4-C
OUTFALL GEOPHYSICAL SURVEYS

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

King County Brightwater TREATMENT SYSTEM

Final

Appendix 4-C
Outfall Geophysical Surveys

August 2003

Prepared for King County by

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King County
Department of Natural Resources and Parks
Wastewater Treatment Division

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND / INTRODUCTION

1.1 Project Description

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.

1.2 Objective

Geophysical surveys were performed by Williamson & Associates, Inc., a subcontractor for CDM under King County Contract No. E23007E, Geotechnical Services for the Brightwater Conveyance System. CDM's role related to the Brightwater outfall is to support pre-design activities related to the preferred alternative outfall location (Zone 7S near Point Wells). These surveys were intended to supplement the prior studies (King County, 2001 and King County 2002a) with additional site specific data on bathymetry, bottom conditions, and sediments.

The geophysical surveys were performed in two separate phases: 1) an AMS-120 Geophysical Survey to obtain data over a broad area of potential outfall alignments and 2) a Sub-Bottom Profile Geophysical Survey to obtain more detailed sub-bottom and shallow seismic profiles along a specific target alignment identified based on the first survey results.

Specific objectives of the AMS-120 geophysical surveys were to:

- Characterize the lateral and vertical extent of the surficial sediment and subsurface geology.
- Identify possible surficial and subsurface geohazards or geologic conditions that might impact the construction or operation of the outfall and diffuser.
- Identify an outfall corridor and diffuser locations for further investigation.

The second, high-resolution survey augmented the bathymetric and sub-bottom information collected earlier with the AMS 120 sonar mapping system. This second survey was conducted to provide greater detail related to geology and slope morphology in an area of the survey region identified as a potential outfall pipe route.

1.3 Datum

1.3.1 Horizontal Datum

The project geodetic datum is the North American Datum of 1983, adjusted for HPGN in 1991 (NAD83/91). All coordinates are based on the Washington North Zone of the State Plane Coordinate System (SPCS83) and are in U.S. Survey Feet.

1.3.2 Vertical Datum

The project vertical datum is METRO Datum and all elevations are in feet. METRO Datum = North American Vertical Datum of 1988 (NAVD88) + 96.28 feet.

The bathymetric vertical datum is Mean Lower Low Water (MLLW) and all water depths are in feet. MLLW = NAVD88 + 2.29 feet. MLLW = Metro Datum - 93.99 feet.

2.0 EQUIPMENT AND METHODS

2.1 AMS-120 Geophysical Survey

The AMS-120 Geophysical Survey phase commenced on February 24, 2003 with the mobilization of the equipment on the vessel *Point Lavinia*, a 90-foot converted crew boat.

The AMS-120 is a deep seafloor mapping system capable of generating co-registered sonar imagery and interferometric bathymetry across a swath of up to 3,300 feet. The AMS-120 is a general purpose system with an emphasis on high resolution imagery. The bathymetric mapping capability allows cost-effective seafloor bathymetry maps to be made at 2 foot or better contour intervals.

The following equipment was mobilized:

- AMS-120 swath bathymetric sidescan sonar with integrated 4.5 kHz Sub-Bottom Profiler (SBP)
- ISIS Sonar Image Processing System
- SOSI oceanographic winch with 6500 feet of 0.45 inch oceanographic coax cable
- Trimble AgGPS Receiver with USCG differential signal input for horizontal positioning
- Coastal Oceanographics' HYPACK MAX trackline control and data logging software
- Knudsen 320M 28 and 200kHz depth sounder for "look ahead" towfish safety
- Trackpoint II ultrashort baseline (USBL) system for towfish positioning
- Overside pole for mounting Trackpoint transceiver and Knudsen transducer
- 2000-pound depressor and 24 inch sheave for AMS towing system.
- 60kW Deck Generator
- SeaBird 911 CTD Sound Velocity Profiler
- Pilothouse monitor for the helmsman

The area surveyed was a rectangle extending from a depth of 50 feet, 7,500 feet seaward from Point Wells at Richmond Beach and extending along the shore for 7,000 feet. This is the Zone 7S area from previous surveys. The survey was performed along 15 primary tracklines spaced 400 feet apart and several supplementary and ties lines as shown on Figure 1, AMS-120 Survey Tracklines.

Data was acquired simultaneously with the echosounder, sidescan sonar, and subbottom systems along each trackline to measure water depths and to obtain information on the seabed features and stratigraphy beneath the seabed. The sidescan data is also used to identify possible obstructions along the route. Pseudo range corrections were obtained from USCG beacon stations. The system provided real-time helmsman steering information, logged all position data, and also allowed generation of pre- and post-plot trackline displays for review of survey plan, data coverage and for field plotting of data.

Vessel control and positioning provided navigation and horizontal position accuracy to better than 3 feet. The navigation system was configured to operate at a 1-second data rate to yield an extremely high-density data set.

Calibration of all systems was conducted at the beginning of the survey. Frequent comparison of the single beam echosounder and the first return of the sidescan were made and data from tie lines were cross-checked during post processing to assure accuracy in data acquisition.

It was intended to use the Geopulse Boomer to get additional lower frequency subbottom data but equipment problems and necessity to stay in deeper water to protect the overside pole (which extended 6 feet below the keel) prevented its optimum use. A decision was made to perform the additional sub-bottom survey at a later date when specific outfall alignments had been identified.

2.2 Sub-Bottom Profile Geophysical Survey

Data collection for this portion of the project commenced April 21, 2003 with mobilization of all geophysical survey equipment aboard a privately-owned, 25-foot, jet-powered, survey and fishing charter.

The survey system deployed in this second phase consisted of a high-resolution echo sounder, a 3.5 kHz sub-bottom profiler system, a shallow seismic profiler system, and an integrated navigation and positioning system. The specific systems used were:

- GeoAcoustics GeoPulse Shallow Seismic Profiling System
- Datasonics 3.5kHz Sub-Bottom Profiler System
- Triton-Elics ISIS Sonar Data Acquisition System
- Odom 34kHz Echo Sounder System
- Trimble Ag132 DGPS System for horizontal positioning
- Hypack Max Integrated Navigation System for logging navigation data
- EPC 1086 Thermal Graphic Recorder
- SeaBird 911 CTD Sound Velocity Profiler

The high-resolution survey consisted of a centerline that was axially co-incident to the target pipeline alignment, 2 parallel “wing” lines to the north and 2 parallel wing lines to the south of this line, as shown on Figure 5, Sub-Bottom Survey Tracklines. The line spacing between each of these lines was 50 feet. In order to provide redundant coverage and to remove any echo sounder bias, the centerline was run twice, once in each direction. So as to highlight the regional geology, two additional lines were run: one approximately1,800 feet further to the north of the centerline, roughly parallel to Line 3 of AMS-120 survey and one approximately 800 feet south of the centerline, roughly parallel to Line 9 of the AMS-120 survey. Additionally, seven ‘tie’ lines were run, two in deep water, one at the slope toe, two mid-slope, one at the slope break and one in shallow water.

The transducers for both the 3.5 kHz and the echo sounder were deployed off the port side of the vessel nearest the transom, with the echo sounder being mounted on a separate pole approximately 2 feet forward of the 3.5 kHz transducer. The GeoPulse transducer was deployed to starboard and in line with the Datasonics transducer. The receiver array was towed inline to the transducer with the array center approximately 16 feet aft. The draft to the faces of all three transducers was approximately 2 feet. The DGPS antenna was located atop the pole where the Datasonics transducer was mounted. Given the close proximity of all the geophysical elements, no offsets other than transducer depths were applied.

The Trimble Ag132 provided pseudo-range corrected positions using the differential correction service operated by the USCG; with differential GPS lock being maintained throughout all survey operations. All navigation data were logged to the Hypack integrated navigation system.

The Hypack Max system was set up to output navigation data to the ISIS sonar data acquisition system, permitting the logging of navigation data into the ISIS sonar record. Both the Datasonics 3.5 kHz system and the GeoPulse shallow seismic system were integrated into the ISIS data acquisition system; with the data from each system being a separate sub-bottom/seismic channel in a single Triton-Elics (XTF) file.

The Odom echo sounder was installed with the 34 kHz transducer option and integrated into the Hypack navigation system. The auto ping rate was selected.

3.0 RESULTS

3.1 AMS-120 Geophysical Survey

Data collected during this geophysical survey are presented as Figure 2, AM-120 Survey Bathymetry, Figure 3, AMS-120 Survey 3-D Bathymetric Perspective, and Figure 4, AMS-120 Survey Sidescan Mosaic. The regional setting and man-made considerations are described in the Brightwater background documentation (King County 2001, 2002a, 2002b, and 2002c).

3.1.1 Positioning and Tracklines

All survey tracklines, described previously, are shown on Figure 1. Position data was reduced and checked for accuracy confirming the planned horizontal position accuracy of 3 feet or better.

3.1.2 Bathymetry

Bathymetric data obtained with the deep-towed AMS-120 interferometric swath bathymetry system provides higher resolution and more detail in deeper water than narrow-beam surface transducers. After adjustment for tidal and position, the bathymetric data at a water depth of 50 feet or more is estimated to have an absolute accuracy of better than 3 feet and a repeatability of about 1 foot. Bathymetric contours of the bottom are shown as depth in feet below Mean Lower Low Water (MLLW) on Figure 2.

A three-dimensional perspective view of the bottom surface is shown on Figure 3. The gaps in the data collected, appearing as faint geometric shapes in Figure 3, are visible in the northeast and southeast corners of the study area.

The bathymetry indicates a relatively narrow, shallow near-shore region with a slope break occurring at about 90-110 feet water depth. North of Line 8, the slope is steep and unbroken to the 660 feet contour where beyond the slope base the bathymetry becomes relatively flat. In contrast, in the region of Lines 9, 10, 11 and 12, the slope becomes much more complex with a second break occurring mid-slope and an approximately 600-foot wide, 30-foot deep trench occurring at the slope base.

In addition, three natural ravines occur. The first, a small ravine south of line 5, the second, much more pronounced ravine occurring approximately coincident to Line 11 and a third ravine occurring north of Line 13. The origin of the ravines and of the complex slope morphology is uncertain from the bathymetric data and may warrant further geophysical investigation if the final alignment should encounter these features.

3.1.3 Sidescan

A mosaic of all the sidescan swaths is presented on Figure 4. The higher resolution original records were reviewed to identify slope and bottom features. The sidescan imagery show the steep gradient relatively near shore incised with ravines, a deeper channel at the base of the slope and a relatively flat, featureless deeper floor at depths of 600-700 feet.

Several sidescan targets are noted and are listed in Table 1. Causal inspection of Target 1 suggests that it has the outline of a wreck but closer inspection indicates that this feature is more likely geologic in origin. Targets 2, 3 and 4 are all relatively large features, with hard returns, but show little evidence that they stand proud of the seafloor. Target 5, seen on three separate images, is a hard return that stands well proud of the sea floor; the feature is approximately 35 feet long, relatively thin (about 3 feet) and casts a significant shadow. Preliminary interpretation is that this feature is metal debris, possibly a hatch cover or trawl door that has fallen overboard and knifed into the sediments. Preliminary examination revealed no cables.

Table 1: Sidescan Sonar Target List

Target Number	Line	Location		Size	Evaluation
		Northing	Easting		
1	BW01	290,606	1,253,754	60’ x 19’	Geology
2	BW01	290,515	1,253,415	20’ x 3’	Debris
3	BW09	287,134	1,252,752	32’ x 4’	Debris
4	BW14	284,508	1,252,457	14’ x 3’	Debris
5	BW15a BW15 Cal2	283,582	1,251,658	35’ x 3’ Est. height 6’	Debris, hard return, casts a shadow

3.1.4 Sub-Bottom Survey

As is to be expected, the sub bottom record is limited by the relatively low acoustic penetration of 4.5 kHz system in the sediment types occurring in the region. However, the system is not without merit, as the 4.5 kHz record clearly reveals a relatively thin layer of younger, presumably re-worked material mantling much of the topography. South of Line 9, the sub bottom record hints at further geologic complexity occurring at the toe of the slope. Copies of all the subbottom records were provided to CDM for further interpretation and evaluation.

3.2 Sub-Bottom Profile Geophysical Survey

3.2.1 Positioning and Tracklines

All survey tracklines, described previously, are shown on Figure 5. The navigation data were high quality differential GPS, accurate to within 3 feet and required very little post-processing to produce survey track lines. The boat handling also proved to be quite good, resulting in relatively little cross-track error from the intended survey line. Event marks were recorded every 200 feet along track and are plotted on the track line map, the water depth profiles were recorded in the ISIS file and are displayed on the analog sub-bottom and seismic records.

3.2.2 Bathymetry

Echo sounder data was collected with the Odom set to its auto ranging mode. In auto mode, the Odom worked unattended to approximately 450 feet water depth; however, below this depth the system required occasional transmit power and receive gain adjustments to maintain bottom track. In general, the bathymetric data are of very high quality.

The echo sounder data were edited using the Single Beam Editor Utility in the Hypack Max system and depth corrected using 1,488m/s for the speed of sound in water as calculated from a CTD profile. Editing amounted to de-spiking the raw data and clipping out the areas where bottom track was lost for more than a few successive pings. The edited bathymetric data were tide corrected in Hypack Max using the verified NOAA tide-curve as referenced to the Seattle (9447130) tide-station and zonally corrected to Edmonds, Washington.

Where survey lines intersect, the tide-corrected bathymetry agrees to better than a foot. It is further noteworthy, that in water depths greater than about 70 feet, the bathymetry inferred from the 6 lines (2 centerlines and 4 wing lines) which run the length of the preferred route tied to the bathymetry derived from the February 2003 AMS-120 survey within about one foot.

3.2.3 Sub-Bottom Survey

The Datasonics 3.5 kHz and the GeoPulse profiler systems were operated concurrently and timed via a single trigger pulse initiated by the EPC 1086 recorder. The data from both systems were digitally logged as independent sub-bottom channels to the ISIS sonar data acquisition system while, the navigation string provided by Hypack was logged to the header of each ping. The ping rate of 450 μs was selected to maximize the data coverage across the widely varying water depth. An 8 bit, 4 Kb sample was taken for each channel and for each ping.

As is expected, the 3.5 kHz Datasonics system produced a record similar to the AMS 120’s 4.5 kHz sub-bottom profiler; and as with the 4.5 kHz, the acoustic penetration of the 3.5 kHz, was typically 10-15 feet and occasionally as much as 30-40 feet. On both 4.5 kHz and the 3.5 kHz records, indications of bedding were typically indistinct so that relationships between geologic units were most often indeterminate.

The GeoPulse system, with a center frequency of ~700 Hz, was selected as an acoustic source because it is capable of greater acoustic penetration than the 3.5 kHz while providing better resolution than a bubble pulser. On the slope and in shallow water, the acoustic penetration of this system was typically 80 feet or more and often in excess of 150 feet. In the deep-water flats, the acoustic resolution was much less, likely due to thick, weakly layered homogeneous sediments. The GeoPulse record, in general, was good at revealing bedding and highlighting the stratigraphic relationships between geologic units. The GeoPulse system proved particularly useful at delineating the thickness of the postglacial sediment drape.

Synthesizing the available geophysical data from the GeoPulse, the 3.5 kHz and from the AMS-120 survey and summarizing this information, six informal geologic units and a regional unconformity are recognized as shown on Figure 6, Sub-Bottom Centerline Profile:

- **Upper Stratified Unit** – This unit is horizontally stratified to slightly westward dipping and occurs from approximately 35 feet to 330 feet water depths. The base of the unit is sub-horizontal with perhaps 15 feet of topography.

- **Unstratified Unit** - This unit is massively bedded, approximately 100 feet to 165 feet thick. The basal contact of the unit dips eastward and cuts the lower stratified unit. The unit is probably a glacial till.

- **Lower Stratified Unit** - This unit is horizontally stratified with the base of the unit at 575 feet water depth. Compared to the upper stratified unit, acoustic penetration is relatively low. Some evidence for (active?) soft-sediment deformation and down-slope sediment transport, particularly near the basal contact of the unit.

- **Acoustically Opaque Sediments** – This unit has very low acoustic penetration on either the 4.5 kHz, 3.5 kHz or GeoPulse records. The basal contact was not observed but the unit is interpreted to be well indurated glacial till at greater than 575 foot water depth beneath the slope.

- **Regional Unconformity** - This feature is a glacial erosional surface that cuts the Upper Stratified, Unstratified, Lower Stratified units, and Acoustically Opaque Sediments.

- **Deepwater Sediments** – These weakly layered, horizontal bedded, homogeneous sediments occur stratigraphically above the regional unconformity. Low acoustic penetration was achieved on the 4.5 kHz, 3.5 kHz or GeoPulse records. The unit is most likely post-glacial infill of the Puget Sound.

- **Post-Glacial Sediment Drape** – This is the surficial unit in the survey area that mantles the postglacial topography. On the slope, the unit is variable in thickness from less than about 5 feet to occasionally more than 20 feet, tending to be thickest nearest shore and at the slope toe. In deepwater, the unit grades into a thick, weakly layered homogenous sediment.

4.0 SUMMARY

The AMS-120 and Sub-Bottom geophysical surveys, conducted in the vicinity of the proposed outfall pipe alignment, were successful in identifying the subsurface bathymetric and geologic conditions. Key information gained from the surveys included:

- **Sidescan Targets** – Generally the bottom is free of ship wrecks or other man-made features. Five targets were evaluated with the sidescan sonar. Of the five, one appeared to be geologic in nature, three were evaluated to be flat-lying debris, and one was evaluated to be debris standing about 6 feet above the sediment surface.

- **Bathymetry** - The bathymetry indicates a relatively narrow, shallow near-shore region with a steeper slope break occurring at about 90-110 feet water depth. In the northern portion of the survey area the steeper slope is unbroken to about the 660 feet contour becoming relatively flat further to the west. In the southern portion of the survey area the slope becomes much more complex with a second break occurring mid-slope. An approximately 30 feet deep trench occurs at the base of the slope. An area near Tracklines 7 and 8 has the flattest slope (about 15 degrees), a more uniform slope, a less abrupt transition at the base of the slope, and no significant, unusual bathymetric or sub-bottom features that are evident. This is the area selected for further study. Other locations have a more irregular slope; the slopes are much steeper towards their toe (on the order of 26 – 35 degrees in some areas).

- **Ravines** – Three natural ravines occur within the survey area. The origins of the ravines and of the slope break are uncertain from the bathymetric data. The ravines have irregular features and are considered to have a potential for continuing down slope movement of the post-glacial sediment.

- **Sub-Bottom Profile** – The sub-bottom profile encountered a veneer of more recent sediments (Holocene drape) over topography of denser, stratified and unstratified sediments probably of glacial origin. The sediment drape is variable in thickness from less than about 5 feet to occasionally more than 20 feet, but tending to be thickest nearest shore and at the slope toe and beyond. The sub-bottom data implies potential movement of these surficial soils on the slope.

Using the bathymetry, side-scan sonar and sub-bottom profile data, the CDM Team examined alternate alignment configurations and recommended an outfall alignment for further study centered in the area where the second phase Sub-Bottom Survey was performed. This alignment crosses the seabed with the least gradient and the least irregular centerline profile as compared to other potential alternatives. The recommended alignment avoids the three ravines disclosed in the bathymetric and sidescan sonar data, and none of the identified sidescan targets surveys are near the alignment. The recommended route alignment also revealed the minimum thickness of potentially weaker Holocene drape (the surficial veneer of more recent sediments), which would lessen the risk for earthquake-induced liquefaction or slope failure. The side-scan sonar data also confirmed that the recommended route alignment avoids slope areas that may have experienced deeper slope failures in the geologic past.

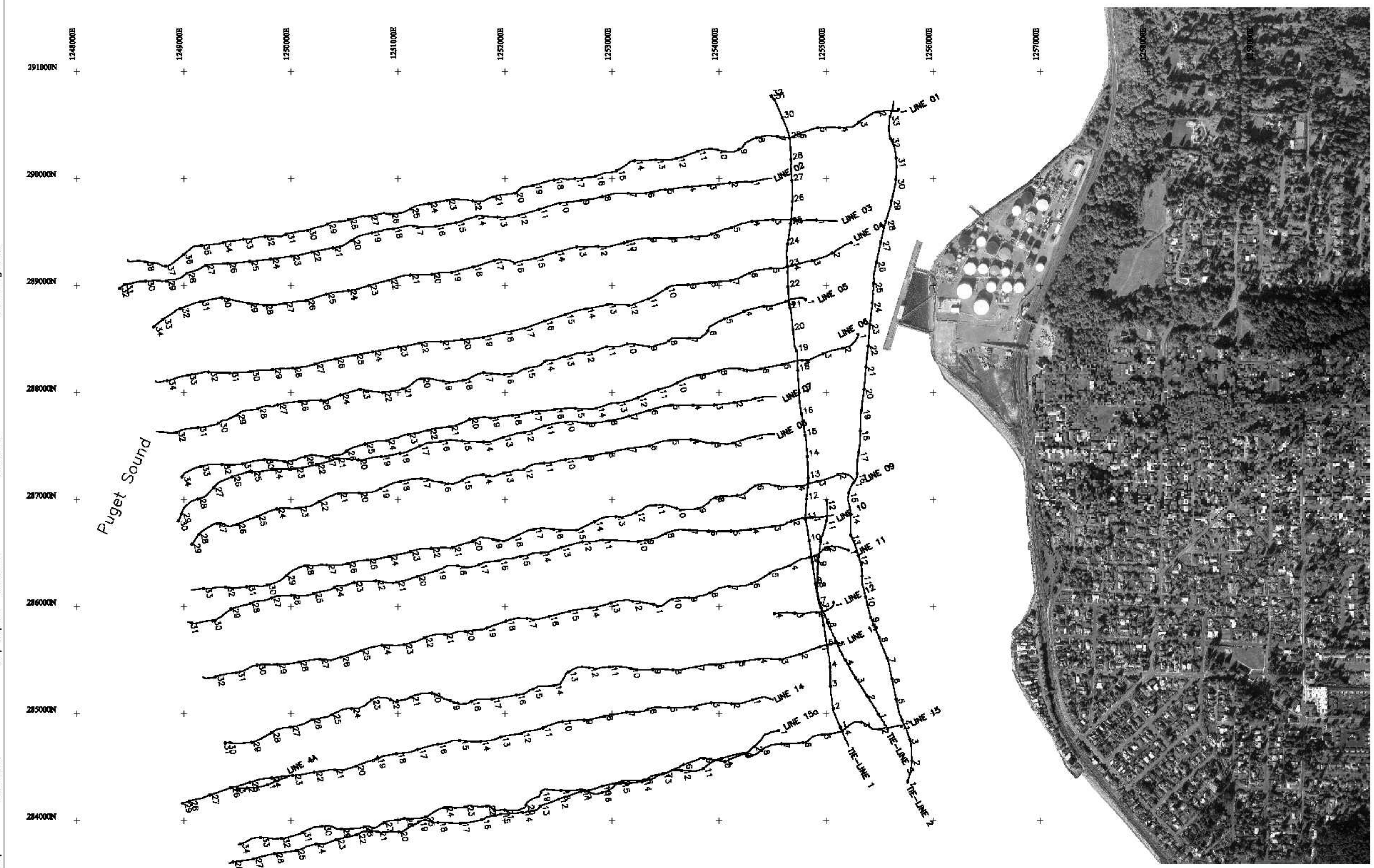
5.0 REFERENCES

King County, 2001. *Marine Geophysical Investigation, Marine Outfall Siting Study.* Seattle, Washington.

King County, 2002a. *Brightwater Marine Outfall Conveyance System, Interim Conceptual Geotechnical Assessment.* Seattle, Washington.

King County, 2002b. *Brightwater Regional Wastewater Treatment System Draft Environmental Impact Statement.* Seattle, Washington.

King County, 2002c. *Brightwater Marine Outfall Conceptual Design Report*. Seattle, Washington.



Notes:

System: AMS-120 Deep Seafloor Mapping System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Swath Width: 1,000 feet

Geodetic Parameters:

Horizontal Datum: NAD83/91

SPSC Zone: Washington North

Grid Units: U.S. Survey Feet

LEGEND

TRACKLINE WITH TIMING MARKS

N

0 500 1000 Feet

June 2003

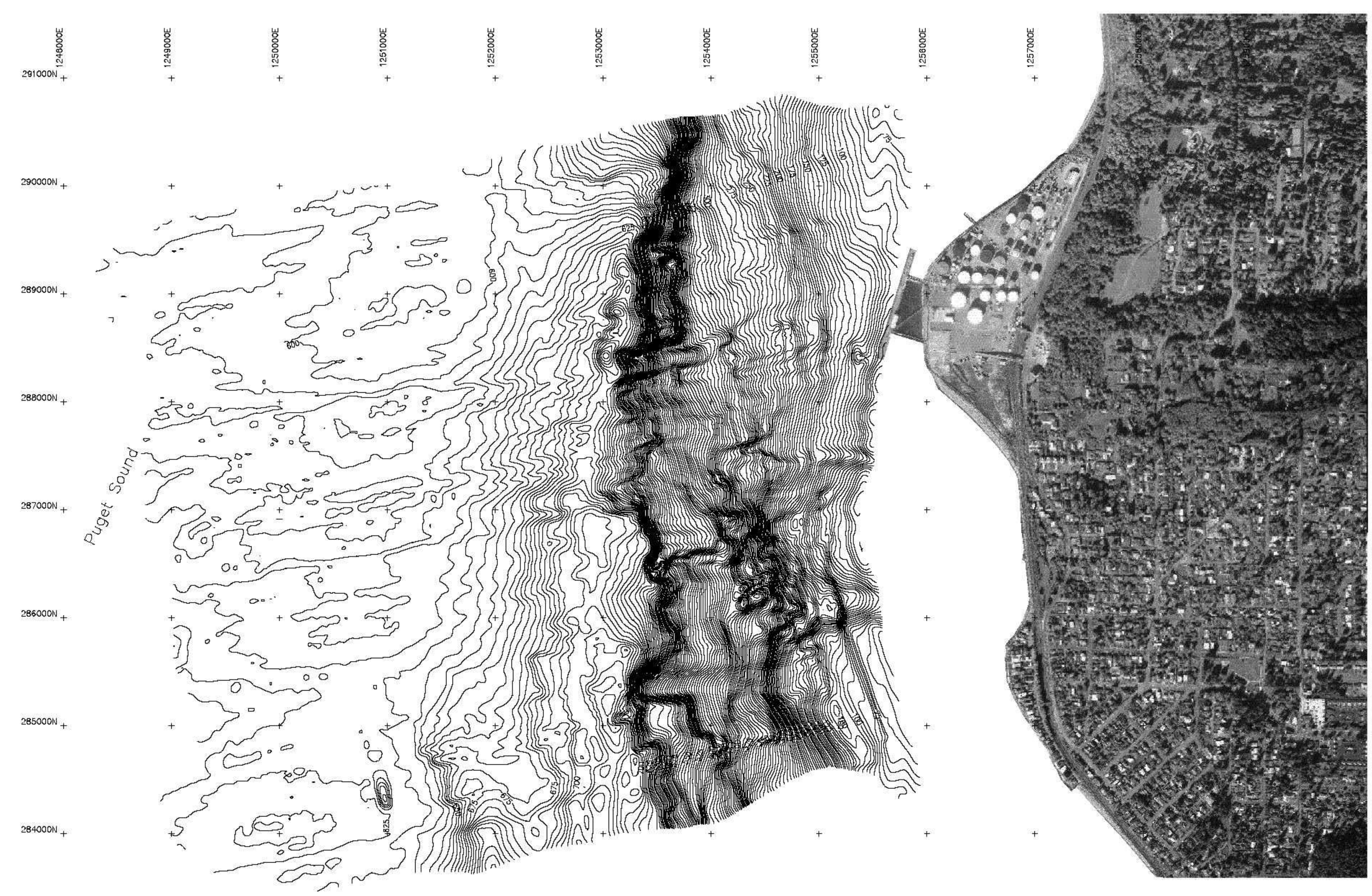
P:\19897\37576\offshore\track01 06/12/03 10:28:21 7:52:38 Wainwrightmd

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Data Sources: Williamson and Associates, March 2003

File Name: [illegible].dwg

Figure 1
AMS-120 Survey Tracklines
BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



Notes:

System: AMS-120 Deep Seafloor Mapping System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Swath Width: 1,000 feet

Geodetic Parameters:

Horizontal Datum: NAD88/91

SPSC Zone: Washington North

Grid Units: U.S. Survey Feet

Vertical Datum: MLLW

Conversions: MLLW = NAVD88 + 2.32 feet;
MLLW = Metro Datum - 93.96 feet

LEGEND

250 / 225 Bathymetric Contours (Depth)
Contour Interval = 5 feet

N

0 500 1000 Feet

June 2003

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Department of
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Wastewater Treatment Division

Data Sources: Williamson and Associates, March 2003

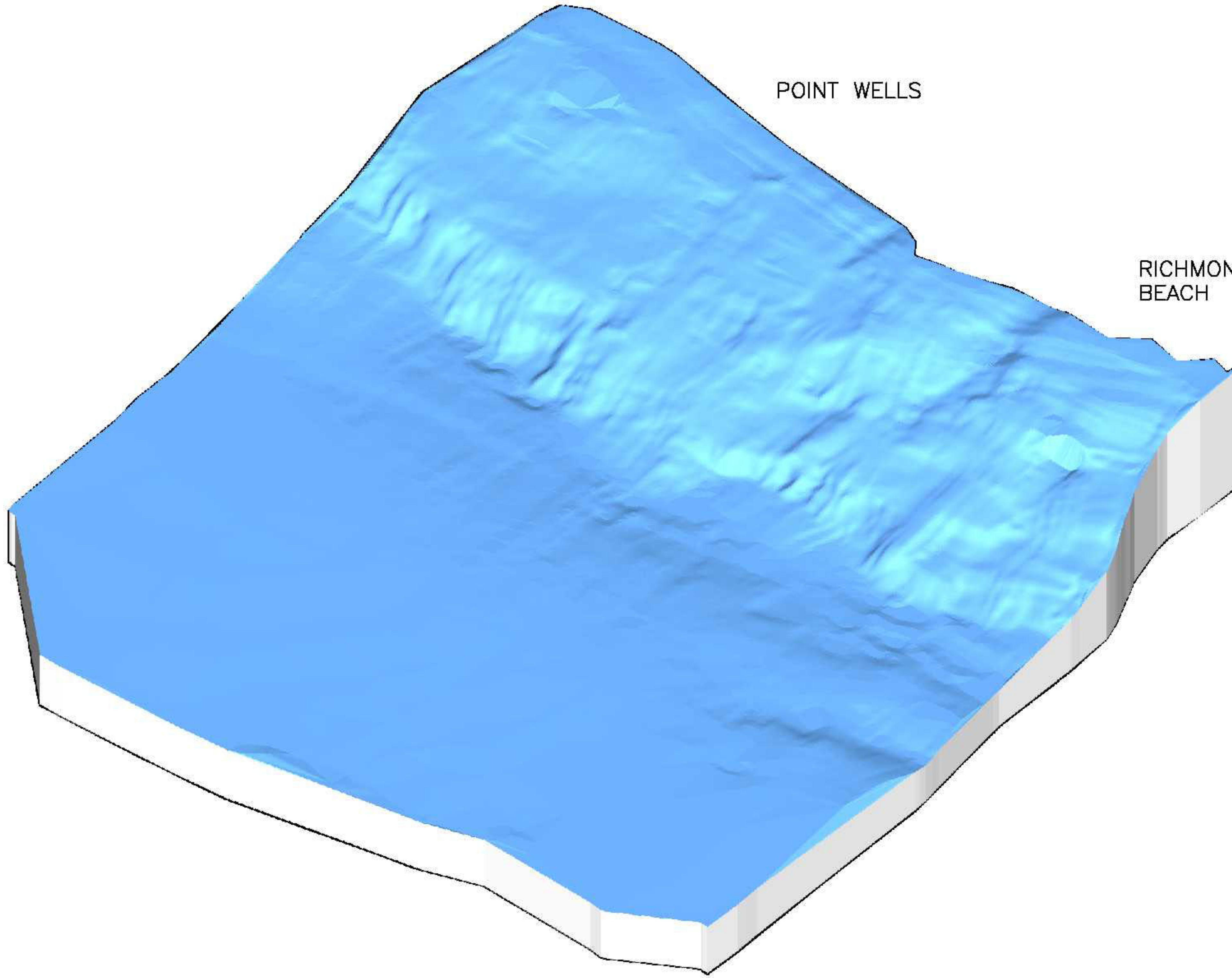
File Name: bath01.dwg

Figure 2

AMS-120 Survey Bathymetry

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM

P:\19897\37576\offshore\ bath01 06/12/03 11:58:09 9:10:23 Wainwrightmd



Notes:

System: AMS-120 Deep Seafloor Mapping System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Swath Width: 1,000 feet

Geodetic Parameters:

Horizontal Datum: NAD83/91

SPSC Zone: Washington North

Grid Units: U.S. Survey Feet

King County
Department of
Natural Resources and Parks
**Wastewater Treatment
Division**

Data Sources: Williamson and Associates, March 2003

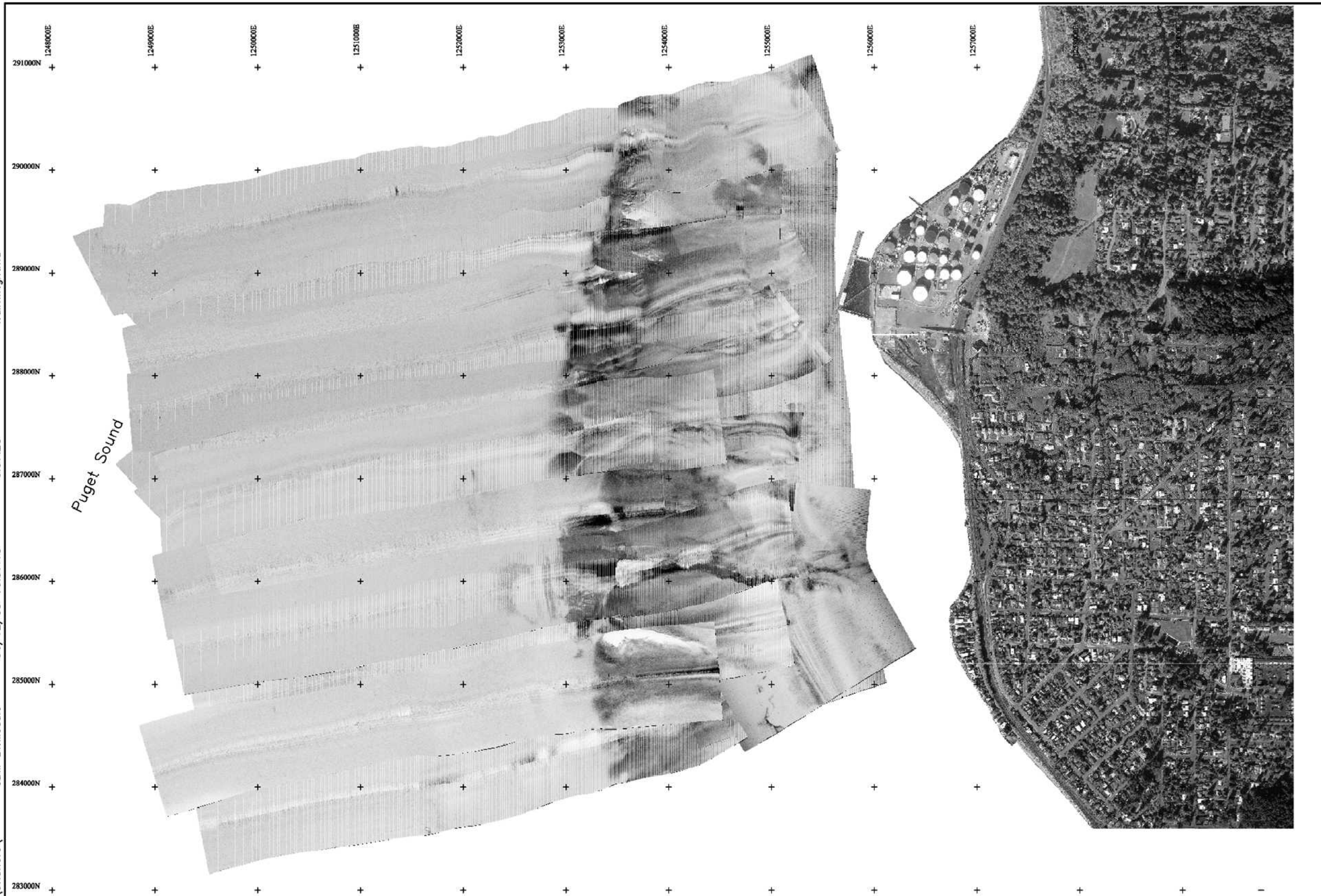
File Name: tm05af03.dwg

Figure 3

AMS-120 Survey 3-D Bathymetric Perspective

BRIGHTWATER REGIONAL
WASTEWATER TREATMENT SYSTEM

P:\19897\37576\offshore\ 3d 06/12/03 11:06:35 11:33:46 Wainwrightmd



Notes:

System: AMS 120 Deep Seafloor Mapping System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Swath Width: 1,000 feet

Geodetic Parameters:

Horizontal Datum: NAD88/91

SPSC Zone: Washington North

Grid Units: U.S. Survey Feet

N

0 500 1000 Feet

June 2003

P:\19897\37576\offshore\ CDM BWMosaic 06/12/03 10:57:13 6:07:23 Wainwrightmd

King County
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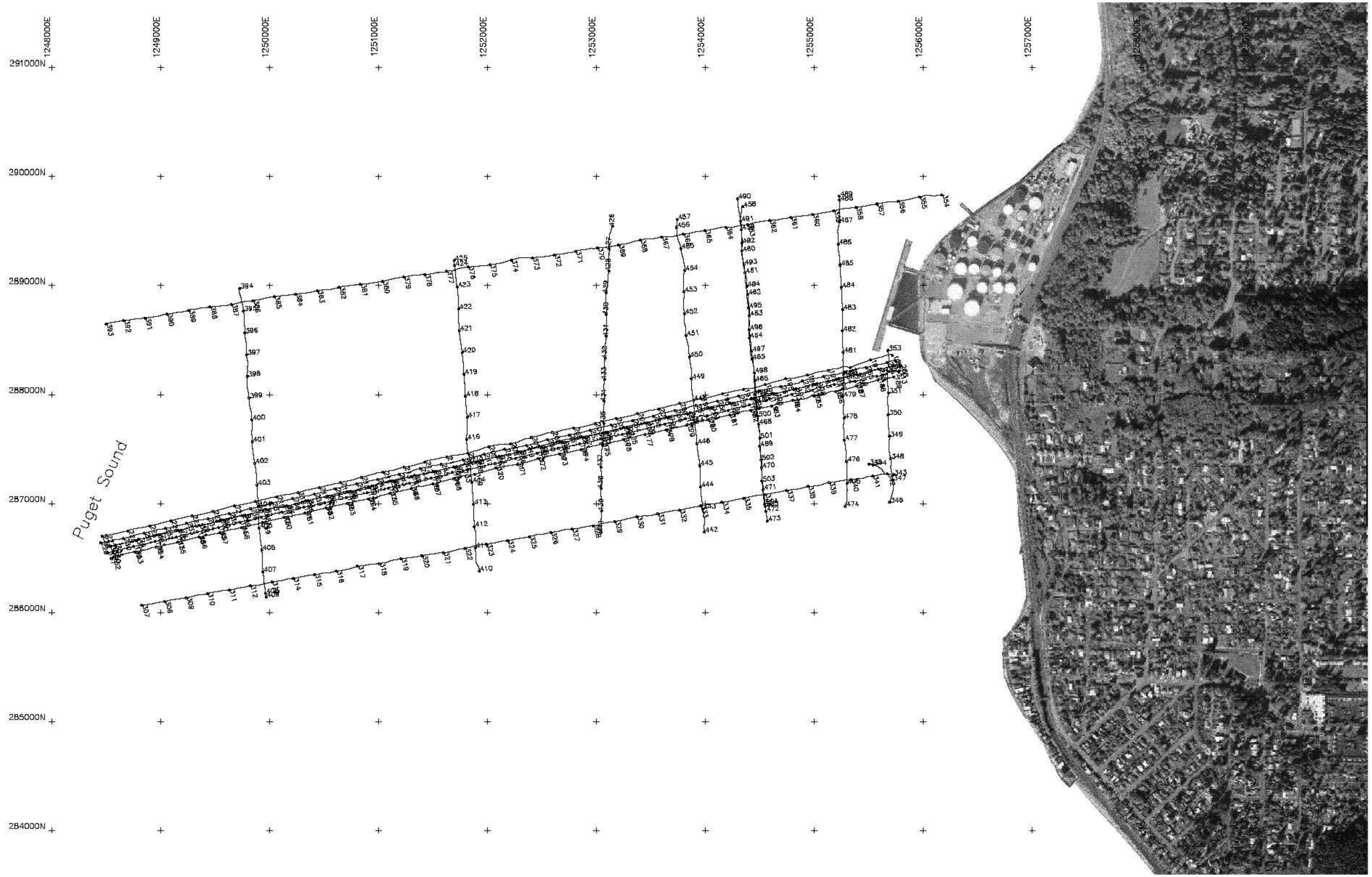
Wastewater Treatment Division

Data Sources: Williamson and Associates, March 2003

File Name: tm85af04.dwg

Figure 4
AMS-120 Survey Sidescan Mosaic
BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



Notes:

System: Odem Echo Sounder System, Datasonics Sub-Bottom Profiler System, GeoAcoustics GeoPulse Shallow Seismic Profiling System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Geodetic Parameters:

Horizontal Datum: NAD88/91

SPSC Zone: Washington North

Grid Units: U.S. Survey Feet

LEGEND

Trackline with Timing Marks

N

0 500 1000 Feet

June 2003

King County
Department of
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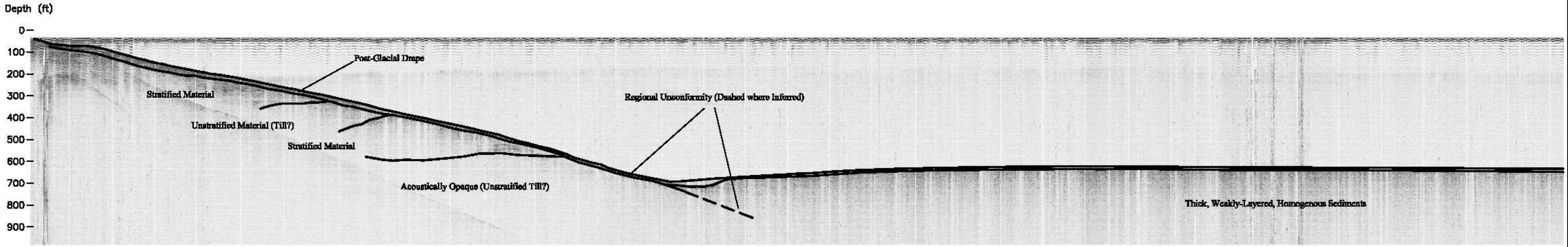
Wastewater Treatment Division

Data Sources: Williamson and Associates, March 2003

File Name: track02.dwg

Figure 5
Sub-Bottom Survey Tracklines
BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM

P:\19897\37576\offshore\track02 06/12/03 11:50:19 7:26:11 Wainwrightmd



Notes:

System: GeoAcoustics GeoPulse Shallow Seismic Profiling System

Navigation: Trimble AG132 DGPS and Trackpoint II, Hypack Integration

Vertical Exaggeration ~ 1.15x

0 250 500 Feet

June 2003

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Data Sources: Williamson and Associates, May 2003

File Name: tm65a06.dwg

Figure 6
Sub-Bottom Survey Centerline Profile
BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM

P:\19897\37576\offshore\sub-bottom 06/12/03 11:30:25 13:28:06 Wainwrightmd