MEMORANDUM BV97016D

TO: Roger Nye, Department of Ecology

FROM: John Strunk, Associated Earth Sciences Inc.
Mike Riley, S.S. Papadopulos & Associates, Inc.

DATE: January 31, 2000

CC: Paul Agid, Port of Seattle
Mike Staton, Maul Foster & Alongi, Inc.

Subject: Response to Ecology Comments
Conceptual Flow Model Boundary Presentation
Ground Water Study
Seattle-Tacoma International Airport

On January 13, 2000, Paul Agid, Port of Seattle verbally transmitted your (Ecology) comments on the Conceptual Flow Model Boundary Presentation that was presented to you on December 8, 1999. The following memo is a summary of our understanding of your comments and provides a response to each of your comments. Please let us know if we have interpreted you comments accurately and if you require additional clarification or detail.

1) **Comment: Ecology has no issues with the proposed model setup.**

Response: The model boundary conditions as presented covers approximately 36 square miles. The model area will consist of constant head boundaries along Puget Sound to the west, and the western edge of the Duwamish River Valley. No Flow Boundaries will be applied to the north and south of the model area and will be outside of areas of influence from public water supply systems.

2) **Comment: Ecology would like have an "on-screen" demonstration of the current model setup.**

Response: A demonstration has been scheduled for February 3, 2000 at the Port of Seattle which will enable Ecology to view the current status of the MODFLOW model set-up and current configuration of the physical layout of model layers and hydrology.

3) **Comment: Ecology would like more detail on the source of data that were used to develop Figure 10 Summary of Aquifer Parameters.**

Response: The aquifer parameter data were compiled from a variety of sources including Department of Ecology well logs, and environmental and water resource consulting reports. The majority of hydraulic conductivity data for the C1 aquifer was catalogued from environmental consultant reports that were completed for various airport projects in the terminal area. The C1 data were mainly derived from slug tests and therefore no yield measurements were obtained which would enable the calculation of specific capacity. The slug test data were reported as hydraulic conductivity values and were entered into the STIA database as such. A corresponding transmissivity value could be calculated based on the estimated aquifer thickness by the multiplying the hydraulic conductivity value by the aquifer thickness. MODFLOW can use either hydraulic conductivity or transmissivity values as the standard input parameter. If hydraulic conductivity is used, MODFLOW computes the transmissivity from the hydraulic conductivity and the aquifer thickness or saturated thickness of the model layer.

Attached to this memo are the raw data used in developing the summary table and a reference list of the data source.

4) Comment: Ecology would like further explanation of why the model will be run under steady state conditions.

Response: Transient calibration is appropriate to simulate conditions that are changing significantly with time. In the case of the present project, the following were considered in selecting a steady-state as opposed to transient flow simulation:

- Transport analysis is a long-term process and short-term fluctuations in water levels or gradients do not significantly affect long-term transport.
- Water levels fluctuations at the airport do not show strong seasonal patterns, but are quite steady over time.
- The east and west boundary conditions do not change significantly over the long time periods.
- Tidal fluctuations do not affect groundwater flow or transport in the vicinity of the airport
- Drawdown from production wells to the north and south are not observed at the airport.

Based on the above considerations, boundary conditions and pump rates can be simulated as long-term average conditions, such as annual average levels or pump rates.

5) Comment: Ecology requests how the model will account for limited data in the lower layers.

Response: Two pieces of data are needed for including the deeper layers in the model: hydraulic conductivity and initial estimated heads. The deeper layers are similar to the more shallow layers as being a sequence of fine and course layers. Consequently, the hydraulic conductivity values used in the shallow layers provide a guide for selecting values in deeper layers. In addition, grain size data and information on the geology of the deeper layers can be used to estimate values from the literature. The sensitivity of model results to the values used in the deeper layers can also be tested to determine if model results would change significantly with different hydraulic conductivity values in the deeper layers.

Initial heads are only estimated heads for the purposes of starting the model simulation. The model will compute heads based on the boundary conditions and inflows and outflows to each layer. Consequently, the limited head data are not a limitation to the model, but may result in longer run times if the initial head estimates are different from the final computed heads.

6) Comment: Ecology is interested in what types of graphics will be develop to represent model results

Response: Standard output from MODFLOW includes heads, flows, and drawdown. In our case only heads and flows will be used as drawdown is not computed for steady-state simulations. The standard output from MT3D is concentration distribution over space and time. Standard output from particle tracking analysis (PATH3D) is the location and trajectory of particles over time.

Using the standard outputs from MODFLOW, MT3D, and PATH3D, various graphic outputs have been prepared for previous projects. These include standard head, plume, and particle path line maps. More colorful presentations can include plume and particle flow animations. Presently, we plan on preparing head, plume, and particle path line maps as these are quantitative representations of the model results. These maps are most often produced in SURFER, although ArcView has been used in some projects. Animations may be appropriate for public presentations. Animations are non-quantitative and are not effective in some cases.

7) Comment: Ecology would like to know why Figure 8A changed between the Conceptual Flow Model and the Conceptual Flow Boundary Model presentation package.

Response: Ecology requested AESI to review additional C1 wells from MTCA and UST reports that were on file at the agency. AESI reviewed over 30 sites that Ecology identified and determined that 3 wells were located in areas of the study area that were missing C1 water level elevations. The second version of figure 8A also accounts for the discharge areas of the C1 aquifer into surface water bodies of Miller and Des Moines Creek. Areas of the creek were identified as C1 discharge zones based on topography, cross section review and field observations of outcrops along sections of the creeks. Control points were established along sections of the creeks and were set to elevation of the creek. The control points, used in conjunction with ground water elevations from the C1 wells, show areas of the creeks that receive ground water from the C1 aquifer.

8) Comment: Ecology is concerned that there are no ground water wells in the C2 aquifer across a large encompassing the portions of STIA and southwest of the airport. Ecology has referenced a Hart Crowser and AGI figures that show two wells with C2 water levels in the area of the data gap and was wondering why they are not included on Figure 8b.

Response: AESI has reviewed the two wells in question 22N4E4C1 and 22N4E4N1 that are located south of the eastern runway and southwest of the airport. Well data from these wells were tabulated in the Hart Crowser Technical Memorandum No. 1, Summary of Data Review, Highline Well Field Study, November 28, 1984. AESI has also reviewed the well drillers logs for both of these wells to evaluate the stratigraphy. Well 22N4EC1 was used to construct cross section B – B' in the Boundary Condition presentation package. The screen sections of both wells are interpreted to be completed in the C3 aquifer and therefore were not used for creating the C2 ground water flow map.

9) Comment: Ecology has questioned why the Unit Thickness plots that were in the Conceptual Flow Model presentation package were left out of the Boundary Condition presentation.

Response: The main purpose of the unit thickness mapping was to evaluate the area of a unit that is missing or of zero thickness. The zero thickness overlays were included in the unit elevation maps that were presented in the Boundary Condition package. The areas of zero thickness combined with the elevation of the top of the unit surface are prepared and used to input the unit surface configuration into MODFLOW.

sys_loc_code	Biblio Number	Loc_name	X_coord	Y_cord	surf_elev	Spec_Cap (gpm/ft)	T (ft^2/d)	Kh (ft/d)	Storativity	Aquifer_Unit	Hydrostrat	Test_Method
BDGPL_MW-1_0863	863	BDGPL_MW-1	16035	13385.34	345.74		1686.0	2.835E+01	0.09	Qva	C1	Pump Test
GATB2_MW-3_0625	625	GATB2_MW-3	15033.68	12945.31	379.82			2.835E+01		Qva	C1	Constant Head
PAFAT_B-10D_1007	1007	PAFAT_B-10D	15953.1	12422.92	379.86			2.835E+01		Qva	C1	Slug Test (Rising Head) - Bouverd & Rice, 1976
PAFAT_B-11D_1007	1007	PAFAT_B-11D	15983	12449.22	379.79			2.835E+01		Qva	C1	Slug Test (Rising Head) - Bouverd & Rice, 1976
PAFAT_B-12D_1007	1007	PAFAT_B-12D	15968.54	12402.13	379.13			5.670E+01		Qva	C1	Slug Test (Rising Head) - Bouverd & Rice, 1976
PAFAT_B-13D_1007	1007	PAFAT_B-13D	16028.49	12457.31	378.7			5.670E+01		Qva	C1	Slug Test (Rising Head) - Bouverd & Rice, 1976
PAFAT_B-14D_1007	1007	PAFAT_B-14D	15878.65	12361.79	379.16			5.670E+01		Qva	C1	Slug Test (Rising Head) - Bouverd & Rice, 1976
RACFT_HZ-11_0833	833	RACFT_HZ-11	16326.17	13690.15	349.17			2.835E+01		Qva	C1	Slug Test
RACFT_HZ-5_0729	729	RACFT_HZ-5	16371.78	13614.44	349.12			1.106E+01		Qva	C1	Slug Test
RACFT_HZ-6_0729	729	RACFT_HZ-6	16314.08	13642.55	348.92			2.835E+01		Qva	C1	Slug Test
RACFT_HZ-8_0833	833	RACFT_HZ-8	16345.92	13563.65	350.19			5.897E-02		Qva	C1	Slug Test
UNFHS_CMW-4_0758	758	UNFHS_CMW-4	16145.9	14718.9	393.13			2.835E+01		Qva	C1	Grain Size
UNFHS_CMW-5_0758	758	UNFHS_CMW-5	15851.38	14494.69	393.79			1.134E+02		Qva	C1	Grain Size
UNFHS_CMW-6_0758	758	UNFHS_CMW-6	15826.62	14344.34	393.46			8.505E+01		Qva	C1	Grain Size
UNFHS_CMW-7_0758	758	UNFHS_CMW-7	15722.7	14382.4	392.6			5.670E+01		Qva	C1	Grain Size
23N4E28H2	2095	23N4E28H2	17149.33	17699	382	4				Qva	C1	
GATB2_DMB-4_0625	625	GATB2_DMB04	15102	13080	380			5.670E-01		Qva	C1	Constant Head
GATB2_DMB-4_0625	625	GATB2_DMB04	15102	13080	380			2.325E+01		Qva	C1	Constant Head
23N4E16D4	9999	23N4E16D4	13667	29803	365				4.00E-05	Qc(3)	C2	
23N4E21C11	9999	23N4E21C11	14304	23883	432.7		45127.9	1.419E+02	4.72E-05	Qc(3)	C2	K from triax. Perm. Test in sample from 27'
23N4E21C12	9999	23N4E21C12	14372	23801	435		45.1	2.149E-01	4.72E-05	Qc(3)	C2	
22N4E15F1	9999	22N4E15F1	19583.53	-3603.26	305	4	1337.0		5.10E-03	Qc(3)	C2	
22N4E15L1	9999	22N4E15L1	19492.25	-4982.99	275	2	267.4		5.40E-04	Qc(3)	C2	
22N4E4Q1	9999	22N4E4Q1	15791.71	3809.52	295		4946.9			Qc(3)	C2	
22N4E8K4	2095	22N4E8K4	11134.78	336.17	135		2674.0			Qc(3)	C2	
22N4E9A2	9999	22N4E9A2	16759.84	2902.62	330	6				Qc(3)	C2	
23N4E19B1	9999	23N4E19B1	5842.87	24015.21	375	12	10027.5		2.00E-04	Qc(3)	C2	
23N4E21C1	1007	23N4E21C1	15053.68	23258.94	432	105	66850.0		2.00E-05	Qc(3)	C2	
23N4E21C5	9999	23N4E21C5	14431.3	23862.45	429	43	46795.0		4.00E-04	Qc(3)	C2	
23N4E22B1	9999	23N4E22B1	21847.03	24517.41	285	1				Qc(3)	C2	
23N4E27C3	9999	23N4E27C3	20032.99	18223.78	490	36				Qc(3)	C2	
23N4E27P1	9999	23N4E27P1	19644.9	14370.82	455		2807.7		9.00E-04	Qc(3)	C2	
23N4E27P2	9999	23N4E27P2	19369.87	14368.89	455	30	2807.7		9.00E-04	Qc(3)	C2	
23N4E29N1	9999	23N4E29N1	8441.79	14201.63	240	3				Qc(3)	C2	
23N4E34F2	9999	23N4E34F2	20001.54	12245.15	397	7	2406.6			Qc(3)	C2	
23N4E16D1	2095	23N4E16D1	13572.16	29734.63	365		18584.3		1.10E-03	Qc(3)	C2	
23N4E16D1	2095	23N4E16D1	13572.16	29734.63	365		20589.8		9.70E-04	Qc(3)	C2	
23N4E16D1	2095	23N4E16D1	13572.16	29734.63	365		23798.6			Qc(3)	C2	
23N4E16D1	2095	23N4E16D1	13572.16	29734.63	365		16846.2			Qc(3)	C2	
23N4E16D3	2095	23N4E16D3	13639.07	29937.37	358	27	20055.0		1.00E-03	Qc(3)	C2	
23N4E16D3	2095	23N4E16D3	13639.07	29937.37	358		20589.8			Qc(3)	C2	
23N4E16M1	2095	23N4E16M1	15586.32	26099.23	395		2366.5		1.30E-04	Qc(3)	C2	
23N4E27C4	2095	23N4E27C4	19700	19250	420	19	8556.8			Qc(3)	C2	
23N4E27C4	2095	23N4E27C4	19700	19250	420		8423.1			Qc(3)	C2	
23N4E27C4	2095	23N4E27C4	19700	19250	420		8556.8			Qc(3)	C2	
22N4E8A2	9999	22N4E8A2	11255.81	3275.13	188.3	20.4	2371.6			Qc(4)	C3	
22N4E8K8	9999	22N4E8K8	11070.64	-373.65	175	9				Qc(4)	C3	
22N4E9A4	9999	22N4E9A4	16829.39	2802.34	332	33.7	4479.0			Qc(4)	C3	
22N4E9A3	9999	22N4E9A3	16828.84	2903.36	332	4	4011.0			Qc(4)	C3	
23N4E30J1	9999	23N4E30J1	6640.81	16521.99	160	4	254.0			Qc(4)	C3	

Document_ID	Author	Document_Date	Title
625	Dames & Moore	02-Mar-93	Report Remedial Investigation of Soils & Groundwater B-Concourse
729	McCulley Frick & Gilman, Inc.	20-Sep-94	Site Characterization Report
758	Converse Consultants NW	17-Aug-94	Concourse D Groundwater Remedial Investigation, Seattle-Tacoma International Airport, Seattle, Washington
833	McCulley Frick & Gilman, Inc.	12-May-95	Additional Subsurface Investigation Report Former Hertz, Avis, and National Fueling Facility
863	AGRA Earth & Environmental	01-Oct-95	Results of Monitor Well Sampling, Vapor Extraction System Testing, Remedial System Evaluation
1007	Landau & Associates, Inc.	25-Jul-97	Supplemental Report, Former Pan Am Avgas Tank Site Investigation, Seattle-Tacoma International Airport
2095	Hart Crowser	09-Sep-85	Technical Memorandum No. 4, Hydrogeological Assessment with Results of Exploratory Drilling and Testing Program, Highline Well Field Study
9999	Well Log	-	

AR 044095