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Associated Earth Sciences, Inc.

DRAFT
TECHNICAL MEMORANDUM

ANALYSIS OF PREFERENTIAL GROUND WATER FLOW PATHS RELATIVE TO PROPOSED THIRD RUNWAY

SEATTLE-TACOMA INTERNATIONAL AIRPORT

PREPARED FOR:
PORT OF SEATTLE

AESI PROJECT NO. BV99122C
JUNE 19, 2001

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12-21-01
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1.0 INTRODUCTION

The Port of Seattle (Port) presents this technical memorandum in response to a request from the Washington Department of Ecology (Ecology). Ecology has asked the Port to respond to a concern expressed by members of the public and certain State legislators opposed to construction of the proposed Third Runway at Seattle-Tacoma International Airport (STIA). The issue presented is whether known contaminated ground water conditions located below the principal aviation operations and maintenance area (AOMA) of STIA will migrate to the third runway construction area due to the presence of subsurface utilities and/or perched zones acting as pathways of contaminant migration, and/or the natural westward flow of ground water in the upper-most regional aquifer (Qva).

The purpose of this technical memorandum is to report the findings of the Port's evaluation of potential contaminant migration from the AOMA to the third runway area.

The scope of this technical memorandum is to review and evaluate available data to enable a technical conclusion in response to the issues raised about proposed construction of the third runway. The issue is the potential for ground water flow and contaminant migration from the AOMA to the construction area. Of particular interest to the reviewers is the likelihood of migration of perched ground water contamination via preferred flow paths formed by constructed utility trenches and similar subsurface infrastructure.

This scope of inquiry is different from the scope of the STIA Ground Water Study being performed by the Port under a Model Toxics Control Act (MTCA) Agreed Order. The purpose of the MTCA Ground Water Study is to determine whether contamination in the Qva aquifer below the AOMA constitutes a risk to ground water at identified potential local receptors. The scope of that study includes only the Qva aquifer, making the conservative technical assumption that all contaminants released from sources in the AOMA reach the Qva, rather than remaining in soil or in perched ground water zones. The scope of the Ground Water Study also excludes consideration of the third runway. Some of the analysis presented here will inform the Ground Water Study inquiry.

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As presented below, the findings of this evaluation lead to our conclusion that there is no reasonable threat that contaminated ground water will migrate from the AOMA to the Third Runway area, either due to the properties of ground water flow or due to the presence of subsurface utilities or perched zones to act as preferred contaminant transport pathways.

2.0 EXISTING CONDITIONS WITHIN THE AOMA

2.1 GENERAL

As described in the May 1999 Agreed Order, the AOMA is the area of the airport where most aircraft fueling and maintenance operations have historically occurred. Within the AOMA, contaminated ground water exists in several localized, discrete sites as a result of nearly fifty years of airport operations. The boundaries of the contaminated ground water have been defined by site investigation data that were obtained through the placement and sampling of ground water monitoring wells, and data and observations obtained in other subsurface data collection activities. Ground water monitoring continues at active remediation and post-remediation sites (subject to temporary disruption due to construction).

Within the AOMA, areas of contaminated ground water exist in both shallow perched zones and in the Qva. The perched zones are isolated and discontinuous, while the Qva is continuous. Figure 1 is a conceptual diagram illustrating the typical hydrogeologic properties and relationships below the AOMA. Figure 1 significantly simplifies typical conditions, but identifies key features:

- Perched Zone – The perched zone is discontinuous and is present in isolated areas of the AOMA. Perched ground water may appear on local till surfaces (where present) and may also collect in interbeds and lenses within the till. Therefore, multiple discontinuous perching "layers" are frequently identified as discrete water bearing zones within the same area. To the extent there is horizontal perched flow, it is typically localized and flows along the top surface of the till unit, but becomes more vertical at the edge of perching surface; there is no regionally extensive predominant horizontal perched flow direction. Typical low permeability geologic units (glacial till), that result in perched ground water conditions, are located from the near surface to about 40 feet below ground surface (about 10 to 32 feet below ground surface below most AOMA contaminated sites); the unsaturated region between the perching zone and ground water surface in the Qva is approximately 20 to 50 feet thick. Glacial till and perching conditions are not uniformly present below the AOMA. Till is absent in some locations due to natural processes, as well as construction related activities (such as deep excavations for building foundations, excavation for transit tunnels, and site grading activities) which appear to have breached the till unit at several locations at STIA.

- Qva aquifer in the STIA area – The Qva aquifer is the uppermost aquifer of regional extent. It is continuous throughout the AOMA and STIA and is in most areas of STIA classified as an unconfined aquifer. In some locations it is interconnected with the underlying regional aquifer which is identified in the South King County Groundwater Management Plan as the "intermediate" regional aquifer. Typical ground water flow in the Qva aquifer is to the west, varying from northwest to southwest as a result of influence of local discharge zones such as Miller Creek, Des Moines Creek and associated wetlands. Typical depth to the Qva aquifer below the AOMA is about 60-90 feet below ground surface, with the variability primarily due to changes in surface elevation across STIA.

Figure 2 is a site map that presents the major features at STIA. The AOMA is shown in the southeastern portion of STIA and contains the main terminal area and airport concourses. The majority of the impacted ground water resulting from airport operations is located within the AOMA. The third runway construction area is located approximately 2800 feet to the west of the AOMA. Figure 2 also presents the typical Qva ground water contours and flow direction, a west to northwest flow direction in the Qva aquifer. The location of a conceptual cross section through the AOMA, extending to the proposed third runway embankment area, is shown as A-A' (see Figure 6 and Figure 7).

2.2 EXISTING CONDITIONS – PERCHED ZONE

Soil and ground water samples collected during individual site investigations, together with other subsurface observations within the AOMA, indicate that existing perched zone contamination has remained localized near source areas and release points within the AOMA. The sampling data show that the ground-water contaminants have not migrated significantly along constructed utilities or infrastructure, despite the dense array of underground facilities in the AOMA (see Figure 8 for location of utilities relative to existing areas of impacted ground water).

The following paragraphs describe the figures provided with this report. Data and observations for each site at which contaminant concentrations in perched ground water exceed MTCA standards are discussed in the subsequent subsections.

- Figure 3 – Figure 3 is a map that indicates the extent of impacted perched ground water in the area of the AOMA. Ground water monitoring wells completed in perched water bearing zones are plotted based on the most recent ground water quality data in the Ground Water Study database. The ground water quality data are compared to MTCA standards, and wells are distinguished by colors indicating whether sample data contain compounds exceeding MTCA standards. Figure 3 also includes a portion of the conceptual cross section line A-A', which extends to the proposed Third Runway area (see Figure 2 for the entire cross section line; the cross sections are illustrated in Figures 6 and 7. The map also presents data for the following conditions:
    - Monitoring wells with measurable fuel product floating on the perched ground water surface are indicated in green.
    - Monitoring wells that contain concentrations of compounds exceeding the MTCA Method A or B standards are shown in red.
    - Monitoring wells that do not contain concentrations of compounds exceeding the MTCA Method A or B standards are shown in blue.

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- The maximum western boundary of impacted soil is shown as a light blue line. This boundary indicates the area between the AOMA and proposed Third Runway project where soil boring data indicate no MTCA exceedences at depth.

Four sites within the AOMA are shown in yellow shading, indicating the approximate area of fuel impacted perched ground water. These sites include the United/Continental Fuel Farm Area, the PanAm Avgas Tanks, the Northwest Airlines Bulk Fuel Farm and the Delta Autogas Tank site. Two additional areas in the AOMA, the Northwest Airlines Former Hanger Tank site and monitoring well AGC-5 at the Delta Autogas Tank site, shown with gold shading, represent areas that contain solvent impacted perched ground water. The shaded boundaries were established within areas surrounding monitoring wells that have exhibited ground water quality that has exceeded MTCA standards.

Figure 3 also illustrates additional evidence of the limit of the extent of impacted perched ground water in the AOMA. The hatched blue lines shown on Figure 3 at the south end of the AOMA are based on environmental investigations at several potential sites in that area. The unhatched blue lines around the northern and western AOMA are based on environmental soil boring data adjacent to the fuel hydrant pits and along fuel supply lines. The unbroken sections of the blue lines indicates soil conditions that do not exceed MTCA standards. The criteria for establishing this boundary was that the two deepest soil samples collected at a specific location were below MTCA standards. Areas that do not meet this requirement are shown by breaks in the lines and are of a very limited extent. Likewise, areas where no soil data currently exist are between the jagged ends of the blue lines (e.g., between the South Satellite and Concourse B).

- Figure 4 – Figure 4 provides supporting evidence that perched ground water is limited in extent at several locations within the AOMA. The inferred western extent of the perched zone horizons at each of the known release sites appears to be bound by soil conditions that do not indicate wet, saturated or perched ground water conditions. Data points presented on Figure 4 as brown solid circles indicate soil conditions that do not contain evidence for wet soil conditions or perched ground water conditions at the time of drilling. These data were obtained from environmental and geotechnical explorations performed at areas surrounding known perched ground water zones. These data show that the extent of the perched zones are limited in a western direction and that the perched ground water is confined to isolated areas.

Figure 4 also presents generalized perched ground water elevation contours and associated flow directions. The ground water contours were developed by plotting the average ground water surface elevation that has been measured in monitoring wells completed in the perched zones at the various sites. The contoured data set also includes the elevation of saturated conditions noted on logs of the boreholes and wells completed below the perched aquifer. An average ground water level was used where multiple measurements were available from a well. This reduced variability from seasonal fluctuations and simplified complex perching levels in areas that contain multiple perched zones. Flow direction arrows indicate the general direction of ground water flow and indicate that the perched ground water flow is

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variable and generally in directions that are away from the proposed Third Runway construction area.

- Figure 5 – Figure 5 presents the extent of impacted ground water in the Qva aquifer within the AOMA. See Section 2.3 for a description of this figure.

- Figure 6 – Figure 6 is a conceptual cross section that shows a generalized representation of geologic formations, ground water conditions, typical STIA utility trench depths, monitoring well completion details and general AOMA site features. The cross section is developed from the eastern boundary of the AOMA past the western end of the proposed Third Runway embankment, oriented generally parallel to the Qva ground water flow direction. Isolated perched ground water zones are identified within glacial till horizons within the AOMA and in recessional sandy outwash soils near the proposed Third Runway horizon. The inferred thickness of the glacial till horizon has been determined based on available subsurface soil data compiled throughout STIA. These data indicate an irregular till surface with variable thickness and show several areas along the cross section where the till unit is absent as a result of either natural processes or construction activities.

- Figure 7 – Figure 7 presents an enlargement of the Figure 6 cross-section through the AOMA area. The enlarged cross section is developed through the Northwest Bulk Fuel Farm and the Pan Am Avgas Tanksites, areas where impacted perched ground water has been characterized. The perched ground water observed at the Pan Am Avgas Tank site represents the western-most area within the AOMA that contains impacted perched ground water exceeding MTCA standards. The cross section shows wells completed in the perched horizons at both the Northwest Bulk Fuel Farm and Pan Am Avgas Tank sites and indicates the perched water level elevation as shown by the blue triangle. Utility lines are shown on the cross section, which are positioned at a typical construction depth of 10 feet.

2.2.1 United/Continental Fuel Farms Area

The United/Continental Fuel Farms Area site is located in an area where three discontinuous perching zones between the surface and about 40 feet below ground surface have been mapped (Figure 4). Area utilities are located from the near surface to a depth of about 20 feet below ground surface. Local perched water contours suggest radial flow, although the multiple perching layer stratigraphy also suggests a strong vertical component of flow. In addition, it appears that localized mounding of perched ground water is occurring at this site as a result of infiltration resulting from precipitation collecting in the tank farm backfill and surrounding unpaved areas. This mounding has resulting in a radial direction of perched ground water flow. However based on soil data collected to the west of this area, it appears that the perched water condition is limited to the tank farm area. Boring logs for adjacent site wells on the west suggest no perched water is present. Remediation is ongoing, including planned installation of additional perched wells to the southeast.

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2.2.2 Pan Am Avgas Tanks

The Pan Am Avgas Tanks site is located in an area in which at least two perching zones have been recognized. The local perched zones extend from about 10 feet to about 31 feet below ground surface. Area utilities are located from the near surface to a depth of about 12 feet below ground surface (Figure 4). The perched ground water flow direction at this site is to the northeast. As shown on Figure 4, the area to the west of Pan Am Avgas Tank contains a number of soil borings that did not encounter perched ground water. The unsaturated soil borings delineate the western extent of perched water at this location. The perched ground water appears restricted to lenses within the till unit. In addition, it appears that the perched ground water is generally at a lower elevation than the bottom of typical utility trenches. Remediation continues through current construction; monitoring will be reinitiated following construction.

2.2.3 Northwest Hangar Tanks

The Northwest Hangar Tanks site is located in an area where perched ground water occurs at about 18 feet to about 32 feet below ground surface in the immediate vicinity of the tanks excavation area (Figure 4). Area utilities are located from the near surface to a depth of about 12 feet below ground surface. Frequent observation of unsaturated well conditions just outside the tank excavation area, and the absence of perched water in the boring for the nearest down gradient (west) well indicate the perching zone is localized to the tank area. The inferred direction of perched ground water flow in this area appears to the south towards the Northwest Airlines Hanger building. It appears that perched ground water is at a lower elevation than the depth of utilities, however, the deep foundation structure at the Northwest Airlines Hanger could provide a vertical pathway for perched ground water migration through the glacial till zone. Data from ground water monitoring wells indicated solvent-impacted perched ground water at this site. It appears that solvents in the perched ground water have migrated vertically and caused an impact to the Qva. Remediation continues through current construction; monitoring will be reinitiated following construction.

2.2.4 Northwest Fuel Farm

The former Northwest Fuel Farm is located above a perched zone measured at about 18 feet to 29 feet below ground surface (Figure 4). Area utilities are located from the near surface to a depth of about 20 feet below ground surface. The absence of contamination and the absence of perched water in site wells to the west and northwest suggests that the contamination is bounded in these directions. The absence of a perched zone in borings for an adjacent site to the southwest also implies a perched zone boundary. Dissolved contamination is bound on the west side, as evidenced by the absence of wet soil conditions which define the western extent of the perched zone and a southerly inferred perched ground water flow direction (Figure 4). It also appears that the perched zone water level elevations are predominantly at depths that are below the depth of utilities in the area (Figure 6 and 7). Remediation was completed in 1999, and ground water monitoring will be reinitiated following construction.

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2.2.5 Delta Auto Gas Cluster

The former Delta tank installation was located in an area where multiple perching zones were identified, with zones between about 9 to 22 feet, and about 33 to 45 feet below ground surface (Figure 4). Area utilities are located from the near surface to a depth of about 10 feet below ground surface. Shallow perched ground water was observed to occur within the vicinity of the tank excavation but has not been observed beyond the tank excavation. The perched ground water flow direction appears to be towards the south. Dissolved contamination is bound on the west side by the presence of unsaturated soil conditions, suggesting the perched zones are restricted to the backfill areas of the tank excavations. Planned remediation was completed in conjunction with construction in 2000; additional evaluation of current conditions is pending.

2.3 EXISTING CONDITIONS – QVA AQUIFER

Figure 5 is a map that shows the extent of Qva impacted ground water. Ground water flow direction in the Qva aquifer is to the west/northwest between the AOMA and the proposed Third Runway project (Figure 2). Figure 5 indicates that the impacted ground water areas in the Qva are bounded by data from downgradient monitoring wells that do not exceed MTCA standards. The wells that generate data below MTCA standards are located to the west of the impacted ground water areas, between the contaminant release areas and the western AOMA boundary.

Ground water and soil samples collected from individual site investigations within the AOMA have also indicated that existing Qva aquifer contamination remains localized, despite the presence of several facilities that have been constructed at depth within the AOMA. For example, the maximum measured migration of impacted Qva ground water is about 550 feet in a down gradient direction from a specific source (tanks that were installed around 1949 and removed in 1990). This area is well within the AOMA and suggests that impacted Qva ground water is not migrating beyond the AOMA boundary. Natural attenuation and dispersion conditions are also probably limiting the extent of migration of impacted Qva ground water. Contaminant source control and remediation measures also function to limit the size of the ground water plumes observed in the Qva aquifer.

2.3.1 RAC "Rental Car" Tank Site

The former tank site for a group of rental car businesses appears to have no underlying perched ground water, but has impacted ground water in the Qva (Figure 5). The impacted area is bound in the downgradient (west and northwest) direction, as evidenced by data from a series of perimeter wells reporting contaminant concentrations below MTCA standards. Ground water monitoring continues.

2.3.2 Budget Rent-a-Car Pipe Leak Site

This site was impacted by a break in a fuel line, and has been undergoing remediation, which continues. The site appears to have no underlying perched ground water, but has impacted ground water in the Qva (Figure 5). The impacted area is bound in the downgradient (west)

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direction, as evidenced by data from a downgradient well reporting contaminant concentrations below MTCA standards.

2.3.3 Pan Am Avgas Tank Site

Perched zone contamination at the Pan Am Avgas Tank site was discussed above in Section 2.2.2. The Qva-impacted area is bound in the downgradient (west) direction, as evidenced by data from a series of downgradient wells reporting contaminant concentrations below MTCA standards (Figure 5).

2.3.4 Northwest "Closed" Fuel Hydrant System

Fueling operations at the Northwest "Closed" hydrant system were discontinued in about 1996. This facility caused Qva impacts in three locations (shown on Figure 5), a fuel release at the South Satellite Baggage Tunnel Site, and indications of ground water impact near two fuel hydrant pits.

The South Satellite Baggage Tunnel Site was impacted by a leak from the hydrant line. No perched ground water was observed in the impacted area, but contamination was observed in the Qva. The impacted area is bound in the downgradient (west) direction, as evidenced by data from a series of downgradient wells reporting contaminant concentrations below MTCA standards. Ground water monitoring continues.

Fuel system closure characterization activity for this facility indicated two locations where ground water in the Qva may have been impacted. In both locations data from wells associated with other sites indicate contaminant concentrations downgradient (west) from these borings are below MTCA standards, although the southernmost of the hydrant borings is not directly upgradient of the wells providing the observation data.

2.3.5 Northwest "Abandoned" Fuel Hydrant System

Fueling operations at this facility were discontinued in about 1976. Fuel system closure characterization activity for the Northwest "Abandoned" hydrant system indicated a location where ground water in the Qva may have been impacted (Figure 5). The impacted area is bound in the downgradient (west) direction, as evidenced by data from a downgradient well reporting contaminant concentrations below MTCA standards.

3.0 GROUND WATER FLOW – THIRD RUNWAY EMBANKMENT

3.1 EMBANKMENT AREA GROUND WATER FLOW CONDITIONS – PRE- AND POST-CONSTRUCTION.

Ecology has developed ground water flow information relevant to third runway embankment construction. This information was presented in the SeaTac Runway Fill Hydrologic Studies (Pacific Ground Water Group (PGG) June 19, 2000). For one part of that study, PGG compared predicted changes in ground water flow and recharge due to the construction of the third runway embankment by modeling pre-construction and post-construction conditions. In comparison, the scope of the MTCA Agreed Order Ground Water Study is limited to modeling of flow and contaminant fate and transport within and below the Qva aquifer. The MTCA model was designed specifically to model pre-third runway conditions.

The PGG ground water findings concerning ground water flow predict runway construction will not significantly impact the flow direction or flow volume of the Qva aquifer or any aquifer below it. The findings and conclusions of the Ecology's PGG study include the following:

- The third runway embankment will have no significant impact on aquifers below the Qva.
- The third runway embankment will have no significant impact on Qva flow direction.
- In the pre-construction condition, the Qva contribution to base flow is small.
- Post-construction, the volume of water from all sources (including Qva and shallower ground water zones, precipitation, and other sources) discharging to baseflow could decrease slightly. However, the volume of seepage water through the till to the Qva will be about the same as in the pre-construction condition.

3.2 CONSTRUCTION OF THE THIRD RUNWAY AND PREFERENTIAL FLOWPATHS: PERCHED GROUND WATER

The perched ground water conditions observed in the AOMA appear to be present in areas of tank backfill and isolated and discontinuous zones within the glacial till. Flow of perched ground water in the AOMA appears to be generally east and southeast, with a strong downward vertical component.

Perched ground water at the Third Runway area appears to be mainly associated with recessional outwash deposits and or alluvial deposits overlying the till. Alluvial deposits were generally not deposited in the uplands of the STIA operational area, and recessional outwash deposits were removed from much of the central STIA operational area during past site grading. Figure 6 presents a conceptual cross-section through the AOMA and Third Runway area. The absence of recessional outwash and thick fill deposits in the central and western AOMA, and the discontinuous nature of the till surface suggest that natural recessional outwash pathways are not laterally extensive and are unlikely to accommodate extended horizontal migration of perched ground water from the AOMA to the Third Runway area.

The environmental data indicate utility backfill corridors are not preferred pathways of migration. The ground water and soil data show very limited contaminant migration despite the existing array of STIA subsurface utilities and infrastructure as shown in Figure 8, and despite the long term of contamination presence in the subsurface. There is no evidence of extended migration of perched zone contamination along existing utility backfill corridors. Construction of the third runway embankment includes completion of only one utility, a new section of a communications ductbank, which establishes a direct connection from the AOMA to the embankment. The trench excavated for the ductbank is about 4-1/2 feet deep and backfill for the new section will consist of concrete and controlled density fill. This combination of backfill material results in very low trench permeability, and would restrict or prevent the movement of water within the backfill between the Third Runway construction area and the AOMA.

Note also that any utilities that would cross directly from the airfield to the Third Runway construction area would cross locations where the till unit is absent. In areas absent of till, there is no evidence of perching zones, and vertical flow predominates. Lateral contaminant migration is expected to be very limited.

The bottom of the ductbank is approximately 70 to 75 feet above the Qva water table. Infiltration by precipitation and stormwater runoff is virtually immeasurable because of the impermeable cover over the ductbank and the routing of stormwater runoff away from it to the airport's Industrial Waste System (IWS). The ductbank is covered with about 18-inches of concrete.

3.3 CONSTRUCTION OF THE THIRD RUNWAY AND PREFERENTIAL FLOWPATHS: QVA GROUND WATER

The Qva aquifer is present as a continuous aquifer throughout STIA, including areas of the proposed Third Runway construction area. The Qva aquifer is located at a depth that is, in most instances, below the proposed embankment construction area; and therefore construction activities associated with the proposed runway will not significantly impact the Qva. As noted above, the Ecology study conducted by PGG concluded that the proposed runway construction would not affect the current ground water flow direction or significantly affect the amount of recharge to the Qva aquifer system. There is no indication that ground water in the Qva that has been impacted as a result of historic STIA operations has migrated beyond the western boundary of the AOMA.

As described above, the single newly constructed utility that is proposed as part of the Third Runway is not a preferred pathway for contaminant to migration toward the runway embankment. In addition, it will be constructed well above the depth of ground water in the Qva. Likewise, no deep infrastructure is proposed for the third runway that would establish a direct connection from the AOMA to the embankment. Therefore, the construction should not create a preferred pathway for the existing Qva contamination in the AOMA to migrate to the third runway area.

4.0 CONCLUSIONS

Based on our analysis of the available geologic, environmental, and historical data, it appears unlikely that contaminated ground water is migrating from or would migrate from the AOMA to the proposed Third Runway area either as a result of natural ground water gradients or from preferential flow through existing or proposed STIA utilities. The following conclusions regarding preferential ground water pathways have been developed:

4.1 PERCHED GROUND WATER

- Ground water flow directions in the perched water bearing horizons within the AOMA are variable and with a predominant direction away from the proposed Third Runway.
- Impacted ground water in the perched zones appears to be contained laterally to areas adjacent to the source releases.
- Perched ground water will tend to move as vertical flow especially in areas where the till is discontinuous or in areas where construction activities have breached the till.
- The depth to perched ground water generally exceeds the typical depth of STIA utilities. Therefore much of the impacted perched ground water is vertically isolated from utility backfill areas.
- Any perched ground water moving along utilities that cross areas where the till horizon is absent will drain vertically towards the Qva aquifer.
- There is no indication of contaminated ground water outside the western extent of the AOMA.
- Existing contaminated perched ground water has not migrated far from source areas, and there is no evidence to suggest contaminant migration beyond the western boundary of the AOMA will occur.

4.2 QVA GROUND WATER

- Ground water flow in the Qva aquifer is in a west to northwest direction between the AOMA and the proposed Third Runway construction area.
- Impacted ground water is contained within the AOMA with the maximum migration of impacted water no greater than 550 feet in length from its contaminant source.
- Data from ground water monitoring wells completed in a downgradient direction from known Qva impacted ground water sites are below MTCA standards and provide a defined plume boundary.
- Ground water in the Qva aquifer is at a depth of between 60 to 90 feet below ground surface, well below the depth of typical utilities, and no deep infrastructure is planned to be constructed for the third runway that would establish a direct connection from the AOMA to the embankment.

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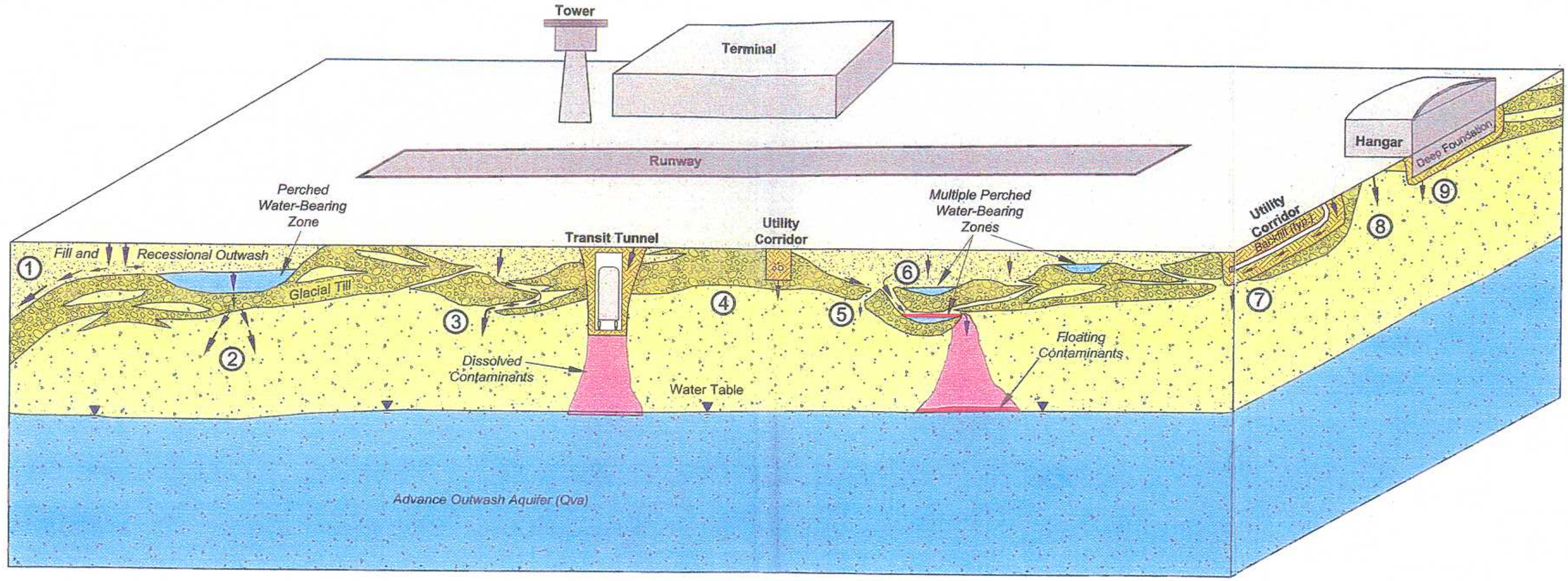
Conceptual Model of Potential Perched Ground Water Flow Paths

Seattle-Tacoma International Airport

Figure 1



POSSIBLE PERCHED GROUND WATER FLOW PATHS ON AND THROUGH GLACIAL TILL

1. Lateral migration on till surface - slow where slope is gentle, faster where slope is steep
2. Slow seepage through till where perched
3. Flow where till is discontinuous or through sand and gravel lenses
4. Vertical flow through backfill for transit tunnels or utility corridors
5. Vertical flow where till was not deposited
6. Flow between multiple perched zones
7. Lateral flow along utility corridors
8. Vertical flow where till has been removed by grading
9. Flow where till has been penetrated by deep foundations

Potential Flow Path

- Relatively slow
- Relatively fast
- Floating Contaminants
- Dissolved Contaminants

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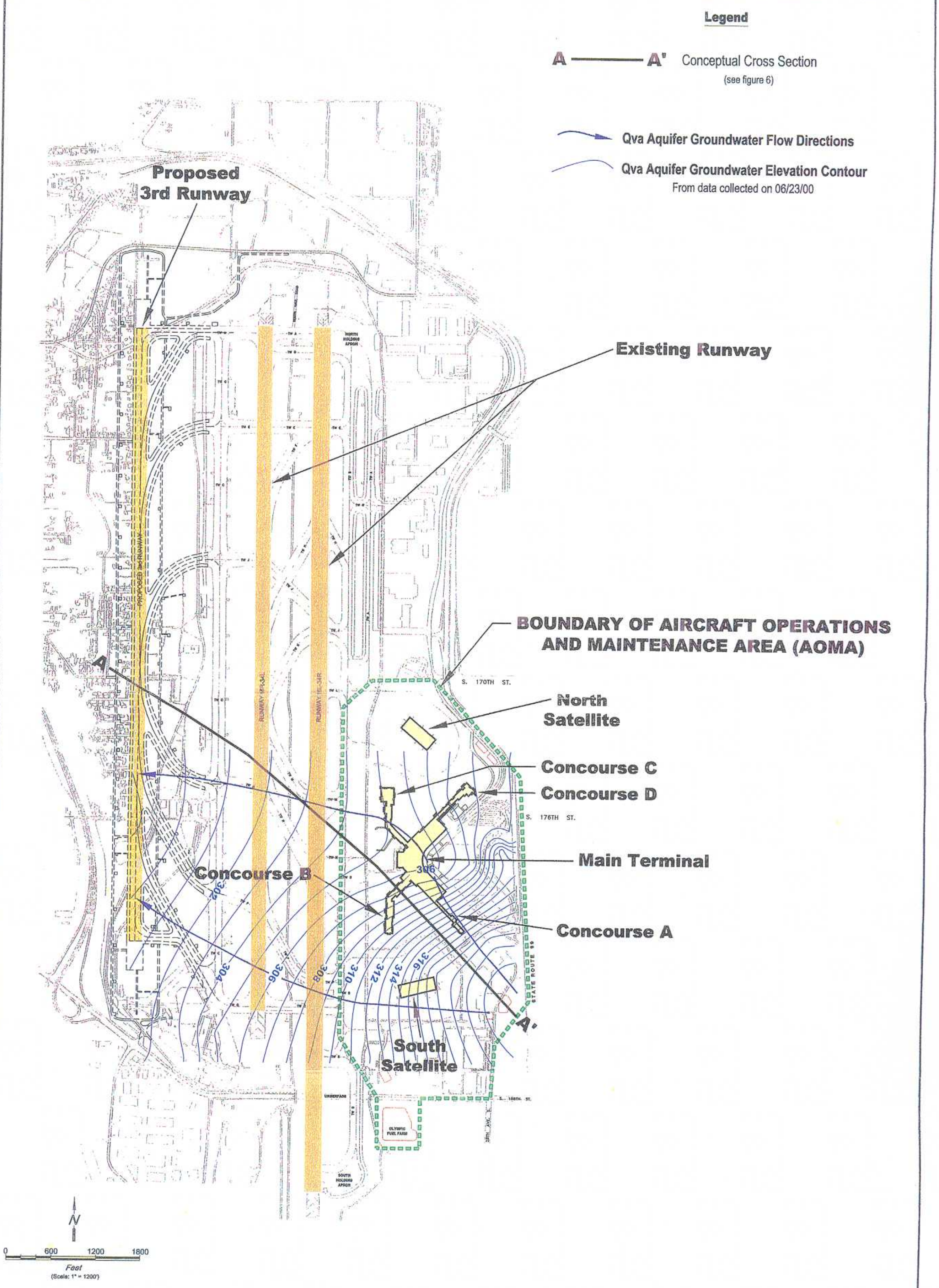

Seattle Tacoma International Airport

Site Reference Map

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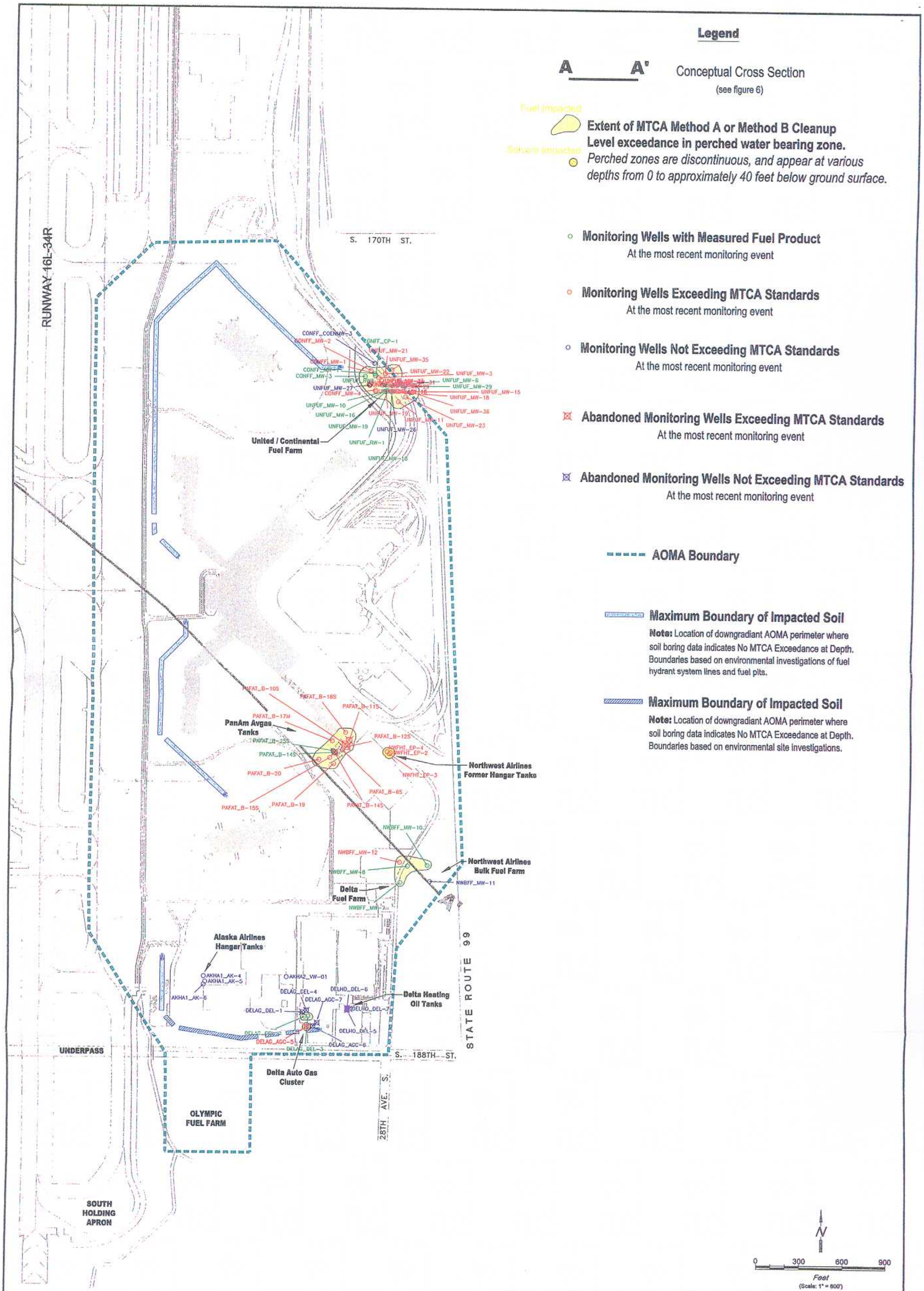
FIGURE NO. 2



Seattle Tacoma International Airport

AOMA Wells in Perched Water Bearing Unit
W/ MTCA Ground Water Standard Exceedances

DATE: 06/21/01
FILENAME: SV99122-Perched.dwg
FIGURE NO. 3

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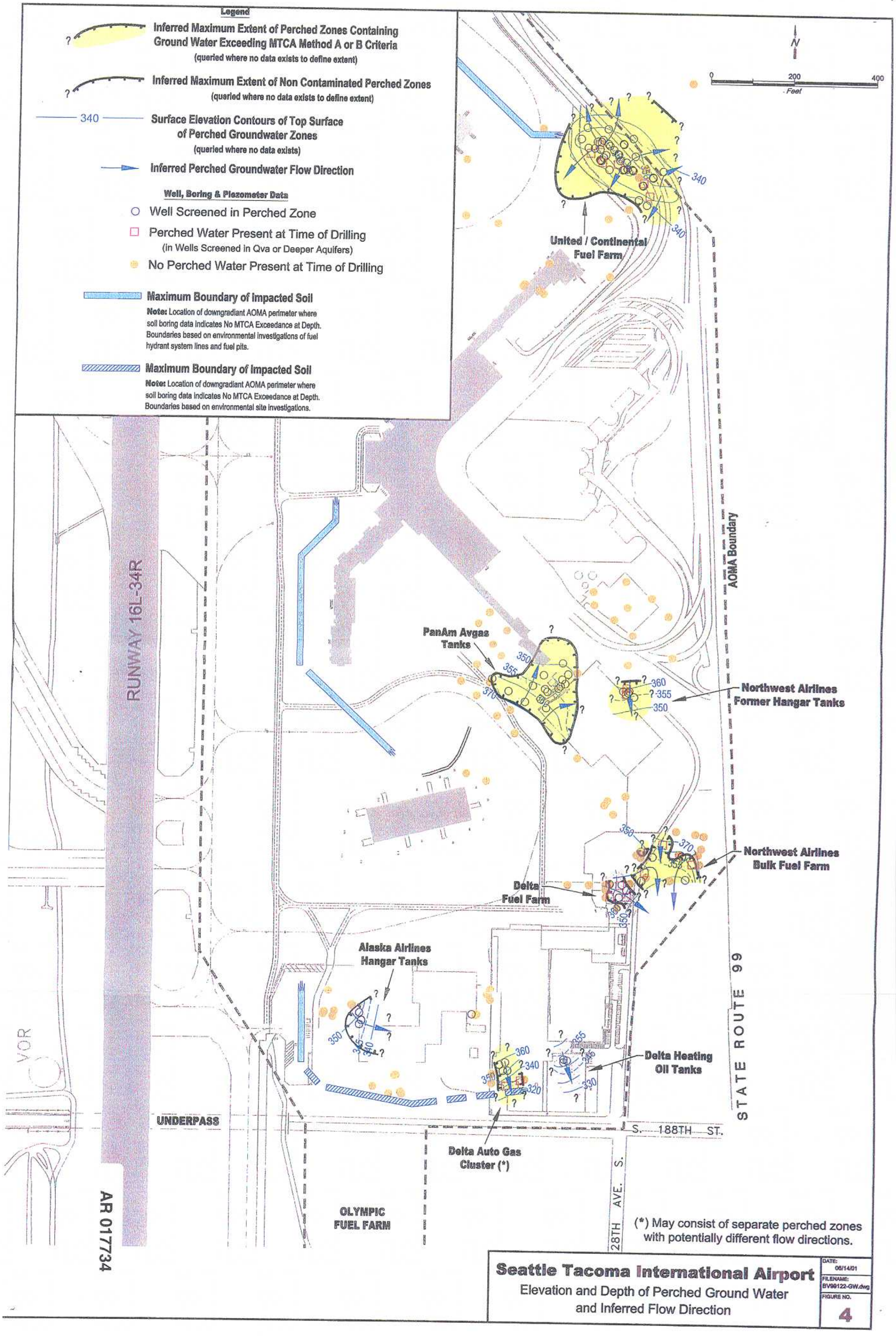
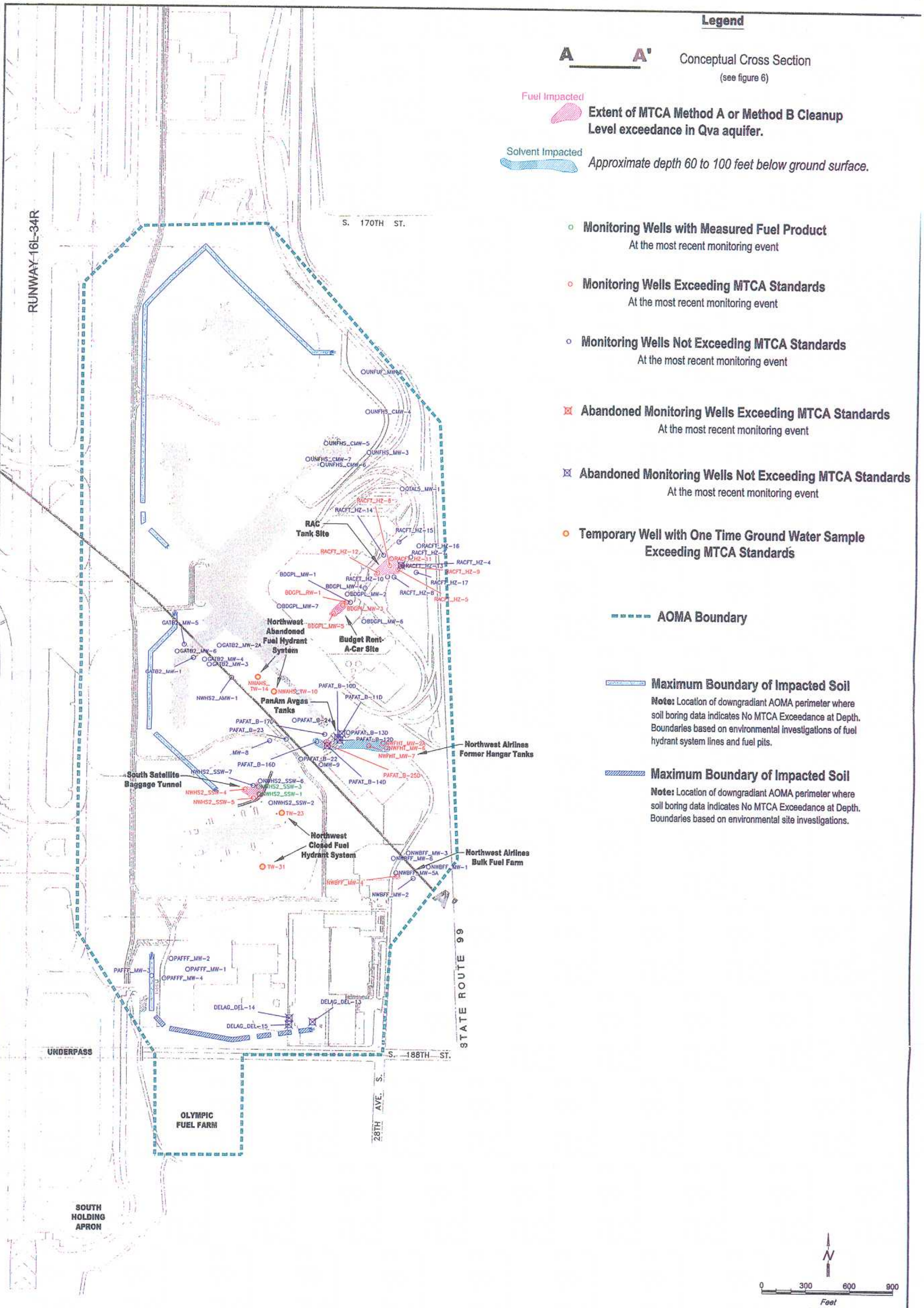


Seattle Tacoma International Airport
Elevation and Depth of Perched Ground Water and Inferred Flow Direction



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Seattle Tacoma International Airport

AOMA Wells in Qva Aquifer W/ MTCA Ground Water Standard Exceedances

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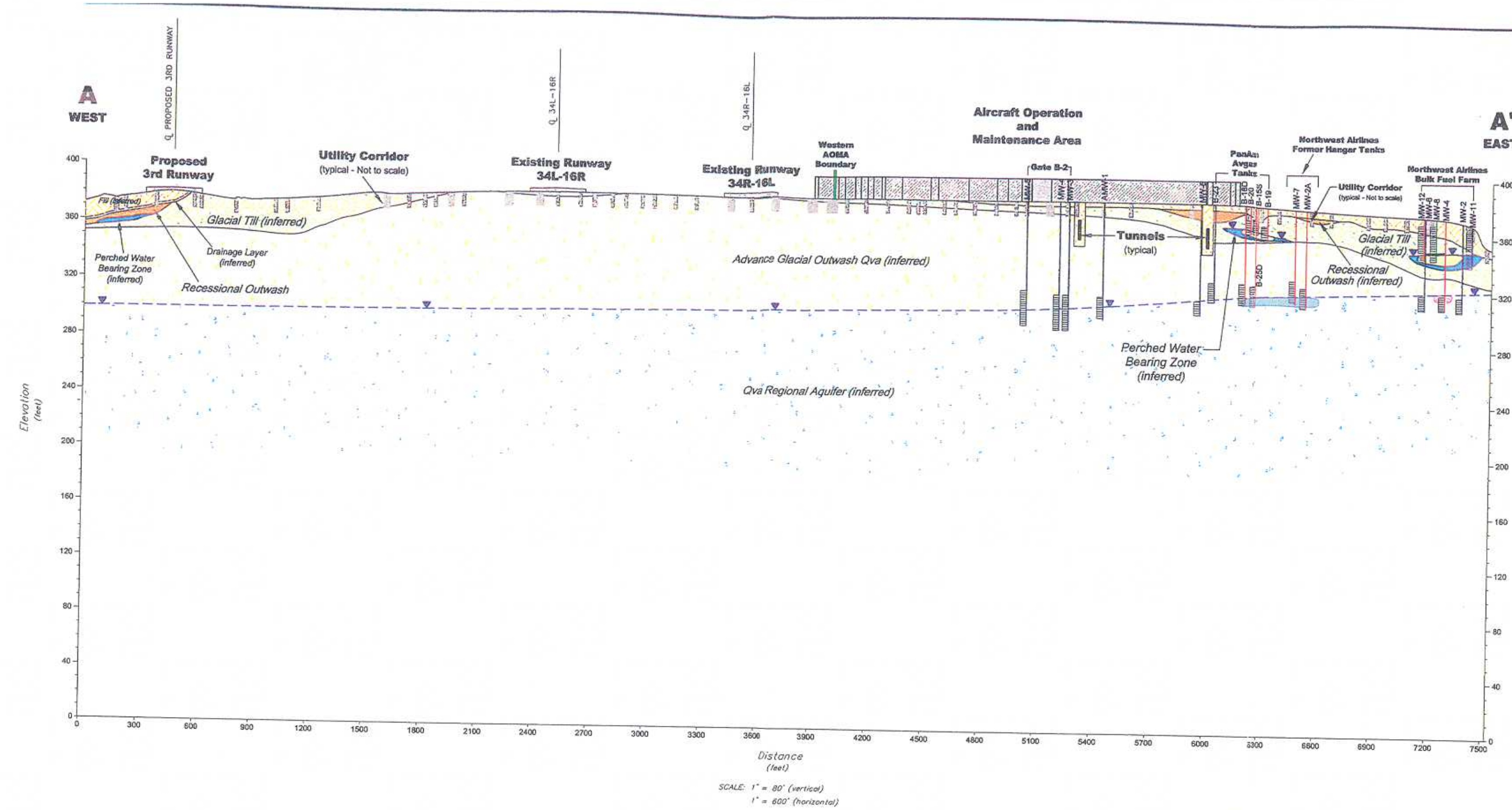
FIGURE NO. 5



Legend

Extent of MTCA Method A or Method B Cleanup Level exceedance in perched water bearing zone.
Perched zones are discontinuous, and appear at various depths from 0 to approximately 40 feet below ground surface.

Fuel Impacted / Solvent Impacted — Extent of MTCA Method A or Method B Cleanup Level exceedance in Qva aquifer.
Approximate depth 60 to 100 feet below ground surface.

Ground Water Surface

Monitoring Well with Measured Fuel Product

Monitoring Well Exceeding MTCA Standards

Monitoring Well Not Exceeding MTCA Standards

Well Screen

Note: *Typical depth of 3rd Runway utilities, including water, sewer, IWS lines, electrical and communications ductbanks, etc. are 5 - 10 feet below ground surface, with a maximum depth of 15 feet. Proposed stormwater detention vaults and outlet piping may be located as deep as 40 - 45 feet below ground surface.*

The yellow, aqua and lavender shaded areas represent locations where ground water quality has exceeded MTCA Method A or Method B Cleanup Levels in perched water bearing zones and in the Qva aquifer. These areas are illustrated using the most recent chemical analysis data and may not represent present day conditions. The shaded areas are not compound specific, but were drawn based on an exceedance value for any one of the suite of constituents analyzed.

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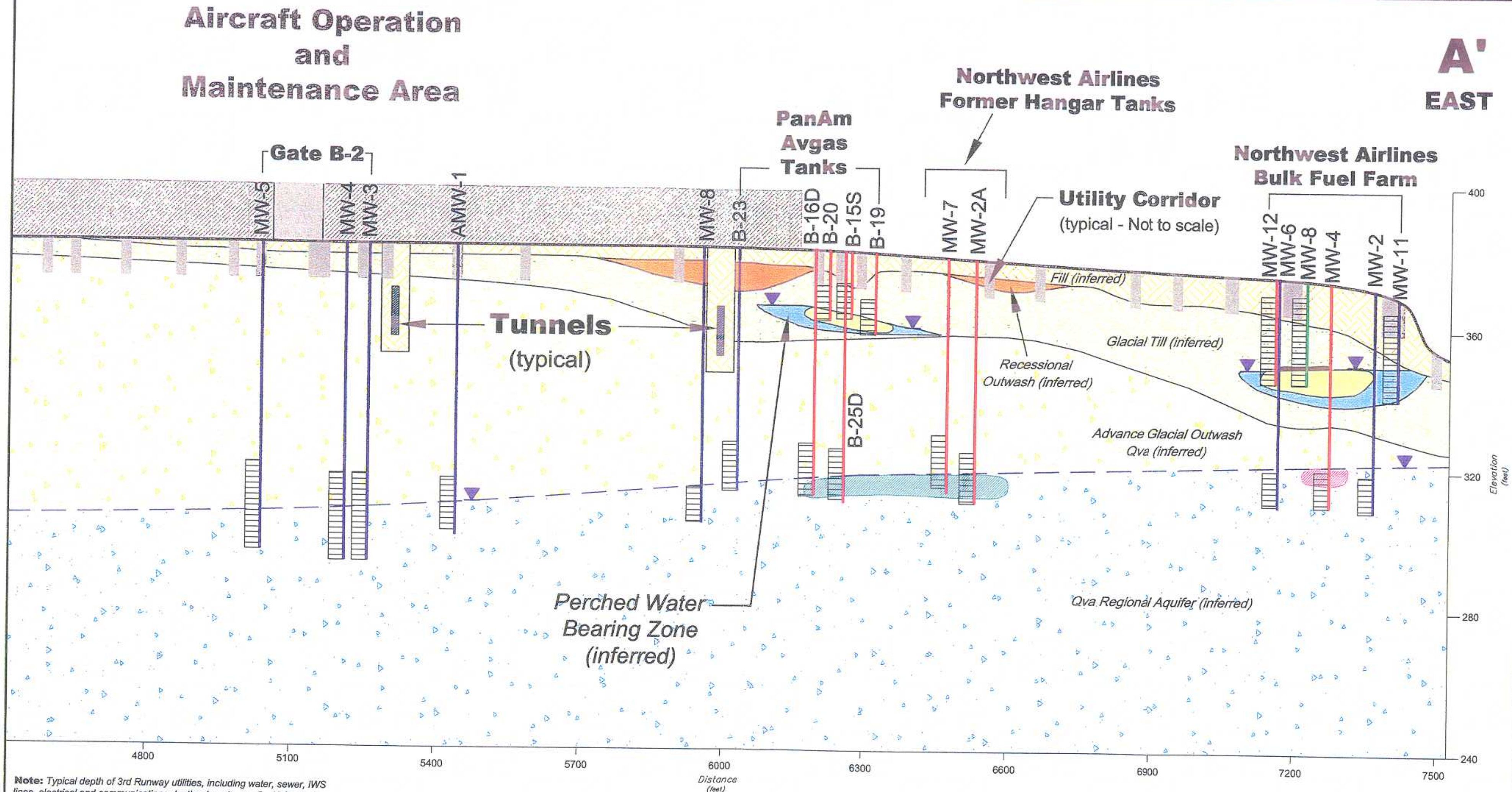
Seattle Tacoma International Airport
Conceptual Cross Section A-A', Showing Underground Utilities and MTCA Ground Water Exceedances

DATE:	06/21/01
FILENAME:	BV99122-SE1.dwg
FIGURE NO.	6



Note: *Typical depth of 3rd Runway utilities, including water, sewer, IWS lines, electrical and communications ductbanks, etc. are 5 - 10 feet below ground surface, with a maximum depth of 15 feet. Proposed stormwater detention vaults and outlet piping may be located as deep as 40 - 45 feet below ground surface.*

Legend

- **Extent of MTCA Method A or Method B Cleanup Level exceedance in perched water bearing zone.** *Perched zones are discontinuous, and appear at various depths from 0 to approximately 40 feet below ground surface.*
- Fuel Impacted / Solvent Impacted — **Extent of MTCA Method A or Method B Cleanup Level exceedance in Qva aquifer.** *Approximate depth 60 to 100 feet below ground surface.*
- **Ground Water Surface**
- **Monitoring Well with Measured Fuel Product**
- **Monitoring Well Exceeding MTCA Standards**
- **Monitoring Well Not Exceeding MTCA Standards**
- **Well Screen**

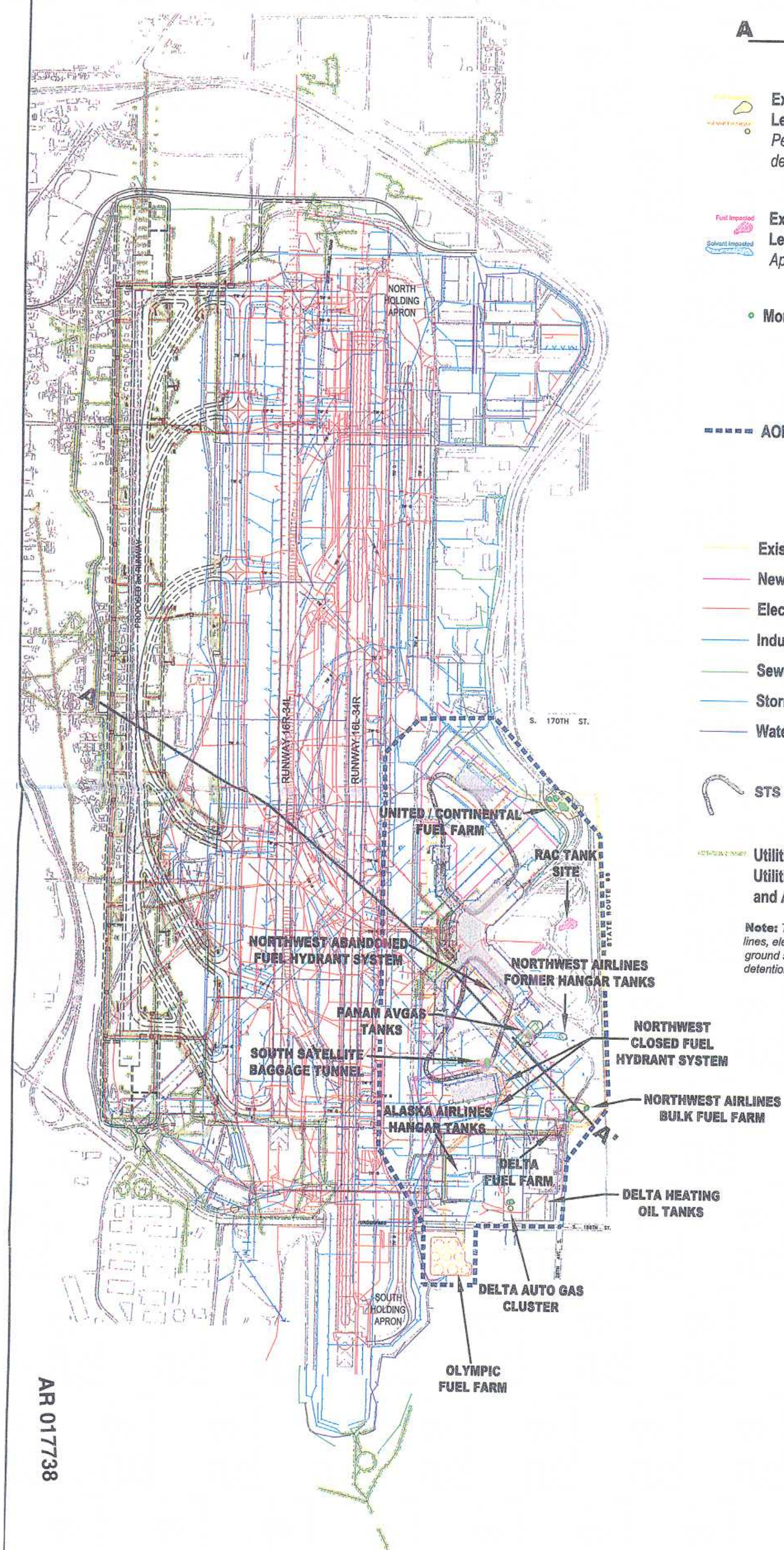
The yellow, aqua and lavender shaded areas represent locations where ground water quality has exceeded MTCA Method A or Method B Cleanup Levels in perched water bearing zones and in the Qva aquifer. These areas are illustrated using the most recent chemical analysis data and may not represent present day conditions. The shaded areas are not compound specific, but were drawn based on an exceedance value for any one of the suite of constituents analyzed.

AR 017737

Seattle Tacoma International Airport

Expanded View of Conceptual Cross Section A-A', Showing Monitoring Well Detail

DATE:	06/20/01
FILENAME:	BV99122-SE2.dwg
FIGURE NO.	7



Legend

A ——— A' Conceptual Cross Section (see figure 6)

Extent of MTCA Method A or Method B Cleanup Level exceedance in perched water bearing zone.
Perched zones are discontinuous, and appear at various depths from 0 to approximately 40 feet below ground surface.

Fuel Impacted / Solvent Impacted — **Extent of MTCA Method A or Method B Cleanup Level exceedance in Qva aquifer.**
Approximate depth 60 to 100 feet below ground surface.

Monitoring Wells with Measured Fuel Product
At the most recent monitoring event

AOMA Boundary

Underground Utilities

- Existing Fuel Line
- New Fuel Line
- Electric Line
- Industrial Waste System
- Sewer Line
- Storm Drain
- Water Line

STS and Baggage Tunnels

Utilities with a shaded background represent New Utilities Constructed in 2001 (near Main Terminal) and All New Utilities and Electric for the New Runway.

Note: *Typical depth of 3rd Runway utilities, including water, sewer, IWS lines, electrical and communications ductbanks, etc. are 5 - 10 feet below ground surface, with a maximum depth of 15 feet. Proposed stormwater detention vaults and outlet piping may be located as deep as 40 - 45 feet below ground surface.*

AR 017738

N

0 600 1200 1800
Feet
(Scale: 1" = 1200')

The yellow and lavender shaded areas represent locations where ground water quality has exceeded MTCA Method A or Method B Cleanup Levels in perched water bearing zones and in the Qva aquifer. These areas are illustrated using the most recent chemical analysis data entered in the Port of Seattle Environmental Management Information System database, and may not represent present day conditions. The shaded areas are not compound specific, but were drawn based on an exceedance value for any one of the suite of constituents analyzed.

Seattle Tacoma International Airport
Underground Utilities, with MTCA Ground Water Standard Exceedances

DATE: 06/20/01
FILENAME: BV99122-MTCA.dwg
FIGURE NO. 8