Supplement

Biological Assessment

Master Plan Update Improvements Seattle-Tacoma International Airport

Port of Seattle

Parametrix, Inc.
December 2000

with Attachments

AR 049788

SUPPLEMENT

BIOLOGICAL ASSESSMENT FOR THE REINITIATION AND INITIATION OF CONSULTATION FOR CERTAIN MASTER PLAN UPDATE IMPROVEMENTS AND RELATED ACTIONS

BIOLOGICAL ASSESSMENT
MASTER PLAN UPDATE IMPROVEMENTS

SEATTLE-TACOMA INTERNATIONAL AIRPORT

Prepared for

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure

LIST OF TABLES

Table

1. HYDROLOGIC IMPACTS AND MITIGATION

1.1 INTRODUCTION

On June 15, 2000, the Federal Aviation Administration (FAA) and U.S. Army Corps of Engineers (ACOE) submitted a biological assessment (BA) to the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS) (the Services) as required by Section 7 of the Endangered Species Act (ESA) (FAA 2000). The BA was prepared for reinitiation and initiation of consultation by FAA and initiation of consultation by ACOE over certain actions for which the agencies possess discretionary involvement or control as required by Section 7 of the ESA. FAA is presently consulting with the Services over construction of navigation aids, future grants, and grants issues since May 24, 1999, related to implementation of certain Seattle-Tacoma International Airport Master Plan Update improvements. This consultation also covers FAA's future approval of certain passenger facility charges (PFCs) for collection and use authorizations related to implementation of Master Plan Update improvements.

The ACOE is presently consulting with the Services concerning its approval of a Clean Water Act Section 404 permit application pertaining to Master Plan Update improvements. The ACOE proposed action relates to those Master Plan Update improvements that result in the placement of fill in wetlands, as regulated by Section 404 of the Clean Water Act. The ACOE's action also includes the temporary, indirect, and cumulative impacts to wetlands and the environment which the ACOE is mandated to consider.

The *Biological Assessment* (BA) addresses impacts to wetlands and stream in Section 7.3, specifically:

- The impacts of Master Plan Update improvements that place fill in streams on listed species are considered in Section 7.3.1.1 and Section 7.3.1.2. The impacts relate primarily to the relocation of a portion of Miller Creek.

- The impacts of Master Plan Update improvements that directly affect wetlands on listed species are addressed in Section 7.3.1.3 and Section 7.3.1.4. These potential impacts include filling of wetlands for construction projects, and the grading or excavation of wetlands to implement mitigation projects.

- Potential indirect impacts to wetlands that could affect listed species are part of the ACOE 404 permit action. These indirect impacts are addressed in Section 7.3.1.5.

Finally, the ACOE will consider the potential impacts of Master Plan Update improvements on local streams and listed species. The effect of the projects on base flows, high flows, and water quality are addressed in Sections 7.1 and Section 7.2.

As discussed in the June 2000 BA, consultations with FWS identified threatened bald eagles, threatened marbled murrelets, and threatened Coastal/Puget Sound bull trout as potentially occurring in the action area. NMFS identified Puget Sound chinook salmon, a threatened species, as also potentially occurring in the action area. NMFS has also designated critical habitat for Puget Sound chinook salmon in the vicinity of the action area.

1.2 MODIFICATIONS AND REFINEMENTS TO PROPOSED ACTION

The purpose of this document is to supplement the June 2000 BA to reflect the modifications and refinements to the proposed action and to provide updated information concerning potential stormwater and related impacts associated with Master Plan Update improvements. Updated information indicates that the design and location of stormwater facilities and associated measures discussed in the June 2000 BA should be modified to ensure stormwater impacts are adequately addressed. The updated information below is provided to ensure the ongoing ESA consultation between the federal action agencies and the Services is based upon the "best available scientific and commercial information" as required by the ESA. See 50 C.F.R. § 402.14(d).

The stormwater analysis contained in the June 2000 BA was based on information contained in the November 1999 *Preliminary Comprehensive Stormwater Management Plan* (SMP) *for Seattle-Tacoma International Airport Master Plan Update Improvements* (Parametrix 1999). After submission of the June 2000 BA, King County completed a technical review of the November 1999 SMP through an agreement with the Washington Department of Ecology (Ecology). Following this technical review, an updated SMP was submitted to King County and Ecology in August 2000 (Parametrix 2000a). King County subsequently completed a technical review of the August 2000 SMP as well. As part of the ongoing discussions between the Port of Seattle and Ecology concerning CWA 401 Certification, updated data were submitted to King County and Ecology in October 2000 in response to the technical review of the August 2000 SMP. King County subsequently found these data to be consistent with the stormwater management standards described below. The updates and revisions provided in this document are based on the *Comprehensive Stormwater Management Plan for Seattle-Tacoma International Airport Master Plan Update Improvements* (Parametrix 2000b) and represent the best available scientific and commercial data.

The best available scientific data indicates that modifications to the design and location of stormwater facilities described in the June 2000 BA are needed to avoid impacts to listed species and critical habitat. Specifically, available information indicates that stormwater detention facilities should be modified to ensure that potential peak flow impacts associated with stormwater runoff are adequately addressed. This document describes these required changes to stormwater facilities in detail, including changes to design and location of such facilities, and modifies the proposed action to incorporate such facilities. In doing so, this document likewise analyzes the potential effects associated with peak flow impacts, and concludes that baseline conditions will be improved or maintained as a result of modifying the stormwater facilities as proposed and insuring the contemplated stormwater standards are met (See Table 2).

The best available scientific data indicates that a potential effect of modifying stormwater facilities to achieve contemplated stormwater standards may be a slight negative impact on low stream flows in Miller, Des Moines, and Walker Creeks. As a result, the proposed action is also modified to include mitigation measures to ensure low stream flow levels are maintained or improved.

1.3 HYDROLOGIC IMPACTS AND MITIGATION

The listed species evaluated here could be impacted from increasing the impervious area. These actions could increase peak flows and reduce base flows in Miller, Walker, and Des Moines Creeks, and thus affect habitat quality at the mouths of these creeks. The addition of new impervious area associated with the Master Plan Update improvements affecting the hydrology of Miller, Walker, and Des Moines Basins are discussed in the following sections, along with associated mitigation measures that compensate for these actions.

1.3.1 Flow Impacts

The activities associated with implementing the Master Plan Update improvements will include adding new impervious surfaces (new runways, taxiways, parking, and roadways). This action, if unmitigated, could change the hydrologic flow regime of Miller, Walker, and Des Moines Creeks, including increased peak-flow magnitude and frequency, and increased peak-flow duration. The potential effects of high-flow impacts in the stream are increased erosion and sedimentation, habitat damage from scouring flows, and impaired habitat use during high-flow period.

Potential impacts in critical habitat in the estuaries of Miller and Des Moines Creeks include increased sedimentation in these estuaries caused by high-flow erosion in the upper watershed and potential changes in the estuarine hydrology. However, with flow mitigation, it is unlikely that the critical habitat at the mouths of these creeks could be affected by hydrologic changes when flows in the creeks relative to the influence of tides are considered. Proposed peak-flow mitigation reduces peak flows from existing levels in both creeks, which will reduce bank and channel erosion as well as sedimentation in estuaries. Additional detail on hydrology and stormwater management are provided in the *Comprehensive Stormwater Management Plan for Seattle-Tacoma International Airport Master Plan Update Improvements* (Parametrix 2000b), which addresses mitigation of flow impacts on the drainage basins. The plan includes modeling conducted to estimate the impacts of the project on the Miller and Des Moines Creek systems. The Hydrologic Simulation Program – FORTRAN (HSPF) model was used for this purpose. Details of the model application are discussed in the SMP (Parametrix 2000b). This document discusses the results of HSPF modeling and flow mitigation design.

1.3.1.1 Impervious Area

In the Miller Creek Basin, Master Plan Update improvement projects will result in a net increase of 105.6 acres[1] of impervious surface area (Table 1 and Figure 1), increasing the overall impervious area in the basin by about 1 percent above the existing baseline condition (about 25 percent of impervious surface-see Table 4-1 in the December 2000 SMP [Parametrix 2000b]). In the Walker Creek Basin, Master Plan Update improvements will result in an increase of 6.2 acres. In the Des Moines Creek Basin, Master Plan Update improvements will result in an increase of 128.2 acres of impervious surface, increasing the overall impervious area in the basin by about 4 percent above the

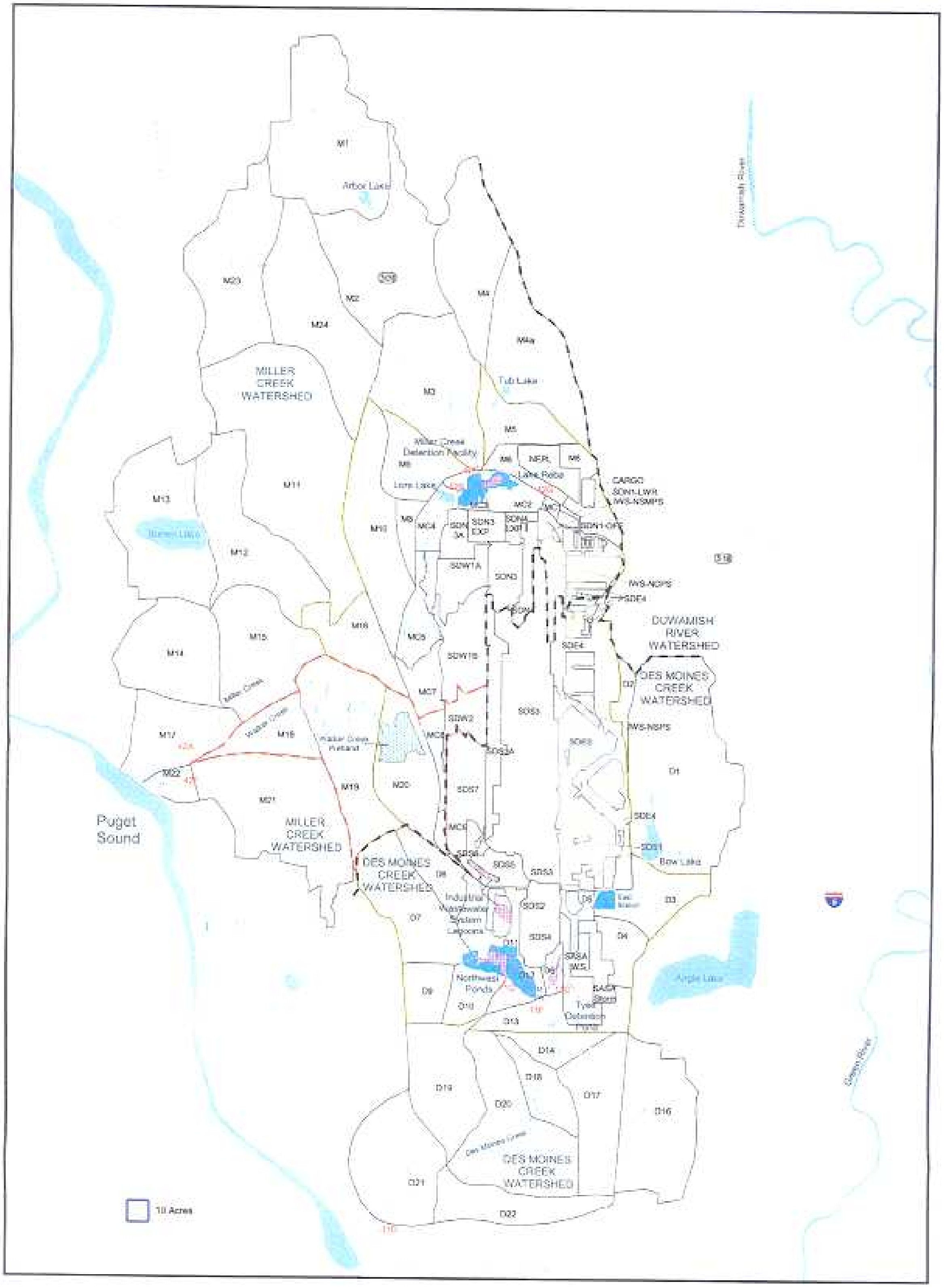
[1] The net change in impervious area excludes a reduction of approximately 50 acres of impervious surfaces (streets, driveways, and rooftops) that will result when existing houses and streets are removed in the acquisition area. Demolition in these areas is ongoing and is expected to be completed by 2002.

existing base condition (approximately 35 percent impervious surface-see Table 4-1 in the November 2000 SMP [Parametrix 2000a]). In addition, 109.0 acres of impervious area drain to the IWS.

The new impervious surfaces could increase stormwater runoff rates (FAA 1996) and volumes. Unless mitigated, changes in runoff would be expected to increase flooding and erosion and would degrade instream habitat and water quality in Des Moines and Miller Creeks downstream of stormwater inputs from the improved areas. Chinook salmon critical habitat in the estuaries of Miller and Des Moines Creeks will not be directly altered by runoff from new impervious surfaces in the Master Plan Update. In addition, existing hydrologic impacts from existing impervious surfaces will be mitigated.

Stormwater Peak Flow Mitigation

As part of the Master Plan Update improvement, the Port will construct stormwater conveyance, detention, and water quality treatment facilities to manage runoff from both newly developed project areas and existing airport areas, as described below. Additional detail on the proposed stormwater controls is provided in the *Comprehensive Stormwater Management Plan for Seattle-Tacoma International Airport Master Plan Update Improvements* (Parametrix 2000b). This plan was prepared to analyze and describe stormwater management for projects associated with the STIA Master Plan Update improvements. The stormwater management facilities will mitigate the impacts of new construction on Miller, Walker, and Des Moines Creeks, as required by current stormwater regulations and mitigation goals identified during the environmental review process. The facilities will also mitigate stormwater impacts from current development by reducing the magnitude and duration of existing peak flows.



Source: Roads based on King County data. Water bodies derived from USGS hypsography data. Detention boundaries are approximate.
Note: Subbasin boundaries shown outside of STIA area are for illustration and reference only.
STIA subbasins assume future (2006) conditions.

N

1000 0 1000 2000 Feet

1" = 3,000'

- Roads
- Future (2006) Drainage Subbasins
- STIA Area (see note)
- Constructed Water Features
- Subwatershed Boundary
- Watershed Boundary
- Rivers
- Water Bodies
- Detention Facilities (existing)
- IWS Drainage Area
- Precipitation Gaging Stations:
  - Type 1 - National Weather Service (Gage relocated 1996)
  - Type 2 - POS Rainfall Monitoring
  - Type 3 - King County Rainfall Monitoring
- Streamflow King County Gaging Stations:
  - 42A - Miller Ck @ SW 175th Pl & 12th Ave SW
  - 42B - Miller Ck @ Lake Reba/RDF Outlet
  - 42E - Walker Ck @ 12th Ave SW
  - 42F - Miller Ck @ SR518
  - 42G - Miller Ck @ East Branch
  - 11D - Des Moines Ck near mouth
  - 11F - Des Moines Ck @ Golf Course
  - 11C - Des Moines Ck @ Tyee Pond
  - 11G - Des Moines Ck @ NW Ponds

Figure 1 Miller, Walker, and Des Moines Creek Watersheds

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Table 1. Summary of Miller, Walker, and Des Moines Creek drainage areas at STIA and change in impervious area between 1994 baseline and 2006 future conditions (acres).

	1994 Baseline			2006 Future Condition			Increase in Impervious Area
	Pervious	Impervious[1]	Total	Pervious	Impervious[1]	Total	
Miller Creek							
SDN1	6.2	9.9	16.1	3.5	12.7	16.1	2.8
SDN1LWR	5.0	0.4	5.4	4.9	0.6	5.4	0.2
SDN1OFF	25.8	10.5	36.3	28.3	8.0	36.3	-2.5
SDN2X	7.2	0.3	7.5	5.3	2.2	7.5	1.9
SDN3	33.4	14.5	47.9	23.6	24.3	47.9	9.8
SDN3A	28.6	1.9	30.5	22.2	8.2	30.5	6.3
SDN3X	25.4	0.0	25.4	25.4	0.0	25.4	0.0
SDN4	27.7	2.6	30.3	18.1	12.3	30.3	9.7
SDN4X	14.1	1.1	15.2	11.0	4.2	15.2	3.1
SDW1A	52.0	0.9	52.8	37.4	15.4	52.8	14.5
SDW1B	92.5	4.3	96.9	69.9	27.0	96.9	22.7
NEPL	41.4	0.9	42.3	10.0	32.3	42.3	31.4
CARGO	7.0	1.1	8.1	0.0	8.1	8.1	7.0
Other STIA[2]	246.5	15.1	261.8	247.8	13.8	261.8	-1.3
Total							**105.6**
Walker Creek							
SDW2	41.3	3.3	44.6	35.1	9.5	44.6	6.2
M8	22.2	6.6	28.8	22.2	6.6	28.8	0.0
M9	76.1	22.5	98.6	76.1	22.5	98.6	0.0
Total							**6.2**
Des Moines Creek							
SDE4	50.7	115.5	166.2	40.1	126.1	166.2	10.6
SDS1	0.9	16.8	17.7	1.4	16.3	17.7	-0.5
SDS2	7.7	1.5	9.2	8.1	1.0	9.2	-0.5
SDS3	165.5	178.0	343.5	144.3	199.2	343.5	21.2
SDS3A	62.7	7.1	69.8	34.6	35.1	69.8	28.0
SDS4	45.4	19.2	64.6	32.1	32.5	64.6	13.3
SDS5	32.1	0.4	32.5	28.3	4.2	32.5	3.8
SDS6	12.5	4.3	16.7	13.5	3.2	16.7	-1.1
SDS7	83.2	8.0	91.3	55.1	36.2	91.3	28.2
SASA	25.3	8.9	34.3	0.0	34.3	34.3	25.4
Other STIA[3]	136.1	57.7	194.4	136.0	57.5	193.5	-0.2
Total							**128.2**
IWS							
NCPS	6.9	28.8	35.7	4.8	30.9	35.7	2.1
NSMPS	6.6	0.0	6.6	4.7	2.0	6.6	2.0
NSPS	0.3	13.5	13.8	0.3	13.4	13.8	-0.1
Primary	24.9	233.9	258.8	13.5	289.1	302.6	55.2
SASA	51.8	6.5	58.3	0.1	58.3	58.4	51.8
Total							**111.0**
TOTAL	**1465.0**	**796.0**	**2261.9**	**1157.7**	**1147.0**	**2304.9**	**351.0**

Note: Rows may not total exactly as shown due to rounding. Source: GIS coverage.

1 Impervious area includes impervious area, lakes, and detention ponds.

2 Includes subbasins M6, MC1, MC2, MC3, MC4, MC5, MC6, MC7

3 Includes subbasins D5, D6, D11, D13

The overall goal of the SMP is to provide a design basis for all Master Plan Update improvements to meet applicable local and state stormwater regulatory requirements for stormwater management and mitigate potential stormwater runoff impacts. The King County Surface Water Design Manual (the King County Manual; King County Department of Natural Resources 1998) and Ecology's Stormwater Management Manual for the Puget Sound Basin (the Ecology Manual; Ecology 1992) provide the foundation for these requirements. Additional stormwater management standards were identified to protect Miller, Walker, and Des Moines Creeks from increased stormwater runoff. To achieve these goals, the following specific objectives have been identified:

- Design the Master Plan Update improvements in accordance with applicable stormwater regulations and the conditions of approval for the Master Plan Update Final Supplemental Environmental Impact Statement (FSEIS) (Port of Seattle 1997) and the Governor's Certification of Compliance with Applicable Air and Water Quality Standards (the Governor's Certification; Locke 1997);
- Meet Level 2 stormwater discharge criteria (as described in the King County Manual) for all airport runoff, as measured downstream of proposed detention facilities, to mitigate impacts of stormwater peak discharge and flow duration, thereby reducing potential impacts from stream erosion;
- Reduce existing stormwater impacts by identifying a pre-development target flow that uses reduced impervious area and extensive forest (retrofitting existing stormwater impacts and developed areas).

In addition to providing stormwater management for all new Master Plan Update improvements, the Port is actively working with King County and local jurisdictions to implement the recommendations of the Des Moines Creek Basin Plan (Des Moines Creek Basin Committee 1997), and is supporting a similar planning process for the Miller Creek Basin. The Port is committed to supporting the recommendations of these studies to (1) improve the management of stormwater runoff in Miller and Des Moines Creeks, (2) help implement those recommendations that are found to be feasible, and (3) explore opportunities to increase the performance of existing facilities, if the proposed enhancement does not create a safety hazard to air traffic.

1.3.1.2 Flow Control for New Master Plan Update Improvements and Retrofitting for Existing Airport Areas: Level 2

To protect instream and estuarine habitat, the Port has committed to achieving stream flows that maintain or reduce existing peak-flow magnitude and duration in Miller, Walker, and Des Moines Creeks. The Level 2 flow control standard, as defined by the King County Manual, requires matching or improving post-developed flow duration to pre-developed flow durations[2] for all flow magnitudes between 50 percent of the 2-year event and the full 50-year event.

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[2] Flow duration control refers to limiting the duration of geomorphically significant flows (i.e., those flows that initiate bedload movement) to baseline (pre-Master Plan Update) conditions.

The Level 2 analysis is more protective than stormwater control standards that have been used in the past. Previous controls allowed using an "event model," which is a hydrologic model that compares pre-development runoff with post-project runoff using a hypothetical design storm. Only peak flows were evaluated for compliance with standards. The Level 2 analysis requires that a "continuous simulation" model is used and actual precipitation runoff is modeled. Pre-development runoff is compared with post-project flows over a range of probable flows. Level 2 flow analysis evaluates flow protection and mitigation measures over a wide range of erosive storm flows, whereas Level 1 analysis and event models are only protective of certain peak flows or flooding events. Level 2 is more protective of stream morphology, habitat (such as stream substrate), and hydrologic flow patterns.

The pre-developed condition for the Level 2 standard will be based on a *target flow regime*. The target flow regime used assumes that the existing watershed land cover is 10 percent impervious (or less if the existing impervious area is less that 10 percent impervious), 15 percent pervious "grass," and 75 percent pervious "forest."[3] Basing target flow on theoretical basin development of 10 percent (Miller Creek and Des Moines Creek existing impervious areas are 25 percent and 35 percent respectively) is expected to reduce existing peak flows and be beneficial in maintaining stable stream channels.

In the Des Moines Creek Basin, the target flow regime was determined in a study by the University of Washington (King County CIP Design Team 1999). The flow regime determined for Des Moines Creek coincides with a target flow regime that would occur with an effective watershed impervious area of 10 percent. In studies of several Puget Sound streams, Booth and Jackson (1997) identified an approximately 10 percent impervious area threshold above which stream channel instability and habitat degradation occur.

The net result of flow retrofitting in the watersheds will be to reduce existing stormwater peak flows downstream of STIA in Miller and Des Moines Creeks *before flow impacts and controls for the Master Plan Updates are considered.* That is, even though the Miller Creek and Des Moines Creek watersheds have an existing impervious area of about 25 and 35 percent, respectively, the flows from areas draining the airport would be reduced to a level corresponding to approximately 10 percent impervious area[4].

1.3.1.3 Estimated Detention Storage Requirements

Proposed stormwater detention facilities for the Master Plan Update were designed based on the drainage area served by each facility, the detention standard, the detention storage volume required to meet the flow control standards, and potential for waterfowl attraction. Approximately 326.5 ac-ft of new stormwater detention storage will be needed to mitigate the impacts of increased stormwater runoff (Table 2) associated with Master Plan Update projects. The locations of new facilities are shown in Figure 2.

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[3] In areas where existing impervious 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.

[4] The HSPF model was calibrated with recorded flow data and actual basin land use prior to simulation of adding Level 2 flow control retrofits. The calibration accounts for flows attributable to each type of land use, based on existing conditions. Flows for other land use and hydrologic control conditions (such as 10 percent impervious surfaces and the Level 2 flow control retrofit) were then simulated using the HSPF model.

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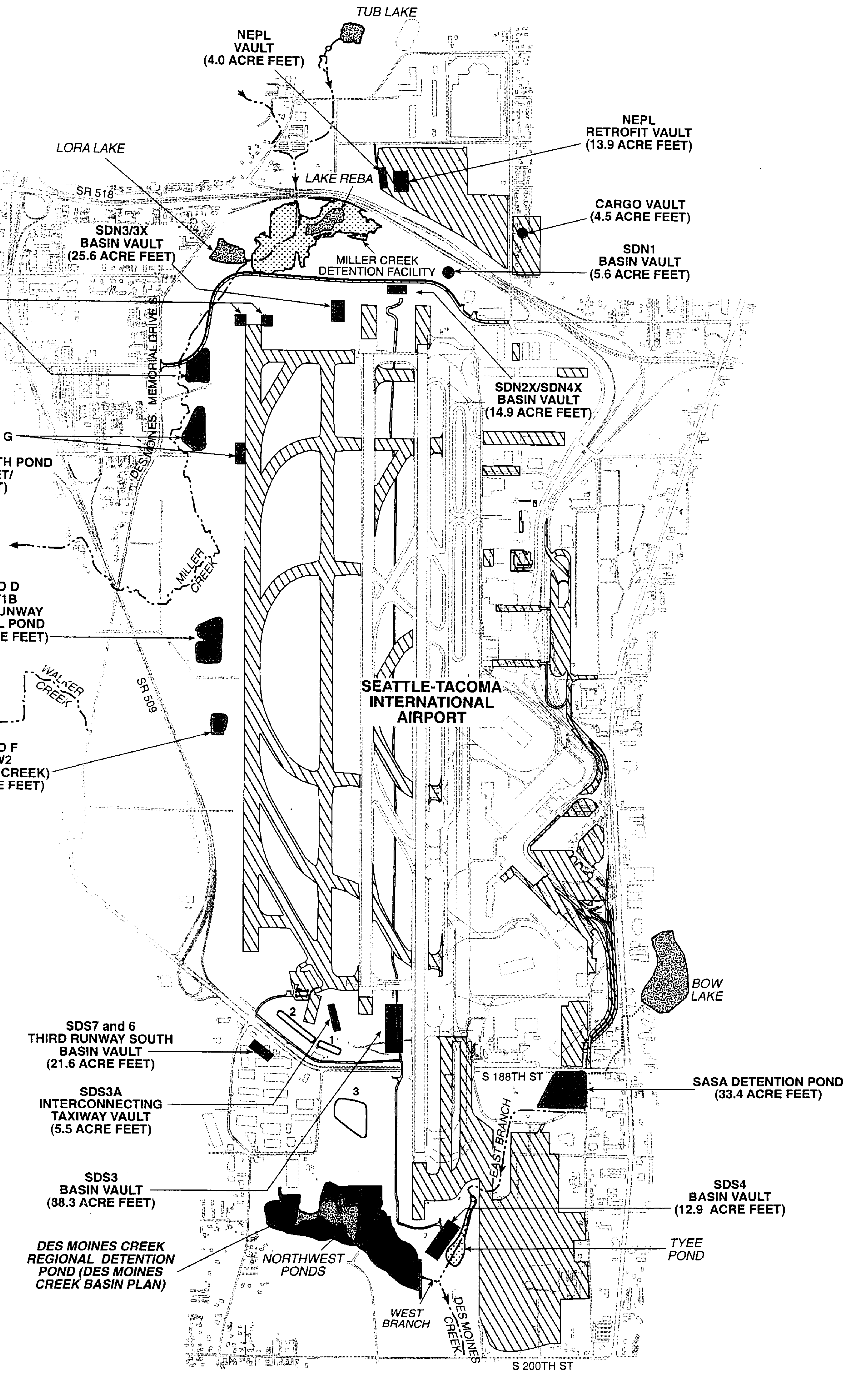

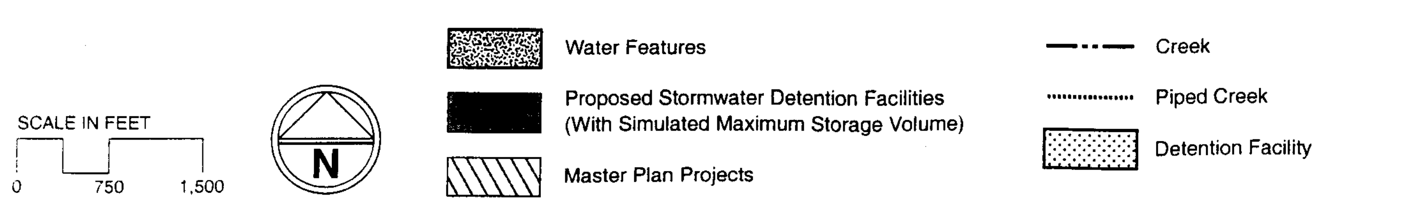

Figure 2
Detention Facilities for Master Plan Projects

Table 2. **Summary of required detention facility volumes.**

Watershed	Hydrologic Evaluation Point	Volume Required (acre-ft)	Type of Facility[a]	Comments
Miller Creek	NEPL	13.9[b]	Vault	In addition to existing 4 ac-ft
	CARGO	4.5	Vault	
	SDN2x + SDN4x	14.9	Vault	
	SDN3/3x	25.6	Vault	
	SDN1	5.6	Vault	
	SDN3A	Pond: 14.8 / Vault: 7.0	Pond/Vault	
	SDW1A	Pond: 25.5 / Vault: 7.4	Pond/Vault	Infiltration used
	SDW1B	38.3	Pond	Infiltration used
Total Miller Creek		**157.5**		
Walker Creek	**SDW2**	**7.2**	**Pond**	
Des Moines Creek	SASA Detention Facility	33.4[c]	Pond	
	Interconnecting taxiway (SDS3A)	5.5	Vault	
	Third Runway South (SDS7 and 6)	21.6	Vault	
	SDS3	88.3	Vault	
	SDS4	12.9	Vault	
Total Des Moines Creek		**161.7**		

a Types of facilities: Vault – enclosure with multiple orifice outlets on vertical riser with overflow spillway; Pond – open earth construction with netting or other means to provide wildlife deterrent.

b Volume needed to retrofit existing facility.

c Retrofit STIA area only.

Pond and Vault Construction and Operation

The feasibility of proposed stormwater ponds and vaults is demonstrated by the recent construction of similar facilities at STIA, including the NEPL Vault (1997) and the Interconnecting Taxiways Vault (1998). Only the South Aviation Support Area (SASA) detention pond will displace wetlands, a 0.06-acre shrub wetland. All other on-site detention facilities will be constructed in non-wetland areas. The primary discharge from the detention facilities is predicted to be surface discharge (not infiltration). However, infiltration is proposed at two stormwater facilities, SDW1A and SDW1B, to enhance base flows and reduce detention facility size. Detention facilities will consist of dry ponds with live storage[5] and will not include wet ponds with dead storage.

Net Result of Hydrologic Mitigation

The net result of flow controls for the Master Plan Update improvements will be to maintain or reduce peak flows in Miller, Walker, and Des Moines Creeks to a stable flow regime downstream of STIA discharges (Tables 3 and 4). Stormwater facilities will retrofit existing flows to the target watershed flow regime pre-development conditions before new development is considered. The net effect of flow controls for Miller, Walker, and Des Moines Creeks (Figures 3, 4, and 5) will be to maintain flows below existing conditions or the target watershed flow regimes following Master Plan construction and flow mitigation, whichever is less. The target flow regime will reduce flows in the stream channels, thereby reducing erosion and improving channel stability.

Low Stream Flow Impacts

Hydrologic modeling has also demonstrated a potential low stream flow impact due to the Master Plan Update (Parametrix 2000b). The HSPF model was used to analyze the potential hydrologic effects on creek low flow[6] after construction of the project in pervious areas. Results for the pre-project base condition (1994) were compared to the developed project condition (2006) in Miller, Walker, and Des Moines Creeks.

Potential low stream flow changes were evaluated using a comparison between pre-project and project stream flow conditions during the typically driest times of year (August and September). Using HSPF, average changes in stream flow were simulated as shown in Table 5 (EarthTech 2000).

If low stream flow impacts are large enough, the wetted stream area of the creeks could be reduced and adversely affect critical habitat. However, low stream flow impacts estimated for Miller, Walker, and Des Moines Creeks are insignificant and would not measurably change the wetted area of critical habitat. Critical habitat for chinook salmon does not extend upstream of the wetted area of the tidal influence, and flow changes would not affect the wetted area of critical habitat that is controlled by tidal influence.

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[5] Live storage is that volume of stormwater stored in a detention facility that drains following the storm. Live storage is used for hydrologic benefit to reduce flow peaks and durations.

[6] Base flow is defined as the contribution normally made to stream flow by groundwater in undeveloped watersheds. It is sometimes referred to as dry-weather flow.

While the HSPF modeling summarized in Table 5 indicates reduced low stream flow, elements of project hydrology have not been calculated and are beyond the capability of the HSPF model to closely evaluate. For example, stormwater from detention ponds SDW1A and SDW1B in the Miller Creek basin will be infiltrated. Infiltration will offset some low flow reduction, as water will be infiltrated in trenches near Miller Creek to slowly seep through the soil back into the stream long after the rain has stopped. Also, stormwater that infiltrates into the fill embankment (a large soil mass that will collect, store, and transmit water) and slowly leaks out has not been accounted for in the HSPF model due to limitations in the model to simulate these constructed systems. The relatively small numbers shown on Table 5 will in fact be lower due to the limitations of the HSPF model to model these positive effects.

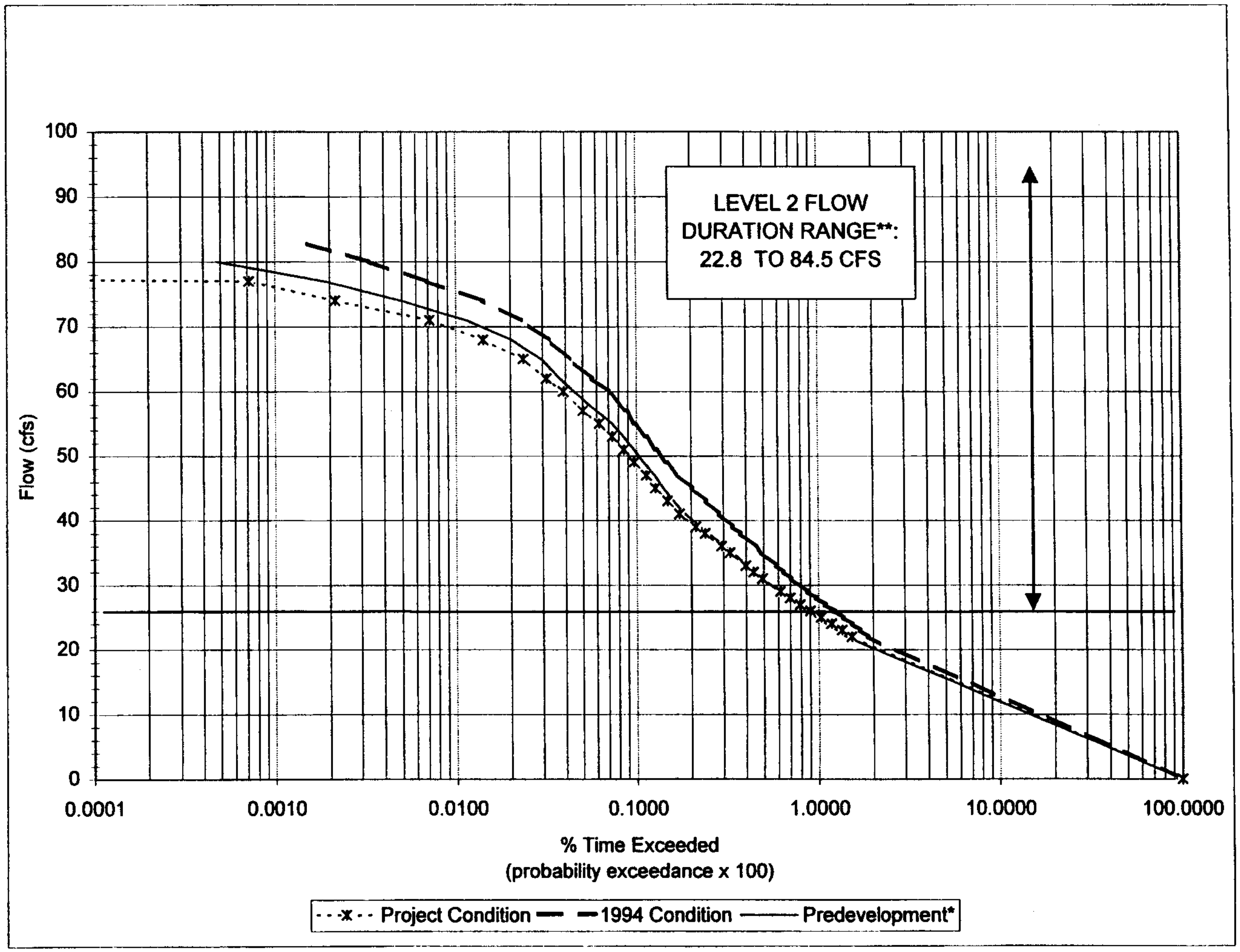
Low stream flow impacts, while small, are predicted by the HSPF model. Methods to offset low stream flow impacts are being evaluated to minimize predicted impacts. The method(s) selected will depend on the amount of flow support needed, viability of the alternative, and ability to offset impacts at critical flow periods. Reduced low stream flow will be mitigated by using one or a combination of the following:

Supplemental flow from collected and slowly released stormwater. Water will be collected in storage vaults during the wet season. The required volume will be determined using an analysis of estimated flow support and length of time the flow support would be needed during low flows. For example, if the low stream flow support needed during the one-in-five-year low flow is 0.1 cfs, and flow support is needed for 45 days or less (the longest rain-free period in the Sea-Tac rain record is less than 51 days), a storage vault of approximately 9 ac-ft would be needed. This vault is the same magnitude as other stormwater detention vaults proposed. (Note: it is likely that this mitigation measure, if required, would be implemented separately from the stormwater detention to ensure that adequate water volume is stored).

Flow augmentation from a well (Des Moines Creek basin only). An existing irrigation well in the Des Moines Creek basin can be used to offset low flow impacts. Available water is in excess of average low stream flows, so there is ample water for augmentation. A change of use in the water right will be required to implement this measure.

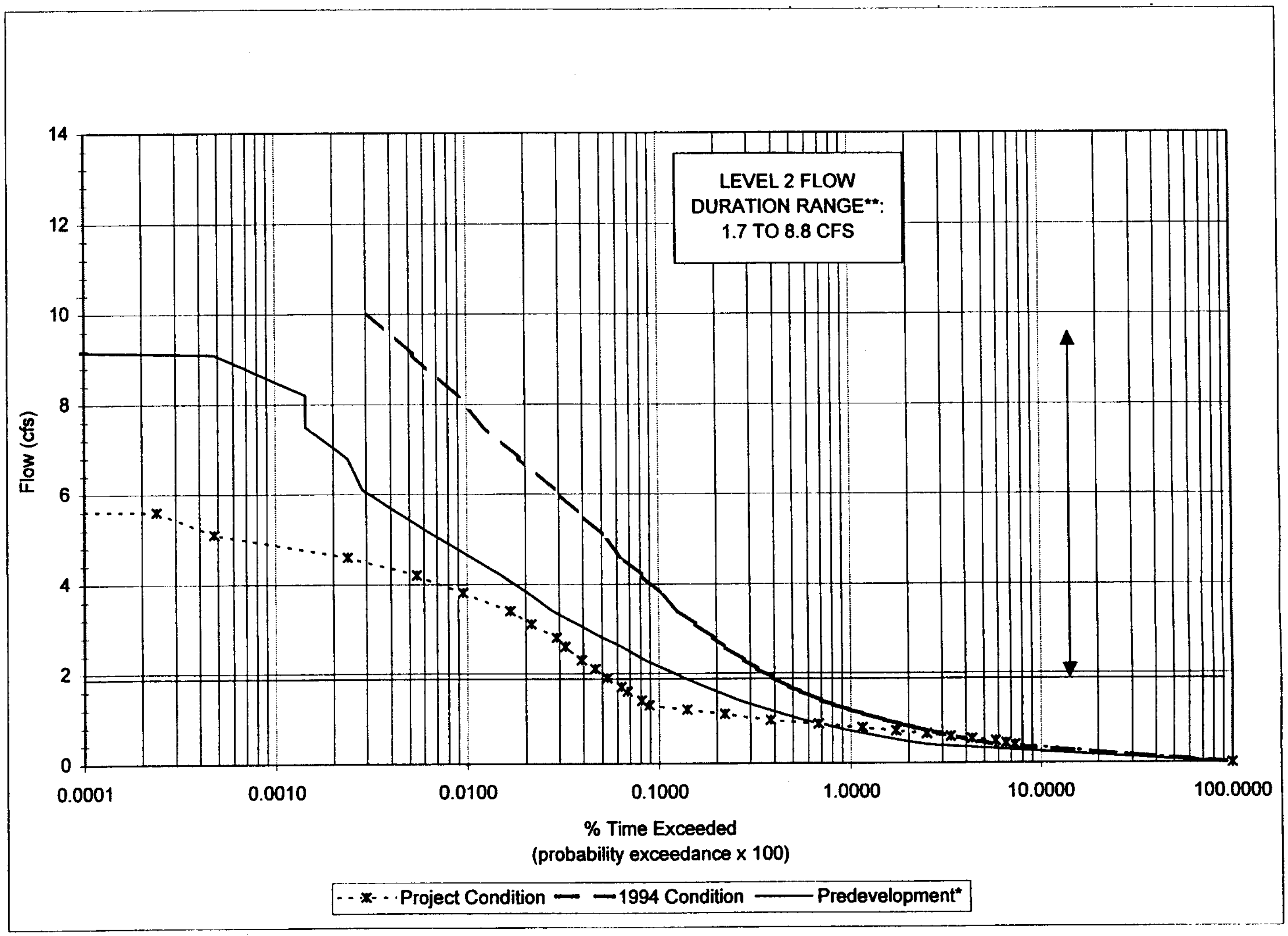
Retiring water rights and water withdrawals. Existing water uses can be retired to offset the low flow impacts.

One or more of these flow mitigation measures will be implemented to ensure that existing baseline conditions are maintained or improved. As stated above, selection of these measures will depend on the magnitude of impact to be addressed, but in any case, impacts attributed to base flow reductions should be small and will not pose any adverse effects to listed species or critical habitat.



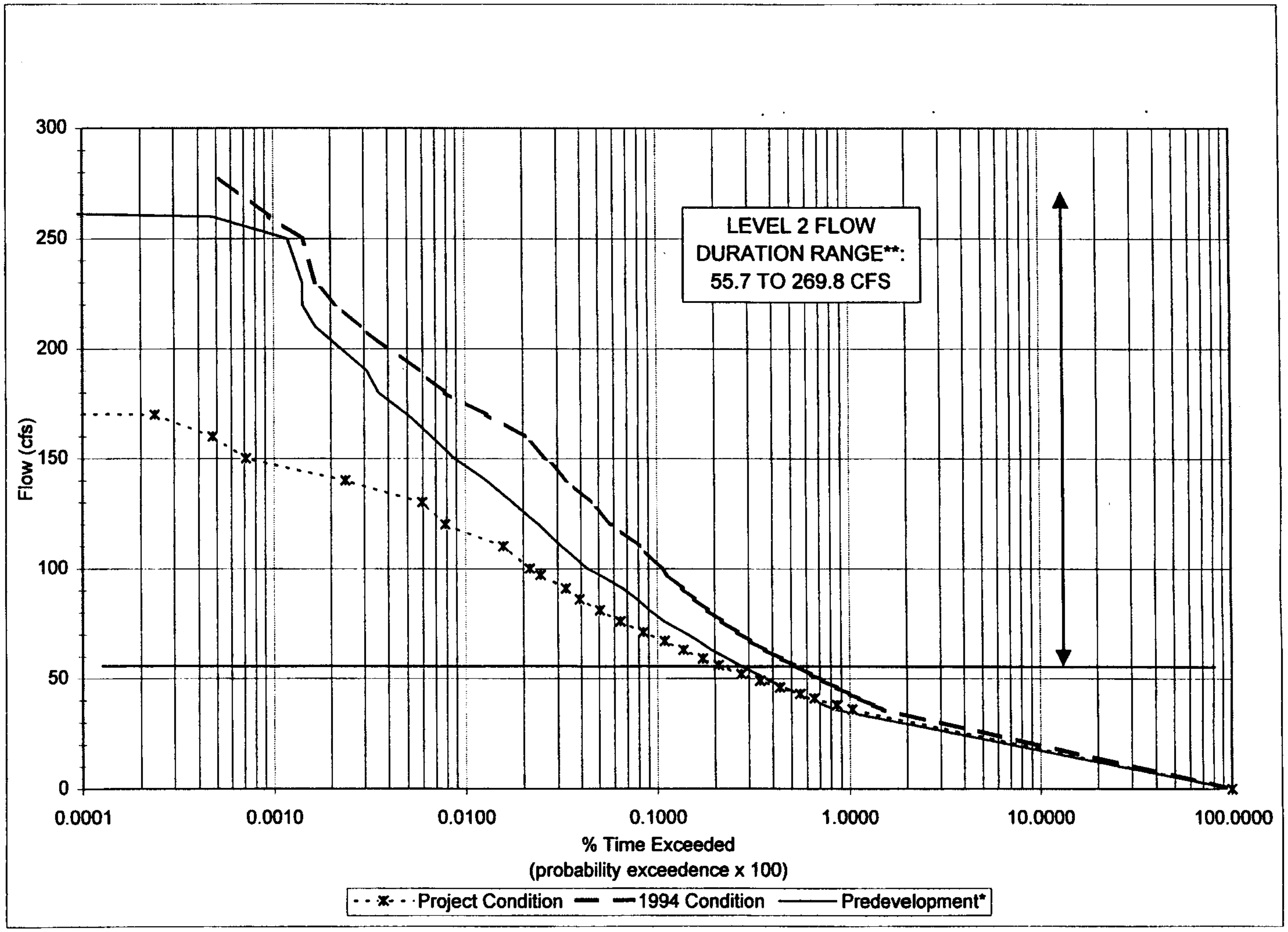
* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.
** For the target flow regime.

Figure 3
Flow Duration Curve for Miller Creek at SR509



* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.
** For the target flow regime.

Figure 4
Flow Duration Curve for
Walker Creek at South 12th Street



* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.
** For the target flow regime.

Figure 5
Flow Duration Curves for Des Moines Creek at South 200th Street

Table 3. Summary of flood peak flow frequency results for Miller/Walker Creek subbasins (all values are cubic feet per second).

Return Period Peak	NEPL		CARGO		SDW2		SDW1B		SDN3A (Vacca)	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.61	0.22	0.12	0.05	1.65	0.54	0.68	0.19	0.27	0.09
Q_2	1.22	0.44	0.24	0.09	3.30	1.07	1.35	0.39	0.53	0.18
Q_{10}	1.70	0.73	0.33	0.14	6.22	2.83	2.11	0.82	0.75	0.28
Q_{25}	1.96	0.96	0.38	0.18	7.71	4.60	2.57	1.28	0.87	0.34
Q_{50}	2.16	1.18	0.42	0.21	8.82	6.53	2.96	1.80	0.96	0.40
Q_{100}	2.37	1.46	0.46	0.25	9.92	9.21	3.39	2.54	1.05	0.45

Return Period Peak	SDWIA		SDN3, SDN3X		Combined SDN2X/SDN4/SDN4X	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.15	0.07	0.71	0.25	0.57	0.22
Q_2	0.30	0.14	1.41	0.50	1.15	0.44
Q_{10}	0.58	0.18	2.01	0.83	1.61	0.65
Q_{25}	0.79	0.19	2.33	1.06	1.86	0.78
Q_{50}	0.99	0.20	2.58	1.27	2.06	0.88
Q_{100}	1.24	0.20	2.84	1.52	2.26	0.99

Return Period Peak	Miller Creek at SR509[a]		Walker Creek at South 12th Street		SDN1	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	22.81	22.36	1.90	0.95	0.28	0.12
Q_2	45.62	44.72	3.80	1.90	0.56	0.24
Q_{10}	67.23	64.93	6.83	3.48	0.79	0.40
Q_{25}	77.29	74.11	8.51	4.57	0.91	0.54
Q_{50}	84.53	80.63	9.83	5.54	1.00	0.67
Q_{100}	91.58	86.92	11.20	6.66	1.10	0.82

[a] Does not include any retrofit of MCDF for non-airport property development.

Table 4. Summary of flood peak flow frequency results for Des Moines Creek subbasins (all values are cubic feet per second).

Return Period Peak	SASA[a]		SDS3		SDS3A	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	37.25	13.56	6.03	2.40	1.22	1.52
Q_2	74.50	27.13	12.06	4.79	2.45	3.05
Q_{10}	114.55	44.53	21.07	10.85	4.28	7.80
Q_{25}	137.75	56.20	26.92	16.51	5.47	12.09
Q_{50}	156.42	66.33	31.92	22.46	6.49	16.50
Q_{100}	176.31	77.81	37.52	30.39	7.62	22.26

Return Period Peak	SDS4		SDS - Point of Compliance	
	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.86	0.35	8.06	4.35
Q_2	1.72	0.69	16.11	8.71
Q_{10}	2.65	1.29	28.45	18.58
Q_{25}	3.21	1.80	36.55	26.66
Q_{50}	3.67	2.29	43.51	34.51
Q_{100}	4.17	2.92	51.33	44.30

Return Period Peak	SDS7		Des Moines Creek @ S. 200 St.	
	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	1.47	0.64	55.72	36.29
Q_2	2.94	1.28	111.45	72.58
Q_{10}	5.23	2.84	184.86	117.11
Q_{25}	6.73	4.45	231.02	145.08
Q_{50}	8.03	6.25	269.81	168.55
Q_{100}	9.48	8.77	312.64	194.44

[a] Based on analysis of STIA properties draining to SASA; non-STIA tributary area is not included.

Table 5. Estimated Low Stream Flow Changes.

	Average Flows (cfs)					
	1994		2006		Change	
	Aug	Sept	Aug	Sept	Aug	Sept
Miller Creek	1.27	1.50	1.21	1.45	- 0.06	- 0.05
Walker Creek	0.033	0.035	0.041	0.045	+ 0.008	+ 0.01
Des Moines Creek	1.08	1.64	1.07	1.73	- 0.01	+ 0.09

Table 6. Effects of Master Plan Update improvements for STIA on relevant indicators in Miller Creek.

Pathways: Indicators	Effects of the Action(s): Restore[1]	Maintain[1]	Degrade[1]	Explanation
Flow/Hydrology:				
Peak Flows	X			Stormwater detention, standards, elimination of impervious surfaces that lack stormwater management, restoration of wetlands, and promotion of side channels will serve to restore a more natural runoff regime. Retrofitting existing impervious areas with stormwater detention will reduce existing peak flow impacts. Using Level 2 standard will reduce the duration of erosive peak storm flows.
Drainage Network Increase		X		Incorporation of stormwater detention will keep runoff rates below existing and mitigate potential impacts of increasing drainage network. The subsurface drainage system incorporated into the embankment will maintain base flow to downslope wetlands and mitigate impacts of wetland fill.

[1] For the purposes of this checklist: "restore" means to change the function of an "at risk" indicator to "properly functioning," or to change the function of a "not properly functioning" indicator to "at risk" or "properly functioning" (i.e., it does not apply to "properly functioning" indicators); "maintain" means that the function of an indicator does not change (i.e., it applies to all indicators regardless of functional level); "degrade" means to change the function of an indicator for the worse (i.e., it applies to all indicators regardless of functional level).

Table 7. Effects of Master Plan Update improvements for STIA on relevant indicators in Des Moines Creek.

Pathways: Indicators	Effects of the Action(s): Restore[1]	Maintain[1]	Degrade[1]	Explanation
Flow/Hydrology:				
Peak Flows	X			Stormwater detention, floodplain restoration, and wetland restoration will help restore more natural runoff patterns. Hydrographic peaks will be reduced, returning precipitation to the channel over a longer period. Retrofitting existing impervious areas with stormwater detention will reduce existing peak flow impacts. Using Level 2 standard will reduce the duration of erosive peak storm flows.
Drainage Network Increase		X		New stormwater detention facilities associated with the runway and other projects will maintain the function of existing drainage network.

[1] For the purposes of this checklist: "restore" means to change the function of an "at risk" indicator to "properly functioning," or to change the function of a "not properly functioning" indicator to "at risk" or "properly functioning" (i.e., it does not apply to "properly functioning" indicators); "maintain" means that the function of an indicator does not change (i.e., it applies to all indicators regardless of functional level); "degrade" means to change the function of an indicator for the worse (i.e., it applies to all indicators regardless of functional level).

AR 049809

Table 8. Environmental baseline conditions in Des Moines Creek, near STIA.

Pathways: Indicators	Environmental Baseline: Properly Functioning	Environmental Baseline: At Risk	Environmental Baseline: Not Properly Functioning	Explanation
Flow/Hydrology:				
Peak Flows			X	Impervious surfaces are extensive and may comprise up to 35% of the watershed area. Little of this area receives adequate stormwater management. Most runoff from residences and roads in the mid and lower basin is conveyed directly back to the channel, with little or no detention. Current conditions likely result in strong hydrographic peaks immediately following precipitation.
Drainage Network Increase			X	Impervious surfaces are extensive throughout the basin and include the roads, residences, commercial development, and airport facilities. Most runoff from impervious surfaces is conveyed through ditches and pipe systems to the creek without adequate stormwater management.

Table 9. Environmental baseline conditions in Miller Creek, near STIA.

Pathways: Indicators	Environmental Baseline: Properly Functioning	Environmental Baseline: At Risk	Environmental Baseline: Not Properly Functioning	Explanation
Flow/Hydrology:				
Peak Flows			X	Negative effects of stormwater runoff in the upper basin have been moderated through regional and STIA detention ponds. Most runoff from residences and roads in the mid and lower basin is conveyed directly to the channel, with little or no detention. Current conditions result in strong hydrographic peaks immediately following precipitation. Reduced infiltration and water withdrawals reduce summer base flows.
Drainage Network Increase			X	Impervious surfaces are extensive throughout the basin including the airport, roads, residences, and commercial development. Most runoff from impervious surfaces is conveyed through an extensive network of stormwater pipes and open drainage ditches. This increase in drainage network accentuates peak runoff rates.

2. REFERENCES

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ATTACHMENTS

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MEMORANDUM

Date: **December 21, 2000**

To: **Dennis Ossenkop**
Federal Aviation Administration
Northwest Mountain Region
ANM-450T3
1601 Lind Avenue SW
Renton, Washington 98055-4056

From: **Paul Fendt**

Subject: **BA Supplement Update**

cc: **Nancy Brennan-Dubbs, US Fish and Wildlife Services**
Jim Lynch, Stoel Rives LLP
Tom Sibley, NMFS

Project Number: **556-2912-001 (1)(48)**

Project Name: **Port of Seattle Master Plan Update**

The following is a brief description of revised stormwater data in the Supplement to the Biological Assessment for Master Plan Update Improvements at Seattle-Tacoma International Airport, submitted by the FAA to USFWS and NMFS on December 14, 2000. The revisions are a result of final checking and comparing of the values reported in the supplement with the updated stormwater report results. These changes do not affect the overall effects determination contained in the supplement; rather, as a result of the revisions, our analysis indicates impacts are generally less likely than previously reported.

The revisions, as shown in the attached tables, are depicted with strikeout/replacement with updated values shown:

Table 1

Impervious area in the 1994 baseline condition Primary IWS basin omitted one subbasin of approximately 43 acres. The result of the change is that the increased impervious area is actually smaller than previously shown. There is no change in the previously reported conclusions due to this revision.

Table 2

The total volume of detention required to meet the target flows and maintain or improve baseline conditions was reduced by 0.1 acre-feet from 326.5 to 326.4. The change is insignificant and does not change the conclusions of the BA supplement.

Table 3

There were revisions to the peak flow estimates reported in the previous BA supplement due to additional checking and slight modifications to the proposed detention areas. Notably, stormwater infiltration and reconfiguration of some detention ponds changed downstream flow rates. However, all flows continue to meet the level 2 flow requirement to match or reduce target flows (which are typically lower than baseline conditions). Peak flows for the 100-year event exceed target flows by 0.03 cfs in the Walker Creek basin, which is an insignificant increase (less than 0.3 percent) and still lower than baseline conditions.

Table 5

Table 5 in the BA supplement showed only the change in average flow rates determined by the hydrologic model. The numbers shown did not account for seepage from the embankment, infiltration into the fill, and slow release of stored stormwater. The results of the new analysis are shown in the revised Table 5a, b, and c. A net increase in low stream flow is shown for all three watersheds over baseline conditions. Therefore, low stream flows in the streams will be maintained or improved, which changes the conclusion reached in the supplement submitted on December 14, 2000.

Please let me know if you have any questions or if I can provide additional information.

Table 1. **Summary of Miller, Walker, and Des Moines Creek drainage areas at STIA and change in impervious area between 1994 baseline and 2006 future conditions (acres).**

	1994 Baseline			2006 Future Condition			Increase in Impervious Area
	Pervious	Impervious[1]	Total	Pervious	Impervious[1]	Total	
Miller Creek							
SDN1	6.2	9.9	16.1	3.5	12.7	16.1	2.8
SDN1LWR	5.0	0.4	5.4	4.9	0.6	5.4	0.2
SDN1OFF	25.8	10.5	36.3	28.3	8.0	36.3	-2.5
SDN2X	7.2	0.3	7.5	5.3	2.2	7.5	1.9
SDN3	33.4	14.5	47.9	23.6	24.3	47.9	9.8
SDN3A	28.6	1.9	30.5	22.2	8.2	30.5	6.3
SDN3X	25.4	0.0	25.4	25.4	0.0	25.4	0.0
SDN4	27.7	2.6	30.3	18.1	12.3	30.3	9.7
SDN4X	14.1	1.1	15.2	11.0	4.2	15.2	3.1
SDW1A	52.0	0.9	52.8	37.4	15.4	52.8	14.5
SDW1B	92.5	4.3	96.9	69.9	27.0	96.9	22.7
NEPL	41.4	0.9	42.3	10.0	32.3	42.3	31.4
CARGO	7.0	1.1	8.1	0.0	8.1	8.1	7.0
Other STIA[2]	246.5	15.1	261.8	247.8	13.8	261.8	-1.3
Total							**105.6**
Walker Creek							
SDW2	41.3	3.3	44.6	35.1	9.5	44.6	6.2
M8	22.2	6.6	28.8	22.2	6.6	28.8	0.0
M9	76.1	22.5	98.6	76.1	22.5	98.6	0.0
Total							**6.2**
Des Moines Creek							
SDE4	50.7	115.5	166.2	40.1	126.1	166.2	10.6
SDS1	0.9	16.8	17.7	1.4	16.3	17.7	-0.5
SDS2	7.7	1.5	9.2	8.1	1.0	9.2	-0.5
SDS3	165.5	178.0	343.5	144.3	199.2	343.5	21.2
SDS3A	62.7	7.1	69.8	34.6	35.1	69.8	28.0
SDS4	45.4	19.2	64.6	32.1	32.5	64.6	13.3
SDS5	32.1	0.4	32.5	28.3	4.2	32.5	3.8
SDS6	12.5	4.3	16.7	13.5	3.2	16.7	-1.1
SDS7	83.2	8.0	91.3	55.1	36.2	91.3	28.2
SASA	25.3	8.9	34.3	0.0	34.3	34.3	25.4
Other STIA[3]	136.1	57.7	194.4	136.0	57.5	193.5	-0.2
Total							**128.2**
IWS							
NCPS	6.9	28.8	35.7	4.8	30.9	35.7	2.1
NSMPS	6.6	0.0	6.6	4.7	2.0	6.6	2.0
NSPS	0.3	13.5	13.8	0.3	13.4	13.8	-0.1
Primary	24.9	~~233.9~~277.6	~~258.8~~302.6	13.5	289.1	302.6	~~55.2~~11.5
SASA	51.8	6.5	58.3	0.1	58.3	58.4	51.8
Total							~~111.0~~67.3
TOTAL	**1465.0**	~~796.0~~839.7	~~2261.9~~2305.8	**1157.7**	**1147.0**	**2304.9**	~~351.0~~307.3

Note: Rows may not total exactly as shown due to rounding. Source: GIS coverage.

1 Impervious area includes impervious area, lakes, and detention ponds.

2 Includes subbasins M6, MC1, MC2, MC3, MC4, MC5, MC6, MC7

3 Includes subbasins D5, D6, D11, D13

Table 2. **Summary of required detention facility volumes.**

Watershed	Hydrologic Evaluation Point	Volume Required (acre-ft)	Type of Facility[a]	Comments
Miller Creek	NEPL	13.9 [b]	Vault	In addition to existing 4 ac-ft
	CARGO	4.5	Vault	
	SDN2x + SDN4x	14.9	Vault	
	SDN3/3x	25.6	Vault	
	SDN1	5.6	Vault	
	SDN3A	Pond: 14.8 / Vault: 7.0	Pond/Vault	
	SDW1A	Pond: 25.5 / Vault: 7.4	Pond/Vault	Infiltration used
	SDW1B	38.3	Pond	Infiltration used
Total Miller Creek		**157.5**		
Walker Creek	**SDW2**	**7.2**	**Pond**	
Des Moines Creek	SASA Detention Facility	33.4 [c]	Pond	
	Interconnecting taxiway (SDS3A)	5.5	Vault	
	Third Runway South (SDS7 and 6)	21.6	Vault	
	SDS3	88.3	Vault	
	SDS4	12.9	Vault	
Total Des Moines Creek		161.7		
TOTAL		326.4		

[a] Types of facilities: Vault – enclosure with multiple orifice outlets on vertical riser with overflow spillway; Pond – open earth construction with netting or other means to provide wildlife deterrent.

[b] Volume needed to retrofit existing facility.

[c] Retrofit STIA area only.

Table 3. Summary of flood peak flow frequency results for Miller/Walker Creek subbasins (all values are cubic feet per second).

Return Period Peak	NEPL		CARGO		SDW2		SDW1B		SDN3A (Vacca)	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.61	0.22	0.12	0.05	1.65	0.584	0.68	0.2019	0.27	0.09
Q_2	1.22	0.44	0.24	0.09	3.30	1.1607	1.35	0.4039	0.53	0.18
Q_{10}	1.70	0.73	0.33	0.14	6.22	2.833.14	2.11	0.7182	0.75	0.28
Q_{25}	1.96	0.96	0.38	0.18	7.71	4.605.06	2.57	1.0428	0.87	0.4434
Q_{50}	2.16	1.18	0.42	0.21	8.82	6.537.13	2.96	1.0480	0.96	0.5640
Q_{100}	2.37	1.46	0.46	0.25	9.92	9.9521	3.39	2.541.89	1.05	0.7045

Return Period Peak	SDWIA		SDN3, SDN3X		Combined SDN2X/SDN4/SDN4X	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.15	0.07006	0.71	0.25	0.57	0.2220
Q_2	0.30	0.1401	1.41	0.50	1.15	0.4439
Q_{10}	0.58	0.1805	2.01	0.83	1.61	0.6568
Q_{25}	0.79	0.1912	2.33	1.06	1.86	0.7895
Q_{50}	0.99	0.2025	2.58	1.27	2.06	0.881.22
Q_{100}	1.24	0.2052	2.84	1.52	2.26	0.991.57

Return Period Peak	Miller Creek at SR509[a]		Walker Creek at South 12th Street		SDN1	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	22.81	22.3672	1.9065	0.9558	0.28	0.12
Q_2	45.62	44.7245.44	3.8030	1.9016	0.56	0.24
Q_{10}	67.23	64.9365.61	6.8322	3.4814	0.79	0.40
Q_{25}	77.29	74.1182	8.517.71	4.575.06	0.91	0.54
Q_{50}	84.53	80.6381.38	9.838.82	5.547.13	1.00	0.67
Q_{100}	91.58	86.9287.72	11.209.92	6.669.95	1.10	0.82

[a] Does not include any retrofit of MCDF for non-airport property development.

AR 049818

Table 4. Summary of flood peak flow frequency results for Des Moines Creek subbasins (all values are cubic feet per second).

Return Period Peak	SASA[a]		SDS3		SDS3A	
	Pre-Project	Project	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	~~37.25~~31.95	13.~~56~~57	6.03	2.40	1.~~22~~23	1.52
Q_2	~~74.50~~63.90	27.13	12.06	4.79	2.45	3.05
Q_{10}	~~114.55~~97.35	44.~~53~~54	21.07	10.85	4.28	7.80
Q_{25}	~~137.75~~116.65	56.20	26.92	16.51	5.47	12.09
Q_{50}	~~156.42~~132.17	66.~~33~~34	31.92	22.46	6.49	16.50
Q_{100}	~~176.31~~148.69	77.~~81~~82	37.52	30.39	7.62	22.26

Return Period Peak	SDS4		SDS - Point of Compliance	
	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	0.86	0.35	8.06	4.35
Q_2	1.72	0.69	16.11	8.71
Q_{10}	2.65	1.29	28.45	18.58
Q_{25}	3.21	1.80	36.55	26.66
Q_{50}	3.67	2.29	43.51	34.51
Q_{100}	4.17	2.92	51.33	44.30

Return Period Peak	SDS7		Des Moines Creek @ S. 200 St.	
	Pre-Project	Project	Pre-Project	Project
1/2 Q_2	1.47	0.64	55.72	36.29
Q_2	2.94	1.28	111.45	72.58
Q_{10}	5.23	2.84	184.86	117.11
Q_{25}	6.73	4.45	231.02	145.08
Q_{50}	8.03	6.25	269.81	168.55
Q_{100}	9.48	8.77	312.64	194.44

[a] Based on analysis of STIA properties draining to SASA; non-STIA tributary area is not included.

Table 5a. Summary of Miller Creek Streamflow Effects.[a]

Period of Flow	HSPF Model Streamflow (CFS) 1994 Condition	HSPF Model Streamflow (CFS) 2006 Condition	Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[b] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[c] (cfs)	Net Change from 1994 Condition (cfs)
August	1.27	1.10	0.108	(0.04)	0.04	0.10	1.31	+0.04
September	1.50	1.40	0.065	(0.04)	0.025	0.10	1.55	+0.05
August/September	1.39	1.25	0.09	(0.04)	0.03	0.10	1.43	+0.04
7-day/2-year low flow	0.79	0.64	0.065[d]	(0.04)	0.024[d]	0.10	0.79	-0-

[a] Miller Creek at SR 509.
[b] Assumes secondary recharge from impervious areas behaves similarly to pervious area recharge.
[c] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes, secondary impervious recharge, and reserved stormwater release.
[d] Calculated as 75 percent of the average increase in discharge over August and September.

Table 5b. Summary of Walker Creek Streamflow Effects.[a]

Period of Flow	HSPF Model Streamflow (CFS) 1994 Condition	HSPF Model Streamflow (CFS) 2006 Condition	Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[b] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[c] (cfs)	Net Change from 1994 Condition (cfs)
August	0.033	0.031	0.005	=	0.005	=	0.041	+0.008
September0.035	0.035	0.039	0.003	=	0.003	=	0.045	+0.010
August/September	0.034	0.035	0.004	=	0.004	=	0.043	+0.009
7-day/2-year low flow	0.021	0.015	0.003[d]	=	0.003[d]	=	0.021	-0-

[a] Walker Creek at 12th Avenue South.
[b] Assumes secondary recharge from impervious areas behaves similarly to pervious area recharge.
[c] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes, secondary impervious recharge, and reserved stormwater release.
[d] Calculated as 75 percent of the average increase in discharge over August and September.

Table 5c. Summary of Des Moines Creek Streamflow Effects.[a]

Period of Flow	HSPF Model Streamflow (CFS) 1994 Condition	HSPF Model Streamflow (CFS) 2006 Condition	Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[b] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[c] (cfs)	Net Change from 1994 Condition (cfs)
August	1.08	1.07	=	=	=	0.08	1.15	+0.07
September	1.64	1.73	=	=	=	0.08	1.81	+0.17
August/September	1.36	1.40				0.08	1.48	+0.12
7-day/2-year low flow	0.35	0.27				0.08	0.35	-0-

[a] Des Moines Creek at South 200th Street.
[b] Assumes secondary recharge from impervious areas behaves similarly to pervious area recharge.
[c] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes, and secondary impervious recharge.

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