5-B
ODOR ANALYSIS: CONVEYANCE

FINAL
ENVIRONMENTAL
IMPACT STATEMENT

Brightwater
Regional Wastewater
Treatment System

APPENDICES

King County Brightwater TREATMENT SYSTEM

Final

Appendix 5-B
Odor Analysis: Conveyance

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Introduction

King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

Executive Summary

This technical memorandum presents odor-prevention design standards and requirements for the influent connections to the proposed Brightwater influent tunnel as well as air handling and odor prevention requirements for the proposed effluent tunnel. A summary is provided of the preferred liquid and vapor-phase technology systems considered for the influent and effluent tunnel connections. Odor and corrosion prevention scenarios were developed to achieve the design standard for a high level of hydrogen sulfide (H_2S) removal so that there are no odors at the property line.

Influent tunnel alternatives are proposed for the Brightwater Conveyance System, with the following odor and corrosion prevention requirements:

- The same odor prevention design standards would apply for each alternative.
- Connection structures for each alternative would require corrosion protection.
- The Route 9-195th Street and Route 9-228th Street Alternatives are similar and would require the same odor and corrosion prevention methods. Both alternatives consist of a 7.3-mile influent tunnel along the north end of Lake Washington between Kenmore and the proposed Route 9 site alternative in Snohomish County.

- The Unocal Site Alternative would require different odor and corrosion prevention methods. This alternative consists of an 11.6-mile influent tunnel beginning in the North Creek vicinity and ending at the proposed Brightwater Treatment Plant site alternative in Edmonds.
- For all alternatives, connections to the proposed influent tunnel would occur in the vicinity of the Kenmore Pump Station in Kenmore (proposed Portal 11) and the North Creek Pump Station and Storage Facility in Bothell (proposed Portal 41 and 14). Two- stage odor scrubbing would be required at these proposed portals.
- For the Route 9-195th and Route 9-228th Street Alternatives, an option includes diverting Swamp Creek Trunk flows to Portal 44. Two-stage scrubbing would be required.
- For the Unocal Alternative, Portal 7 in the Lake Forest Park area would be required to serve as a force main discharge structure; influent would be pumped from a new Kenmore Pump Station (proposed Portal 11) to the proposed Portal 7. Three-stage scrubbing would be required. Odor prevention will not be required for proposed Portal 3 since there will be no hydraulic structures at this site which could cause odor release.

Two effluent tunnel alternatives are proposed for the Brightwater Conveyance System, with the following odor and corrosion prevention requirements:

- The Route 9-195th and Route 9-228th Street effluent alternatives consist of different alignments, but the portals requiring ventilation would be similar and would require the same odor design approach. Air-handling facilities would be required at Portal 5 for the Route 9-195th Street Alternative and at Portal 26 for the Route 9-228th Street Alternative. Carbon scrubbing would be used at either location.
- Odor prevention would not be required at proposed Portal 33 or 39 on the Route 9-228th Street Conveyance System since there would be no hydraulic structures at these sites which could cause odor release.
- The Unocal Site Alternative would not require an effluent tunnel, thus eliminating effluent tunnel connections.

Regulatory Requirements

While the Clean Air Act and state and local regulations set numerical standards for criteria pollutants, they do not set numerical standards for odors. The Puget Sound Clean Air Agency (PS Clean Air) regulates odors in the Puget Sound area and enforces local and state law. Puget Sound Clean Air Regulation I, Article 9.11(a), Chapter 70.94 (Revised Code of Washington (RCW)) and WAC 173-400-040 (4) and (5) address odors and emissions that may be a detriment to a person or property. Puget Sound Clean Air Regulation I, Article 9.11(a) says that:

It shall be unlawful for any person to cause or allow the emission of any air contaminant in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.

The PS Clean Air may take enforcement action under this regulation upon the proper documentation and identification of the source of odor.

Attachment A summarizes sensitive receptors within a one-mile radius of each portal location requiring ventilation for each corridor. Sensitive receptors are defined as people that may have compromised respiratory systems and may be more sensitive to air pollutants that may or may not be odorous.

Odor Prevention and Control Approach

King County is committed to no odors in the Brightwater Conveyance System. Stringent design and performance criteria have been established for odor prevention at portal sites. Key elements of this program are:

- Odor standard of no detectable odors at the property line.
- King County is accountable to PS Clean Air, State of Washington, and portal neighbors regarding odors.
- The proposed odor prevention system would also be one of the most advanced in the United States. Technology would include:
    - Two- stage scrubber treatment depending on portal location. The activated carbon would be used to remove any residual odors from the multiple-stage scrubbers. This is similar to the activated carbon filters used in homes to remove any trace contaminants in drinking water.
    - Liquid-phase treatment would be provided in the collection system to reduce the formation of odors at the portals and the influent pump station.
    - Odor-prevention systems would be designed to handle peak odor emissions.
    - Odor-prevention systems would be sized to handle worst-case operating conditions.
    - Connections will be provided for mobile odor prevention units at each portal odor prevention facility to allow maintenance of existing equipment without compromising treatment standards.

Odor Sources

Odors can occur throughout the entire influent tunnel and in the gravity flow portion of the effluent tunnel. Odors become a problem when they are released into the environment at manholes, access points, or other structures. The release of odorous air into the environment is a complex function of conveyance system hydraulics and structures. As the flow rate changes in open-channel gravity-flow pipes and structures, air either enters or leaves these structures. Gravity flows in pipelines typically pull air in the direction of the flow. During steady or declining flows, air enters, or “ingasses,” into the pipe. During rising flows, air is purged, or “outgassed,” from the pipe. Structures in the gravity system can block air flows or change air flow patterns, resulting in pressurization of the pipe or structures and the release of odorous gases to the environment.

Force Main or Pressure Pipe Discharge Points

Odors may be a problem at force main or pressure pipe discharge locations because of long detention times in the force main or pressure pipe, resulting in anaerobic conditions. The turbulence at the discharge points not only releases entrained odorous gases from the force main/pressure pipe but also from the receiving gravity wastewater flow. The combination of air released from the force main or pressure pipe and air displaced at the discharge point can force odorous air into the environment.

Gravity Pipe Structures

Transition, flow diversion, and junction structures may be areas where odors can occur because of turbulence and air displacement associated with changes in flow direction and merging of flows.

Drop Structures

Drop structures are normally highly turbulent structures that may experience releases of odorous gases. Vortex-type drop structures are often used to minimize the amount of turbulence, but they still can experience releases of entrained odorous gas. In addition, drop structures can entrain a significant volume of air and pressurize downstream pipes and structures.

Brightwater Conveyance System Odor and Corrosion Assessment

This section identifies the potential causes and locations of potential odor associated with the proposed Brightwater influent and effluent tunnel alignment alternatives. An odor assessment was performed for three conveyance system alternatives:

- Route 9-195th Street System—The influent tunnel conveyance alignment would begin at proposed Portal 11, north to proposed Portal 44, and east along NE 195th to proposed Portal 41 and to the proposed treatment plant. The effluent tunnel conveyance would follow the same alignment as the influent from the Route 9 site to proposed Portal 44. At this point, the effluent tunnel would continue as a pressurized pipeline west along NE 195th to proposed Portal 5. From there, the effluent tunnel would convey flow by gravity to the outfall.
- Route 9-228th Street System—The influent tunnel conveyance alignment would be similar to that of the Route 9-195th Street System. The effluent tunnel would follow along 228th Street SW to proposed Portal 39. At this point, the effluent tunnel would continue as a pressurized pipeline along 100th Avenue West to proposed Portal 26. From there, the effluent tunnel would convey flow by gravity to the outfall.
- Unocal System—The influent tunnel would begin in the vicinity of the existing North Creek Pump Station at proposed Portal 14. The influent tunnel would convey flow by gravity to proposed Portal 11 in the Kenmore vicinity to a new Kenmore pump station. Flows would then be pumped from the new Kenmore pump station to

proposed Portal 7 and then flow by gravity to the proposed Brightwater Plant at the proposed Unocal site. No effluent tunnel is required for this alternative.

The odor assessment was based on initial preliminary design efforts associated with connections of the Swamp Creek Trunk, the Kenmore/Bothell-Woodinville Interceptor, the Sammamish Valley Interceptor, and the North Creek Trunk to the influent tunnel. The assessment was also based on the need for air-handling facilities at the high point in the effluent tunnel, which would be at proposed Portal 5 for the Route 9-195th Street Alternative and proposed Portal 26 for the Route 9-228th Street Alternative.

Influent Tunnel Odor Prevention

Three service basins (Swamp Creek, North Creek, and Sammamish Valley) along the influent tunnel alignment will connect to the tunnel with diversion structures and drop structures. The diversion and drop structures are determined by the influent tunnel alignment selected. Table 1 summarizes the new structures associated with the influent tunnel alignments and the need for odor prevention at these structures. Secondary portals are not listed since odor prevention would not be required at these structures. Secondary portals will have no hydraulic structures and will not vent odorous gases to the atmosphere.

Table 1. Influent Tunnel Odor Prevention Requirements for Primary Portals

Influent Tunnel Alternative	Proposed Portal	Structures	Odor Prevention
Route 9 -195th and 228th St	11	Diversion Structure	Yes
		Junction Structure	Yes
Route 9 - 195th and 228th St	44	Drop Structure	Yes
Route 9 - 195th and 228th St	41	Diversion Structure	Yes
		Drop Structure	Yes
Unocal	14	Drop Structure	Yes
Unocal	11	Diversion Structure	Yes
		Pump Station wet well	Yes
Unocal	7	Force main Discharge Structure	Yes
Unocal	3	Manhole	No

The following sections describe the existing odor potential and existing equipment in the vicinity of each proposed portal. An odor prevention program is proposed for each portal. The proposed odor prevention programs will be refined as data is collected and analyzed from the odor monitoring and sampling program scheduled for summer 2003. Final data from this study was not available at the time of the publication of this report. A report of the data and findings of the sampling and monitoring program will be released in late 2003.

Portal 11

For the Route 9 influent tunnel alignment, this system could flow directly to the proposed influent tunnel via the proposed diversion structures. Under the proposed Brightwater Flow Management Plan, the Woodinville and North Creek pump station flows would be diverted to Brightwater at the North Creek Diversion Structure. North Lake Washington, Inglewood, and remaining flows in the Kenmore/Bothell-Woodinville Interceptor and Swamp Creek Trunk flows would be conveyed to the Brightwater Wastewater Treatment Plant. The new tunnel flows may still be diverted to the West Point Treatment Plant via the existing Kenmore Pump Station. Preliminary work on the tributary connections to the Brightwater influent tunnel indicate that a diversion structure would be constructed just upstream of the existing Kenmore Pump Station. The diversion structure would direct flows to proposed Portal 11, at the beginning of the influent tunnel. The Swamp Creek Trunk flows may be diverted to Portal 44 instead of connecting to the Kenmore/Bothell-Woodinville Interceptor.

For the Unocal Site Alternative, flows would enter the influent tunnel at Portal 14 at North Creek and at Portal 11 just upstream of the proposed Kenmore Pump Station. The influent tunnel would discharge by gravity to the new Kenmore Pump Station wet well, and from there flows would be pumped to proposed Portal 7.

Existing Odor Potential

The existing Kenmore Pump Station receives wastewater flows that are generally from separated systems and the flows have long residence times inside the conveyance facilities.

Odor data available for this basin consists of grab samples taken between July 1999 and September 2002. Table 2 summarizes the measured hydrogen sulfide concentrations at the Kenmore Pump Station and associated facilities.

Table 2. Hydrogen Sulfide and Dissolved Sulfides Concentrations near Kenmore Pump Station

Structure	Date	H_2S Concentration (ppm)	Peak Dissolved Sulfide Concentration (mg/l)
Kenmore Interceptor	9/99-8/02	0-1.5	0.6
Kenmore Pump Station Wet Well	7/99-9/02	0-7.0	1.1
Kenmore Secondary Distribution Structure	7/99-9/02	1.7-12.0	0.3

Existing Odor and Corrosion Facilities

Table 3 lists the existing odor and corrosion prevention equipment in the vicinity of proposed Portal 11.

Table 3. Existing Odor and Corrosion Equipment in the Vicinity of Portal 11

Location	Equipment Type	Size	Area Served
Kenmore Pump Station	Two Carbon Units	4,800 cfm	Wet well, Primary and Secondary Distribution Structures
	Chemical Injection	7,000 gallons	Primary and Secondary Distribution Structures, Lakeline Interceptor
Logboom Regulator Station	Carbon Unit	4,800 cfm	Gate Room, Twin 132" Pipes and Lakeline Interceptor

New Brightwater Conveyance Facilities Requiring Odor Prevention

For all three influent tunnel alternatives, the proposed diversion structure would be located upstream of the Kenmore Pump Station. Flows would be diverted to proposed Portal 11 for the Route 9-195th Street and Route 9-228th Street Alternatives, or to the new Kenmore Pump Station wet well for the Unocal Site alternative. The proposed diversion structure, Portal 11, and the new wet well would require vapor-phase treatment. Odorous gases are expected to be released from the structures during increasing flow conditions. The structures would also be susceptible to outgassing air from the influent tunnel.

Chemical injection would be required for flows upstream of the proposed Diversion Structure to reduce dissolved sulfide levels in the influent tunnel. For the purposes of this study, it is assumed that Bioxide would be used. Assuming an average wet-weather flow of 6.1 million gallons per day (mgd), the chemical injection rate would be 115 gallons per day (gpd). For a two-week supply of chemical, 1,600 gallons of chemical storage would be required. The Kenmore Pump Station has a 7,000-gallon chemical injection facility. It is assumed that the existing chemical injection system would be reused and chemical injection piping would be rerouted to inject upstream of the diversion structure.

Portal 44

For the Route 9 Alternatives, the Swamp Creek Trunk service basin may be diverted to proposed Portal 44, rather than diverting to proposed Portal 11. Connection of the Swamp Creek Trunk flows to proposed Portal 44 would require a drop structure.

Existing Odor Potential

There are no existing odor and corrosion problems associated with the Swamp Creek Trunk in the vicinity of proposed Portal 44.

Existing Odor and Corrosion Facilities

There are no existing odor and corrosion facilities associated with the Swamp Creek Trunk in the vicinity of Portal 44.

New Brightwater Conveyance Facilities Requiring Odor Prevention

For this alternative, the drop structure inside of Portal 44 would require vapor-phase treatment. The structures would also be susceptible to outgassing air from the influent tunnel. Chemical injection would not be required for flows upstream of Swamp Creek Trunk since flows consist of fresh sewage with low dissolved sulfide concentrations.

Portals 41 and 14

For the proposed Route 9 treatment plant influent tunnel alignment, this entire system would drain directly to the proposed influent tunnel via the proposed diversion structures. Under the proposed Brightwater Flow Management Plan, flows from the Sammamish Valley Interceptor and North Creek Trunk would be conveyed to the Brightwater Wastewater Treatment Plant. Peak flows may still be diverted either to West Point via the Kenmore/Bothell-Woodinville Interceptor or to the South Plant via the North Creek Pump Station. Preliminary work on the tributary connections to the Brightwater influent tunnel indicates that the existing North Creek Diversion Structure would be modified or a new diversion structure would be constructed in the vicinity of the existing structure. The diversion structure would convey flows to proposed Portal 41 and connect to the influent tunnel via a drop structure.

For the Unocal Site Alternative, the entire system would also drain directly to the proposed influent tunnel via a new diversion and drop structure at Portal 14. The flows would then be conveyed by gravity to proposed Portal 11.

Existing Odor Potential

Portions of the Sammamish Valley Interceptor and the Kenmore/Bothell-Woodinville Interceptor upstream of the North Creek Diversion Structure have significant corrosion damage. This corrosion damage is an indication of odor and corrosion potential that can be anticipated when flows are diverted to proposed Portal 41.

Odor data available for this service area consists of grab samples taken between March 2000 and June 2002. Table 4 summarizes the measured hydrogen sulfide concentrations at the facilities in the vicinity of the North Creek Diversion Structure and proposed Portal 41.

Table 4. Hydrogen Sulfide and Dissolved Sulfides Concentrations near North Creek Pump Station

Structure	Date	H_2S Concentration (ppm)	Peak Dissolved Sulfide Concentration (mg/l)
North Creek Wet Well	3/00-5/00	<0.15	<0.1
North Creek Force Main Discharge Structure	7/99-9/02	0 - 13.0	1.1

Existing Odor and Corrosion Facilities

Table 5 lists the existing odor and corrosion prevention equipment in the vicinity of the new diversion structure.

Table 5. Existing Odor And Corrosion Equipment in the Vicinity of Portal 41

Location	Equipment Type	Size	Area Served
North Creek Pump Station	Two Carbon Units	8,000 cfm	Wet Well
	Chemical Injection	7,000 gallons	Force Main/Discharge Structure
	Two Carbon Units	32,000 cfm	Storage Tank

New Brightwater Conveyance Facilities Requiring Odor Prevention

For all three influent tunnel alternatives, the existing North Creek diversion structure would be modified or a new one would be built to divert flows. For the Route 9-195th Street and Route 9-228th Street Alternatives, flows would be diverted to proposed Portal 41. Flows would be conveyed by approximately 3,000 feet of microtunneled 72-inch pipe that would be connected to the drop structure at proposed Portal 41. The drop structure at proposed Portal 41 would be susceptible to pressurization and would require vapor-phase treatment of all outgassing air. The structure would also be susceptible to outgassing air from the influent tunnel.

For the Unocal Site Alternative, flows would be diverted to proposed Portal 14, located in the North Creek Pump Station vicinity. The diversion structure would be similar to the proposed structure for the Route 9-195th Street and Route 9-228th Street Alternatives. Since this would be the beginning of the influent tunnel, the portal invert would be approximately 30 feet shallower than the invert of proposed Portal 41. A drop structure would still be required, and odor prevention would be required to treat the air volume of the diversion structure and access shaft at proposed Portal 14. The structure would also be susceptible to outgassing air from the influent tunnel.

For all influent tunnel alternatives, chemical injection would be required at the North Creek Diversion Structure to reduce dissolved sulfide levels in the influent tunnel. For the purposes of this study, it is assumed that Bioxide would be used. Assuming an average wet-weather flow of 35.3 mgd, the chemical injection rate would be 700 gpd. For a two-week supply of chemical, 10,000 gallons of chemical storage would be required. The North Creek Pump Station currently has a 7,000-gallon chemical injection facility that is dedicated for use with the North Creek force main.

Portal 7

The Unocal Site Alternative requires a proposed Portal 7 which would serve as the force main discharge structure for the influent tunnel. From proposed Portal 7, the influent tunnel would route flows to the treatment plant by gravity. Preliminary work on the tributary connections to the Brightwater influent tunnel indicates that proposed Portal 7 would include an access shaft.

Existing Odor and Corrosion Facilities

There is no existing odor or corrosion prevention equipment in the vicinity of proposed Portal 7 that would impact the proposed conveyance system.

New Brightwater Conveyance Facilities Requiring Odor Prevention

Proposed Portal 7 would receive flows from the influent tunnel force main. From there, flows would be conveyed by gravity to the Unocal Site. The force main structure would be susceptible to turbulences and pressurization and would require three-stage vapor-phase treatment of all outgassing air. It is assumed that additional chemical injection would not be required at proposed Portal 7, but would occur upstream at the proposed Kenmore Pump Station.

Effluent Tunnel Air Handling Facilities and Odor Prevention

For the Route 9-195th Street Alternative, air handling facilities would be required at proposed Portal 5 to allow air into and out of the effluent tunnel. For the Route 9-228th Street Alternative, air handling facilities would be required at proposed Portal 26. Proposed Portals 5 and 26 would have similar air volumes requiring treatment and the same odor prevention scenario would apply. Table 6 summarizes the new structures that would be associated with the effluent tunnel and the need for odor prevention at these structures. Those portals not requiring odor prevention will have sealed manhole lids, operate full with effluent, and will not vent to the atmosphere.

Table 6. Effluent Tunnel Odor Prevention Requirements for Primary Portals

Effluent Tunnel Alternative	Proposed Portal	Structures	Odor Prevention
Route 9 - 195th Street	5	Transition Structure	Yes
Route 9 - 228th Street	26	Transition Structure	Yes
Route 9 - 195th Street & 228th Street	19	Pressure Transition Structure	No
Unocal	33	Pressure Manhole	No
Unocal	39	Pressure Manhole	No

Targeted Odor Compounds

Wastewater odors are a complex mixture of chemical compounds from domestic and industrial sources. Odorous compounds most often emitted from domestic wastewater collection systems include inorganic and organic gases. The primary inorganic odorous gases are hydrogen sulfide and ammonia, which are a result of biological activity in the conveyance system or discharges of chemical waste from industrial facilities. Other odorous wastewater gases often found in collection systems include compounds such as mercaptans, organic sulfides, and amines.

Hydrogen sulfide and ammonia are often the most recognizable of wastewater odorous gases. Other odorous compounds in wastewater conveyance systems are not as easily recognizable and often are identified or described in general terms such as “general wastewater odors” or “organic odors.” The most frequently-identified odors in conveyance systems throughout the country, including King County’s system, are hydrogen sulfide and “general wastewater odors.” Ammonia odors are more often associated with processes that treat solids at wastewater treatment plants.

Quantification of Odor Impacts

Ventilation Rates

The air flow rates required for the tunnel portals for the Route 9 and Unocal Alternatives are presented in Tables 7 and 8. The rates shown are based upon the structure sizing as provided in the *Influent Tunnel Connections Technical Memorandum* and the requirement of 6 air-changes-per-hour in the connection structures and 12 air-changes-per-hour within the pump station wet well. The estimated purge rate of air from the influent tunnel during storage mode was estimated by the Brightwater Treatment Plan Design Team as 8,700 CFM. The purged air would result from the filling of the tunnel and the air volume being forced out either upstream or downstream at the connection structures. The odor-prevention equipment would be designed to treat this purged air.

Table 7. Ventilation Rates for Route 9 Portals

Location	Required # of Air Changes per Hour	Ventilation Rate (cfm)
Portal 11	6	9,000
Portal 44	6	9,000
Portal 41	6	11,000
Portal 5	6	2,000

Table 8. Ventilation Rates for Unocal Portals

Location	Required # of Air Changes per Hour	Ventilation Rate (cfm)
Portal 11	6 – Diversion Structure 12 – Pump Station Wet Well	25,000
Portal 14	6	7,000
Portal 7	6	5,000

Odor Concentrations

There is insufficient data available from the Kenmore/Bothell-Woodinville, Swamp Creek, North Creek, and Sammamish Valley Interceptors to estimate peak and average hydrogen sulfide concentrations for design purposes. King County conducted an odor monitoring and sampling program during the summer of 2003. Data from this study was not available at the time of publication of this report. Until data are available from the 2003 summer monitoring program, hydrogen sulfide concentrations are assumed for preliminary equipment sizing and selection. These concentrations are based on available information and experience. These concentrations are presented in Table 9. The concentration for annual peak and average daily hydrogen sulfide levels will be validated after data from the 2003 summer monitoring and sampling program is collected and analyzed.

Table 9. Assumed Annual Peak and Average Daily Hydrogen Sulfide Levels

Location	Tributary Interceptors	Assumed Hydrogen Sulfide Concentrations	
		Annual Peak (ppm)	Average Daily (ppm)
Portal 11	Kenmore/Bothell/Woodinville, Swamp Creek	15	1.5
Portal 44	Swamp Creek	5	<1
Portal 41 and 14	Sammamish Valley, North Creek	35	5.4
Portal 7	New Kenmore Pump Station Force Main Discharge	100	- - -
Portal 5 and 26	Effluent	< 1	< 1

Technology Selection

This section evaluates the technologies recommended at the screening workshops as potential odor-control strategies for the Brightwater Conveyance System. The odor-prevention technologies selected are consistent with experience at King County and on other conveyance system odor prevention projects.

Liquid-Phase Treatment Technologies

Liquid-phase treatment technologies treat the hydrogen sulfide (H_2S) in the liquid stream of collection systems before it is released as a vapor. Chemical injection stations are designed to reduce dissolved sulfide concentrations and resulting odors in the wastewater before it would reach the proposed Brightwater Wastewater Treatment Plant Influent Pump Station. Chemical injection would help in reducing the hydrogen sulfide loading associated with the air outgassing from the proposed tunnel, but would have minimal impact on requirements associated with the expected stripping of odorous gases from the tributary connection structures. The preferred liquid-phase treatment technologies are described below.

- Calcium Nitrate
- Iron Salts
- Sodium Hypochlorite
- Chemical Scrubber

Vapor-Phase Treatment Technologies

Vapor-phase treatment does not prevent corrosion, but treats the foul air emanating from sewers by removing odor-causing compounds from a gaseous stream prior to discharge to the atmosphere. The most common sewage system odor, often compared to the smell of rotten eggs, is attributable to hydrogen sulfide. Other reduced-sulfur compounds and low molecular-weight volatile organic compounds can also be part of an odor problem. The

vapor-phase treatment technologies discussed below were selected at the screening workshop.

- Activated Carbon – removes odor by filtering air through a bed of activated carbon.
- Biofiltration – removes odor by filtering air through a bed of compost or other biological media.
- Bioscrubber – removes odor by passing air through a wet scrubber which uses water which has active microbes that remove odors from the air.

Based on the assumed hydrogen sulfide design concentrations, two stage scrubbing would be required for most facilities for the Route 9 and Unocal primary portals. Some facilities would need three-stage scrubbing, depending upon the technologies selected. Tables 10 and 11 summarize the alternative technologies available for each portal for the Route 9 and Unocal Alternatives. The tables summarize expected hydrogen sulfide exhaust concentration based on typical removal efficiencies for each technology type and required facility size. Hydrogen sulfide exhaust concentrations were calculated based on the assumed annual peak concentrations presented in Table 9. Liquid-phase treatment would be required to reduce dissolved sulfide levels and hydrogen sulfide loading in the influent tunnel for all odor prevention equipment options. Odor prevention is not required at Portals 3, 33, and 39.

Table 10. Proposed Odor Prevention Facilities for Route 9-195th Street and Route 9-228th Street Alternatives

Location	Option No.	Odor Prevention Equipment Option[1]	Meets Removal Standard	Required Facility Footprint (sq.ft.)	
				Liquid Phase	Vapor Phase
Portal 11	1	2-stage Carbon Bed	Yes	Existing[2]	1,500
	2	Chemical Scrubber + Carbon Bed	Yes	Existing[2]	1,250
Portal 41	1	Chemical Scrubber+dual Carbon Bed	Yes	6253	1,000
	2	Bioscrubber + 2-stage Carbon Bed	Yes	625	3,150
	3	Bioscrubber +Chemical Scrubber + Carbon Bed	Yes	625	2,800
	4	2-stage Chemical Scrubber+Carbon Bed	Yes	625	1,250
Portal 44	1	2-stage Carbon Bed	Yes	____	1,500
Portal 5 or Portal 26	1	Carbon Bed	Yes	____	400

Table 11. Proposed Odor Control Facilities for Unocal Alternative

Portal	Option No.	Odor Prevention Equipment Option[1]	Meets Removal Standard	Required Facility Footprint (sq. ft.)	
				Liquid Phase	Vapor Phase
14	1	Chemical Scrubber+Carbon Bed	Yes	625	300
	2	Bioscrubber+2-stage Carbon Bed	Yes		800
	3	Bioscrubber+Carbon Bed+Chemical Scrubber	Yes		600
11	1	Chemical Scrubber+Carbon Bed	Yes	625	2,000
	2	2-stage Carbon Bed	Yes		3,200
7	1	2-stage Chemical Scrubber+Carbon Bed	Yes	—	700
	2	Chem Scrubber+2-stage Carbon Bed	Yes		1,000
	3	Bioscrubber+Chemical Scrubber+Carbon Bed	Yes		1,200
	4	3-Stage Chemical Scrubber	Yes		500

Comparison to Other Conveyance Facilities

The Brightwater Conveyance Facilities would have an odor-prevention system that is more sophisticated and comprehensive than most conveyance facilities in the United States. Not only would all the portals and hydraulic structures have odor prevention for treating escaping air, but the air would be treated in a multi-stage odor-prevention system to achieve low emission rates. There will be several additional features that would add factors of safety to the system. The following summarizes elements of the Brightwater Conveyance System Odor Prevention program that are not found in typical conveyance systems.

- Ability to capture all air and eliminate odor emissions and fugitive emissions from all structures along the pipeline
- Treats the collection system and treatment plant as one odor generation system
- Ability to capture and treat peak emissions
- Ability to meet low off-site odor thresholds
- Uses combined approach of liquid and vapor-phase treatment
- Provides for maintenance air treatment

Monitoring Effectiveness of Odor-Prevention System

Monitoring the odor-prevention system to ensure that it is working as designed will be paramount to the success of the odor-prevention program. There are five components that would be monitored:

- **Routine exhaust gas monitoring and scrubber hydrogen sulfide removal efficiency checks for the scrubber**. All odor prevention scrubbers would have routine measurements of the inlet and outlet (stack) gas hydrogen sulfide concentrations to make sure that the scrubber operation would be optimized.
- **Continuous scrubber chemical dose optimization**. Scrubber monitoring systems would measure residual hydrogen sulfide in the scrubber exhaust. If the levels are below the detection thresholds at the stack, then the levels would be even further below them at the property line. The monitoring would provide instant feedback to operators to raise or lower the chemical feed rate.
- **Handheld instrument checks of exhaust gas hydrogen sulfide concentration.** Handheld instruments would be used to spot-check scrubber inlet and outlet concentrations to calibrate continuous monitoring equipment. Handheld instruments can be more sensitive than online instruments and can help refine chemical dosing and ensure that the scrubbers are performing as designed.

If the odor-prevention system does not meet the design criteria for hydrogen sulfide or odor during routine operations, investigation of performance loss would be conducted using more refined analytical equipment. The sampling period could also be extended to ensure that the original sampling event was not caused by equipment parts failure, needs of equipment operating adjustments, or mistakes by the odor-analysis laboratories. If refined sampling or repairs showed that the scrubbers of the process still exceeded the design criteria, then each stage of the scrubber would be tested to see if the scrubber stage that was not performing adequately could be identified. Scrubber inspections and operation and maintenance (O&M) activities, such as scrubber cleaning or carbon replacement, could then be implemented. After the O & M activities, the scrubbers would be retested.

These monitoring procedures would be further refined in the design and startup phases. The monitoring would make certain that the existing scrubbing system functions optimally to meet the Brightwater odor standard of no detectable odors at the property line.

Attachment A

List of Sensitive Receptors for Each Corridor

Route 9-195th Street and Route 9-228th Street Corridors Sensitive Receptors within One-Mile of Portal Locations

Portal 11	Portal 44	Portal 41	Portal 5	Portal 19	Portal 26	Portal 33	Portal 39
Kenmore Elementary School	Kenmore Elementary School	Sorenson Early Childhood Center	North Seattle Christian School	Pacific Montessori Learning Center	Chase Lake Elementary	Shelton View Elementary School	Canyon Creek Elementary School
	Westhill Elementary School	Woodin Elementary School	Lake Forest Park Montessori	Hurray for Me School	Evergreen Elementary	Frank Love Elementary School	Canyon Park High School
	Shelton View Elementary School	Maywood Hills Elementary School	Cornerstone Christian School		Edmonds-Woodway High School	Lockwood Elementary School	Skyview High School
		Heritage Christian School	Snohomish County Christian School		Paladin Academy	Brier Terrace Middle School	Healthteam Northwest
		Saint Brendan Parish School	Medalia Health Care		Snohomish County Christian School	Providence Classical Christian School	
					Kumon Math & Reading Center of Edmonds		
					Brighton Elementary School		
					Cornerstone Christian School		
					Saint Pius X School		
					Stevens Hospital		

Unocal Corridor
Sensitive Receptors within One-Mile of Portal Locations

Portal 3	**Portal 7**	**Portal 11**	**Portal 14**
Chase Lake Elementary School	Lake Forest Park Montessori	Kenmore Elementary School	Sorenson Early Childhood Center
Sherwood Elementary	North Seattle Christian School		Woodin Elementary School
Madrona School	Saint Mark's Catholic School		Woodinville High School
Woodway Elementary School	Snohomish County Christian School		The Whole Earth Montessori School
Westgate Elementary School	Cornerstone Christian School		
	Medalia Health Care		