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FOR THE STATE OF WASHINGTON

AIRPORT COMMUNITIES COALITION and CITIZENS AGAINST SEA-TAC EXPANSION, Appellants, v. STATE OF WASHINGTON DEPARTMENT OF ECOLOGY, and THE PORT OF SEATTLE, Respondents.	PCHB No. 01-160 **PREFILED TESTIMONY OF JOSEPH BRASCHER (with errata corrections)**

Outline of Testimony

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1. I have personal knowledge of the facts stated in this testimony and would be competent to testify to those facts.

BACKGROUND

Current Position and Experience

2. I have been employed by AQUA TERRA Consultants for almost nine years, since May 1993. My responsibilities with the firm currently include, project management, hydrologic analysis and computer programming, in addition to management of the Olympia satellite office. Prior to beginning my employment with AQUA TERRA, I was employed by the City of Olympia Surface Water Department as temporary technician from June 1991 until April 1993. My duties included hydrologic model review and model application. From May 1992 until April 1993, I worked for the Thurston County Water and Waste Management division, where my duties included hydrologic model review and model application. A copy of my C.V. describing my professional experience and education is attached as Exhibit A.

Retention and Overall Role

3. My involvement in the Seattle-Tacoma International Airport (STIA) proposed third runway project began in December 1999, when I was retained by Earth Tech to aid in the review of Des Moines Creek, Miller Creek, and Walker Creek Hydrologic Simulation Program — FORTRAN (HSPF) models. In July 2000 the King County Department of Natural Resources retained me to aid in their on-site review of the recalibration of Miller and Walker Creeks. In August 2000 I was retained by Parametrix to aid in continued use of the Miller Creek and Walker Creek HSPF models and to prepare the calibration reports for these streams. My work for Parametrix included making modifications to the models as improved data was made available and components of the hydrologic modeling conducted on the third runway embankment.

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Prior Experience with HSPF Modeling

4. I have extensive experience working with hydrologic models, including the Hydrologic Simulation Program — FORTRAN, which I will refer to as HSPF. HSPF is generally recognized as the most complete and defensible process-based continuous simulation watershed model for quantifying runoff and addressing water quality impairments. Since its initial development nearly twenty years ago, the HSPF model has been applied in numerous countries throughout North America and the world and in numerous climatic regimes; it enjoys the joint sponsorship of both the U.S. Environmental Protection Agency and the U.S. Geological Survey.

5. Over the past 10 years, I have calibrated HSPF models representing more than 15 watersheds in western Washington using the HSPF software package. These projects include a wide range of watershed conditions from highly developed areas to regions that are mostly forested. I have used HSPF models to determine impacts caused by various types of development, including small residential developments, large commercial developments, and primarily basin wide impacts due to projected future developments. Typically, the impacts analyzed include future peak flows, future flow durations, and impacts to future low flows. My role in the hydrologic modeling of the STIA proposed third runway embankment called for similar analyses.

LOW STREAMFLOW MODELING AT STIA

Modeling Goals and Selected Approach

6. The work performed by Aqua Terra comprised several components of the overall low streamflow analysis conducted for the third runway project at the Seattle-Tacoma International Airport (STIA). Our goals in performing this analysis were to determine the critical low-streamflow periods for Miller Creek, Walker Creek, and Des Moines Creek, the existing streamflow magnitudes (target streamflows) for each stream, and the impacts to each stream resulting from construction projects in the Master Plan Update for STIA. A detailed

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modeling analysis was used to determine the impacts to streamflows during the summer low-streamflow periods. Aqua Terra's work was one part of this detailed analysis.

Integration of HSPF Model with Hydrus and Slice Models

7. The overall modeling plan implemented for the proposed third runway embankment can be summarized as follows: (1) calculate the runoff and recharge from precipitation; (2) model the variable saturated vertical flow through the embankment fill; (3) model saturated, quasi-horizontal flow at the bottom of the embankment; (4) integrate those results across the fill embankment; and (5) incorporate the results back into the Miller and Walker Creek recharge models.

8. In designing our approach, we decided to employ a combination of what we determined to be the best and most appropriate tools available for modeling the introduction of the third runway fill embankment area. Because of HSPF's superior evapotranspiration (ET) and runoff-modeling capabilities, we selected it to model runoff and recharge (Step 1 as described above), and to model the net effects to flow during the summer low-streamflow periods (Step 5). We determined that additional modeling tools, Hydrus and Slice, would more effectively simulate flow through and below the proposed embankment. We selected Hydrus to simulate vertical flow through the embankment fill and Slice to simulate flow beneath the embankment fill. Aqua Terra was responsible for performing recharge calculations through the use of HSPF (Step 1) and incorporating Hydrus and Slice results obtained by Pacific Groundwater Group (PGG) back into the Miller Creek and Walker Creek HSPF models (Step 5). PGG performed intermediate Steps 2 through 4.

9. I disagree with ACC consultant William Rozeboom's criticism that our integrated approach "involves an apples-to-oranges mixture of methods" that is "unlikely to produce meaningful results." In my opinion, the use of a single model to simulate runoff, infiltration, flows over and through the third runway embankment, and stream recharge, although superficially less complex, would have resulted in a deeply flawed analysis due to the particular limitations inherent in each of the specific models used. For example, although

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it is possible to use HSPF to model active groundwater, the HSPF models alone are not in my opinion capable of accurately simulating groundwater flows of this type. For this reason, we determined that a combination of HSPF with additional modeling tools was a more appropriate approach to simulate flow through the proposed embankment in the Miller and Walker Creek watersheds. By integrating HSPF with Hydrus and Slice, we were able to capitalize on the advantages and the best features offered by each model, while eliminating or at least minimizing the drawbacks and limitations of each model.

10. In summary, HSPF was used to compute runoff from the pervious and impervious surfaces accounting for the evapotranspiration into the atmosphere. PGG then applied the data derived from HSPF modeling into Hydrus and Slice to determine the amount of surface runoff that would result from filter strips, the timing of the movement of water through the vertical soil column, and the resultant split in flow between the drains that underlie the embankment and the seepage into the till layer. Aqua Terra then entered the resultant time series from the Hydrus/Slice models into the HSPF models for Miller and Walker Creeks to determine the impacts of the embankment on low flows in these streams.

CALIBRATION

11. The calibration of hydrologic models allows the adjustment of model parameters to achieve a close match between recorded streamflows and simulated streamflows for a period when flow data are available. Hydrologic modeling using HSPF requires the consideration and calibration of many model-specific parameters that describe the different hydrologic processes. These processes include:

- Rainfall runoff from pervious and impervious surfaces.
- Infiltration of rainfall to soils.
- Soil moisture accounting.
- Flow of groundwater from soils to streams.
- Loss of groundwater to deep aquifers.

AR 002325

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12. Our calibration process included the use of all available data related to the stream reach and its tributary watershed. During the calibration process we attempted to match as closely as possible all existing recorded streamflow data and to reflect the general behavioral characteristics of each watershed without sacrificing accuracy and defensibility. We used the HSPF model to simulate continuous watershed hydrology and to design stormwater detention facilities for the Port's Master Plan Update. Because the third runway project encompasses three watersheds, we developed three separate HSPF models, one each for Miller, Walker, and Des Moines Creeks. Calibration of Des Moines Creek was performed by Dr. David Hartley of the King County Department of Natural Resources. The Miller and Walker Creek models were calibrated by the Calibration team, which was comprised of David Harms, Kelly Whiting from King County, and myself. Following calibration, the models could then be run to compare base conditions (1994) with post-project conditions (2006).

13. I understand that King County has raised concerned about the potential impact to the Miller and Walker Creek calibrations based on the minor changes that have been made to 1994 land use conditions. These impacts have been examined and have been determined to be inconsequential. Our evaluation of these impacts was summarized in a calibration verification report recently provided to the County.

Miller Creek Low Streamflow Calibration

14. We used two streamflow gages in the Miller Creek watershed to perform low-streamflow analysis calibration. One gage was located near the mouth of Miller Creek and a second gage was located further upstream at the Miller Creek detention facility. The results of our analysis are summarized in Tables 2-1 and 2-2 of the December 2001 Low Streamflow Report prepared by Parametrix, which has been submitted as an Exhibit. Those tables list average simulated and observed streamflows for each 7-day low-flow period during 1991 through 1996 for the downstream gage (Table 2-1) and the upstream gage (Table 2-2). Gage locations are depicted in Figure 2-1. For the Board's convenience, all tables and figures from the 2001 Low Streamflow Report that I refer to in my testimony are attached collectively as

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Exhibit B. The data we computed revealed that in general the observed 7-day low flows exceeded the predicted 7-day low flows at both gages, particularly for the gage located at the Miller Creek detention facility. In other words, the models tended to underestimate flows at Miller Creek.

15. In his pre-filed written direct examination, ACC's consultant Keith Malcolm Leytham is critical of the calibration we performed on Miller Creek, asserting that the calibration fails to incorporate groundwater inputs from the noncontiguous Miller Creek groundwater area. However, Dr. Leytham himself points out that "the exact noncontiguous area [is] . . . difficult to define." See Dr. Leytham's pre-filed written direct examination, ¶ 19.

16. Moreover, Dr. Leytham's colleague at Northwest Hydraulic Consultants, William Rozeboom, has stated his approval of the Miller Creek calibration. In his Declaration of October 8, 2001 (¶ 8), Mr. Rozeboom states: "I am in partial agreement with the Port and Ecology as to the adequacy of the HSPF model calibration for this project . . . . It is my opinion that the HSPF model calibration to Miller Creek is adequate for a range of applications." A true and correct copy of Mr. Rozeboom's Declaration is attached as Exhibit C. I agree with Mr. Rozeboom's assessment of the Miller Creek calibration and continue to maintain its validity.

Walker Creek Low Streamflow Calibration

17. As we did in the Miller Creek analysis, we used two streamflow gages in the Walker Creek watershed to conduct our low streamflow calibration. One gage was located near the mouth of Walker Creek, and a second gage was located further upstream near the Walker Creek wetland. The results of our analysis are summarized in Tables 2-3 and 2-4 of the December 2001 Low Streamflow Report. Those tables list the average simulated and observed streamflows for each 7-day low-flow period for the gage near the mouth of Walker Creek (Table 2-3) and for the gage near the wetland (Table 2-4). See Exhibit B. In general, with the exception of 1995, the observed 7-day low flows exceeded the predicted 7-day low flows at both gages.

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18. ACC's consultant William Rozeboom challenges the Walker Creek low flow calibration. In his pre-filed testimony (¶ 12), Mr. Rozeboom states, "For Walker Creek the main concern is over how Industrial Wastewater System (IWS) expansion and leak reduction efforts may be causing potentially-large reduction in headwater baseflows." For the following reasons, I disagree with Mr. Rozeboom and maintain that the approach we adopted and implemented provided the most accurate, valid, and useful data.

19. The issue of base flows for Walker Creek is admittedly a complex one, as the Walker Creek watershed has several unique characteristics. The tributary drainage area upstream of gage 42c (the upper Walker Creek gage) is approximately 233 acres. The average base flow at gage 42c is approximately 0.7 cfs. In contrast, Miller Creek at its mouth has a drainage area of approximately 4700 acres and an average base flow of approximately 1.4 cfs. In other words, an area of approximately 1/20 the size of Miller Creek produces approximately one half the base flow.

20. In my opinion, base flow of this magnitude cannot be generated locally. An outside source of groundwater is therefore likely to be contributing to base flow. After investigating all potential sources of groundwater, I have concluded that the probable source is the non-contiguous groundwater basin. Using the groundwater maps, we determined the size of the contributing groundwater basin. We added this area to the Walker Creek model and connected the groundwater from this area to the Walker Creek wetland. These steps greatly improved the base flow and volume calibrations of the Walker Creek model.

21. In my investigation we could identify no other probable sources of base flow. We considered many other potential sources, including the IWS drainage system, the IWS lagoons, and the possibility that Miller Creek groundwater that had been lost to a deep aquifer, but could not locate any quantitative flow information for any of these sources. We therefore concluded that the inclusion of these potential sources in the calibration would be purely speculative. Although such inclusion could make the calibration *appear* more accurate and valid, it was unlikely to actually improve the accuracy or validity of the calibration.

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22. Furthermore, there is no conclusive data indicating that any of these inputs changed significantly during the calibration time period. Because the IWS lagoons were lined after the period in which the calibration was conducted, they could not be considered an impact to the calibration process. Potential leaks to the IWS drainage system would be impossible to quantify and would at best introduce error into the calibration. It is possible that a portion of the groundwater lost from the Miller Creek watershed reaches the Walker Creek wetland, but the mapping renders this possibility highly unlikely.

23. ACC's consultants have also pointed to the 30% decline in base flows over the calibration period, asserting that the decline reveals a flaw in the calibration. However, this "pronounced" 30% reduction in low flows can be attributed entirely to reductions in precipitation during the calibration period. A review of measured precipitation from 1991 to 1995 makes this point clear. Total precipitation in 1991 was 45.6 inches. Precipitation in water-year 1992 was 30.62 inches, a 33 percent reduction from the previous year. Similarly, precipitation in water year 1993 was reduced by 30 percent compared to 1991, precipitation in 1994 by 44 percent, and precipitation in 1995 by 14 percent. Notably, in his pre-filed direct examination, Mr. Rozeboom also refers to the dramatic reduction in precipitation during the calibration period, noting that the years between 1991 and 1994 ranked as first, fifth, tenth and 25th driest years. See ¶ 32. I believe that this reduced precipitation, considered alone, more than explains the 30 percent reduction in base flows over the calibration period.

24. In summary, the low streamflow analysis calibration performed in Miller Creek and Walker Creek indicated that calibrated low flows at the mouth of each stream were reasonably accurate, while calibrated low flows at the upstream gages typically showed lower flows than actually observed. These discrepancies do not impair the validity or usefulness of the models. Rather, they are likely the result of unusual or unverifiable groundwater conditions in each of the watersheds, combined with general and typical streamflow gaging inconsistencies. I understand from my review of King County's streamflow gaging records for gage 42c, for example, that unexplained drops were common and that such reductions

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possibly resulted from water leaving the stream or from a gage malfunction. I agree. It has been my experience that observed streamflow records, while generally good, often have unexplained flaws. It is therefore my general practice not to make unsubstantiated changes to a model just to match potentially erroneous observed streamflow data.

LOW STREAMFLOW ANALYSIS

Determination of Low Streamflow Periods

25. We determined the low-streamflow period for each stream by analyzing modeled streamflow from the calibrated HSPF model for each stream. Our analysis used land use conditions existing in 1994. The 7-day low-flow period for each year in the 47-year period of record (1949 to 1995) for each stream was determined at points of compliance near the airport, specifically, 200th Street in Des Moines Creek, SR 509 in Miller Creek, and at the outlet of the wetland near Des Moines Memorial Drive in Walker Creek. The 7-day flow was selected as an indicator of persistent dry season flow. For example, summer low streamflows tend to decrease gradually; therefore, a shorter low-streamflow period is unlikely to result in significantly lower average flows or target flows.

Determination of Existing Summer Low Streamflows

26. The magnitude of existing summer low streamflow (target streamflow) in each stream was determined through analysis of the 7-day low-flow periods under existing (1994) conditions described above. Based on the analysis described in detail in the December 2001 Low Streamflow Analysis, the existing summer low streamflows (7-day, 2-year-frequency) were determined to be 0.33 cfs for Des Moines Creek, 0.77 cfs for Walker Creek, and 0.73 cfs for Miller Creek.

EMBANKMENT MODELING

27. Our goal in calculating recharge through HSPF models was to produce unit area run-off from pervious and non-pervious surfaces. Precipitation on the modeled fill area (MFA) was used to calculate hourly runoff (designated "SURO") from impervious surfaces

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(runway and taxiways), and hourly infiltration (designated "AGWI") into pervious areas. Pervious areas were modeled as grass on flat outwash.

28. For pervious areas, application of the generic HSPF model yielded hourly volumes of water that infiltrate beyond the bottom of the root zone (AGWI). This hourly volume was combined with the SURO time series from which groundwater recharge was calculated. Unit area runoff was applied to filter strips and other pervious areas. A separate calculation was used to estimate the extent to which runoff from impervious surfaces would also infiltrate, or conversely, run off, from filter strips. PGG then used the total amount of infiltration into filter strips (a portion of AGWI and SURO) and other pervious areas (AGWI only) as input to the Hydrus models. The process can be more specifically described as follows:

HSPF Input and Runoff Calculations

29. The HSPF model allowed us to account for precipitation, runoff, infiltration, and evapotranspiration on an hourly basis between 1984 and 1994 on outwash soils with land slopes of less than five percent. HSPF model output (AGWI) provided hourly estimates of recharge below the root zone, taking into account the effects of runoff and evapotranspiration.

30. HSPF also allowed us to calculate hourly volumes of runoff (SURO) from a typical acre of impervious surface. Under current plans, runoff from impervious surfaces will be routed into "filter strips" that treat the water prior to storage and discharge. The filter strips are part of the pervious surface of the new fill. Therefore, the SURO and AGWI water volumes were added together and compared to the infiltration capacity of the filter strips. We considered water in excess of the infiltration capacity of the filter strips to constitute runoff. Remaining water was considered to infiltrate and become groundwater recharge. For these calculations, areas of impervious surface and filter strips were based on GIS analysis of design data. We assumed uniform flow over the filter strip and ignored likely storage of water in surface irregularities. The infiltration capacity was calculated as the saturated hydraulic conductivity of the fill under a unit hydraulic gradient, over the area of the filter strip.

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31. A small amount of runoff was also calculated for "other pervious areas" (pervious areas that are not filter strips and therefore do not receive runoff) because AGWI on occasion exceeded the calculated infiltration capacity of other pervious area. The total volume of runoff from the other pervious areas was 6 percent of the AGWI volumes for both basins.

32. ACC's consultant William Rozeboom takes issue with our decision to use hourly volumes rather than a shorter time step. Our decision to use hourly volumes can be explained quite simply. All of the HSPF modeling work we performed up to this point had used an hourly time step. For the sake of consistency, we believed that runoff from the runway embankment and runoff from the rest of the basin should be computed on the same time step. I agree with Mr. Rozeboom that the use of a shorter time step could potentially increase the amount of surface runoff. In other words, the switch from hourly to 15-minute data may slightly increase the amount of surface runoff from the embankment (just as the use of a 5-minute time step will produce more surface runoff than a 15-minute time step). However, I believe that the key concern as it relates to the time step selected and applied is consistency. I previously noted Mr. Rozeboom's and ACC's general complaint about the Port's decision to integrate hydrologic models. Given that complaint, it is ironic that Mr. Rozeboom now criticizes our decision to use a single, consistent time step for the HSPF phases of the modeling

Effective Recharge

33. Effective recharge is the average downward groundwater flux over the entire pervious area, just below the root zone. It consists of those portions of AGWI and SURO that infiltrate. The filter strips and other pervious areas receive different amounts of water. In order the simplify the analysis, PGG calculated the *average* effective recharge for the entire pervious area as the summed volume of water infiltrated in those two areas, divided by the total pervious area.

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34. For the 11-year embankment modeling period of 1984 through 1994, the following water volumes, total runoff, and total infiltration on Miller and Walker Creeks were determined:

	Miller Creek Modeled Fill Area (ft3)	Miller Creek Modeled Fill Area (percent of total water)	Walker Creek Modeled Fill Area (ft3)	Walker Creek Modeled Fill Area (percent of total water)
Water Available to Filter Strip	69,006,026	70%	12,821,485	88%
Water Available to OPA	29,689,341	30%	1,688,604	12%
Runoff from Filter Strip	19,625,881	20%	2,650,317	18%
Runoff from Other Pervious Area	1,652,948	2%	94,013	1%
Water excluded by Hydrus	220,585	0%	40,091	0%
Water artificially removed from Hydrus to promote stability	0	0%	8,686	0%
Total Runoff	21,499,415	22%	2,793,108	19%
Total Infiltration	77,196,293	78%	11,716,981	81%

INCORPORATION OF HYDRUS/SLICE INTO HSPF MODELS

35. We reported the SURO and AGWI time series to PGG, which input that data into the Hydrus model to determine the variable saturated vertical flow through the embankment fill. PGG then input the resulting data into its Slice models to determine saturated, quasi-horizontal flow at the bottom of the embankment and to integrate the Slice results across the fill embankment. The Hydrus/Slice modeling performed by PGG produced three time series of flow data for both the Miller and Walker Creek watersheds: (1) surface runoff from the embankment area; (2) flow through the drain at bottom of embankment area; and (3) till seepage flow. These three time series of flow data were then provided to us to incorporate into the HSPF model for each watershed and to complete the overall modeling.

Miller Creek

36. The surface runoff from the embankment area was split into three time series based on the ratio of contributing areas. These time series were then linked to the drainage systems that serve the embankment area. The flow through the drain at the bottom of the embankment area modeled by the Slice model was connected directly to Miller Creek stream

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reach 35. Till seepage flow was routed to PERLND (Pervious Land Segment) 80, which represents the soil beneath the till layer underlying the embankment area and possesses the same parameter values as a Till Grass PERLND. The groundwater outflow from PERLND 80 was then routed the appropriate downstream receiving waters.

37. I am aware that King County has recently raised some concerns relating to precipitation being applied to PERLND 80 and the final destination of PERLND 80 groundwater. The December 2001 Miller Creek HSPF model has been modified to address these concerns by removing the precipitation from PERLND 80 and routing the groundwater to the locations suggested. The County also expressed concerns regarding the routing of the PGG surface flow time series, proposing that the new embankment model surface discharge time series should be routed to the same point as other surface discharges. This change has been incorporated into the Miller Creek model.

38. Finally, I understand that King County has recommended that the point of compliance (POC) defined at SR509 crossing should include MC7B and MC7 in the 1994 HSPF stream model. Specifically, the County proposed that the area associated with the MC7B subbasin (1994 model: 46.5 pervious acres) become the 2006 SDW1B subbasin (groundwater included to POC in 2006 model) and suggested that the POC in the HSPF model should be the outlet of RCHRES16 in both 1994 and 2006 models. An additional benefit identified by the County is that RCHRES16 would also include the MC7 subbasin, which loses 4 pervious groundwater acres and was found to be the furthest downstream subbasin subject to STIA related land cover changes. As suggested by the County, this issue was addressed by including MC7B and MC7 in the 1994 HSPF stream model.

Walker Creek

39. For Walker Creek, the surface runoff from the embankment area was routed directly to the SDW2 pond. The flow through the drain at the bottom of the embankment area was connected directly to the wetland near Des Moines Memorial Drive. Till seepage flow was routed to PERLND 80, which represents the soil beneath the till layer underlying the

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embankment area. The groundwater outflow from PERLND 80 was then routed to the headwater wetland for Walker Creek.

RESULTS OF ANALYSIS

40. The HSPF model was run for the four-year study period. We determined the net effects to flow during the summer low-streamflow periods by comparing the modeled streamflow before project construction to modeled streamflow after project construction, with non-hydrologic impacts included as appropriate. Based on the previously described analyses, we determined the total net summer low-streamflow impacts to be 0.08 cfs for Des Moines Creek, 0.11cfs for Walker Creek and 0.00 cfs for Miller Creek. These results and supporting data were reported to Parametrix.

I declare under penalty of perjury under the laws of the State of Washington that the foregoing is true and correct.

Executed at Tumwater Washington, this 13th day of March 2002.

[signature]
Joseph Brascher

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AIRPORT COMMUNITIES COALITION, Appellant, v. STATE OF WASHINGTON DEPARTMENT OF ECOLOGY, and THE PORT OF SEATTLE, Respondents.	No. PCHB 01-160 CERTIFICATE OF SERVICE

Holly Simmelink, Certified PLS, certifies that, on March 7, 2002, I filed/served the following documents on the following persons by the means specified below:

1. Port of Seattle's Anticipated Order of Witnesses

2. Errata for Prefiled Testimony of James C. Kelly, Ph.D. and Prefiled Testimony of Joseph Brascher;

3. Prefiled Testimony of James C. Kelley, Ph.D. (with errata corrections)

4. Prefiled Testimony of Joseph Brascher (with errata corrections)

5. this Certificate of Service.

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I declare under penalty of perjury under the laws of the state of Washington that the foregoing is true and correct.

Executed this 14th day of March 2002, at Seattle Washington.

Holly Simmelink, Certified PLS

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