Appendix A

PRELIMINARY GEOLOGIC/GEOTECHNICAL EVALUATION OF SOUTH MAGNOLIA CSO ALTERNATIVES

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON

December 1, 2009

Mr. Allen de Steiguer
Carollo Engineers
1218 Third Avenue, Suite 1600
Seattle, WA 98101

RE: PRELIMINARY GEOLOGIC/GEOTECHNICAL EVALUATION OF MAGNOLIA COMBINED SEWER OVERFLOW (CSO) ALTERNATIVES, SEATTLE, WASHINGTON

Dear Mr. de Steiguer:

At your request, we have performed a preliminary evaluation of potential alternatives along an alignment for a proposed CSO project at the southeastern corner of Magnolia, otherwise known as the Magnolia Bluff. We understand that you are evaluating approximately nine alternatives for this CSO, of which these three appear to contain particular geotechnical challenges. The purposes of our preliminary study are to understand the geologic conditions in this area and to determine the geotechnical limitations and opportunities for the CSO project.

The scope of our preliminary study included a literature review consisting of Shannon & Wilson and City of Seattle (City) files, a site reconnaissance, a meeting with you to discuss our preliminary findings, and preparation of this report.

SITE DESCRIPTION

The project site is Magnolia Bluff, between 32nd Avenue West and 23rd Avenue West. The proposed schemes include a structure(s) on the east side of the 32nd Avenue West ravine, a tunnel and/or shallow trench along an approximate alignment of Magnolia Boulevard West and West Galer Street, and structure(s) near the corner of 23rd Avenue West and West Marina Place. A LiDAR image, Figure 1, shows this approximate alignment.

Topography of the alignment is varied. The east side of the 32nd Avenue West ravine is a 50-foot-high steep slope. The alignment is relatively flat in Magnolia Park, east of which the ground surface slopes up steeply about 20 feet to Magnolia Boulevard West. This street and

West Galer Street are somewhat level until the road slopes down to the east toward the Magnolia Bridge near Thorndyke Avenue West. At this point, the alignment diverges from the roadway, going down a steep hillside to the east or southeast. This hillside is about 140 feet high and contains a wide bench on which a U.S. Navy residence is located. The bottom of the slope is the southwestern corner of Smith Cove and the entrance area of the Elliott Bay Marina.

GEOLOGIC CONDITIONS

The soil conditions in the project area are the result of nonglacial and glacial processes during the Pleistocene Epoch, post-glacial geologic processes, and human modification of the ground surface. As shown in the profile of Figure 1, a 10- to 20-foot-thick layer of Vashon till (Qvt) covers the upland. Our knowledge of this is derived from borings completed for previous projects as well as exposures of soil noted by our geologists. The till is a very dense, gray, silty, gravelly sand that has a low permeability. Till is underlain by Vashon advance outwash (Qva), as noted in past geotechnical reports; however, it appears to be thin to non-existent in this area; an unusual condition compared to the rest of the Seattle area. The advance outwash is a sand or sand and gravel that in general has a high permeability. The dominant geologic unit in the Magnolia Bluff area is the Lawton Clay or glaciolacustrine deposit (Qvgl). On the western end of the proposed alignment, this clay and silt may be only tens of feet thick where it is underlain by sand, gravel, silt, and clay layers of the Olympia Beds (Qpnl and Qpnf). However, in the central part of the alignment, the Lawton Clay may be more than 100 feet thick and extend to below sea level. Older pre-Vashon clay layers (Qpgl) also underlie younger sediments beneath Smith Cove.

At the eastern end of the proposed alignment, the level ground between the toe of the steep slope and 23rd Avenue West contains landslide debris (Hls) from the steep hillside. This is overlain by natural beach deposits (Hb). Both are underlain at about 50 feet by a hard pre-Vashon clay deposit. Farther eastward, the natural soils of Smith Cove are covered with fill that is 10 to 20 feet thick.

The steep hillsides of Magnolia Bluff are well known for slope instability. The Galer Street Landslide was active in 1969, and was explored and studied by Shannon & Wilson for the City in 1970. There are no records to indicate whether the proposed remedial measures (horizontal drains and a toe buttress) for this landslide were implemented by the City. A low retaining wall

was constructed along the headscarp of the landslide (southern edge of Magnolia Boulevard West); however, it does not appear that the retaining wall is deep enough to permanently retain the roadway.

The Magnolia Bluff Landslide was a deep-seated rotational feature. It frequently pushed up the beach at the toe of the bluff. Placement of fill for the Elliott Bay Marina parking lot and restaurant in the 1980s stopped the deep-seated rotational movement; however, there is still potential for localized shallow sloughing of the bluff to the south of the residences that line the top of the slope.

The Magnolia Bridge Landslide occurred in January 1997 as a result of a major rain-on-snow event. This landslide was stabilized in 1997 by constructing a reinforced, tieback wall and regrading the slope below it. No reports of landsliding have been reported at this site since the completion of the remediation.

During the exploration phase for the Magnolia Bridge replacement in 2007 and 2008, historical research was performed and environmental testing was carried out on soil samples obtained from test borings. These activities indicate that the Port of Seattle Terminal 91 bulk fuel facility is under an Agreed Order with the Washington State Department of Ecology for soil and/or groundwater contamination. Soil in three of the borings drilled and tested to the north and east of Pier 91 for the Magnolia Bridge alignment were determined to contain contaminants. It was determined that excavations or groundwater pumping would be likely to encounter contaminated soil and groundwater in these areas.

GEOTECHNICAL APPLICATIONS

Four types of construction were considered for the proposed Magnolia CSO in this preliminary study: open trench, horizontal directional drilling (HDD), microtunnel boring machine (MTBM), and conventional large-diameter tunnel boring machine (TBM). Open trench would be suitable on the level portions of the alignment, although portions are in active Seattle parks and excavation on arterials would disrupt traffic. Additionally, the 400-foot-long section of pipeline to the north of the headscarp of the Galer Street Landslide would require additional study of that landslide and perhaps a more positive stabilizing measure than is presently in place. Open trench construction on the steep slopes at the eastern and western ends of the alignment

would be technically possible; however, construction in an environmentally sensitive area would be likely to trigger a lengthy regulatory process, particularly with the Seattle Department of Parks and Recreation.

HDD would be suitable technology for this project, either with two short runs on the eastern (700 feet) and western (500 feet) ends of the alignment, or a single run of about 3,000 feet from east to west. We understand that the pipe diameter would range from about 18 to 21 inches for such a force main, which would require a bore diameter ranging from about 27 to 30 inches. Owing to the elevation differential for both of the shorter bores (140 feet on the east end and 70 feet on the west end), we recommend that the entry points be located at the lower elevations. The paucity of sand and the dominance of clay are positive factors for an HDD application, as the high groundwater pressure at the sand/clay contact commonly found in the Puget Lowland region may not be present. Layout corridors for pipe for the two relatively short bores are suitable, assuming that a lane of the arterials (West Galer Street and Magnolia Boulevard West) could be temporarily blocked for the pipe pullback. Installation of these two relatively short bores could likely be accomplished by local construction companies.

Alternatively, an HDD could be completed in a single bore from the east (lower) portal to the west (upper) portal. The pipeline layout area in the 32nd Avenue West ravine would be more difficult than the eastern end across Smith Cove but, nevertheless, still achievable, in our opinion. Such a long HDD bore would likely require the resources of a large, national construction company.

A MTBM in the range of 8- to 10-foot-diameter would be feasible. Diameters of 12 feet are also possible, but few machines are available locally. The hard glacial clay anticipated along the majority of the alignment is considered to be a good tunneling medium for a MTBM. Since groundwater is anticipated along the tunnel drive, the MBTM will likely be a closed-face pressure balance machine, either slurry pressure balance (SPB) or earth pressure balance (EPB). The SPB machine is better suited for excavating cohesionless granular soils and the EPB machine is better suited for cohesive clayey soils. Consequently, an EPB machine is likely the best machine for this project. To facilitate the long tunnel drive, a series of intermediate jacking stations will be required at about every 800 to 1,000 feet, so two to three would be needed for a 3,000-foot-long tunnel. An intermediate jacking station consists of a fabricated steel cylinder with integrated hydraulic jacks that are incorporated into the pipeline string between two

consecutive pipe segments. Their function is to distribute the jacking load along the pipeline string on long drives. To construct the tunnel, a launch and retrieval shaft will be required at each end of the project. The east side of the alignment would be a logical choice for a launch shaft and staging area, because of the open area between the toe of the slope and 23rd Avenue West compared to the confined space in the 32nd Avenue West ravine at the western end. The launch shaft will have to be sized to accommodate the MBTM, a 10-foot-section of pipe, the jacking mechanism, and the reaction block. Typically, a launch shaft for an 8- to 10-foot-diameter MTBM is about 25 feet wide by 40 feet long by about 20 to 25 feet deep. The retrieval shaft is generally smaller since it is only needed for the removal of the MTBM. Typical retrieval shafts are 25 feet square by 20 to 25 feet deep. The depth of the shaft provides for a minimum soil cover of about one tunnel diameter.

If King County requires in-line storage, a larger tunnel could be bored with a conventional TBM. We understand that a diameter of 12 to 14 feet would be likely in this case. Similar to the MTBM, the hard glacial clay will be a good tunneling medium and the TBM will likely be a closed-face EPB machine. The TBM tunnel will also require a launch and retrieval shaft at each end of the project. The launch shaft should be sized to accommodate placement of the TBM and trailing gear. Typically, a launch shaft for a 12- to 14-foot-diameter TBM is about 35 feet wide by 140 feet long by about 25 to 30 feet deep. A typical retrieval shaft for a 12- to 14-foot-diameter TBM is about 35 feet wide by 50 feet long by 25 to 30 feet deep. Like the MTBM, the depth of the shaft provides for a minimum soil cover of about one tunnel diameter.

For any of the options that involve excavation into the steep hillsides, shoring would be necessary for the portals and the structures there. Because the excavations may be as high as 70 feet, tieback installations would also be necessary. The shoring could be temporary or permanent, depending on the desired final configuration and City requirements. Foundation support would be suitable on the western end, because the soils will be glacially overridden; however, at the eastern end, the soil at the bases of the structures would be either landslide debris or beach deposits, both of which would not be suitable for bearing. Therefore, deep foundations to depths of about 50 to 60 feet would likely be necessary.

LIMITATIONS

This preliminary evaluation is intended for use in comparing alternatives for the Magnolia CSO project. No subsurface explorations were performed for this project. After selection of the preferred alternative, subsurface explorations and testing will be completed for design of the chosen facilities.

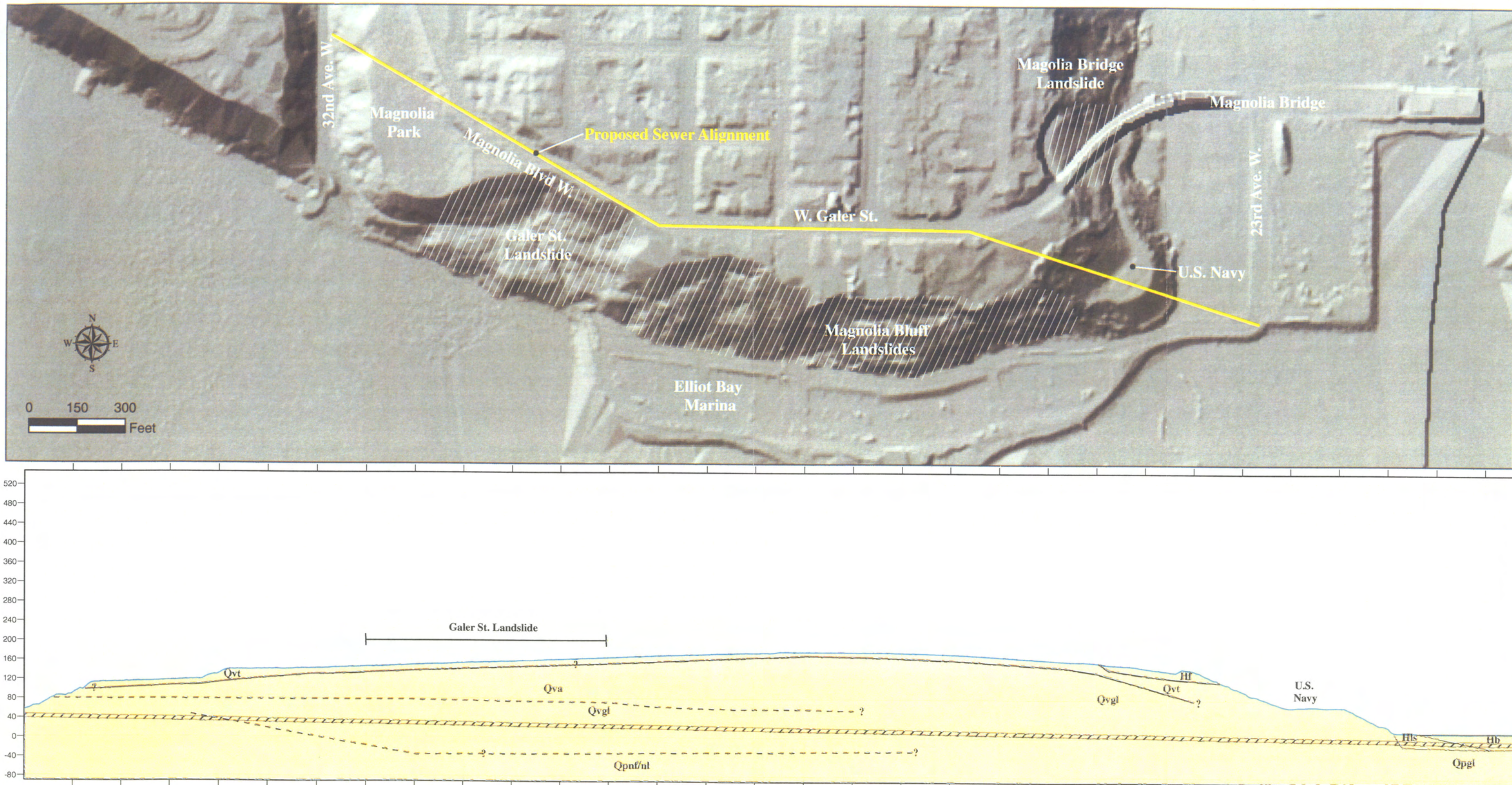
Sincerely,

SHANNON & WILSON, INC.

William T. Laprade, L.E.G.
Senior Vice President

WTL:MSK/wtl

Enc: Figure 1 – Site Plan and Profile



LEGEND

HF Fill	Qva Vashon advance outwash
Hb Beach deposit	Qvgl Vashon glaciolacustrine deposit (Lawton clay)
Hls Landslide deposit	Qpnf/nl Pre-Vashon nonglacial fluvial and lacustrine deposit
Qvt Vashon till	Qpgl Pre-Vashon glaciolacustrine deposit

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Site Plan and Profile

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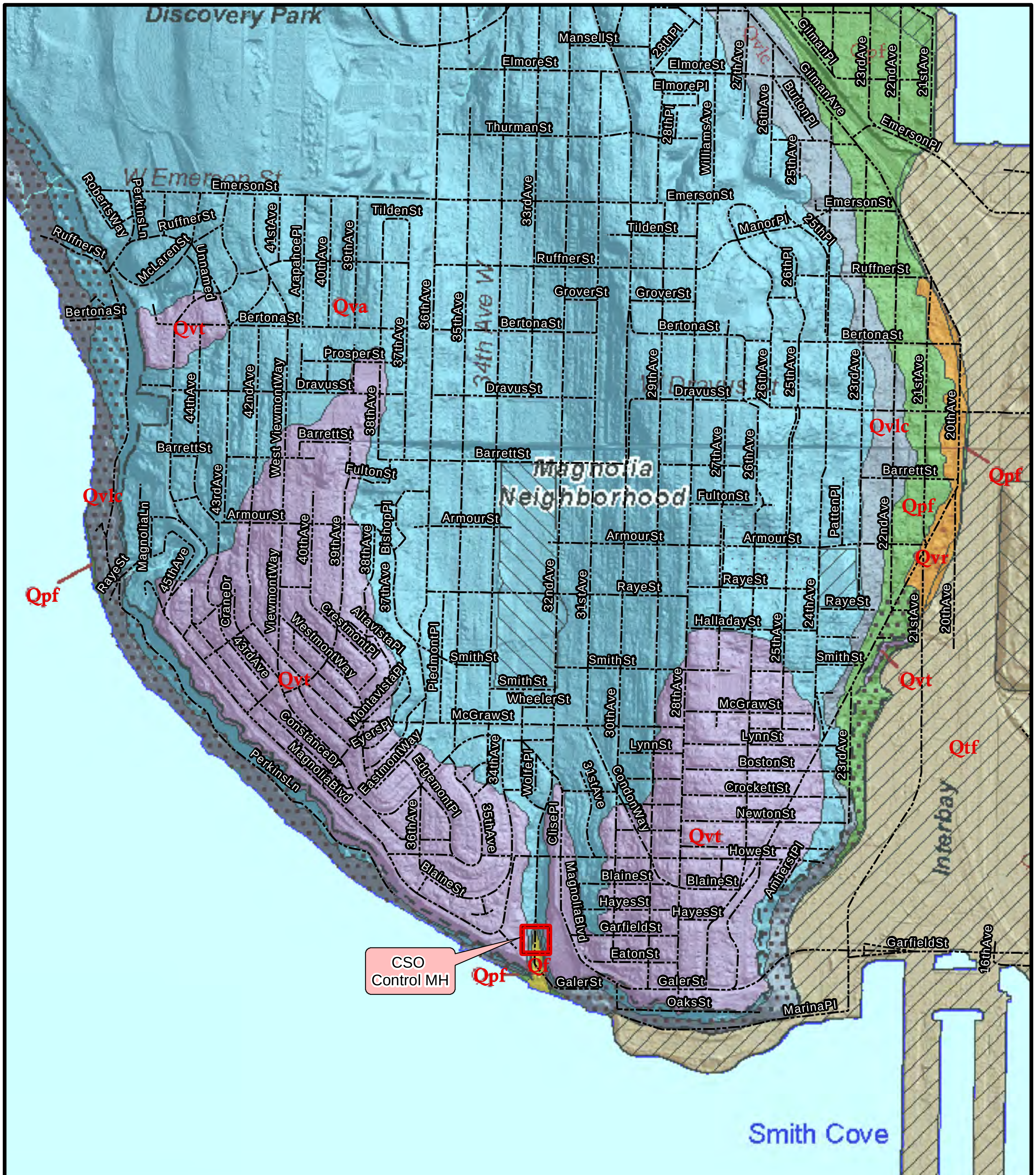
FIG. 1

Filename: T:\Project\21-1\20698_Beach_CSOs\AV_mxd\LIDAR.mxd Date:11/23/2009 ATJ



LEGEND

Qtf	Tidalflat Deposits	**Qva**	Vashon Advance Outwash
Qvr	Recessional Outwash Deposits	**Qvlc**	Lawton Clay Member of the Vashon Drift
Qvt	Vashon Till	**Qpf**	Pre-Vashon Deposits

Stippled Area is Covered with Mass-Wastage Deposits

N W E S

0 700 1,400 Feet

NOTE - Geology by GeoMap Northwest at the University of Washington.

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MAGNOLIA BASIN GEOLOGY

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FIG. 3.5