

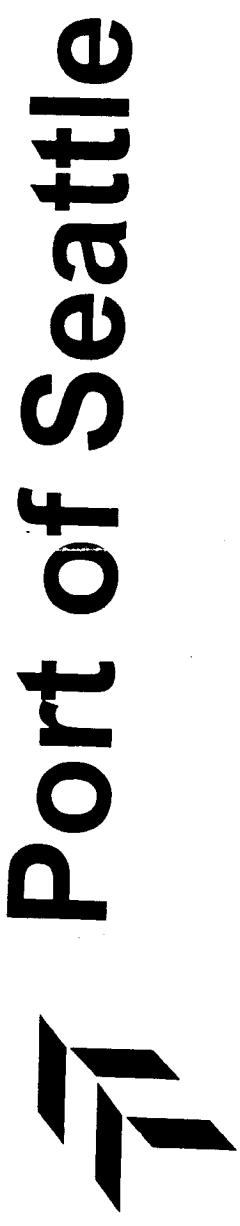
**Seattle-Tacoma International Airport
Ground Water Study**

**Ecology Meeting
October 4, 2000**

AGENDA

- **Project Overview**
 - **Database Development**
 - **Conceptual Ground Water Model**
 - **Ground Water Level Monitoring – Qva Aquifer**
 - **Ground Water Flow Model**
- **Fate & Transport Issues**
 - **Agreed Order Sites**
 - **Potential Sites**
 - **Exposure Pathway Analysis**
 - **Summary of Qva Aquifer Analytical Data**
 - **TPH Data Gap Analysis**
 - **Compounds of Concern Proposed for Fate & Transport Modeling**

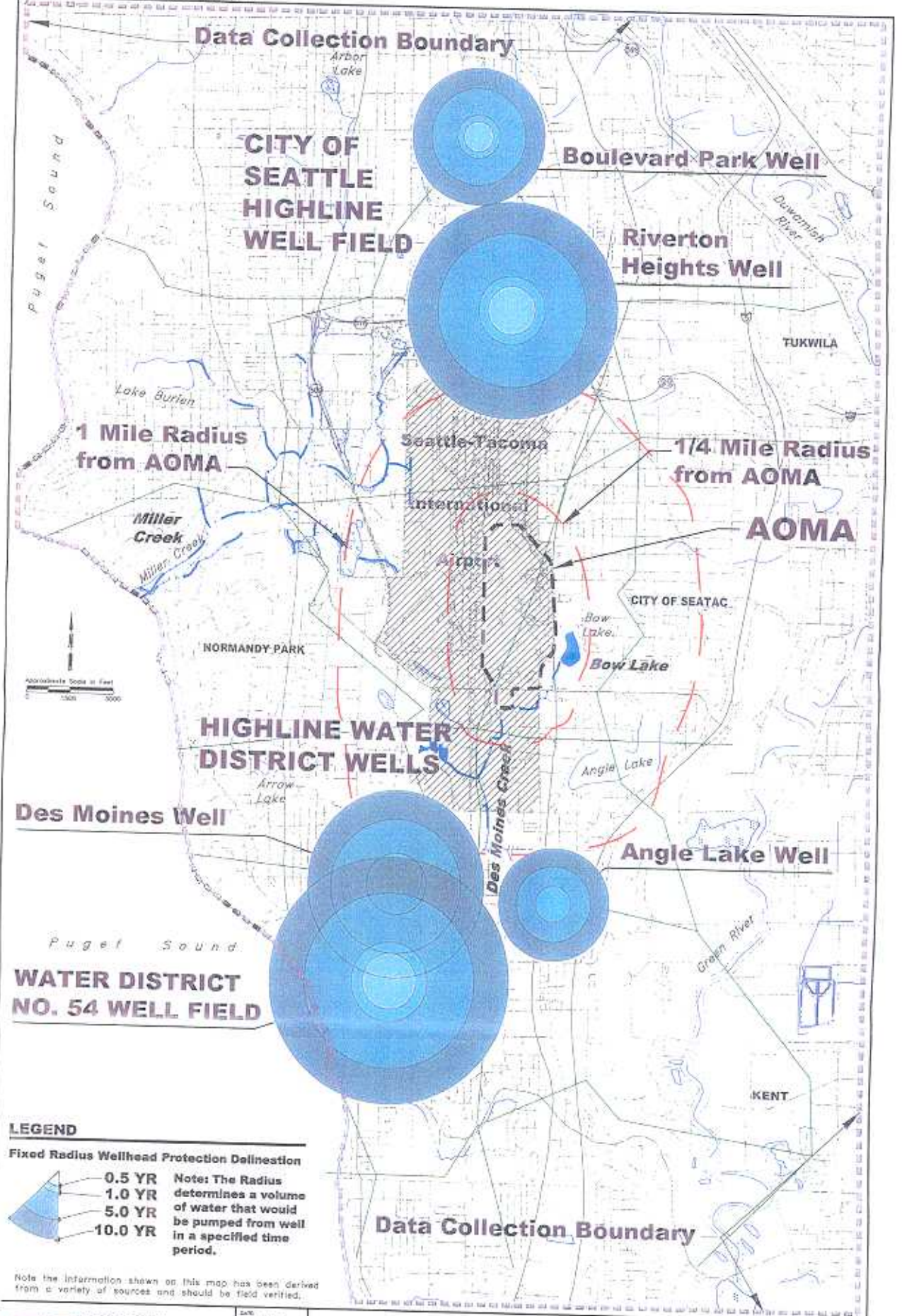
Seattle-Tacoma International Airport Ground Water Study

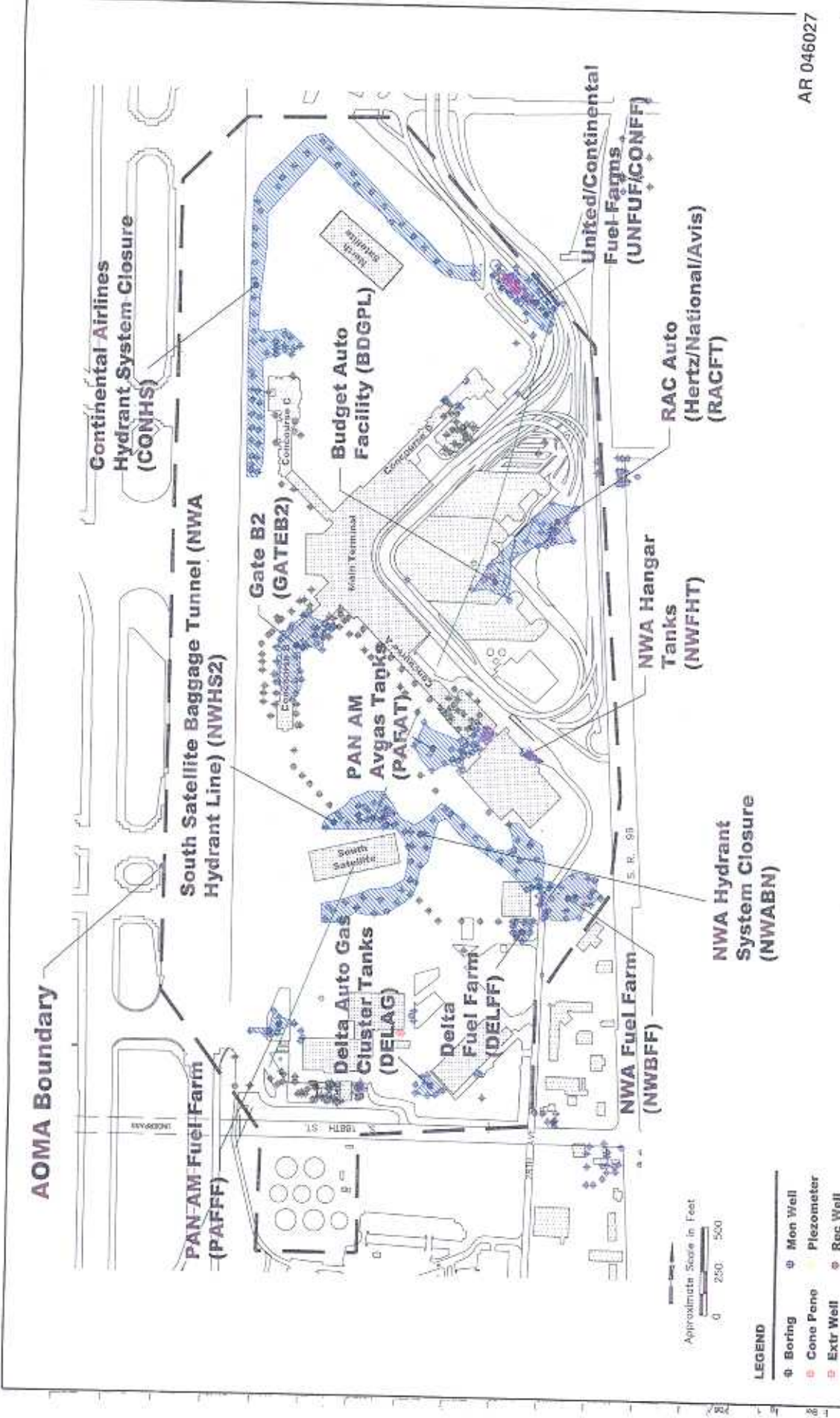


**Seattle-Tacoma International Airport
Ground Water Study**

**Project Overview / Conceptual Fate & Transport
Model Presentation**

**Associated Earth Sciences, Inc.
S.S. Papadopoulos and Associates, Inc.
EA Engineering, Science, and Technology**





- LEGEND**
- ⊕ Boring
 - ⊕ Cone Pen
 - ⊕ Extr Well
 - ⊕ Gas Probe
 - ⊕ Geotech
 - ⊕ Mon Well
 - ⊕ Piezometer
 - ⊕ Rec Well
 - ⊕ Unknown

AR 046027

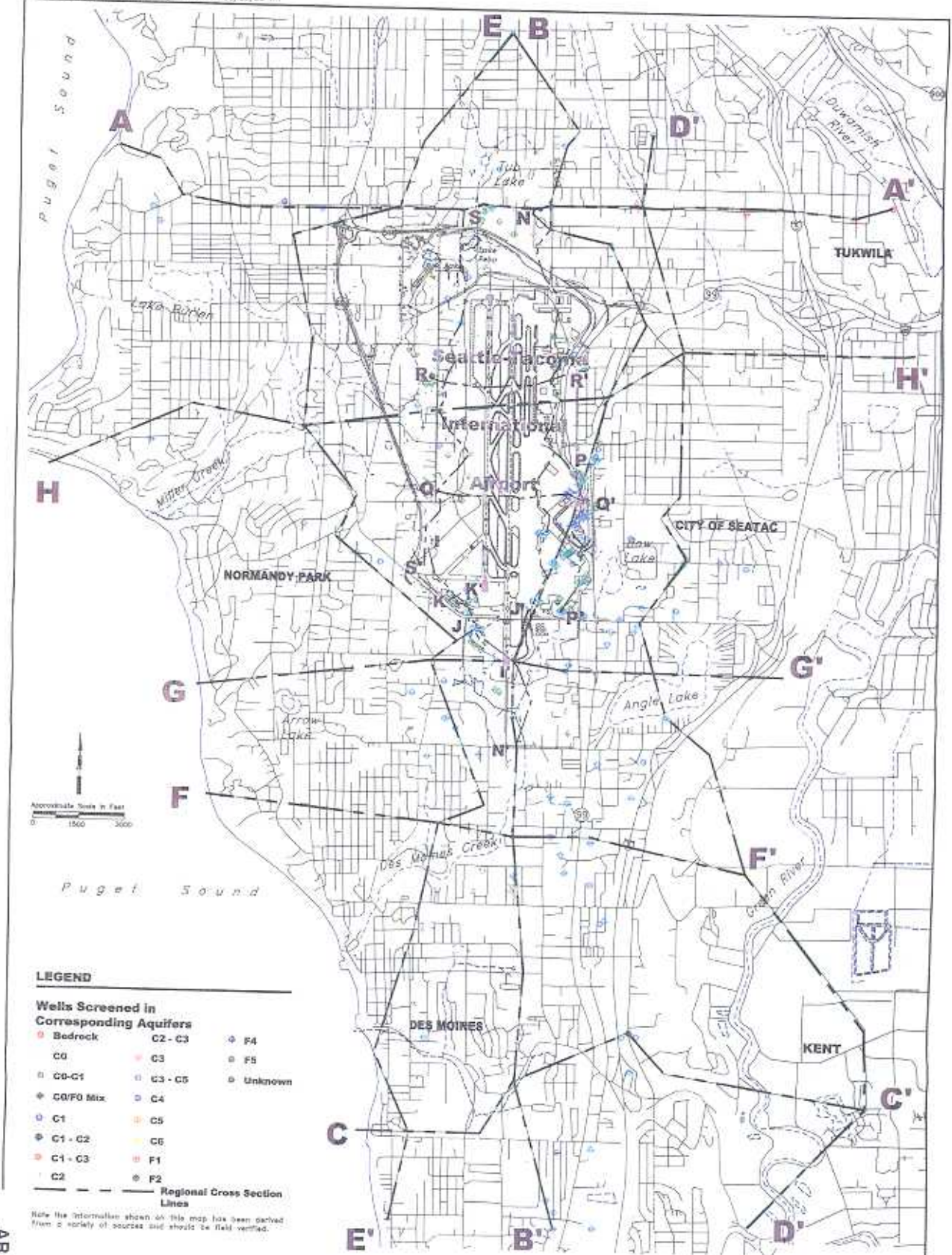


**ASSOCIATED
EARTH
SCIENCES, INC**

DATE: 03/28/78
ISSUED BY: [Signature]
BY: [Signature]

PROJECT NO. 897018
SHEET NO. 2

Airport Operations and Maintenance Area (AOMA)
Ground Water Study
Seattle - Tacoma International Airport



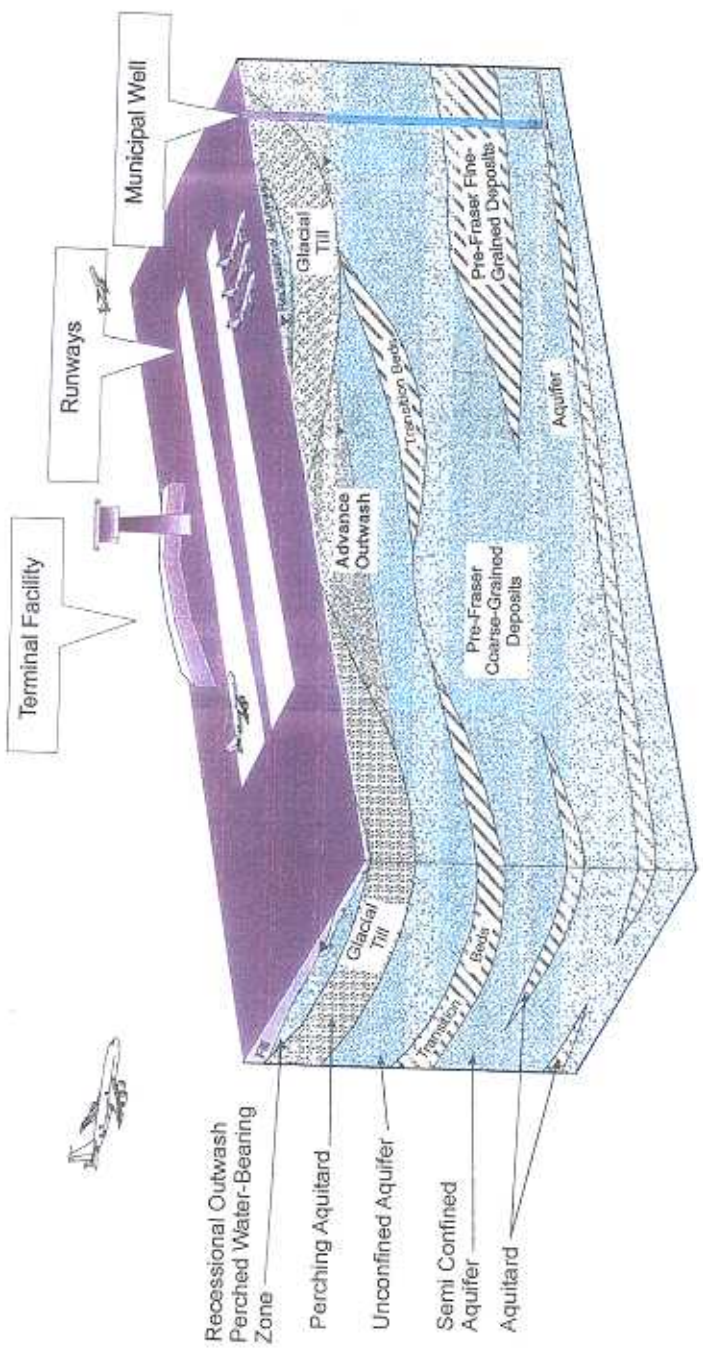
AR 046028

AR 046029

Geologic Group	Proposed Seattle Map Unit	Geologic Unit Name	Schematic Geologic Column	Hydro-Stratigraphic Unit	South King Co. Ground Water Regmt. Plan Unit	Model Condition
Post Glacial Deposits	m?	Fill		C0 and F0 (Mixed Order)	Qal and Qvr	Perched Water Bearing Zones and Aquitards
	Qyal Qoc1	Recent Alluvium (fine and coarse grained)				
Fraser Glacial Deposits	Qvt Qvr	Recessional Outwash (fine and coarse grained)		F1	Qvt	Aquitard
	Qvt	Vashon Glacial Till				
	Qvas Qviag	Advance Outwash "Esperance Sand"				
	Qtb	Transition Beds "Lawton Clay"				
	Qpfc	Olympe Non-Glacial, Periglacial Outwash, and Whidbey Non-Glacial Deposits				
	Qpff	Older Pre-Fraser Deposits (fine grained)				
	Qpfc	Older Pre-Fraser Deposits (coarse grained)				
	Qpff	Older Pre-Fraser Deposits (fine grained)				
	Qpfc	Older Pre-Fraser Deposits (coarse grained)				
	Qpff	Older Pre-Fraser Deposits (fine grained)				
Pre-Fraser Glacial and Non-Glacial Deposits	Qpfc and Qpff	Additional Coarse Grained units and Fine Grained units		C2 C2P C2	Qc(3) "Intermediate Aquifer"	Aquifer
	Qpff	Older Pre-Fraser Deposits (fine grained)				
	Qpfc	Older Pre-Fraser Deposits (coarse grained)				
	Qpff	Older Pre-Fraser Deposits (fine grained)				
	Qpfc	Older Pre-Fraser Deposits (coarse grained)				
Bedrock	Tu	Tertiary Bedrock		C3 F3	Qc(4) "Deep Aquifer"	Aquifer
	Qpff	Older Pre-Fraser Deposits (fine grained)				
	Qpfc	Older Pre-Fraser Deposits (coarse grained)				
				C4	Qc(4)	Aquitard
				C5, F6, C6		Aquitard
				Br	Tbr	Aquitard

DATE: 24/07/99
 PROJECT: Ground Water Study
 DRAWING: J5/9LE
 SHEET NO: 4

Conceptual Hydrostratigraphic Framework
 Ground Water Study
 Seattle - Tacoma International Airport

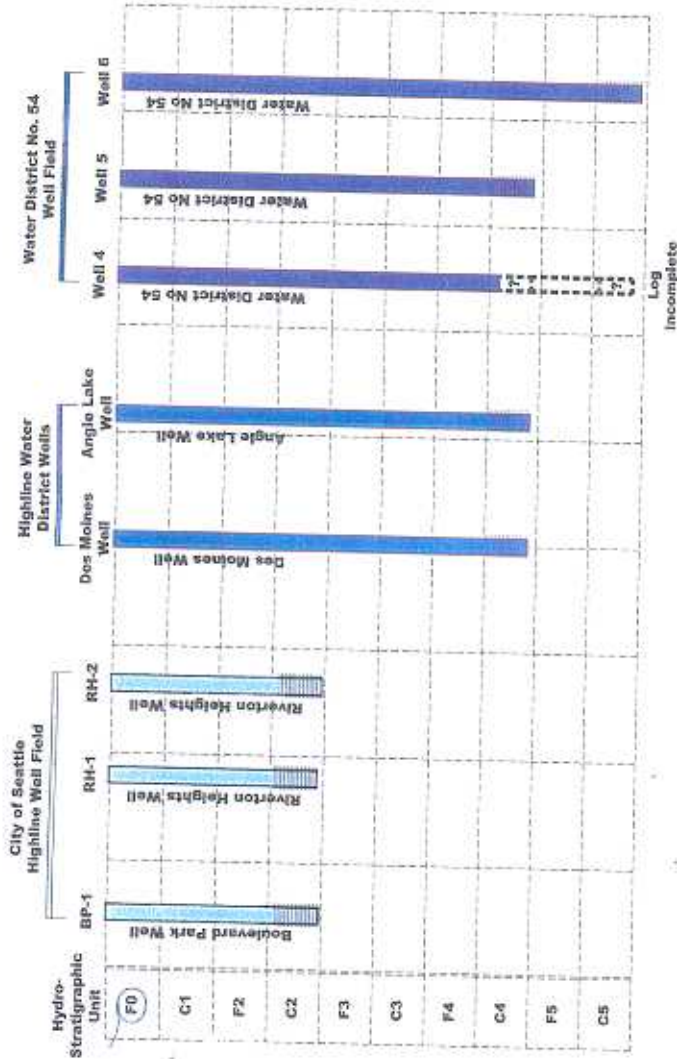


Note: Schematic Unit Thicknesses, Not to Scale

AR 046030

	Date: 08/24/99	Conceptual Model Ground Water Study Seattle - Tacoma International Airport	
	Designed/Drawn: JUS/BLB		
			Figure No: 5

Engineering and Construction Services, Inc.



Pumping Summaries

○ City of Seattle Highline Well Field

Well	Pumping Rate	Pumping Duration
Riverton No. 1	3200 gpm	3mos.-yr, no recharge
Riverton No.2	1800 gpm	3mos.-yr, no recharge
Boulevard Park No. 1	2000 gpm	3mos.-yr, no recharge

- Second well at Boulevard Park proposed

- Aquifer Storage and Recovery (ASR) program - injection water to intermediate aquifer if water levels do not return to static or pre-pumping levels by May of any year.

● Highline Water District

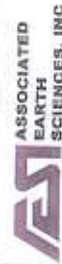
Well	Pumping Rate	Pumping Duration
Des Moines Well	1200 gpm	5 days/wk, 8 hrs/day
Angle Lake Well	1200 gpm	5 days/wk, 8 hrs/day

District may increase pumping duration to 24 hours per day seasonally, pending sustainability testing.

● Water District No. 54

Well	Pumping Rate	Pumping Duration
Well No. 4	3200 gpm	25 millions gallons
Well No. 5	1800 gpm	90 millions gallons
Well No. 6	2000 gpm	32 millions gallons

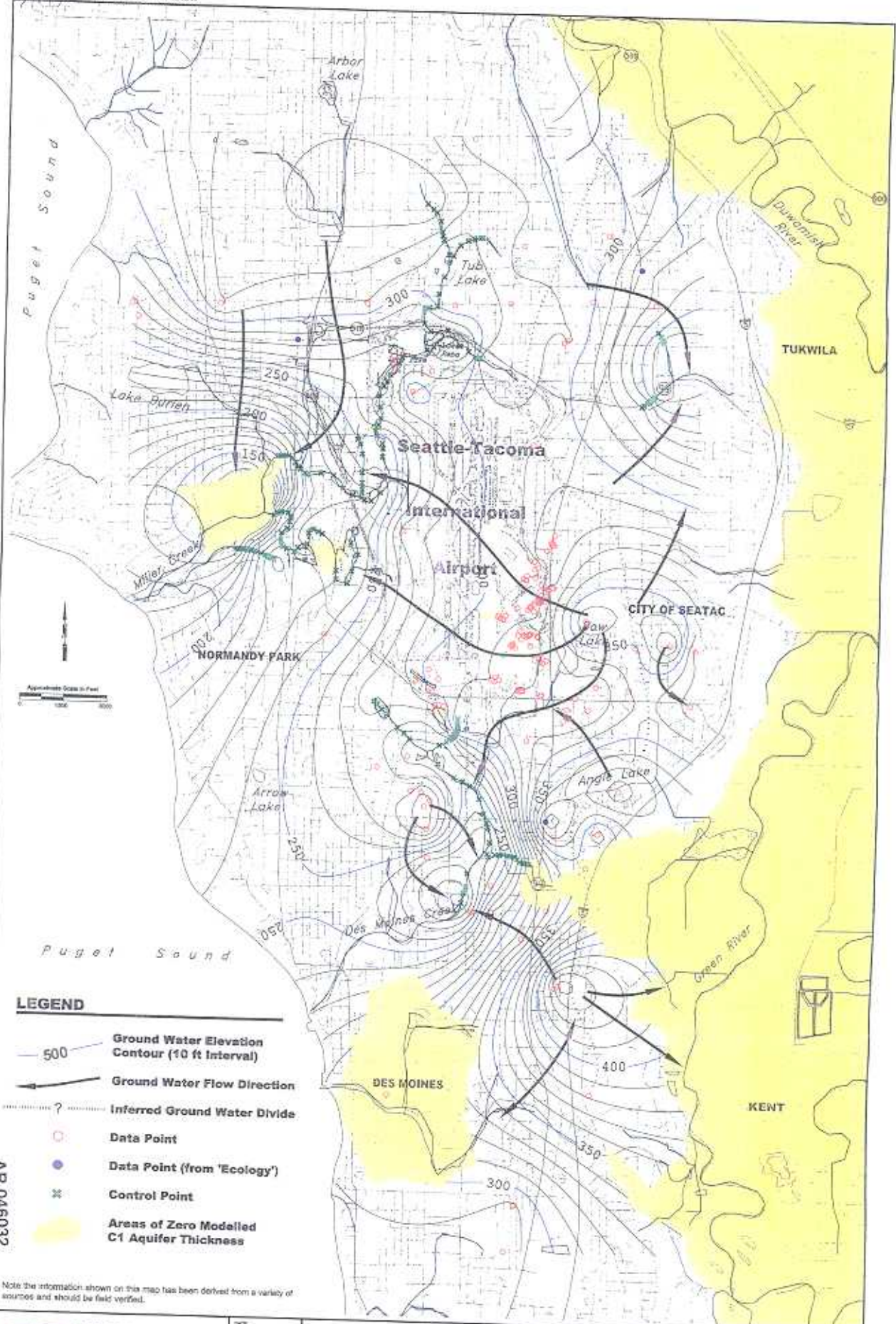
AR 046031



DATE: 08/07/99
 Revised On: JY/BJJ

Summary of Public Water Supply Wells
 Ground Water Study
 Seattle - Tacoma International Airport

PROJECT NO. 046031
 PAGE NO. 6



LEGEND

- 500 Ground Water Elevation Contour (10 ft Interval)
- Ground Water Flow Direction
- Inferred Ground Water Divide
- Data Point
- Data Point (from 'Ecology')
- Control Point
- Areas of Zero Modelled C1 Aquifer Thickness

AR 046032

Note: the information shown on this map has been derived from a variety of sources and should be field verified.

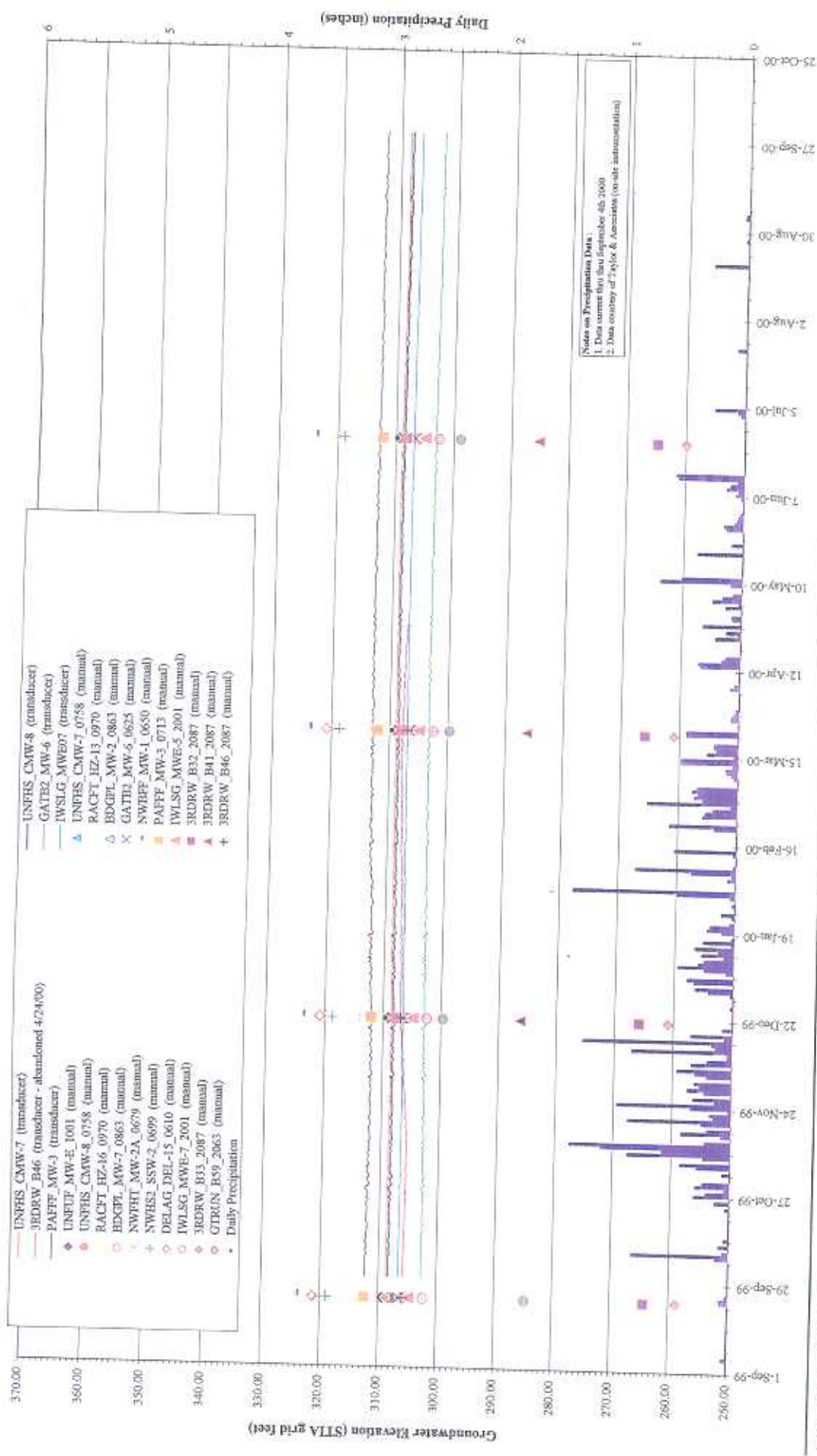
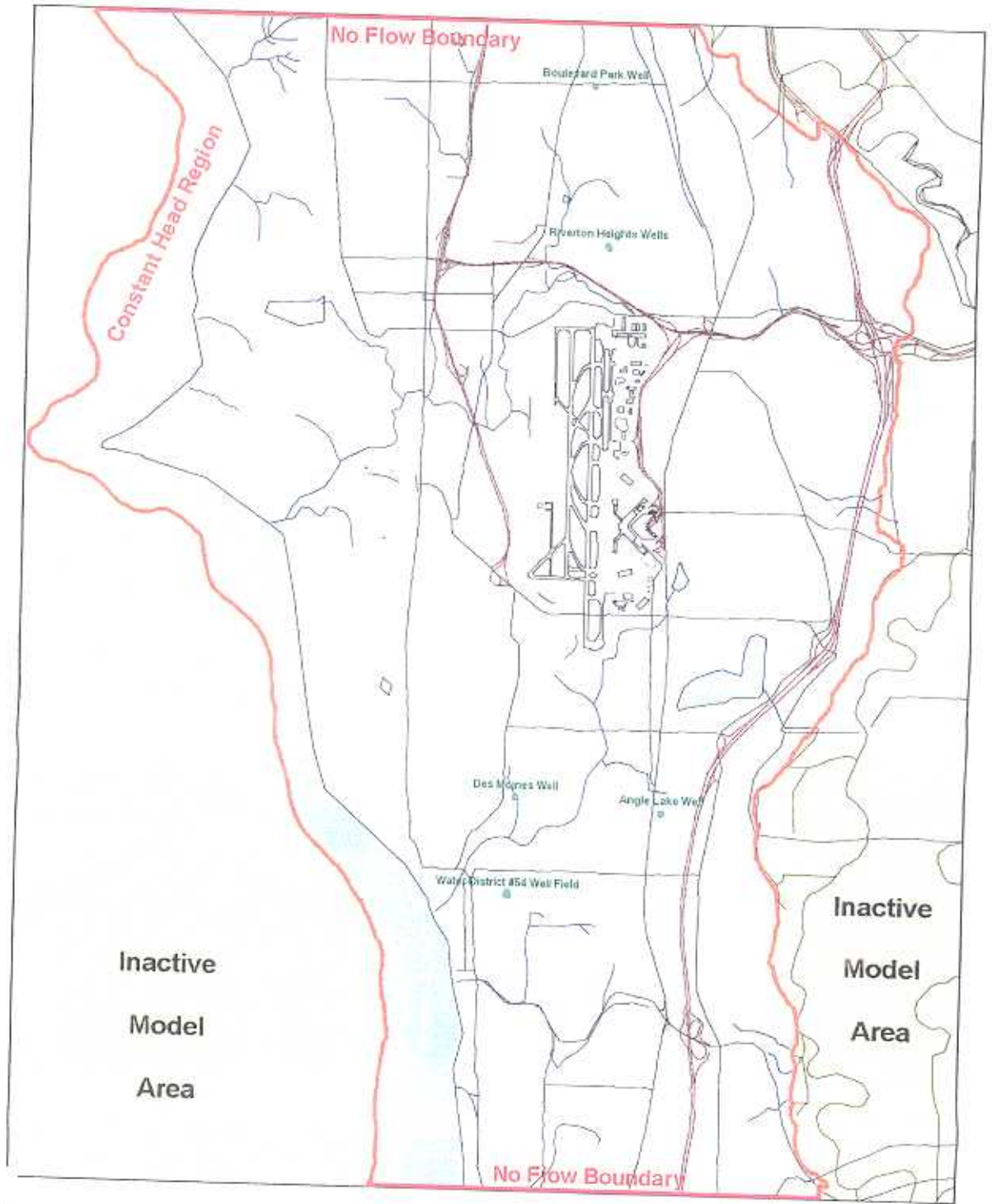
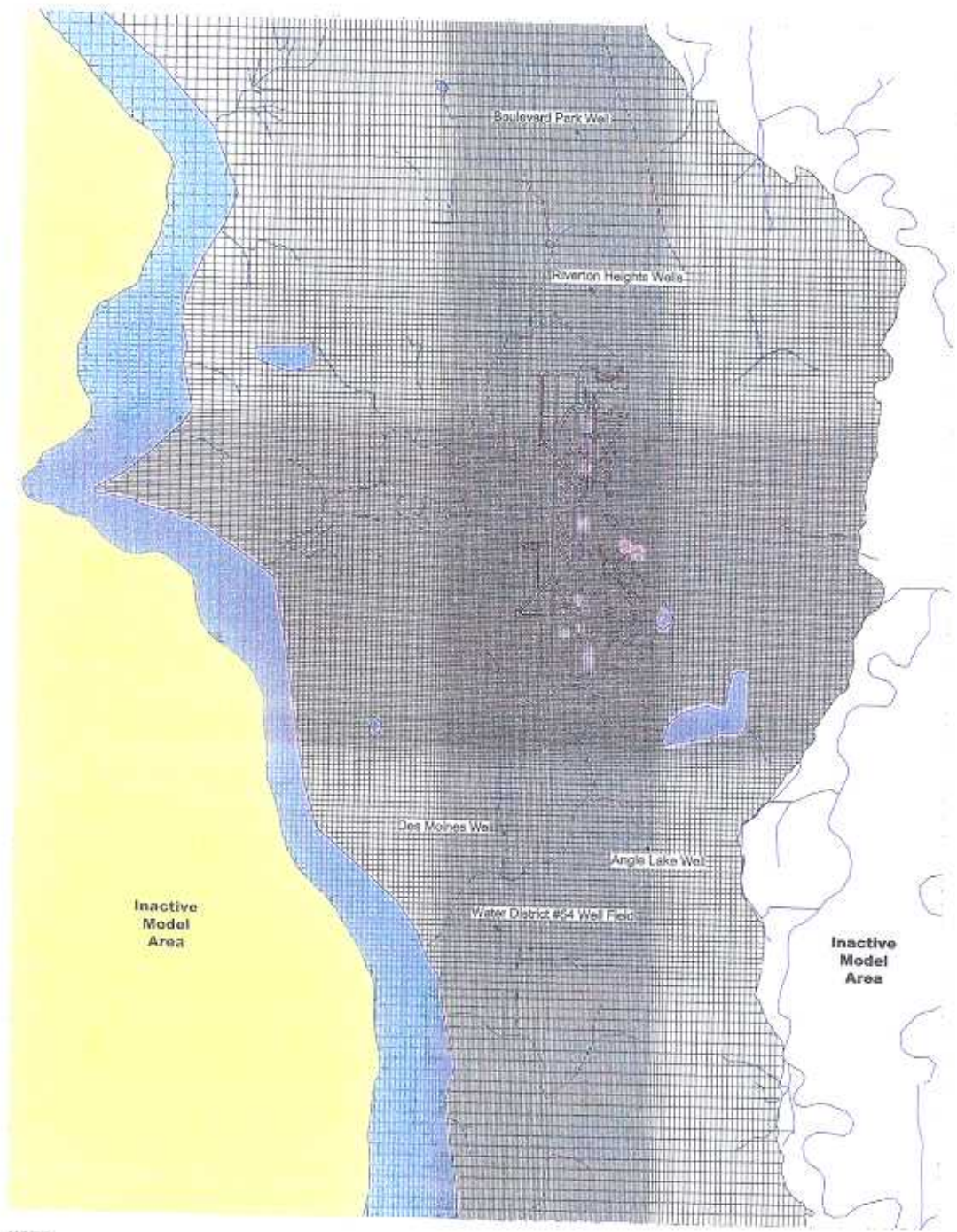


Figure 8
Measured Ground Water Elevations (Transducer & Manual Readings)
Seattle-Tacoma International Airport Ground Water Study



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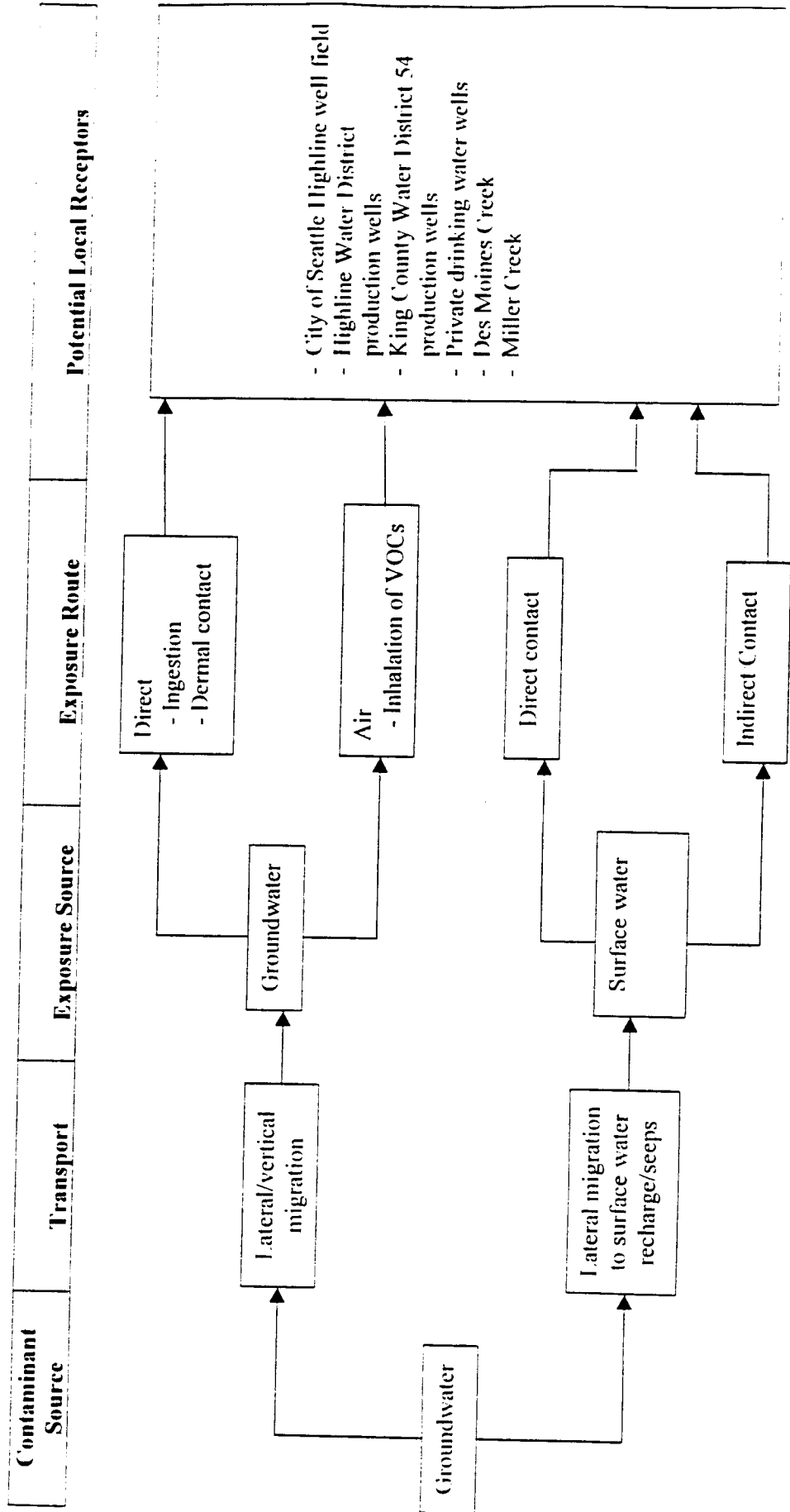
NOTE:
 - public water supply wells are in green
 - inactive model areas are shaded yellow

AR 046035



SEATTLE-TACOMA INTERNATIONAL AIRPORT GROUNDWATER STUDY

EXPOSURE PATHWAY ANALYSIS





LEGEND

Symbol	Feature Description	Modeling Method
Blue square	Reserve	Transport
Yellow square	Two Hydrocarbons in Indicator Compound	Transport
Blue square	1,1-Dichloroethane	Transport
Yellow square	Unknown/Not Identified	Vehicle Tracking



Potential Sites Key

Site #	Identified Potential Class
P1	Former Maintenance and Fuel Shop
P2	Former Gas Blending (pre-1973)
P3	Former Logistics Area (pre-1961)
P4	Former Fuel Area "Tank"
P5	Abandoned Hydrant Line (pre-1971-1980)
P6	Possible Compressor Area Fuel "Tank"
P7	Possible 50000 Gallon Fuel Tank
P8	Former Gas Blending (pre-1980)
P9	Possible Transformer Room Fuel Tank
P10	Abandoned Hydrant Line (pre-2002)
P11	Former Maintenance Building "at Area"
P12	Possible Air Cargo Area "Tank"

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Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
AGREED ORDER & POTENTIAL SITES

DATE: 08/11/2010
BY: [Signature]
FOR: [Signature]

Figure 11
AR 046037

**Seattle-Tacoma International Airport
Ground Water Study**
Detected Levels of Contaminant above the MTCA Method B Cleanup Level in Qva Aquifer

Source	VOC's												
	Benzene*	Toluene	Ethylbenzene	Total Xylenes	1,1-dichloroethylene*	Carbon Tetrachloride*	1,2-dichloroethane*	1,1,2-trichloroethane*	Tetrachloroethene*	Dichloromethane*	Cis-1,2-dichloroethene	1,1,1-Trichloroethane	1,1-dichloroethane
Budget Auto Facility	•												
Delta Auto Gas Cluster Tanks													
Gate B-2 Site													
NWA Fuel Farm													
NWA Hangar Tanks													
South Satellite Baggage Tunnel													
PANAM Avgas Tanks													
PANAM Fuel Farm													
RAC Auto													
United/Continental Fuel Farms													
MTCA Method B (µg/l)	1.51	1600	800	16000	0.0729	0.337	0.481	0.768	0.858	80	7200	800	
Fate and Transport Parameters													
Partitioning Coefficient, log K _{oc}	1.1 - 2.1	1.3 - 2.4	2.0 - 2.3		1.5 - 1.7	1.3 - 2.1	1.1 - 2.2	1.8	2.0 - 2.6	0.9 - 1.4	1.6 - 1.8	2.2	
Degradation half life (yrs)	0.1 - 1	0.3	0.3		0.2 - 1.0	0.01 - 1	0.3 - 1.0	0.4 - 13	0.3 - 4.8	0.2 - 10	3'	1.8 - 2.2	

NOTES
 1) Volatile Organic Compounds are in order of decreasing toxicity. The degree of toxicity is based on the MTCA Method B Cleanup Level.
 2) Analytes denoted * are carcinogens.
 3) • Denotes compound detected elevated above MTCA Method B Cleanup Level.
 4) NA - Compound was not Analyzed.
 5) From Mackay, Shiu and Ma, Illustrated Handbook of Physical-chemical Properties and Environmental Fate for Organic Chemicals, 1992.

AR 046039

**Seattle-Tacoma International Airport
Ground Water Study**

Detected Levels of TPH above the Proposed MTCA Method A Cleanup Level in Qva Aquifer

	TPH-G	TPH-D	TPH-O
Budget Auto Facility	1		•
Delta Auto Gas Cluster Tanks		•	
Gate B-2 Site		•	
NWA Fuel Farm ³		•	
NWA Hangar Tanks		•	
South Satellite Baggage Tunnel ³		•	
PANAM Avgas Tanks	2	•	
PANAM Fuel Farm ³		•	
RAC Auto Facility	1	•	
United/Continental Fuel Farms			
Proposed MTCA Method A CLU (µg/l)	800/1000	500	500

- Notes: 1) Benzene detected therefore MTCA Method A CUL is 800 ug/l
 2) Benzene not detected therefore MTCA Method A CUL is 1000 ug/l
 3) TPH-D is only compound elevated above MTCA CUL

AR 046040

10/03/2000

VALIDATED DATA

Ground Water TPH Data Gap Analysis
Seattle-Tacoma International Airport

Monitoring Well Date Sampled	MW-4 06/01/2000	B-16D 06/02/2000	B-17D 06/02/2000	B-25D 06/01/2000	SSW-1 06/01/2000	SSW-2 06/01/2000	SSW-3 06/01/2000	SSW-5 06/01/2000	SSW-7 06/01/2000	Blank	MTCA Method B
Poly-nuclear Aromatic Hydrocarbons (ug/l)											
Acenaphthene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	0.674	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	960
Acenaphthylene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Anthracene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Benzo (a) anthracene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Benzo (a) pyrene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Benzo (a) fluoranthene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Benzo (k) fluoranthene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Chrysene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
(b)benz (a,h) anthracene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Fluoranthene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Fluorene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	1.48	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	640
Indeno (1,2,3 cd) pyrene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
1 Methyl-naphthalene	<0.10 U	<0.10 U	<0.10 U	0.48	30	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
2 Methyl-naphthalene	<0.10 U	<0.10 U	<0.10 U	0.105	20.7	<0.10 U	59.9 D	<0.10 U	<0.10 U	<0.10 U	
Naphthalene	<0.10 U	<0.10 U	<0.10 U	0.941	36.2	<0.10 U	63.1 D	<0.10 U	<0.10 U	<0.10 U	
Phenanthrene	<0.10 U	<0.10 U	<0.10 U	0.155	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	0.557	<0.10 U	370
Pyrene	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 D,U	<0.10 U	<0.10 U	<0.10 U	
Volatile Organic Compounds (ug/l)											
Methyl tert-butyl ether	<2 U	<2 U	<2 U	<2 U	<2 U	<2 U	<2 U	<2 U	<2 U	<2 U	
Benzene	<1 U	<1 U	<1 U	<1 U	<1 U	0.854	<1 U	<1 U	<1 U	<1 U	1.51
Toluene	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	
Ethylbenzene	<1 U	<1 U	<1 U	3.34	3.88	<1 U	<1 U	<1 U	<1 U	<1 U	
m,p Xylene	<2 U	<2 U	<2 U	5.99	18.8	2.83	6.71	<1 U	<1 U	<1 U	800
o Xylene	<1 U	<1 U	<1 U	<1 U	11.6	<1 U	5.56	<2 U	<2 U	<2 U	16000
Naphthalene	<1 U	<1 U	<1 U	10.4	56.1	6.42	<1 U	<1 U	<1 U	<1 U	16000
1,2,3 Trimethylbenzene	<1 U	<1 U	<1 U	10.3	9.51	1.01	<1 U	<1 U	<1 U	<1 U	320
1,2,4 Trimethylbenzene	<1 U	<1 U	<1 U	4.53	70.5	<1 U	<1 U	<1 U	<1 U	<1 U	
1,3,5 Trimethylbenzene	<1 U	<1 U	<1 U	19.3	20.6	2.72	10.7	<1 U	0.816	<1 U	

Note: U - Analyte included in the analysis, but not detected
 J - Estimated value
 D - Data reported from a dilution
 B - Analyte detected in the method blank
 All data reported in parts per billion (ug/l)

Seattle-Tacoma International Airport
Ground Water Study

Selection of (Indicator) Chemicals for Modeling Fate and Transport of Jet Fuel in Groundwater

Location	VOC's										Polycyclic Aromatic Hydrocarbons (PAHs)					
	Benzene*	Ethylbenzene	Total Xylenes	1,2,3-Trimethylbenzene	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Acenaphthene	Fluorene	1-Methylnaphthalene	2-Methylnaphthalene	Naphthalene	Phenanthrene				
South Satellite Baggage Tunnel	✓															
PANAM Argos-Tanks Fuel Tanks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
PANAM Fuel Farm Argos Tanks		✓	✓	✓	✓	✓										
MTCA Method B (µg/l)	1.51	800	16000	NA	NA	NA	960	640	NA	NA	320	NA				
Fate and Transport Parameters																
Partitioning Coefficient, log K _{ow}	1.1 - 2.1	2.0 - 2.3	NA	3.08	3.11	3.1	3.38	3.59	3.34	3.33	2.93	3.91				
Degradation half life (yrs)	0.1 - 1	0.3	NA	NA	<0.01	0.09 - 0.12	0.03 - 0.3	0.01 - 0.3	0.7 - 3.3	NA	0.2 - 3.3	0.01 - 1.1				

NOTES

- 1) Compounds with * denotes carcinogen
- 2) No compounds exceeded MTCA Method A or Method B Ground Water Cleanup Levels ✓ Indicates detected compound.
- 3) From Mackay, Shiu and Ma, Illustrated Handbook of Physical-chemical Properties and Environmental Fate for Organic Chemicals, 1992
Montgomery, J.H., 2000. Groundwater Chemicals Desk Reference, 3rd Edition.
BIODEG Database (<http://esc.syres.com/ids/biodeg/html>)
Howard, P.H., et al. 1991. Handbook of Environmental Degradation Rates
Gustafson, J.B. 1997. Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Total Petroleum Hydrocarbon Criteria Working Group Series, Vol. 3.

Seattle-Tacoma International Airport
Ground Water Study

Summary of Chemicals of Concern for Fate & Transport Modeling

Agreed Order Site	Chemical of Concern
Gate B-2 Site	1,1 DCE
NWA Hangar Tanks	1,1 DCE
PANAM Avgas Tanks	1,1 DCE
Delta Auto Gas Cluster Tanks	1,2 DCA
Budget Auto Facility	Benzene
RAC Auto Facility	Benzene
NWA Fuel Farm	Napthalene
South Satellite Baggage Tunnel	Napthalene
PANAM Fuel Farm	Napthalene
Northwest Airlines Hydrant System Closure	Napthalene
United/Continental Fuel Farms	No Impact to Qva Aquifer
Continental Airlines Hydrant System Closure	No Impact to Qva Aquifer
Delta Airlines Fuel Farm	No Impact to Qva Aquifer

AR 046043