the steel pipeline. Impressed current systems are based on an external source of current (cathodic protection rectifier) to reverse corrosion currents. The rectifier is connected to the pipeline as well as a group of buried metal rods, which are sacrificially corroded instead of the pipeline.

For steel pipelines, it is anticipated that an impressed current system would be used to protect the outfall. The galvanic systems offer no practical method for monitoring performance. An impressed current system is more space efficient and cost effective for corrosion protection of large-scale pipelines. Impressed current systems are also more easily monitored and can be adjusted to balance with the corrosion protection needs of the pipeline. The current King County maintenance schedule for cathodic protection systems includes quarterly monitoring of the rectifier and monitoring of the current interceptors every 5 years.

D.8.3.2 Remote Effluent Sampling Station

Treated effluent from the proposed Route 9 plant site may require systematic sampling at the end of the conveyance system and prior to the offshore discharge into Puget Sound due to the long travel time within the conveyance pipeline. A remote effluent sampling station would not be required for the proposed Unocal plant site due to its proximity to the shoreline. Telemetry equipment at the remote effluent sampling station would be used to measure fecal coliform levels. Access to the outfall pipeline through a manhole located near the terminus of the conveyance line and installation of sample ports would allow for periodic grab sample collection.

D.8.3.3 Air Release Valves

Air release valves vent small pockets of air as they accumulate at high points in the outfall system. Air release valves are designed for automatic operation, but would require scheduled inspection. Frequency of air valve maintenance would be based on the observed condition of the valves during inspection. Offshore air valves would require diver inspection, such as at offshore tunnel access portals.

D.8.3.4 Offshore Outfall Pipeline and Diffuser

Additional maintenance activities for the offshore outfall include removal of biological growth from diffuser ports and potential cleaning of the pipeline and diffuser. Approximately every 5 years the exterior of pipeline, diffusers, and access portals would be inspected visually by divers and/or by a remotely operated vehicle (ROV). The inspection crew would check the pipeline for slide, anchor, or other damage and make certain that diffuser ports were free from blockage caused by accumulation of biological growth.

In the long term, the outfall and diffuser may require an interior inspection and cleaning as was performed for the King County West Point Treatment Plant Outfall. The interior cleaning would identify potential blockage due to accumulated solids present in the outfall and the interior inspection would reveal the structural integrity of the pipeline. Due to the level of wastewater treatment (secondary) provided by Brightwater and potential “self-cleaning” diffuser design, it is likely that solids would accumulate in the outfall and diffuser at a very slow rate, if at all.

D.8.4 Cost Comparison

Outfall construction and O&M costs were developed by King County’s Brightwater program consultant as part of an overall system-wide cost estimating effort. The cost estimates were presented in the *Brightwater Regional Wastewater Treatment System,*

Draft EIS Estimates (King County, 2002i). A summary of estimated marine outfall costs is presented in Chapter 5 of this report.

D.9 Land Lease/Acquisition and Land Use Considerations

D.9.1 Lease/Acquisition Considerations

Property issues for Zone 6 or Zone 7S are similar. In both cases the installation of an outfall will impact submerged lands where the transition from upland construction to Puget Sound takes place. The boundary between uplands and all tidelands is defined as the line of ordinary high tide. Tidelands extend into the water varying distances depending on their location and the date on which they were acquired. Title to most submerged lands, tidelands, and beds of navigable waters are vested in the State and are managed by the Department of Natural Resources (DNR). Areas of State ownership will require a negotiated Aquatic Land Lease with DNR. In Zone 6 and Zone 7S there are current Aquatic Land Use Agreements (Leases) for dock or outfall uses. Additionally, both Zone 6 and 7S have areas of private tideland ownership. Predominately these ownerships belong to Burlington Northern Santa Fe Railroad and Chevron USA Inc. with some smaller private individual ownership' in areas of residential development. Private tideland ownership will necessitate the acquisition of subterranean easements or purchase of the tidelands. Obtaining private property rights for tidelands will follow King County Wastewater Treatment Division Real Property Acquisition and Relocation Policy, Procedures and Guidelines Manual.

D.9.2 Land Use Considerations

No significant long-term land use impacts are anticipated from construction of the outfall in Zone 6 or Zone 7S. Shoreline areas adjacent to the outfall zones include recreational, industrial, and residential uses. During construction, recreational activities would be temporarily disrupted along the shoreline within Zone 6. Construction would occur both onshore and offshore. A shoreline substantial development permit would be required for all construction activities within 200 feet of the shoreline.

Outfall Zone 6 is located within the shoreline area of the City of Edmonds, just west of the Unocal site. Adjacent land use includes the Port of Edmonds Marina, Marina Beach Park, and Olympic View Park to the north; the BNSF Railroad to the east; and residences and shoreline to the southeast and south within the Town of Woodway. The current comprehensive plan designation for the shoreline within the outfall zone is Downtown/Waterfront Activity Center. The zoning for the shoreline area within the outfall zone is Commercial Waterfront. The Commercial Waterfront zone is intended to

reserve areas for water-dependent and water-related uses as well as to protect and enhance the natural features of the waterfront.

Zone 7S is located within the shoreline area adjacent to Point Wells in unincorporated Snohomish County and residential neighborhoods in the City of Shoreline and Town of Woodway. The land use within this area includes the Chevron asphalt and bulk fuel storage facility in the northern part of Zone 7S and residential uses and the Richmond Beach pump station in the southern part. The BNSF Railroad track is located along the eastern edge of the outfall zone. The shoreline within the outfall zone is within an area designated as Urban Industrial in the City of Shoreline Comprehensive Plan and the Snohomish County Comprehensive Plan. The Point Wells site is zoned Rural Use by Snohomish County, the area to the south that is in the City of Shoreline is zoned Residential (6 units/acre), and a small area to the east that is within the Town of Woodway is zoned Suburban Residential (SR 14.5).

Operation of the outfall would not require permanent structures that would impact surrounding land uses.

D.10 Reasonable Potential Analysis

A reasonable potential analysis was made of the likelihood for the discharged effluent from the Brightwater Treatment System to exceed state water quality standards, following Ecology's published guidance (Ecology, 2002). The reasonable potential analysis considered outfall Zones 6 and 7S when operated under Year 2050 flows projected for the Brightwater Service Area.

Some assumptions and deviations were made from Ecology's reasonable potential guidance, since the outfall is still evolving through the design process. Other deviations were made for convenience; in these cases a more conservative value was used. The following sections summarize the data that was used in the reasonable potential analysis, and highlight the variations that were made from Ecology's guidance. The reasonable potential analysis will be refined as the project proceeds towards NPDES permitting.

D.10.1 Effluent Quality

Since Brightwater is presently under design, no data are available on the actual quality of effluent that will be discharged by the facility. To perform the reasonable potential analysis, effluent from King County's South Treatment Plant was used as a surrogate for the Brightwater System. The South Treatment Plant has a substantially separated sewer system and includes a significant portion of the Brightwater Service Area. Thus, the influent quality is expected to be similar to what the Brightwater Treatment Plant will receive, more so than a comparison with King County's West Point Treatment Plant, which serves an area with a significant amount of combined sewers. The South Treatment

Plant provides secondary-level treatment through an activated sludge process. With the proposed split flow membrane bioreactor (MBR) treatment process, Brightwater is anticipated to produce an effluent with higher average effluent quality than the South Treatment Plant. Thus, the use of South Treatment Plan data in the reasonable potential analysis provides conservative assumptions, protective of water quality.

Monitoring data from the South Treatment Plant, effluent channel during a 5-year period (1996-2000) was used. The reasonable potential analysis spreadsheet provided by Ecology (tsdcalc9.xls) was used to compute the 95th and 99th percentile effluent concentrations. This spreadsheet calculates the percentile effluent concentrations from the maximum measured value, the coefficient of variation (CV) and an assumed geometric statistical distribution of the samples. For constituents with 20 or fewer samples, the CV suggested by Ecology of 0.6 was assumed. For those compounds with greater than 20 samples, the CV was computed as the ratio of the geometric standard deviation to the geometric mean. Ecology recommends a value of zero be used for measurements below the method detection level (MDL), and the MDL value be used for measurements below the quantitation level (QL). For convenience and since a geometric mean cannot be computed with zero values, a value of ½ the MDL was assigned to values below the MDL, and values below the QL were used as reported. Pollutants that were undetected in the South Treatment Plant effluent were not included n the analysis.

D.10.2 Ambient Water Quality

Ambient conditions in Puget Sound were based on data collected by King County from 1999 to 2001 at several locations throughout the northern portion of the Main Basin. No statistically significant difference was found between stations, so all results from all stations were included. Ecology guidance recommends using zero for values below the MDL, and the MDL for values between the MDL and QL. In order to calculate a geometric mean, values below the MDL were given a value of 0.0001 ug/l; values above the MDL were used as reported.

D.10.3 Dilution Scenario

The particular dilution scenario at which reasonable potential is evaluated is comprised of four factors, the diffuser design, the effluent flow rate, the ambient stratification, and the ambient current velocity. The size of the chronic mixing zone was assumed to be 200 feet plus the diffuser depth; the acute mixing zone is 10 percent of the chronic.

As the diffuser design is not yet finalized, the shortest diffuser option (250 feet) evaluated in the Brightwater Draft EIS was selected. A longer diffuser would result in greater dilutions (King County, 2002d), and less potential to exceed standards. The two diffuser zones, Zone 6 at Point Edwards and Zone 7S at Point Wells have characteristic depths of 580 feet (177 m) and 660 feet (201 m), respectively, at MLLW. At these depths, the

dilution is relatively insensitive to the diffuser depth so that any difference between these characteristic depths and the final diffuser depth is not expected to affect the potential to exceed standards.

Ecology recommends the critical conditions be simulated with the maximum daily flow for the acute standards, and the maximum monthly flow for the chronic standards. For convenience, the maximum one-hour flow, estimated at the time of analysis at approximately 161 mgd, was used for the acute modeling. Since this will always be greater than the maximum daily flow, these predictions are conservative. For non-carcinogens, the maximum monthly flow (68 mgd) was used, and the average wet weather flow (54 mgd) was used for carcinogens in evaluating human health standards. These are the predicted flow rates for the Brightwater system at final capacity, after a plant expansion around 2040

The ambient stratification was selected from 28 profiles obtained over a 2-year period at King County's Point Wells 2 station. The profile corresponding to the lowest mixing (greatest stratification) was used. For comparison with human health standards, Ecology's guidance suggests using the density profile that results in average mixing. To simplify the number of scenarios run, the density profile that resulted in the lowest dilution was used instead.

The effluent dilution was modeled with the 10th, 50th, and 90th percentile currents, determined from a current meter located off Point Wells at King County's Mooring 23. Ecology recommends the 50th percentile current be used with the chronic flow scenario, and the minimum dilution under either the 10th and 90th percentile values for the acute flow scenario.

Under these conditions, the critical case for acute dilution was found to have a dilution of 47:1 at Zone 6 and 56:1 at Zone 7S. The critical case for chronic resulted in dilutions of 452:1 and 684:1 for Zones 6 and 7S, respectively. Ecology recommends that assumed refluxing reduces the dilution factor by ½, resulting in a dilution for chronic conditions of 226:1 and 342:1. Refluxing was not assumed to affect the acute dilution, since most of the mixing is predicted to occur below the depth at which most of the effluent is trapped.

For chemicals with human health standards, Ecology recommends using the dilution at the chronic mixing zone under the maximum monthly flow for non-carcinogens, and under the AWWF for carcinogens. The predicted dilution for non-carcinogens is the same as the chronic conditions above, 226:1 and 201:1, for Zones 6 and 7S. The predicted dilutions for carcinogens are 231:1 and 274:1, after being reduced by ½ to account for the potential of refluxing.

D.10.4 Results of Reasonable Potential Findings

The reasonable potential analysis for protection of marine aquatic life is presented in Table D-17. The reasonable potential analysis for protection of human health is presented in Table D-18. In each analysis, discharge impacts were evaluated using the lowest dilution (most conservative assumption) for each condition. These calculations suggest that there is no reasonable potential that the Brightwater system will exceed any of the water quality criteria. Thus, technology-based effluent limitations for secondary treatment appear appropriate for the proposed marine discharge.

D.11 Recommended Alternative: Zone 7S

The available information and analyses for the alternative outfall zones indicate that both Zone 6 (for the Unocal System) and Zone 7S (for the Route 9 Systems) are conducive to outfall construction and long-term operations and maintenance. Each of the alternatives has adequate on land area for the staging of the nearshore construction, and these locations should have minimal effect on the quality of life for area residents and commercial enterprises. The magnitude and direction of both the tidal and net currents are parallel to the shoreline and should provide strong mixing and dilution of the effluent plume with the surrounding water. Both outfall zones will be protective of water quality standards and the health of Puget Sound. Therefore, selection of the recommended outfall zone was made with respect to the entire Brightwater System, consisting of the treatment plant, conveyance pipelines and most easily accessible outfall zone in Puget Sound. Since the Route 9 site has emerged as the preferred alternative, the associated Zone 7S outfall is therefore identified as the recommended outfall location.

Tunnel construction is the recommended method for pipeline installation at the shoreline and nearshore areas. Use of tunneling methods will minimize construction impacts to plant and animal life as compared to trench construction. The tunnel would begin from the conveyance pipeline terminus at Portal Site 19 and would extend under the nearshore either to the existing seafloor slope or an offshore tunnel access portal. The tunnel segment would terminate at water depths between -40 and -100 feet MLLW, beyond the sensitive nearshore habitat.

The tunnel construction method, offshore construction method, segment lengths, diffuser configuration and other outfall installation details would be determined during final design based on site specific information and further design analyses. The final selection of the pipe diameter is an iterative process involving allowable span lengths, pipe diameter and pipe wall thickness. Currently available information indicates that each of the alternatives presented in this Facility Plan are viable. The final selection of outfall construction methods and pipeline materials will result in a properly functioning outfall over its design life while minimizing costs and environmental impacts.

Table D-17. Representative Reasonable Potential Calculation for Protection of Marine Life

Parameter	Metal Criteria Translator as decimal	Metal Criteria Translator as decimal	Ambient Concentration (metals as dissolved)	State Water Quality Criterion		Max concentration at edge of mixing zone		LIMIT REQ'D?	Effluent percentile value		Max effluent conc. Measured (metals as total recoverable)	Coeff Variation		# of samples	Multiplier	Acute Dil'n Factor	Chronic Dil'n Factor
	Acute	Chronic	ug/L	Acute ug/L	Chronic ug/L	Acute Mixing Zone ug/L	Chronic Mixing Zone ug/L			Pn	ug/L	CV	s	n			
AMMONIA unionized			4.05E-02	233.00	35.00	1.17	0.30	NO	0.95	0.688	28.00	0.60	0.55	8	1.90	47	201
ARSENIC (dissolved) 7440382 2M	1.00		1.21E-03	69	36	0.00	0.00	NO	0.95	0.996	0.06	0.17	0.17	747	0.84	47	201
BIS(2-ETHYLHEXYL) PHTHALATE 117817 13B			2.25E+00	2944	3.40	5.24	2.95	NO	0.95	0.944	133.00	2.02	1.28	52	1.07	47	201
CADMIUM - 7440439 4M Hardness dependent	0.994	0.99	6.93E-05	42.00	9.3	0.00	0.00	NO	0.95	0.996	0.00	0.16	0.16	747	0.85	47	201
CHLORPYRIFOS 2921882				0.011	0.0056	0.00	0.00	NO	0.95	0.807	0.02	0.58	0.54	14	1.52	47	201
CHROMIUM(HEX) 18540299	0.993	0.99	1.71E-04	1100	50	0.00	0.00	NO	0.95	0.996	0.01	0.33	0.33	747	0.72	47	201
COPPER - 744058 6M Hardness dependent	0.83	0.83	4.00E-04	4.80	3.10	0.00	0.00	NO	0.95	0.996	0.21	0.48	0.46	747	0.63	47	201
CYANIDE 57125 14M				1.00	1.00	0.00	0.00	NO	0.95	0.962	0.02	0.87	0.75	78	0.90	47	201
1,2 DICHLOROBENZENE 95501 20B				1970		0.02	0.01	NO	0.95	0.944	1.03	0.51	0.48	52	1.03	47	201
1,4 DICHLOROBENZENE 106467 22B				1970		0.07	0.02	NO	0.95	0.944	3.22	0.85	0.74	52	1.04	47	201
1,2 DICHLOROETHANE 107062 15V				113000		0.05	0.01	NO	0.95	0.966	2.50	0.79	0.70	87	0.88	47	201
DIETHYLPHTHALATE 84662 24B			3.74E-02	2944	3.40	2.45	0.60	NO	0.95	0.944	103.00	4.27	1.72	52	1.10	47	201
DIMETHYLPHTHALATE 131113 25B			6.90E-03	2944	3.40	0.02	0.01	NO	0.95	0.944	0.71	0.52	0.49	52	1.03	47	201
HEXACHLOROCYCLOHEXANE-GAMMA (lindane) 58899 4P				0.16		0.00	0.00	NO	0.95	0.933	0.05	0.46	0.44	43	1.07	47	201
LEAD - 7439921 7M Dependent on hardness	0.951	0.95	6.90E-06	210.00	8.10	0.00	0.00	NO	0.95	0.996	0.03	0.17	0.17	747	0.84	47	201
MERCURY 7439976 8M	0.85		0.00	1.80	0.0250	0.00	0.00	NO	0.95	0.996	0.02	4.37	1.73	758	0.17	47	201
NICKEL - 7440020 9M - Dependent on hardness	0.99	0.99	4.87E-04	74.00	8.20	0.00	0.00	NO	0.95	0.996	0.02	0.14	0.13	747	0.87	47	201
PENTACHLOROPHENOL 87865 8A (pH dependent)				13.00	7.90	0.01	0.00	NO	0.95	0.950	0.65	0.48	0.45	59	1.00	47	201
PHENOL 108952 10A			7.21E-02	5800		0.38	0.14	NO	0.95	0.944	13.90	0.92	0.78	52	1.04	47	201
SILVER - 7740224 11M dependent on hardness.	0.85			1.90	NA	0.00	0.00	NO	0.95	0.996	0.01	0.43	0.41	747	0.66	47	201
TETRACHLOROETHYLENE 127184 24V				10200	450	0.15	0.03	NO	0.95	0.966	8.44	1.33	1.01	87	0.83	47	201
TOLUENE 108883 25V				6300	5000	0.12	0.03	NO	0.95	0.966	6.93	1.23	0.96	87	0.84	47	201
ZINC- 7440666 13M hardness dependent	0.946	0.946	1.16E-03	90.00	81.00	0.13	0.03	NO	0.95	0.966	6.93	0.28	0.28	87	0.95	47	201

Table D-18. Representative Reasonable Potential Calculation for Protection of Human Health

Parameter	Ambient Concentration (Geometric Mean)	Water Quality Criteria for Protection of Human Health	Max concentration at edge of chronic mixing zone.	LIMIT REQ'D?	Expected Number of Compliance Samples per Month	AVERAGE MONTHLY EFFLUENT LIMIT	MAXIMUM DAILY EFFLUENT LIMIT	Estimated Percentile at 95% Confidence	Pn	Max effluent conc. measured	Coeff Variation	S	# of samples from which # in col. K was taken	Multiplier	Calculated 50th percentile Effluent Conc. (When n>10)	Dilution Factor	CARCINOGEN? (Y = Yes, N = No)
	ug/L	ug/L	ug/L			ug/L	ug/L			ug/L	CV		n				
ANTIMONY (INORGANIC) 7440360 1M	8.12E-05	4300	0.00	NO	2	NONE	NONE	0.50	0.95	0.02	0.81	0.7	56	0.31	0.00	201	
ARSENIC (inorganic)	3.35E-05	0.14	0.00	NO	2	NONE	NONE	0.50	1.00	0.06	0.17	0.2	747	0.63	0.00	231	Y
BIS(2-ETHYLHEXYL) PHTHALATE 117817 13B	7.68E-02	5.9	0.15	NO	2	NONE	NONE	0.50	0.94	133.00	2.02	1.3	52	0.13	0.00	231	Y
CHLOROFORM 67663 11V		470	0.01	NO	2	NONE	NONE	0.50	0.97	5.06	0.28	0.3	87	0.60	0.00	231	Y
CYANIDE 57125 14M		220000	0.00	NO	2	NONE	NONE	0.50	0.96	0.02	0.87	0.8	78	0.26	0.00	201	
1,2 DICHLOROBENZENE 95501 20B		17000	0.00	NO	2	NONE	NONE	0.50	0.94	1.03	0.51	0.5	52	0.47	0.00	201	
1,4 DICHLOROBENZENE 106467 22B		2600	0.00	NO	2	NONE	NONE	0.50	0.94	3.22	0.85	0.7	52	0.31	0.00	201	
1,2 DICHLOROETHANE 107062 15V		99	0.00	NO	2	NONE	NONE	0.50	0.97	2.50	0.79	0.7	87	0.28	0.00	231	Y
DIETHYLPHTHALATE 84662 24B	4.21E-03	120000	0.04	NO	2	NONE	NONE	0.50	0.94	103.00	4.27	1.7	52	0.07	0.00	201	
DIMETHYLPHTHALATE 131113 25B	7.66E-06	2900000	0.00	NO	2	NONE	NONE	0.50	0.94	0.71	0.52	0.5	52	0.46	0.00	201	
DI-n-BUTYL PHTHALATE 84742 26B	6.77E-03	12000	0.01	NO	2	NONE	NONE	0.50	0.94	2.87	0.93	0.8	52	0.29	0.00	201	
HEXACHLOROCYCLOHEXANE-GAMMA (lindane) 58899 4P		0.063	0.00	NO	2	NONE	NONE	0.50	0.93	0.05	0.46	0.4	43	0.52	0.00	231	Y
METHYLENE CHLORIDE 75092 22V		1600	0.02	NO	2	NONE	NONE	0.50	0.97	25.00	1.03	0.8	87	0.21	0.00	231	Y
MERCURY 7439976 8M	1.08E-07	0.15	0.00	NO	2	NONE	NONE	0.50	1.00	0.02	4.37	1.7	758	0.01	0.00	201	
NICKEL - 7440020 9M - Dependent on hardness	4.22E-04	4600	0.00	NO	2	NONE	NONE	0.50	1.00	0.02	0.14	0.1	747	0.70	0.00	201	
PENTACHLOROPHENOL 87865 8A (pH dependent in		8.20	0.00	NO	2	NONE	NONE	0.50	0.95	0.65	0.48	0.5	59	0.47	0.00	231	Y
PHENOL 108952 10A	1.19E-04	4600000	0.02	NO	2	NONE	NONE	0.50	0.94	13.90	0.92	0.8	52	0.29	0.00	201	
TETRACHLOROETHYLENE 127184 24V		8.85	0.01	NO	2	NONE	NONE	0.50	0.97	8.44	1.33	1.0	87	0.16	0.00	231	Y
TOLUENE 108883 25V		200000	0.01	NO	2	NONE	NONE	0.50	0.97	6.93	1.23	1.0	87	0.17	0.00	201	

D.12 References

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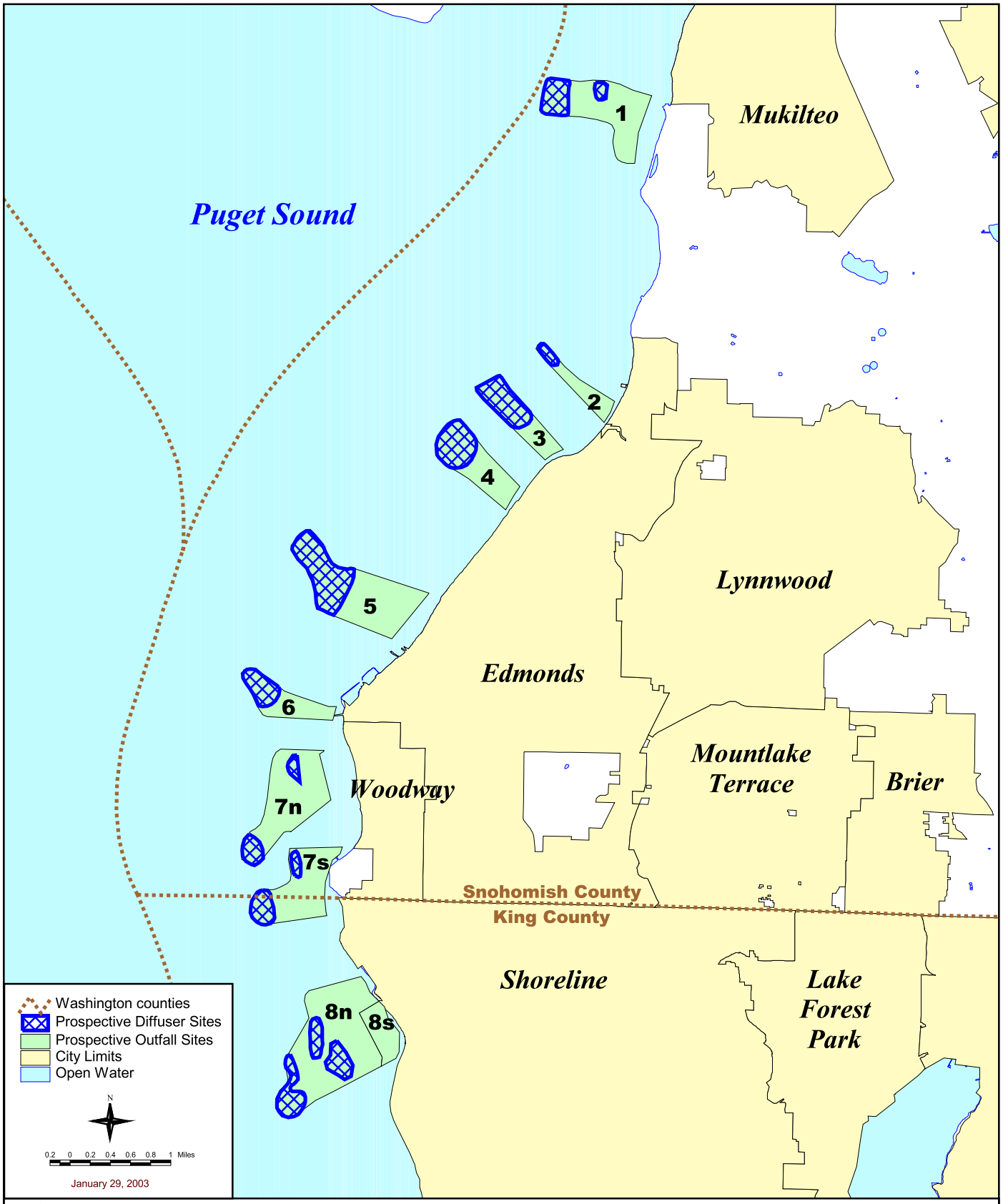

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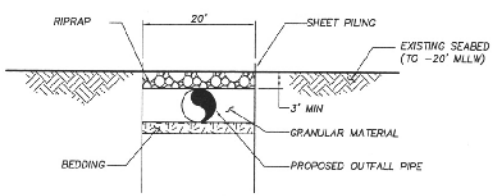
Figure D-1

Prospective Outfall Sites

BRIGHTWATER FACILITIES PLAN



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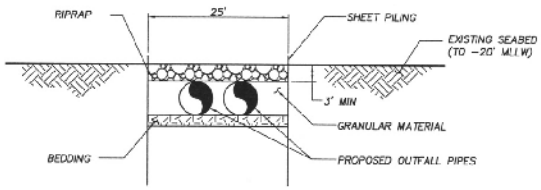

TWO PIPE SECTION

NEARSHORE SHEETED
PIPE TRENCH (TO -20 MLLW)

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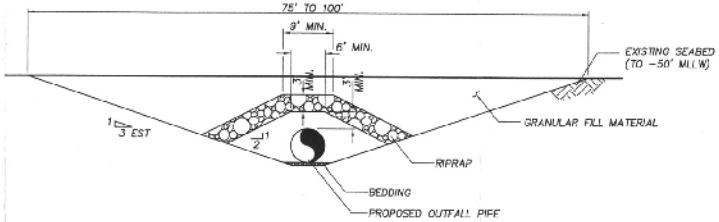

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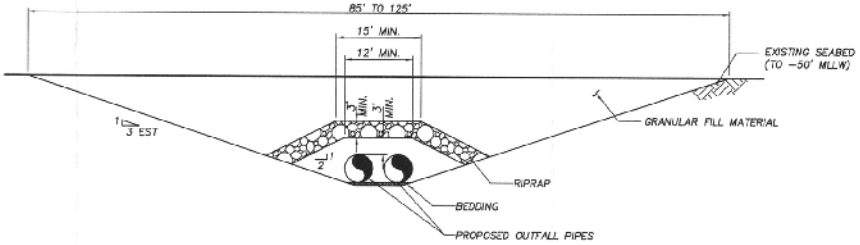

TWO PIPE SECTION

NEARSHORE UNSHEETED
PIPE TRENCH (TO -50 MLLW)

NOT TO SCALE

NO.	REVISIONS	DATE	BY

DESIGNED M. DEROER
DRAWN N. HENRY
CHECKED
APPROVED

0 1' 2'
TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
SCALE NO SCALE
DATE JULY 2002

DRAFT

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

PROJECT NAME
KING COUNTY
BRIGHTWATER MARINE OUTFALL
CONCEPTUAL DESIGN ALTERNATIVES
JOB NO. 555-1521-045 FILE 15214502AF4-2

FIGURE 4-2
TRENCH CROSS-SECTIONS

SHEET NO.

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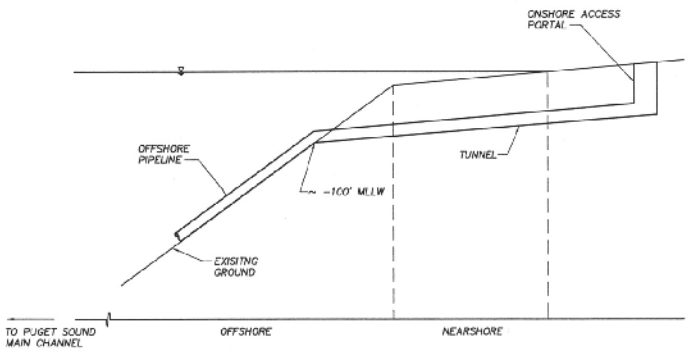
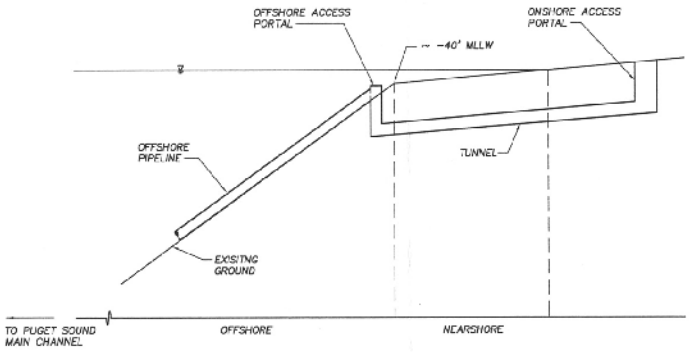
Figure D-2

Trench Cross-Sections

BRIGHTWATER FACILITIES PLAN



T1 VARIATION



T2 VARIATION

NO.	REVISIONS	DATE	BY

DESIGNED M. DEBOER
DRAWN K. TAYLOR
CHECKED
APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
SCALE 1" = 10'
DATE JULY 2002

DRAFT

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

PROJECT NAME
KING COUNTY
BRIGHTWATER MARINE OUTFALL
CONCEPTUAL DESIGN ALTERNATIVES
JOB NO. 555-1521-045 FILE: 15214602AF4-2

FIGURE 4-3
TUNNEL VARIATION SCHEMATIC

SHEET NO.

DATE: 08/13/03

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Figure D-3

Tunnel Variation Schematic

BRIGHTWATER FACILITIES PLAN

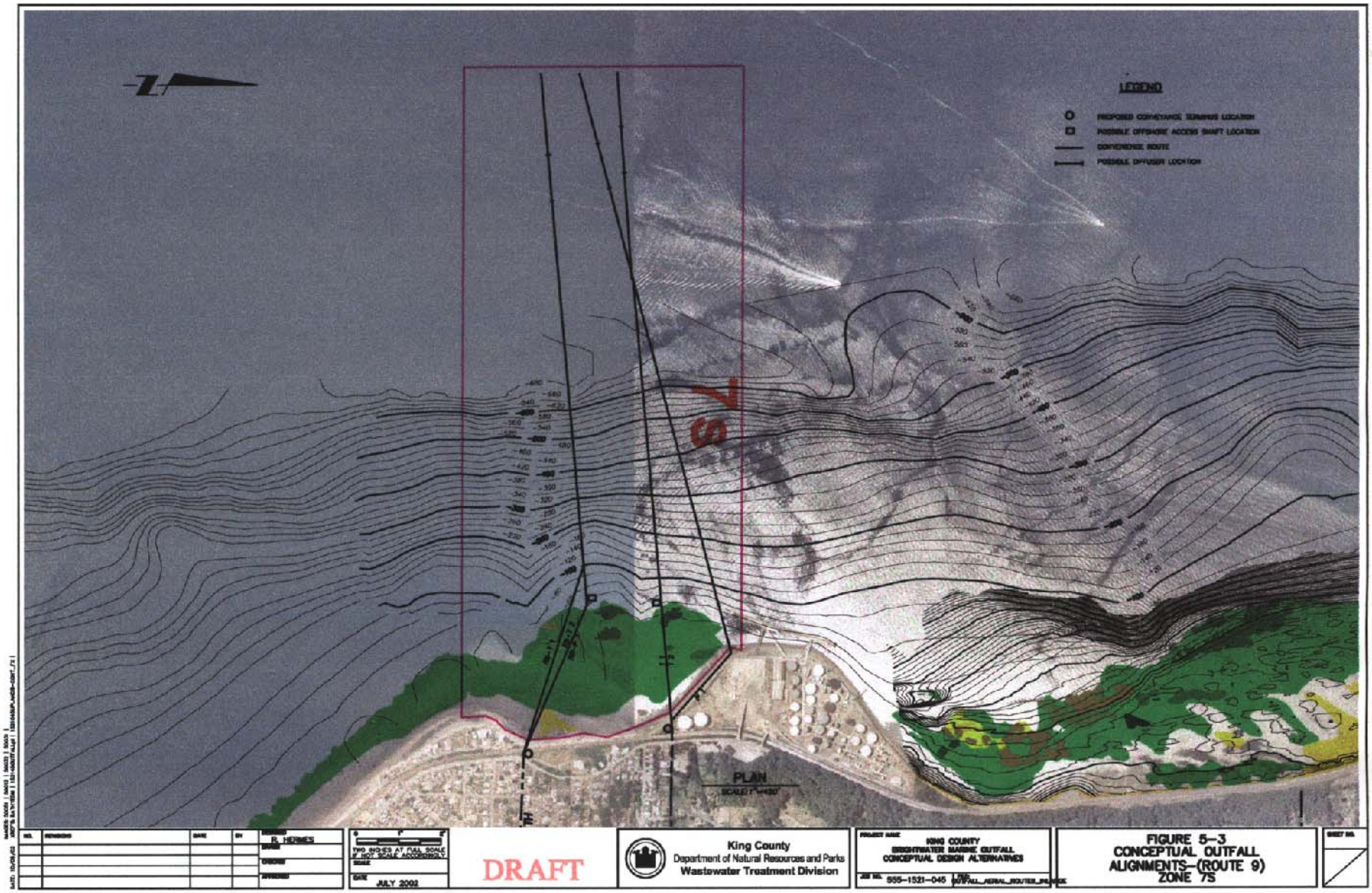

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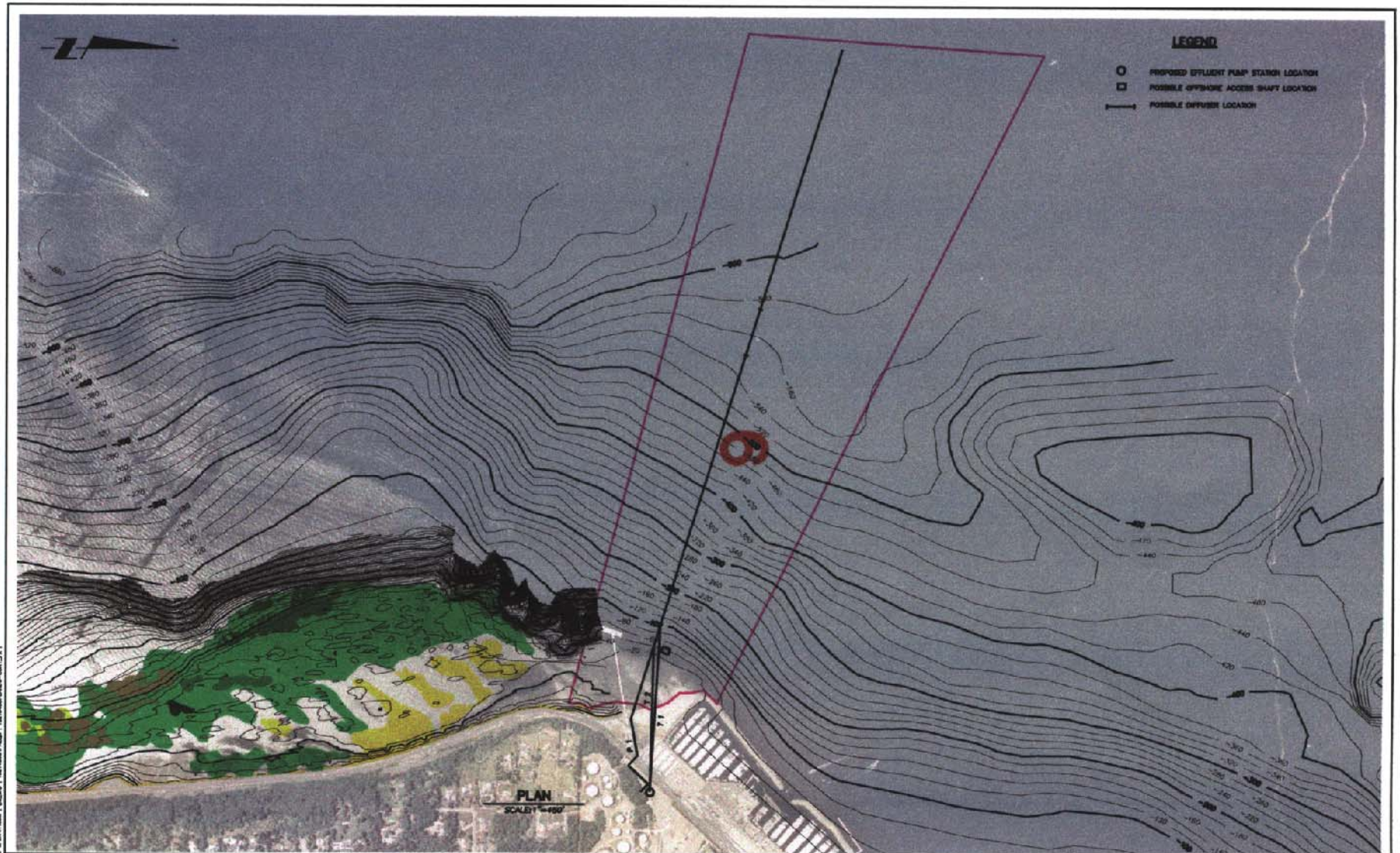
Figure D-4

Conceptual Outfall Alignments
Route 9 - Zone 7S

BRIGHTWATER FACILITIES PLAN



NO.	REVISIONS	DATE	BY

DRAWN: D. HERMES
CHECKED:
APPROVED:

TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
SCALE
DATE: JULY 2002

DRAFT

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

PROJECT NAME: KING COUNTY BRIGHTWATER MARINE OUTFALL CONCEPTUAL DESIGN ALTERNATIVES
JOB NO. 555-1521-045

FIGURE 5-4
CONCEPTUAL OUTFALL ALIGNMENTS-(UNOCAL) ZONE 6

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Figure D-5

Conceptual Outfall Alignments
Unocal - Zone 6

BRIGHTWATER FACILITIES PLAN

Appendix E

Brightwater Predesign

Technical Memorandum

Disinfection Process Evaluation

To:	Stan Hummel, King County
From:	Steve Krugel, Brown and Caldwell Bill Persich, Brown and Caldwell Dave Murray, Brown and Caldwell
Cc:	Dave Evans, CH2M-HILL
Date:	Prepared: February 4, 2003 Revised: April 11, 2003
Subject:	Brightwater Predesign Phase I Task1.03.05.07 Disinfection Process Evaluation

Note: This Technical Memorandum has been superceded by Appendix 3-K, Treatment Plant Disinfection Alternatives.

Appendix F

Brightwater Predesign Technical Memorandum:

Reclaimed Water Technology Review

Evaluation of Potential Water Reuse Opportunities

To be submitted at later date

Appendix F

Brightwater Predesign Technical Memorandum, Uplands Discharge

TO: Dave Evans, CH2M HILL

FROM: Steve Krugel, Brown and Caldwell
Justin Twenter, Brown and Caldwell
Mike Milne, Brown and Caldwell
Ken Trotman, CH2M HILL

CC: Stan Hummel, King County

DATE: January 22, 2003

SUBJECT: Brightwater Predesign Phase 1
Task 165: Upland Discharge Evaluation - Stream Flow Augmentation Feasibility

---

INTRODUCTION

The objective of Subtask 1.16.05 within the Brightwater Treatment Plant Scope of Work, Task 1.16 is to evaluate long-term effluent flow management strategies other than marine discharge that *could potentially eliminate the need for the effluent outfall to Puget Sound*. The Washington State Department of Natural Resources requires applicants for lease of state bottomlands for marine outfalls to evaluate potential options to a marine outfall. To fulfill this requirement, King County is evaluating four alternative effluent flow management strategies:

- Use of reclaimed water for irrigation and industrial processes
- Discharge of highly treated effluent into Lake Washington (to create opportunities for additional withdrawals from the Lake)
- Groundwater injection
- Stream flow augmentation

Potential use of reclaimed water for irrigation and industrial processes and potential discharges to Lake Washington were addressed in two recent studies, which are summarized below.

Potential Irrigation and Industrial Uses

The potential use of reclaimed water for irrigation and industrial purposes was addressed in a September 10, 2002 technical memorandum entitled "Brightwater Predesign Phase I, Task 1.06.01 and 1.06.02: Identify Reclaimed Use Opportunities and Evaluate Short-Term Sites," from Bill Persich (Brown and Caldwell) to Stan Hummel (King County). Potential short-term and long-term reclaimed water application sites were identified within a radius of approximately five miles from the Route 9 and the Unocal treatment plant sites. Potential application sites for the beneficial, direct, non-potable use of Class A reclaimed water were identified for irrigation of landscaped areas (e.g., parks, commercial nurseries, golf courses, cemeteries, and agricultural operations). No potential industrial uses were identified.

For the Route 9 site, the study identified potential landscape irrigation opportunities (primarily golf courses and cemeteries) with a total peak day reclaimed water demand of approximately 10.9 mgd, and potential agricultural opportunities with a total peak day reclaimed water demand of 35.3 mgd. Thus, the total potential peak day demand could be as high as 46.2 mgd. However, it may be difficult to attain the peak potential agricultural demand because this would require development of new agricultural operations where none currently exist. It should be noted that the evaluation did not include in-depth analyses or a survey of potential customers for reclaimed water. The project team is now conducting additional evaluations to refine the potential reclaimed water application opportunities identified in the September 2002 memorandum.

Potential Discharge to Lake Washington

Potential discharge to Lake Washington was addressed in "Indirect Potable Reuse of Reclaimed Water at Lake Washington from the Route 9 Site," (CH2M HILL, November 2002). This study evaluated the potential to treat and discharge highly treated effluent to Lake Washington, which could create opportunities for additional withdrawals from the Lake. In addition, discharging to Lake Washington instead of Puget Sound would reduce the length of the effluent conveyance system. The November 2002 study identified two alternative tertiary treatment process trains that would produce a highly treated effluent or reclaimed water:

- Microfiltration and reverse osmosis
- Ballasted coagulation and microfiltration

Microfiltration and reverse osmosis would provide reclaimed water similar to drinking water, while ballasted coagulation and microfiltration would provide slightly lower

quality reclaimed water. Both alternatives would also include year round nutrient removal and effluent cooling.

It should be noted that the State of Washington has not established specific standards for discharge of reclaimed water to a fresh water body. King County would need to negotiate specific treatment and discharge requirements with the Washington State Department of Ecology. The treatment process trains summarized above might need to be revised in order to meet the negotiated permit requirements.

GROUNDWATER INJECTION AND STREAM FLOW AUGMENTATION

This present memorandum summarizes our preliminary evaluation as to whether groundwater injection or stream flow augmentation appears to be a viable alternative to a marine outfall. It is intended to complement the recent studies summarized above and fulfill the requirements of Subtask 1.16.05 within the Brightwater Treatment Plant Scope of Work.

GROUNDWATER INJECTION

Preliminary evaluation of the technical feasibility of artificially recharging all the Brightwater treated effluent through recharge wells was conducted to provide the basis for this analysis. The evaluation was conducted assuming an average wastewater volume of 54 mgd and a peak daily flow of 170 mgd.

Two hydrogeologic units located in the vicinity of the Brightwater facility were considered: 1) the Vashon recessional outwash; and 2) the Vashon advance outwash (referred to locally as the Cross Valley Sole Source Aquifer or regionally as the Esperance Sand). Aquifer characteristics of the Cross Valley Aquifer were obtained from the *Cross Valley Sole Source Aquifer Wellhead Protection Plan* (Golder Associates Inc., 2000). Both aquifers are sources of drinking water supply. Note: Deeper aquifers were not considered for this preliminary order-of-magnitude feasibility study, however the same limitations would apply and the potentially lower permeability of the deeper zones would increase costs.

The recharge of treated effluent into the recessional outwash geologic unit (i.e., unit closest to the ground surface) does not appear to be feasible. The recessional outwash generally consists of localized deposits of sand and gravel overlying the Vashon till. These deposits are relatively thin (typically 40 feet thick), discontinuous, and due to their limited extent, have limited storage capacity. If underlain by glacial till, deeper vertical groundwater movement is limited, resulting in shallow perched groundwater zones within the unit. Recharge of effluent into these isolated recessional outwash deposits would

likely result in significant groundwater mounding with rapid radial flow away from the recharge well; this would result in substantial groundwater discharge along the perimeter of the deposits at ground surface.

There are some areas in the project vicinity where the low-permeability till is absent and the recessional outwash directly overlies the advance outwash (Golder, 2000). These areas could be incorporated as a component of an advance outwash recharge program; however, it is unlikely that the recessional outwash deposits in these areas have the permeability or storage capacity to handle the entire disposal amount.

Injecting 170 mgd (or 54 mgd if storage is built) into the advance outwash is technically feasible. However it would require numerous recharge wells, as discussed below.

The number of recharge wells necessary to inject 170 mgd, or approximately 118,000 gallons per minute (gpm), was estimated assuming the Cross Valley Water District (CVWD) production well characteristics are "typical" of the proposed injection well network. This assumption likely results in a "best case" scenario because the wells were probably sited in the most productive zones of the aquifer; aquifer yields may not be as high in other areas. A more detailed assessment of the advance outwash hydrogeologic characteristics would be needed to refine the injection properties.

The yield of the CVWD production wells ranges from 40 (gpm) to 900 gpm (Golder, 2000); the average yield is approximately 400 gpm. The CVWD production wells are generally 200 to 300 feet deep. For injection purposes, it was assumed that the effluent can be recharged at approximately two-thirds the average recovery rate (approximately 250 gpm); this was done to account for O&M considerations and the likelihood that many wells will not be placed in the more transmissive portions of the aquifer.

Based on these assumptions, about 500 wells, each with a recharge rate of 250 gpm, would be needed to recharge the peak effluent discharge at full build-out (170 mgd peak flow). Approximately 150 wells would be needed to recharge the average wet weather effluent discharge (54 mgd); however, in addition to the wells, this option would require sufficient storage to handle higher flows.

Storage Requirements for Groundwater Injection

The requisite storage volume was estimated based on King County's wastewater model, which simulated 50 years of daily flows from Brightwater at full build-out (Phase 2). Figure 1 shows the maximum estimated storage volume in each year of the 50-year simulation period. Based on this analysis, roughly 2,500 acre feet (about 800-million gallons) of storage would be required to handle the largest flow event during the 50-year simulation period.

Due to the limited transmissivity of the Esperance sand, the recharge wells would need to be widely spaced (on the order of several hundreds to several thousands of feet) in order

to minimize well interferences and control groundwater mounding. This would result in a very large array of recharge wells necessitating many miles of transmission pipeline. Determining the optimum well spacing would require detailed studies to assess the presence of till, aquifer geometry/properties, the presence of springs, the presence of stream channels cutting into the advance outwash deposits, and the location of wellhead protection zones for CVWD production wells.

The treated effluent must meet Drinking Water Quality Standards (WAC 173-200) in order to be recharged into these potable aquifers. This would likely require reverse osmosis treatment. The TSS should be treated to the 1-2 ppm range to minimize recharge well clogging and lengthen the time between well backflushings and redevelopment.

An Underground Injection Permit must be obtained (WAC 173-218). If the water is to be stored and recovered later (Aquifer Storage and Recovery—ASR), then a Reservoir Permit (and other related permits associated with WAC 173-157) must be obtained. If the water is to be recovered via ASR, then a valid water right to the recharged water must be obtained.

Planning-Level Costs for Groundwater Injection

Direct groundwater injection of Phase 2 flows (170 mgd peak) without storage would cost on the order of $330 million, plus land, treatment, and operation and maintenance costs. Operation and maintenance costs are likely to be substantial. Groundwater injection with storage may cost on the order of $800 million plus land, treatment, and operation and maintenance costs. These planning-level estimates include:

- 8.6% state sales tax
- 10% for survey & design
- 5% for permitting
- 5% for construction administration
- 30% for contingencies

As noted above, treatment to drinking water standards would probably be required, which would probably entail reverse osmosis. URS' March 22, 2002 memorandum indicated that reverse osmosis for Phase 1 (130 mgd peak flow) would increase the costs for the Brightwater treatment plant by roughly $800 million. The peak flow rate for Phase 2 (170 mgd) is about 1.3 times the Phase 1 peak flow; thus, reverse osmosis for Phase 2 would cost roughly $1,040 million ($800 million * 1.3), based on URS' Phase 1 estimate.

The effluent conveyance tunnel and marine outfall would not be needed if all effluent from Brightwater is disposed of via groundwater injection. URS' March 22, 2002 memorandum indicated that the tunnel and marine outfall would cost roughly $450 million.

STREAM FLOW AUGMENTATION

The stream flow augmentation assessment focused on the three stream basins in the vicinity of the proposed Route 9 treatment plant site: North Creek, Swamp Creek, and Little Bear Creek.

The first step in the evaluation was to estimate the amount of flow that could be added to these creeks without causing adverse impacts. Channel erosion is a pervasive problem in the Puget Sound Lowlands, particularly in urbanized areas with altered hydrologic regimes. Creation of impervious surfaces and construction of efficient stormwater collection and conveyance systems have resulted in higher peak flow rates and more frequent channel-forming flows. Channel erosion has been observed at various locations along North, Swamp, and Little Bear Creeks (King County 2001).

The Department of Ecology has adopted 50% of the 2-year pre-developed (forested conditions) flow rate as an approximate threshold for streambank erosion. Thus, to minimize potential channel erosion problems, treated effluent from Brightwater should not be discharged at rates that would cause the receiving streams to exceed this flow rate.

Ideally, the appropriate reuse quantities should be estimated by comparing existing stream flow against 50% of the 2 year peak flow in the streams in the general vicinity of the treatment plant site. However, detailed, continuous simulation using HSPF or a similar hydrologic model would be required to develop reliable estimates of the 2-year flow rates under pre-developed, forested conditions.

A simplified modeling approach was used to develop rough estimates of the 2-year flows under forested conditions in the North, Swamp, and Little Bear Creek basins.

King County's Runoff Time Series (KCRTS) model and Ecology's Western Washington Hydrologic Model (WWHM) were used to simulate flows under current and pre-developed (i.e., forested) conditions. These models use regional input parameters that generalize the runoff characteristics based on soil type and land cover. Fifty years of precipitation records (1948-1998) were run through the model to produce a 50-year time series of basin runoff. Basin-specific land cover and soils data were used for the existing condition simulations. The land use was then changed to 100% forested to simulate the pre-developed conditions over the same 50-year period.

The threshold for stream flow augmentation was estimated for each creek based on 50% of the 2-year pre-developed flow, which is Ecology's general criterion for avoiding streambank erosion. This flow rate was then compared to the daily flows for each creek to estimate the available capacity to accept Brightwater flows without causing streambank erosion.

The simulated daily Brightwater discharges were then compared to the daily creek capacities in order to estimate the storage volume that would be required to discharge all

of the Brightwater flows without exceeding the streambank erosion threshold flow rate. All three creeks were combined for the final storage estimation.

The necessary model inputs, mainly land cover and soils data, were collected for each basin from previously published technical reports of Cooper (1996) and May (1997). These data sources provided the model inputs for both developed and pre-developed (forested) conditions. Table F-1 shows the model inputs used for this analysis.

Table F-1. Hydrologic Model Inputs for Analysis of Stream Flow Augmentation Feasibility in the Northern Lake Washington Watershed

North Lake Washington Drainage Basins Land Cover and Soils Data						
	Little Bear Creek		***North Creek***		***Swamp Creek***	
		Acres		**Acres**		**Acres**
Basin area (km^2)[1]		29		71.5		59.2
Basin area (acres)[1]		7,166		17,668		14,629
TIA (%)[1]	8.3%	595	26.3%		31.5%	4,608
EIA (%)[1]	5.4%	387	21.1%	3,728	25.8%	3,774
% Till[1]	78.0%		78.0%		78.0%	
Undeveloped Forest[2]	43.0%	3,081	28.0%	4,947	22.0%	3,218
Developed Open[2]	12.0%	860	8.0%	1,413	11.0%	1,609
LD Residential[2]	32.0%	2,293	18.0%	3,180	13.0%	1,902
MD Residential[2]	6.0%	430	26.0%	4,594	29.0%	4,242
HD Residential[2]	0.0%	0	9.0%	1,590	13.0%	1,902
Commercial/Industrial[2]	7.0%	502	11.0%	1,943	12.0%	1,755
Total Developed[2]	57.0%	4,085	72.0%	12,721	78.0%	11,410
Modeled Developed[2]		3,698		8,993		7,636

[1] From "Hydrologic Effects of Urbanization on Puget Sound Lowland Streams" by Catherine Cooper, 1996, University of Washington Masters Thesis.

[2] From "Quality Indices for Urbanization Effects in Puget Sound Lowland Streams" by C.W. May et al., 1997, Water Resources Series Technical Report No. 154.

Peak annual series analysis was conducted on the model output for both pre-developed (100% forested) and developed conditions to estimate the 2-year flow.

Storage Requirements for Stream Flow Augmentation

The WWHM was used for the stream flow augmentation analysis. Precipitation records for 1948 through 1998 were run through the WWHM to produce a 50-year time series of basin runoff. The results are summarized in Table F-2.

Table F-2. Western Washington Hydrologic Model Simulation Results for North, Swamp, and Little Bear Creeks

Creek	Current Conditions 2-year Flow (cfs)	Forested Conditions 2-year Flow (cfs)	Streambank Erosion Threshold (50% of Forested 2-year Flow)
North	1,096	244	122
Swamp	1,044	202	101
Little Bear	238	99	49

The KCRTS model was run to check the results of the WWHM. The KCRTS model produced 2-year flow estimates similar to the WWHM (within 4 to 10%).

As noted above, the estimated streambank erosion threshold for each creek was then compared to the simulated (existing conditions) daily creek flows in order to estimate how much Brightwater effluent could be safely discharged to the creeks. The available daily creek capacities were then compared to the corresponding estimated daily Brightwater flows derived from King County's wastewater flow model in order to estimate storage requirements. (The King County model used the same 50-year precipitation time series to estimate daily flows from the new Brightwater facility at full build-out.) A spreadsheet was used to determine the maximum storage requirement for the 50-year simulation period.

Figures 2, 3, and 4 show the modeling results and storage estimates for North Creek, Swamp Creek, and Little Bear Creek, respectively, during a fairly typical water year. As shown in Figure 4, our preliminary analysis indicated that Little Bear Creek rarely had sufficient capacity to accept even the average Brightwater effluent flow rate without exceeding the streambank erosion criterion. Thus, discharge of all Brightwater effluent to Little Bear Creek does not appear to be feasible.

Figures 5 through 7 show the maximum storage volumes that would have been required if the projected Brightwater effluent flows at full build-out (Phase 2, 170 mgd peak flow rate) had been used to augment flows in North Creek, Swamp Creek, and all Creeks combined during 1948 through 1998.

Table F-3 summarizes the estimated storage volumes for three stream flow augmentation scenarios. As shown in Table F-3, roughly 1,000 to 3,500 million gallons of effluent storage would be required to avoid exceeding the streambank erosion thresholds in North, Swamp, and/or Little Bear Creeks.

Table F-3. Estimated Effluent Storage Volumes[1]

Stream Flow Augmentation Scenario	Max. Storage Volume (MG)
Discharge All Effluent to North Creek	2,150
Discharge All Effluent to Swamp Creek	3,500
Discharge to All Three Creeks	1,000

[1] Based on estimated daily Brightwater flows at full build-out, assuming 1948-98 daily precipitation

Conveyance Requirements

Brightwater effluent could be discharged into the creeks either directly via surface conveyances or indirectly via infiltration into shallow aquifers that discharge into the creeks. The latter option does not appear to be a viable means for disposing of all of the Brightwater flows, however. As noted in Section 2 above, the surficial materials in the project area are thin and discontinuous, with limited storage capacity. Infiltration of large volumes of Brightwater effluent into this material would likely cause groundwater mounding and flooding problems in some areas. While it may be possible to use infiltration on a limited basis where local conditions allow, it does not appear to be a feasible means for handling the entire projected flow from Brightwater.

Stream flow augmentation via surface conveyance would be possible. However, discharge at discrete points could cause channel erosion and other adverse impacts to the creeks. To minimize this problem, linear wetlands with numerous small outlets (e.g., a permeable gravel embankment) could be constructed adjacent to each creek. The wetlands would also provide some water quality “polishing” and habitat benefits.

Treatment Requirements

The NPDES permit for the Brightwater facility would specify the effluent limitations that the effluent must meet prior to discharge to the creeks. Given the large volume of Brightwater flow relative to flow in the creeks, mixing zones may not be allowed. Thus, the Brightwater effluent may need to meet state water quality standards prior to discharge. At a minimum, the effluent would probably require cooling and phosphorus removal in addition to the proposed MBR treatment.

Planning-Level Costs for Stream Flow Augmentation

The preliminary modeling indicates that a large volume of storage (~1,000 MG) would be required to augment stream flow in North, Swamp, and Little Bear Creeks without causing channel erosion. Providing the requisite storage volume in open impoundments

and conveyance system would cost on the order of $325 million, not including land and operation and maintenance costs. This planning-level estimate includes:

- 8.6% state sales tax
- 10% for survey & design
- 5% for permitting
- 5% for construction administration
- 30% for contingencies

Given the large volume of storage required (approximately 1,000 MG or 3,000 acre feet), land costs may be substantial.

Based on URS' March 2002 memorandum, advanced treatment for effluent cooling and phosphorus removal for full build-out (Phase 2, 170 mgd peak flow rate) would increase Brightwater treatment plant costs by approximately $340 million.

The effluent conveyance tunnel and marine outfall would not be needed if all effluent from Brightwater can be disposed of via stream flow augmentation. URS' March 22, 2002 memorandum indicated that the tunnel and marine outfall would cost roughly $450 million.

CONCLUSIONS

1. When compared to the proposed marine outfall the groundwater discharge and stream flow augmentation options are significantly more costly as shown in Table F-4. The groundwater option would cost roughly $920 million more than the proposed marine outfall option, while the stream flow augmentation option would cost roughly $320 million more than the marine discharge option.

2. Groundwater injection in the surficial aquifer does not appear to be technically feasible due to its limited capacity.

3. Groundwater injection in the Cross Valley Aquifer appears to be technically possible. However, it may be economically infeasible due to high costs for storage, treatment, and conveyance. Thus, groundwater injection does not appear to be a practical substitute for a marine outfall.

4. Preliminary modeling indicates that using Brightwater effluent to augment flow in local creeks would require a very large volume of storage in order to avoid adverse impacts on the creeks. The requisite storage would require a substantial amount of land, including extensive riparian areas. In addition, a higher level of treatment may be required to ensure that ambient water quality standards are met prior to discharge. For these reasons, stream flow augmentation to local creeks does not appear to be a practical alternative to a marine outfall.

5. The local streams appear to have the capacity to accept some Brightwater flow without undue risk of streambank erosion. This might be desirable if low summer baseflows are deemed a problem in the nearby creeks. Additional field investigations and analyses would be required if the County decides to pursue this option.

Table F-4. Capital Cost Impacts of Groundwater Injection and Stream Flow Augmentation (Phase 2, 170 mgd Peak Flow)[1]

Cost Item	Capital Costs (Million $)	
	Direct Groundwater Injection[2]	Stream Flow Augmentation
Additional Costs[3]		
Treatment	+1,040	+340
Conveyance, Storage, & Discharge	+330	+325
Subtotal:	+1,370	+665
Reduced Costs[4]		
Effluent Conveyance Tunnel	-415	-415
Marine Outfall	-35	-35
Subtotal:	-450	-450
Net Impact on Capital Cost	**+920**	**+215**

[1] Costs do not include additional land.

[2] Costs for direct injection via 500 wells (assumes no effluent storage needed).

[3] Capital costs for items that would not be required for proposed marine discharge.

[4] Capital costs for items that would not be required for groundwater injection or stream flow.

LIMITATIONS

The evaluations described in this memorandum should be regarded as preliminary and suitable for general planning purposes only. The key limitations are listed below.

Groundwater Injection

- The estimated injection well requirements should be regarded as preliminary. A detailed assessment of the advance outwash hydrogeologic characteristics would be needed to confirm the feasibility of groundwater injection and provide a more reliable estimate of the size, number, and spacing of recharge wells necessary to inject the projected Brightwater flows.

- Determining the optimum well spacing would require detailed studies to assess the presence of till, aquifer geometry/properties, the presence of springs, the

presence of stream channels cutting into the advance outwash deposits, and the location of wellhead protection zones for CVWD production wells.

- Based on the preliminary evaluation, a large array of injection wells would be required to dispose of the projected Brightwater flows. This preliminary evaluation did not include investigation of potential well or pipeline locations. There is no assurance that the requisite land would be available.
- There is no guarantee that the requisite permits for groundwater injection can be acquired.
- The cost estimates are based on numerous assumptions. The estimates do not include potential costs for land acquisition, easements, and operation and maintenance, which are likely to be substantial.

Stream Flow Augmentation

- The recommended basin size for the WWHM is between 0 and 320 acres. The basins modeled for this analysis are considerably larger than this limit; thus the results may be inaccurate because they are outside the inputs are outside the intended range of the model.
- As stated previously, both the WWHM and the KCRTS model are calibrated to regional parameters. This loose calibration could possibly allow error to enter the model results because specific basin conditions are generalized and are not represented in the model.
- No flow routing was performed for this analysis. Lack of flow routing can result in miscalculation of runoff timing and volume. For basins the size of North, Swamp, and Little Bear Creeks, proper routing of flows through the drainage networks is necessary to accurately simulate runoff hydrographs.
- Cooper (1996) included estimates of the 2-year developed flow estimated from her modeling analysis, which provided a point of comparison with current developed model results. Table F-5 displays the results of the current modeling as compared with Cooper (1996).

As shown in Table F-5, the differences between the WWHM and the current KCRTS model are minimal with the KCRTS results consistently larger than the WWHM. Significant discrepancies are evident when comparing the historical work done by Cooper (1996) and the current results. It appears the 2 year flow for Little Bear Creek is relatively the same (less than 10% difference) as that estimated by Cooper (1996), but the North Creek and Swamp Creek results are different by as much as 60%. The Cooper (1996) report did not contain enough information to allow us to determine the cause(s) of the discrepancy in the model results.

Table F-5. Comparison of Modeled 2-Year Flow Estimates

Creek	Developed conditions WWHM (cfs)	Developed conditions KCRTS (cfs)	Developed conditions from Cooper[1] KCRTS model (cfs)
North Creek	1,096	1,195	692
Little Bear Creek	386	402	343
Swamp Creek	1,044	1,156	823

[1] From "Hydrologic Effects of Urbanization on Puget Sound Lowland Streams" by Catherine Cooper, 1996, University of Washington Masters Thesis

- Detailed field investigations and modeling would be required if the County decides to pursue the stream flow augmentation option.

REFERENCES

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King County. 2001. "Habitat Inventory and Assessment of Three Sammamish River Tributaries: North, Swamp, and Little Bear Creeks." Water and Land Resources Division, King County, Washington.

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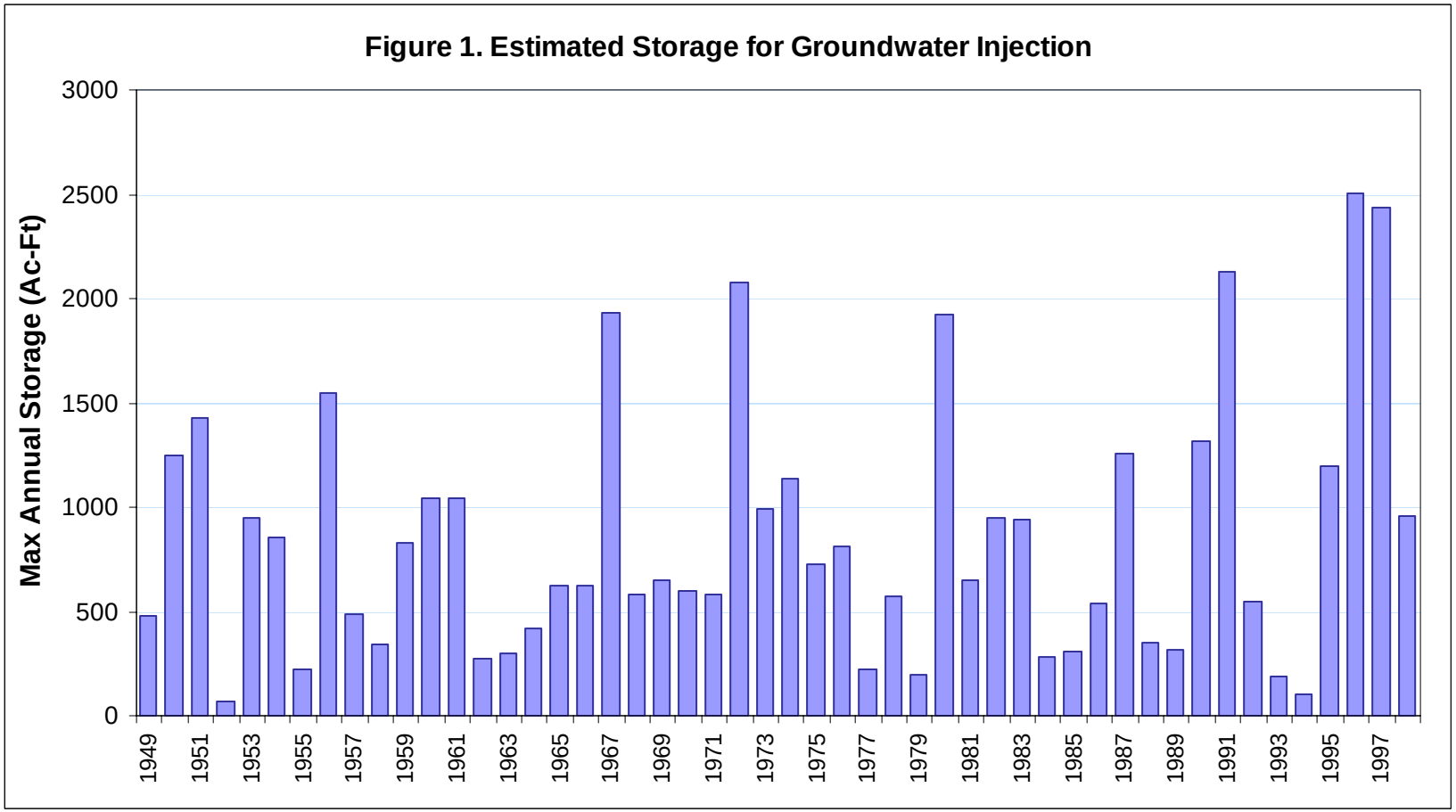


Figure 1. Estimated Storage for Groundwater Injection
Max Annual Storage (Ac-Ft)
3000
2500
2000
1500
1000
500
0
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997

Figure 2. Brightwater Upland Discharge Feasability:
North Creek Flow Augmentation Modeling for 1997 Water Year

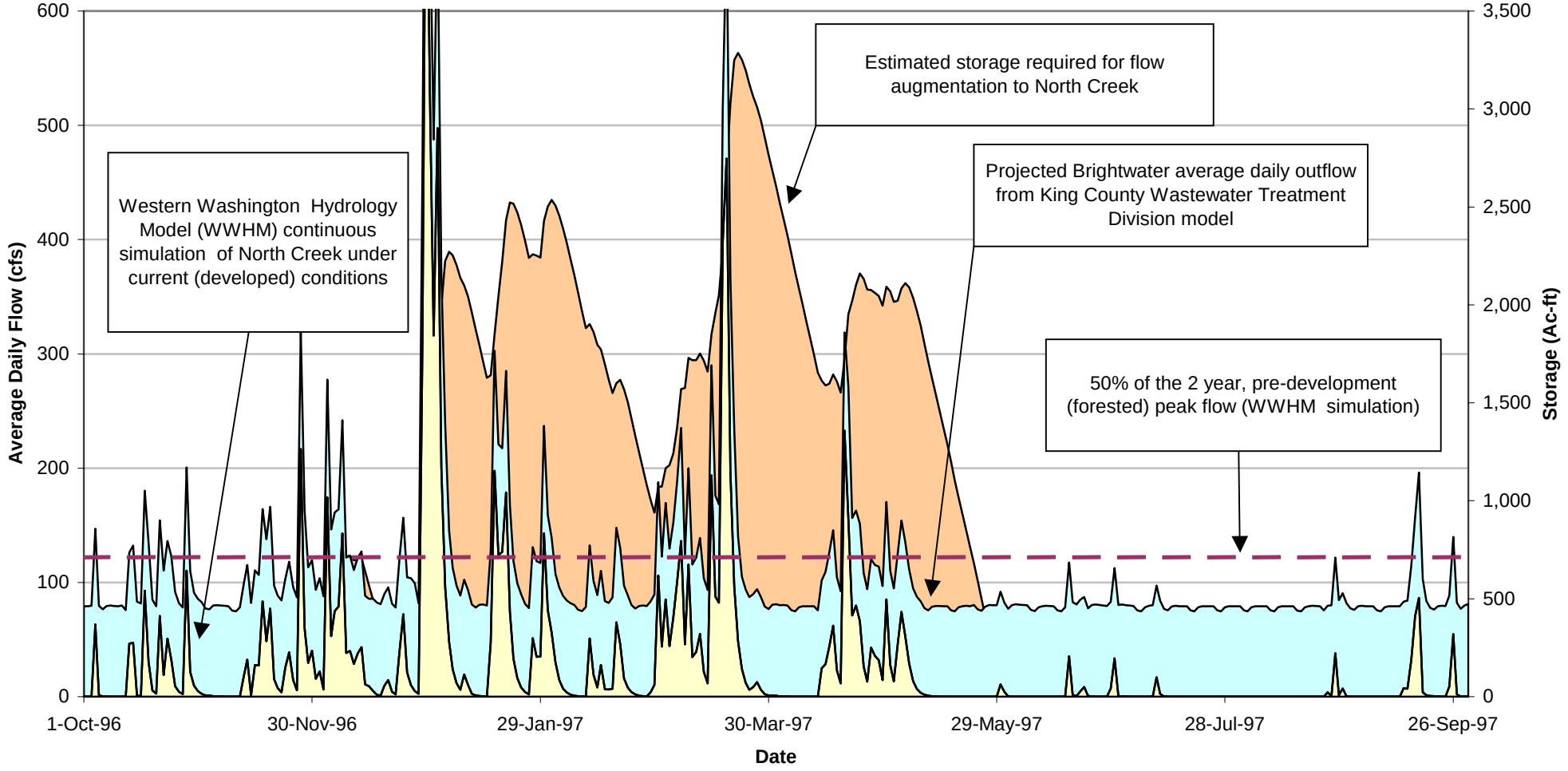


Figure 3. Brightwater Upland Discharge Feasability:
Swamp Creek Flow Augmentation Modeling for 1997 Water Year

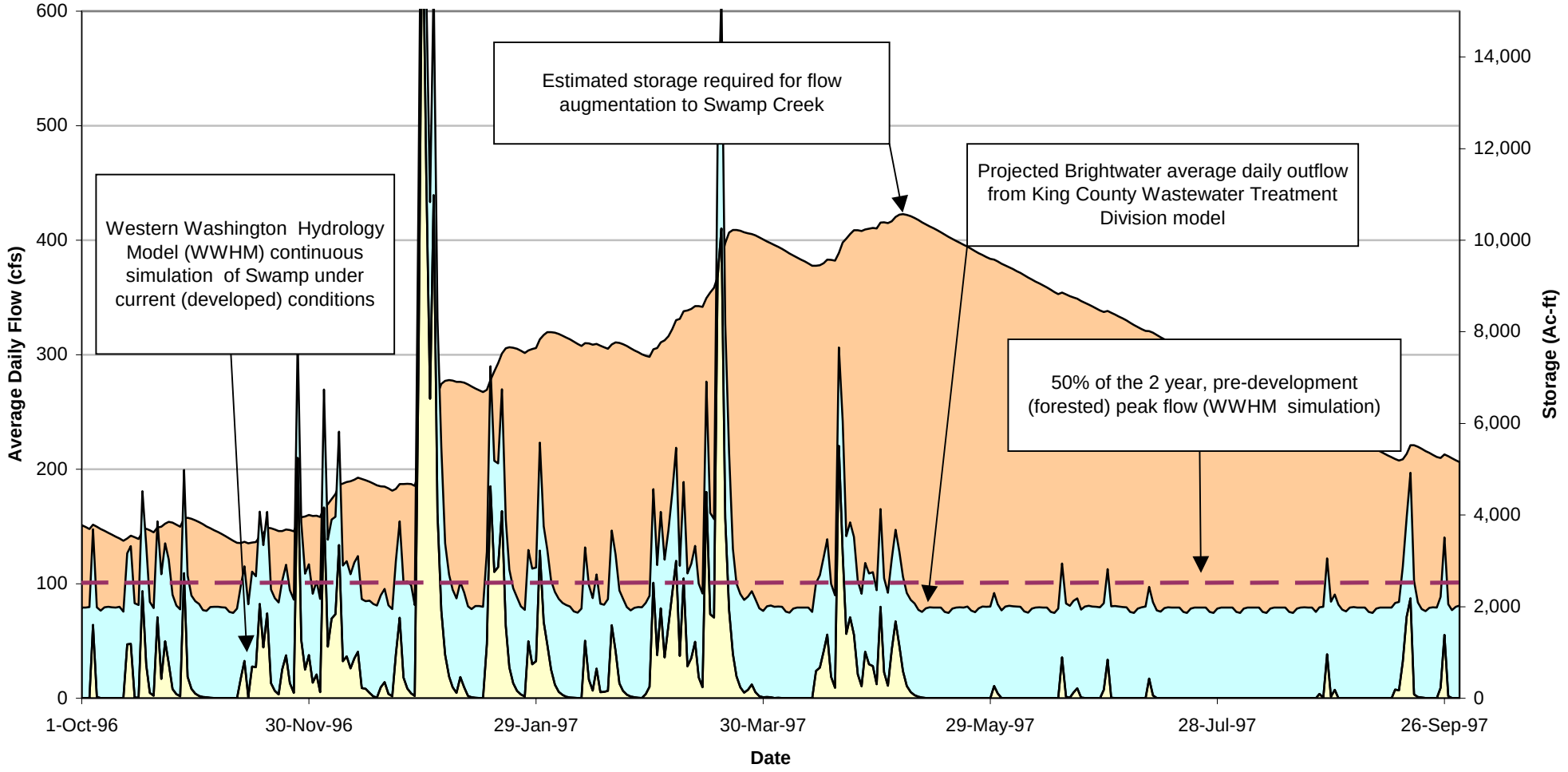


Figure 4. Brightwater Upland Discharge Feasability:
Little Bear Creek Flow Augmentation Modeling for 1997 Water Year

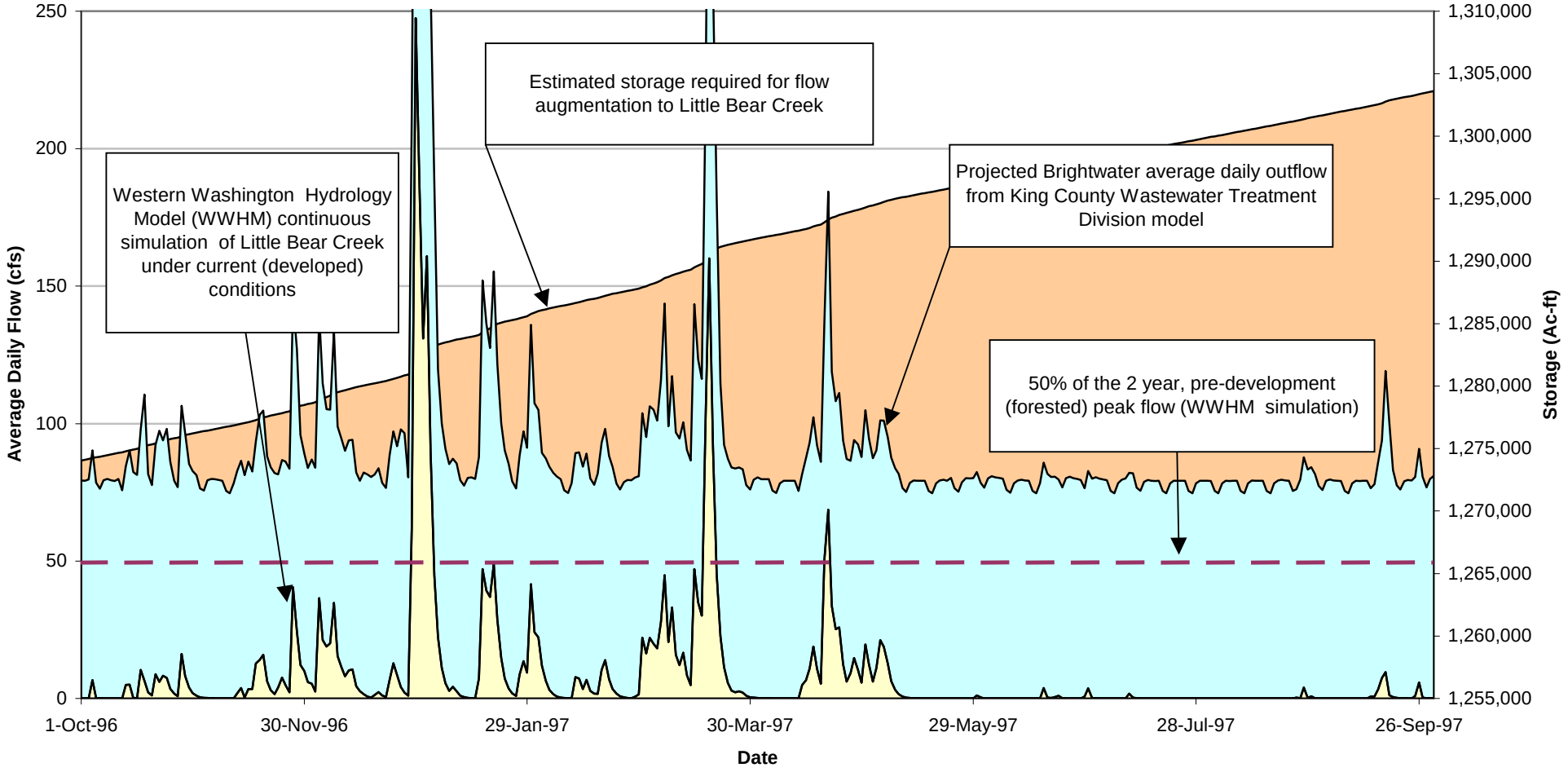
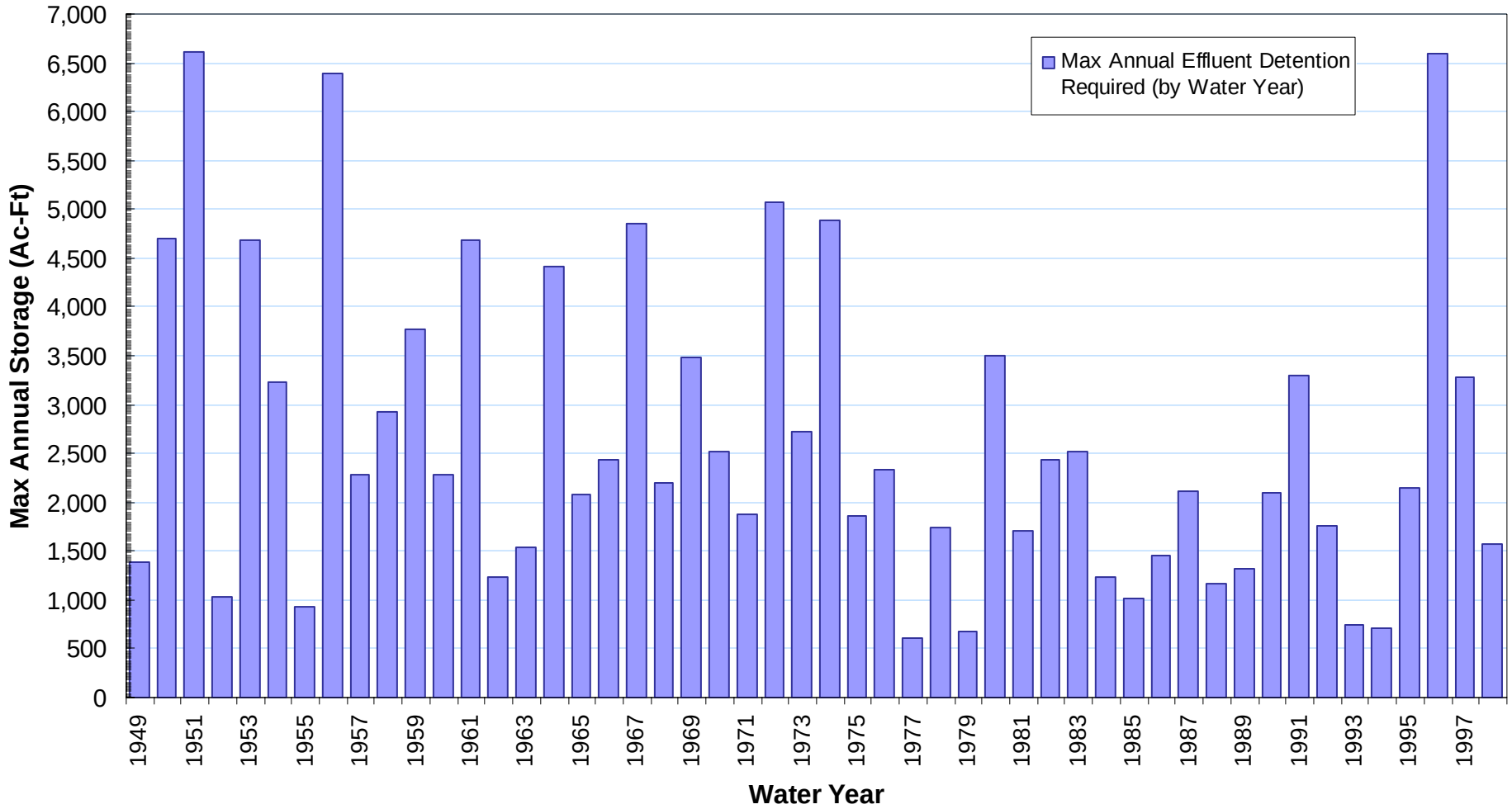


Figure 5. Maximum Annual Effluent Detention Volume for Streamflow Augmentation to North Creek



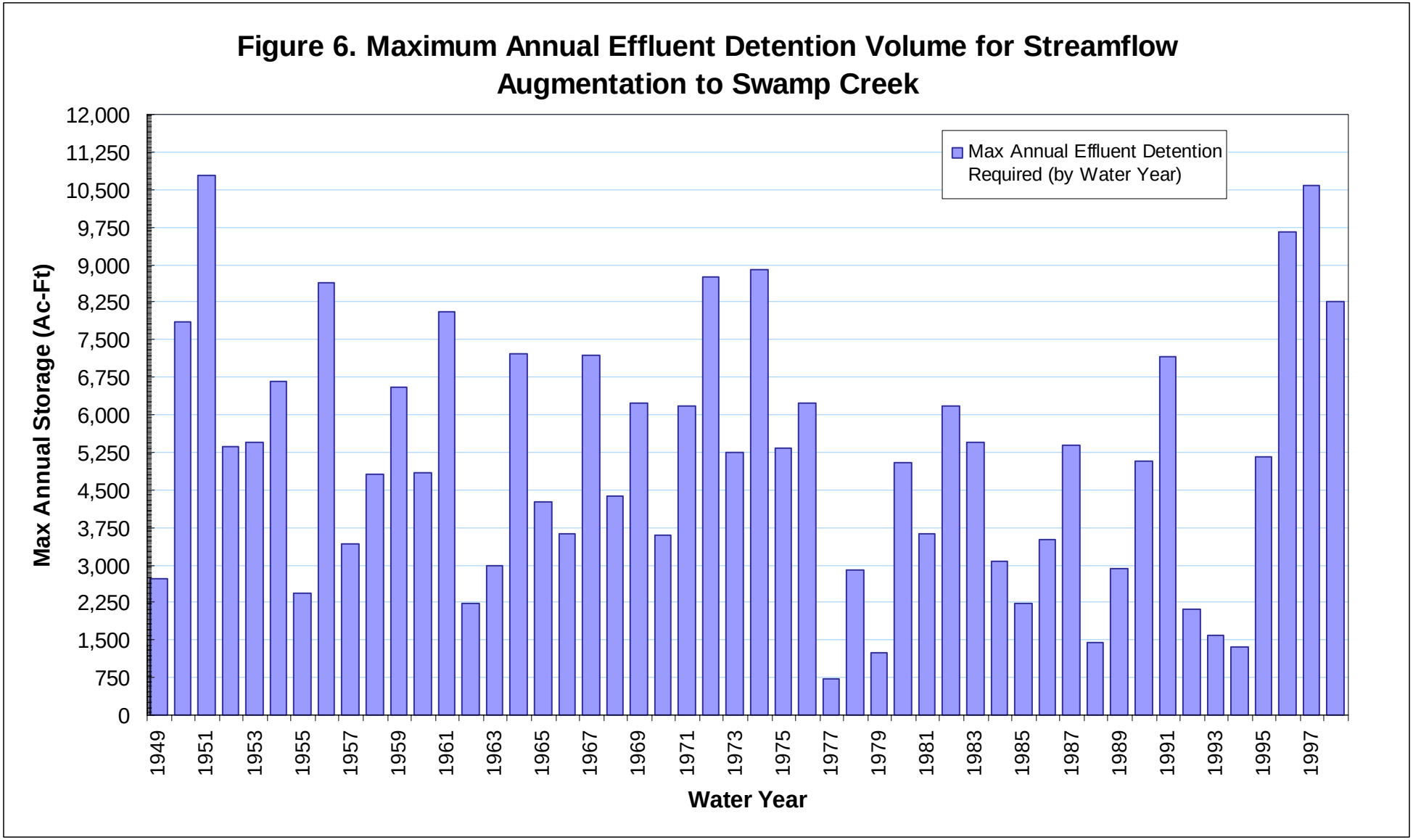
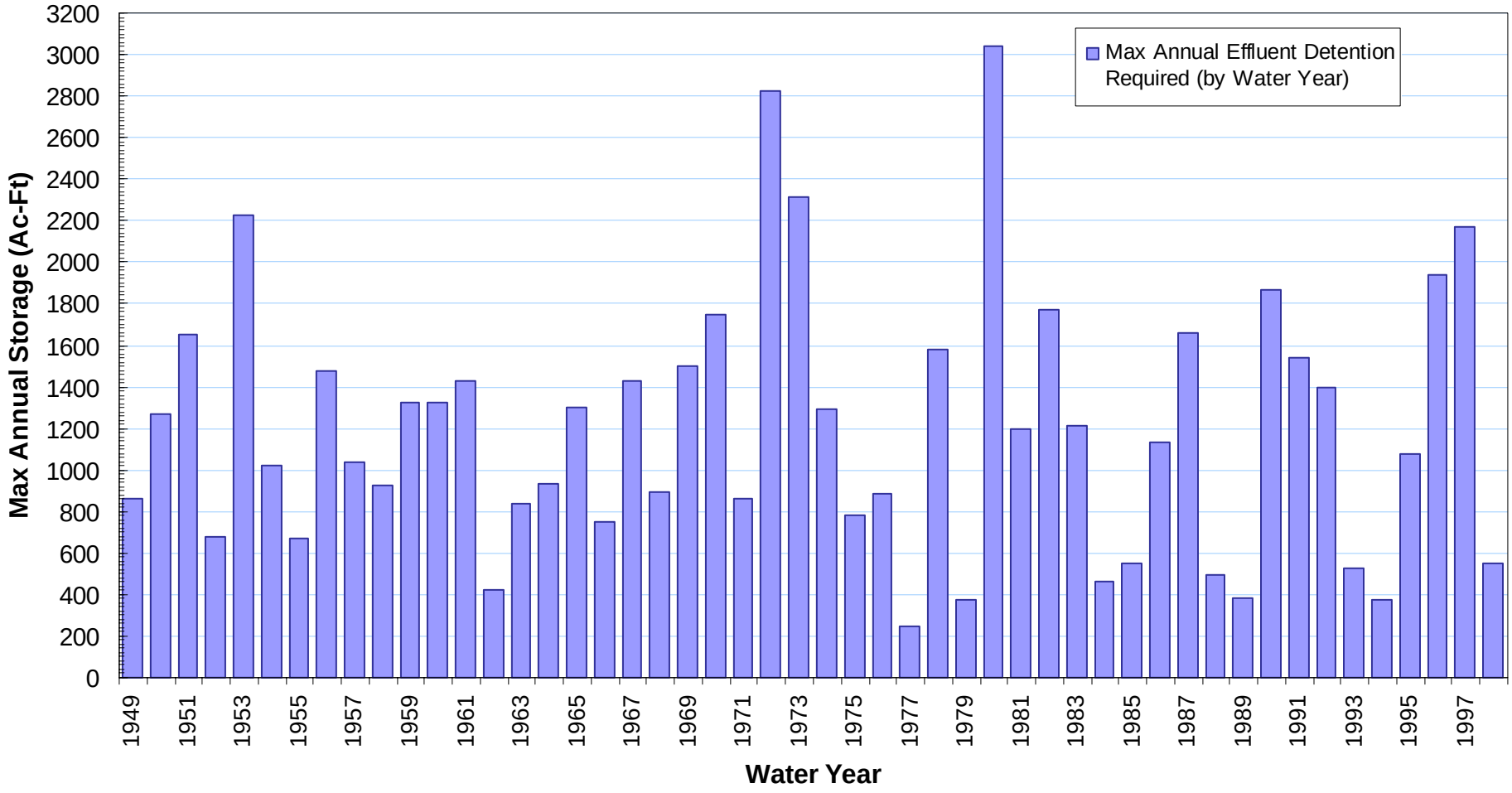


Figure 6. Maximum Annual Effluent Detention Volume for Streamflow Augmentation to Swamp Creek
Max Annual Effluent Detention Required (by Water Year)
Max Annual Storage (Ac-Ft)
12,000
11,250
10,500
9,750
9,000
8,250
7,500
6,750
6,000
5,250
4,500
3,750
3,000
2,250
1,500
750
0
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
Water Year

Figure 7. Maximum Annual Effluent Detention Volume for Streamflow Augmentation to North, Swamp, and Little Bear Creeks



Appendix G
Unit Treatment Process Technology Fact Sheets

This Appendix presents brief summaries of the treatment processes proposed for Brightwater, describing advantages, disadvantages, required support systems, typical design criteria, typical process performance, and technological status. Unit Treatment Process Technology Fact Sheets are presented for the following processes:

- Influent Screen – Climber Type
- Grit Separation – Vortex System
- Grit Separation – Aerated System
- Conventional Primary Clarification
- Ballasted Primary Clarification
- Membrane Bioreactor
- Bulk Sodium Hypochlorite Disinfection
- Ultraviolet Light (UV) Disinfection
- Gravity Belt Thickeners
- Conventional Anaerobic Digestion
- Thermophilic-Mesophilic Anaerobic Digestion
- Centrifuge Dewatering

APPENDIX G

Influent Screen - Climber Type

Process Description

A bar screen is composed of parallel bars or rods and cleaned mechanically by a sliding rake arm. Gear-motor driven cogwheels running on a pin rack are used to lower the rake into the wastewater channel. The rake engages the bar screen from the front side and lifts screenings to a discharge chute. The cross section of the bars can be provided in various shapes, including rectangular, wedge and teardrop. Non-rectangular shapes are designed to reduce wedging of materials between the bars. Typically, the bars are ¼-inch thick and bar spacing is between 9 mm (3/8-inch) and 19 mm (3/4-inch). Bar screens with 6 mm (1/4-inch) bar spacing are available from some manufacturers, but this size tends to have greater potential for misalignment and tooth breakage.

Advantages

- No moving parts or bearings permanently below water
- A simple, strong, and reliable raking mechanism
- All maintenance work can be performed without dewatering the channel
- Rugged design and does not require upstream coarse screening protection

Disadvantages

- Within each cleaning screen cleaning cycle, there is an interval when there is no clean section of screen and the screen can become blinded.
- Odor control is more difficult
- Questionable track record on 6 mm (1/4 inch) opening applications and not applied on smaller screen openings
- High headroom requirements and this adds to the odor control issues

Support Systems

- Screenings processing system

Design Loading Criteria

Velocity through the screen opening of 2 ft/second

Process Performance

Good reliable performance except with heavy loadings when screen can become blinded. Example; CSO application and first fall storm with a lot of leaves in the wastewater

Technology Status and Implementation

Established. One of the more widely used systems in the world. Many large treatment plants in North America: Seattle, WA West Point.; Minneapolis- St. Paul, MN Metro Plant (new installation 1/2 inch screen opening)

APPENDIX G

Grit Separation - Vortex System

Process Description

A low headloss vortex system where screened raw wastewater, in a non-turbulent flow regime, is introduced into a small diameter (less than 25 feet) circular basin. The tangential flow introduction aided by slow speed mechanical impeller develops a low velocity vortex flow pattern with in the basin. The heavier grit particles are collected on the basin floor and then migrate to the center of the basin where they drop into a deeper sump section and are pumped to a grit separation process.

Multiple basins are required for flows above 75 mgd.

Advantages

- Low headloss
- No submerged chain and flight system
- No submerged bearings
- Good performance for a 2:1 flow range
- Small foot print
- Low odor emissions
- No accumulation of scum
- Low energy requirements

Disadvantages

- Below grade pump gallery for grit slurry pumps
- Complex basin construction
- Feed channel length and influent velocity (2 feet per second) requirements
- Some systems have experienced plugging of the grit sump section due to inadequately screened wastewater or inadequate grit slurry pumping capacity

Support Systems

- Grit slurry pumping system
- Odorous air collection system
- Plant air system for assisting organic separation in grit sump section
- Effective debris removal by influent screening systems

Design Loading Criteria (values in parentheses denote ranges for low to high rate systems)

Influent velocities of 2 - 3 feet per second

Diameter by manufacturer but 24 foot diameter is rated for 75 mgd by one manufacturer.

Process Performance

65% removal of 0.15 mm

85% removal of 0.24 mm

95 % removal of 0.30 mm

Technology Status and Implementation

Established. One of the more widely used systems in the world.
Milwaukee MSD Jones Island WWTP
Boston - Deer Island on primary sludge
Alexandria, Virginia

APPENDIX G

Grit Separation - Aerated System

Process Description

Aerated grit chamber systems remove higher density solids from the wastewater flow stream by the introduction of air along the bottom of one side of the chamber to create a spiral roll velocity pattern perpendicular to the flow through the chamber. The roll velocity keeps the lighter organic material in suspension while allowing the heavier, mostly inorganic materials, to settle to the bottom. The rolling action is flow rate independent and allows the grit chamber to operate effectively over a wide flow range. The spiral flow carries the grit across the tank bottom and into a hopper. Various means are used to convey the grit from the hopper to a bin including chain and bucket collectors, screw augers, and pumps. Aerated grit chambers are characterized by low head loss. Pre-aeration also may alleviate septic conditions in incoming wastewater, improving performance of downstream processes. Over the years, the design has evolved to adjust tank geometry and to add baffling to improve grit removal efficiency.

Advantages

- Low headloss
- Good performance over 3:1 flow range, with appropriate baffling
- Partial aeration of plant influent flow and stripping of foul gases
- Less organic materials in the grit slurry

Disadvantages

- Maintenance of submerged grit removal equipment and/or the large number of grit slurry pumps for effective grit removal in large basins
- Odorous off gases requiring larger odor control system. Also VOC emissions issues.
- Separate low pressure air supply system due to different air pressure requirements than secondary treatment low pressure air systems
- Higher energy requirements
- Larger foot print and more basin construction
- Construction of steep slopes in base of basin to develop girt collection sump(s)

Support Systems

- Grit slurry pumping system
- Low pressure air system
- Odorous air collection system
- Effective debris removal by influent screening systems

Design Loading Criteria (values in parentheses denote ranges)

Detention Time @ peak flow 3 min (2-5 minutes)

Width/depth ration 1.5:1 (1:1-2:1)

Length/width ratio 4:1 (3:1-5:1)

Air supply per foot of length 5 cfm/ft

Process Performance

85 % Removal of .25 mm grit and larger

Less effective on smaller grit.

Technology Status and Implementation

Established. One of the most widely used systems in the world. Many large treatment plants in North America: Seattle, WA -West Point; Cleveland, OH -Southerly, San Diego, CA- Point Loma & NCWRP

APPENDIX G

Conventional Primary Clarification

Process Description

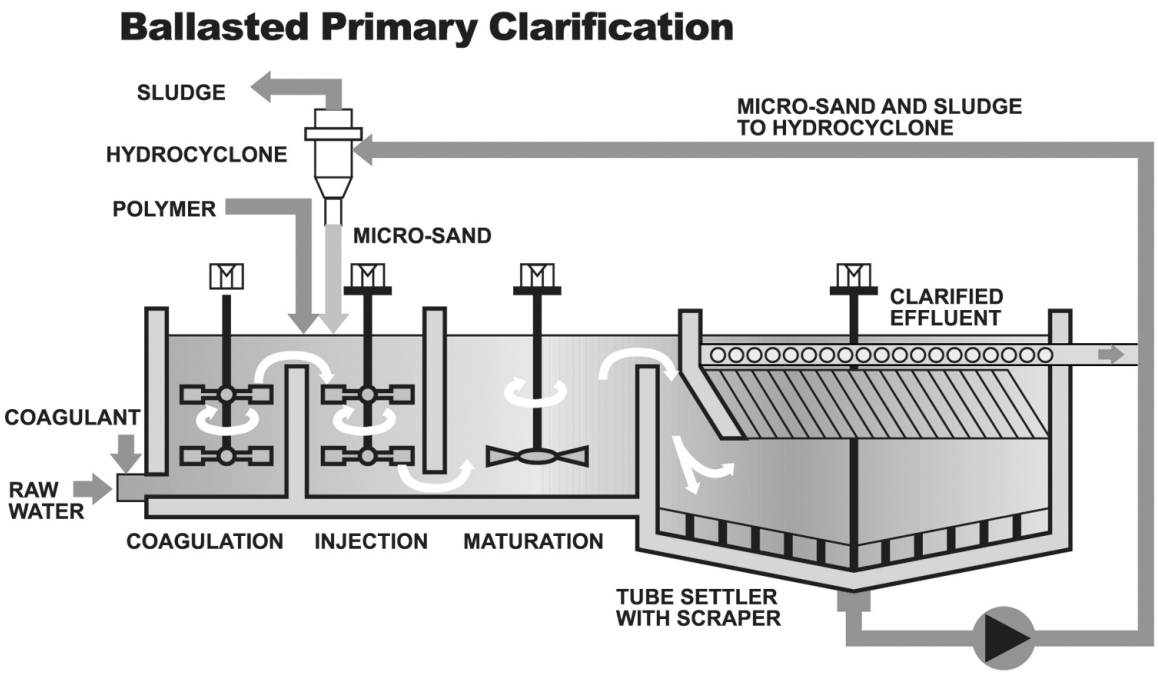
Conventional primary clarification is a settling process that is carried out in a relatively quiescent tank. Primary clarification used to remove settleable solids from degritted sludge. BOD removal is achieved through removal of organic matter associated with the solids. Oil, grease, and other floatable materials are removed through scum skimming mechanisms.

Advantages	Disadvantages
• Modular nature of process makes it readily expandable • Requires no chemical addition. • Insensitive to water chemistry. • Sludge produced is readily stabilized and biodegradable. • Inexpensive method for removing BOD.	• Requires larger footprint than primary processes that use chemical addition. • Achieves lower TSS and BOD removal compared to processes that use chemical addition. • Operation with deep sludge blankets can cause odor emissions.
Design Loading Criteria Peak surface overflow rates 3,000 to 3,500 gpd/ft^2	**Process Performance** BOD removal – 20-30% TSS removal - 40-60%

Technology Status and Implementation

Established. Commonly used in wastewater treatment plants throughout the world, including King County's West Point Treatment Plant and South Plant.

APPENDIX G



Ballasted Primary Clarification

Process Description

Adding chemicals to flocculate colloidal material in influent wastewater will enhance settling properties of primary solids and increase BOD and TSS removal in primary clarifiers. Seeding the influent with ballast to speed up the formation of floc structures further enhances primary clarification; introducing sand particles or returning sludge particles to the influent provides the ballast that act as seeding agents. In both cases, chemicals are added to the influent with rapid mixing and then sand or recycled solids with polymer. Floc maturation occurs under slow mixing conditions before settling occurs in shallow inclined tubes. The whole process occurs in less than 15 minutes. Settled sludge is removed from the bottom of the clarifier and a portion is recycled. If sand is used as the seeding agent, the recycle sludge stream is first passed through a hydrocyclone to recover the sand. Clarifier primary effluent overflows to downstream processes.

Ballast Provided by Recycled Sludge

Advantages

- The increase in settling velocity reduces clarifier HRT and footprint - <70% of conventional primary
- Flexible - by varying chemical dosage, process can respond to wide variation in influent loading
- Modular nature of process makes is readily expandable
- Smaller area reduces potential for odor

Disadvantages

- High continuous chemical addition. Will increase sludge production by >50%
- Process is sensitive to water chemistry and chemical dosage
- High chemical usage may impact sludge stabilization process
- Some chemicals used are hazardous and will need care in handling
- Tube settlers are prone to plugging and tank internals are difficult to access for maintenance

Ballast Provided by Sand

Advantages

- Sand ballast provides particles with highest settling velocity and lowest footprint - <50% of conventional primary clarifiers
- Flexible - by varying chemical dosage, process can respond to wide variation in influent loading

Disadvantages

- Grit removal required to ensure sand particle size distribution is not compromised
- 1-3 % sand loss occurs
- High continuous chemical addition. Will increase sludge production by >50%

Advantages (cont.)	Disadvantages (cont.)
• Modular nature of process makes it readily expandable • Smaller area reduces potential for odor	• Process is sensitive to water chemistry and chemical dosage • High chemical usage may impact sludge stabilization process • Some chemicals used are hazardous and will need care in handling • Tube settlers are prone to plugging and tank internals are difficult to access for maintenance
Design Loading Criteria HRT in rapid mix tank - 1-3 min HRT in maturation tank - 2-5 min Settling tube rise rate - 10-60 gpm/ft^2	**Process Performance** BOD removal - >55% TSS removal - >70%
Technology Status and Implementation Developing. Both types of ballasted systems are operating in large treatment plants in Europe. There are several recycled sludge ballasted systems at large treatment plants in North America but no sand ballasted systems: Beloeil, Quebec, Canada - 14.5 mgd Laval Station de Lapiniere, Quebec, Canada - 160 mgd Sherbrooke, Quebec, Canada - 38 mgd	

APPENDIX G

Membrane Bioreactor (MBR)

Process Description

A suspended solids growth system. This is a variation of the activated sludge system. Primary or preliminary effluent is directed to an aeration basin where it mixes with return activated sludge. The resulting mixed liquor is aerated until BOD removal has occurred; oxygen is most likely supplied via high efficiency fine pore aeration devices in large plants. The MBR differs from the conventional activated sludge system in that treated effluent is separated from the solids using membranes in place of secondary clarifiers. Membranes with pore size 0.1-0.4 micron are placed in mixed liquor and permeate passes through the membrane by gravity or flows through under a slight vacuum. Most of the settled sludge is returned to the aeration basin to maintain the desired level of microbial mass. A portion of the sludge is wasted to offset microbial growth so that the desired solids retention time is maintained. In the absence of secondary clarifiers, selectors are not required for control of settleability but may be incorporated to implement biological removal of nitrogen and/or phosphorus or to maintain high flux rates through the membranes. Membranes may be located in separate tanks from the main aeration basins to optimize energy consumption. MBR systems are low rate since they can carry high MLSS concentrations (10,000-15,000 mg/L).

Advantages

- Robust process
- Absence of secondary clarifier and increased MLSS concentrations result in significant space savings. Footprint reduced by approx. 50%
- Filtering action produces high quality effluent. Eliminates need for effluent filters
- Bulking is not an operational problem
- Readily expandable in modules
- Operation is simplified without secondary clarifiers. Lends itself to automation - can operate largely unattended except for occasional routine performance checks and maintenance of mechanical components
- Process can be readily modified to achieve BNR
- Provides partial, if not full, disinfection

Disadvantages

- High cost of membranes. Current life expectancy is 5 to 8 years depending upon vendor
- Operation at high MLSS and with membrane causes build up of non-biodegradable organics that will reduce alpha and reduce oxygen transfer efficiency of transfer devices
- Limited peak wet weather flow capability
- Membranes need short and long term cleaning regimes. Can be labor-intensive. New systems provide in-situ cleaning options
- Need to store hypochlorite and citric acid cleaning chemicals - will take up footprint
- Screening to small particle size is required. Size varies from 2 to 6 mm according to vendor
- Annual cleaning of diffusers in main aeration basin typically required
- High dependence on sequencing valves
- Blower noise can be a problem

Support Systems

- Blowers and motors
- Aeration devices and associated piping
- Dissolved oxygen control system
- Mixed liquor pumping systems
- Membrane cleaning systems

Design Loading Criteria

HRT - >3 hr (w/ primary clarifier)
>6 hr (w/o primary clarifier)
SRT - >10 day
F/M - <0.2 lb BOD/lb MLVSS-day

Process Performance

Effluent BOD - <1 mg/L
Effluent, TSS - <1.5 mg/L
Effluent NH_3N - <0.5 mg/L
Effluent TP - <0.06 mg/L (with chemical precipitation

Technology Status and Implementation

Developing. Some large plants have been built in Europe. The largest in North America are:

American Canyon, CA - 3.8 MGD
Lone Tree, Arapahoe, CO - 2.4 MGD, MMF

Delivered Bulk Sodium Hypochlorite Disinfection

Process Description

Sodium hypochlorite in an aqueous solution that exists as a mixture of hypochlorous acid and hypochlorite ion, which are the same active compounds as in chlorination. Bulk hypochlorite is sold as 12.5 percent concentrated solution and is delivered in tank trucks or railcars. The delivered solution is stored on-site in either storage tanks or railcars, and is pumped to the injection points of the chlorine contact basin. Dosing is generally controlled with chemical metering pumps based on the flow and chlorine residual.

Contact basins for hypochlorite are identical to contact basins for chlorine. The plug-flow contact basins are usually built in a serpentine fashion to conserve space. Hydraulic retention times ranging from 20 to 90 minutes are required to allow for pathogen inactivation.

Sodium bisulfite is normally used for dechlorination. The sodium bisulfite is handled in the similar fashion to sodium hypochlorite. The solution at 40 percent strength is delivered and stored in the tanks, and fed to the end of contact basin or the outfall by metering pumps. When dissolved in the water, sodium bisulfite provides sulfite ions that react with chlorine to form chloride and sulfate.

Advantages

- Mitigates catastrophic release
- Relatively low capital costs
- Minimal operations and maintenance requirements
- Applicable to reclaimed water
- Provides some level of color removal

Disadvantages

- Different set of handling/exposure risks
- Dechlorination may be required
- Unwanted byproducts
- Relatively high chemical costs
- Sodium hypochlorite is corrosive
- Potentially toxic to higher aquatic species

Support Systems

- Hypochlorite solution storage tanks
- Hypochlorite transfer pumps and associated piping
- Hypochlorite dosing pumps
- Sodium bisulfite storage tanks
- Sodium bisulfite injection pumps and piping

Design Loading Criteria

Hydraulic retention time - ≥1 hr (average flow)
- 20 min (peak flow)
Hypochlorite dosage - 4 mg/L as chlorine (2 - 10)
Sodium bisulfite dosage – 2 mg/L (0 – 4)

Technology Status and Implementation

Established. One of the most widely used systems in the world. Many large treatment plants in America:
Hyperion Plant, Los Angeles CA - 350 MGD
69th Street WWTP, Houston TX - 75 MGD
East Bay Municipal Utility District, Oakland CA – 90 MGD
Littleton/Englewood WWTP, Englewood CO - 36 MGD
Southeast Water Pollution Control Plant, San Francisco CA - 68 MGD

Ultraviolet Light Disinfection

Process Description

Ultraviolet light (UV) disinfection is a physical process relying on the transference of electromagnetic energy from a source (lamp) to an organism's cellular material. The lethal effects of this energy results primarily from the cell's inability to replicate. The effectiveness of the radiation is a direct function of the quantity of energy, or dose, which was absorbed by the organism. UV lamps are mounted in a pipe or open channel. The open channel provides easy access to the lamps for maintenance and cleaning. In-line or pipe systems utilize less space and may be effective for retrofitting existing facilities. Plant effluent flows through the pipe or channel, and undergoes a short contact time (on the order of seconds) around the lamp. Open channel systems are typically preferred in the wastewater treatment plants. The system has in-place automatic wiping system to periodically clean quartz sleeves during operation. Due to the short contact time and self-cleaning system, the space required by UV system is small.

Advantages

- Small footprint requirement
- Minimal chemical delivery/use
- Eliminates byproduct formation
- Self-cleaning UV lamps require minimum maintenance
- Is not corrosive
- Produces no hazardous byproducts and is not toxic to higher aquatic species

Disadvantages

- Effectiveness sensitive to water quality (UV % transmittance, TSS, particles)
- Relatively high capital costs
- Relatively high power use
- No residual. Chlorine or NaOCl must be added for reclaimed water use.

Support Systems

- UV lamps
- Quartz Sleeves
- Accessory cleaning equipment
- Ballasts and Electronic Controls
- Voltage control (transformers)
- Power supply and power panels

Design Consideration

- Hydraulics
- Wastewater characteristics (TSS, UV % transmittance, and particles distribution)
- UV intensity (UV dose)

Range for UV Dosage:

- 2.2 Total Coliforms per 100 mL for filtered effluent - 100 to 150 mJ/cm^2
- 200 Fecal Coliforms per 100 mL for secondary effluent - 25 to 430 mJ/cm^2

Technology Status and Implementation

Increasingly used. The number of wastewater treatment facilities using UV irradiation in the United States has been estimated to be approximately 1,500. In Canada, approximately 15 percent of wastewater facilities which have disinfection requirements use UV, per estimation in 1998.

Westside WWTP, Vancouver WA	- 25 MGD
Central Contra Costa, Martinez CA	- 45 MGD
LOTT Bud Inlet, Olympia WA	- 22 MGD
Centralia WWTP, WA	- 2.5 MGD
Laguna Subregional WWTP, Santa Rosa CA	- 22 MGD

APPENDIX G

Gravity Belt Thickeners

Process Description

Gravity belt thickeners (GBTs) are comprised of a slowly moving fabric belt onto which sludge is distributed. The sludge is thickened by drainage and by capillary suction forces imparted by the fabric's interstitial voids. As the material travels the length of the belt, plows mix and turn the sludge to enhance drainage characteristics. Gravity belt thickening is similar to the first pass (gravity drainage section) of a three belt, belt filter press. Polymers must be used when gravity belt thickening is applied to secondary sludge or co-thickened sludge.

Gravity belt thickeners are currently used for co-thickening primary and secondary sludge at King County's West Point Treatment Plant.

Advantages

- Low energy demands
- Low equipment costs
- High solids concentrations
- Consistent thickened solids concentration achievable with appropriate operator attention.

Disadvantages

- Operator must control many variables to optimize sludge thickening. High operator attention.
- Require periodic cleaning.
- High odor potential that is difficult to contain.
- Require large amounts of washwater.

Typical Design Loading Criteria

- 100 to 250 gpm per meter belt width

Projected Process Performance

- Thickened WAS sludge is 4 to 8% TS
- Thickened primary sludge is 6 to 10% TS
- Capture efficiency is 90 to 98%
- Polymer dosage is about 10 lb/ton

Technology Status and Implementation

Established: Gravity belt thickeners are used throughout North America.

West Point Treatment Plant, King County, WA; 133 mgd

Chambers Creek Wastewater Treatment Plant, Pierce County, WA; 28 mgd

Akron, OH; 110 mgd

Medford Water Reclamation Facility, Medford, OR; 20 mgd

APPENDIX G

Conventional Anaerobic Digestion

Process Description

In conventional anaerobic digestion, the solubilization and reduction of complex organic matter to methane, carbon dioxide, and stable biosolids is carried out in a single stage operated at mesophilic temperatures and in the absence of oxygen. There are both high rate and low rate anaerobic digestion systems. The low rate systems are characterized by no mixing and heating; whereas, a high rate system is heated to 95ºC and is completely mixed. To achieve Class B biosolids, a high rate system is required to have a minimum 15-day SRT per 40 CFR Part 503 (20 day SRT is recommended for stable operation). Low rate systems are rarely designed for large treatment plants.

Advantages

- Process has been proven reliable at many plants throughout the world including King County's West Point and South Plants.
- Produces a fuel value gas product.
- Individual digesters can be added to expand solids stabilization capacity.
- Decreases biosolids to be hauled off site through volatile solids destruction.
- Biosolids product is stabilized and its odor potential has been reduced through destruction of odor causing compounds.
- Anaerobic digestion has been shown to reduce pathogen levels significantly.

Disadvantages

- Anaerobic digestion can be upset by high loadings or toxic events and can be slow to recover.
- Dewatering centrate or filtrate is relatively strong and will increase loading to liquid stream processes.
- Requires large tanks for the slow growing mesophilic methanogen bacteria, a minimum of 20 days of storage is required.

Support Systems

- Hot water system and boilers
- Odor control

Typical Design Loading Criteria

- SRT minimum is 20 days
- VS loading rate maximum is 0.18 lb/ft^3/day

Projected Process Performance

- Volatile solids reduction (of primary and WAS sludge mixture) typically 50 to 60%
- Dewatered cake (centrifuges) approximately 25%

Technology Status and Implementation

Established: Conventional anaerobic digestion has been implemented throughout North America.
West Point Treatment Plant, King County, WA; 133 mgd
South Treatment Plant, King County, WA; 144 mgd
Chambers Creek Wastewater Treatment Plant, Pierce County, WA; 28 mgd
Budd Inlet Wastewater Treatment Plant, Olympia, WA; 22 mgd

APPENDIX G

Thermophilic-Mesophilic Anaerobic Digestion

Process Description

In a thermophilic-mesophilic anaerobic digestion system the solubilization and reduction of complex organic substances is carried out in two sequential steps. The first step typically has a short solids retention time (SRT) and an operating temperature within the range of 130-140ºF. This thermophilic step is a high rate step that rapidly hydrolyzes solids and breaks down organic constituents to short change volatile acids and to methane. Because of the increased buffering capacity provided by the higher operating temperatures, the thermophilic reactor can operate at much higher volatile acid concentrations than mesophilic digesters without effecting reactor pH. Sludge leaving the thermophilic stage is cooled and enters the second stage mesophilic stage. The mesophilic stage is responsible for system polishing, including reduction of VFAs and odors. There is also some evidence that the mesophilic stage provides some conditioning prior to dewatering. A two-stage system, such as thermophilic mesophilic anaerobic digestion, may be more stable in the event of a toxic or shock event due to the ability of the first stage to remove hydrogen gas. Hydrogen gas is an intermediate product that slows the conversion of propionic acid to acetic acid.

- **Advantages**
- The thermophilic-mesophilic system provides two stages of treatment. Research has observed that when the thermophilic performance is compromised there is little effect on the mesophilic stage and overall system performance, resulting in a robust system.
- Thermophilic-mesophilic digestion operates at lower SRTs than conventional anaerobic digestion processes and therefore has a smaller footprint.
- Additional digesters can be added to the digestion system to accommodate plant expansions. Adding Class A batch facilities has minimal effect on O&M costs.
- Decreases biosolids to be hauled off site through volatile solids destruction. Volatile solids destruction is about 10 to 20% greater than conventional mesophilic digestion.
- Thermophilic-mesophilic anaerobic digestion has been shown to increase dewatered cake concentration by 1 to 2 percentage points.
- Production of a fuel value gas. Fuel gas production is 10 to 20% greater than conventional anaerobic digestion.
- Biosolids product is stabilized and its odor potential has been reduced through destruction of odor causing compounds.
- Thermophilic-mesophilic anaerobic digestion has been shown to reduce pathogen levels below the requirements of the part 503 Class A requirements.

Disadvantages

- Early literature of thermophilic anaerobic digestion indicated that it was susceptible to shock loading and temperature changes. Recent evidence, including more operating plants, suggests that this may not be true.
- Startup of thermophilic digesters is not immediate. However as more thermophilic digesters are operational, the availability of thermophilic seed sludge will increase.
- Some evidence exists that thermophilic digestion increases dewatering polymer demand and reduce the quality (i.e. higher TSS) of the dewatering centrate or filtrate.
- Thermophilic-mesophilic anaerobic digestion requires more heat exchangers and pumping relative to conventional anaerobic digestion, resulting in increased maintenance costs.
- Thermophilic anaerobic digestion has been reported to have stronger odors than mesophilic digestion. However, the thermophilic digester can be contained and the mesophilic digester reduces the product odors.

Support Systems

- Hot water system and boilers
- Heat recovery system
- Odor control

Typical Design Loading Criteria	**Projected Process Performance**
• Thermophilic SRTs between 4 and 8 days. • Mesophilic SRTs between 10 and 15 days.	• Volatile Solids Reduction (of primary and WAS sludge mixture) 60 to 70%. • Dewatered cake 1 to 2 percentage points greater than conventional mesophilic digested sludge.
Technology Status and Implementation Emerging: Thermophilic-mesophilic anaerobic digesters are operated at about 10 plants in North America. Western Lake Superior Sanitary District, Duluth, MN; 43 mgd Sioux City, IA; 30 mgd Iowa City, IA; 10 mgd Waterloo, IA; 35 mgd	

APPENDIX G

Centrifuge Dewatering

Process Description

Centrifuges that are used for dewatering revolve at high speeds and impart centrifugal forces of about 3,000 G to the sludge. Dewatering centrifuges consist of a cylindrical "bowl" that terminates at one end with a concentric weir and at the other end with a tapered section that acts as a "beach". A screw conveyor, or "scroll" rotates at a slightly slower speed than the bowl. The scroll collects and conveys dewatered solids to the beach, where they are discharged.

Centrifuges are capable of achieving dewatered cake concentrations of 25 to 30 percent. Centrifuges being sold today have torque control. The torque that the centrifuge experiences is related to the solids inventory in the bowl. As the torque fluctuates, the differential between the speed of the bowl and the scroll is varied proportionally. This controls the rate at which dewatered solids are removed from the bowl. Torque control provides more consistent cake and minimizes uneven wear.

King County's West Point currently operates four dewatering centrifuges. The King County South Plant is in the processes of bidding three dewatering centrifuges.

Advantages	**Disadvantages**
• Achieves highest cake concentration of all dewatering technologies • Has small footprint requirements • Provides sludge containment • Highly reliable process • Flexible process	• High capital costs • High power consumption • Machines spin at high rpms, therefore there are long term maintenance and wear requirements • Machines are noisy • Requires substantial overhead space for centrifuge disassembly
Typical Design Loading Criteria	**Projected Process Performance**
• A range of centrifuge sizes is available. Typical loading criteria depends on the specific machine selected	• Cake solids concentration typically 25 to 30%. • Polymer demand typically 25 to 35 lb/ton • Capture rate is about 95%

Technology Status and Implementation

Established: Centrifuge dewatering has been implemented throughout North America.

West Point Treatment Plant, King County, WA; 133 mgd

Annacis Island Treatment Plant, Vancouver, BC; 124 mgd

Kitsap County, WA; 12 mgd

South Treatment Plant, King County, WA; 144 mgd (In the process of bidding and designing the facility)

Appendix H

Master List of Permits and Approvals

Federal Permits and Approvals

U.S. Army Corps of Engineers Permit, with Jurisdiction under Section 404 Clean Water Act, Section 10 Rivers and Harbors Act, and Section 7 Endangered Species Act

National Oceanic and Atmospheric Administration (Formerly National Marine Fisheries Service), Endangered Species Act Section 7 Consultation

U.S. Fish and Wildlife Service, Endangered Species Act Section 7 Consultation

Essential Fish Habitat Assessment under the Magnuson-Stevens Fisher Conservation and Management Act (50 CFR 600.905-930) and the 1996 Sustainable Fisheries Act

U.S. Coast Guard, Local Notice to Mariners

State Permits and Approvals

Department of Ecology, NPDES Construction Permit

Department of Ecology, NPDES Waste Discharge Permit

Department of Ecology, Clean Water Act, Section 401 Water Quality Certification

Department of Ecology, Model Toxics Control Act, Prospective Purchaser Agreement; Voluntary Cleanup Program

Department of Ecology, Coastal Zone Management Consistency Determination

Departments of Ecology/Health Wastewater Reuse Approval

Department of Fish and Wildlife, Hydraulic Project Approval

State Permits and Approvals (cont.)

Department of Natural Resources, Lands Lease (Tidelands and stream crossings)

Department of Transportation, Utility or Franchise Permit

Puget Sound Clean Air Agency, Title V Permit

Department of Health, Food Safety and Shellfish Programs

Snohomish County Permits and Approvals

Land Use Permitting

Essential Public Facility (Siting) Permit

Master Permit

Conditional Use Permit

Street/Right-of-Way Use Approvals

Critical Areas Ordinance Review

Construction Permitting

Clearing and Grading Permit

Excavation and Shoring Permit

Foundation Permit

Construction Dewatering

Building Permit/Uniform Building Code Review

- Structural
- Electrical
- Mechanical
- Plumbing

Fire Code Permit

- Access Review
- Hazardous Materials/Storage
- Fuel Storage Tanks

Demolition Permit

Local Jurisdiction Permits and Approvals

It is anticipated that local land use and construction permits will be required from some or all of the following cities:

- Bothell
- Kenmore
- Lake Forest Park
- Mountlake Terrace
- Shoreline

	Description	Agency Requiring	Comments	JARPA --- Federal/State Permits								State Permits									Local Permits									
				Clean Water Act, Section 10/404 (Corps)	ESA Sect 7 Sect 10 (NMFS/USFWS)	401 Water Quality Certification (Ecology)	Safe Drinking Water Act SSA Protect (EPA/Ecology)	CZM Consistency (Ecology)	HPA (WDFW)	Section 106 (OAHP)	Title 5 Op. Permit (PSCAA)	Aq Land Use Auth (DNR)	NPDES Construction Stormwater General (Ecology)	NPDES Discharge Permit (Ecology)	MTCA (Ecology)	Waste Disposal Permit (Ecology)	Groundwater Management Program Compliance (Ecology/DOH)	SEPA (Ecology)	Utility or Franchise (WSDOT)	Archaeol Approval (OAHP)	Shoreline Substantial Devel. (City/Co.) (Ecology)	Commercial Bldg (City/Co.)	Clearing & Grading (City/Co.)	Critical Areas (City/Co.)	Drainage Review (City/Co.)	Cultural and Historic (City/Co.)	Local Dept of Health (City/Co.)	Right-of-Way Use (City/Co.)	Haul Route (City/Co.)	Noise Variance (City/Co.)
1	**NEPA/SEPA Compliance**																													
2	NEPA Scoping Notice (for Section 106 also)	Lead Federal Agency	Oversight by CEQ and EPA	P																										
3	NEPA EA and Related Tech Studies	Lead Federal Agency	Oversight by CEQ and EPA	P	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
4	NEPA EIS and Related Tech Studies	Lead Federal Agency	Oversight by CEQ and EPA	P	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
5	NEPA Supplemental EIS and Related Tech Studies	Lead Federal Agency	Oversight by CEQ and EPA	P	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
6	Finding of Non Signficance (FONSI)	Lead Federal Agency		P																										
7	Administrative Record	Lead Federal Agency	Includes Mitigation Commitments	P																										
8	Administrative Record	Lead Federal Agency	Determine early what to be included in record	P																										
9	SEPA Scoping Notice	Lead State/Local Agency																P												
10	SEPA Checklist and Related Tech Studies	Lead State/Local Agency	Key requirement for various permit applications	X		X	X	X	X		X	X	X	X	X	X	X	P	X	X	X	X	X	X	X	X	X	X	X	X
11	SEPA Threshold Determination	Lead State/Local Agency		X		X	X	X	X		X	X	X	X	X	X	X	P	X	X	X	X	X	X	X	X	X	X	X	X
12	SEPA EIS and Related Tech Studies	Lead State/Local Agency	Key requirement for various permit applications	X		X	X	X	X		X	X	X	X	X	X	X	P	X	X	X	X	X	X	X	X	X	X	X	X
13	SEPA Supplemental EIS and Related Tech Studies	Lead State/Local Agency	Key requirement for various permit applications	X		X	X	X	X		X	X	X	X	X	X	X	P	X	X	X	X	X	X	X	X	X	X	X	X
14	**General Project Design Plans and Information**																													
15	Project location and vicinity map	All	Basic requirement for most permit applications	P	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X
16	Project description including purpose and need	All	Basic requirement for most permit applications	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
17	Description of existing and proposed buildings and uses	State/Local Agency			X			X		P	X		X			X	X	X		X	X	P	X	X	X	X				
18	Description of size & location of existing and proposed utilities	State/Local Agency		X	X	X	X	X	X	X	X	X	X	X		X	X	X	P		X	X	X	X	X					
19	Description of construction sequencing, phasing, and timing	State/Local Agency		X	X	X			X			X	X			X	X	X	X		X	X	P	X	X					
20	Description of work within waters of the U.S.	Federal/State Agencies		P	X	X			X			X	X		X	X	X	X	X		X		X	X	X					
21	Description of impacts to uses of waters of the U.S.	Federal/State Agencies		P	X	X		X	X			X	X	X	X	X	X	X	X		X		X	X	X					
22	Quantity and area of fill waterward of ordinary high water (OHW)	Federal/State Agencies		P	X	X		X	P			X	X	X	X			X	X		X		X	X	X					
23	Quantity and area of excavation waterward of OHW	Federal/State Agencies		P	X	X		X	P			X	X	X	X			X	X		X		X	X	X					
24	Relationship of proposal to shoreline zone per local SMP	State/Local Agency						X										X			P		X	X	X					
25	Relationship of proposal to 100-year floodplain and OHW	State/Local Agency		X	X	X			X												X	X	X	X	P					
26	List of permits required (Master list of permits)	Federal/State/Local Agencies		P	X	X			X			X	X	X	X	X	X	X			X	X	X							
27	Plans and specifications for fish/habitat protection	Federal/State/Local Agencies		X	X				P			X						X			X		X							
28	Assessor's maps	Local Agency										X							X		P		P			X				
29	Legal description(s)	Federal/State/Local Agencies		P								X							X	X	X	X	X			X				
30	Easements, deed restrictions, and encumberances	Local Agency										X							X	X	P	X	P	X				X		
31	Architectural and structural plans	State/Local Agency		X	X	X			X	X									X	X	X	P				X				
32	Civil engineering plans (plans, profiles, cross-sections)	Federal/State/Local Agencies		P	X	X			X	X		X						X	X	X	X	P	X	X	X	X	X	X		
33	Summary of impacts and proposed mitigation	All		X								X	X	X	X	X	X	X	X	X	X		X	X	X	X		X		X
34	Total project value and costs related to design alternatives	Federal/State/Local Agencies		X														X			P	P								
35	**Land Use**																													
36	Comprehensive Plan amendment (as required) / Conditional Use Permit Application	Local Agency																P			X									
37	Essential public facility siting analysis/report (as required)	Local Agency																X			X	P	P							
38	Shoreline Substantial Development Permit Questionaire	Local Agency																			X									
39	Input to staff report on consistency of project with local codes	Local Agency																X			P	X	X	X	X	X	X	X		X

P = Primary agency/permit requiring information
X = Other agency/permit requiring information

				JARPA --- Federal/State Permits								State Permits									Local Permits									
	Description	Agency Requiring	Comments	Clean Water Act, Section 10/404 (Corps)	ESA Sect 7 Sect 10 (NMFS/USFWS)	401 Water Quality Certification (Ecology)	Safe Drinking Water Act SSA Protect (EPA/Ecology)	CZM Consistency (Ecology)	HPA (WDFW)	Section 106 (OAHP)	Title 5 Op. Permit (PSCAA)	Aq Land Use Auth (DNR)	NPDES Construction Stormwater General (Ecology)	NPDES Discharge Permit (Ecology)	MTCA (Ecology)	Waste Disposal Permit (Ecology)	Groundwater Management Program Compliance (Ecology/DOH)	SEPA (Ecology)	Utility or Franchise (WSDOT)	Archaeol Approval (OAHP)	Shoreline Substantial Devel. (City/Co.) (Ecology)	Commercial Bldg (City/Co.)	Clearing & Grading (City/Co.)	Critical Areas (City/Co.)	Drainage Review (City/Co.)	Cultural and Historic (City/Co.)	Local Dept of Health (City/Co.)	Right-of-Way Use (City/Co.)	Haul Route (City/Co.)	Noise Variance (City/Co.)
40	**Air Quality / Odor Control**																													
41	Calculation, modeling, and dispersion analysis of air emissions	State/Local Agency									P																			
42	Report on compliance/monitoring and source testing methods	State/Local Agency									P																			
43	**Noise and Vibration**																													
44	Analysis of baseline conditions, impacts, and mitigation related to system construction and operation	Local Agency, WDFW, NMFS	Required to evaluate compliance with local noise ordinance and potential impacts to ESA species (aquatic and terrestrial). Include analysis of proposed construction at batch plants and access portals		X				X													X								P
45	Evaluation of suitable locations and types of noise barriers	Local Agency	For temporary and permanent structures																											P
46	**Clearing, Grading & Geotech**																													
47	Signficant Tree Survey	Local Agency	Required for federal/state agency review also		X																X		P	X						
48	Geotechnical report	Local Agency	Including seismic analysis	X	X		X		X			X	X		X			X	X	X	X	X	P	P	X	X				
49	Clearing and Grading Plan/Calculations (rough/finish grades)	Local Agency	Including all related temp/perm facilities (trails too)	X	X				X			X	X		X			X		X	X	X	P	X	X			X		
50	Analysis of cut and fill quantities	Local Agency	Required for federal/state agency review also	X	X				X			X	X		X			X			X	X	P	X	X					
51	Analysis of Alternative Methods/Routes Import/Export of Soils	Local Agency	Required for federal/state agency review also	X	X													X			X		X	X	X			P		X
52	Slope Stabilization Plan; identify retaining walls/slope butressing	Local Agency	Required for federal/state agency review also		X				X				X					X			X		P	X	X					
53	Site Restoration and Revegetation/Landscape Plan	Local Agency	Required for federal/state agency review also	X	X				X			X	X		X						X		P							
54	Landslide/Seismic Hazard Areas Analysis	Local Agency			X													X	X		X	X	X	P	X					
55	Erosion Hazard Areas Analysis	Local Agency			X								X					X	X		X	X	X	P	X					
56	Steep Slope Hazard Areas Analysis	Local Agency			X								X					X	X		X	X	X	P	X					
57	Coal Mine Hazard Areas Analysis	Local Agency											X					X			X	X	X	P	X					
58	Study Plan for geophysical studies (upland or in-water)	State/Local Agency		X								X						X	X		X		P							
59	**Contaminated Soils**																													
60	Phase I Environmental Site Assessment / areas surrounding	Ecology	Also pertains to properties acquired for mitigation												P															
61	Phase II-III ESA (if onsite soil remediation needed)	Ecology	Also pertains to properties acquired for mitigation												P															
62	Remedial Investigation/Feasibility Study, Cleanup Action Plan, Remediation Design	Ecology		X	X	X									P			X			X		X							
63	**Dredging / In-Water Construction**																													
64	Bathymetry Study	WDFW/DNR	Required for federal/state agency review also	X	X	X			P			X		P							X									
65	Sediment Characterization, Dredging and Disposal Plan	Federal/State	Required for other federal agency review also	P	X	X						X			X			X												
66	Evaluate need for in-water pile driving activities	Corps	Required for federal/state/local agency review also	X	P	X		X	P			X						X			X		X							
67	Evaluate need for waterfront access, temp work piers	Federal/State/Local		X	P	X		X	X			X						X			X		X							
68	Evaluate construction options for new/improved stormwater outfalls	Federal/State/Local		X	X	P		X	P			X						X			X		X		X					
69	**Groundwater**																													
70	Impacts Analysis on Groundwater Quality/Quantity; Pump Tests	EPA/Local Jurisd.	Per EPA/Local groundwater management criteria				P						X			P	P	X												
71	Analysis of impacts on local critical aquifer recharge areas, on State Source Water Assessment and Protection Program, sole source aquifers, wellhead protection areas	Ecology/Local Jurisd.	Potential EPA review				P									X	X	X												
72	Identification and analysis of adjacent private/public wells; evaluate need for decommissioning	EPA/Dept of Health	Assess location, condition, risks, decommissioning				P									X	X	X									P			
73	Identification and analysis of adjacent septic systems	Local Jurisdiction	Assess locations, risks, and functional displacements															X									P			
74	Groundwater Management/Dewatering Plan	Local Jurisdictions	Also required for federal/state agency review				P						X			X	X				X				X					

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				JARPA --- Federal/State Permits								State Permits									Local Permits									
	Description	Agency Requiring	Comments	Clean Water Act, Section 10/404 (Corps)	ESA Sect 7 Sect 10 (NMFS/USFWS)	401 Water Quality Certification (Ecology)	Safe Drinking Water Act SSA Protect (EPA/Ecology)	CZM Consistency (Ecology)	HPA (WDFW)	Section 106 (OAHP)	Title 5 Op. Permit (PSCAA)	Aq Land Use Auth (DNR)	NPDES Construction Stormwater General (Ecology)	NPDES Discharge Permit (Ecology)	MTCA (Ecology)	Waste Disposal Permit (Ecology)	Groundwater Management Program Compliance (Ecology/DOH)	SEPA (Ecology)	Utility or Franchise (WSDOT)	Archaeol Approval (OAHP)	Shoreline Substantial Devel. (City/Co.) (Ecology)	Commercial Bldg (City/Co.)	Clearing & Grading (City/Co.)	Critical Areas (City/Co.)	Drainage Review (City/Co.)	Cultural and Historic (City/Co.)	Local Dept of Health (City/Co.)	Right-of-Way Use (City/Co.)	Haul Route (City/Co.)	Noise Variance (City/Co.)
75	**Stormwater / Hydrological Analysis**																													
76	Analysis of Impacts to FEMA Floodway	Local Jurisdiction	Required for federal/state agency review also															X					X	X	P					
77	Analysis of Needed Culvert Improvements	WDFW	Required at fish bearing streams if ROW will be widened		X				P			X						X			X				X					
78	Analysis of water quality baseline conditions	Ecology/Local Jurisd.				P	X							X		X									P					
79	Stormwater/Construction:																													
80	Off-site analysis	Ecology/Local Jurisd.											X												P					
81	Stormwater Pollution Prevention Plan/Monitoring	Ecology/Local Jurisd.	Required for federal/state/local agency review	X	X	X	X		X			X	P	X		X		X					P		P					
82	Temporary Erosion & Sediment Control Plan	Ecology/Local Jurisd.	Required for federal/state/local agency review	X	X	X			X			X	P	X				X					P		P					
83	Spill Prevention, Control, & Countermeasures Plan	Ecology/Local Jurisd.	Required for federal/state/local agency review; includes spill contingency plan	X	X	P	X		X			X	P	X		X		X					X		X					
84	Stormwater/Operation:																													
85	Stormwater Drainage Plan	Ecology/Local Jurisd.	Including Treatment System/Outfall Design		X	X							X										X		P					
86	Stormwater Plume Dispersion Analysis	Ecology/Local Jurisd.	For new/upgraded stormwater outfalls		X	X								P											X					
87	Evaluate location, risks, impacts of overflows	Ecology/Local Jurisd.			X	X						X		P		X									X					
88	Fluvial Geomorphology Study (for cut/cover stream crossings)	Local Jurisdictions	Potentially required for federal/state agency review also		X				X			X												P	X					
89	Evaluate need for new/upgraded stormwater outfalls	Feds/Ecology/WDFW/Local Jurisd.		X	X	X			X									X			P				X					
90	Predesign drawings for outfalls (plan, profile, cross-section)	Ecology/Local Jurisd.	Required for federal/state/local agency review	X	X	X		X	X			X		X				X			P				X					
91	**Wastewater**																													
92	Wastewater Containment and Disposal Plan	Ecology	Required for federal/state/local agency review		X											X					X	X			X					
93	Monitoring Plan for Batch Plant / Tunneling Discharges	Ecology	Required for federal agency review also		X											X					X	X			X					
94	Effluent Plume Dispersion Analysis	Ecology	For Wastewater/Stormwater Outfalls; input to NPDES Permit		X									X		X									X					
95	Facilities Plan/Engineering Report; Plans and Specifications	Ecology												X		X									X					
96	Outfall mixing zone study	Ecology	Input to NPDES Permit		X									P											X					
97	**Fish, Wildlife, Habitat, and Critical Areas**																													
98	Public agency utilities exemption (PAUE) justification report regarding critical areas	Local Jurisdiction																X			X	X	X	P	X					
99	Alternatives Analysis (Clean Water Act 404(b)(1))	Corps	Other state/local agencies review also	P	X				X												X		X	X						
100	ESA-Biological Assessment and Baseline Studies	Federal Lead Agency	Other state/local agencies review also	X	P				X			X						X				X	X	X						
101	Magnuson Stevens - Essential Fish Habitat Evaluation	Federal Lead Agency	Other state/local agencies review also	X	P				X																					
102	ESA-Species Monitoring (Bald Eagles, Salmonids, etc)	Federal Lead Agency	Other state/local agencies review also	X	P													X					X	X						
103	Upland/Riparian Habitat Survey	State/Local Jurisdiction	Other state/local agencies review also	X	X													X					X	P						
104	Wetland Determination Report and Impacts Analysis	Corps/Local Jurisdiction	Other state agencies review also	P	X				X									X					X	P						
105	Wetland Mitigation and Monitoring Plan (onsite/offsite)	Corps/Local Jurisdiction	Other state agencies review also	P	X				X									X					X	P						
106	Stream Special Study	Local Jurisd./WDFW		X	X				X									X					X	P						
107	Stream Mitigation & Monitoring Plan (onsite/offsite)	WDFW/Local Jurisdiction		X	X				P									X					X	P						
108	Eelgrass/Macroalgae Survey	WDFW/Local Jurisdiction	Other federal and state agencies review also	P	P				P			X						X			X		X	X						
109	Eelgrass/Macroalgae Mitigation & Monitoring Plan	WDFW/Local Jurisdiction	Other federal and state agencies review also	P	P				P			X						X			X		X	X						
110	Herring Spawning, Pacific Sand Lance Survey	Federal Lead Agency/WDFW	Other federal and state agencies review also	X	P				P									X			X		X	X						
111	Marine fish/shellfish, benthic survey	WDFW/WDNR	Other federal and state agencies review also	X	X				P			X						X			X		X	X						
112	Intertidal/Subtidal Marine Habitat Survey	WDFW/Local Jurisdiction	Other federal and state agencies review also	X	X				P			X						X			X		X	X						
113	Intertidal/Subtidal Mitigation & Monitoring Plan (onsite/offsite)	WDFW/Local Jurisdiction	Other federal and state agencies review also	X	X				P			X						X			X		X	X						
114	**Utilities**																													
115	Analysis of existing and proposed utilities in project vicinity	State/Local Jurisdiction																	P						X			X		

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116	Analysis of joint use opportunities of existing utility corridors	State/Local Jurisdiction																X	P									X		
117	**Traffic / Roads**																													
118	Analysis of planned traffic improvements in project area	State/Local Jurisdiction			X								X					X	X		X		X	X	X			P		
119	Analysis of joint use opportunities in road rights of way	State/Local Jurisdiction																	X		X			X				P		
120	Traffic Management and Control Plan for Construction	State/Local Jurisdiction																X										P		
121	Road Condition and Concurrency Analysis (THU 26B Sno Co.)																											P		
122	Alternative Construction Transpo Routes/Modes Analysis	State/Local Jurisdiction			X								X					X			X			X				P		
123	Street vacation analysis	Local Agency																										P		
124	**Construction**																													
125	Environmental Management Plan	Federal/State/Local Jurisdictions	For overall management and monitoring of BMPs and other permit conditions	X	P							X	X		X			X		X	X		X	X	X	X				
126	Project Health and Safety Plan	State																				P	X							
127	Hazardous Waste Emergency Response and Contingency Plan	Ecology	Other federal, state, local agencies review also	X	X							X	X					X			X	P	X	X	X					
128	Identify location/design of temp. access roads, staging areas	Federal/State/Local Jurisdictions	Key importance if near shoreline areas		P								X					X	X		X	X	P	X	X			X		
129	Public Access/Notification Plan During Construction	Local Jurisdictions	For upland and water access/uses															X			P									
130	**Operation**																													
131	Emergency Response & Contingency Plan	Ecology	Other federal, state, local agencies review also	X	X	X	X		X				X					X			X	P	X	X	X		X	X		
132	**Parks/Trails/Access**																													
133	Analysis of joint siting opportunities w/ local trail systems	Local Jurisdictions	Often becomes a mitigation issue															X	X		P		X	X				X		
134	Design of potential trail mitigation elements	Local Jurisdictions	Could expand impacts to sensitive areas/buffers															X	X		P		X	X				X		
135	**Landscape Maintenance**																													
136	Integrated Pest Management Plan	Ecology/Local Jurisd.																X							P					
137	**Historic & Cultural Resources/Section 106**																													
138	Historic/Cultural Resource Survey	OAHP	Related to structures on or nominated for National Register	X						P								X		P			X			X				
139	Determination of Effect Analysis/Section 106	OAHP	For Historic/Cultural Properties	X						P																				
140	Section 106 MOA	OAHP	Also Local Jurisdications and Tribes	X						P																				
141	Unanticipated Discovery Plan	OAHP	Also Local Jurisdications and Tribes; Includes Environmental Awareness and Training Plan for Construction	X						P																				
142	Subtidal / offshore analysis of historic/cultural resources	OAHP	For Historic/Cultural Properties	X						P								X		X						X				

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Attachment

System Alternatives

Map appearing in May 2003 Preliminary Working Draft Facilities Plan has been superceded.

Refer to Volume 1 of the Final EIS.