RECEIVED
MAR - 7 2002
ENVIRONMENTAL
HEARINGS OFFICE

PAUL S. FENDT, P.E.

POLLUTION CONTROL HEARINGS BOARD
FOR THE STATE OF WASHINGTON

AIRPORT COMMUNITIES COALITION and CITIZENS AGAINST SEA-TAC EXPANSION, Appellants, v. DEPARTMENT OF ECOLOGY and THE PORT OF SEATTLE, Respondents.	No. PCHB 01-160 PRE-FILED DIRECT TESTIMONY OF PAUL S. FENDT, P.E.

Table of Contents

ORIGINAL

1. I have personal knowledge of the facts stated in this testimony.

2. I have more than 18 years of stormwater engineering and planning experience, encompassing a broad range of stormwater and surface water projects. I have significant experience working with hydrologic and hydraulic modeling (HEC-1, WaterWorks, HEC-2, HEC-RAS), NPDES stormwater permits, erosion control on creeks and lake shores, comprehensive storm and surface water plans, preparation of drainage ordinances and environmental impact statements. I have worked extensively with the Department of Ecology's Stormwater Manuals and with the King County Surface Water Design Manual.

3. I have been the project manager for stormwater management and low flow mitigation for the Port of Seattle's Master Plan Update ("MPU") projects for the past four years. I was the principal author of the Port of Seattle's Comprehensive Stormwater Management Plan ("SMP") and a principal author of the Low Streamflow Analysis and Summer Low Flow Impact Offset Facility Proposal ("Low Flow Analysis"). As Project Manager for the stormwater management and low flow mitigation projects at Sea-Tac International Airport ("STIA"), I have been responsible for analyzing and mitigating the impacts of the MPU improvements on surface water and ground water resources.

4. I graduated from the University of North Dakota with a degree in Geological Engineering in 1981. I was licensed as a Professional Engineer (Civil) by the State of Washington in January 1991 and the State of Florida in February 1990. I have been employed by Parametrix, Inc. for the past 11 years. A copy of my current curriculum vitae is attached to this declaration as Exhibit A.

5. The storm and surface water drainage systems at STIA are large and complex. Runoff from the airport drains to four separate streams. There are tens of thousands of feet of storm drainage system, an Industrial Wastewater System ("IWS") that collects and treats runoff from STIA, and two regional detention systems, with another in design.

6. Understanding the complexity of the system and analyzing impacts takes years of study, review, and modeling. In my opinion, the Port, its consultants, King County, and Ecology have a solid

understanding of the complexity of the system and have appropriately and thoroughly analyzed existing conditions, evaluated impacts, and developed effective mitigation for those impacts.

STORMWATER IMPACTS FROM THE MPU IMPROVEMENTS

7. The Port's proposed MPU improvements will add a total of approximately 106, 6, and 128 acres of new impervious surface to the Miller, Walker, and Des Moines Creek drainages, respectively. New impervious surface will change the hydrology and stormwater runoff patterns of land draining from STIA. During rainstorms, increased volumes of stormwater will drain to Miller, Walker and Des Moines Creeks that, if unmitigated, would cause peak flows in those streams. Stream flows in the summertime during periods of low rainfall will also be reduced if left unmitigated.

8. The Port's NPDES permit requires the Port to develop appropriate facilities and systems to capture, detain, treat and release stormwater generated at STIA. The water quality certification issued by Ecology for the MPU project adds additional stormwater mitigation requirements. Following is a general description of the stormwater management system developed by the Port to comply with Ecology's regulatory requirements.

9. Rain that falls on the third runway will run off from the new pavement across 75 feet of gently sloping infield grass to newly constructed catch basins. The infield grassy areas are referred to as "filter strips," an approved water quality BMP that removes particulates from stormwater. Precipitation that falls directly on the filter strips, along with some of the runoff from the impervious areas, infiltrates into the ground. Much of this pervious area surrounding the third runway is new embankment material, which is several feet thick and wide. The rainfall and runoff that infiltrates into the new embankment has been modeled in order to determine the rate and volume at which this stormwater moves through the embankment and flows to Miller and Walker Creeks (there is little new embankment in Des Moines Creek basin).

10. Stormwater runoff from the runway that does not infiltrate into the ground or embankment will be collected in catch basins that convey the stormwater to detention facilities,

including ponds and vaults. Stormwater collected in the detention facilities will be slowly released at carefully developed flow rates to avoid peak flow impacts, as required by Ecology's and King County's continuous flow analysis methods. As described below, detention times of up to 89 days are possible when the stormwater management facility is filled to the design level. In addition, some of the stormwater collected in the vaults will be detained for a slightly longer period of time and slowly released to Walker and Des Moines Creeks during the summer months when it is anticipated that the MPU projects will periodically reduce low summer flows.

11. The purpose of mitigating high flow and low flow impacts is the same – to mimic pre-development conditions, to maintain streamflows to protect aquatic habitat and aquatic organisms, and to ensure that water quality standards will be met.

12. In developing the MPU stormwater management plan, it was necessary to determine how the proposed development and its new impervious surfaces would affect volumes and flow rates of stormwater and, correspondingly, flows in affected streams. Both high flow and low flow impacts were calculated using state of the art computer modeling. The modeling process is described in detail in both the SMP and the Low Flow Analysis.

13. It is important to understand that the projected low flow impacts to be mitigated are minimal. The Low Flow Analysis shows that the predicted change in water depth during low flow conditions caused by MPU projects is 0.4 inches and 0.1 inches for Des Moines and Walker Creeks, respectively. There is no predicted change to flow depth in Miller Creek.

THE PORT'S STORMWATER MANAGEMENT PLAN CONTROLS FOR PEAK FLOW, LOW FLOW, AND WATER QUALITY IMPACTS.

14. Peak flow impacts resulting from new and existing impervious surface will be mitigated by capturing all stormwater runoff and detaining it in 344.1 acre-feet of stormwater detention storage. As described above, the detained peak flow stormwater will be released over time at prescribed rates so as to avoid erosion, scouring and habitat damage associated with uncontrolled stormwater discharges.

15. Low flow impacts will be offset by three methods: (1) seepage of infiltrated stormwater from the new third runway embankment (Miller and Walker Creeks); (2) detention and release of stored stormwater during the summer low flow season (Des Moines and Walker Creeks); and (3) retirement of existing water uses (Miller Creek).

16. The first method by which low flow impacts will be mitigated is the infiltration of stormwater into the third runway embankment. The infiltrated stormwater will move through the embankment relatively slowly, and some of it will emerge as seeps that will, in turn, flow into Walker and Miller Creek. It is anticipated that the maximum flow of infiltrated stormwater will reach Miller Creek in July, or approximately six to seven months after maximum precipitation. Because this seepage will reduce the overall low flow impact on Walker Creek, and mitigate these impacts altogether in Miller Creek, less mitigation water will be needed through releases from other detention facilities.

17. The second method for offsetting low flow impacts is detention and release of collected stormwater. Low flow impacts in Des Moines Creek and Walker Creek not mitigated by seepage from the embankment will be mitigated by retaining a small portion (32.0 acre-feet, or approximately 9% of the total collected volume of detained stormwater – 376.1 acre/feet) and releasing it to area streams during low flow periods. Detained stormwater will be discharged continuously into the affected streams during the normal low stream flow period for each of the streams. This slow release of detained water will replicate the timing and amount of stormwater baseflow. The amount of low flow releases has been determined using hydrologic modeling.

18. Stormwater from the airport runways is treated using BMPs listed in the Ecology and King County manuals. The primary components of the treatment system are filter strips and bioswales. Filter strips allow stormwater runoff to sheet flow over large grassy areas. Flow velocity is slowed by the grass, thereby enhancing the settling of particulates. The vegetation also traps particles. Some stormwater infiltrates into the ground, further filtering the particles. Metals and organic compounds are removed as these pollutants bind to the organic material in the soil. Bioswales are grassy, flat-bottomed

swales that receive runoff after it has been collected in a detention facility. Although flow depths and path lengths are typically greater than for filter strips, the pollution removal mechanisms are the same. Vaults and ponds also treat stormwater by allowing for additional settling and removal of particulates.

19. In my opinion, the stormwater management system for STIA described above and in the SMP and Low Streamflow Analysis reports will adequately mitigate the peak flow, low flow, and water quality impacts of the proposed MPU projects. In addition, stormwater impacts from built areas at STIA and surrounding developed areas recently acquired by the Port will be retrofit with new stormwater management systems to mitigate existing stormwater impacts in the streams surrounding STIA.

STORMWATER DETENTION AND TREATMENT

20. The Airport Communities Coalition ("ACC") has asserted that managing stormwater so as to avoid low flow impacts is unusual and unprecedented. This is not consistent with my understanding of Washington's stormwater regulatory requirements, nor is it consistent with my professional experience.

21. **Infiltration and Detention are the Preferred Methods of Controlling Stormwater Flows**. Infiltration is listed in Ecology's Manual as the preferred stormwater flow control method because it most closely resembles natural recharge conditions. When stormwater is infiltrated, it is collected and allowed to move through the soil so it recharges groundwater and reduces the potential for low flow impacts. Infiltration is not an appropriate stormwater management technique in all areas, such as sites where the soils have poor infiltration characteristics or high water tables. In these instances, especially locations where low flow reduction could cause adverse impacts, alternate low flow mitigation is needed. One such alternative is the collection and detention of runoff, which is then slowly released to avoid flow impacts. This is the alternative required by Ecology to mitigate impacts – both high flow and low flow – in Walker and Des Moines Creeks.

22. Infiltration is not feasible in the Walker Creek and Des Moines Creek watersheds at the locations where low flow mitigation is needed. This is due primarily to the poor infiltration

characteristics of the soil. Instead, this stormwater will be detained in vaults and ponds and then be released to the streams at approximately the same time and in approximately the same amount that the natural system would have provided water to the stream.

23. **Retention of Stormwater is a BMP of Stormwater Management**. In addition to flow controls described above, the Ecology Manual requires that BMPs designed to reduce pollutant concentrations be applied to all new development and redevelopment. Wetponds, wetvaults, and constructed wetlands are all Ecology-approved BMPs that can be used for water quality mitigation (the Port is not using these water quality BMPs because these techniques attract wildlife, which is dangerous at an airport). Each of these techniques relies on a permanent pool of stored water to provide stormwater treatment.

24. Water in a wetpond, for example, is displaced by new stormwater coming into the wetpond, but a permanent pool of water is always left in the pond. The permanent pool of water in the wetpond can only leave the pond by infiltration, evaporation, or transpiration, and this loss must be continually replaced by additional stormwater to maintain the design pool depth. Wetponds, wetvaults, and constructed wetlands have been allowed for stormwater management for several years and many have been constructed. To my knowledge, a water right has not been required for this commonly used stormwater management facility which permanently retains stormwater. In fact, to my knowledge, a water right has never been required in Washington to manage stormwater.

25. **Even the Port's <u>Peak</u> Flow Plan Detains Stormwater for Extended Periods**. Several of the Port's <u>peak flow</u> stormwater facilities will detain stormwater for more than 50 percent of the year, and can take up to three months to drain after a design storm event. To meet peak flow control requirements, several of these detention facilities have very low prescribed flow release rates. This means that the ponds and vaults detain stormwater for much of the year to avoid peak flow impacts. The following table shows that three proposed peak flow ponds (one from each watershed) will be storing stormwater more than 62 percent of the time.

Facility	Percent of Time with Stormwater in Storage
MILLER CREEK	
SDW1B Pond	73%
WALKER CREEK	
SDW2 Pond	66%
DES MOINES CREEK	
SDS3 VAULT	62%

26. When the ponds or vaults collect water from the design storm, the amount of time that it takes to release the detained stormwater is considerable because the release rate is exacting, precise and prolonged. As explained above, this is because the goal of the stormwater management system is to mimic predevelopment conditions. Therefore, stormwater release rates are carefully prescribed so that streamflows do not exceed the levels experienced before the development occurred. For example, when detention Pond SDW1B (located in the Miller Creek basin) is filled to its design level (53.6 acre-feet), it will take 89 days to discharge all of the water, assuming no additional runoff enters the pond during this period. In Walker Creek and Des Moines Creek for the facilities in the table above, the discharge time is 17 days and 15 days, respectively.

27. **Treatment of Stormwater is Required and Often Involves Lengthy Detention Periods**. Stormwater treatment is a required BMP under the Ecology and King County stormwater manuals. The purpose of water quality BMPs is to remove pollutants before they can be discharged into surface waters, where they can harm fish and other aquatic organisms. One mechanism by which these systems work is through particulate removal, where pollutants that are attached to particulates are settled out of the stormwater in pools of still water.

28. Typical settling facilities identified in the stormwater treatment BMPs include bodies of deep (up to eight feet), still water, also known as wetponds or wetvaults, where suspended particulates are allowed to settle out. Wetponds are typically located after detention ponds, with grassy slopes, three to eight feet deep, with a "baffle" or other means to prevent water flowing into the pond from stirring up settled particulates.

29. The pool of water in a wetpond (or wetvault or constructed wetland) is filled and maintained by stormwater runoff from the project site. This is intended to be a permanent pool of water for use exclusively to remove pollutants from stormwater runoff. Thus, treatment may require lengthy or even indeterminate detention periods. Wetponds, wetvaults, and constructed wetlands, all approved Ecology and King County stormwater BMPs, have been constructed throughout the region absent, to my knowledge, a water right. Each of these facilities permanently requires a pre-determined amount of stormwater runoff for the purpose of mitigating runoff impacts from development.

30. The Port's proposal for managing stormwater to meet the requirements of its NPDES permit and the Water Quality Certification follows the Ecology and King County Stormwater Manuals. The Port has selected and applied BMPs in a manner consistent with the Manuals. Low flow mitigation has been provided in a manner that is consistent with the intent of the Manuals to "achieve no net detrimental change in natural surface runoff and infiltration." Where infiltration is infeasible, alternate and approved low flow mitigation has been provided.

LOW FLOW MODELING AND MITIGATION

31. **Modeling and the Identification of Low Flow Mitigation**. The HSPF model developed for the Airport's streams is an effective tool for analyzing existing streamflow conditions and designing mitigation. Under the HSPF model, all periods of flow are considered and flow is evaluated for multiple years of the precipitation record. There is significant variability in the area streams and low streamflow is a relatively small amount of flow when compared to runoff that comes from storms. For example, the 2-year peak flow in Miller Creek at SR 509 is 45 cfs. By contrast, the 2-year seven-day low flow in Miller Creek at SR 509 is 0.75 cfs. Despite this variability, it is possible to determine the effects of new development in the watershed to predict potential impacts in the watershed with a high degree or reliability.

32. **Low Flow Mitigation History**. The analysis of potential low flow impacts in the Miller, Walker, and Des Moines Creek watersheds began in November 1995 with hydrologic modeling study

contained within the EIS. The impact was calculated based on groundwater recharge potential. In that analysis, the impact calculated at the mouth of Miller Creek was 0.1 cfs, and Des Moines Creeks low flow reduction is 0.1 cfs as calculated at S 208th St. (Walker Creek is a tributary to Miller Creek that was not evaluated separately in the original study. The 0.1 cfs impact includes Walker Creek).

33. The 1997 Des Moines Creek Basin Plan prepared by the Des Moines Creek Basin Planning Committee (which includes the Port, King County, and the Cities of Des Moines and SeaTac) identified low flow conditions as a problem in Des Moines Creek and recommended a low flow augmentation plan that included well water. It also determined a current "summer baseflow" in the "Des Moines Creek mainstem" of 0.55 cfs. In addition, the estimated summer baseflow before urbanization was 0.70 cfs. A copy of Table A.11 from the Des Moines Creek Basin Plan is attached as Exhibit B.

34. In July 1998, Appendix E of the Preliminary Comprehensive Stormwater Management Plan determined the change in streamflow during low flow periods in Des Moines and Miller Creeks. The mitigation plan at that time consisted of using groundwater pumped from a Port-owned well near Des Moines Creek and retired water withdrawals in Miller Creek, as described in Appendix E of the July 1998 Preliminary Comprehensive Stormwater Management Plan. This approach to mitigating low flow impacts was discontinued due to questions raised by the Department of Ecology regarding the need for amendments to the water right associated with the Port owned well.

35. The Port also considered using water from Seattle Public Utilities to mitigate low flow impacts. However water quality issues and a failure of Seattle Public Utilities to guarantee water required a new plan.

36. Originally, using collected stormwater to mitigate low flow impacts had not been pursued, other than that limited portion of stormwater that was to be infiltrated into on-site soils, because of cost and feasibility concerns. However, given the problems with other alternatives, and the consistency of managing stormwater to mitigate low flow impacts with the Puget Sound and King

County Stormwater Manuals, the Port authorized an analysis of using stormwater to mitigate low flow impacts. Consequently, the Port developed preliminary designs for retention vaults to provide low flow mitigation. King County reviewed the plan and required that the modeling of stream flows in HSPF and embankment modeling be combined into a single analysis.

37. In July 2001, the Port submitted the Low Streamflow Impact Analysis and Flow Offset Plan. Additional modeling required by Ecology combining the HSPF and embankment models found that Des Moines, Miller, and Walker Creeks would require 0.10, 0.13, and 0.09 cfs of low flow mitigation respectively. However, modeling errors were found that miscalculated the amount of water coming from the embankment fill in Miller Creek. In addition, a groundwater routing error was found in the Des Moines Creek model that also affected the Walker Creek area. These errors were corrected and a revised analysis was reported in the December 2001 Low Flow Report, which found that Des Moines, Miller, and Walker Creeks would require 0.08, 0.00, and 0.11 cfs respectively.

38. Even though the methodology, modeling, points of compliance, and design standards have changed, the magnitude of mitigation required has remained very small when compared to normal stream flows in the streams.

39. **Low Flow Mitigation Required in Des Moines Creek**. In his testimony, Mr. Luster misstates the Port's proposal to provide low flow mitigation. Mr. Luster indicates (at 22-23) that 1.0 cfs minimum flow would need to be provided in Des Moines Creek to maintain existing beneficial uses. The 1.0 cfs figure is unsupported by the measured flows in Des Moines Creek, the modeled 7-day low flows at 200th Street (which range from 0.17 to 0.51 cfs), and the flows calculated by King County for the Des Moines Creek Basin Plan (undeveloped flows of 0.70 cfs). What Mr. Luster is demanding is that the Port provide low flow mitigation going beyond any impact associated with the Port's proposed projects. In my experience, Mr. Luster's suggestion that the Port be required to provide low flow mitigation for impacts that are not related to its development action is entirely unprecedented.

40. **Calculation of Summer Low Flow Impacts**. Summer low flow impacts in Miller, Des Moines and Walker Creeks were calculated using methods described in the Low Flow Analysis. The first step in the process was identifying current stream flow levels, focusing on low flow periods of the year. The HSPF model of current conditions (pre-MPU project development) provided daily average flows in each of the streams for 47 years of precipitation record (1949-1995). The daily average flow was grouped and averaged in seven-day increments. The lowest seven-day flow in each year of the record (a total of 47 values) was selected and ranked in order of smallest to largest seven-day low flow. The 24th value in the ranking statistically has a 50 percent chance of being equaled or exceeded in any year (also referred to as the 2-year, 7-day low flow).

41. The 2-year, 7-day low flow was selected as the flow value for impact and mitigation evaluation. The 2-year flow is protective, since the magnitude (flow rate) of more extreme low flows is lower than the 2-year flow, so the subsequent impact would be the same or lower flow rate. Therefore, impacts from more extreme droughts would be mitigated with this standard.

42. The time of year that low flows typically occur and the amount of low stream flow impact were determined in order to quantify the amount of stormwater to be reserved for release during the low flow period. The 47 years of record for each stream were plotted to determine when seven day low flows have occurred historically. In Miller Creek, 44 of the 47 seven-day annual low flows occurred between August 7 and November 1. In Walker Creek, 44 of the 47 low flows occurred between August 7 and November 9. The three remaining low flows in each stream occurred in November and December during the typical rainy season. In Des Moines Creek, low flows in all 47 years of record occurred between August 3 and October 24. Graphs showing the low flow periods are attached as Exhibit C.

43. **Definition of Baseflow and Relative Flow Magnitude**. Stream flows generally rise and fall in response to rainfall and runoff. In addition to rainfall response, streams have a baseflow that is generally water from groundwater seepage or other water slowly released from lakes or wetlands (e.g.

not in direct response from rain or surface soil seepage). Water from baseflow generally comes from rain that fell long before it is expressed as baseflow. For example, rainfall that recharges groundwater and becomes stream baseflow could take years to travel through the ground in large river systems, and weeks or months in small stream systems. In western Washington, it is normal for several weeks to pass in the summer with little or no precipitation, during which time stream flow is nearly all baseflow. For purposes of the Low Flow Analysis, the lowest seven-day average stream flow for each year of the rainfall record was modeled. This period was a baseflow period.

44. Baseflow variability from year to year is a result of precipitation variability. For example, the lowest annual 7-day baseflow recorded at the mouth of Miller Creek varied from a high of 2.7 cfs to a low of 1.3 cfs between 1991 and 1996 (reference table 2-1 Low Flow Analysis) (attached as Exhibit D). In Walker Creek, at a gage near STIA, the annual 7-day baseflow varied from a high of 1.21 cfs to a low of 0.67 cfs between 1991 and 1994 (see Table 2-4 Low Flow Analysis) (also included as Exhibit D). The years 1991 through 1996 were ranked the 19th, 8th, 4th, 16th, 37th and 45th during the 47 years of precipitation record (from driest to wettest). These results show that natural baseflow can vary from year to year by 100 percent or more. Biota living in the stream are adapted to highly variable low flows found from year to year. See Pre-Filed Direct Testimony of Donald E. Weitkamp, Ph.D., ¶¶ 35-37.

45. We have found in our modeling that new impervious surface is the predominant cause of baseflow reduction, and that other changes, such as vegetation or changes in infiltration, have little or no perceptible effect. We have also found that the impact of new impervious surfaces on baseflow generally does not exceed the impact of new impervious surface as a relative proportion of the total basin area.

46. **Low Flow Augmentation Period and Determining Low Flow Mitigation Flows.** Based on the review of precipitation records, a low flow period was established for each of the area streams. In Des Moines Creek, low flows in all 47 years of records occurred between August 3 and

October 24. For that reason, the Port will provide mitigation from July 24 through October 24 and has designed the low flow facilities to provide flow during this timeframe. In addition, as described in Section 3.2 of the Low Flow Analysis, any water remaining in the vault could continue to be discharged until the vaults are taken off-line for December maintenance. (The relevant portion of Section 3.2 of the Low Flow Analysis is attached as Exhibit E). Because the vaults are sized to provide water for the driest year in the 47 years of record, in most years we anticipate that they will be at least one third full at the end of the mitigation period. If the vault were one-third full, drainage from that vault would provide mitigation water for approximately one month, which would provide low flow mitigation through the month of November.

47. In Walker Creek, 44 of the 47 low flows occurred between August 7 and November 9. The three remaining low flows in this stream occurred in seven-day periods starting on November 9, November 23, and December 15, during the typical rainy season. December and November are on average the wettest and 3rd wettest months of the year respectively. Accordingly, the potential for low flow impacts during those months is low. Similar to the Des Moines Creek vault, in Walker Creek, the water remaining in the vault would be discharged until the vaults are taken off line in December. Based on the 47 years of streamflow data, the Walker Creek vault would be expected to be one third full for 33 of the 47 years, which would cover the low flow periods during November.

48. **Determining the Low Streamflow Impact Value for the 2-year low flow period in Miller and Walker Creek**. Mr. Rozeboom (¶ 32) misrepresents the methodology used to calculate low streamflow impacts and mitigation. The low streamflow impact for all of the streams was determined based on the seven-day low flows within each stream that would occur at a 2-year return frequency. For Des Moines Creek, the entire flow record (47 years) was available to compare 2-year flows. For Miller and Walker Creeks, a shorter record was available (four years: 1991-1994).

49. For the four-year record, the 7-day low flow data for existing conditions was ranked corresponding to the same year for the full 47 years of record. For example, the full 47-year record in

Walker Creek ranked the years 1991- 1994 25th, 10th, 5th, and 1st respectively, when ranked from lowest to highest. The 24th ranked value corresponds to the 2-year value for Walker Creek in 1991. Because 1991 is coincident with the 50 percent return frequency flow, the difference between modeled 1994 and 2006 flows in 1991 was used to determine the mitigation value of 0.10 cfs. For the other three years, 1992-1994, the low flow difference was 0.08, 0.08, and 0.09 cfs respectively. For Miller Creek, the 1994 HSPF 7-day low flows 1991 to 1994 were assigned return frequencies according to the corresponding years from the 1994 full record 7-day low flows. A regression analysis was conducted on the 7-day low flows at the assigned return frequencies for existing 1994 low flows and future 2006 low flows. Values estimated the 7-day low flows corresponding to the 50 percent return frequency, based on the results of the regression analysis. The difference between the 1994 and 2006 simulated 7-day low flows for the 50 percent return frequency was calculated and determined to be the mitigation value for Miller Creek. Contrary to the opinion advanced by Mr. Rozeboom, the mitigation flows values determined are consistent with the methodology described above.

50. **Low Streamflow Model Calibration**. A hydrologic model consists of a number of parameters that represent natural conditions to the extent practicable. The goal of the modeler is to attempt to replicate conditions found in the watershed and streams, generating results that approximate the "best fit" when compared to existing, known, and measurable conditions. In establishing a best fit, the modeler will evaluate the best available information and make judgements based on experience and standards of practice.

51. When calibrating a model, the experienced modeler will judge if additional information will serve to improve the model calibration or if more detailed information can explain hydrologic conditions that may not be readily understood. A hydrologic model is never perfect; there is no way to perfectly replicate a complex natural system. However, a model can be calibrated to replicate a system to the extent that it significantly simulates natural conditions so that the modeler can use the model to correctly determine impacts from development actions and provide appropriate mitigation.

52. Calibration is a matter of judgment and professional disagreement can arise with respect to calibration. An ironic example of this is the opinions of two of ACC's experts, Mr. Rozeboom and Dr. Leytham. Both have submitted opinions on behalf of ACC with respect to the calibration of the Port's HSPF modeling – however, even the opinions of ACC's experts (both of whom work for Northwest Hydraulics and both of whom have submitted co-signed comment letters on the Port's low flow plan) do not agree. Mr. Rozeboom has stated that the calibration for the peak flows in Miller, Walker and Des Moines Creeks are acceptable and the calibration for low flows in Miller Creek is acceptable (see Exhibit F), while Mr. Leytham maintains that those same calibrations are suspect.

53. Calibration of hydrologic models relies on the concept of mass balance water accounting. What this means is that all of the precipitation that falls from the sky must be accounted for in the stream or receiving water (including lost or gained groundwater). A model such as HSPF, which is a continuous simulation model that calculates runoff continuously must "spread" the mass balance of water across time. In addition to accounting for all of the water that enters a system, a model must depict natural and artificial components of a watershed. The model does this by using parameters that describe the area of the watershed, how the soils, vegetation, and impervious areas respond to rainfall, how water is routed from upstream to downstream areas, and how interflow and groundwater are removed and added to the surface water system.

54. Models are used to predict the effects of changes to one or more of the watershed parameters as the result of development and mitigation actions. Typically, the amount of impervious surface and land cover changes. The remaining watershed parameters are unchanged, and modeling parameters used in the existing condition models are applied to the modified areas of the model. By only changing parameters that are directly related to the new development, the impacts that result from that development can be isolated. This is significant because it is the difference between existing modeled and future modeled runoff conditions for which mitigation is required, not the difference between the existing measured flows and the modeled predicted future flows. As a result, a comparison

between future calibrated model results and existing measured flows, such as the one offered by Dr. Willing at ¶19 of his testimony, is an incorrect application of the model results.

55. In ¶6 of his testimony, Dr. Leytham indicates that limited detail is provided regarding calibration. On the contrary, the SMP includes an entire volume discussing calibration (Appendix B, Volume 3) and the low flow report provides an additional volume (Appendix A, Volume 2). These documents include discussion of model calibration methodology, documentation of input data, presentation of results (comparison hydrographs as well as summary statistics) and evaluation of calibration model performance.

56. Mr. Rozeboom asserts (¶13) that the Low Flow Analysis does not discuss the accuracy of the low streamflow calibration and adequacy for the purpose of low flow simulation. The Low Flow Analysis discusses the accuracy of the calibration model in predicting low flows in "HSPF Model Low Flow Calibration Review", Volume 2, Appendix A. The Review presents comparison tables of observed average low flows and calibrated average flows and comparison hydrographs at each of the stream gauges in each of the creeks. In addition, these tables and figures are accompanied by narrative discussing the accuracy of the calibration model in simulating low flows. In my opinion, the low flow models are adequate in simulating low flow and are appropriate for the purpose of assessing low flow stream impacts.

57. **Des Moines Creek HSPF Model Calibration.** The calibration model for Des Moines Creek was previously developed and used by King County for the Des Moines Creek Basin Plan. Small changes to the calibration model (land uses and watershed areas) were made during development of SMP. No changes were made to the model calibration parameters. Current modelers were discouraged by King County from making any significant changes to the calibration model. King County, on behalf of Ecology, has asked for additional information regarding comparisons of calibration results with 1994 pre-project conditions used for calculating low flow impacts, information that will be provided to the County for review.

58. Dr. Leytham's concerns regarding the Des Moines Creek calibration (¶21) are at odds with the available gage data. Model calibration made use of all available data at all available gages. The model was calibrated to gages 11C and 11D, because those two gages had the longest available records (1991 through 1996). The model could not have been calibrated completely to gage 11F, because of lack of any records before 1995. As was noted above, the County previously approved the calibration of the model and encouraged the Port not to recalibrate the model.

59. The observed average low flows and calibrated average low flows are compared at each of the stream gauges in Table 4-1, Table 4-2, Table 4-4 and Table 4-5 of the Low Flow Calibration Review. Table 4-1 shows the average difference between low flows from June through November to be 0.122 cfs, or only 3.4% of the observed flows for Des Moines Creek at the mouth. Table 4-4 shows the average difference to be 0.611 cfs or 37% of the observed flows for Des Moines Creek at gage 11-C. Dr. Willing and Mr. Rozeboom's statements regarding the unresponsiveness of the model to hydrological events recorded at gage 11-C oversimplify the model calibration by looking at only portions of the results. During model calibration, the overall best match is developed by using the best available data and adjusting the calibration parameters to create a best fit of the measured flow hydrograph with the simulated flow hydrograph. As is the nature of hydrologic modeling calibration, portions of the simulation hydrograph from the calibration model are going to match some observed flows better than others. While there are modeling periods not simulated as accurately (for example, during the summers of 1993 and 1994), the model shows a good match at other times (for example, during the summers of 1991, 1992, 1995, and 1996). The overall performance of the calibration model needs to be considered when evaluating its accuracy and adequacy.

60. Dr. Leytham notes correctly (¶29) that different infiltration parameters are used for Des Moines and Walker Creeks. This was because the calibration of the Walker Creek model was done by a different modeling group and at different time than modeling of the Des Moines Creek model. They are different streams with different soils, land cover, and levels of development. Therefore, calibration

parameters of Walker Creek and Des Moines Creek are different, including the infiltration parameter INFILT. However, this is not the issue here. For the Des Moines Creek calibration, 1994 land use and soil GIS coverages were used to categorize each land area into one of five different pervious soil-land cover types. The infiltration parameters values used are appropriate for modeling Des Moines Creek hydrology for each of the unique soil types.

61. In the Walker Creek calibration, it was determined that there was additional groundwater coming into the system from areas outside of the Walker Creek surface water drainage area. The modelers first determined a single pervious land cover segment to generally reflect the average performance of the five possible soil types in the area. This also explains why there are different infiltration parameters for the two watersheds. The modelers then determined the area of "non-contiguous pervious land" that would produce the amount of groundwater seen in Walker Creek. The concept of a non-contiguous groundwater area is supported by groundwater mapping in the area. While the calibration modeling did not define a precise location of the non-contiguous basin, it became clear that such an area would need to be defined to determine where the low flow impacts from new development would occur and to what magnitude. The area of pervious land in the Walker Creek non-contiguous area is approximately 610 acres. Land use tables showing the non-contiguous areas are shown on Exhibit G.

62. Dr. Leytham claims (¶¶30, 31) that there is double-counting of groundwater in SDS 5, 6, and 7. There is no "double-counting" of groundwater; non-contiguous groundwater areas were carefully determined, as shown on the map entitled "Change between existing and Future Groundwater Basins" in the Low Flow Report, provided as Exhibit H.

63. **The IWS system and Low Flow**. In Mr. Rozeboom's testimony (¶¶18 and 19) he asserts that failure to take account of the IWS system calls the model into question. However, these criticisms do not survive a close examination of the IWS and the way it was actually modeled. The IWS drainage system and lagoons are man-made facilities for collecting stormwater runoff from industrial

areas at Sea-Tac Airport, which were originally constructed to divert stormwater from industrial areas to reduce the impacts of stormwater draining from high-use areas at the airport. Existing drainage from existing impervious areas have been added and deleted from the IWS drainage system as a means of reducing water quality impacts. Impacts from new impervious areas in the IWS drainage areas have been modeled and mitigated in the Low Flow Mitigation Plan.

64. The three IWS lagoons at STIA are lined or scheduled to be lined, as required by Section S4 of the NPDES permit. The purpose of the liner is to prevent any seepage. Lagoon 1 was lined in 1997, followed by Lagoon 2 in 1998. Lagoon 3 is now under construction for expansion and lining. The expansion and lining of IWS Lagoon 3 is not an MPU project, although additional capacity in the lagoon will serve MPU projects.

65. The HSPF model modeled the IWS lagoons as "water." Water in the model is treated as an area that neither infiltrates nor contributes runoff. The existing lagoons therefore do not contribute infiltration to the modeled system in either the predeveloped or the built condition.

66. The expansion of IWS Lagoon 3 will increase new impervious area in the basin by only approximately 8 acres, compared to approximately 314 acres of existing IWS impervious area (less than 3 percent). This will have a negligible effect on groundwater recharge. Moreover, IWS Lagoon 3 was designed with a drainage and pump system beneath the liner to reduce upward groundwater discharge pressure, suggesting that this area is actually a groundwater discharge area and an insignificant groundwater recharge area. This fact provides another basis for the conclusion that no significant impact will result from the expansion of IWS Lagoon 3.

67. The IWS drainage system and lagoons are not and have never been designed or used as a groundwater recharge or infiltration system. In fact, the very purpose of the leak detention program and lagoon lining is to prevent leakage from the system. The Port is therefore maintaining the design intent of the original IWS system, which did not leak water to the groundwater system.

68. Mr. Rozeboom's assertion (¶¶16-17) that the Port will construct 163 acres of new impervious surfaces in the Port's IWS system as part of the MPU improvements is incorrect. Mr. Rozeboom apparently arrived at this number by comparing the IWS service area in 1994 with the total IWS drainage area in 2006. In fact, the MPU improvements will result in the addition of 67 acres of new impervious surface in the IWS service area. The 1996 FEIS correctly identified the IWS service area as 254 acres. (Table 3-1, FEIS, attached as Exhibit I). The Port began transferring existing impervious areas (approximately 72 acres), constructed prior to development of the MPU, from storm drainage basins to the IWS system, as shown on the table in Exhibit J, which was published in the November 1999 Preliminary Comprehensive Stormwater Management Plan. The purpose of these diversions was to implement a source-control Best Management Practice (BMP) to reduce stormwater runoff to the area streams from high-activity areas. The Port will add 67 acres of new impervious area for the MPU in the IWS area. Approximately 23 acres of the future IWS drainage area is pervious land, which would continue to provide recharge to the groundwater. The sum of the areas (254+72+67+23) is 416 acres, which compares with the 417 acres of future IWS area in the SMP and Low Flow Reports. These 67 acres of new impervious surface have been fully analyzed and mitigated in the Low Flow Mitigation Plan. Accordingly, low stream flow impacts from IWS areas have not been underestimated, as claimed by Mr. Rozeboom.

69. **Impacts from Borrow Areas.** Mr. Rozeboom (¶20) incorrectly asserts that land use changes between 1994 and 2006 have not been addressed. New impervious surface from MPU projects has been included in the analysis. The impacts from borrow areas do not include impervious area and are temporary and reversible. In addition, the Sea-Tac Runway Fill Hydrologic Studies Reports (PGG 2000), prepared by PGG for the Department of Ecology, indicated that recharge to the shallow regional aquifer would be expected to increase because of excavation in the borrow area. Des Moines Creek receives base flow from this aquifer.

70. In addition, Mr. Rozeboom's assertion that the low flow impacts from removal of soil at the borrow areas has not been considered is inaccurate. It is erroneous to state that hydrogeologic conditions at the borrow areas are comparable to the proposed Third Runway embankment, when considering the depth of material, location, material composition (grain size distribution), position relative to the respective streams, and variable stream hydrology.

71. In Mr. Rozeboom's testimony (¶21) he describes an agreement between the Port of Seattle and the City of SeaTac for use and redevelopment of Borrow Areas 3 and 4, arguing that the agreement between the City and Port requires future redevelopment of the site. While the Port is considering and negotiating the agreement, the Port has not signed it. In any event, the potential for redevelopment is speculative at this time, and would be subject to full environmental review at such time as a development proposal was prepared.

72. **Low Flow Monitoring**. The monitoring protocol described in Section I.1.e.i of the 401 Certification requires that the monitoring plan address: "Collection of stream gage data and an evaluation/correlation to expected flow rates established by the model." (A copy Section I.1.3.i is attached for reference as Exhibit K). Mr. Rozeboom asserts in his testimony that stream monitoring in June and July is "not very useful" (¶35). This assertion is based on an incorrect interpretation of the purpose of the condition, and erroneously describes how the data would be interpreted. The additional data would in fact be used to further the efficacy of the model.

73. In addition, Mr. Rozeboom makes reference to the "status quo (degraded stream)" when referring to concerns with the low flow monitoring protocols (¶36). There is no information that I am aware of that indicates there are low flow problems in Miller or Walker Creeks (Des Moines Creek low flow issues are described in the basin plan). Mr. Rozeboom then suggests that there is no value in the extensive stream restoration and stormwater retrofitting provided by the project without low flow retrofitting. The Port has provided mitigation for its low flow impacts. I have discussed above the relative significance of low stream flows, as well as the possible extent of impacts or benefits based on

land area under Port control. Mr. Rozeboom has incorrectly interpreted the low flow monitoring requirements and their relative importance to protect the resource and provide reasonable assurance.

OTHER STORMWATER ISSUES

74. Dr. Willing's statement (¶47) that that there will be insufficient water for "dilution" during low flows demonstrates a lack of understanding of flow conditions in the streams surrounding STIA. Dr. Willing claims that flows in the streams are below 0.5 cfs for extended periods of time. To the contrary, the modeling shows that 7-day low flows at the downstream measurement locations for the entire 47 years of the record in Miller and Walker Creek never fall below 0.5 cfs. *See* Table: Statistical Ranking of Average Seven-Day Low Flows (attached as Exhibit L) (the seven-day low flows in Des Moines Creek are below 0.5 cfs). However, the amount of flow in a stream at any point has a relationship to amount of watershed draining to the stream at a point of interest. For example, the baseflow in Miller Creek at STIA is lower than baseflow at the mouth, because there is gradually more contributing groundwater area downstream. When there is a storm, flows increase downstream because there is more basin area contributing to the stream. The relationship of runoff to baseflow is consistent and unchanged under similar baseflow and storm conditions; therefore the dilution is relatively constant. It is a misrepresentation of the flow conditions in these streams to compare stormwater runoff amounts to baseflow conditions.

75. The "first flush" effect that Dr. Willing (¶47) refers to is also incorrect. By definition, when rain is falling and runoff is entering the stream, the stream is no longer at baseflow. Typically, even small rainfall amounts increase stream flow many times over.

76. **Applicability of the King County Design Manual**. In Mr. Rozeboom's testimony (¶ 7), he states that "Airport development projects are subject the requirements of the KCSWDM because the airport is located in the jurisdiction of the city of SeaTac." This is incorrect. Pursuant to a 1997 interlocal agreement between the Port and the City of SeaTac, the Port is required to comply with SeaTac Municipal Code §12.10.010 as it existed on September 4, 1997. Further, the Port is obligated by

the interlocal agreement to be "consistent with City standards." The current King County Stormwater Design Manual was not in place at the time of the agreement. As a result, the Port's Master Plan Update improvements are not subject to the provisions of the current Manual. Notwithstanding this fact, the Port has used the technical provisions of the 1998 Manual to demonstrate compliance with standard stormwater management practices applied to new development projects.

77. **Construction of the Proposed Des Moines Creek Regional Detention Facility**. Mr. Rozeboom contends that the fact that the Des Moines Creek's Regional Detention Facility may be built and that the Port has indicated it would utilize that facility in conjunction with its stormwater plans somehow indicates that the Port is "planning to design and construct basin flow control facilities which are different that those designed and approved in the SMP." (Rozeboom, ¶9). This contention not only misrepresents the Port's intentions, but also fails to acknowledge the fact that SMP has consistently stated that the Port planned on integrating the Des Moines Creek RDF, if and when it was constructed. The SMP shows in Section 2.1.4 that "if the proposed Des Moines Creek RDF is constructed, the detention standard will be Enhanced Level 1, and 1994 land cover used." (Relevant portions of the SMP are attached as Exhibit M).

78. The Port is fully committed to providing peak flow mitigation as outlined in the SMP. In the event the Des Moines Creek RDF is constructed, that RDF would provide retrofitting for existing impacts. Consequently, the Port's facilities would no longer need to provide peak flow retrofitting. However, impacts from new impervious surfaces would be required. It is misleading for Mr. Rozeboom to allege that somehow the Port would rely on the RDF and then not construct the facilities proposed whether or not the RDF was constructed.

79. In the event the RDF is constructed, the Port would revise the SMP to take account of that fact (just as is indicated in the document itself). Any such revision would require the review and approval of Ecology, as required in the §401 certification (*see* Condition J.1, which mandates that any modification to the SMP requires written review and approval by Ecology) (Condition J.1 is attached as

Exhibit N). The §401 Certification (J.1.d) specifically contemplates the possible construction of regional detention facilities and outlines provisions that must be met for the Port to rely on facilities other than those described in the SMP. Further, the condition requires that the plan "achieve the performance goals of the CSMP and the corresponding basin plan."

80. **Stormwater Quality.** Dr. Willing's discussion of dissolved metals and the use of advanced treatment technologies in paragraphs 30 and 31 of his pre-filed testimony demonstrates his lack of understanding with respect to metals toxicity and the state-of-the-science on using filter media for stormwater. First, Dr. Willing's contention that there are "demonstrated problems of dissolved metals in the Port's stormwater discharges" is irrelevant since measuring for dissolved metals in stormwater discharges or within pipe is not an indication of potential effects to aquatic life living in a stream. As whole effluent toxicity testing has shown, samples of within pipe, end of pipe, and in-stream receiving water have demonstrated no toxicity to sensitive test organisms such as the water flea and juvenile fathead minnows on numerous occasions (Port 2000; Parametrix 1999).

81. To my knowledge, the newly released Stormwater Management Manual does not clearly expect the application of advanced treatment technologies (i.e., media filtration). Instead, Section 12.3 of the Manual recommends that local governments "exercise reasonable caution" when applying emerging technologies, and includes media filters as one example of "emerging technologies for stormwater treatment and control" in Section 12.6 (A copy of the relevant portion of Sections of 12.3 and 12.6 is attached as Exhibit O). Contrary to Dr. Willing's contention, the exact expectations on the use of filter media for stormwater are not clear at all. It should also be noted that filter media testing conducted by the Port (Tobiason et al., 2002) demonstrates that while the percentage of metals removal can provide some indication of filter media effectiveness, it does not provide an indication of toxicity reduction to aquatic life. For example, it was not necessary for metals removal to be 100 percent for toxicity to be removed. In addition, one of the media tested actually imparted toxicity on the effluent even though there was some metals removal. Indeed, this latter finding would suggest that application

of media filter based on metals removal data without testing for toxicity is unscientific at best, and at worst, could actually be detrimental to the receiving water aquatic life intended for protection.

82. **Construction of the MPU Improvements Will Result in Increased Water Quality.** The MPU projects will be constructed on existing STIA areas or, in the case of the third runway, on recently acquired residential land. Many existing land uses and potential water quality impact sources will be retired as a result of the MPU projects. For example, over 400 houses and businesses will be removed, each of which contributes stormwater pollutants such as sediment, metals, pesticides, herbicides, fertilizers, and animal waste. In addition, farms in the Port's acquisition area will be removed, reducing pollutants commonly associated with farms, such as sediments, animal waste (fecal coliforms) and agrichemicals. Removing uses such as houses, septic systems, a golf course (favored goose habitat), and a farm should have a positive impact on fecal coliform. The new uses (runways, taxiways, infields, and rooftops) are insignificant contributors of fecal coliform into the environment.

83. Stormwater runoff from runways compares favorably with runoff from residential areas. Dr. Willing has made misleading statements (¶ 29) concerning the "stormwater waste stream" and "stormwater quality concerns arising from a large complex industrial facility such as SeaTac Airport." However, Dr. Willing points to no stormwater runoff results from other developed areas, nor does he demonstrate how STIA is different from hundreds of other urban/suburban settings throughout the region.

84. Contrary to Dr. Willing's assertions, what is unique about the stormwater from STIA is that runways and aircraft movement areas typically have *lower* concentrations of stormwater pollutants, especially when compared with other land uses in the vicinity of STIA and in the affected watersheds. *See* 2000-2001 Annual Stormwater Monitoring Report (page attached as Exhibit P)

85. Dr. Willing also argues that augmenting streamflows by the "means of stored stormwater does not provide reasonable assurance that water quality standards of the state will not be violated." (¶20). In one sense, Dr. Willing's statement is completely correct. In any other sense, this statement is

meaningless and should be disregarded. Under the Low Flow Analysis, stored stormwater is being used solely to augment streamflows, and not to assure compliance with numeric water quality standards. Instead, the Port is applying a number of other BMPs to assure that water quality standards will be met.

NATURAL RESCOURCE MITIGATION DESIGN

86. Ms. Sheldon has raised issues in her testimony regarding the Port's proposal to construct a stream channel in peat soils (¶44). While there are design challenges related to constructing a channel in this type of environment (poor soil strength), those issues have been carefully considered and addressed. The purpose of the geotextile liner is to keep different types of material separated. This greatly improves constructability, especially when working in a peat soil. This is a very common design; in fact the King County Design Manual requires geotextile fabric in sand filters to separate the sand from the underlying gravel. The geotextile will serve to "spread out" the load of gravel and other constructed stream features on the peat, and it is intended to limit differential settling, which is a secondary design consideration that was contemplated in the overall design. The overall construction is expected to settle, and I considered the effects of settling when designing the stream restoration. If peat soil is displaced, it is likely to rise in areas with no new construction. Based on the weight distribution of the new construction, it would emerge from behind the stream bank areas that are already designed to be higher than the channel. In other words, because the constructed stream banks (the areas adjacent to the high flow channel) are already intentionally raised relative to the stream, soil displacement caused by the weight of new channel would only change in a manner that is consistent with the overall design. This change was considered in the overall design of the restoration to prevent the need for reconstruction or regrading.

87. It is unclear what Ms. Sheldon is describing regarding connection with the "floodplain" at the Koll Business Park (¶44). Without definitions of the terms "floodplain" (viz., the 2, 5, 25 or 100-year flood) and "high and dry," Ms. Sheldon's comment has no meaning. In a natural system, streams flow in their banks until a large enough storm arrives to overflow the banks. Overbank flow is

commonly defined by the 2-year flood event. If this were the case, one would expect water in the stream floodplain once every two years. However, if the overbank areas are intended to be more frequently flooded or seasonally flooded for long periods, a more appropriate term may be riparian wetlands. Flooding in these areas would be from a combination of factors, such as stream overbank flooding, seasonal soil saturation, or water impoundment such as is described in Ms. Sheldon's testimony at ¶48. I have considered flooding, settling, the hydrologic relationship between the stream and the adjacent wetland, and other dynamic changes when designing the relocation project. The anticipated dynamic changes are consistent with the overall design goals of the project. While unanticipated field conditions and outcomes could affect the Miller Creek site, adaptive management strategies are available to mitigate any unintended consequences.

88. Ms. Sheldon also indicates that beavers now control hydraulic conditions on the creek (¶48). While their actions are apparently influencing water regimes at the site, the fact that Ecology and the Army Corps of Engineers also required the applicant to regrade the North Creek site has no doubt contributed to improved flooding and standing water conditions.

89. Ms. Sheldon demonstrates a lack of understanding of the Miller Creek relocation site and site conditions (¶36). The flat, shallow channel that divides the floodplain is designed to allow gradual drainage of water from the floodplain that can come from four sources: rainfall directly on the floodplain; seepage from subsurface water; storm drains from Des Moines Memorial Drive; or flood water that overflows onto the floodplain or "backs up" into the floodplain from the point where the channel connects with the stream. Ms. Sheldon suggests that floodwater (that comes from the stream) does not recharge the stream, though she gives no indication of how water that came from the stream as overflow water or backwater from the stream would be denied to the stream. In addition, if the floodplain channel is draining toward the stream, it is unclear how floodwater in that floodplain would not recharge the stream. In fact, all surface water from all sources in the floodplain drain to Miller Creek.

90. The NRMP clearly shows the storm drains described by Ms. Sheldon in ¶37 of her testimony (*see* Appendix A, sheet number C2). As noted by Ms. Sheldon, these are existing storm drains. Stormwater comes from Des Moines Memorial Drive and other areas adjacent to the road. These storm drains have likely been in place since the road was constructed. The Port must provide drainage for this stormwater, and has done so by providing the pipe outlet energy dissipater and drainage channel.

THE PORT'S PROPOSED PLANS PROVIDE REASONABLE ASSURANCE THAT WATER QUALITY STANDARDS WILL BE MET.

91. The Port has approached stormwater management at STIA with BMPs that have been studied, applied, updated, and monitored for decades. Potential stormwater and water resource impacts from the MPU project have been thoroughly assessed. Peak flow impacts due to new impervious surfaces and embankment construction are mitigated with 344.1 acre-feet of stormwater detention. Existing airfield facilities will be retrofit to mitigate existing peak flow impacts as well. The MPU projects are redevelopment of land that caused water quality impacts without mitigation, such as residential areas, streets, businesses and farms. Water quality impacts have been addressed using BMPs to reduce pollutants in stormwater runoff for new MPU projects, as well as existing Port facilities. These BMPs are continually reviewed and tested, and emerging technology to address complex or unique stormwater runoff is being evaluated for use at STIA. The Port's NPDES permit provides the opportunity to continually monitor stormwater and update BMPs as problem areas are found. Finally, the Port's low stream flow mitigation plan has been developed using innovative applications of state of the art modeling approaches to determine impacts and simple, straightforward BMPs to offset impacts.

92. The Port will operate STIA for many years to come. There is continual oversight of the Port's operations and permits. The NPDES permit provides a mechanism to implement updated stormwater control BMPs. The Port has sufficient resources to perform ongoing monitoring, apply new technology BMPs when needed, and implement contingencies. There is reasonable assurance that water quality impacts have been fully mitigated for MPU projects.

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

Executed at Kirkland, Washington, this 7th day of March 2002.

Paul S. Fendt, P.E.

PRE-FILED TESTIMONY OF PAUL S. FENDT, P.E.

EXHIBITS

A	Curriculum Vitae
B	Table A.11 from the Des Moines Creek Basin Plan
C	Graphs showing low flow periods
D	Tables 2-1 and 2-4 Low Flow Analysis
E	Relevant Portion of Section 3.2 of the Low Flow Analysis
F	Pertinent Portions of Mr. Rozeboom's Declaration
G	Land use tables showing the non-contiguous areas
H	Map entitled "Change between existing and Future Groundwater Basins" in the Low Flow Report
I	Table 3-1, FEIS
J	Table from November 1999 Preliminary Comprehensive Stormwater Management Plan
K	Section I.1.3.i
L	Table: Statistical Ranking of Average Seven-Day Low Flows
M	Relevant portions of the SMP
N	Condition J.1
O	Relevant Portion of Sections of 12.3 and 12.6
P	2000-2001 Annual Stormwater Monitoring Report

A

Paul S. Fendt, P.E.

Bachelor of Science, Geological Engineering
Registered Professional Engineer in Washington and Florida

Paul Fendt has more than 18 years of stormwater engineering and planning experience. His project experience includes a broad range of stormwater and surface water projects, including hydrologic and hydraulic modeling (HEC-1, WaterWorks, HEC-2, HEC-RAS), NPDES stormwater permits, erosion control on creeks and lake shores, comprehensive storm and surface water plans, and preparation of drainage ordinances and environmental impact statements.

Prior to joining Parametrix, Mr. Fendt was the manager of the Polk County, Florida, Surface Water Management Plan (SWMP). His other job responsibilities included the preparation of applications for environmental permits related to wetlands and surface water protection, public drainage project design, stormwater detention facility design, and reports on county projects related to stormwater, wetlands, permitting and flooding.

Sea-Tac Airport Master Plan Update and On-Call Stormwater Services – Port of Seattle, WA
Mr. Fendt is Parametrix Project Manager providing environmental services to the Port of Seattle in support of the Master Plan Update EIS, SEPA and permitting process, and on-call services to support the Sea-Tac Airport stormwater program. The Master Plan Update project, which includes a new third runway and many redevelopment projects, will require extensive environmental mitigation of wetland, stream, and stormwater impacts. Parametrix is responsible for wetland delineations and other field work and obtaining the permits needed to implement the Master Plan projects, including Section 404 and 401 approvals for wetland impacts, HPA for instream work, and several local permits. Parametrix is conducting studies and preparing design plans for the mitigation required projects, including:

- A large wetland mitigation project at a 69-acre site in Auburn.
- Relocation of approximately 1,000 feet of Miller Creek.
- Restoration of a 200-foot-wide buffer along 6,500 feet of Miller Creek.
- Fish passage improvements along Miller Creek.

Mr. Fendt is also responsible for development of a comprehensive stormwater management plan for the Master Plan projects and is conducting hydrologic modeling and stormwater treatment analyses in support of stormwater detention and treatment facility design. On-call stormwater support has included updating of the airport stormwater conveyance maps and hydraulic models, field investigations of drainage and water quality problems, design of stormwater improvements, preparation of stormwater pollution prevention plans for construction activities, monitoring of stormwater runoff for the airport NPDES construction permit, and numerous other activities to support the environmental and stormwater management programs at Sea-Tac Airport. The contract has included 91 tasks to date.

Valley Creek Estuary Restoration – Port of Port Angeles, WA
Project Hydrologist for design and permitting of a new, man-made 4-acre marine estuary in downtown Port Angeles. The new estuary and associated park is a centerpiece for the downtown Port Angeles redevelopment program. The project consists of converting an existing log-sort yard and tight-lined 84-inch-diameter culvert into a combination of a park, marsh, beach, and mud-flat estuary.

Design and Operation of Stormwater Treatment System – Port of Seattle, WA
Parametrix staff designed two movable stormwater treatment systems to treat up to 500 gpm stormwater per unit from a 40-acre parking lot construction site. The systems were designed to reduce turbidity and were operational within two weeks. Alum was used as the coagulant. Additionally, our staff also managed the procurement and assembly of rental equipment and were responsible for the operation and staffing of the units, which are operated two shifts a day, 7 days a week, when required by weather conditions.

Butter Creek Engineering Analysis – Lewis County, WA
Parametrix will provide an engineering analysis of revetment repair and actions taken in response to flooding along lower Butter Creek. Responsibilities will include document review, scheduling interviews, and site visits.

Sammamish River Habitat Improvements – City of Redmond, WA
Parametrix was selected by the City of Redmond to design habitat enhancements for the Sammamish River through downtown Redmond. The river was channelized for flood control with little consideration of habitat and aesthetics. Mr. Fendt is the Project Manager and Fluvial Geomorphologist for the habitat enhancement planning and design effort. Habitat enhancements include modifying the channel geometry with benches and meanders, adding emergent wetland habitat, enhancing channel substrate, removing exotic vegetation, and replanting the riparian corridor with native plants to improve wildlife habitat. Project planning has included public workshops and meetings with affected agencies, including the Army Corps of Engineers, Washington Department of Ecology, Washington Department of Fish and Wildlife, the Muckleshoot Tribe, and King County. Construction was completed in the summer of 1997.

On-Call Small Stormwater Projects Program – City of Redmond, WA
Provides on-call services for the City's Stormwater Management Division. Projects include small project designs to solve neighborhood flooding problems, drainage studies to identify alternatives for solving flooding problems, surveying easements for stormwater facility maintenance, basin planning assistance, and spill response. The key to the success of the project has been our rapid turnaround preparing work authorizations.

Dredge Island Stormwater Sampling Program – Lavaca Bay Superfund Site, Point Comfort, TX
Mr. Fendt designed and implemented a stormwater runoff collection program on a contaminated dredge spoil island in Lavaca Bay on the South Texas coast. Automated stormwater samplers were installed to collect water and sediment associated with stormwater runoff. Using the results of the six-month program, sediment and contaminant loading will be calculated. The collection system includes lined collection channels and pre-fabricated channels and flumes and collect runoff, transport sediment, and measure flows. The samplers have been programmed to trigger a sampling program when a pre-determined flow rate is measured. Grain size distribution of the sampled storm sediments will be determined to correlate storm intensity and sediment yield.

Stormwater Pollution Prevention Plan (SWPPP) – Port of Vancouver, WA
Project Manager for the completion of an SWPPP for the Port's facilities on the Columbia River. The plan includes a number of Best Management Practices (BMPs) and identifies potential stormwater treatment alternatives.

Strandley Environmental Services – Seattle City Light, Purdy, WA
Project Engineer for a multi-disciplined Superfund site cleanup. A PCB contaminated stream flowing through the project site required assessment and design of a new cleanup project. The project includes removing PCB contaminated soils from the creek while minimizing site disturbance. Stream habitat will be restored using log weirs, deflector logs, and large woody debris from the adjacent remediation areas. Will direct field oversight and field placement of new stream habitat features during construction.

South Prairie Creek Flood Study – Pierce County, WA
The Pierce County Public Works Department is proposing to improve South Prairie Road, with safety improvements that include widening the road and straightening several curves. To improve drainage and public safety in an emergency, the road, which is partially constructed in the South Prairie Creek floodplain, will be raised above the existing 100-year flood elevation of South Prairie Creek. Concerns about potential floodplain impacts from the proposed road improvements prompted the preparation of a new flood study for the potentially affected portion of South Prairie Creek.

A computer simulation of the floodplain was prepared, using the hydraulic backwater model HEC-2. Two HEC-2 models of South Prairie Creek were prepared: the first was created using the input parameters from the original Federal Emergency Management Agency (FEMA) floodplain study; the second model was prepared by supplementing the original study with new channel cross sections. The new model with added cross sections was then checked and used as the basis for comparing impacts from the proposed road improvements. The proposed road improvements were added to the new study and compared to determine flood elevations and impacts from the new road.

Clover Island Redevelopment Stormwater Management Plan – Port of Kennewick, WA
The Port of Kennewick, Washington is proposing redevelopment of Clover Island as part of its future expansion plans. The plans include redevelopment of existing developed areas, expansion of water-dependent businesses, and expansion of the island with new development. A Conceptual Stormwater Management Plan (SWMP) for Clover Island Redevelopment was prepared. The plan included measures for reducing existing stormwater runoff impacts from existing Port facilities. Alternatives for controlling runoff from newly developed areas included biofiltration swales and constructed wetlands.

87th Street Extension Burnt Bridge Creek Flood Study – City of Vancouver, WA
The proposed 87th Street extension contemplated by the City of Vancouver requires a new Burnt Bridge Crossing. To ensure that the crossing will cause no floodplain impacts, Parametrix prepared a flood study of the creek using HEC-2. There was limited existing data available for completing the study, and the existing FEMA study was flawed. Working with the County and City, Parametrix prepared a hydraulic model that determined flood elevations and allowed for bridge design that mitigated potential impacts.

Kalauao Stream Flood Study – Department of the Navy, Oahu, HI
Sediment and debris collecting at the mouth of Kalauao Stream raised concerns about potential house flooding and property damage near the mouth of the stream. Parametrix prepared a study to: (1) determine the current extent of the 100-year floodplain; (2) determine the probable causes of flooding and factors that have changed flood patterns since development along the lower stream banks; (3) develop and compare alternatives for controlling flooding and limiting flood damage; and (4) make recommendations for action (or no action) to limited flood damage. Several flood control alternatives were considered, and action recommendations were made, including reconstruction of the gas and sewer lines crossing the stream and causing floodplain impacts.

Woodland Creek – Pierce County, WA
Prepared a conceptual regional stormwater reduction plan to reduce potential peak flows. The project included hydraulic modeling (compared HEC-1 against WaterWorks modeling program) and predesign of regional stormwater management ponds to reduce peak flows generated from increased development of the watershed.

Canyon Creek – Pierce County, WA
Prepared a conceptual regional stormwater reduction plan to reduce potential peak flows. Similar in scope to the Woodland Creek project with its own specific design criteria.

Southwest Harbor Project – Port of Seattle, WA
Prepared a site stormwater management assessment and mitigation plan for the proposed expansion of container facilities and site remediation for existing tenants. The project included recommended Best Management Practices (BMPs) for source reduction as well as alternatives for stormwater treatment, such as wet ponds and biofiltration swales.

Storm and Surface Water Master Planning Study – City of Camas, WA
Prepared a storm and surface water management plan for a new industrial area. The project includes hydrologic modeling and pre-design of regional stormwater management ponds to mitigate potential impacts from development of the industrial area. Stormwater management planning will be concurrent with wetlands management planning to develop an integrated approach to water resource planning.

Stormwater Improvements – U.S. Navy SUBASE Bangor, Kitsap County, WA
Concept study and design of stormwater improvements for the industrial and vehicle maintenance area at the Bangor base. A stormwater pollution prevention plan (SWPPP) includes a number of source control options for reducing stormwater runoff contact with pollutants. Because of the extensive vehicle maintenance activity at the site, oil/water separators have been included as a stormwater treatment option. The project included modeling the existing storm sewer system, investigating sources of oily discharges, and preparing drawings of the existing storm sewer system.

East Texas Hydrologic Study – Confidential Client
Conducting a hydrologic analysis and model of an interconnected lake system in eastern Texas. The project includes the interpretation of rainfall data, development of a continuous hydrologic model for the watershed, stream gaging, automated sampling, and the use of GIS for determining hydrologic parameters for the model. The results will be used to determine annual pollutant loading in the system.

Waiawa Stream Sediment Removal and Wetland Enhancement – U.S. Navy, Oahu, HI
Prepared a hydrologic study and conceptual engineering design of a wetland enhancement and sediment removal facility to reduce sediment load to Pearl Harbor. The project includes a detailed study of rainfall and stream flow conditions, sediment loads, and wetland hydrology. The conceptual design of the proposed wetland includes removal of suspended sediments in constructed wetlands and enhancement of existing wetland habitat and function.

Lake Park Condominiums Drainage Plan Review – City of Kirkland, WA
Reviewed the drainage plans for a condominium development proposed in Kirkland. The review included potential hydrologic impacts to wetlands, flooding impacts, and flood stages on Lake Kirkland (Forbes Lake). Stormwater mitigation measures were proposed for basin build-out on Lake Kirkland.

The Forbes Lake drainage basin was also modeled for existing and basin build-out to determine 100-year flood stages on Forbes Lake.

Aberdeen Sawmill Stormwater Plan – Weyerhaeuser, Aberdeen, WA
Prepared a hydrologic analysis of a sawmill site which included analyzing rainfall records determining return frequencies for different storm durations; estimating runoff volumes and contaminant concentrations; and evaluating stormwater control and treatment alternatives.

Kitsap County Stormwater Management Ordinance – Kitsap County, WA
Prepared a stormwater management ordinance for the County. The Ordinance has heavy emphasis on inspection, maintenance, and enforcement of stormwater systems and construction. The ordinance approval process included a multidisciplinary technical advisory committee review. The ordinance was written to comply with the Stormwater Management Manual for the Puget Sound Basin.

Utilities Comprehensive Plan – Grays Harbor County, WA
Managed storm and surface water portion of the County utilities comprehensive plan. The plan includes water resource protection, facilities improvements, and basin planning concepts. The project has an emphasis in public participation and economic development.

Fitzgerald Road Culvert Replacement – Polk County, FL
Prepared the design and specifications for replacement of culverts in a high, unstable road fill. Existing culverts had been blocked and failed due to bank slumping, causing a back-up that threatened the road and a downstream mobile home park. The design required the use of level pool routing models, riser sizing with trash skimmers, and tightline culverts down the backslope. The project was constructed, and the structure has experienced a significant storm event (between a 10- and 25-year storm) with no further problems.

Lyon Creek 100-year Flood Study – Canaan Apartment, Lake Forest Park, WA
Managed determination of the 100-year flood plain of Lyon Creek for an apartment complex in Lake Forest Park (North Seattle area). Mitigation for proposed flood plain encroachments were included in the final project report.

Derby Ditch – Lake Jessie, Polk County, FL
Developed the conceptual design for a stormwater detention facility in a 400-acre urbanized drainage basin to provide water quality enhancement of runoff to a recreational lake chain. The system will provide treatment of approximately one-third of the contributory drainage basin to the lake.

Amendment to Polk County Flood Protection and Surface Water Management Ordinance – Polk County, FL
Prepared for adoption of a major revision and subsequent amendment to the Polk County, Florida, Flood Protection and Surface Water Management Ordinance. The ordinance also provided for the protection of wetlands and water resources. Responsibilities as program manager included preparation of map amendments and revisions, interpretation of Flood Insurance Rate Maps, and county compliance with the National Flood Insurance program.

Comprehensive Growth Management Plan – Polk County, FL
Prepared and presented the drainage sub-element of the infrastructure element of the County's Comprehensive Growth Management Plan. Provided technical assistance in the preparation of the

Conservation (surface water, wetlands, floodplains, groundwater sub-elements), infrastructure (potable water, aquifer recharge), and land use (wetland, floodplain overlays) elements.

Mill Creek Erosion Control – City of Kent, WA
Comprehensive study and preliminary design to reduce erosion in an unstable urban canyon damaged by high flows. Project elements included the following: inventory and prioritization of erosion problems; surveying; hydrologic and hydraulic modeling; and bioengineering and engineering designs for stabilization of streambanks and slopes.

Luther Burbank Park Erosion Control Project – King County Parks Department, WA
King County's Luther Burbank Park on Lake Washington was experiencing accelerated shoreline erosion. Mr. Fendt led Parametrix's investigation of the historical rates of erosion and determined probable causes of the shoreline erosion problems. An innovative combination of engineering design alternatives and recommended operation and use modifications were developed to control the erosion rate while also maintaining the natural, recreational, and aesthetic values of the park.

Madsen Creek Interceptor Environmental Analysis – Metro, Renton, WA
Conducted reconnaissance of streambank and side slope erosion sites in an unstable canyon subjected to increased peak stormflows from urbanization. Evaluated alternatives to reconstruct the sewer interceptor pipe in Madsen Creek Canyon. Identified bioengineering and engineering alternatives for stabilization and erosion control including riprap, gabions, live cribwalls, live staking, and branch packing.

Inspection and Maintenance Manuals for Tyee Pond and Miller Creek Regional Detention Facilities – Port of Seattle, WA
Paul managed the development of inspection and maintenance manuals for two stormwater detention facilities (Tyee Pond and Miller Creek Regional Detention Facility) located on Port of Seattle property to help facilitate the transfer of responsibilities for the facilities from King County to the Port of Seattle. The inspection and maintenance manuals are intended to be working documents that could be used by the field crew responsible for inspecting and maintaining the facilities. In addition, the manuals will serve as documentation of facility maintenance in compliance with State and Local stormwater regulations. Manual development included researching standard inspection and maintenance procedures used by King County and others; conducting interviews with County employees familiar with the operation and maintenance of the facilities; gathering information relevant to the proper functioning of the facilities, such as as-built diagrams and specific equipment operation manuals; evaluation of current facility conditions and operation; development of an inspection and maintenance schedule; and development of inspection and maintenance checklists to be used in the field.

King County Regional Justice Center EIS – King County, WA
Analyzed stormwater quality and quantity discharge on four alternative sites for both pre- and post-development conditions. Developed recommendations for stormwater management facilities to comply with the King County Surface Water Design Manual.

Black River Transfer Facility EIS Stormwater Management – City of Renton, Tukwila, WA
Prepared the conceptual design of a stormwater management system for a regional waste transfer site, and included the preparation of an EIS document for impacts to water. The project required analysis of stormwater quantity and quality discharges, wetlands, and floodplains. The proposed stormwater management facilities were designed for compliance with the King County Surface Water Design Manual.

Indian Summer EIS – Private Developer, Olympia, WA
Reviewed stormwater impacts for a new residential subdivision. The review included an analysis of proposed stormwater management techniques, including filtration facilities. BMPs for erosion control and stormwater discharging to significant wetland resources were also reviewed, and additional mitigation measures were proposed.

Lake Marion Creek – Polk County, FL
Prepared a land acquisition proposal submitted to Florida Water Management Districts under the Save Our Rivers (SOR) acquisition program. The proposal recommends the purchase of an 18,000-acre watershed, nearly one-half of which contains a variety of wetland types. The remainder is relict sand dunes, noted for their high aquifer recharge potential. The watershed is a major tributary to the Kissimmee River, which is the upper watershed of the Florida Everglades. The project was "A" listed, and negotiations are presently underway for purchase of several tracts.

Hillsboro Light Rail Extension – Metro, Portland, OR
Mr. Fendt was the task manager for hydraulic and hydrologic analysis of eight proposed light-rail stream crossings. The proposed alignment was on an existing rail line. Each crossing was assessed for potential floodplain impacts and new crossings were designed to mitigate potential impacts.

Bear Creek Habitat Assistance – City of Redmond, WA
Parametrix has been retained by the City of Redmond to assist with review of the proposed lower Bear Creek Habitat Restoration Plan. The Army Corps of Engineers is preparing the project plans, with participation by the City. Responsibilities include assisting the City with defining project goals, providing technical review and analysis, and participating in team meetings. Technical elements include engineering, floodplain analysis, fish passage and use, and habitat planting review.

State vs. Spath – Olympia, WA
Parametrix will provide expert testimony in support of WSDOT litigation.

B

In figure A.10, current conditions are used as the normalizing reference value with a corresponding relative value of 1.0. By comparison, relative erosivity under forest conditions was less than one tenth the current value. This means that even when flows between 17 cfs and 40 cfs are discounted, current erosive flow durations are more than 10 times as persistent as under pristine, forested conditions.

Current Summer Base Flow Conditions

Base flow represents that portion of flow in a stream derived from groundwater discharge that persists for days and weeks following rainfall and declines very slowly over time. For purposes of comparison in this study, base flow is defined as the discharge that is exceeded 95 percent of time during the driest 6 months (April through September) of the year. On average, discharge falls below this level only 5 percent of the time during the driest part of the summer. It is therefore a good comparative measure of 'minimum' flow for fish habitat assessment, water quality and other purposes.

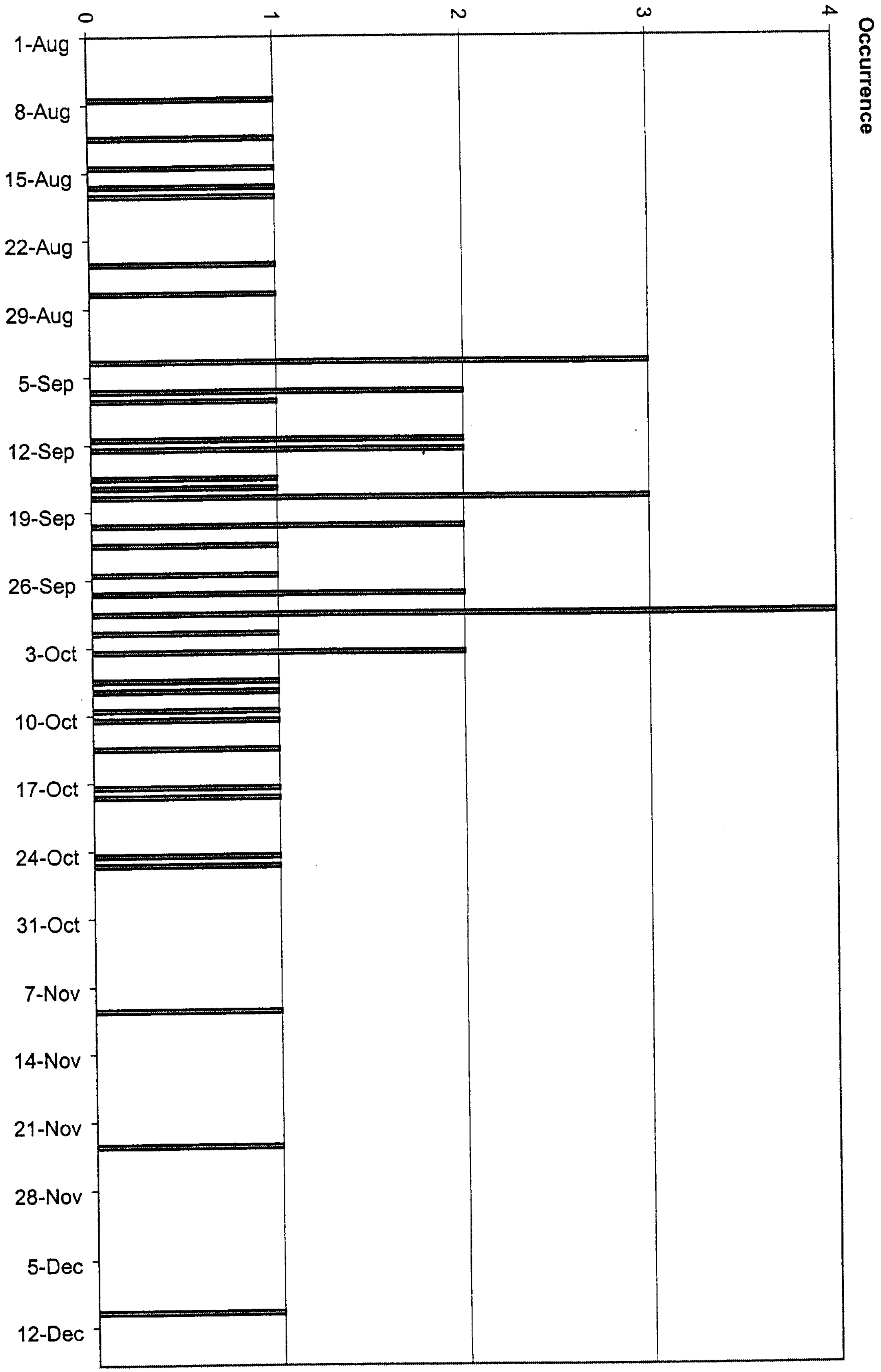
As shown in Table A.11, currently summer base flows in the mainstem of Des Moines Creek are 0.55 cfs and this represents approximately 21 percent loss since basin urbanization began. This result demonstrates that the currently elevated summer monthly mean discharges results from storm spikes while steady base flows have declined.

Table A.11 Effect of Urbanization on Base Flows

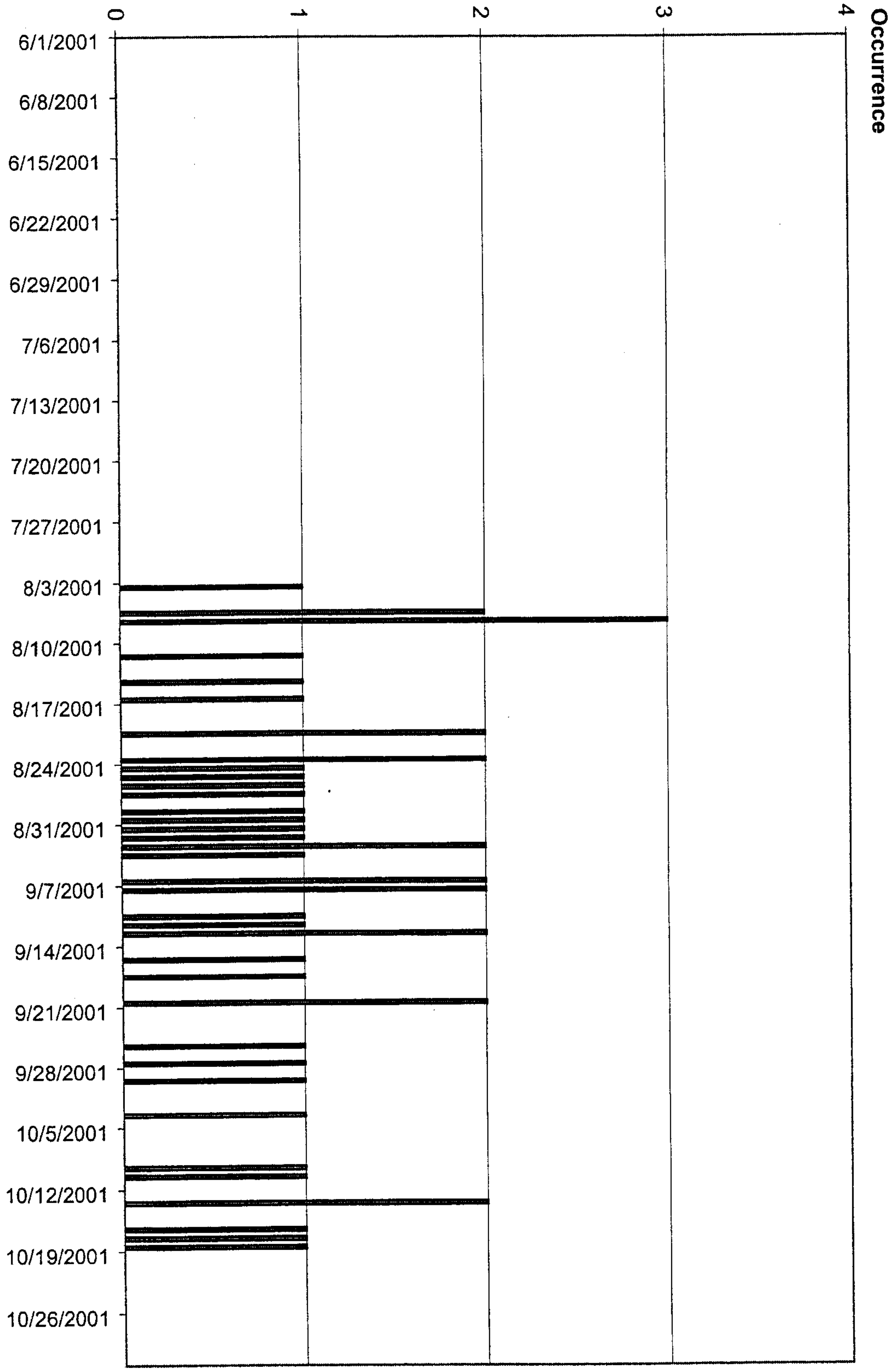
Scenario	Base Flow In Mainstem (Cfs)	Loss Relative To Forest
Forest	0.70	0 percent
Current	0.55	21 percent
Future (4, 5, & 6)	0.41	41 percent

C

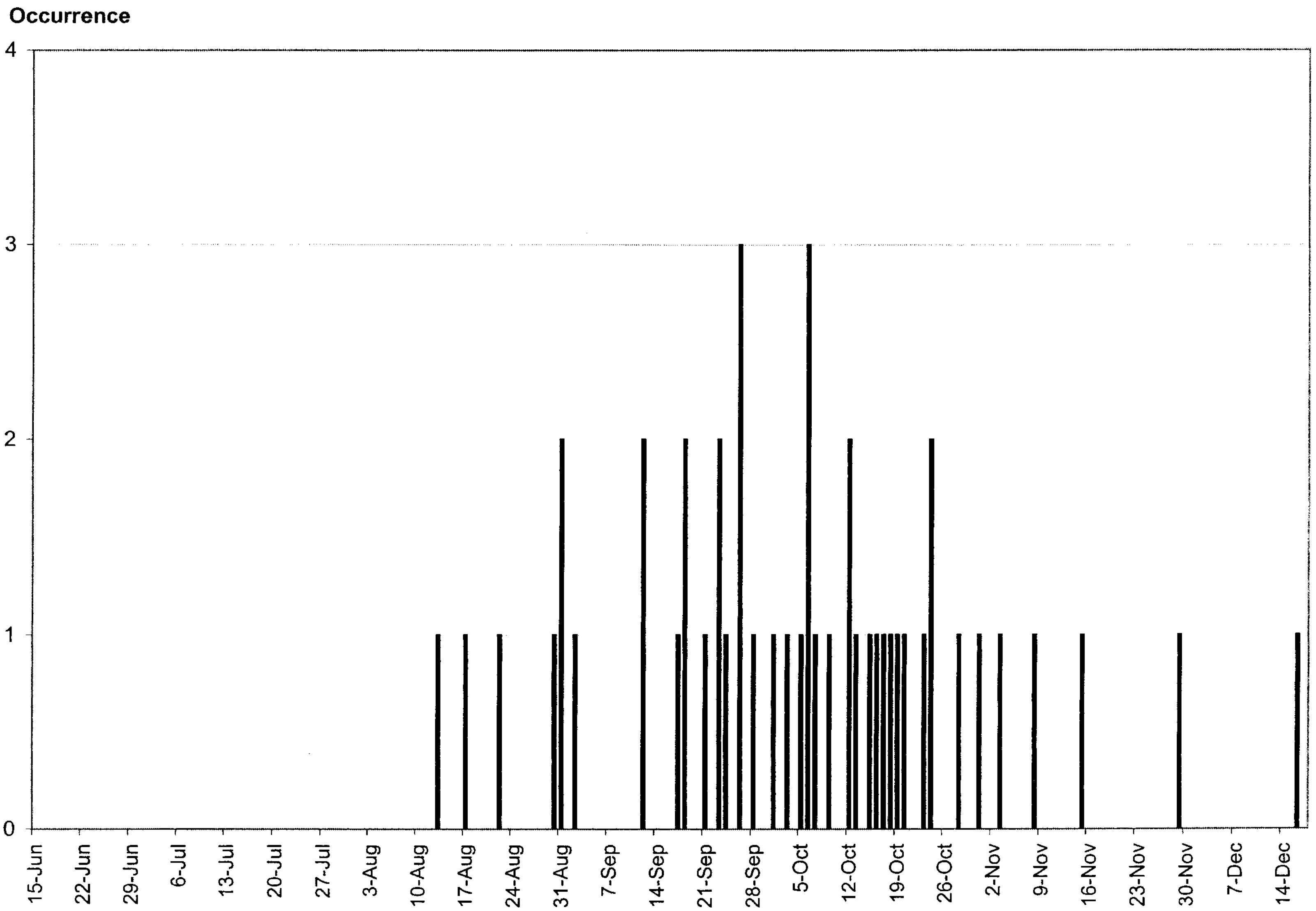
Low Flow Occurrences in Miller Creek, 1949-1995 (1994 HSPF)



7-Day Low Flow Occurrences in Des Moines Creek, 1949-1995 (1994 HSPF)



7-Day Low Flow Occurrences in Walker Creek, 1949-1995 (1994 HSPF)



D

2.2.2.1 Miller Creek Low Streamflow

Two streamflow gages located in the Miller Creek watershed were used in the low-streamflow analysis calibration review (Figure 2-1). One of these streamflow gages was located near the mouth of Miller Creek, and the other was located further upstream at the Miller Creek detention facility.

Average simulated and observed streamflows for each 7-day low-flow period during 1991 through 1996 are listed in Table 2-1 for the gage near the mouth and Table 2-2 for the gage at the Miller Creek detention facility. 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.

Table 2-1. Miller Creek at the mouth, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.348	1.749	-0.401
1992	1.457	1.390	0.067
1993	1.639	1.300	0.339
1994	1.361	1.100	0.261
1995	1.500	1.661	-0.161
1996	2.762	2.138	0.624
Average Difference	**2.517**	**2.335**	**0.182**

Table 2-2. Miller Creek at the detention facility, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	0.400	0.150	0.250
1992	0.127	0.124	0.004
1993	0.190	0.110	0.080
1994	0.000	0.090	-0.090
1995	0.183	0.137	0.045
1996	0.263	0.189	0.074
Average Difference	**0.291**	**0.200**	**0.091**

2.2.2.2 Walker Creek Low Streamflow

Two streamflow gages located in the Walker Creek watershed were used in the low-streamflow calibration review (see Figure 2-1). One of these streamflow gages was located near the mouth of Walker Creek, and the other was located further upstream near a wetland.

Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-3 (1993 through 1996) for the gage near the mouth and Table 2-4 (1991 through 1996) for the gage near the wetland. In general, with the exception of 1995, the observed 7-day low flows exceeded the predicted 7-day low flows at both gages.

Table 2-3. Walker Creek at the mouth, 7-day low flows for water-years 1993 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.502	0.923	0.579
1994	0.987	0.833	0.154
1995	0.915	1.077	-0.163
1996	1.719	1.287	0.432
Average Difference	**1.281**	**1.030**	**0.250**

Table 2-4. Walker Creek near wetland, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.208	0.786	0.422
1992	1.098	0.682	0.416
1993	0.800	0.666	0.134
1994	0.670	0.614	0.056
1995	0.256	0.750	-0.494
1996	0.896	0.870	0.026
Average Difference	**0.656**	**0.725**	**-0.069**

2.2.2.3 Des Moines Creek Low Streamflow

Two streamflow gages located in the Des Moines Creek watershed were used in the low-streamflow calibration review (see Figure 2-1). One of these streamflow gages was located near the mouth of Des Moines Creek, and the other gage (11c) was located further upstream.

Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-5 (1992 through 1996) for the gage near the mouth and Table 2-6 (1991 through 1996) for gage 11c. In general, the observed 7-day low flows were close to the predicted 7-day low flows at the gage near the mouth, while the observed 7-day low flows at gage 11c exceeded the predicted 7-day low flows.

2.2.2.4 Summary

Low-streamflow analysis calibration review was performed for two gage locations in Miller, Walker, and Des Moines Creeks. Results generally indicated that calibrated low flows at the mouth of each stream were fairly good, while calibrated low flows at the upstream gages typically showed lower flows than observed flows. Groundwater conditions in each of the watersheds are somewhat speculative and may account for these discrepancies at the upstream gage locations.

E

3. MITIGATION PROPOSAL

3.1 INTRODUCTION OF APPROACH

Hydrologic modeling of the airport drainage areas to determine the potential impacts of Master Plan Update projects, combined with the embankment modeling described in Section 1.3, demonstrate the magnitude of potential low-streamflow impacts due to the construction of Master Plan Update projects. To mitigate these impacts, the Port will collect excess runoff from impervious surfaces during winter storms and reserve that stormwater for discharge during the defined summer low-flow period. This mitigation plan includes the following components:

- Low-flow mitigation performance standards.
- Determination of the season and duration for low-flow mitigation.
- Sizing and location of storage vaults.
- Water quality design aspects.

The proposed mitigation plan is described in the following selections. In addition, a pilot program to test the efficacy of this mitigation approach is described in Section 3.6.

3.2 PERFORMANCE STANDARDS

The overall goal of the Flow Impact Offset Facility is to provide water to Walker and Des Moines Creeks at rates and times equal to the impacts to streamflows calculated by the low-flow analysis. The following measurable performance standards have been developed in order to facilitate meeting this goal:

- To fill the vaults during the rainy season according to the analysis provided in Section 3.3.

- To provide flow at the rates specified in Section 2.5.1 for the entire annual low-flow period each year for each stream (July 24 through October 24 in Des Moines Creek; August 1 through October 31 in Walker Creek).

- To provide flow for additional periods (throughout the month of November) using water remaining in the vaults at the end of the low-flow period.

- To operate the facility in a manner to prevent instream water quality violations caused by operation of the facility.

- To design, operate, and maintain the facility so an adaptive management strategy can be applied.

3.3 WATER QUANTITY – VAULT SIZING ANALYSIS

The vault sizing and vault fill time analyses are summarized below. Additional information and data are provided in Appendices I and J.

F

POLLUTION CONTROL HEARINGS BOARD
FOR THE STATE OF WASHINGTON

AIRPORT COMMUNITIES COALITION, Appellant, v. STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY; and THE PORT OF SEATTLE, Respondents.	No. 01-133 No. 01-160 DECLARATION OF WILLIAM A. ROZEBOOM IN SUPPORT OF ACC'S REPLY ON MOTION FOR STAY (Section 401 Certification No. 1996-4-02325 and CZMA concurrency statement, Issued August 10, 2001, Reissued September 21, 2001, under No. 1996-4-02325 (Amended-1))

William A. Rozeboom declares as follows:

1. I am over the age of 18, am competent to testify, and have personal knowledge of the facts stated herein.

2. I have reviewed the declarations of Steven G. Jones, Joseph Brascher, Donald W E. Weitkamp, Paul S. Fendt, and the Port of Seattle's Memorandum Opposing ACC's Motion for Stay, all filed by Foster Pepper & Shefelman, PLLC. I have also reviewed the declarations of Ann Kenny, Eric Stockdale, Kelly Whiting, and the Department of Ecology's Response to Appellant's Motion for Stay, all filed by the Attorney General of Washington. I offer responses to the above documents, most of which include some reference to my declaration filed previously in support of ACC's Motion for Stay.

does not assure successful calibration to low flows. My overall opinion of the current (September 2001) calibration of the models being used for this project is as summarized below.

HSPF Model -- Flow Regime	Calibration Adequate?
Miller Creek – Peak Flow	YES
Miller Creek – Low Flow	YES
Walker Creek – Peak Flow	YES
Walker Creek – Low Flow	NO
Des Moines Creek – Peak Flow	YES
Des Moines Creek – Low Flow	NO

My statements in the remainder of this declaration focus on the Walker Creek and Des Moines Creek low flow models which are in my opinion deficient.

9. I believe that my assessment of the HSPF model calibration is more or less consistent with the opinions of the King County reviewer retained by Ecology, and possibly the Port's own consultants with credible expertise in HSPF modeling. The King County reviewer's declaration (Whiting, Page 7, Line 7) states that *"These calibrations have been accepted for purposes of SMP flow control mitigations."* However, the King County reviewer does not provide any endorsement or acceptance of the model calibration relative to low flow analysis or mitigation. Instead, he recommends further documentation and discussion of the accuracy of the calibrations in predicting upper-stream low flows (Whiting, Page 7, Line 18). Aqua Terra, the Port's consultant responsible for modeling flows and impacts in Miller and Walker Creeks, states (Brascher, ¶11) that *"The HSPF Modeling that will be included in the final version of the Low Flow Analysis will be peer reviewed and endorsed by Norman Crawford, the hydraulic engineer who actually developed the model itself."* By inference, there is an expectation by the Port's own consultant that

G

Wal reek Non-Contiguous Groundwater Area
Grounawater Subbasins (1994 Land Use - Future Basins)

			Groundwater Subbasin Areas (Acres)													
		% of total basin	D3		D8		SDE4		SDS1		SDS3		SDS3A		SDS5	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.010		1.820		48.975		0.069		162.030		60.575		21.531	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		1.459		-		-		-		-		-	
PERLND 54	(SA)		-		0.050		-		-		-		-		-	
Pervious Subtotal			0.010		3.328		48.975		0.069		162.030		60.575		21.531	
IMPLND 14	(EIA)		0.058		2.801		99.123		7.732		175.197		6.776		0.041	
Subbasin Total			0.068		6.130		148.098		7.801		337.227		67.350		21.572	

Wal reek Non-Contiguous Groundwater Area
Groundwater Subbasins (1994 Land Use - Future Basins)

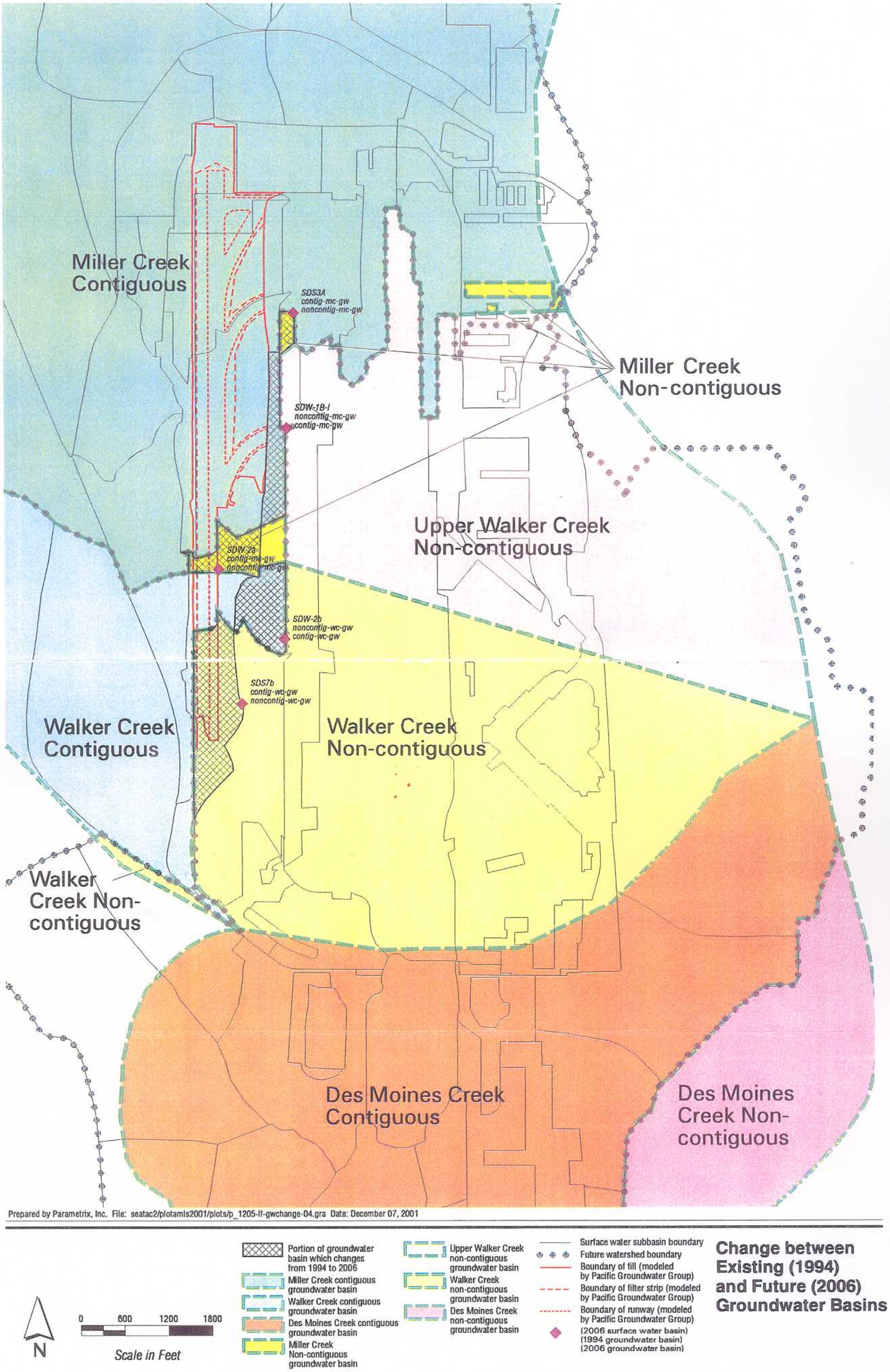
			Groundwater Subbasin Areas (Acres)													
		% of total basin equal to EIA	SDS6		SDS7a		IWS NSPS		IWS PRIMARY		IWS WEST		MC9		SDW2b	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		10.686		54.978		0.307		11.961		1.625		0.514		13.735	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		-		-		-		-		-		-	
PERLND 54	(SA)		-		0.016		-		-		-		-		0.454	
Pervious Subtotal			10.686		54.994		0.307		11.961		1.625		0.514		14.189	
IMPLND 14	(EIA)		4.102		6.214		13.441		215.980		0.416		-		0.883	
Subbasin Total			14.788		61.207		13.747		227.941		2.041		0.514		15.072	

Wall reek Non-Contiguous Groundwater Area
Grounawater Subbasins (1994 Land Use - Future Basins)

			Non-STIA Groundwater Subbasin Areas (Acres)											
		% of total basin	SDW2b*		SDW-1B-I*		D1		D2		GL2		Walker Creek Non-Contiguous Area	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:														
PERLND 16	(TF)		-		-		0.620		-		-		0.62	
PERLND 26	(TG)		4.059		10.144		140.570		0.880		8.860		553.33	
PERLND 34	(OF)		-		-		-		-		-		0.00	
PERLND 44	(OG)		-		-		14.770		11.810		18.260		46.30	
PERLND 54	(SA)		-		-		9.730		-		-		10.25	
Pervious Subtotal			4.059		10.144		165.690		12.690		27.120		610.50	
IMPLND 14	(EIA)		0.610		1.793		85.140		11.940		7.240		639.48	
Subbasin Total			4.669		11.937		250.830		24.630		34.360		1249.98	

* From Miller Creek Noncontiguous GW - 2006 Basins

H



Prepared by Parametrix, Inc. File: seatac2/plotamls2001/plots/p_1205-lf-gwchange-04.gra Date: December 07, 2001

Change between Existing (1994) and Future (2006) Groundwater Basins

lower Miller Creek during these design storms are 172 cfs, 277 cfs, and 433 cfs, respectively, compared to the flood frequency estimates of 173 cfs, 293 cfs, and 468 cfs, respectively (for the 2-year, 10-year, and 100-year return intervals). Since the January 1990 runoff event was less than the estimated 100-year flow, the hourly precipitation amounts in this storm were proportionately increased by a factor of 1.10, which raises the total runoff volume from that event to an amount equal to the average of the January and November 1990 runoff events (the two largest events on record).

TABLE 3-1
SUMMARY OF LAND USE CHANGES IN SEATAC SUBBASINS ASSUMED FOR PROPOSAL

	Des Moines Creek (acres)	Miller Creek (acres)	Total
CURRENT LAND USE			
- SDS impervious area[a]	369	60	429
- IWS[a]	204	50	254
- Fill and other[a]	410	83	493
- Non-airport[b]	204	326	530
Total	**1,187**	**519**	**1,706**
PROPOSED CHANGES			
- New SDS impervious area	95.4	97.4	192.8
- New IWS	65.7	0	65.7
- New fill	282.5	262.3	544.8
PROPOSED LAND USE			
- SDS impervious area	464.4	157.4	621.8
- IWS	269.7	50	319.7
- Fill and other	452.9	311.6	764.5
Total	**1,187**	**519**	**1,706**

[a] Includes Subbasins 19 and 24 (SDW-3), 20 and 25 (SDS-3), 21 and 26 (SDS-1), and 23 and 28 (SDE-4) in Des Moines Creek, and Subbasins 23 and 27 (SDN-1), 24 and 28 (SDN-2), and 25 and 29 (SDN-3 and SDN-4) in Miller Creek.

[b] Areas in other subbasins affected by airport expansion.

J

SDS/IWS Drainage Basin Areas
Detail of Drainage Basin Changes
DRAFT 12/22/98

		Change in Drainage Area		
Projects: 1994-1998	Year	From:	To:	Total Acres
1. SWPPP No. 1: North Cargo Area Pump Station (STIA-9707)	1997	SDN-2	IWS	39.79
2. SWPPP No. 2: Cargo Area 4 (at SDE2-29)	1996	SDE-4	IWS	4.40
3. SWPPP No. 3: North Satellite Pump Station at SDE3-23 (STIA-9452)	1995	SDE-4	IWS	6.63
4. SWPPP No. 4: Gate C8 (at SDS2-17A)	1995	SDS-3	IWS	0.27
5. SWPPP No. 5: South Satellite Apron (at SDS1-100)	1997	SDS-1	IWS	1.75
6. SWPPP No. 6: Gate B5 (included in SWPPP No. 7)	1995	SDS-1	IWS	0.25
7. SWPPP No. 7: Concourse A-D Apron (at IWS-475A)	1996	IWS	IWS	16.82
8. North Snowmelt Pump Station (STIA-9759)	1998	SDN-2	IWS	6.63
9. Central (Firestation) Snowmelt Pump Station (STIA-9759)	1998	SDE-4	IWS	0.75
10. South Snowmelt Pump Station (STIA-9759)	1998	SDS-4	IWS	0.34
11. Runway 34R Safety Fill (STIA-9602)	1996	offsite	SDS-4	5.88
12. Terminal Garage Expansion (STIA-9723)	1998	SDE-4	IWS	4.76
13. Fed-Ex Cargo Expansion (tenant)	1997	SDN-1	IWS	0.33
14. Third Runway 16R-34L Interconnecting Taxiway (STIA-9721)	1998	W3,B,D	SDS-3	17.02
15. Interconnecting Taxiways 16R-34L (STIA-9420)	1994	no change		0.00
16. Snow Equipment Storage Shelter (STIA-9639)	1996	no change		0.00
17. D-Gate flush gutter reroute (at SDS3-33, 34)	1994	SDE-4	IWS	5.26
18. North Employee Parking Lot (STIA-9748)	1998	offsite	offsite	40.82

Projects: 1999-2000

19. Phase 2 Third Runway 16R-34L Interconnecting Taxiway (STIA-9819)
20. Emery/Aeroground Air Cargo
.1. Westin Hotel
22. IWS-510 et.al. Reroute
23. South Terminal (Concourse A)
24. Northwest/Delta Hangar Relocation
25. 154th/156th Street Relocation
26. Acquisition Area Demolition
27. Air Traffic Control Tower

New Stormwater Detention Facilities: 1994-2004	Storage (ac-ft)	
D1. NEPL vault	4.0	(as-built)
D2. SDS-3 Taxiway vault	2.9	(as-built)
D3. Expanded Miller Creek Detention Facility	16.4	(estimated)
D4. 24th Avenue Commercial Development vault	1.9	(estimated)
D5. 3rd Runway Miller North pond	13.8	(estimated)
D6. 3rd Runway Miller Middle pond	4.8	(estimated)
D7. 3rd Runway Miller South pond	6.6	(estimated)
D8. SASA Pond (replacement of Tyee Pond)	18.5	(estimated)
D9. SDS-3 Taxiway vault #2	2.9	(as-built)
D10. SDS-3 3rd Runway Vault	3.8	(estimated)
TOTAL	75.7	

K

e) <u>Monitoring and Reporting Requirements</u>: The revised plan shall develop a comprehensive monitoring protocol that, at a <u>minimum</u>, addresses the following elements:

i) Collection of stream gage data and an evaluation/correlation to expected flow rates established by the model.
ii) Water quality sampling and reporting. Water quality shall be tested at vault outflow and instream at a point 100 feet downstream of the outflow.
iii) Metering of water from vaults.
iv) Infiltration rate sampling and monitoring to evaluate performance of the fill.
v) Contingency if water quality in vaults does not meet water quality criteria (e.g., additional treatment, other source, flocculation, coalescing oil water separator, etc.).
vi) Instream biologic monitoring shall occur in Des Moines, Miller and Walker Creeks to assess the impacts of the Port's low flow offset proposal. The Port shall develop an instream monitoring protocol that shall at a minimum include the following elements:

- Existing low-flow conditions of Des Moines, Miller and Walker Creek will be evaluated by conducting Benthic Index of Biotic Integrity (BIBI) monitoring (Karr and Chu 1999). Monitoring shall occur four times per year and shall continue through year five (5) after construction and then yearly until completion of the fifteen (15)-year monitoring period. In addition to the BIBI monitoring required above, the Port shall develop a that monitors at a minimum temperature, turbidity, channel morphology, substrate quality, type and amount of large woody debris and other habitat features, riparian habitat cover and fish use. Representative stream channel cross-sections shall be utilized. Information must be synthesized to determine how these elements may be impacting overall stream health.

- Mitigation during the proposed period appears to effect low flow frequencies during June and July. Monitoring shall specifically address potential adverse impacts to fish or aquatic biota during June and July. If monitoring shows an adverse effect during this time period the Port shall implement contingencies to address the impact (such as providing additional mitigation water during June and July).

J. Operational Stormwater Requirements:

1. <u>Approved Stormwater Plan</u>: The Comprehensive Stormwater Management Plan (CSMP), Volumes 1 through 4, December 2000 as revised by the July 2001 Replacement pages is the approved stormwater management plan for this project. It shall be implemented in its entirety. No changes to the CSMP

L

Start of 7-Day Low Flows with
Average Flow Rates

	Date		1994 Miller Creek at SR509 Flow / cfs
1949	Sep	7	0.59
1950	Sep	17	0.88
1951	Sep	17	0.79
1952	Nov	23	0.53
1953	Sep	15	0.75
1954	Oct	3	0.87
1955	Sep	6	0.83
1956	Sep	3	0.87
1957	Sep	20	0.78
1958	Sep	29	0.63
1959	Aug	24	0.88
1960	Sep	29	0.84
1961	Sep	29	0.83
1962	Sep	3	0.73
1963	Sep	27	0.71
1964	Oct	25	0.88
1965	Sep	27	0.78
1966	Sep	3	0.78
1967	Sep	22	0.73
1968	Aug	7	0.97
1969	Sep	6	0.82
1970	Aug	27	0.72
1971	Aug	14	0.92
1972	Sep	11	1.01
1973	Sep	12	0.65
1974	Oct	13	0.72
1975	Aug	11	0.78
1976	Dec	10	0.69
1977	Aug	16	0.53
1978	Aug	17	0.80
1979	Oct	7	0.54
1980	Oct	17	0.66
1981	Sep	12	0.69
1982	Sep	17	0.81
1983	Oct	10	0.90
1984	Oct	1	0.78
1985	Sep	29	0.62
1986	Oct	18	0.59
1987	Oct	24	0.58
1988	Sep	11	0.60
1989	Oct	3	0.67
1990	Sep	25	0.71
1991	Oct	9	0.79
1992	Sep	16	0.65
1993	Nov	9	0.58
1994	Oct	6	0.50
1995	Sep	20	0.76

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

Year	Average 7-Day Lows Ordered	Rank	Rank/(N+1)	Return Frequency
1994	0.50	1	0.02	2.08
1952	0.53	2	0.04	4.17
1977	0.53	3	0.06	6.25
1979	0.54	4	0.08	8.33
1987	0.58	5	0.10	10.42
1993	0.58	6	0.13	12.50
1949	0.59	7	0.15	14.58
1986	0.59	8	0.17	16.67
1988	0.60	9	0.19	18.75
1985	0.62	10	0.21	20.83
1958	0.63	11	0.23	22.92
1973	0.65	12	0.25	25.00
1992	0.65	13	0.27	27.08
1980	0.66	14	0.29	29.17
1989	0.67	15	0.31	31.25
1976	0.69	16	0.33	33.33
1981	0.69	16	0.33	33.33
1963	0.71	18	0.38	37.50
1990	0.71	18	0.38	37.50
1974	0.72	20	0.42	41.67
1970	0.72	21	0.44	43.75
1962	0.73	22	0.46	45.83
1967	0.73	23	0.48	47.92
1953	0.75	24	0.50	50.00
1995	0.76	25	0.52	52.08
1966	0.78	26	0.54	54.17
1957	0.78	27	0.56	56.25
1975	0.78	27	0.56	56.25
1965	0.78	29	0.60	60.42
1984	0.78	29	0.60	60.42
1951	0.79	31	0.65	64.58
1991	0.79	32	0.67	66.67
1978	0.80	33	0.69	68.75
1982	0.81	34	0.71	70.83
1969	0.82	35	0.73	72.92
1961	0.83	36	0.75	75.00
1955	0.83	37	0.77	77.08
1960	0.84	38	0.79	79.17
1956	0.87	39	0.81	81.25
1954	0.87	40	0.83	83.33
1950	0.88	41	0.85	85.42
1964	0.88	41	0.85	85.42
1959	0.88	43	0.90	89.58
1983	0.90	44	0.92	91.67
1971	0.92	45	0.94	93.75
1968	0.97	46	0.96	95.83
1972	1.01	47	0.98	97.92

Rank = Numerocal Position of ordered low flow data
with driest year equal to one.
N = 47

Start of 7-Day Low Flows with Average Flow Rates

	Date		1994 HSPF Walker Creek at POC
1949	Oct	17	0.66
1950	Sep	13	0.83
1951	Sep	11	0.78
1952	Nov	15	0.65
1953	Sep	5	0.76
1954	Sep	30	0.87
1955	Aug	23	0.83
1956	Sep	2	0.85
1957	Sep	2	0.80
1958	Sep	10	0.70
1959	Aug	2	0.85
1960	Sep	20	0.83
1961	Sep	4	0.80
1962	Aug	23	0.79
1963	Sep	6	0.74
1964	Aug	8	0.90
1965	Aug	24	0.78
1966	Aug	25	0.77
1967	Aug	15	0.75
1968	Jun	28	0.94
1969	Jul	26	0.82
1970	Sep	2	0.76
1971	Jul	10	0.88
1972	Jul	25	0.94
1973	Jul	24	0.74
1974	Aug	22	0.77
1975	Jun	18	0.79
1976	Oct	15	0.73
1977	Jun	19	0.66
1978	Jun	26	0.78
1979	Aug	6	0.63
1980	Aug	14	0.68
1981	Jul	8	0.70
1982	Jul	23	0.75
1983	Aug	1	0.90
1984	Jul	21	0.77
1985	Jul	27	0.68
1986	Aug	3	0.66
1987	Aug	16	0.64
1988	Jul	18	0.65
1989	Jul	13	0.69
1990	Jul	3	0.71
1991	Aug	3	0.76
1992	Jul	26	0.67
1993	Aug	11	0.65
1994	Jul	18	0.60
1995	Jun	18	0.73

Statistical Ranking of Average 7-Day Low Flows

Period of Record: 1949-1995

Date	Average 7-Day Lows Ordered	Rank	Rank/N+1	Return Frequency
1994	0.60	1	0.02	2.1
1979	0.63	2	0.04	4.2
1987	0.64	3	0.06	6.3
1952	0.65	4	0.08	8.3
1993	0.65	5	0.10	10.4
1988	0.65	6	0.13	12.5
1986	0.66	7	0.15	14.6
1949	0.66	8	0.17	16.7
1977	0.66	9	0.19	18.8
1992	0.67	10	0.21	20.8
1985	0.68	11	0.23	22.9
1980	0.68	12	0.25	25.0
1989	0.69	13	0.27	27.1
1958	0.70	14	0.29	29.2
1981	0.70	15	0.31	31.3
1990	0.71	16	0.33	33.3
1976	0.73	17	0.35	35.4
1995	0.73	18	0.38	37.5
1963	0.74	19	0.40	39.6
1973	0.74	20	0.42	41.7
1982	0.75	21	0.44	43.8
1967	0.75	22	0.46	45.8
1970	0.76	23	0.48	47.9
1953	0.76	24	0.50	50.0
1991	0.76	25	0.52	52.1
1966	0.77	26	0.54	54.2
1974	0.77	27	0.56	56.3
1984	0.77	28	0.58	58.3
1951	0.78	29	0.60	60.4
1965	0.78	29	0.60	60.4
1978	0.78	31	0.65	64.6
1962	0.79	32	0.67	66.7
1975	0.79	33	0.69	68.8
1961	0.80	34	0.71	70.8
1957	0.80	35	0.73	72.9
1969	0.82	36	0.75	75.0
1960	0.83	37	0.77	77.1
1950	0.83	38	0.79	79.2
1955	0.83	39	0.81	81.3
1959	0.85	40	0.83	83.3
1956	0.85	41	0.85	85.4
1954	0.87	42	0.88	87.5
1971	0.88	43	0.90	89.6
1964	0.90	44	0.92	91.7
1983	0.90	44	0.92	91.7
1972	0.94	46	0.96	95.8
1968	0.94	47	0.98	97.9

Rank = Numerical position of ordered low flow data with the driest year equal to one.

N = 47

Start of 7-Day Low Flows
with Average Flow Rates

	Date		1994 HSPF Des Moines Creek at 200th St. / Flow cfs Average 7-Day Low Flow
1949	Sep	7	0.18
1950	Sep	17	0.40
1951	Aug	20	0.35
1952	Oct	13	0.21
1953	Sep	15	0.35
1954	Aug	7	0.48
1955	Sep	6	0.34
1956	Sep	3	0.43
1957	Sep	20	0.32
1958	Sep	2	0.27
1959	Aug	24	0.38
1960	Aug	7	0.39
1961	Aug	23	0.40
1962	Sep	2	0.33
1963	Sep	27	0.36
1964	Aug	31	0.47
1965	Aug	3	0.38
1966	Aug	20	0.32
1967	Aug	25	0.33
1968	Aug	6	0.47
1969	Sep	6	0.38
1970	Aug	27	0.33
1971	Aug	14	0.41
1972	Oct	18	0.51
1973	Sep	12	0.27
1974	Oct	13	0.31
1975	Aug	11	0.33
1976	Oct	17	0.34
1977	Aug	16	0.17
1978	Oct	16	0.41
1979	Aug	7	0.22
1980	Aug	23	0.33
1981	Sep	12	0.28
1982	Aug	6	0.41
1983	Oct	10	0.45
1984	Aug	29	0.36
1985	Aug	30	0.25
1986	Sep	10	0.26
1987	Sep	7	0.29
1988	Sep	11	0.25
1989	Oct	3	0.35
1990	Sep	25	0.31
1991	Oct	9	0.33
1992	Sep	1	0.31
1993	Sep	29	0.27
1994	Aug	26	0.22
1995	Sep	20	0.35

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

Year	Average 7-Day Lows Ordered	Rank	Rank/(47+1)	Return Frequency
1977	0.17	1	0.02	2.1
1949	0.18	2	0.04	4.2
1952	0.21	3	0.06	6.3
1994	0.22	4	0.08	8.3
1979	0.22	5	0.10	10.4
1988	0.25	6	0.13	12.5
1985	0.25	7	0.15	14.6
1986	0.26	8	0.17	16.7
1993	0.27	9	0.19	18.8
1973	0.27	10	0.21	20.8
1958	0.27	11	0.23	22.9
1981	0.28	12	0.25	25.0
1987	0.29	13	0.27	27.1
1990	0.31	14	0.29	29.2
1974	0.31	15	0.31	31.3
1992	0.31	16	0.33	33.3
1966	0.32	17	0.35	35.4
1957	0.32	18	0.38	37.5
1970	0.33	19	0.40	39.6
1975	0.33	20	0.42	41.7
1962	0.33	21	0.44	43.8
1980	0.33	22	0.46	45.8
1991	0.33	22	0.46	45.8
1967	0.33	24	0.50	50.0
1976	0.34	25	0.52	52.1
1955	0.34	26	0.54	54.2
1951	0.35	27	0.56	56.3
1995	0.35	27	0.56	56.3
1953	0.35	29	0.60	60.4
1989	0.35	30	0.63	62.5
1984	0.36	31	0.65	64.6
1963	0.36	32	0.67	66.7
1965	0.38	33	0.69	68.8
1969	0.38	34	0.71	70.8
1959	0.38	35	0.73	72.9
1960	0.39	36	0.75	75.0
1961	0.40	37	0.77	77.1
1950	0.40	38	0.79	79.2
1971	0.41	39	0.81	81.3
1978	0.41	40	0.83	83.3
1982	0.41	41	0.85	85.4
1956	0.43	42	0.88	87.5
1983	0.45	43	0.90	89.6
1964	0.47	44	0.92	91.7
1968	0.47	44	0.92	91.7
1954	0.48	46	0.96	95.8
1972	0.51	47	0.98	97.9

Rank = Numerical position of ordered average 7-day low flow values with the driest year equal to one.

N = 47

M

and 1998). In the Miller Creek basin, the MCDF was constructed in 1992 by King County to reduce downstream flooding and reduce the impacts of future development.

Therefore, for the purposes of establishing a target flow regime, a uniform watershed[7] land cover of 10 percent impervious was assumed, with 15 percent pervious grass and 75 percent pervious forest.[8,9] Basing target flows on theoretical basin development of 10 percent is expected to reduce existing peak flows and durations and be beneficial in maintaining stable stream channels (Ecology 2000a).

The above assumptions and goals are compatible with the goals of the Des Moines Creek Basin Committee for stabilizing the Des Moines Creek channel. The Draft Preliminary Design Report for the Des Moines Creek Regional Detention Facility (RDF) notes that the critical erosive flow rate under current conditions is higher than would exist under forested conditions (King County CIP Design Team 1999). With the proposed reduction in assumed impervious area, the resulting assumed pre-development flow duration curve will be lower than the actual existing conditions flow duration curve.

2.1.4 Updated Detention Requirements

During Section 401 Water Quality Certification discussions with Ecology in 1998, additional mitigation to reduce stormwater discharge rates was identified. To provide additional protection to Miller, Walker, and Des Moines Creeks, the following standards were added to the mitigation requirements for MPU improvements:

- In the Miller and Walker Creek basins (draining airport areas), the stormwater detention facilities will be designed to Level 2 (using a theoretical basin development of 10 percent impervious area as described above). For sub-watersheds draining to the Miller Creek Detention Facility (MCDF), additional future analysis by the Port or the Miller Creek Basin Committee may show that the target flow and Level 2 standards can be met at the outlet of the MCDF (with or without expansion or modification of the facility). Stormwater detention facilities shown by the Port may be modified, with approval by Ecology, to reflect using available detention in the MCDF and a new point of compliance. In either case, the objective to meet the target flow using the Level 2 standard in Miller Creek will be met.
- The Level 2 detention storage will be provided in on-site stormwater detention vaults in the Des Moines Creek basin (using a theoretical basin development of 10 percent impervious area). However, if the proposed Des Moines Creek RDF is constructed, the detention standard will be Enhanced Level 1, and 1994 land cover will be used.

---

[7] For application of this standard a "watershed" means the area that drains to a detention pond and/or has a unique point of compliance.

[8] This target flow regime of 10 percent impervious area, 15 percent grass, and 75 percent forest is more restrictive than the flow regime used in the November 1999 SMP. The previous retrofitting target flow also assumed 10 percent impervious area, but existing impervious was converted to grass, and the remaining pervious area was unchanged.

[9] In watersheds when existing imperious area is less than 10 percent, the impervious area is not changed and the difference between actual percent impervious and 10 percent is assumed to be grass.

- 100-year peak flows will be matched to address potential downstream flooding.

The point of compliance for Level 2 analysis is the downstream future subbasin outlet (see Appendix A – Figure A-7 for node locations).[10]

2.2 WATER QUALITY MANAGEMENT STANDARDS

This section describes the regulatory and treatment standards required to retrofit existing developed areas and to provide water quality BMP guidance for MPU projects.

2.2.1 Regulatory Requirements

Water quality is regulated by the Federal Water Pollution Control Act (33 USC § 1251, et seq.), also known as the Clean Water Act, and the Washington Water Pollution Control Act (RCW 90.48).

The Clean Water Act was designed to protect the "chemical, physical, and biological integrity of the Nation's waters (U.S. Environmental Protection Agency [EPA] 1993)."

The portions of the Clean Water Act relevant to this project are implemented through Section 401 (water quality certification), Section 402 (NPDES) and Section 404 (addressing fill in waters of the United States). Issuance of a 401 Certification for the MPU improvement considers standards that are required at one point in time, whereas the NPDES Permit under Section 402 considers compliance with standards over time.

The Port's ongoing compliance with the Clean Water Act and, in turn, protection of STIA's receiving waters, are demonstrated through compliance with its Section 402 (NPDES) Permit, administered in Washington by Ecology (Ecology 1998). As stated in the associated Fact Sheet for the Permit, "compliance with the effluent limitations and other conditions in this permit constitutes compliance with the Federal Water Pollution Control Act… and the Washington Water Pollution Control Act (RCW 90.48)."

NPDES Permit Compliance is continually executed via an adaptive management process by which (1) BMPs are implemented, (2) monitoring and inspections demonstrate BMP effectiveness, (3) BMP improvements are made when necessary, and (4) follow-up sampling demonstrates that the improvements are effective. Ecology reviews and approves this process annually to ensure that the Port's discharges are in compliance with the Clean Water Act, and that the discharge conditions are protective of the receiving waters. Numerous BMP improvements have been implemented through this process and follow-up monitoring has confirmed their efficacy.

Specifically, the NPDES Permit requires the following measures for stormwater:

- A stormwater pollution prevention plan (SWPPP) that identifies and implements source control and treatment BMPs;

---

[10] The downstream future subbasin outlet for the relocated 154th Street is the MCDF.

N

e) Monitoring and Reporting Requirements: The revised plan shall develop a comprehensive monitoring protocol that, at a minimum, addresses the following elements:

i) Collection of stream gage data and an evaluation/correlation to expected flow rates established by the model.
ii) Water quality sampling and reporting. Water quality shall be tested at vault outflow and instream at a point 100 feet downstream of the outflow.
iii) Metering of water from vaults.
iv) Infiltration rate sampling and monitoring to evaluate performance of the fill.
v) Contingency if water quality in vaults does not meet water quality criteria (e.g., additional treatment, other source, flocculation, coalescing oil water separator, etc.).
vi) Instream biologic monitoring shall occur in Des Moines, Miller and Walker Creeks to assess the impacts of the Port's low flow offset proposal. The Port shall develop an instream monitoring protocol that shall at a minimum include the following elements:

- Existing low-flow conditions of Des Moines, Miller and Walker Creek will be evaluated by conducting Benthic Index of Biotic Integrity (BIBI) monitoring (Karr and Chu 1999). Monitoring shall occur four times per year and shall continue through year five (5) after construction and then yearly until completion of the fifteen (15)-year monitoring period. In addition to the BIBI monitoring required above, the Port shall develop a that monitors at a minimum temperature, turbidity, channel morphology, substrate quality, type and amount of large woody debris and other habitat features, riparian habitat cover and fish use. Representative stream channel cross-sections shall be utilized. Information must be synthesized to determine how these elements may be impacting overall stream health.

- Mitigation during the proposed period appears to effect low flow frequencies during June and July. Monitoring shall specifically address potential adverse impacts to fish or aquatic biota during June and July. If monitoring shows an adverse effect during this time period the Port shall implement contingencies to address the impact (such as providing additional mitigation water during June and July).

J. Operational Stormwater Requirements:

1. Approved Stormwater Plan: The Comprehensive Stormwater Management Plan (CSMP), Volumes 1 through 4, December 2000 as revised by the July 2001 Replacement pages is the approved stormwater management plan for this project. It shall be implemented in its entirety. No changes to the CSMP

shall be made without prior review and written approval from Ecology.

a) The Port shall provide Ecology with draft proposed changes to the Plan no later than 60 days prior to the date it seeks to implement a change to the .

b) The Port shall implement the project in accordance with the schedule provided in Table A-3 (July 2001). Any changes to the schedule must be reviewed and approved in advance by Ecology. The Port shall provide Ecology with a draft revised schedule no later than 60 days prior to the date it seeks to implement the change to the schedule. The following facilities/projects listed in Table A-3 (July 2001) do not yet have approved stormwater treatment facilities, proposed: expansion of NEPL to 6000 stalls, additional taxiway exits on 16L/34R, additional expansion of main parking garage, additional expansion of NEPL, expansion of North Unit parking structure, SR 509 extension/South Access, ASDE, and NAVAIDS. If the Port decides to build any of these facilities/projects the Port must submit conceptual drawings that meet the performance standards of the CSMP to Ecology no later than sixty (60) days prior to the date it seeks to commence construction.

c) Retrofitting of stormwater management facilities at the STIA shall occur at a rate commensurate with the construction of new impervious surface at the STIA. For every ten (10) percent of new impervious surface added at the project site, the Port must demonstrate that twenty (20) percent of retrofitting has occurred unless demonstrated that a twenty (20) percent rate isn't feasible. The Port shall document the implementation of retrofitting in quarterly progress reports. The Port shall develop and submit for review and written approval a schedule of construction of stormwater management facilities within 60 days after receipt of the Section 404 permit from the U.S. Army Corps of Engineers. Where the project schedule in the Stormwater Management Plan (including Table A-3) conflicts with this condition, the Port and Ecology shall discuss an appropriate retrofit schedule.

d) Nothing in this Order shall be deemed to prohibit continued participation by the Port in planning efforts to establish regional detention facilities for Des Moines or Miller Creek. The Port may request to amend this Order and the Comprehensive Stormwater Management Plan if it decides to route stormwater to future regional detention facilities and it is demonstrated that under future build-out conditions the combination of on-site and regional flow controls will achieve the performance goals of the CSMP and the corresponding basin plan. If the Port decides to participate in future regional detention facilities, the Port shall submit documentation to Ecology that substantiates that Regional Detention Facilities will be constructed and that the Port may legally route stormwater to a RDF before Ecology will allow a change to the CSMP.

2. Discharge of operational stormwater to state receiving waters:

a) No stormwater generated by operation of new pollution generating impervious surfaces of projects for which the §404 permit was sought (excluding surfaces not to be included in the airport NPDES permit, e.g., South 154th Street which is a City of SeaTac facility) shall be discharged to state receiving waters until a site specific study, e.g., a Water Effects Ratio Study (WERS), has been completed and approved by Ecology and appropriate limitations and monitoring requirements have been established in the Port's NPDES permit. The study may use existing impervious surfaces as a surrogate for future new impervious surfaces, and it shall be submitted to Ecology for review and written approval. The Port shall consult with Ecology's Northwest Regional Office Water Quality Program's SeaTac NPDES Manager to determine an appropriate time for submittal of the study.

b) All stormwater discharges from the project shall be in compliance with state of Washington surface water quality standards (Chapter 173-201A WAC), sediment management standards (Chapter 173-204 WAC) and ground water quality standards (Chapter 173-200 WAC).

c) The Port shall design, construct, operate, and maintain stormwater treatment facilities to ensure that discharges shall not result in exceedances of state water quality criteria in receiving waters. Ecology may require changes to the approved CSMP as a part of future NDPES permits.

d) If monitoring indicates a need for additional BMPs, the Port may propose other BMPs for stormwater treatment if it can be demonstrated that they will result in stormwater discharges that meet the state water quality standards. Any proposed changes are subject to review and written approval by Ecology.

e) The Port shall submit the final stormwater treatment and flow control facility designs to Ecology for review and written approval 60 days prior to the start of construction of the facilities. During final design the Port shall evaluate the likelihood that stormwater facilities will intercept groundwater and make modifications to the designs so as to either prevent the interception of groundwater or increase facility sizing to accommodate the groundwater. If facility sizes increase the Port shall evaluate potential impacts to wetlands and other waters of the state and whether the increase facility size triggers Dam Safety requirements under Chapter 173-175 WAC.

0

12.3 Local Government Evaluation of Emerging Technologies

Local governments should consider the following as they make decisions concerning the use of new stormwater technologies in their jurisdictions:

Remember the goal:

The goal of any stormwater management program or BMP is to treat and release stormwater in a manner that does not harm beneficial uses. Compliance with water quality standards is one measure of determining whether beneficial uses will be harmed.

Exercise reasonable caution:

It is important to be cautious with the use of emerging, unproven, technologies for new development and for retrofits. Before selecting a new technology for a limited application, the local government should review evaluation information based on an acceptable protocol.

An emerging technology *must not be used* for new development sites unless there are data indicating that its performance is expected to be reasonably equivalent to a Basic Treatment, or as part of a treatment train. Local governments can refer to Ecology's web site to obtain the latest performance verification of an emerging technology.

Local governments are encouraged to:

- Conduct a monitoring program, using an acceptable protocol, of those emerging technologies that have not been verified for limited or full-scale statewide use at Ecology's web site.
- Look for achieving acceptable performance objectives as specified in Chapter 3.

To achieve the goals of the Clean Water Act and the Endangered Species Act, local government may find it necessary to retrofit many, existing stormwater discharges. In retrofit situations the use of any BMPs that make substantial progress toward these goals is a step forward and is encouraged by Ecology. To the extent practical, the performance of these BMPs should be evaluated, using approved protocols.

12.4 Acceptable Evaluation Protocol (APWA Task Committee, 1999)

AR 016413

To properly evaluate new technologies, performance data must be obtained using an accepted protocol. Such a protocol has been drafted by the Washington State Chapter of the APWA. Ecology plans to publish the final version of the APWA Protocol at its web site for use by local governments, suppliers of new technologies, and consultants. The current version can be downloaded from the APWA web site at http://www.mrsc.org/stormwater. Other acceptable protocols may also be added to Ecology's web site. Such protocols may be developed by local, state, or federal agencies.

12.5 Assessing Levels of Development of Emerging Technologies

Ecology has received several submittals from vendors to approve their new technologies for statewide applications. However, none of the submittals included performance information using the APWA. or equivalent protocol. Moreover, it is evident that some technologies have been under development for many years and have been improved considerably during that time.

To assess and classify levels of developments, Ecology is proposing to use the criteria given below. These criteria will be included on the planned web site. Emerging technologies shall be used only within the application criteria and performance limits listed at Ecology's web site. Best Professional judgment may be used in the interim until the APWA-TRC process is operational.

- *Pilot Level* - Pilot studies could typically be conducted at roadway. commercial and residential sites, or specific land uses for which the system is marketed. Runoff at each site should be tested at full flow (design flow) conditions using reasonable evaluation criteria before deciding on a limited or general statewide use of the technology. The pilot studies should be conducted during dry and wet seasons.
- *General Statewide Use.* - To obtain general statewide acceptance the performance criteria as specified in Chapter 3 must be met using the APWA protocol, or other acceptable protocol. Final application. design and O&M criteria, and costs must be determined. Approvals may include application as part of a treatment train and or as a stand-alone BMP.

12.6 Examples of Emerging Technologies for Stormwater Treatment and Control

The descriptions and other supplier information provided in this section should not be construed as approvals by Ecology of any of the technologies. Suppliers of these emerging technologies are encouraged to submit performance verification data to Ecology in accordance with the APWA-TRC process described earlier in this chapter.

12.6.1 Media Filters

Introduction

The media filter technology has been under development in the Pacific Northwest since the early 1990s. During the early stages of development, a leaf compost medium was used in fixed beds, replacing sand. Continued development of this technology is based on placing the media in filter cartridges (vertical media filters) instead of fixed beds, and amending the media (Varner, Phyllis, City of Bellevue, 1999) with constituents that will improve effectiveness (See Figure 12.1). Many systems have been installed in the U.S. The primary target pollutants for removal are: TSS, total and soluble phosphorous, total nitrogen, soluble metals, and oil & grease and other organics.

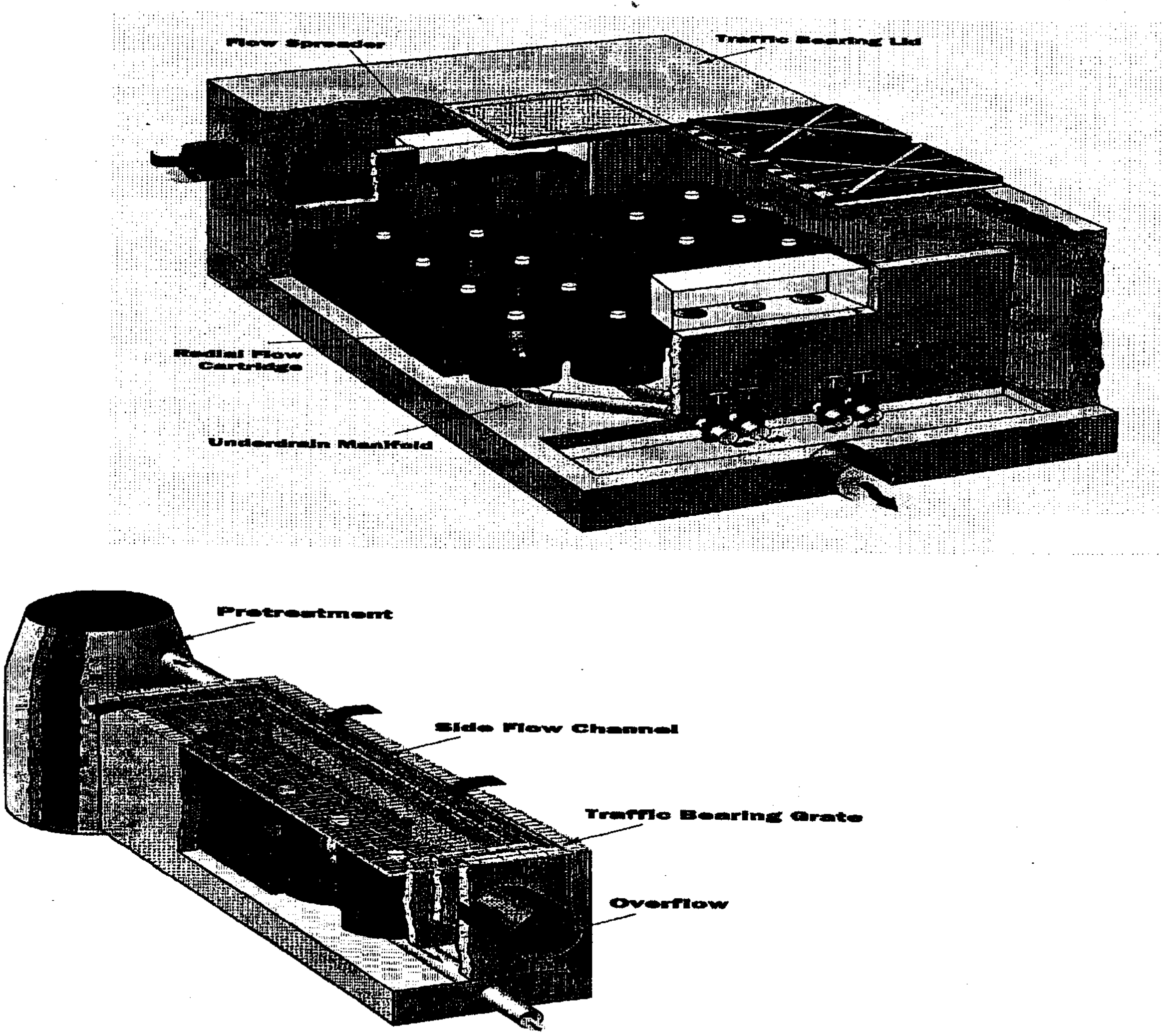


Figure 12.1. Vertical Media Filter

Courtesy of Stormwater Management Co.

P

Logan

Port of Seattle

Annual Stormwater Monitoring Report

for

Seattle-Tacoma International Airport

for the period July 1, 2000 through June 30, 2001

September 2001

Table 4 Stormwater Quality Comparators[a]

Constituent	Units	Comparative Study Data[a]						STIA		
		NURP 1983	BURP 1984	Metro 1982	Bellevue 1995[b]	Highway Runoff[c] 1981	Portland NPDES[d] 1993	Landside (SDE4, SDN1)	Airfield (SDS3, SDS4, SDN3, SDN4)	WA State Standard[e]
pH	std units		**5.2 - 7.4**		7.2 - 7.8			6.7	7.3	6.5 - 8.5
TPH	mg/l				**3.7**		6.5	2.6 FOG 1.8 TPH 1.7 TPH-Dx	0.5 FOG 0.13 TPH 0.08 TPH-Dx	*no standard*
Fecal coliforms	mpn per 100 ml	1000 to 21000	*980*		**201**			110	8	50
BOD_5	mg/l	9	***6.6***				20	6.7	6	*no standard*
TSS	mg/l	100	***50***		82.3	106	119	42.5	7.45	*no standard*
Turb	mg/l		19		**29.4**			22	6.2	based on background
glycols	mg/l	*not analyzed in any of these studies*						5[i]	5[i]	*no standard*
Cu (TR)[f]	µg/l	34		20	10.4	43	**40**	24	27	10.3[f]
Pb (TR)[f]	µg/l	144	170	210	**26.3**	466[c]	25	11	1	39[f]
Zn (TR)[f]	µg/l	160	120	110	**161.4**	638	376	171	32	72[f]
statistic reported		median	mean[g], *median*	mean	log-normal median	mean	median	7-yr median	7-yr median	na

(a) Comparative values used in this report are in bold. Blank space means no data available, reported, or applicable.

(b) Bellevue, 1995 data are for instream stormwater runoff samples from the "Sturtevant Creek, downstream" site.

(c) Highway runoff from an I5 location in Seattle with 57,000 ADT, 43 to 54 storm samples in 1980-81 (Chui, Mar, and Horner, 1982). Because this study was conducted prior to the phase-out of leaded gasoline, lead results were higher than for other later studies.

(d) City of Portland 1993 NPDES Part 2 Municipal Application. Median of 10 samples from "I2" "industrial" outfall.

(e) Standards listed are for class AA waters, see WAC 173-201A.

(f) Total recoverable metals. WA State acute standards expressed as total recoverable, calculated at 56 mg/l hardness using generic translators in Ecology's "TSDCALC8.XLW" spreadsheet (see Section 4.5.3). This hardness value is the median of seven instream samples collected in Miller and Des Moines Creeks in 1999.

(g) For Turb, Cu, Pb, and Zn, BURP 1984 data was mean of grab samples, therefore Bellevue, 1995 data are more representative comparators because they represent median of composite samples, comparable to STIA samples and data for these parameters.

(h) STIA median data cited reflect 37 to 112 samples per parameter for landside group samples, and 90 to 153 samples per parameter for airfield group samples

(i) About 70% of all STIA sample results for glycols have been below detection limits of 5 mg/l (to April 1997) and 2 mg/l (May 1997-current). .