APPENDICES

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Appendix A: Data Sources and Compilation

Data used in the correlation between B-IBI and various land cover characteristics in Thurston County Lowland Basins came from the following sources:

Indicator	Source
Total impervious area (TIA)	2001 and 2006 NOAA C-CAP/Ecology impervious data layer
Streams that were buffered	tc_streams (Wild Fish Conservancy) and hydro_lidar. Note: including tc_streams adds over 50 miles of streams not in the LiDAR layer). Lake or marine shorelines were not included
Basin forest canopy (over 40% canopy)	2001 and 2006 NOAA C-CAP/Ecology Canopy data layers. 2006 NOAA canopy raster data layer had canopy values of 0-100 for each cell, these were reclassified as 0 (0-39) and 1 (40-100) to be consistent with earlier years of data.
Land Cover Forest Layer	2001 and 2006 NOAA C-CAP/Ecology Land Cover 10 Evergreen Forest 9 Deciduous Forest 11 Mixed Forest
Land Cover Wetland Layer	2001 and 2006 NOAA C-CAP/Ecology Land Cover 13 Palustrine Forested Wetland 14 Palustrine Scrub/Shrub Wetland 15 Palustrine Emergent Wetland 16 Estuarine Forested Wetland (Included, but none in TC) 17 Estuarine Scrub/Shrub Wetland (Included, but none in TC) 18 Estuarine Emergent Wetland
Land Cover Scrub Shrub Layer	Scrub Shrub 12 Scrub/Shrub
Basin unmodified wetlands	Thurston Regional Planning Council Wetlands Indicator data Layer – select on the special modifier fields.
Road crossings per mile of stream	Intersections of the DNR stream layer and geocdroads.

Data on Thurston County's basins included in the appendix and tables were compiled from all available sources including:

- Salmon and Steelhead Habitat Limiting Factors reports for Water Resource Inventory Areas 13 (1999), 14 (2002), 22 and 23 (2001).
- Thurston County Water Resource Monitoring Report 2007-2008 Water Year, 2008-2009 Water Year (Thurston County, 2010).
- Salmon Habitat Protection and Restoration Plan for Water Resource Inventory Area 13, Deschutes. Thurston Conservation District Lead Entity. (2005).
- Salmon Habitat Protection and Restoration Plan for Water Resource Inventory Area 14, Kennedy-Goldsborough. Mason Conservation District Lead Entity. 2004.
- Basin Plans for Indian/Moxlie Creek (1993), Percival Creek (1993), Chambers/Ward/Hewitt (1995), Woodland and Woodard Creeks (1995), Green Cove Creek (1998)
- Evaluations and descriptions of Olympia's wetland and wildlife habitats (Shapiro and Associates, 1994).
- The Washington State Water Quality Assessment 305(b) report and 303(d) list. (Ecology, 2008).

In addition, the following Geographic Information System (GIS) sources were used:

General GIS Sources

GIS Data Layer Name	Description of Data Layer	Reference for Data Layer
Basin Area	Aggregation of Ecology sub-watersheds to approximate Thurston County basin boundaries; Ecology's sub-watershed based on aggregations of the Salmon and Steelhead Habitat Inventory and Assessment Program	SSHIAP, Northwest Indian Fisheries Commission
Total impervious area	Impervious data layer, 1991, 2001, 2006	NOAA C-CAP & Ecology
Future total impervious area	Estimates of future impervious area (2030; Buildout)	TRPC
Effective impervious area	Estimates of effective impervious area	TRPC
Land cover	Landcover, 1991-2006	NOAA C-CAP & Ecology
Forest Cover	Land Cover 2006: 10 Evergreen Forest 9 Deciduous Forest 11 Mixed Forest	NOAA C-CAP & Ecology
Unmodified Wetlands	Wetland Indicators (wetland_trpc) Selected on field: MODIFIER (includes h,f,x,d)	Thurston Regional Planning Council and Thurston County
Miles of Stream	Dnr_wa_strm (excluding lakes/ponds)	DNR
Lake Acres	Hydro layer as developed by Thurston Regional Planning Council and Thurston County (hydro_lidar)	Thurston Regional Planning Council and Thurston County
Miles of Marine Shoreline	Traced by TRPC from WRIA 13 & 14 basin boundaries	TRPC
Modifications	Basin Plans	Thurston County and Cities
Areas of high ground water flooding	High ground water flooding areas as developed by Thurston County. (hgw)	Thurston County
Coniferous Forest	Land Cover for Thurston County, 2001	Thurston Regional Planning Council
Forest, scrub shrub, and wetlands	Land Cover 2006: 9 Deciduous Forest 10 Evergreen Forest 11 Mixed Forest 12 Scrub/Shrub 13 Palustrine Forested Wetland 14 Palustrine Scrub/Shrub Wetland 15 Palustrine Emergent Wetland 16 Estuarine Forested Wetland (Included, but none in TC) 17 Estuarine Scrub/Shrub Wetland (Included, but none in TC) 18 Estuarine Emergent Wetland	NOAA C-CAP & Ecology
Streams that were buffered	Hydro layer as developed by Thurston Regional Planning Council and Thurston County (hydro_lidar)	Thurston Regional Planning Council and Thurston County. For data, contact Thurston Regional Planning Council.
	Water type survey data for watersheds that drain into South Puget Sound within Thurston County, 20100204 (tc_streams)	Wild Fish Conservancy
Road crossings per mile of creek	Intersections of the DNR stream layer and geocdroads (see below)	

GIS Data Layer Name	Description of Data Layer	Reference for Data Layer
dnr_streams	Statewide stream centerline layer developed by Washington State Department of Natural Resources	WDNR
GeoCdRoads	Thurston County's ground transportation network as developed by CAPCOM, 11/15/2010	Thurston County - CAPCOM
Urban and Rural Areas	Urban growth areas	Thurston County
WRIA 13 and 14 Results	Ecology's sub-watershed units and water flow assessment results as part of the Puget Sound Watershed Characterization Study. January 7, 2011.	Ecology
Soils	Coverage of Thurston County describing the soil composition, slope, and recharge potential according to the Soil Conservation Service (A) Low runoff potential when thoroughly wet (B) Moderately low runoff potential when thoroughly wet (C) Moderately high runoff potential when thoroughly wet (D) High runoff potential when thoroughly wet	US Dept of Agriculture
Fish_Passage_Barrier_Inventory	Location, type, and fish passage barrier status of road-based stream crossing structures, dams, and miscellaneous instream structures in Washington State 20100716	Washington Department of Fish and Wildlife

GIS Sources for Water Quality

GIS Data Layer Name	Description of Data Layer	Reference for Data Layer
303d_list_County	303(d) list for Thurston County, 2008. Contains only category 5 listings from Washington State's 2008 Water Quality Assessment.	Washington Department of Ecology
305b_list	305(b) list for Thurston County, 2008. Lists all waters and all categories of listings from Washington State's 2008 Water Quality Assessment.	Washington Department of Ecology
growingareas_county	Commercial Shellfish Growing Areas and pollution closure and restriction areas.	Washington State Department of Health

GIS Sources for Aquatic Biota

GIS Data Layer Name	Description of Data Layer	Reference for Data Layer
Fishdist_sv	Anadromous and resident fish distribution, 20081001	Washington Department of Fish and Wildlife
sandlance	Sandlance spawning locations. 08/01/2008	Washington Department of Fish and Wildlife
smelt	Smelt spawning locations. 08/01/2008	Washington Department of Fish and Wildlife
Shell	Locations of shellfish. 200312.	Washington Department of Fish and Wildlife
SSG_Benthics	South Sound Green Benthic Index of Biotic Integrity (B-IBI) monitoring locations and monitoring results. 2006.	Barbara Wood, Thurston County Water Resources Department
TC_EH	Thurston County Environmental Health Benthic Index of Biotic Integrity (B-IBI) monitoring locations and monitoring results. 2009.	Barbara Wood, Thurston County Water Resources Department
TC_EH_ST	Thurston County Environmental Health Stream Team Benthic Index of Biotic Integrity (B-IBI) monitoring locations and monitoring results. 2009.	Barbara Wood, Thurston County Water Resources Department

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Appendix B: Summary of B-IBI Data

Watershed/Site	Site Location	2002	2003	2004	2005	2006	2007	2008	2009	Range	Av.
Budd/Deschutes											
Chambers Creek	End of 58th Avenue	40	44	44	42	36	42	42	38	36-44	41.0
East Bay Adam's Creek	Liengang @ Gull Harbor	n/a	n/a	28	28	38	n/a	n/a	n/a	28-38	31.3
Ellis Creek	Priest Point Park	46	48	48	44	48	46	40	46	40-48	45.8
Indian Creek	Wheeler Avenue SE	n/a	36	30	34	34	34	34	34	30-34	33.7
Mission Creek	East Bay Drive	30	24	36	18	28	n/a	n/a	n/a	18-36	27.2
Moxlie Creek	Watershed Park	n/a	28	14	28	26	28	28	40	14-40	27.4
Percival Creek	Footbridge below Evergreen Park Dr.	n/a	n/a	n/a	n/a	24	28	36	34	24-36	30.5
	Chapparal Road	n/a	28	32	28	32	n/a	n/a	n/a	28-32	30.0
	SPSCC Artist's Bridge	32	30	36	32	34	34	30	30	30-36	32.3
Black Lake Ditch	R.W. Johnson Road	n/a	16	n/a	18	20	n/a	n/a	n/a	16-20	18.0
Schneider B Creek	West Bay Drive	46	28	26	24	26	32	34	40	24-46	32.0
Henderson Inlet											
Woodard Creek	4116 Libby Road	40	40	44	46	36	40	42	36	36-46	40.5
Woodland Creek	Pleasant Glade Road	30	38	34	26	32	34	36	34	30-38	33.0
	Draham Road	42	38	34	36	30	38	40	28	30-42	35.8
Eld Inlet											
Green Cove Creek	36th Avenue NW	38	38	42	48	30	40	42	38	30-48	39.5
	4311 Cooper Point Road	n/a	46	40	38	30	40	38	36	30-46	38.3
McLane Creek	Delphi Road Bridge	40	38	38	36	38	36	46	36	34-46	38.5
	DNR Nature Trail	46	46	48	48	44	44	46	44	44-48	45.8
Perry Creek	Perry Creek Road	40	44	46	40	38	46	50	44	38-50	43.5
Totten Inlet											
Kennedy Creek	Near Highway 101	42	42	40	40	34	42	44	40	34-44	40.5
Schneider T Creek	4100 Pneumonia Gulch Lane NW	46	36	38	38	36	42	44	46	36-46	40.8

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Appendix C: Status of Fish Barriers at Road/Stream Crossings

TABLE 1: STATUS OF FISH BARRIERS AT ROAD/STREAM CROSSINGS, THURSTON COUNTY WRIA 13/14 BASINS

Fish Use	Yes					Unknown
Barriers	**Barriers Present**			**Unknown**		**Yes or Unknown**
Blockage	**Total**	**Partial**	**Unknown**	**Total**	**Partial**	
Budd/Deschutes						
Black Lake		1				
Capitol Lake	5					
Chambers		2				3
Deschutes River (Mainstem Lower)	2	5		1		1
Deschutes River (Mainstem Middle)	1	4		4	3	7
Deschutes River (Mainstem Upper)	1					1
East Bay	1	8	1	1		2
Ellis Creek	3	2	1			2
Indian Creek	4	11				
Lake Lawrence						1
McIntosh Lake	8	4		2		
Mission Creek		2				3
Moxlie Creek		6				
Offut Lake		3				
Percival Creek		4				2
Reichel Lake	2	1				
Schneider Creek (West Bay)		1				
Spurgeon Creek		2				5
West Bay	1	2		1		3
Eld Inlet						
Eld Inlet (East)	1	1				3
Eld Inlet (West)	4	3		2		1
Green Cove Creek		2				
McLane Creek	8	2		1	1	1
Perry Creek	6	4				
Henderson Inlet						
Dana Passage	2					2
Henderson Inlet (East)	1	5		1	1	3
Henderson Inlet (West)				1		
Woodard Creek	1	5				2
Woodland Creek	5	3	1		3	10
Nisqually Reach						
Nisqually Reach	2	1			3	2
Totten Inlet						
Burns/Pierre						
Kennedy Creek	14	5		2		
Schneider Creek (Totten)	2	3			1	5
Totten Inlet (East)	1					

SOURCE: GIS DATA LAYER: LOCATION, TYPE, AND FISH PASSAGE BARRIER STATUS OF ROAD-BASED STREAM CROSSING STRUCTURES IN WASHINGTON STATE, 20100716 WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

TABLE 2: STATUS OF DAMS AND FISH PASSAGE IN THURSTON COUNTY RIVERS AND STREAMS, WRIA 13/14

Fish Use	***Yes***					***Unknown***
Barriers	***Presents a Barrier***			***No Barrier***	***Unknown***	***Yes***
Blockage	***Total***	***Partial***	***Unknown***			***Total***
Budd/Deschutes						
Capitol Lake				1		
East Bay			1			1
Percival Creek						1
West Bay	2					
Henderson Inlet						
Woodard Creek	1		1			
Woodland Creek		1				
Nisqually Reach						
Nisqually Reach						1
Totten Inlet						
Kennedy Creek					1	2

SOURCE: GIS DATA LAYER: LOCATION, PURPOSE, AND FISH PASSAGE BARRIER STATUS OF DAMS IN WASHINGTON STATE, 20100716 WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

Appendix D: Fish Species in Thurston County WRIA 13/14 Stream Basins

TABLE 3: PRESENCE/ABSENCE OF FISH SPECIES BY BASIN

Basin	Coho Salmon	Fall Chinook Salmon	Fall Chum Salmon	Large-mouth Bass	Rainbow Trout	Resident Cutthroat	Winter Steelhead
Budd/Deschutes							
Black Lake				x		x	
Capitol Lake	x	x	x			x	x
Chambers	x					x	
Deschutes River (Mainstem Lower)	x	x				x	x
Deschutes River (Mainstem Middle)	x	x				x	x
Deschutes River (Mainstem Upper)	x	x				x	x
East Bay	x		x				
Ellis Creek	x		x				
Indian Creek	x	x				x	
Lake Lawrence						x	
Mission Creek	x		x				
Moxlie Creek	x	x	x			x	
Offut Lake	x					x	x
Percival Creek	x	x	x			x	
Reichel Lake	x					x	x
Schneider Creek (West Bay)	x						
Spurgeon Creek	x	x					
West Bay						x	
Eld Inlet							
Eld Inlet (East)	x		x				
Eld Inlet (West)	x		x			x	
Green Cove Creek	x		x			x	x
McLane Creek	x	x	x			x	x
Perry Creek	x		x			x	x
Henderson Inlet							
Henderson Inlet (East)	x		x			x	
Henderson Inlet (West)	x						
Woodard Creek	x		x			x	x
Woodland Creek	x	x	x	x	x	x	x
Nisqually Reach							
Nisqually Reach			x				
Totten Inlet							
Kennedy Creek	x		x			x	x
Schneider Creek (Totten)	x		x			x	x
Totten Inlet (East)						x	

SOURCE: GIS DATA LAYER: FISH DISTRIBUTION, 20081001, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE.

TABLE 4: MILES OF STREAM OCCUPIED BY FISH SPECIES BY BASIN

Basin	Coho Salmon	Fall Chinook Salmon	Fall Chum Salmon	Large-mouth Bass	Rainbow Trout	Resident Cutthroat	Winter Steelhead
Budd/Deschutes							
Black Lake				0.0		2.3	
Capitol Lake	0.1	0.1				0.1	0.1
Chambers	2.9					2.3	
Deschutes River (Mainstem Lower)	15.5	14.2				14.9	13.5
Deschutes River (Mainstem Middle)	23.4	19.5				24.7	23.1
Deschutes River (Mainstem Upper)	18.6	12.8				40.5	19.8
East Bay	1.3		0.7				
Ellis Creek	0.5		0.5				
Indian Creek	0.5	0.6				2.9	
Lake Lawrence						0.8	
Mission Creek	0.4		0.4				
Moxlie Creek	1.6	1.6	1.6			0.6	
Offut Lake	0.4					0.7	0.4
Percival Creek	5.5	5.5	3.7			3.2	
Reichel Lake	3.6					5.6	4.5
Schneider Creek (West Bay)	0.4						
Spurgeon Creek	5.3	1.1					
West Bay						0.5	
Eld Inlet							
Eld Inlet (East)	0.4		0.3				
Eld Inlet (West)	1.1		0.4			5.2	
Green Cove Creek	2.9		1.6			3.3	2.9
McLane Creek	12.9	4.3	7.3			12.1	4.3
Perry Creek	2.0		1.8			5.0	1.1
Henderson Inlet							
Henderson Inlet (East)	1.4		1.4			1.0	
Henderson Inlet (West)	1.0						
Woodard Creek	6.8		3.2			7.0	6.8
Woodland Creek	6.6	4.5	4.1	5.8	0.4	5.5	6.0
Nisqually Reach							
Nisqually Reach			0.5				
Totten Inlet							
Kennedy Creek	1.3		0.9			30.4	1.3
Schneider Creek (Totten)	6.1		5.6			10.8	5.2
Totten Inlet (East)						0.9	

SOURCE: GIS DATA LAYER: FISH DISTRIBUTION, 20081001, WASHINGTON DEPARTMENT OF FISH AND WILDLIFE.

Appendix E: List of Sources of Impervious Area for Thurston County

This study utilized land cover and impervious area data from the NOAA-C-CAP program and Sanborn available from the Washington State Department of Ecology websites. These data were chosen as they:

- Offered a time series to compare against benthic invertebrate monitoring data;
- Were generated from a consistent data source and in a consistent manner for the entire study area; and,
- Were the most recent data available for the entire study area.

Other sources of data were considered and are compared in Table 5 and Table 6.

TABLE 5: SOURCES OF IMPERVIOUS AREA ESTIMATES CONSIDERED FOR THIS STUDY

Source	Date	Source Imagery	Spatial Resolution	Spectral Resolution	Accuracy Assessment	Uses & Limitations
Olympia – Feature Extraction	2009	Air Photos		Visible	Unknown	Local data Only available for City of Olympia
NOAA – C-CAP Land Cover Impervious Data Layers (1% intervals) Canopy Layer	2006; 2001; 1996; 1991 Four seasons for each year (leaf on- leaf off) of Landsat – TM Imagery	Four seasons for each year (leaf on- leaf off) Landsat – TM Imagery	30 m Impervious area calibrated to air photos	Three infrared and three visible wavelengths	86% Impervious data layer – no accuracy assessment but calibration to orthophotos	National data set; some correction at state level Good time series for change detection Available for entire County Published documentation
Thurston County Watershed Characterization Land Cover Impervious data layer created by combining several land cover classes	September 2005 for Henderson and Totten/Eld Inlets 2009 for Budd/Deschutes	One date of SPOT Image	10 m; 20 m	Two visible wavelengths Two near infrared bands	84% Unknown	Local data Available WRIA 13 & 14 Shadowing 3% in 2005 data layers Metadata provided with data layer
Thurston Regional Planning Council Land Cover Impervious Data Layer	2000	IKONOS merged with Landsat – TM	1 m 30 m	Visible Three infrared and three visible wavelengths	94%	Local data Available for entire County Full report and documentation

TABLE 6: COMPARISON OF ESTIMATES OF TOTAL IMPERVIOUS AREA FROM VARIOUS SOURCES

Basin	TRPC 2000	NOAA C-CAP 2006	Thurston County 2005	Thurston County 2005*	Thurston County 2009
Budd/Deschutes					
Capitol Lake	32.8%	27.0%			36.9%
Chambers	19.0%	18.3%			23.9%
Deschutes River (Mainstem Lower)	15.3%	14.8%			19.0%
Deschutes River (Mainstem Middle)	3.3%	1.9%			4.0%
Deschutes River (Mainstem Upper)	0.3%	0.9%			1.4%
East Bay	4.9%	5.9%			8.4%
Ellis Creek	3.7%	7.3%			7.1%
Indian Creek	31.4%	28.3%			31.7%
Lake Lawrence	6.2%	4.8%			7.7%
McIntosh Lake	2.5%	2.1%			2.6%
Mission Creek	28.9%	24.1%			30.3%
Moxlie Creek	45.5%	39.9%			46.1%
Offut Lake	3.5%	2.9%			5.4%
Percival Creek	26.5%	24.8%			32.5%
Reichel Lake	2.1%	1.5%			2.4%
Schneider Creek (West Bay)	19.9%	21.4%			26.4%
Spurgeon Creek	2.5%	1.4%			3.6%
West Bay	19.5%	18.3%			25.3%
Deschutes Watershed Total	***9.1%***	***8.3%***			**11.2%**
Eld Inlet					
Eld Inlet (East)	5.5%	6.9%	8.5%	12.1%	
Eld Inlet (West)	4.0%	4.1%	6.2%	8.4%	
Green Cove Creek	8.1%	11.7%	12.9%	14.2%	
McLane Creek	1.2%	1.0%	1.9%	3.8%	
Perry Creek	1.8%	1.9%	2.4%	6.0%	
Squaxin Passage	11.8%	9.6%	13.6%	18.6%	
Eld Inlet Total	**3.6%**	**4.1%**	**5.4%**	**7.9%**	
Henderson Inlet					
Dana Passage	2.9%	3.8%	7.1%		
Henderson Inlet (East)	3.0%	4.5%	6.4%		
Henderson Inlet (West)	2.2%	2.6%	4.4%		
Woodard Creek	13.4%	14.2%	16.9%		
Woodland Creek	21.9%	21.4%	26.1%		
Henderson Inlet Total	**15.3%**	**15.3%**	**19.0%**		
Totten Inlet					
Burns/Pierre	4.0%	2.5%	4.3%	9.1%	
Kennedy Creek	1.4%	1.5%	2.2%	5.1%	
Schneider Creek (Totten)	2.4%	1.8%	3.3%	6.3%	
Totten Inlet (East)	3.0%	2.9%	4.7%	8.7%	
Totten Inlet Total	**1.9%**	**1.8%**	**2.9%**	**6.0%**	

* The Thurston County Totten/Eld Inlet Watershed Characterization includes the land cover class “asphalt/wetlands/shadowing” in impervious calculations listed in the report, but it excludes the “Composite Roof/Bare and Compacted Earth.” Data are shown both ways in the table above for consistency with published reports.

What is Spatial and Spectral Resolution?

Spatial resolution refers to the picture element “pixel” cell size of the data acquired by a satellite. The Landsat Enhanced Thematic Mapper (ETM) data has a resolution of 30 meters. SPOT satellite data are acquired in two resolutions: 20 meters for a far infrared band, and 10 meters for the near infrared and visible bands. IKONOS data, which were merged with Landsat TM data to develop the Thurston Regional Planning Council’s land cover data layer, have a spatial resolution of 1m. Figure 1 shows a comparison of “pixel” size overlain on a football field. Note: IRS data has not been used to develop Thurston County land cover data layers.

Spectral resolution is equally important when developing land cover and impervious area estimates. The spectral resolution refers to the wavelengths of light in which the satellite collects data. IKONOS satellite, for instance, only collects light in the visible wavelengths of light. This is adequate for a black and white “photo” type product, but it cannot be used alone to develop a land cover data layer. Although SPOT data provides more spatial detail, they have less spectral detail making some land cover classes difficult to distinguish. In comparison to Landsat TM data, SPOT does not collect data in the “blue” visible wavelength, or the “middle” infrared. In general, the greater the variety of spectral wavelengths, the greater accuracy in developing land cover data layers.

SPOT data also offer the flexibility of being collected more often. The sensor has off-nadir capabilities, meaning that it can sweep back and forth. This feature allows SPOT data to be collected in overlapping swaths. Stereoscopic (three dimensional) data sets are developed from SPOT imagery. This off-nadir capability can also lead to increased shadowing when the camera angle is severe.

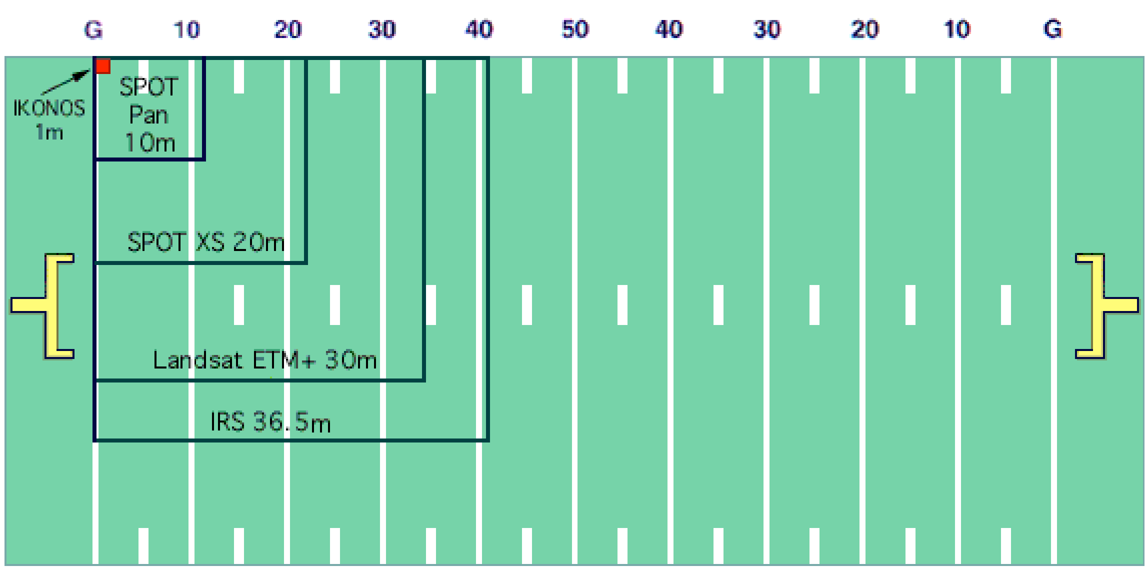

FIGURE 1: COMPARISON OF SPATIAL RESOLUTION OF SATELLITE DATA USED TO DEVELOP IMPERVIOUS AREA ESTIMATES FOR THURSTON COUNTY.
SOURCE: BLUTH, 2006.

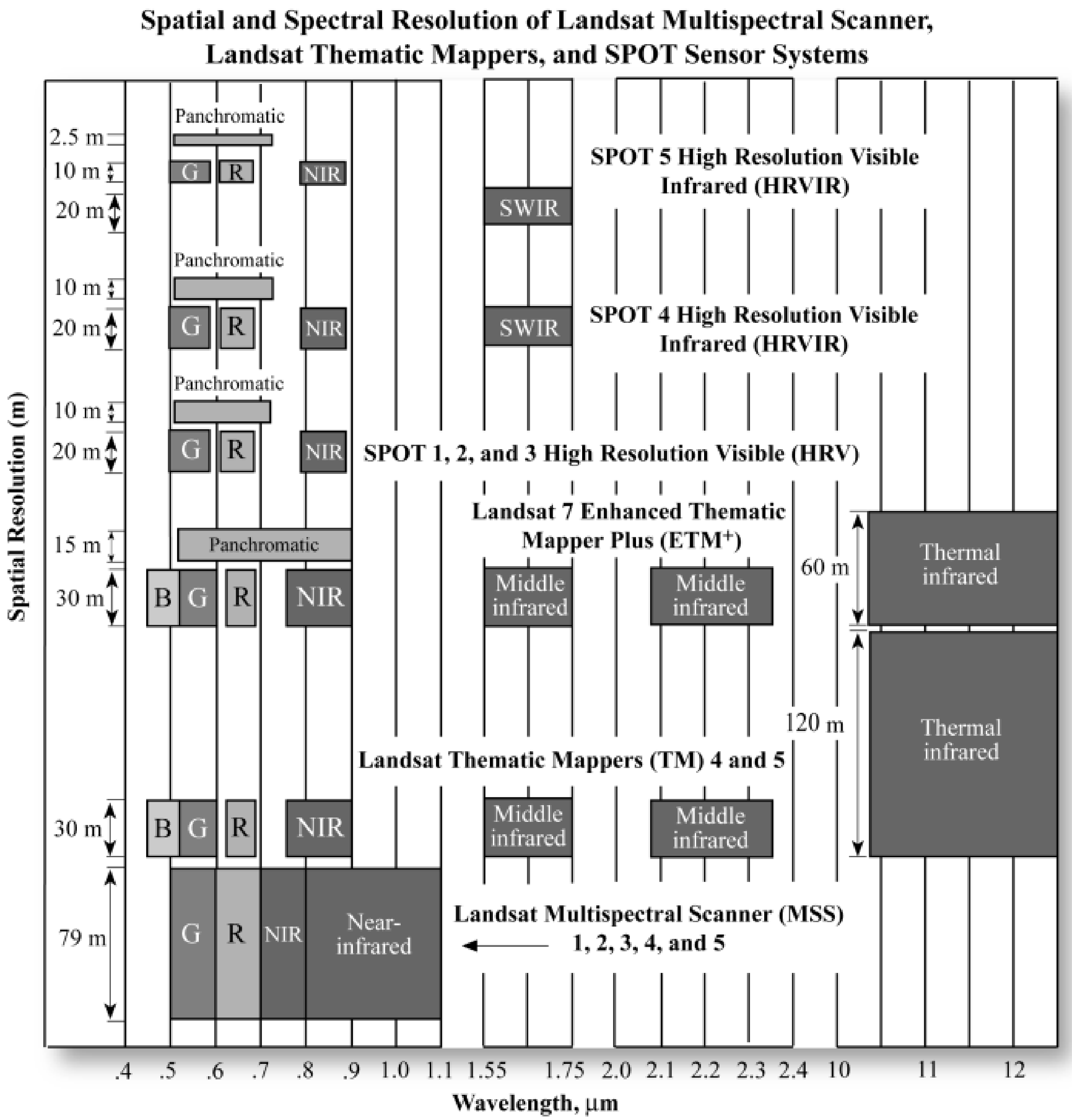

FIGURE 2: SPATIAL RESOLUTION COMPARISON – LANDSAT THEMATIC MAPPER AND SPOT
SOURCE: JENSON 2004.

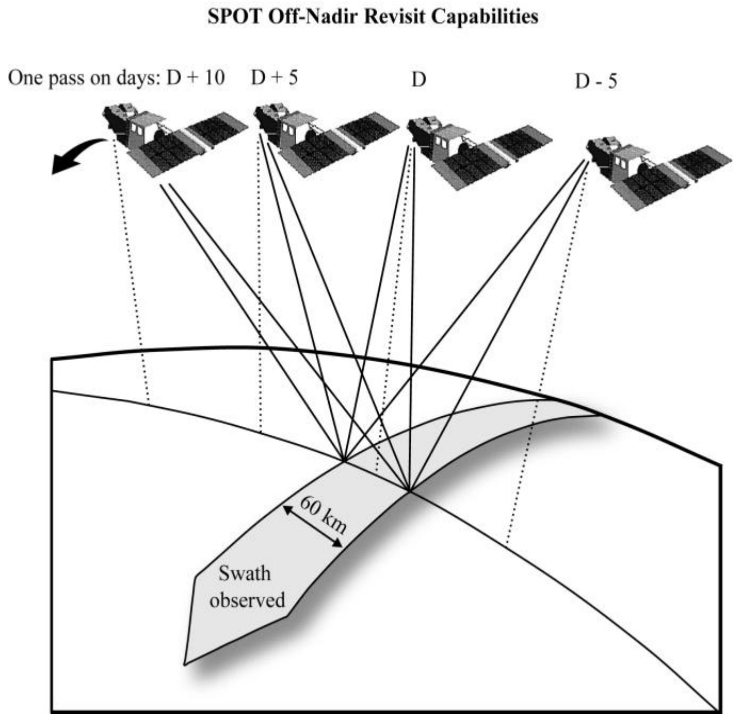

FIGURE 3: SPOT SATELLITE OFF-NADIR REVISIT CAPABILITIES.
SOURCE: JENSON, 2004.

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Appendix F: Comparison of Watershed Characterizations

Watershed characterizations are one source of information that will be used in implementing watershed-based land use planning in Thurston County. Two watershed characterizations were available for Thurston County for use in the Guiding Growth – Healthy Watersheds project. The primary purposes of the two watershed characterizations were different, although both identify sites (Thurston County) or areas (Ecology) where restoration or protection should be focused.

While Ecology's watershed characterizations have been used in other pilot studies in the Puget Sound area, this project will be the first use of Thurston County's watershed characterization results for watershed-based land use planning.

Due to differences in scale, comparability of results across the study area, and completion of peer reviews (to meet the Best Available Science requirement under the Growth Management Act), the two watershed characterizations were considered complementary and are anticipated to be used in different phases of the study.

Ecology's Watershed Characterization: Impairment results from this watershed characterization of water flow processes were used at the basin and sub-basin (sub-watershed) scales to inform basin current conditions (along with other sources of available data including existing reports, plans, and GIS data layers), and sub-basin relative importance (compared to other sub-watersheds) for protection or restoration activities.

Thurston County Watershed Characterization: Natural resource sites identified as potential restoration or protection sites are anticipated to provide information to inform a restoration scenario in hydrologic modeling in subsequent phases of the project.

Table 7 provides a detailed comparison of the two watershed characterizations, as of March of 2011.

TABLE 7: COMPARISON OF AVAILABLE WATERSHED CHARACTERIZATIONS FOR THURSTON COUNTY

	Thurston County Watershed Characterization	**Ecology Puget Sound Watershed Characterization – Water Flow Assessment**
	Overview	
Primary Purpose	Thurston County's Watershed Characterization identifies and ranks natural resource sites that could serve as restoration and enhancement sites to mitigate impacts of the built environment.	Ecology's Watershed Characterization Water Flow Assessment is a tool that allows communities to identify and prioritize areas within specific watersheds where aquatic resources should be restored or protected.
Management Strategies	Suggested at the site level by combining the landscape condition at the Drainage Analysis Unit scale (0.25 sq. miles) with site condition (i.e., Individual natural resource sites: wetlands, floodplains, or riparian sites).	Suggested at the sub-watershed level by combining levels of impairment and importance. Management Strategy Matrix developed with peer review group
Area of Study	Henderson, Eld/Totten, and Deschutes watersheds. Nisqually currently underway.	Puget Sound basin.
Site Information	Resource Site (Riparian, Floodplain, or Wetland) ranked for restoration for Drainage Analysis Units (DAUs) identified as being "At Risk"	No
	Ecological Processes	
Current Conditions Water Flow Processes	At DAU scale: • Delivery and routing of water to a stream system (surface water)	At sub-watershed scale (Impairment): • Delivery of water • Surface Water (Surface storage) • Recharge (Groundwater) • Discharge (Groundwater)
Current Conditions **Other processes**	DAU scale Other Physical Processes • Delivery & routing of Sediment to a Stream System • Delivery and routing of Nutrients, Toxicants, and Bacteria to a Stream System • Delivery & routing of Large Wood to a Stream System • Delivery and Routing of Heat to a Stream System Biological Elements • Aquatic Integrity • Upland Habitat Connectivity	No Other processes such as water quality are under development
Importance	Sites identified for importance (priority) for restoration of ecologic processes are DAUs with ecological processes or biological elements in "at risk" condition. The more "at risk", the higher the priority.	Sub-watersheds identified for importance to water flow processes
	Other Information	
Future Conditions	No	No
Peer Review	Underway	Complete for water flow processes

TABLE 7: COMPARISON OF AVAILABLE WATERSHED CHARACTERIZATIONS FOR THURSTON COUNTY

	Thurston County Watershed Characterization	**Ecology Puget Sound Watershed Characterization – Water Flow Assessment**
	Scale	
Drainage Analysis Units (DAUs) (0.25 square mile)	Yes. *"This scale was used because one of the main focuses of this study was to restore hydrologic function using natural resource sites (wetlands, riparian, and floodplains)."* TC methods report. Primary use for this scale is stormwater management and site design (Zielinski, 2002). "*The analysis of Thurston County's Watershed Characterizations takes place at the DAU scale, not at the sub-watershed scale. The data sets are developed for the DAU scale, the indicators are applicable to the DAU scale, and the results are targeted to the DAU scale." Written comment provided from TC WC team.*	No
Sub-watershed scale *The term sub-watershed is used in both studies but does not mean the same thing between studies	No. Sub-watersheds were used as a method of grouping analysis units for the report. They don't follow the hydrologic network and no analysis is conducted at this scale (see note above). *"The sub-watershed boundaries were created from an aggregation of the DAU's. The context in which these boundaries were identified is for two primary reasons: 1. Consolidation of reporting. Easier to read 12 chapters on 12 sub-watersheds than 275 chapters on 275 DAU's. 2. The sub-watershed delineation also assists in "place" recognition for the reader." Written comment provided from TC WC team.*	Yes. The analysis units are based on stream hydrology. Primary use for this scale is stream classification and management (Zielinski, 2002) Sub-watersheds range in size from 1 to 10 square miles, smaller ones near the marine shoreline and larger ones in mountainous uplands. Sub-watersheds used by Ecology are not "headwater" sub-watersheds, but rather sub-sets of basins (see below).
Basin (or "headwater" sub-watershed in table below) scale (as shown on existing Thurston County basin maps) and used in Basin Baseline Conditions Report and proposed for hydrologic modeling. Primary use for this scale is basin-level zoning and stream basin classification and management.	No	No – but sub-watersheds are consistent with the hydrologic network, and therefore can be aggregated into basin level information.
Watershed	No analysis at this level	No analysis at this level

Table 7: Comparison of Available Watershed Characterizations for Thurston County

	Thurston County Watershed Characterization	Ecology Puget Sound Watershed Characterization – Water Flow Assessment
Summary on Use in Basin Selection		
Are the results at an appropriate scale that they can be used for the basin selection process currently underway?	No. The landscape analysis (DAU scale) is not able to inform decisions at the basin scale. Note: The landscape analysis methods are currently under peer review and further changes to the methods are expected.	Yes. The primary intent of this WC is that it could be used by local governments in this way
Are the results comparable across the study area?	No. Different source data (land cover dates vary) and/or methods were used between the Henderson Inlet, Totten/Eld Inlet, and Deschutes watershed characterizations. Note: The landscape analysis methods are currently under peer review and further changes to the methods are expected.	Yes. Ecology provided the analysis to Thurston County using the WRIA 13/14 project boundaries.

Additional Notes on Scale

The watershed characterizations conducted by Thurston County and Ecology are a Geographic Information System (GIS) based approach to characterize ecosystem processes and functions.

> *"Ecosystem processes deliver, move, and transform water, sediment, wood, nutrients, pathogens, and organic matter. These processes are responsible for creating and maintaining the habitats that we see and for the functions that habitats provide."* (Stanley et al., 2009).

Ecosystem processes operate at a large variety of scales (from site, to basin, to watershed level) and time frames. Ecology and Thurston County's watershed characterization are conducted at two very different scales, as they are meant to be used for different purposes.

Thurston County's watershed characterization was originally developed as a tool for stormwater management, and developed at a catchment (called drainage analysis unit) scale. The catchments are comparable to small reaches of the stream network and do not reflect headwater basins.

Ecology's watershed characterization is conducted at what is referred to in Table 8 as a sub-watershed scale. This scale is more suited for stream management and basin-scale land use decisions. Ecology's sub-watersheds also do not reflect headwater basins; however, they are consistent with the hydrologic network and therefore can be aggregated into basin-level information.

Thurston County Basins

Thurston County Water Resource Inventory Area (WRIA) 13 and 14 headwater basins (basins defined from the headwaters to the outlet) range from small coastal catchments or mostly unnamed streams, to the lowland stream basins that drain directly into the Puget Sound or Deschutes River, to the mainstem Deschutes River.

TABLE 8: DESCRIPTION OF THE VARIOUS WATERSHED MANAGEMENT UNITS

Watershed Management Unit	Typical Area (square miles)	Influence of Impervious Cover	Sample Management Measures	Comparison to Local Naming Strategy
Catchment	0.05 to 0.5 32 to 320 acres (Zelinski, 2002)	very strong	stormwater management through Best Management Practices (BMPs) and site design	Called (Drainage Analysis Unit (DAU)) in the TC Watershed Characterization
Sub-watershed	0.5 to 30 (Zelinski, 2002)	strong	stream classification and management carried out by local government	Ecology's analysis units (called sub-watersheds) are at this scale. Puget Sound Lowland Basin (called "basins" in Thurston County's naming convention) are also within this scale range. In general Ecology's sub-watersheds are subsets of the Puget Sound lowland basins, and do not contain the headwaters to outlet area.
Watershed An area including the lands that drain larger streams, and composed of several sub-watersheds (NOAA, 2003).	30 to 100 (Zelinski, 2002) 10 to100 (NOAA, 2003)	moderate	watershed-based zoning and planning by a local or multi-local government	Deschutes Watershed
Sub-basin Area draining to a large receiving water, typically a river or estuary (NOAA, 2003)	100 to 1,000 (Zelinski, 2002; NOAA, 2003)	weak	basin planning (Local, regional, and/or State planning authorities are the typical planners conducting Basin Planning).	Guiding Growth – Healthy Watersheds: Science to Local Policy study area
Basin Area draining to a major receiving water such as a larger river, estuary, or lake (NOAA, 2003).	1,000 to 10,000 (Zelinski, 2002; NOAA, 2003)	very weak	basin planning (Typically conducted by State, Multi-State, or Federal governments as the primary planning authorities)	Puget Sound Basin

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Appendix G: Budd Inlet Landscape Assessment

The Budd Inlet Landscape Assessment used ranked quartiles for percent land development at both the site and landscape scales. The ranked quartiles translate to a matrix for identifying management strategies based upon degree of disturbance at both the site and landscape scales. For the purposes of translating the ranked quartiles into management strategies, "high disturbance" equals both high and highest development quartiles. The results of the ranked development quartiles for each catchment and its neighbors are included in Table 10.

The Budd Inlet Landscape Assessment included a "catchment of interest" approach to prioritization and restoration in Budd Inlet. The "catchment of interest" approach was used in this report and the results are shown in Table 1. "Catchments of interest" are defined as catchments that are in the bottom 25 percent for development (least development) (respective of nearshore or upland catchments), or catchments (respective of nearshore or upland catchments) that had neighboring catchment development scores (neighborhood score) in the 25 percent least developed quartile. Catchments of interest fall either into the least-developed 25 percent of catchments (site level) or are surrounded by a landscape of catchments that on average fall into the least developed 25 percent (landscape level). These "catchments of interest" are considered the least impaired areas of the landscape.

The amount of "development" was defined by impervious surface area types (taken from the NOAA-C-CAP land cover data (2006)). The impervious land cover types used to determine "development" included High Intensity Development, Medium Intensity Development, Low Intensity Development, and Open Space Developed.

The "neighborhood score" evaluates ecosystem conditions at the landscape scale. The "neighborhood score" was determined by summing the total land development scores for catchments sharing a common border with a given catchment of interest and then averaging by the number of neighboring catchments. All neighboring catchments are included, regardless of whether they are an upland catchment or nearshore catchment. The neighborhood score indicates the average total land development at the landscape scale relative to the given catchment unit of interest (site scale).

TABLE 9: RESTORATION STRATEGIES BASED ON DEGREE OF DISTURBANCE AT THE SITE SCALE
FROM: DIEFENDERFER ET AL. 2007 TABLE 11; ADAPTED FROM THOM AND OTHERS 2005A.

		Landscape Scale		
	Disturbance	**Low**	**Medium**	**High**
Site Scale	**High**	Restore Enhance	Enhance Restore	Create Enhance
	Medium	Restore Enhance Conserve Preserve	Enhance Restore Conserve	Enhance Create
	Low	Conserve Preserve	Conserve Enhance Restore Preserve	Enhance Conserve

TABLE 10: RESULTS OF THE BUDD INLET LANDSCAPE ASSESSMENT USING THE CATCHMENT OF INTEREST APPROACH

Ellis Creek	
Nearshore catchment: 4262 ***Catchment of Interest**	Site scale: medium disturbance Landscape scale: low disturbance
Nearshore catchment: 5002 ***Catchment of Interest**	Site scale: low disturbance Landscape scale: low disturbance
Upland catchment: 5905 ***Catchment of Interest**	Site scale: high disturbance Landscape scale: low disturbance
Upland catchment: 4257	Site scale: medium disturbance Landscape scale: medium disturbance
Upland catchment: 5085	Site scale: medium disturbance Landscape scale: high disturbance
Upland catchment:4724	Site scale: high disturbance Landscape scale: medium disturbance
Upland catchment:5473	Site scale: high disturbance Landscape scale: high disturbance
Moxlie Creek	
Nearshore catchment: 4211	Site scale: high disturbance Landscape scale: high disturbance
Mission Creek	
Upland catchment: 5842 ***Catchment of interest**	Site scale: low disturbance Landscape scale: high disturbance
Nearshore catchments: 4605 and 4857 and Upland catchments: 5574 and 5804	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 4812	Site scale: medium disturbance Landscape scale: medium disturbance

TABLE 10: RESULTS OF THE BUDD INLET LANDSCAPE ASSESSMENT, CONTINUED.

Percival Creek	
Upland catchment: 5394	Site scale: high disturbance Landscape scale: high disturbance
Capitol Lake	
Capitol Lake 1:	
Nearshore catchments: 4419, 4726, 4739, 5050, 5124, 5164	Site scale: high disturbance Landscape scale: high disturbance
Moxlie Creek	
Moxlie 1:	
Nearshore catchments: 4345, 4659	Site scale: high disturbance Landscape scale: high disturbance
East Bay	
East Bay 1:	
Nearshore catchment: 4784 ***Catchment of Interest**	Site scale: low disturbance Landscape scale: low disturbance
Nearshore catchment: 5502 ***Catchment of Interest**	Site scale: low disturbance Landscape scale: medium disturbance
Nearshore catchment: 5177	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5335	Site scale: medium disturbance Landscape scale: high disturbance
Nearshore catchment: 5601	Site scale: high disturbance Landscape scale: medium disturbance
Upland catchment: 5191	Site scale: high disturbance Landscape scale: high disturbance
Upland catchment: 5421	Site scale: medium disturbance Landscape scale: high disturbance
East Bay 2:	
Nearshore catchments: 4405, 4438, 4564, 5122, 5293, and 5447 **and** Upland catchments: 4276, 5437 ***All catchments of interest**	Site scale: low disturbance Landscape scale: low disturbance

TABLE 10: RESULTS OF THE BUDD INLET LANDSCAPE ASSESSMENT, CONTINUED.

East Bay, continued	
East Bay 3:	
Nearshore catchment: 4420 and 5351 and upland catchment: 5093 ***Catchments of Interest**	Site scale: low disturbance Landscape scale: medium disturbance
Nearshore catchments: 4708 and 4721 and upland catchment: 5686 ***Catchments of Interest**	Site scale: medium disturbance Landscape scale: low disturbance
Nearshore catchment: 5619 and upland catchment: 5809 ***Catchments of Interest**	Site scale: low disturbance Landscape scale: low disturbance
Upland catchment: 5837 ***Catchment of Interest**	Site scale: high disturbance Landscape scale: low disturbance
Nearshore catchment: 4953 and upland catchment: 5100	Site scale: high disturbance Landscape scale: medium disturbance
Nearshore catchment: 4969	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5108, 5123, 5495, 5599	Site scale: medium disturbance Landscape scale: medium disturbance
East Bay 4:	
Nearshore catchment: 4420 and 5351 ***Catchments of Interest**	Site scale: low disturbance Landscape scale: medium disturbance
Nearshore catchments: 4708 and 4721 ***Catchments of Interest**	Site scale: medium disturbance Landscape scale: low disturbance
Nearshore catchment: 5619 ***Catchment of Interest**	Site scale: low disturbance Landscape scale: low disturbance
Nearshore catchment: 4953 and upland catchment: 4282	Site scale: high disturbance Landscape scale: medium disturbance
Nearshore catchment: 4969	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5108, 5123, 5495, 5599	Site scale: medium disturbance Landscape scale: medium disturbance
Schneider Creek (Budd Inlet)	
Nearshore catchment: 5302 ***Catchment of interest**	Site scale: high disturbance Landscape scale: low disturbance
Nearshore catchment: 4188, 4893, and 4917 and upland catchments 5506, 5510, 5635	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5291	Site scale: medium disturbance Landscape scale: high disturbance

TABLE 10: RESULTS OF THE BUDD INLET LANDSCAPE ASSESSMENT, CONTINUED.

West Bay

West Bay 1:

Nearshore catchments: 4879, 5415 ***Catchments of interest**	Site scale: medium disturbance Landscape scale: low disturbance
Nearshore catchments: 5623, 5761 and upland catchment: 5131 ***Catchments of interest**	Site scale: low disturbance Landscape scale: low disturbance
Nearshore catchments: 5832 ***Catchments of interest**	Site scale: low disturbance Landscape scale: high disturbance
Nearshore catchments: 5877 ***Catchments of interest**	Site scale: low disturbance Landscape scale: medium disturbance
Nearshore catchments: 4400, 4828, 5304, and 5559	Site scale: medium disturbance Landscape scale: medium disturbance
Nearshore catchments: 4874, 5091, and 5800 and upland catchment 4876	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5678	Site scale: high disturbance Landscape scale: medium disturbance

West Bay 2:

Nearshore catchment: 4303 and upland catchments: 5141 and 5564 ***Catchments of interest**	Site scale: low disturbance Landscape scale: medium disturbance
Upland catchment: 4992	Site scale: medium disturbance Landscape scale: high disturbance
Upland catchment: 4255	Site scale: high disturbance Landscape scale: high disturbance

West Bay 3:

Nearshore catchments: 4619, 4717, 4740, and 5118 and upland catchment: 5440	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchment: 5134	Site scale: medium disturbance Landscape scale: high disturbance

Dana Passage

Dana Passage 2:

Nearshore catchments: 5032 ***Catchment of interest**	Site scale: medium disturbance Landscape scale: low disturbance
Nearshore catchments: 4310, 4939, and 5448	Site scale: medium disturbance Landscape scale: high disturbance
Nearshore catchment: 5205	Site scale: high disturbance Landscape scale: high disturbance
Nearshore catchments: 5538, 5890	Site scale: medium disturbance Landscape scale: medium disturbance

TABLE 10: RESULTS OF THE BUDD INLET LANDSCAPE ASSESSMENT, CONTINUED.

Woodard Creek	
Upland catchment: 5328 ***Catchment of interest**	Site scale: low disturbance Landscape scale: low disturbance
Eld Inlet East	
Eld Inlet 14:	
Upland catchment: 4877 ***Catchment of interest**	Site scale: low disturbance Landscape scale: low disturbance
Upland catchment: 5568 ***Catchment of interest**	Site scale: low disturbance Landscape scale: medium disturbance
Upland catchment: 5900 ***Catchment of interest**	Site scale: low disturbance Landscape scale: high disturbance
Upland catchment: 5543 ***Catchment of interest**	Site scale: high disturbance Landscape scale: low disturbance
Upland catchment: 5713 ***Catchment of interest**	Site scale: medium disturbance Landscape scale: low disturbance
Upland catchment: 4815, 5248, 5693	Site scale: high disturbance Landscape scale: high disturbance
Green Cove Creek	
Upland catchment: 5325	Site scale: high disturbance Landscape scale: medium disturbance

Appendix H: Summary of Data on Thurston County Basins

Budd Inlet/Deschutes River Watershed

- Black Lake
- Capitol Lake
- Chambers/Ward/Hewitt
- Deschutes River (mainstem)
- East Bay
- Ellis Creek
- Indian/Moxlie
- Lake Lawrence
- McIntosh Lake
- Mission Creek
- Offut Lake
- Percival Creek
- Reichel Lake
- Schneider
- Spurgeon Creek
- Tempo Lake
- West Bay

Eld Inlet Watershed

- Green Cove Creek
- Eld Inlet (East)
- Eld Inlet (West)
- McLane Creek
- Perry Creek
- Squaxin Passage

Nisqually River Watershed (but in WRIA 13)

- Nisqually Reach

Henderson Inlet Watershed

- Dana Passage
- Henderson
- Woodard
- Woodland

Totten Inlet Watershed

- Burns/Pierre
- Kennedy Creek
- Schneider Creek
- Summit Lake
- Totten Inlet

A. *Budd Inlet/Deschutes River Watershed Basins*

A large percentage of the lake shore is moderate density residential. There are two large mobile home parks on the east shoreline and two RV commercial resorts on the west side of the lake. The south and north ends are dominated by extensive wetland systems (Thurston County, 2010).

1. Black Lake

Black Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 4,390 acres; urban growth area 53%; rural 47% • Total Impervious Area Estimate 1991: 5.1% 2006: 8.0% 2030: 12.4% Buildout: 13.7%	• Effective Impervious Area: 2006: 5.9% • Forest Cover 44.1% • Unmodified Wetlands: 20.6% • Extensive wetlands at south and north ends • Miles of Stream: 9.2 • Lakes: Black Lake, 565.6 ac • Areas of high ground water flooding: 1.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 9.6% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 88.4% 250 ft: 79.9 1000 ft: 57.1% • # of road crossings per mile of creek: 1.9	• Amount of fine sediments: no data • Black Lake Ditch lowered lake level so Black River salmon cannot access Black Lake except during high flows • South wetland filling from pipeline and lower water level from Black Lake Ditch • Beaver activity in lake outlet results in high lake levels and flooding.	• Monitoring results: fair water quality • Moderate to high nutrient concentrations result in nuisance blue-green algae growth. • 303(d): Total Phosphorus and PCB • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Chehalis coastal resident cutthroat, largemouth bass

a) Basin Conditions

Hydrology

The hydrology of the Black River was severely altered after the Black Lake Ditch was excavated at the north end of Black Lake in 1922, 1952, and 1976. Originally, Black Lake drained into Black River, but the Black Lake ditch was developed at the other end of the lake to help control flooding of private property along Black Lake. However, as the ditch down-cut, it became the primary outlet for Black Lake. Since then, the wetlands near the upper Black River have slowly filled in, resulting in greatly decreased flows into Black River except during flooding (J. Roach, Association of Black Lake Enhancement; Hawkins 2000). Thurston County Environmental Health Division currently identifies Black Lake as part of the Puget Sound drainage (Thurston County Environmental Health Department 2000).The Chehalis River Basin Action Plan indicates that Black Lake drains to Black Lake Ditch and then to Percival Creek, except during flooding (LCCD 1993). However, it acknowledges that Black River has a hydrologic connection to Black Lake via ground water (Smith and Wenger, 2001).

These hydrologic flow problems were further exacerbated in 1965, when a gas pipeline excavation left spoils along the sides of the pipeline trench, and subsequently, beaver dam debris and vegetative dams have developed in the area. This resulted in a reversal of the wetland drainage, such that the upper 1.5 miles of Black River flows north into Black Lake (Smith and Wenger, 2001).

(1) In-Stream and Wetland Habitat Conditions

Physical

One notable barrier in this area is the lost access to Black Lake. Black River Chinook salmon, coho and chum salmon historically spawned in tributaries to Black Lake and used the lake and upper Black River for rearing. However in 1922, the Black River Ditch was excavated at the north end of the lake to help control flooding. Since then, the ditch has downcut, draining increasing amounts of water. This results in less flow to the Black River. In the 1960s, a gas pipeline was constructed across the Black River. The decreased flows, wetland filling, and pipeline crossing with accumulated beaver debris have all combined to block access to the upper Black River (upstream of the confluence of Dempsey Creek) and Black Lake, except during high flows (J. Roach, Association of Black Lake Enhancement, personal communication; Hawkins 2000). It has also resulted in reversing the water flow of the upper Black River into Black Lake, which then flows via the ditch to Puget Sound. Salmon that currently spawn in tributaries to Black Lake are stray Chinook salmon from a salmon net pen operation in Budd Inlet and coho hatchery strays (J Roach, Black Lake resident, personal communication). There is no screen installed at the lake outlet to Black River Ditch, which allows Puget Sound salmon to access Black Lake and potentially intermingle with Chehalis origin salmonids. The access problems in the upper Black River result in a "poor" access rating (Smith and Wenger, 2001).

Water Quality

Fair - The lake has moderate-to-high nutrient concentrations which often result in nuisance blue-green algae growth in late summer and fall. The algae blooms result in pea-green water color and thick scums on the water which often interfere with recreational uses (Thurston County, 2010).

Issues - Blue-green algae blooms that occur during late summer and fall interfere with the recreational uses of the lake. Lake residents and users should avoid recreation activities and keep children and pets out of the lake during these severe algae blooms. Swimmer’s itch is reported to be a regular summer problem in this lake, so preventative measures should always be taken by bathers. Beaver activity in the lake outlet ditch can cause the lake level to rise resulting in flooding of yards and docks. Thurston County Public Works is responsible for maintaining the ditch (Thurston County, 2010).
Black Lake is listed on Washington State’s Clean Water Act Section 303(d) list of impaired water bodies for total phosphorus and PCB’s. Black Lake is listed on Ecology’s Cat 4C list for impairment by a non-pollutant for invasive exotic species.

(2) Aquatic Biota

Benthic Macroinvertebrates

Benthic macroinvertebrates are not monitored in this basin.

Fish

Chehalis coastal resident cutthroat, largemouth bass.

(3) Action Recommendations

None noted.

2. Capitol Lake

Primary land use in the Capitol Lake basin is suburban and rural residential (Thurston County, 2010).

Capitol Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 1217 acres; urban growth area 100% • Total Impervious Area Estimate 1991: 24.6% 2006: 27.0% 2030: 28.0% Buildout: 14.4%	• Effective Impervious Area: 2006: 22.6% • Forest Cover 28.6% • Unmodified Wetlands: 1.9% • Miles of Stream: 0.6 • Miles of Marine Shoreline: 0.28 • Lakes: Capitol Lake, 257.2 ac • Areas of high ground water flooding: 1.8% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 4.8% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 34.6% 250 ft: 17.3% 1000 ft: 37.9% • # of road crossings per mile of creek: 17.6 • Only 39% riparian area considered high quality	• Capitol Lake dam forces juvenile salmon to immediate transition from fresh to salt water • Sediment accumulation a problem • Capitol Lake fish ladder barrier when water levels not maintained • Original estuary lost to lake	• Monitoring results: fair to poor water quality • High levels of total phosphorus and fecal coliform • Excessive sediment deposition in lake • Capitol Lake impaired by non-pollutants (Ecology Cat 4C): non-native exotic species: Eurasian water milfoil and the New Zealand mudsnail • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Coho, chum, Chinook salmon, coastal resident cutthroat, winter steelhead

a) Basin Conditions

Hydrology

In 1951, Capitol Lake was created from the southern part of Budd Inlet. Since then, there have been a number of fills along the historic shoreline that has reduced the water surface by 124 acres. Today the lake surface is approximately 260 acres in size. The Deschutes River provides the majority of freshwater flow into the lake. Percival Creek provides about 10% of the freshwater flow discharging into Percival Cove (TCDLE, 2005).

b) Riparian Corridor

The construction of Deschutes Parkway, the creation of the Capitol Lake dam, and the creation of the various shoreline parks have significantly reduced the percent of properly functioning conditions, so that only 39 percent of the shoreline can be considered to be high quality (TCDLE, 2005).

c) In-Stream and Wetland Habitat Conditions

Physical

Tumwater Falls and a natural falls on Percival Creek limited the upstream migration until the installation of fish ladders in 1954. Since 1974, WDFW has been raising yearling Chinook salmon in Percival Cove, a practice they are planning to abandon when an alternative facility has been constructed (TCDLE, 2005).

Capitol Lake dam has a five-foot wide fish ladder. With recent restoration of the fish ladder and lake elevation maintained at its summer level of 6.5' NGVD, fish would have year round access to the lake. However, during the winter the lake has been lowered by a foot, which is too low for the fish ladder to function properly. Delays in reaching the lake during the winter months may lead to increased predation in Budd Inlet. The lake has also been drained in advance of a flood event from the Deschutes River. This has led to the premature release of smolts or "zeros" being raised in the lake and yearlings from the Percival Cove net pen (TCDLE, 2005).

The Capitol Lake dam also prevents the natural mixing of fresh and saltwater that occurs in the estuary, so out-migrating smolts and yearlings are forced to immediately transition to salt water on the other side of the dam (TCDLE, 2005).

Sediment accumulation is a significant problem in the lake and has reduced its volume by 25 percent since 1951. This has resulted in many parts of the lake now being too shallow for boating, and an increase in water temperatures during the summer (TCDLE, 2005).

Water Quality

"Poor water quality has been a long-term problem which is now being addressed by a TMDL study by the Washington State Department of Ecology. A recent study indicated that there are no less than 81 stormwater outfalls to Capitol Lake and the Deschutes River downstream of the "E" Stream bridge. TMDL monitoring is on-going to determine which need to be addressed" (TCDLE, 2005).

d) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Coho, chum, Chinook salmon, coastal resident cutthroat, winter steelhead

e) Action Recommendations

"Since 1997, the Washington State Department of General Administration (GA) has headed an effort to adaptively manage the lake, with the assistance of nine government entities representing the state, an Indian Tribe, and local government. Called the Capitol Lake Adaptive Management Plan (CLAMP) – Steering Committee, this advisory body helped GA adopt a 10-Year

Management Plan for the lake. The Plan contains 14 Management Objectives that addresses a wide range of issues including sedimentation, fish ladder operation, flooding, fisheries management, improving shoreline habitat, and improving water quality. One of the management objectives is to undertake a feasibility study of the costs and benefits of returning the basin to an estuary. This estuary feasibility study is to be complete with a recommendation for the long-term aquatic condition of the basin by the end of the 10-Year Plan (2013)" (TCDLE, 2005).

"The WRIA 13 Habitat Limiting Factors noted the loss of estuary habitat to the Deschutes River and Percival Cove, both of which are now a part of Capitol Lake. The restoration of Capitol Lake to a tidally influenced estuary would improve dissolved oxygen levels in Budd Inlet (as noted above), add 260 acres of intertidal habitat, add 6.5 miles of marine shoreline (7.5% increase within WRIA 13), and may increase estuarine marsh habitat" (TCDLE, 2005).

<u>(TCDLE, 2005) recommendations</u>

- "Restore estuarine conditions. Undertake an estuary feasibility study to determine the benefits and cost of restoring Capitol Lake to a tidally influenced estuary. This is one of the Management Objectives contained in the CLAMP 10-Year Management Plan.

- Restore riparian conditions. Replant riparian vegetation (predominantly conifers) and understory along those parts of the lake with less than high quality shoreline habitat. One of the Management Objectives in the CLAMP 10-Year Management Plan is to prepare a landscaping plan of where LWD, aquatic vegetation, and riparian vegetation (particularly conifers) may be planted.

- Ensure Year Round Fish Passage. While GA manages the water body as a lake, it shall maintain the elevation of Capitol Lake at 6.5' NVGD to provide for a fully functional fish ladder year round and increase upland flood protection measures so that winter pre-flood drawdowns that result in premature releases of smolts and yearlings are not needed.

- Remove the WDFW net pens from Percival Cove. This would eliminate a significant source of phosphorous into the lake. WDFW and the Squaxin Island Tribe are cooperating in the construction of a new fish rearing facility for the Deschutes River stocks. Once the new facility is available, the net pens will be removed and sediments of the cove will be remediated, if necessary. This is one of the Management Objectives contained in the CLAMP 10-Year Management Plan.
- Eradicate exotic plant species. While GA manages the water body as a lake, it shall implement actions to control Eurasian milfoil and purple loosestrife. This is one of the Management Objectives contained in the CLAMP 10-Year Management Plan" (TCDLE, 2005).

3. Chambers

The Chambers basin is located on a plateau ranging in elevation from 110’ to 320’ above sea level, between the Deschutes River to the west and the Nisqually River to the east. Level prairies cover much of the Chambers basin, but the northeast corner of the basin contains hills and potholes. Slopes generally range from 0 to 3 percent, with few slopes except around the potholes (Thurston County, 1995a).

The basin is composed of 8,323 acres that drain to Chambers, Little Chambers, Smith Lake, Chambers Ditch, and Chambers Creek. Chambers/Little Chambers Lake complex is the largest waterbody in the basin. It does not have a feeder system, but Little Chambers Lake does form the headwaters for Chambers Ditch. Smith Lake is a 12-acre, groundwater-fed lake (Thurston County, 1995a). *Note: In the Thurston County traditional basins, Ward and Hewitt Lakes are considered part of the Chambers basin. However, for this report, to maintain consistency with Ecology’s sub-watershed boundaries, Ward Lake is included in the Indian/Moxlie Creek basin, and Hewitt Lake is included in the Lower Deschutes Basin. Both Ward and Hewitt Lakes are kettle lakes and have no surface stream input or output, so placing them in a different basin for this report does not impact stream flow in these basins.

Chambers Ditch is a seasonal stream that was ditched for most of its length early in the century. Chambers Ditch flows from Chambers Lake south to its juncture with Chambers Creek and the South Tributary upstream of Rich Road. Chambers Creek is a natural stream with year-round flow through most of its length. Chambers Creek flows into the Deschutes River. The South Tributary is a network of natural channels, artificial ditches, and poorly defined wetlands, which flows intermittently and remains dry most of the year (Thurston County, 1995a).

Chambers Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 8,480 acres; urban growth area 55%; rural 45% • Total Impervious Area Estimate 1991: 10.2% 2006: 18.3% 2030: 22.2% Buildout: 23.1%	• Effective Impervious Area: 2006: 14.7% • Forest Cover 32.3% • Unmodified Wetlands: 15.6% • Miles of Stream: 1.8 • Lakes: Chambers, 128.0 ac; Southwick, 36.0 ac; Sunwood, 26.0 ac; Smith, 19.6 • Areas of high ground water flooding: 3.3% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 12.8% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 0.0% 250 ft: 0.0% 1000 ft: 91.1% • # of road crossings per mile of creek: 2.3 • Inadequate riparian vegetation	• Inadequate spawning gravel • Low summer flows • Some wetlands filled	Chambers Creek: • Monitoring results: good water quality • The creek meets water quality standards. • Nitrate concentrations are very high: contaminated groundwater • Most of the basin is in the urban growth area, and continued development can be expected to increasingly effect stream quality. • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	• B-IBI average 2002-2009: 41 • B-IBI Range 2002-2009: 36-44 • Coho, Coastal resident cuttroat

a) Basin Conditions

Level of Urbanization

The Chambers basin lies just east of the Deschutes River, and takes in portions of east Olympia, western Lacey, and unincorporated Thurston County. Olympia and Lacey share jurisdiction over Chambers Lake and Lacey has jurisdiction over Little Chambers Lake (Thurston County, 1995a).

Chambers basin has experienced considerable urban growth as Olympia, Lacey, and the Thurston County Urban Growth Area have developed (Thurston County, 1995a). Primary land use is suburban and rural residential (Thurston County, 2010).

Some wetlands in the basin have been filled for development. Construction of Chambers Ditch reduced the extent and affected the quality of wetlands in this area. The changes to the natural wetlands have altered the hydrology of the basin (Thurston County, 1995a).

Hydrology

The lakes have no feeder streams. The only surface water feeders to the lakes are stormwater systems from surrounding developments in Olympia and Lacey. Chambers Lake flows into Little Chambers Lake via a 500’ long channel. Little Chambers Lake is the headwaters of Chambers Ditch. Chambers Ditch meets the South Tributary when it flows into Chambers Creek (Thurston County, 1995a).

b) Riparian Corridor

Inadequate riparian vegetation (Haring and Konovsky, 1999).

c) In-Stream and Wetland Habitat Conditions

Physical

Chambers Creek has inadequate spawning gravel and low summer flows (Haring and Konovsky, 1999).

Chambers Creek offers three types of coho habitat. The segment near the mouth contains a few spawning sites. The lower section provides year-round rearing habitat from the springs below Rich Road to the mouth. The portion from the springs below Rich Road up to a point below Yelm Highway provides winter habitat as long as the creek is flowing. The area near the mouth of Chambers Creek is the best remaining habitat for anadromous fish in the basin with relatively clean gravel, large trees, and a well-developed understory near the creek that provides shading. Upstream from the mouth, the habitat quality declines. The riparian cover gives way to open fields south of the creek below Rich Road (Thurston County, 1995a).

The lower quarter mile of the South Tributary upstream of Rich Road contains viable seasonal habitat for migrating fish, with fair overhanging cover and in-stream woody debris. However, upstream, it has been channelized through agricultural lands, and disappears frequently in the wetlands. There is poor substrate and very little large organic debris in the channel (Thurston County, 1995a).

Chambers Ditch dries up between Rich Road and Little Chambers Lake for most of the year. The ditch provides some rearing habitat when it is flowing, but not enough pools, riparian vegetation, or cover to offer good habitat (Thurston County, 1995a).

Water Quality

Chambers Creek - Good – The creek meets water quality standards. However, nitrate concentrations are very high (Thurston County, 2010).

Issues - Chambers Creek - The creek has high nitrate concentrations due to contamination of the groundwater. Most of the basin is within the urban growth area. Continued development can be expected to have an increasing effect on stream quality.

Chambers Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform (Ecology, 2008).

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

There were no salmon or sea-run cutthroat trout in Chambers Creek or the Deschutes River before the fish ladder was developed at Deschutes Falls, but there were trout throughout the area. Now Chambers Creek and Chambers Ditch contain coho and coastal resident cutthroat. Historically, cutthroat trout, bass, perch, catfish, crappie and spiny ray inhabited Chambers and Little Chambers Lakes. In recent years, cutthroat have mostly disappeared. Triploid grass carp were introduced to Chambers Lake in 1990 in an effort to control weed growth. Chambers Lake is blocked to anadromous fish passage by screens meant to keep in the grass carp.

e) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Restore functional riparian buffers,
- Look for solutions to low flow concerns
- Identify and correct fecal coliform sources.

4. Deschutes River (mainstem)

The Deschutes River is the largest drainage in WRIA 13, providing over 256 linear miles of drainage before emptying into Budd Inlet through Capitol Lake. Primarily one commercial timber company owns the upper watershed of the river and its tributaries (TCDLE, 2005). Hewitt Lake is included within the lower Deschutes basin in this study to maintain consistency with the Ecology sub-watershed boundaries. Hewitt Lake is a small pothole kettle lake of 32 acres with no surface inflow or outflow.

Primary land use in the upper watershed is forested, and the mid-watershed is a mix of rural residential, agriculture, and forestry. The lower watershed primarily contains urban land uses, which includes portions of the cities of Tumwater, Olympia and Lacey (Thurston County, 2010). Hewitt Lake is contained entirely within Thurston County jurisdiction (Thurston County, 1995a).

Deschutes River (Mainstem)

Current Aquatic Habitat Conditions

Level of Urbanization	Basin and Riparian Conditions		In-Stream and Wetland Habitat Conditions		Aquatic Biota
	Hydrology	Riparian Corridor	Physical Conditions	Water Quality	
Lower • Basin area 11,220 acres; urban growth area 53%; rural 47% • Total Impervious Area Estimate 1991: 10.6% 2006: 14.8% 2030: 18.2% Buildout: 19.7% Middle • Basin area 23,180 acres; urban growth area 5%; rural 95% • Total Impervious Area Estimate 1991: 1.0% 2006: 1.9% 2030: 2.7% Buildout: 3.2% Upper • Basin area 42,110 acres; 100% rural • Total Impervious Area Estimate 1991: 0.2% 2006: 0.9% 2030: 0.9% Buildout: 0.9%	Lower • Effective Impervious Area: 2006: 12.0% • Forest Cover 41.8% • Unmodified Wetlands: 6.9% • Miles of Stream: 27.7 • Lakes: Barnes, 34.8 ac; Munn, 32.9 ac; Tempo, 32.0 ac; Hewitt, 29.1 ac; Trail's End, 12.4 ac; Lake Susan, 10.9 ac; Sheehan, 4.8 ac • Areas of high ground water flooding: 2.0% of basin Middle • Effective Impervious Area: 2006: 1.3% • Forest Cover 52.9% • Unmodified Wetlands: 4.5% • Miles of Stream: 100.3 • Areas of high ground water flooding: • 4.1% of basin Upper • Effective Impervious Area: 2006: 0.5% • Forest Cover 71.2% • Unmodified Wetlands: 1.9% • Miles of Stream: 599.9 • Areas of high ground water flooding: • 1.8% of basin	Lower • Coniferous forest cover in 250 stream riparian corridor: 2006: 20.5% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 63.6% 250 ft: 54.6% 1000 ft: 34.8% • # of road crossings per mile of creek: 1.1 Middle • Coniferous forest cover in 250 stream riparian corridor: 2006: 29.5% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 65.7% 250 ft: 61.3% 1000 ft: 44.7% • # of road crossings per mile of creek: 1.0 Upper • Coniferous forest cover in 250 stream riparian corridor: 2006: 36.7% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 24.2% 250 ft: 18.0% 1000 ft: 20.7% • # of road crossings per mile of creek: 1.1 • Riparian buffer significantly impaired	• High levels of fine sediment • Inadequate instream flow • Lack of off-channel habitat • Insufficient LWD • Pool habitat limiting • Significantly impaired riparian condition and functions • Elevated summer water temperature in the river • Bank stability limiting • Altered estuary conditions	• Monitoring results: good water quality • Fecal coliform standard met for 2007-2009. • Turbidity sometimes high in winter • Summer temperature violations occur. • Low in-stream flow and habitat deficiencies are concern for fisheries resources • 303(d): Dissolved Oxygen, temperature, fecal coliform, fine sediment • TMDL drafted in 2008 for 1998 listing 303(d) listing for temperature, pH, fecal coliform, in-stream flow, fine sediments, and large woody debris deficiencies.	• Coastal resident cuttroat, coho, fall Chinook salmon, winter steelhead.

a) Basin Conditions

Level of Urbanization

Urbanization has heavily impacted the lower reaches of the river (TCDLE, 2005).

b) Riparian Corridor

The Deschutes mainstem has significantly impaired riparian condition and functions. Riparian vegetation has been altered over time, typically associated with the adjacent land use. Riparian buffer disturbance and removal has occurred in all land use categories, urban and suburban, agriculture, and forest management (Haring and Konovsky, 1999).

Ayer (Elwanger) Creek has poor riparian condition (Haring and Konovsky, 1999).

c) In-Stream and Wetland Habitat Conditions

Physical

Deschutes Mainstem:

- Inadequate instream flow;
- Lack of off-channel habitat;
- Insufficient LWD;
- High levels of fine sediment;
- Elevated summer water temperature in the river; and,
- Altered estuary conditions.

(Haring and Konovsky, 1999).

Human efforts to limit erosion upstream from the falls has inhibited channel migration, thereby limiting off-channel areas for rearing in the lower reaches at the mouth. In the middle and upper reaches however, wetlands and off-channel areas exist in several locations. Much of the middle and upper reaches of the basin are rated as having fair to poor riparian conditions. A riparian assessment, currently underway by the Thurston Conservation District, will identify specific locations of degraded riparian areas so revegetation efforts can be implemented where needed (TCDLE, 2005).

Managed forestlands in the upper watershed and tributaries introduce fine sediment to the system; several significant forest road failures in recent years during abnormally high precipitation events accentuated this problem (TCDLE, 2005).

Capitol Lake was created as a reservoir at the mouth through damming the lower Budd Inlet estuary in the 1950’s (TCDLE, 2005). Historically, anadromy in the Deschutes River extended only to the base of Tumwater Falls. Chinook, as well as other anadromous salmon and steelhead, were introduced into the Deschutes River in the late 1950s. The Deschutes Hatchery is located at Tumwater Falls (Haring and Konovsky,1999). A Chinook hatchery program includes adult capture, along with rearing pens above a fish ladder at the natural falls in Tumwater and in Percival Cove in Capitol Lake (TCDLE, 2005).

There is good spawning habitat on the mainstem Deschutes between the mouth of Spurgeon Creek and Offut Lake outlet that warrants special consideration for protection (Haring and Konovsky,1999).

Ayer (Elwanger) Creek: agricultural impacts, high levels of fine sediment (Haring and Konovsky,1999).

Mitchell Creek: low LWD, high mass wasting, high in-stream bank erosion (Haring and Konovsky,1999).

Johnson Creek: Bank erosion, lack of LWD, and presence of fines in the gravel (Haring and Konovsky,1999).

Fish passage at the Capitol Lake tide gate is limited. Deschutes Falls, a natural waterfall at RM 41, blocks anadromous fish passage (Haring and Konovsky,1999).

Water Quality

Good - Fecal coliform standard was met for water years 2007/08 and 2008/09. Turbidity is occasionally high in winter. Summer temperature violations occur. Low in-stream flow and habitat deficiencies are concern for fisheries resources.

Issues - Parts of the Deschutes River are listed on the Washington State Department of Ecology's 1998 Section 303(d) list of impaired and threatened water bodies for violating temperature, pH, and fecal coliform water quality standards, as well as in-stream flow, fine sediments and large woody debris deficiencies. In response to those listings the Washington Department of Ecology began a total maximum daily load study (TMDL) in 2003 to identify pollution sources and develop a plan to correct them. A draft TMDL technical study report was published in October 2008. An advisory committee began meeting in early 2009 to develop the water clean-up plan. The purpose of the water clean-up plan is to identify the actions needed to bring the water bodies within the Deschutes Watershed into compliance with the state water quality standards.

The Deschutes River is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: Dissolved Oxygen, temperature, fecal coliform, and fine sediment. The Deschutes River is listed on Washington State's Clean Water Act Section Cat4C, list of water bodies impaired by a non-pollutant for: instream flow in two sections, and lack of large woody debris in two sections (Ecology, 2008).

Capital Lake has water quality effects (elevated temperature and phosphorous-induced algal blooms leading to reduced DO) (Haring and Konovsky,1999).

Ayer (Elwanger) Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: Fecal coliform, pH, and Dissolved Oxygen (Ecology, 2008).

Lake Lawrence Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: Dissolved Oxygen (Ecology, 2008).

Spurgeon Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: Fecal coliform (Ecology, 2008).

Unnamed Creek (tributary to Deschutes River) is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: Temperature (Ecology, 2008).

Munn Lake is listed on Washington State's Clean Water Act Section Cat4C, list of water bodies impaired by a non-pollutant for: Invasive exotic species (Ecology, 2008).

d) **Aquatic Biota**

Benthic Macroinvertebrates

The Deschutes River at Pioneer Park had a B-IBI score in 2008 of 36 (moderate biological integrity). The B-IBI score in 2009 was 30 (moderate biological integrity).

Fish

The Deschutes River supports resident and sea-run cutthroat trout, coho, fall Chinook salmon, and winter steelhead.

e) **Action Recommendations**

Deschutes mainstem:

<u>(Haring and Konovsky, 1999)</u>

- Fix the Capitol Lake tide gate to ensure fish passage at all lake and tidal levels;
- Conduct a Watershed Analysis in the upper watershed with particular focus on slope stability, road impacts (density and sedimentation), and culverts;
- Further characterize and resolve fine sediment and water quality problems in the lower river;
- Restore mature coniferous riparian zones (site potential tree height) throughout the watershed, including full protection of the channel meander zone;
- Support bank protection efforts that restore channel and riparian function, and avoid expenditure of funds to try to stop natural channel erosion of glacial terraces;
- Develop and implement a strategy to place LWD, particularly key-piece sized pieces and/or log jams, through the interim period until restored riparian zones are capable of natural contribution of LWD;
- Field verify off-channel habitat maps and protect/enhance high priority areas, and,
- Search for solutions to instream flow concerns.

<u>(TCDLE, 2005)</u>

- Complete and implement Deschutes TMDL action plan to correct the impaired temperature and sediment parameters;
- Protect channel migration zone from incompatible land uses through Thurston County Critical Areas Ordinances regulations;
- Protect and restore off-channel habitat priority sites identified in previous studies (Thurston Conservation District);
- Restore properly functioning estuary (see Capitol Lake section);

- Preserve headwaters from development pressures by evaluating the need for additional or more protective land use ordinances or through conservation easement and fee simple purchases;
- Educate landowners located in the Deschutes River Basin to increase compliance with land use regulations and voluntary implementation of best management practices.

(Haring and Konovsky, 1999)

Ayer (Elwanger) Creek:
- Restore functional riparian habitat;
- Identify and correct sources of fecal coliform;
- Address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids.

Silver Springs Creek:
- Identify the extent of high-quality spring-fed off-channel habitat and available options to ensure long term protection.

Fall Creek:
- Restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion.

Mitchell Creek:
- Restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion; and
- Develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Johnson Creek:
- Restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion; and,
- Develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

5. East Bay

East Bay					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 2,510 acres; urban growth area 2%; rural 98% • Total Impervious Area Estimate 1991: 3.6% 2006: 5.9% 2030: 6.7% Buildout: 7.0%	• Effective Impervious Area: 2006: 4.1% • Forest Cover 62.1% • Unmodified Wetlands: 11.8% • Miles of Stream: 3.9 • Miles of Marine Shoreline: 8.0 • Areas of high ground water flooding: 1.5% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 11.5% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 56.7% 250 ft: 54.2% 1000 ft: 48.2% • # of road crossings per mile of creek: 1.5	• Fish passage is limiting factor	Adams Creek (Eastbay 3): • 303(d): Fecal Coliform and pH • Part of Budd-Deschutes TMDL	Adams Creek: • B-IBI average 2000-2009: 31 • B-IBI range 2000-2009: 28-38 • Chum and coho • Forage fish in marine shoreline • Shellfish habitat south of Boston Harbor

a) In-Stream and Wetland Habitat Conditions

Physical

Fish passage is limiting factor.

Water Quality

Budd Inlet is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: polychlorinated biphenyls (PCB's) contamination in fish, Chrysene, Benzo(b)fluorene, Benzo(a)anthracene, dissolved oxygen, fecal coliform.

Adams Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for: fecal coliform and pH.

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Chum, and coho. The marine shoreline supports forage fish.

Shellfish

Shellfish habitat south of Boston Harbor.

c) Action Recommendations

None noted.

6. Ellis Creek

The primary land use in Ellis Creek basin is rural residential and suburban residential, (Thurston County, 2010). Ellis Creek has three headwater tributaries. The southernmost tributary has headwaters at Setchfield Lake. The lower reach (0.4 mi) used by salmonids is largely within Priest Point Park. Nearly all the natural processes in this rural stream are intact. The low impervious area and few road crossings have maintained the stream's natural hydrology and biotic integrity (as measured by macroinvertebrate diversity). The intact riparian corridor in the lower reaches provides ample shade, though LWD recruitment is unknown. While the estuary is functional, a partial barrier culvert at the mouth constricts the stream and impedes adult and juvenile fish passage. Juvenile fish passage is restricted in the upper tributaries by four additional culverts (TCDLE, 2005). Ellis Creek basin does not contain any shoreline jurisdiction.

The mouth of Ellis Creek is within Priest Point Park, a facility owned by the City of Olympia. The remainder of the creek is in rural residential ownership (TCDLE, 2005).

Ellis Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 940 acres; urban growth area 31%; rural 69% • Total Impervious Area Estimate 1991: 4.5% 2006: 7.3% 2030: 8.3% Buildout: 8.5%	• Effective Impervious Area: 2006: 5.0% • Forest Cover 65.3% • Unmodified Wetlands: 16.4% • Miles of Stream: 3.5 • Miles of Marine Shoreline: 0.2 • Lakes: Setchfield, 6.0 ac • Areas of high ground water flooding: 1.8% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 8.2% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 67.4% 250 ft: 63.3% 1000 ft: 50.5% • # of road crossings per mile of creek: 2.3 • Primarily intact riparian corridor	• Lower reach used by salmonids within Priest Point Park • Stream bed changing from gravel to sand. • Fish passage is limiting. • Functional estuary	• Monitoring results: good water quality • Failed part 2 of the fecal coliform standard, and had one elevated turbidity measurement in 2009, • Due to proximity to city limits, new development is occurring in the basin which may impact flood volumes. • Water quality threatened by erosion from high stream flows and non-point source pollution. • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	• B-IBI average 2002-2009: 46 • B-IBI range 2002-2009: 40-48 • Chum and coho. • Forage fish in marine shoreline

a) In-Stream and Wetland Habitat Conditions

Physical

The stream bed appears to be changing from primarily gravel to sand (Thurston County, 2010). The lower reach (below East Bay Drive) is used by salmonids within Priest Point Park, however, fish passage is limiting above East Bay Drive (Thurston County, 2010).

Water Quality

Good- Failed part II of the fecal coliform standard and had one elevated turbidity measurement in March 2009 (Thurston County, 2010).

Issues - Because of its proximity to the city limits, new development is occurring in the watershed. Full development of the basin could have an appreciable impact on flood volumes. Water quality is threatened by erosion from high stream flows and nonpoint source pollution in the watershed. Stream bed appears to be changing from predominantly gravel to sand. City of Olympia is working to improve fish passage at the East Bay Drive crossing (Thurston County, 2010).

Ellis Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform.

b) Aquatic Biota

Benthic Macroinvertebrates

See Appendix B.

Fish

Ellis Creek contains coho and chum. The marine shoreline supports forage fish.

c) Action Recommendations

<u>(Haring and Konovsky,1999)</u>

- Conduct a feasibility study to identify a cost effective solution to reestablish salmonid access to Ellis Creek.

(TCDLE, 2005)

- Replace culverts at East Bay Drive, 33rd Ave and Gull Harbor Road. These three culverts represent two complete and one partial (67 percent) barrier on the system. Thurston County conducted a feasibility study on the blockage on Gull Harbor Road. Since there is extensive fill, the cost of correction is high and partnerships and diversification of funding is encouraged. (Habitat to be opened: Gull Harbor Road= approximately 2 miles, 1694 square meters of spawning habitat, 7800 square meters of rearing habitat; 33rd Avenue = 197 square meters of spawning habitat and 6391 square meters of rearing habitat).

- Actions should be taken to ensure the protection of the headwaters (wetland) and the riparian corridor. Continue to keep land use conversion minimized (last 15 years there was a 2 percent conversion from forest to urban).

- Educate landowners located in the Ellis Creek Basin to increase compliance with land use regulations and voluntary implementation of best management practices.

- Implement restoration efforts consistent with the findings of the Thurston Conservation District's riparian assessment.

- Conduct habitat assessment to fill data gaps for natural process needs.

7. Indian/Moxlie

The Indian/Moxlie Creek basin contains rolling terraces and numerous small depressions. The two main creeks are fed by many year-round and seasonal tributaries, springs, and seeps.

The Indian Creek main stem begins at Bigelow Lake, a sphagnum bog, and flows south in an unmaintained and heavily vegetated drainage ditch for approximately one mile. The upper portion of the creek flows in a wide floodplain with extensive streamside wetlands. The creek is then piped under several artificial roads, an industrial site, and Interstate 5. South of Interstate 5, the creek flows in a partially channelized and piped corridor that parallels the abandoned Burlington Northern Railroad grade. Downstream, the creek is piped under Interstate 5 and joins Moxlie Creek near the intersection of Plum Street and Union Avenue in Olympia's central business district. The combined creeks are piped 3,200 feet under downtown Olympia. Indian Creek's drainage area includes the Bigelow Lake wetland, several extensive but highly degraded wetlands, two small lakes, and a major tributary (City of Olympia, 1993a; Thurston County, 2010).

Moxlie Creek originates at an artesian spring in Olympia's Watershed Park. The creek flows northerly through the heavily forested and undeveloped park for about one mile before being piped under Interstate 5. Downstream of Interstate 5, the creek enters high-density commercial and industrial areas before the two creeks are combined and piped under downtown Olympia to the eastern portion of Budd Inlet. Moxlie Creek is composed of a main stem and many small springs and tributaries. The creek carries considerable flows year-round. Moxlie creek is tidally influenced throughout most of the culverted segment. The upland terrace in the southern portion of the basin typically drains to kettle lakes rather than to Moxlie Creek (City of Olympia, 1993a; Thurston County, 2010).

Before the City of Olympia's downtown area was developed, Indian and Moxlie Creeks discharged independently into a large estuarine wetland in Budd Inlet. As Olympia's downtown developed, the estuary was filled and the creeks were combined into a 3,200 foot pipe that discharges at the southern end of East Bay in Budd Inlet (City of Olympia, 1993a).

For this study, Ward Lake is included in the Indian/Moxlie Creek basin in order to maintain consistency with Ecology's sub-watershed boundaries. Ward Lake is a 62-acre pothole kettle lake with no surface inflow or outflow. The City of Olympia and Thurston County share jurisdiction of Ward Lake (Thurston County, 1995a).

Indian/Moxlie Creeks					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
Indian • Basin area 1,490 acres; urban growth area 100% • Total Impervious Area Estimate 1991: 24.6% 2006: 28.3% 2030: 32.1% Buildout: 33.2% Moxlie • Basin area 2,505 acres; urban growth area 100% • Total Impervious Area Estimate 1991: 34.4% 2006: 39.9% 2030: 42.7% Buildout: 25.0%	Indian • Effective Impervious Area: 2006: 22.8% • Forest Cover 37.4% • Unmodified Wetlands: 10.1% • Miles of Stream: 3.6 • Lakes: Bigelow, 12.8 ac • Areas of high ground water flooding: 0.3% of basin Moxlie • Effective Impervious Area: 2006: 34.4% • Forest Cover 27.2% • Unmodified Wetlands: 2.3% • Miles of Stream: 2.5 • Lakes: Ward, 65.7 ac • Areas of high ground water flooding: • 0.1% of basin	Indian • Coniferous forest cover in 250 stream riparian corridor: 2006: 7.1% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 86.2% 250 ft: 82.2% 1000 ft: 75.7% • # of road crossings per mile of creek: 6.0 • Riparian canopy in good condition Moxlie • Coniferous forest cover in 250 stream riparian corridor: 2006: 13.2% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 97.3% 250 ft: 95.4% 1000 ft: 91.1% • # of road crossings per mile of creek: 7.8 • Riparian canopy in good condition	• Limited spawning habitat in the upper portion of Moxlie Creek, located within the City of Olympia Watershed Park. Limited spawning due to significant amounts of fine sediments • Many portions of creek ditched • Lower portion of creek is confined to 72” culvert for 0.5 miles under the city which reduces habitat, passage, and survival of salmonids • Fish passage is limiting • Extensive wetlands filled • Large wetland adjacent to Bigelow lake provides habitat and storage capacity	• Monitoring results: Indian Creek has poor water quality. • Fecal coliform is consistently high and fails both parts of the standard, • Elevated metals and organics in creek sediments in past. • Nitrate concentrations are high. • Fecal coliform bacteria continues to be a problem in this urban stream. • Storm runoff from streets and I-5 contributes to water quality problems. • Moxlie Creek has poor water quality. • Failed both parts of the fecal coliform standard. • High total phosphorus and ammonia. • Heavily impacted by urban land uses • Stormwater discharge threatens integrity of stream channel in upper watershed and degrades water quality. • Illicit connection of sewer lines to portion of stream in culvert are pollution problem Indian/Moxlie Creeks: • 303(d): fecal coliform • Part of Budd-Deschutes TMDL Ward Lake: • Monitoring results: excellent to good water quality • 303(d): PCB contamination in fish • Basin developing rapidly, stormwater flows directly into lake in three places • Increased frequency of algal blooms	Indian Creek: • B-IBI average 2002-2009: 34 • B-IBI range 2002-2009: 30-36 Moxlie Creek: • B-IBI average 2002-2009: 27 • B-IBI range 2002-2009: 14-40 Indian Creek: • Coastal resident cutthroat trout, fall Chinook salmon, andcoho, Moxlie Creek: • Coastal resident cutthroat trout, Fall Chinook salmon, coho, chum

a) **Basin Conditions**

Level of Urbanization

Except for the headwaters in Bigelow Lake and Watershed Park, the basin is highly developed. Together, the Indian/Moxlie Creek basin covers 4.5 square miles and includes a section of downtown Olympia and established older residential and commercial neighborhoods on the east side of Olympia. The basins are growing more slowly than many nearby, lesser-developed basins because for the most part they are already developed. The northern portion of Indian Creek contains areas outside the city limits in the Thurston County urban growth area that are semi-rural but developing (City of Olympia, 1993a). Primary land use in the Indian Creek basin within the Olympia city limits is urban – moderate to high density residential and commercial. Primary land use within the county is rural to moderate residential intermixed with businesses (Thurston County, 2010). Residential development dominates the basin. The City of Olympia owns Watershed Park, the headwaters of Moxlie Creek. The City of Olympia owns a portion of the lower reach of Indian Creek (TCDLE, 2005). The majority of future growth within the basins will focus on infilling undeveloped areas within existing neighborhoods and commercial districts (City of Olympia, 1993a).

Hydrology

Impervious surfaces and resulting stormwater, compounded by channel modification and stream piping, have altered hydrologic functions in Indian and Moxlie Creeks. The existing development densities in most of the basin preclude retrofit to meet current stormwater standards to protect flow and water quality (TCDLE, 2005).

In Indian Creek, many culverts and pipe systems generate water velocities in excess of Washington Department of Fisheries (WDF) guidelines addressing fish passage. Future development in Indian Creek could add to runoff flows that exceed downstream culvert capacities. In Moxlie Creek, the culverts and pipe systems generate water velocities within WDF guidelines (City of Olympia, 1993a).

Many of the wetlands historically associated with Indian Creek have been filled, and major portions of the creek have been ditched or rerouted. All of these factors reduce the flood flow storage capacity and increase flows in the system. There are also many instream culverts and pipes that add additional flow to Indian Creek (City of Olympia, 1993a).

The flows in Moxlie Creek are higher than in Indian Creek during low and moderate flow conditions. Flood flows in Moxlie Creek are increased by a large stormwater system outfall and Interstate 5 discharges (City of Olympia, 1993a).

b) **Riparian Corridor**

The riparian canopy in the Indian/Moxlie Creek basin was rated as good (TCDLE, 2005).

The riparian zone along the upper reaches of Indian Creek is densely vegetated with dense patches of wetland species. The creek's lower reaches are bordered by common riparian plants such as willow, red alder, several types of shrubs, as well as large coniferous trees. Several segments of the stream corridor, particularly in the vicinity of the abandoned railroad grade, are naturally vegetated and isolated. These segments provide a wildlife and urban greenway corridor of approximately 100 acres (City of Olympia, 1993a).

The riparian corridor of upper Moxlie Creek has been largely preserved through the protection of 171-acre Watershed Park. The creek flows in a moderate gradient creek channel within a deeply incised canyon surrounded by a densely wooded corridor of large coniferous trees and shrubby undergrowth. Boardwalks have been constructed in the park to protect wetland areas and creek crossings from degradation. Fish and wildlife habitat within the park are of relatively high quality. North of Interstate 5, Moxlie Creek has streamside vegetation ranging from insufficient herbaceous growth to narrow strips of willow and red alder offering poor protective cover and woody debris to the creek. The lower portion of both creeks are entirely enclosed and piped beneath downtown Olympia (City of Olympia, 1993a).

c) **In-Stream and Wetland Habitat Conditions**

Physical

Development at urban densities has caused adverse changes to the physical traits of Indian Creek. Increased runoff and associated flood flows have accelerated erosion of the streambanks and impaired aquatic habitat. Many of the wetlands associated with the creek have been encroached upon and filled, the creek has been ditched in large sections, and there are long sections where the creek flows through pipes. All of these factors reduce the natural ability of the Indian/Moxlie Creek system to detain flood flows in wetlands and riparian areas. High creek flows have created numerous physical problems in Indian and Moxlie Creeks including: eroded streambanks in the moderate gradient segments of the creeks, increased sediment transport and deposition, widening of the creek, reduced frequency of creek meanders, reduced pool spacing, and a lack of large woody debris. Additional development in the headwaters of these streams could lead to increased flooding (City of Olympia, 1993a).

The lower portion of Indian Creek and Moxlie Creek (0.5 mile) is encased in a culvert, which is a loss of habitat. There is limited habitat in the upper portion of Moxlie Creek, located within the City of Olympia Watershed Park. Habitat in the park is in fair condition, although there appears to be significant amounts of fine sediment in the substrate (Haring and Konovsky, 1999). Moxlie Creek has limited spawning areas due to silty substrate. The City of Olympia and Washington Department of Fisheries (WDF) have placed additional gravels in the creek in past attempts to improve existing spawning areas (City of Olympia, 1993a).

Extensive wetlands surround Bigelow Lake and range downstream from the lake to approximately Boulevard Street. These wetlands have been extensively altered by draining and replacement of native wetland species with agricultural plants. Some of the wetlands still maintain a high degree of biological integrity. There is an approximately 140-acre peat bog wetland adjacent to Bigelow Lake at the headwaters of Indian Creek which offers excellent terrestrial and aquatic wildlife habitat as well as water storage capacity (City of Olympia, 1993a).

The large wetland and estuary that were historically associated with the creek mouths have been filled (City of Olympia, 1993a).

Water Quality

Indian Creek is listed on Washington State’s Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform (Ecology, 2008). The high fecal coliform bacteria levels in Indian and Moxlie Creeks have been identified as a primary source of contamination to Budd Inlet (City of Olympia, 1993a).

In Indian Creek, fecal coliform bacteria contamination continues to be a problem. Fecal coliform concentrations are consistently high and fail both parts of the standard. Elevated metals and organics have been detected in creek sediments in past studies. Nitrate concentrations are higher than background surface water concentrations. Stormwater runoff from Interstate 5 and city streets discharge into the creek and contribute to water quality problems (Thurston County, 2010).

Moxlie Creek failed both parts of the fecal coliform water quality standard and had moderately high levels of total phosphorus and ammonia. The presence of ammonia is an indication of sewage contamination. Moxlie Creek is heavily impacted by urban land uses. Water quality is impacted by stormwater runoff from highways and city streets. Stormwater discharges to the creek both threaten the integrity of the natural creek channel in the upper watershed and degrade water quality throughout its length. Illicit connections of sewer lines to the portion of the creek in a culvert are on-going problems, however, specific sources of the contamination have not been identified (Thurston County, 2010).

Ward Lake has excellent-to-good water quality. The lake has low levels of nutrients. Uses are not impeded by rooted aquatic plants; however spring algae blooms have been occurring in recent years. The frequency of late winter / early spring algae blooms seems to be increasing since 2005, raising concerns of water quality degradation and possible impacts from development activities. The lake is on Ecology’s 303(d) list of impaired waterbodies for polychlorinated biphenyls (PCB’s) contamination in fish (Thurston County, 2010). The source of the PCB’s is undetermined (Ecology, 2008).

The area around Ward Lake is developing rapidly. Stormwater flows directly into Ward Lake in at least three locations from high density residential areas. Conversion of a former landscape plant nursery on the west side on the lake to a planned urban village has been under way for several years. Accidental sewage spills and storm-related soil erosion incidents into Ward Lake have occurred in the past.

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Indian Creek contains resident coastal cutthroat trout, fall Chinook salmon, and coho.

Moxlie Creek contains resident coastal cutthroat trout, fall Chinook salmon, coho, and chum.

e) **Action Recommendations**

(Haring and Konovsky, 1999)

- Evaluate production potential of this stream in current and restored conditions, for use in cost/benefit evaluation of habitat restoration projects;
- Develop and implement stormwater controls that will restore the natural hydrology of the basin;
- Prioritize and correct identified fish passage barriers; and,
- Identify and correct water quality problem sources.

(TCDLE, 2005)

"Although the Indian/Moxlie system has been highly impacted and targeted for additional development growth, there is still the need to protect the existing habitats and reduce the degree of impacts future development could impose on its natural processes. A strong outreach/education element exists with the Watershed Park located on Moxlie Creek.

- Educate landowners located in the Indian/Moxlie Creek Basin to increase compliance with land use regulations (enforce existing setbacks along creek and wetlands) and voluntary implementation of best management practices.

- Manage stormwater runoff. In this urban creek, stormwater management is an important factor to improving water quality. Mistaken sanitary pipe hookups to stormwater pipes should continue to be investigated and corrected. Street sweeping and other measures should be pursued to reduce pollution loading to the creek. In most of the developed areas of the watershed, existing densities preclude retrofit to meet current stormwater standards to protect flow and water quality.

- Investigate opportunities to improve estuary conditions. Continue riparian revegetation efforts currently underway with City of Olympia" (TCDLE, 2005).

8. Lake Lawrence

Primary land use is rural with some agriculture and undeveloped forest land (Thurston County, 2010).

<table>
<tr><th colspan="6">Lake Lawrence</th></tr>
<tr><th colspan="6">Current Aquatic Habitat Conditions</th></tr>
<tr><th>Level of Urbanization</th><th colspan="2">Basin and Riparian Conditions</th><th colspan="2">In-Stream and Wetland Habitat Conditions</th><th>Aquatic Biota</th></tr>
<tr><th></th><th>Hydrology</th><th>Riparian Corridor</th><th>Physical Conditions</th><th>Water Quality</th><th></th></tr>
<tr>
<td>• Basin area 2,330 acres; 100% rural
• Total Impervious Area Estimate
1991: 1.6%
2006: 4.8%
2030: 5.4%
Buildout: 5.7%</td>
<td>• Effective Impervious Area:
2006: 3.3%
• Forest Cover: 44.6%
• Unmodified Wetlands: 15.8%
• Miles of Stream: 4.2
• Lakes: Lawrence, 333.6 ac
• Areas of high ground water flooding: 0.8% of basin</td>
<td>• Coniferous forest cover in 250 stream riparian corridor:
2006: 5.5%
• Forest, scrub/shrub vegetation and wetlands in stream riparian corridor:
150 ft: 67.0%
250 ft: 67.1%
1000 ft: 78.2%
• # of road crossings per mile of creek: 1.7</td>
<td>• Lake Lawrence outflow acts as a lake level control structure and fish passage barrier.</td>
<td><u>Lake Lawrence:</u>
• Monitoring results: fair water quality
• Lake is eutrophic resulting in algal blooms that impair uses
• 303(d): total phosphorus
<u>Lake Lawrence Creek:</u>
• 303(d): dissolved oxygen
• Part of Budd-Deschutes TMDL</td>
<td>• Benthic levels unknown
• Stream flowing from Lake Lawrence to the Deschutes River contains coastal resident cutthroat</td>
</tr>
</table>

a) In-Stream and Wetland Habitat Conditions

Physical

Lake Lawrence outflow acts as a lake level control structure and fish passage barrier (WRIA 13, Salmonid Habitat Limiting Factors, 1999).

Water Quality

Fair – Lake Lawrence is eutrophic and uses are impaired by algae and aquatic plant growth (Thurston County, 2010).

Issues - Lake Lawrence Integrated Aquatic Vegetation Management Plan has been implemented. Ecology is conducting a TMDL for the Deschutes River/Budd Inlet system (Thurston County, 2010).
Lake Lawrence is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for total phosphorus (Ecology, 2008).

b) **Aptic Biota**

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

The stream flowing into Lake Lawrence contains coastal resident cutthroat.

c) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

None noted.

9. McIntosh Lake

McIntosh Lake						
Current Aquatic Habitat Conditions						
Level of Urbanization	Basin and Riparian Conditions		In-Stream and Wetland Habitat Conditions		Aquatic Biota
	Hydrology	Riparian Corridor	Physical Conditions	Water Quality	
• Basin area 1,620 acres; 100% rural • Total Impervious Area Estimate 1991: 0.8% 2006: 2.1% 2030: 2.4% Buildout: 2.5%	• Effective Impervious Area: 2006: 1.3% • Forest Cover: 80.6% • Unmodified Wetlands: 12.9% • Miles of Stream: 14.0 • Lakes: McIntosh, 128.5 ac • Areas of high ground water flooding: 0.6% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 33.3% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 59.5% 250 ft: 51.5% 1000 ft: 36.6% • # of road crossings per mile of creek: 3.1	• No Data	• 303(d): PCB contamination in fish • Part of Budd-Deschutes TMDL	• Benthic levels unknown • McIntosh Lake stocked with rainbow and triploid rainbow trout

a) In-Stream and Wetland Habitat Conditions

Water Quality

McIntosh Lake is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for polychlorinated biphenyls (PCB's) contamination in fish (Ecology, 2008).

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

McIntosh Lake stocked with rainbow and triploid rainbow trout.

c) Action Recommendations

(Haring and Konovsky, 1999)

None noted.

10. Mission Creek

Mission Creek flows from the northeast part of Olympia into Budd Inlet along the southern border of Priest Point Park. Primary land use in the Mission Creek Basin is residential, forest cover, and public parks (Thurston County, 2010). Much of the creek is private, urban residential development, while the City of Olympia owns both the headwater wetland and the downstream reach used by fish (TCDLE, 2005). Mission Creek basin falls primarily within the City of Olympia and does not contain shoreline jurisdiction.

Mission Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 740 acres; urban growth area 100% • Total Impervious Area Estimate 1991: 21.3% 2006: 24.1% 2030: 28.1% Buildout: 29.2%	• Effective Impervious Area: 2006: 18.8% • Forest Cover: 44.7% • Unmodified Wetlands: 5.2% • Miles of Stream: 2.1 • Miles of Marine Shoreline: 1.1 • Areas of high ground water flooding: 0.0% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 7.2% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 78.8% 250 ft: 75.3% 1000 ft: 66.0% • # of road crossings per mile of creek: 5.6 • Riparian condition is relatively intact through the Priest Point Park reach, but is impaired with non-native shrubs.	• High peak flows • Little to no LWD • Low LWD recruitment potential due to poor riparian conditions • High level of fine sediments	• Monitoring results: fair water quality • Failed both parts of the fecal coliform standard. • Nutrients are elevated, particularly nitrates. • High levels of bacterial contamination in creek system • Potential for future development in basin may further impact water quality • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	East Bay Drive • B-IBI average 2002-2009: 27 • Note: High B-IBI score in upper basin. • B-IBI range 2002-2009: 18-36 • Coho, chum

a) **Riparian Corridor**

Riparian condition is relatively intact through Priest Point Park, but is generally impaired elsewhere, with high abundance of blackberry and non-native shrubs and deciduous trees (Haring and Konovsky, 1999).

b) **In-Stream and Wetland Habitat Conditions**

Physical

High peak flows, high fine sediment levels, little-to-no LWD and low LWD recruitment potential due to poor riparian conditions (Haring and Konovsky, 1999).

An abandoned roadbed across the mouth constricts tidal exchange and may limit salmonid rearing functions within the estuary (TCDLE, 2005).

Water Quality

Fair - Failed both parts of the fecal coliform standard. Nutrients are elevated, particularly nitrates.

Issues - High levels of bacterial contamination throughout the creek system, including stormwater discharges. The watershed has potential for future development that may further impact water quality.

Mission Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform (Ecology, 2008).

c) **Aquatic Biota**

Benthic Macroinvertebrates

Mission Creek at Bethel Street NE had a B-IBI score in 2008 and 2009 of 42 (high biological integrity).

See Appendix B for remainder of B-IBI data.

Fish

Mission Creek contains coho and chum salmon.

d) **Action Recommendations**

The level of existing development in the Mission warrants primarily enhancement and protection actions (City of Olympia, 2003).

<u>(Haring and Konovsky, 1999)</u>

- Develop and implement stormwater controls that will restore the natural hydrology of the basin;
- Prioritize and correct identified fish passage barriers;
- Restore functional riparian buffers upstream of Priest Point Park; and,
- Identify and correct fecal coliform sources.

(TCDLE, 2005)

- Provide adequate management to reduce/eliminate current stormwater impacts
- Restore estuarine functions through removal of abandoned road and blocking culvert
- Enforce existing setbacks along creek and wetlands
- Eliminate noxious weeds

11. Offut Lake

Offut Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 1,790 acres; 100% rural • Total Impervious Area Estimate 1991: 1.4% 2006: 2.9% 2030: 3.6% Buildout: 4.0%	• Effective Impervious Area: 2006: 2.0% • Forest Cover: 61.2% • Unmodified Wetlands: 22.7% • Miles of Stream: 9.8 • Lakes: Offut, 193.0 ac • Areas of high ground water flooding: 1.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 12.8% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 79.3% 250 ft: 75.2% 1000 ft: 61.1% • # of road crossings per mile of creek: 0.4	• Fish passage limited	• 303(d): PCB contaminatio n in fish • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Unnamed stream connecting Offut Lake to Deschutes River contains winter steelhead, coho, and coastal resident cutthroat trout, Fish end at the barrier between Offut Lake and stream. • Offut Lake contains coastal resident cutthroat.

a) In-Stream and Wetland Habitat Conditions

Physical

No limiting factors were noted for the Offut Lake basin (Haring and Konovsky,1999).

Water Quality

Offut Lake is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for polychlorinated biphenyls (PCB's) contamination in fish (Ecology, 2008).

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

The unnamed stream that connects Offut Lake to the Deschutes River contains winter steelhead, coho, and coastal resident cutthroat trout. These fish are not able to pass into Offut Lake due to a barrier between Offut Lake and the unnamed stream draining to the Deschutes River.

Offut Lake contains coastal resident cutthroat.

c) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Prioritize and correct identified fish passage barriers, and
- Evaluate the merits of providing fish passage at the outlet of Offut Lake.

12. Percival Creek

The Percival Creek basin is located between the Black Hills on the west and Capital Lake/Budd Inlet on the east. The drainage area of the basin is generally moderately sloped. The two main creek channels are Percival Creek and Black Lake drainage ditch. Percival Creek originates at Trosper Lake, flows north for approximately 2.4 miles to its confluence with its major tributary, the Black Lake drainage ditch. After its confluence Percival Creek flows downstream approximately 1.2 miles through a deeply incised canyon to Percival Cove on the western side of Capitol Lake. Capitol Lake then discharges through a tidal get to the western portion of Bud Inlet. Black Lake drainage ditch is a man-made drainage channel built in 1922 originating at Black Lake. The creeks have generally low gradient channels in the upper segments with extensive wetland, and have medium gradients in the lower segments within the deeply-incised Percival Creek canyon. Percival Creek is fed by numerous year-round and seasonal tributaries, springs, and seeps. Black Lake drainage ditch accounts for nearly two-thirds of the total flow of Percival Creek below the confluence. In addition to the creek system, the drainage basin area includes Trosper and Ken Lakes and several extensive wetlands (City of Olympia, 1993b; TCDLE, 2005).

Percival Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 5,650 acres; urban growth area 95%; rural 5% • Total Impervious Area Estimate 1991: 19.5% 2006: 24.8% 2030: 30.3% Buildout: 32.2%	• Effective Impervious Area: 2006: 21.0% • Forest Cover: 45.7% • Unmodified Wetlands: 7.1% • Miles of Stream: 13.9 • Lakes: Ken, 25.6 ac; Trosper, 17.0 ac • Altered hydrology – Black Lake ditch and Percival Creek • Areas of high ground water flooding: 1.3% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 7.4% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 71.6% 250 ft: 70.7% 1000 ft: 64.4% • # of road crossings per mile of creek: 3.0 • The riparian buffer quality was rated as fair in lower Percival, functional in middle Percival, poor in upper Percival, and non-functional in Black Lake Ditch.	• Largely intact instream habitat but degrading due to urbanization • Areas of scour in this sand dominated sytem • Elevated summer temperature • Lack of LWD in upper Percival and Black Lake Ditch • Limited gravel availability in upper Percival and Black Lake Ditch • Pools limiting • Bank stability declining • Altered estuary conditions • Fish passage is limiting • Some altered wetlands, some retain high biological integrity • High quality wetlands at Grass Lake	<u>Percival Creek:</u> • Monitoring results: fair water quality • Elevated turbidity occurred in winter 2009. • One mid-summer DO violation • Possible summer temperature violations. • Basin is within urban growth area and is rapidly developing. Major regional stormwater facility along ditch. Increases in stormwater runoff could impact water quality, and increase erosion. • Homeless camps along riparian corridor may contribute to decline in water quality. • Percival Creek and Black Lake Ditch are part of a TMDL study begun in 2003 by Ecology. • 303(d): temperature, dissolved oxygen, fecal coliform – exceeded state standards • Part of Budd-Deschutes TMDL <u>Black Lake Ditch:</u> • Monitoring results: fair water quality • Met both parts fecal coliform standard. • Violated dissolved oxygen standards during summer months. • Violated turbidity standard twice in 2008/09. • Temperature standard may be violated during the summer. • Because Black Lake is the origin of Black Lake Ditch, high summer temperatures and low dissolved oxygen are a common condition • 303(d): dissolved oxygen, pH, temperature • Part of Budd-Deschutes TMDL	Percival Creek @ footbridge at mouth • B-IBI average 2002-2009: 31 • Note: Black Lake Ditch has Low average B-IBI • B-IBI range 2002-2009: 24-36 • Percival Creek and Black Lake ditch: Fall Chinook salmon, coho, chum, and coastal resident cutthroat.

a) **Basin Conditions**

Level of Urbanization

Development pressures have been significant during the past few decades. Percival Creek basin is located on Olympia's expanding west side and the northern part of Tumwater. Consequently, the area has grown at a higher rate in both residential and commercial development than many of the region's more established neighborhoods (City of Olympia, 1993b).

Primary land use is urban, suburban, residential, and commercial (Thurston County, 2010). The predominant land uses surrounding Black Lake Ditch are industrial and open space. Upstream of the confluence, Percival Creek has open space and residential development. Below the confluence, several land uses including commercial and mixed-residential development are present (TCDLE, 2005).

Thurston County, City of Olympia, and Tumwater own most of the riparian corridor of Black Lake Ditch and Percival Creek. The City of Olympia uses Black Lake Meadows, a large constructed wetland complex adjacent to the Ditch, to treat stormwater (TCDLE, 2005).

Hydrology

The WRIA 13 Limiting Salmonid Factors Report identified Percival Creek as having altered hydrology (Haring and Konovsky, 1999)

Urbanization in the basin has resulted in land clearing and an increase in impervious surfaces which have led to increased stormwater runoff and stream flooding (City of Olympia, 1993b).

Prior to the excavation of the Black Lake drainage ditch, the hydrologic connection between Black Lake and Percival Creek was minimal (City of Olympia, 1993b).

There are many wetlands in the Percival Creek basin, primarily adjacent to the Black Lake drainage ditch, the upstream segments of Percival Creek, and Grass Lake. Some of these wetlands have been altered by draining and replacement of native wetland plants with agricultural plants, though some wetlands retain high biological integrity. The construction of the Black Lake drainage ditch markedly reduced the extent and quality of the wetlands along the periphery of the ditch. The wetland around Yauger Park and downstream along Cooper Point Road has been developed and filled. These changes to the natural wetlands have altered the hydrology of the basin. In the northern portion of the basin, the City of Olympia purchased 162 acres of the extensive wetland associated with Grass Lake to preserve and use for educational purposes (City of Olympia, 1993b).

b) **Riparian Corridor**

The riparian buffer quality was rated as fair in lower Percival, functional in middle Percival, poor in upper Percival, and non-functional in Black Lake Ditch (Haring and Konovsky, 1999).

Percival Creek's riparian zone is primarily densely vegetated with common streamside species including Douglas fir, red alder, Western red cedar, and various shrub species. Much of the creek flows through a deep canyon with high walls and a narrow floodplain. The upstream portions of the creek and the Black Lake drainage ditch have extensive adjacent streamside wetlands.

Percival Creek's vegetated stream channel provides a narrow but contiguous strip of wildlife habitat about six miles long that provides a wildlife access route within and outside of the basin (City of Olympia, 1993b).

c) **In-Stream and Wetland Habitat Conditions**

Physical

- Elevated summer temperature and lack of LWD in upper Percival and Black Lake Ditch;
- Limited gravel availability in upper Percival and Black Lake Ditch; and,
- Altered estuary conditions (Haring and Konovsky, 1999).

Instream habitat in Percival Creek remains largely intact, but is experiencing physical and biological degradation due to the effects of urbanization. In addition, the important estuarine environment historically associated with the mouth of the creek was eliminated with the creation of Capitol Lake (City of Olympia, 1993b).

The lower portions of Percival Creek and a portion of Black Lake drainage ditch is paralled by a Burlington Northern railroad line. Although significant amounts stormwater runoff from the heavily urbanized portions of the basin is treated in regional stormwater facilities, runoff remains a difficult challenge to mitigate, creating pockets of scour in the sand-dominant system. The City of Olympia rated Percival Creek as an "impacted" stream, meaning there is still some potential for properly functioning fish habitat that warrants a moderate level of protection and restoration activity (TCDLE, 2005).

Juvenile and adult fish passage is limited at the Percival Cove screen, which directs hatchery Chinook to the hatchery facility at Deschutes River falls until sufficient eggs are collected. No species can utilize the creek until the WDFW-operated gates are opened. The City of Olympia is discussing options for gate management with WDFW, a proposal that would allow fish access to habitat in Percival Creek before the gate becomes open in the fall (TCDLE, 2005). Adult fish passage is also limited at the Capitol Lake tide gate (Haring and Konovsky, 1999).

Water Quality

Fair — Black Lake Ditch — Met both parts of the fecal coliform standard. Violated dissolved oxygen standards during summer months. Violated turbidity standard twice in 2008/09. Temperature standard may be violated during the summer (Thurston County, 2010).

Issues — Black Lake Ditch — The basin is within the urban growth boundary and is rapidly developing. The City of Olympia has a major regional stormwater facility along Black Lake Ditch that treats and detains stormwater that comes from commercial development on the west side of Olympia. Black Lake Ditch is included in a total maximum daily load study (TMDL) begun in 2003 by Ecology. Because Black Lake is the origin of the Black Lake Ditch, high summer temperatures and low dissolved oxygen are a common condition. Homeless encampments within the riparian corridor are a common occurrence and could be contributing to water quality problems (Thurston County, 2010).

Black Lake Ditch is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen, pH, and temperature.

Fair — Percival Creek — Met both parts of the fecal coliform standard in 2008/09. Elevated turbidity occurred in January and February 2009. There was one mid-summer DO violation, and temperature measurements indicated possible summer temperature violations (Thurston County, 2010).

Issues — Percival Creek basin is within the urban growth boundary and is developing rapidly. Increases in stormwater runoff could impact the stream through degraded water quality, stream bank erosion, hillslope failures, and channel scour. Concerns have been raised regarding the effect of Black Lake water quality on Percival Creek and Percival Cove. Percival Creek was included in a total maximum daily load study (TMDL) begun in 2003 by Ecology. Homeless camps are often built within the riparian corridor (Thurston County, 2010).

Percival Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for temperature, dissolved oxygen, and fecal coliform (Ecology, 2008).

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Percival Creek and Black Lake ditch contain fall Chinook salmon, coho, chum, and resident coastal cutthroat trout.

e) **Action Recommendations**

(Haring and Konovsky, 1999)

- Incorporate Sapp Road culvert partial fish barrier correction into WRIA 13 restoration project prioritization, based on assessment of upstream habitat benefit to salmonids; correction, should involve replacement of the culvert rather than retrofitting,
- Fix Capitol Lake tide gate to ensure fish passage at all lake and tidal levels;
- Evaluate flow impacts (quantity and quality), from Black Lake through Black Lake Ditch, and determine whether modifications are warranted;
- Identify and correct adverse impacts to naturally produced adult and juvenile salmonids resulting from the Percival Cove screen;
- Prioritize new stormwater facilities to resolve current stormwater impacts, and prevent further impacts from construction of new impervious surface;
- Protect riparian zones that are currently in good condition and restore riparian function in areas that have been degraded; and,
- Evaluate condition and production/restoration potential of instream habitat in upper watershed.

(TCDLE, 2005)

- Manage fish access at the mouth of Percival Creek. Work with WDFW to solve the access limitations to the creek for adults and juveniles seeking refuge. Currently, a mesh screen is in place from April to mid May to keep reared Chinook in Percival Cove. Adult salmon passage into Percival Creek is restricted while the diversion pickets/gate is in place at the Deschutes Parkway crossing from August through September;
- Restore properly functioning estuary;
- Improve riparian corridors for increased shade and large woody debris (LWD) recruitment. Publicly owned lands should be targeted for this activity. Utilize Thurston CD riparian assessment to locate riparian restoration sites. Plant appropriate species;
- Evaluate water quality and quantity impacts from Black Lake and Black Lake Ditch (flow regimes, sediment budget, pollutants);
- Improve existing stormwater system (TCDLE, 2005).

13. Reichel Lake

Reichel Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 4,470 acres; 100% rural • Total Impervious Area Estimate 1991: 0.7% 2006: 1.5% 2030: 1.6% Buildout: 1.6%	• Effective Impervious Area: 2006: 1.0% • Forest Cover: 62.3% • Unmodified Wetlands: 4.1% • Miles of Stream: 49.7 • Lakes: Reichel, 22.8 ac • Areas of high ground water flooding: 1.0% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 17.4%% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 65.4% 250 ft: 60.5% 1000 ft: 51.5% • # of road crossings per mile of creek: 0.9 • Lack of functional riparian zones	• High fine sediments • Run-off from former log yard discharges fine sediment and contaminants. • Impaired by agricultural activities including direct animal access to the creeks	Unnamed Creek between Reichel Lake and the Deschutes River: • 303(d): dissolved oxygen, fecal coliform, temperature • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Unnamed stream between Reichel Lake and Deschutes River: coho, coastal resident cutthroat trout, winter steelhead.

a) In-Stream and Wetland Habitat Conditions

Physical

Run-off from former log yard discharges fine sediment and contaminants. The stream is also impaired by agricultural activities including direct animal access to the creeks (Haring and Konovsky, 1999).

Water Quality

Reichel Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen, fecal coliform, and temperature.

Reichel Creek is impaired by agricultural activities including direct animal access to the creeks and lack of functional riparian zones. Run-off from former log yard discharges fine sediment and contaminants (Haring and Konovsky, 1999).

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

The unnamed stream between Reichel Lake and the Deschutes River contains coho, coastal resident cutthroat trout, and winter steelhead.

c) **Action Recommendations**

(Haring and Konovsky, 1999)

- Prioritize and correct identified fish passage barriers;
- Identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction;
- Address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids, identify and address continuing runoff problems associated with the former log sort yard; implement appropriate in-channel mitigation and restoration; and,
- Restore functional riparian buffers throughout drainage.

14. Schneider (West Bay)

Primary land use is urban residential and commercial (Thurston County, 2010).

Schneider Creek (Budd Inlet)					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 670 acres; urban growth area 100% • Total Impervious Area Estimate 1991: 17.0% 2006: 21.4% 2030: 27.1% Buildout: 28.4%	• Effective Impervious Area: 2006: 16.4% • Forest Cover: 55.6% • Unmodified Wetlands: 0.8% • Miles of Stream: 1.7 • Miles of Marine Shoreline: 12.5 • Altered hydrology - high total impervious, low remaining forest cover, and high road densities • Areas of high ground water flooding: 0.0% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 5.2% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 47.3% 250 ft: 43.8% 1000 ft: 27.7% • # of road crossings per mile of creek: 1.7 • Wide riparian areas	• Low pool habitat abundance • Impaired spawning and rearing substrate • Poor bank stability • Upstream half of creek and mouth are piped underground • Headwater wetlands and estuary at mouth filled and degraded	• Monitoring results: good water quality • Failed Part II fecal coliform standard in 08/09. • Stream channel severely impacted by peak stormwater flows. • City of Olympia constructed a stormwater treatment facility at the creek's headwaters to improve quality of stormwater. • High nitrate levels indicate contamination of shallow groundwater and surface runoff. • Part of Budd-Deschutes TMDL	• B-IBI average 2002-2009: 32 • B-IBI range 2002-2009: 24-46 • Coho

a) Basin Conditions

Hydrology

Altered hydrology - high total impervious, low remaining forest cover, and high road densities (Haring and Konovsky, 1999)

Schneider Creek is an urban spring-fed creek discharging into Budd Inlet. In the early history of the City of Olympia, the headwater wetlands of the mainstem and the estuary at the mouth were filled and developed. Now, the upstream half of the stream and the mouth of the creek are underground. The estuary at the mouth where Schneider Creek discharges through a culvert into Budd Inlet has been greatly degraded by filling and past industrial activities (TCDLE, 2005).

b) In-Stream and Wetland Habitat Conditions

Physical

- Low pool habitat abundance
- Impaired spawning and rearing substrate
- Poor bank stability (Haring and Konovsky,1999)

This urban creek has a long history of development which has impaired the natural processes that influence instream structure and overall stream health. Stormwater inputs increase the winter storm event flows causing excessive spawning gravel scour and fill. Good groundwater flow in the summer helps to maintain year-round flows, which help rearing conditions. Seasonally high instream flows also contribute to bank erosion and fine sediment input. Although the wide riparian areas provide good shade, low LWD recruitment has created low pool habitat for juvenile rearing (TCDLE, 2005).

Water Quality

High fecal coliform is a limiting factor to salmonid habitat in Schneider Basin.

Good – Failed Part II of the fecal coliform water quality standard this year. Stream channel is severely impacted by peak stormwater flows (Thurston County, 2010).

Issues - High volumes of stormwater discharging directly to the creek are causing bank failures, streambank erosion, flooding, stream channel scour, and water quality degradation. City of Olympia constructed a stormwater treatment facility at the headwaters of the creek to improve the quality of urban stormwater discharging to the creek. High nitrate levels are high and indicate contamination of both shallow groundwater and surface runoff (Thurston County, 2010).

c) Aquatic Biota

Benthic Macroinvertebrates

See Appendix B.

Fish

Schneider Creek contains coho.

d) Action Recommendations

<u>(Haring and Konovsky, 1999)</u>

- Develop and implement stormwater control measures to restore natural hydrology;
- Restore and maintain functional riparian buffers, including conversion from deciduous to conifer;
- Develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD;
- Identify and implement actions necessary to address fine sediment concerns; and,
- Identify and correct fecal coliform sources.

(TCDLE, 2005)

- Provide adequate stormwater management to reduce/eliminate current stormwater impacts;
- Explore opportunities to re-establish an estuary at the mouth of the creek;
- Replace culverts on West Bay Drive and Bowman Road;
- Restore riparian corridor to provide shade, stabilize streambanks and recruit LWD. Plant appropriate species (incorporate additional conifer in the riparian corridor);
- Utilize the Thurston Conservation District's riparian assessment to identify appropriate locations for riparian restoration actions.

15. Spurgeon Creek

Primary land use is rural residential, small commercial and noncommercial agriculture, and Joint Base Lewis-McChord (Thurston County, 2010).

Spurgeon Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 6,050 acres; 100% rural • Total Impervious Area Estimate 1991: 0.7% 2006: 1.5% 2030: 2.0% Buildout: 2.2%	• Effective Impervious Area: 2006: 1.0% • Forest Cover: 69.4% • Unmodified Wetlands: 5.6% • Miles of Stream: 17.0 • Areas of high ground water flooding: 0.8% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 12.1% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 76.8% 250 ft: 76.4% 1000 ft: 70.4% • # of road crossings per mile of creek: 1.4 • Poor riparian condition	• Direct livestock access to channel • Substrate is primarily sand • Conversion of wetlands to agricultural use	• Monitoring results: good water quality • All water quality standards met in years 07/08 and 08/09 and nutrient levels fairly low. • Non-point pollution from rural residential and agricultural activities. • Encroachment on wetlands and riparian areas by livestock for grazing may impact water quality. • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Coho, and fall Chinook salmon

a) Riparian Corridor

Agricultural impacts, poor riparian condition, direct livestock access to channel (Haring and Konovsky, 1999).

b) In-Stream and Wetland Habitat Conditions

Physical

- Substrate is primarily sand;
- Conversion of wetlands to agricultural use (Haring and Konovsky, 1999).

Water Quality

Good - All water quality standards met in water years 2007/08 and 2008/09 and nutrient levels are fairly low (Thurston County, 2010).

Issues - Nonpoint pollution from rural residential and agricultural activities. Encroachment on wetlands and natural riparian areas for livestock grazing and other uses may impact water quality. Spurgeon Creek was included in a total maximum daily load study of the Deschutes Watershed (TMDL) begun in 2003 by Ecology (Thurston County, 2010).

c) **Aquatic Biota**

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Spurgeon Creek contains coho, and fall Chinook salmon.

d) **Action Recommendations**

(Haring and Konovsky,1999)

- Restore functional riparian habitat;
- Identify benefits and potential of associated wetlands restoration;
- Identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction; and,
- Address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids.

16. Tempo Lake

Tempo Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Conditions described as part of Deschutes River – Mainstem Middle	• Constructed lake in the middle of Tempo Lake Subdivision	• Conditions described as part of Deschutes River – Mainstem Middle	• No data	Tempo Lake outlet: • 303(d): temperature • Part of Budd-Deschutes TMDL	• Benthic levels unknown • No fish usage noted

a) In-Stream and Wetland Habitat Conditions

Water Quality

The outlet of Tempo Lake is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for temperature.

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

No fish usage of Tempo Lake noted.

c) Action Recommendations

(Haring and Konovsky, 1999)

None noted.

17. West Bay

West Bay					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 1,850 acres; urban growth area 48%; rural 52% • Total Impervious Area Estimate 1991: 14.8% 2006: 18.3% 2030: 20.9% Buildout: 22.0%	• Effective Impervious Area: 2006: 14.5% • Forest Cover: 57.3% • Unmodified Wetlands: 1.8% • Miles of Stream: 3.6 • Miles of Marine Shoreline: 6.5 • Areas of high ground water flooding: 0.5% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 8.1% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 54.0% 250 ft: 52.3% 1000 ft: 36.2% • # of road crossings per mile of creek: 3.3	• No data	Butler Creek (West Bay 2): • 303(d): fecal coliform • Part of Budd-Deschutes TMDL	• Benthic levels unknown • Coastal resident cutthroat trout. • Marine shoreline supports forage fish.

a) In-Stream and Wetland Habitat Conditions

Water Quality

Butler Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform (Ecology, 2008).

Budd Inlet is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen (Ecology, 2008).

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Coastal resident cutthroat trout. The marine shoreline is used by forage fish.

c) Action Recommendations

<u>(Haring and Konovsky, 1999)</u>

None noted.

B. Eld Inlet Watershed

1. Eld Inlet (East)

Eld Inlet East					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 3,860 acres; urban growth area 10%; rural 90% • Total Impervious Area Estimate 1991: 4.1% 2006: 6.9% 2030: 9.2% Buildout: 10.0%	• Effective Impervious Area: 2006: 5.1% • Forest Cover: 77.0% • Unmodified Wetlands: 5.9% • Miles of Stream: 6.7 • Miles of Marine Shoreline: 14.2 • Areas of high ground water flooding: 0.4% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 13.8% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 92.9% 250 ft: 89.6% 1000 ft: 82.8% • # of road crossings per mile of creek: 1.9	• No data	• Shellfish growing areas are approved.	• Benthic levels unknown • Chum, coho • Marine shoreline: forage fish. • Shellfish habitat in Mud Bay area, and along Countryside beach and north.

a) In-Stream and Wetland Habitat Conditions

Water Quality

Eld Inlet (east) near Green Cove and south of Shell Point is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform. Eld Inlet (east) near Cooper Point is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen.

The shellfish growing areas are approved.

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Unnamed creeks contain chum and coho salmon. The marine shoreline supports forage fish spawning.

Shellfish

There is shellfish habitat in the Mud Bay area, along Countryside beach and north of Countryside Beach.

c) **Action Recommendations**

(Haring and Konovsky, 1999)

None noted.

2. Eld Inlet (West)

Primary land use is suburban and rural residential, (Thurston County, 2010).

Eld Inlet West					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 6,110 acres; 100% rural • Total Impervious Area Estimate 1991: 2.4% 2006: 4.1% 2030: 5.1% Buildout: 5.3%	• Effective Impervious Area: 2006: 3.0% • Forest Cover: 70.0% • Unmodified Wetlands: 6.4% • Miles of Stream: 15.9 • Miles of Marine Shoreline: 15.8 • Areas of high ground water flooding: 1.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 14.4% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 91.5% 250 ft: 89.0% 1000 ft: 83.0% • # of road crossings per mile of creek: 2.3	• Poor substrate embeddedness in Young (Eld Inlet 5) and Frye Cove Creeks (Eld Inlet 3)	• Shellfish growing areas are approved.	• Benthic levels unknown • Coho, chum and coastal resident cutthroat • Marine shoreline: forage fish and shellfish through much of coastline.

a) In-Stream and Wetland Habitat Conditions

Physical

- Poor-to-fair fish passage;
- Poor substrate embeddedness in Young and Frye Cove Creeks;
- Data gaps: riparian buffers; streambank condition; floodplain connectivity; width/depth ratio; LWD; pool frequency; pool quality; off-channel habitat; water quality; water quantity/dewatering; change in flow regime; biological processes (WRIA 14, Salmonid Habitat Limiting Factors Report, 2002).

Water Quality

Young Cove is listed on Washington State’s Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform.

The shellfish growing areas are approved.

b) Aquatic Biota

Benthic Macroinvertebrates
Benthic Macroinvertebrates are not monitored in this basin.

Fish

Unnamed creeks contain coho, chum, and coastal resident coastal cutthroat trout. The marine shoreline supports forage fish spawning throughout much of the coastline.

Shellfish

The marine shoreline contains shellfish habitat throughout much of the coastline.

c) **Action Recommendations**

(WRIA 14, Salmonid Habitat Limiting Factors Report, 2002)

- Replace culverts acting as fish barriers;
- Replant native riparian vegetation;
- Follow guidelines in "Forest and Fish Report";
- Build fewer roads and maintain existing roads;
- Prevent development on floodplains and along channel banks.

3. Green Cove Creek

Green Cove Creek basin drains 2,626 acres (4.1 square miles) to Eld Inlet. Green Cove Creek basin contains Louise Lake (also called Kaiser Pond or Grass Lake), Green Cove Creek and an unnamed tributary to the creek. The basin has extensive wetlands. Green Cove Creek originates at the outlet of Louise Lake (Thurston County, 1998).

Green Cove Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 2,220 acres; urban growth area 40%; rural 60% • Total Impervious Area Estimate 1991: 4.5% 2006: 11.7% 2030: 13.5% Buildout: 13.9%	• Effective Impervious Area: 2006: 8.8% • Forest Cover: 66.4% • Unmodified Wetlands: 11.6% • Miles of Stream: 5.3 • Lakes: Louise, 12.2 ac • Areas of high ground water flooding: 3.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 12.8% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 88.9% 250 ft: 84.7% 1000 ft: 69.2% • # of road crossings per mile of creek: 1.7 • Riparian corridor in good condition	• Lack of pool habitat • Lack of LWD • Riparian function concerns • Functional estuary at mouth • Headwater wetlands intact, protected, and good wildlife habitat • Many other wetlands have been filled	• Monitoring results: good water quality • Met both parts of the fecal coliform standard in both water years. • All other standards were met. • Urban development and stormwater are the biggest threats to water quality in this stream • Stream is not part of a TMDL	@ Cooper Pt. Rd. • B-IBI average 2002-2009: 38 • B-IBI range 2002-2009: 30-46 • Chum, winter steelhead, coho, and coastal resident cutthroat.

a) Basin Conditions

Level of Urbanization

Primary land use is agriculture and rural residential (Thurston County, 2010). The southern portion of the basin is within the City of Olympia and the Urban Growth Area. The Capitol Land Trust has protected some wetlands and forested uplands in the upper basin. The majority of the basin lies within private ownership characterized by residential land uses (TCDLE, 2005).

Since Green Cove Creek basin is relatively intact, Green Cove Creek is Olympia’s priority for salmon habitat protection measures. The Green Cove Creek Comprehensive Drainage Basin Plan (1998) recommended minimum canopy cover of 60% within the watershed to prevent excessive stormwater impacts. The City of Olympia has downzoned the upper Basin and instituted more stringent development standards to maintain the forest cover and protect the creek. Although the City has instituted these standards, significant residential development pressures exist in this desirable area, especially new home construction.

The headwaters of Green Cove Creek emanate from a large intact wetland complex largely protected by conservation easements, acquisitions, and by the City of Olympia in Grass Lake Park (TCDLE, 2005).

Hydrology

Since the 1850s, approximately 250 acres, or approximately 45 percent of the basin's historic wetlands have been lost.

b) **Riparian Corridor**

The riparian corridor is comprised of mixed conifer and deciduous forest with only a few sites warranting improvement (TCDLE, 2005).

The riparian zone is broad and flat in the areas south of Evergreen Parkway. The vegetation is dominated by wetland shrubs and emergent species. Non-native reed canarygrass and Japanese knotweed have invaded the native vegetation in disturbed areas. Small segments of the upper creek's riparian zone contain mixed forest vegetation.

North of Evergreen Parkway, the creek's riparian zone is densely vegetated with native streamside species such as Oregon ash, black cottonwood, red alder, and western red cedar.

c) **In-Stream and Wetland Habitat Conditions**

Grass Lake wetland and the surrounding area provide habitat for numerous wildlife species. This site was chosen by wildlife biologists as one of the best large wildlife habitats in the Olympia urban area, due to its diversity, size, and shape (Shapiro, 1994). Smaller remnant wetlands are located throughout the upper basin. Some wetlands still maintain high biological integrity, despite human alterations (Thurston County, 1998).

Physical

- Lack of pool habitat and lack of LWD;
- Riparian function concerns (Haring and Konovsky,1999).

Tidal influence occurs in the estuary and at the mouth of the creek, allowing for fresh and saltwater mixing despite the presence of some bulkheads (TCDLE, 2005).

The potential for continued good chum and coho spawning habitat conditions in the future is high. Stormwater discharges have not significantly degraded salmon habitat in the creek, but increased peak flows could cause significant downcutting and lateral stream bank erosion. Upstream wetlands help reduce peak flows in Green Cove Creek (Thurston County, 1998).

The biggest threats to rearing habitat in Green Cove Creek are loss of large woody debris and increased peak flows. The upper basin wetlands mitigate most winter peak flows in the creek, and the relative lack of stormwater discharges to the creek helps prevent peak flow increases. Altering either of these characteristics could lead to degraded rearing habitat (Thurston County, 1998).

Water Quality

Good – Green Cove Creek met both parts of the fecal coliform standard in both water years. All other standards were met (Thurston County, 2010).

Issues: Urban development and stormwater runoff are the biggest threats to water quality in this stream (Thurston County, 2010).

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Green Cove Creek contains chum, winter steelhead, coho, and coastal resident cutthroat.

e) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Implement basin plan recommendation to maintain 60 percent of watershed in undisturbed forest vegetation; and,
- Protect sensitive areas through purchase, conservation easements, or other non-regulatory or regulatory options;
- Restore functional riparian buffers throughout the drainage; and,
- Develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

<u>(TCDLE, 2005)</u>

- Preserve upland forest and restore where necessary. As the basin becomes more developed, peak flow stormwater impacts are expected to adversely affect the watershed. To prevent this, at a minimum, implement the City of Olympia's Green Cove Creek Comprehensive Drainage Plan (1998) that recommends a 60 percent vegetated landscape has been recommended in the City of Olympia's sub-basin plan. Retaining the current forested riparian corridor as habitat is crucial and revegetating areas that have been impacted are very important steps for the creek.
    - Place riparian and wetland areas into easements for long term conservation;
    - Monitor to assure prescriptions recommended in the management plan are adequate.
- Replace the culvert/fishway at Country Club Road. The culvert has been retrofitted with baffles to improve fish passage. However, the culvert still restricts upstream migration for adults and juveniles, limiting access to the wetlands vital to coho and cutthroat for rearing within the freshwater. The culvert also disrupts movement of sediment and wood downstream to lower creek and the marine estuary;
- Preserve estuary functions;
- Restore riparian corridor to provide shade, stabilize streambanks and recruit LWD. Plant appropriate species (incorporate additional conifer in the riparian corridor).

- Conduct a riparian assessment to identify appropriate locations for riparian restoration actions.
- Increase LWD key piece abundance to encourage pool formation and sorting of sediments. Develop a strategy to place instream LWD for immediate benefits until riparian conditions improve to allow natural recruitment.
- Implement restoration efforts consistent with the findings of the Thurston Conservation District's riparian assessment.

4. McLane Creek

Primary land use is rural residential, agriculture, and forestry (Thurston County, 2010). The McLane Creek Basin headwaters originate in the Black Hills, a managed forestland landscape primarily owned by DNR. The middle reach consists of primarily rural residential with some subdivision type development. The lower reach is primarily agriculture, forestry, and rural residential (TCDLE, 2010).

McLane Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 7,100 acres; 100% rural • Total Impervious Area Estimate 1991: 0.6% 2006: 1.0% 2030: 1.5% Buildout: 1.7%	• Effective Impervious Area: 2006: 0.7% • Forest Cover: 72.7% • Unmodified Wetlands: 4.1% • Miles of Stream: 43.8 • Areas of high ground water flooding: 0.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 14.4% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 93.9% 250 ft: 92.0% 1000 ft: 90.8% • # of road crossings per mile of creek: 1.1	• Good amount LWD, poor key piece LWD • Pools fair • Canopy closure not sufficient to maintain water temperatures • Fair amount of fine sediments • Estuary at mouth in good condition	• Monitoring results: fair water quality • The creek usually meets Part 1 but fails Part 2 of the fecal coliform standard. • Phosphorus average is above the reference condition. • Agricultural non-point sources and forest practices have the potential to impact water quality • McLane and Swift Creeks Eld TMDL for fecal coliform	@ Delphi Bridge • B-IBI average 2002-2009: 39 • Note: B-IBI is high at McLane DNR trail • B-IBI range 2002-2009: 36-46 • Chum, coho, coastal resident cutthroat trout, winter steelhead, fall Chinook salmon

a) Basin Conditions

Hydrology

The overall condition of the McLane Creek Basin and estuary at the mouth is relatively good (TCDLE, 2005).

b) **In-Stream and Wetland Habitat Conditions**

Physical

- The total count of LWD pieces in each segment rated as good, the presence of key piece LWD rated as poor;
- Pool surface area >50 percent in both segments (fair), and pool frequency of 2.71 and 2.39 bankfull widths per pool (fair), respectively;
- Mean residual pool depths were 0.39 and 0.41 meters, respectively;
- Substrate sampling using McNeil samplers found fine sediment levels of 16.8 percent and 14.4 percent (both fair), respectively; and,
- Canopy closure was below that necessary to maintain stream temperature in both stream segments (Haring and Konovsky, 1999).

Water Quality

Fair – McLane creek usually meets Part 1 but fails Part 2 of the fecal coliform standard. Phosphorus average is above the reference condition (Thurston County, 2010).

Issues: Agricultural nonpoint sources and forest practices have the potential to impact water quality in this stream. Agricultural nonpoint sources and forest practices have the potential to impact water quality in this stream. A flood event in December 2007 had a significant impact on the creek channel (Thurston County, 2010).

McLane Creek has a TMDL for fecal coliform.

Swift creek has a TMDL for fecal coliform.

c) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

McLane Creek contains chum, coho, winter steelhead, fall Chinook salmon, and coastal resident cutthroat trout.

d) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Restore functional riparian zones (with emphasis on conifer) to address temperature and LWD concerns;
- Develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD; and,
- Identify and implement actions necessary to address fine sediment concerns.

(TCDLE, 2005)

- Improve riparian corridors, primarily in the lower basin, for increased shade and large woody debris (LWD) recruitment. Restore riparian corridor to provide shade, stabilize streambanks and recruit LWD. Utilize Thurston CD riparian assessment to locate riparian restoration sites (in process). Plant appropriate species.
  - Increase LWD key piece abundance to encourage pool formation and sorting of sediments in the lower basin (Swift Creek and McLane Creek). Develop a strategy to place instream LWD for immediate benefits until riparian conditions improve to allow natural recruitment.
- Correct existing fish passage barriers (Beatty Creek, Perkins Creek, Cedar Flats Creek).
- Preserve intact habitat. Several key parcels within the McLane basin have initially been identified for acquisition or easements (e.g. DNR Nature Trail, Sundeen, Drutz). A comprehensive strategy is needed to identify, prioritize, and preserve (acquisition or easements) additional key salmonid habitat areas (off-channel habitats, beaver dam complexes, and wetlands that have open water connections to streams or that regulate the surface water runoff to stream channels).
- Maintain vegetative cover to reduce runoff and erosion that lead to fine sediment deposition. Assure timberland owners within the McLane Creek Basin are in compliance with current regulations.
  - Encourage low impact development.
  - Reforest high impact clearcut-developed areas.
- Educate landowners located in the McLane Creek Basin to increase compliance with land use regulations and voluntary implementation of best management practices.
- Fix road surface runoff from directly entering Beatty Creek on Andreson Road.
- Preserve estuary.
  - Restore/preserve estuary shoreline through riparian plantings, livestock exclusion, and long-term conservation easements. Explore opportunities to alleviate the threat of future development.
- Protect sensitive habitat features/processes from incompatible land uses (impacts) through implementation and enforcement of Thurston County Critical Areas Ordinances regulations.
- Protect hydrologic integrity within the basin. The impervious surface area within the McLane basin is estimated to be close to 5 percent. Over 5 percent is considered the threshold of impervious surface having an impact on instream flows and habitats.

5. Perry Creek

Primary land use is rural residential, agriculture, and forestry (Thurston County, 2010).

Perry Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 4,120 acres; 100% rural • Total Impervious Area Estimate 1991: 1.2% 2006: 1.9% 2030: 2.1% Buildout: 2.1%	• Effective Impervious Area: 2006: 1.3% • Forest Cover: 80.3% • Unmodified Wetlands: 0.5% • Miles of Stream: 20.9 • Miles of Marine Shoreline: 1.3 • Areas of high ground water flooding: 0.0% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 32.4% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 91.9% 250 ft: 91.6% 1000 ft: 91.7% • # of road crossings per mile of creek: 1.7	• Poor to good riparian canopy closure • Poor to fair streambank condition - channelization of portions of lower mile of stream • Poor floodplain connectivity • Poor to good LWD abundance; poor key piece abundance • Poor to fair pool frequency; poor to good pool quality • Fair change in flow regime • Good biological processes • Good substrate embeddedness • A falls blocks anadromy at river mile 1.2	• Monitoring results: good water quality • Met both parts of the fecal coliform standard. • Met all other water quality standards. • Agricultural practices, septic systems, and forest practice may impact the water quality of this stream. • Eld TMDL for fecal coliform	• B-IBI average 2002-2009: 44 • B-IBI range 2002-2009: 38-50 • Chum, coho, winter steelhead, coastal resident cutthroat.

a) In-Stream and Wetland Habitat Conditions

Physical

- Good substrate embeddedness;
- Fair change in flow regime;
- Good biological processes;
- Poor fish passage;
- Poor to good riparian canopy closure;
- Poor to fair streambank condition - channelization of portions of lower mile of stream
- Poor floodplain connectivity;
- Good to poor LWD abundance; poor key piece abundance;
- Poor to fair pool frequency; poor to good pool quality (WRIA 14, Salmonid Habitat Limiting Factors Report, 2002).

A falls blocks anadromy at river mile 1.2 (Washington Department of Fisheries 1975).

Water Quality

Good - Perry Creek met both parts of the fecal coliform standard. Met all other water quality standards (Thurston County, 2010).

Issues: Agricultural practices, on-site septic systems in close proximity to the stream, and forest practice have the great potential to impact the water quality of this stream (Thurston County, 2010).

Perry Creek has a TMDL for fecal coliform (Ecology, 2008)

b) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Perry Creek contains chum, coho, winter steelhead, coastal resident cutthroat.

c) **Action Recommendations**

(WRIA 14, Salmonid Habitat Limiting Factors Report, 2002)

- Replace culverts acting as fish barriers;
- Improve land use regulations and enforcement, and replant native riparian vegetation, particularly conifers along lower mile of Perry Creek;
- Remove any dikes or riprap that are channelizing stream; restore meandering channel geometry;
- Prevent additional development on floodplains and along channel banks;
- Preserve large coniferous trees in riparian zones; place LWD in spawning and rearing reaches; restore meandering channels; leave LWD in channels and replant native riparian vegetation, particularly conifers.

6. Squaxin Passage

Squaxin Passage					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 490 acres; 100% rural • Total Impervious Area Estimate 1991: 5.5% 2006: 9.6% 2030: 10.7% Buildout: 11.2%	• Effective Impervious Area: 2006: 6.8% • Forest Cover: 68.4% • Unmodified Wetlands: 0.3% • Miles of Stream: 0.9 • Miles of Marine Shoreline: 3.4 • Areas of high ground water flooding: 0.2% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 6.0% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 57.6% 250 ft: 53.7% 1000 ft: 56.8% • # of road crossings per mile of creek: 3.5	• No data	• Shellfish growing area on north side is prohibited. Shellfish growing area on east side is approved.	• Benthic levels unknown • Marine shoreline: forage fish • Shellfish habitat along much of coastline

a) In-Stream and Wetland Habitat Conditions

Water Quality

The shellfish growing area on the north side of Squaxin Passage near Carlyon Beach is prohibited. Shellfish growing area on east side of Squaxin Passage south of Hunter Point is approved.

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

The marine shoreline supports forage fish spawning.

Shellfish

The marine shoreline contains shellfish habitat along much of the coastline.

c) Action Recommendations

<u>(WRIA 14, Salmonid Habitat Limiting Factors Report, 1999)</u>
None noted.

C. Nisqually River Watershed (but in WRIA 13)

1. Nisqually Reach

Nisqually Reach					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 5,270 acres; urban growth area 29%; rural 71% • Total Impervious Area Estimate 1991: 2.2% 2006: 9.9% 2030: 13.8% Buildout: 15.0%	• Effective Impervious Area: 2006: 7.7% • Forest Cover: 66.0% • Unmodified Wetlands: 6.5% • Miles of Stream: 10.1 • Miles of Marine Shoreline: 11.1 • Areas of high ground water flooding: 0.3% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 25.4% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 90.6% 250 ft: 88.2% 1000 ft: 78.6% • # of road crossings per mile of creek: 1.4	• No data	• Some shellfish growing areas are approved, and some are prohibited. • Part of Nisqually TMDL	• Benthic levels unknown • Fall chum • Marine shorelines: forage fish • Shellfish habitat along entire coastline

a) In-Stream and Wetland Habitat Conditions

Water Quality

Nisqually Reach/Drayton Passage (just south of the City of Lacey) is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform (Ecology, 2008).

Nisqually Reach/Drayton Passage has a TMDL for fecal coliform in another location (Ecology, 2008).

Some shellfish growing areas are approved, and some are prohibited. The Nisqually Reach is part of the combined Nisqually Reach and Henderson Inlet Shellfish Protection Districts. The Shellfish Protection Districts work to provide recommendations on how to restore water quality in the Nisqually Reach and Henderson Inlet to shellfishing standards.

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

An unnamed stream contains fall chum. The marine shoreline supports forage fish spawning.

Shellfish

The marine shoreline contains shellfish habitat along the entire coastline.

c) **Action Recommendations**

(Haring and Konovsky, 1999)

None noted.

D. Henderson Inlet Watershed

1. Dana Passage

Dana Passage					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 1,500 acres; 100% rural • Total Impervious Area Estimate 1991: 1.8% 2006: 3.9% 2030: 5.2% Buildout: 5.8%	• Effective Impervious Area: 2006: 2.5% • Forest Cover: 78.6% • Unmodified Wetlands: 6.5% • Miles of Stream: 1.8 • Miles of Marine Shoreline: 7.3 • Areas of high ground water flooding: 0.1% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 17.6% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 95.3% 250 ft: 92.0% 1000 ft: 86.2% • # of road crossings per mile of creek: 1.7	• Stormwater impacts	• No data	• Benthic levels unknown • Marine shoreline supports forage fish. • Shellfish habitat is present in the Zangle Cove area. • Shellfish growing area is approved

a) In-Stream and Wetland Habitat Conditions

Physical

Stormwater impacts have been raised as an issue of concern by a private landowner.

Water Quality

The shellfish growing area is approved

b) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Marine shoreline contains forage fish.

Shellfish

Shellfish habitat is present in the Zangle Cove area.

c) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

None noted.

2. Henderson

Within Olympia city limits, the primary land use is urban moderate-to-high-density residential and commercial. Within the county, it is rural-to-moderate-density residential intermixed with businesses. (Thurston County, 2010).

Henderson

Current Aquatic Habitat Conditions

Level of Urbanization	Basin and Riparian Conditions		In-Stream and Wetland Habitat Conditions		Aquatic Biota
	Hydrology	Riparian Corridor	Physical Conditions	Water Quality	
East • Basin area 3,300 acres; 100% rural • Total Impervious Area Estimate 1991: 1.9% 2006: 4.5% 2030: 5.3% Buildout: 5.6% West • Basin area 3,100 acres; 100% rural • Total Impervious Area Estimate 1991: 1.2% 2006: 2.6% 2030: 3.2% Buildout: 3.4%	East • Effective Impervious Area: 2006: 3.0% • Forest Cover: 67.8% • Unmodified Wetlands: 10.9% • Miles of Stream: 7.9 • Miles of Marine Shoreline: 6.5 • Areas of high ground water flooding: 0.2% of basin West • Effective Impervious Area: 2006: 1.7% • Forest Cover: 66.6% • Unmodified Wetlands: 12.8% • Miles of Stream: 7.7 • Miles of Marine Shoreline: 12.5 • Areas of high ground water flooding: 2.8% of basin	East • Coniferous forest cover in 250 stream riparian corridor: 2006: 21.7% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 80.6% 250 ft: 78.4% 1000 ft: 73.6% • # of road crossings per mile of creek: 2.0 West • Coniferous forest cover in 250 stream riparian corridor: 2006: 20.6% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 81.0% 250 ft: 78.1% 1000 ft: 72.9% • # of road crossings per mile of creek: 1.4	• No Data	Fleming Creek (Henderson 6): • 303(d): fecal coliform, pH Sleepy Creek (Henderson 1): • 303(d): pH, dissolved oxygen • Southern inlet part of Henderson TMDL	• Benthic levels unknown • chum, coho, coastal resident cutthroat, Marine shoreline: forage fish. • Shellfish habitat is present throughout Henderson Inlet • Areas of shellfish habitat in Henderson Inlet are prohibited and conditional

a) In-Stream and Wetland Habitat Conditions

Water Quality

Poor - Fecal coliform concentrations are consistently high and fail both parts of the standard. Elevated metals and organics detected in creek sediments in past studies. Nitrate concentrations are high (Thurston County, 2010).

Issues - Fecal coliform bacteria contamination continues to a problem in this urban stream. Storm water runoff from city streets and Interstate Highway 5 discharges into the creek and contributes to water quality problems (Thurston County, 2010).

Fleming Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for fecal coliform and pH.

Sleepy Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for pH and dissolved oxygen.

Henderson Inlet is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen.

Sleepy Creek has a TMDL for fecal coliform.

Dobbs Creek has a TMDL for fecal coliform.

Myer Creek has a TMDL for fecal coliform.

Henderson Inlet has a TMDL for fecal coliform.

Areas of shellfish growing in Henderson Inlet are prohibited and conditional. Henderson Inlet is part of the combined Nisqually Reach and Henderson Inlet Shellfish Protection Districts. The Shellfish Protection Districts work to provide recommendations on how to restore water quality in Henderson Inlet and the Nisqually Reach to shellfishing standards.

b) **Aquatic Biota**

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Henderson Basin includes chum, coho, and coastal resident cutthroat.

The marine shoreline supports forage fish spawning.

Shellfish

Shellfish habitat is present throughout Henderson Inlet

c) **Action Recommendations**

<u>(Haring and Konovsky,1999)</u>
None noted.

3. Woodard

Woodard Creek Basin encompasses eight square miles of mostly level, glacially formed terrain south and west of Henderson Inlet. Most of the basin area lies at an elevation of less than 200 feet above sea level. The basin includes the southern portion of Dickerson peninsula. Several depressions contain small wetlands and a slight rise on the peninsula form the basin's western boundary (Thurston County, 1995b).

Woodard Creek flows out of a 45-acre wetland contained in a small, steep-sided depression just south of the Pacific Avenue/Interstate 5 interchange, at an elevation of about 150 feet. The creek flows north through low-lying wetlands and enters a flat-bottomed ravine on St. Peter's Hospital property north of Martin Way. The creek winds through a strip of riparian wetlands, then the ravine narrows and steepens as it cuts through the Dickerson Point peninsula north of 36th Avenue NE. Woodard Creek empties into the Woodard Bay estuary which is midway along the western shore of Henderson Inlet (Thurston County, 1995b).

Woodard Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 5,310 acres; urban growth area 41%; rural 59% • Total Impervious Area Estimate 1991: 9.1% 2006: 14.2% 2030: 16.6% Buildout: 17.2%	• Effective Impervious Area: 2006: 11.2% • Forest Cover: 45.9% • Unmodified Wetlands: 13.8% • Miles of Stream: 14.8 • Areas of high ground water flooding: 3.4% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 10.0% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 73.3% 250 ft: 69.8% 1000 ft: 55.7% • # of road crossings per mile of creek: 2.8 • Riparian area impaired by removal of riparian vegetation, direct animal access to the stream, and by the lack of conifers in remaining riparian buffers. • Downstream riparian area somewhat impaired by clearing • Upstream riparian area very impaired by clearing	• Natural flow-regime altered from rapid urbanization • High water temperature • Lack of LWD • Alteration of the headwater wetland hydrology, but still high quality habitat • Estuarine wetland at mouth in good condition	• Monitoring results: fair water quality • Met Part I of the fecal coliform standard but consistently fails Part 2. • High nitrate and total phosphorus • Impacts from urban stormwater runoff • Impacts from agricultural practices and septic systems in the rural area. • Urban growth area continuing to develop, making efforts to reduce pollution and meet water quality standards challenging • 303(d): dissolved oxygen • Henderson TMDL for fecal coliform	• B-IBI average 2002-2009: 41 • B-IBI range 2002-2009: 36-46 • Woodard Creek: chum, coho, winter steelhead, coastal resident cutthroat trout.

a) Basin Conditions

Level of Urbanization

Woodard Creek empties into Woodard Bay, an intact salt marsh owned and protected by a Department of Natural Resources (DNR) Natural Areas Preserve. The remainder of the stream is in private development (TCDLE, 2005). Primary land use is urban residential, rural residential, and commercial (Thurston County, 2010).

Woodard Creek basin ranges from highly developed in the urban core to sparsely developed in the rural fringes. Southern Woodard Creek basin is dominated by high-density commercial and industrial areas, with medium-to-high density residential areas encircling the commercial zones. The highly developed commercial district falls on the Olympia-Lacey boundary around Pacific Avenue, Martin Way, Lily Road, and Fones Road. The area includes a shopping center that drains to the wetland at the headwater of Woodard Creek. The northern half of Woodard Creek basin, primarily north of the urban growth area, contains mostly sparse, rural areas with many large lots and small farms. Large tracts of second growth forest still cover northern Woodard Creek basin (Thurston County, 1995b).

Problems associated with the development in Woodard Creek basin are increased runoff, contaminated runoff, decreased groundwater recharge, encroachment into stream buffers, and resulting water quality and habitat degradation (Thurston County, 1995b).

Hydrology

The natural flow regime has been altered by rapid urbanization (Haring and Konovsky, 1999). Woodard Creek is extremely sensitive to individual rain events because stormwater runoff from a major, highly developed commercial and industrial area drains directly into the headwaters of the creek. Extensive wetlands between Fones Road and St. Peters Hospital absorb runoff and reduce the stormwater's impact on downstream flows. Peak flows at the mouth have increased to a lesser extent than upstream flows because the downstream basin has not been developed as extensively as the upper basin (Thurston County, 1995b).

b) Riparian Corridor

The riparian area has been impaired by the removal of riparian vegetation, by direct animal access to the stream at several locations, and by the lack of conifers in remaining riparian buffers. The stream banks in the lower reaches consist of open farmland and rural residences, interspersed with deciduous and coniferous forest. The portion of the stream corridor upstream of 36th Avenue has severely compromised riparian areas in urban and residential areas (Thurston County, 1995b; Haring and Konovsky, 1999).

There are three major road crossings clustered together near the headwaters: Pacific Avenue, Martin Way, and Interstate 5 (Thurston County, 1995b).

c) **In-Stream and Wetland Habitat Conditions**

Physical

- Barriers to fish passage;
- Water temperature;
- Lack of large woody debris (LWD). Lack of LWD has been identified as a habitat concern in several studies. LWD is necessary to create pools and habitat diversity and complexity in this channel, which is currently characterized as monotypic runs (Haring and Konovsky, 1999).

Approximately 6.9 miles of the Woodard Creek mainstem are accessible to anadromous fish. Between the headwaters and 36th Avenue, the stream has a low gradient and a pool/glide configuration with isolated riffles. Downstream of 36th Avenue, the stream has a low-to-moderate gradient and a good pool/riffle configuration. The lower reaches contain fairly pristine estuarine wetlands that offer good habitat for anadromous and resident fishes (Thurston County, 1995b).

However, human encroachment in the basin is rapidly altering and eliminating these fish-producing areas. The existing level of development in the basin has caused increased winter flood flows and summer low flows. Increased winter flood flows have significantly degraded fish habitat in some reaches of both creeks causing considerable erosion, sedimentation, scour out spawning gravels, loss of large logs, eliminating redds, preventing spawning fish from migrating upstream, and reducing the available refuge. Summer low flows may strand young salmon and prevent them from migrating to Puget Sound (Thurston County, 1995b).

The basin contains about 334 acres of inventoried wetlands directly associated with the creek, or about 7.5 percent of the total basin area. The basin contains significant forested or shrub-covered Palustrine wetlands along and adjacent to the creek. About 179 acres of riparian wetland between Pacific Avenue and South Bay Road provide rearing habitat for coho salmon. The Woodard Creek headwaters is a 45-acre wetland. The mouth of Woodard Creek is an estuarine wetland, currently protected as a natural area by the Washington Department of Natural Resources. The 45-acre wetland at the headwaters of Woodard Creek and a 44-acre Palustrine wetland on St. Peter's Hospital Property have been identified by the City of Olympia as significant wildlife habitat, and targeted for acquisition or protection (Thurston County, 1995b).

The Woodard headwater wetland has been altered by humans. A culvert blocked anadromous fish access, eliminating coho-rearing habitat. In 1979, a road was constructed across the wetland, part of the wetland was filled, and a culvert was installed. Some of the fill was removed in the early 1980's after wetland regulations passed. The industrial and commercial development on Fones Road and large, high-density commercial areas drain into the wetland. These alterations have severely changed the wetland's hydrology. Further development threatens the forested uplands abutting the wetland (Thurston County, 1995b).

Water Quality

Fair – Met Part I of the fecal coliform standard but consistently fails Part 2. It is listed on 303d list for past violations of fecal coliform, dissolved oxygen and pH standards. Nitrate and total phosphorus levels are high (Thurston County, 2010).

Issues: Impacts from stormwater runoff in the urban area. Impacts from agricultural practices and septic systems in the rural area are noted. Continuing development within the urban growth area makes efforts to reduce pollution and meet the water quality standards challenging (Thurston County, 2010).

Woodard Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen (Ecology, 2008). Woodard Creek has a TMDL for fecal coliform (Ecology, 2008).

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Woodard Creek contains chum, coho, winter steelhead, and coastal resident cutthroat trout.

Shellfish

Since the mid- 19th century, Henderson Inlet has been one of the Puget Sound's most productive shellfish harvesting areas. Shellfish resources in Henderson Inlet include oysters, clams, mussels, and geoducks. Pollution from surface water runoff threatens this industry. Since 1983, 163 acres of commercial shellfish beds at the mouth of Henderson Inlet have been closed or conditionally closed, due to fecal coliform pollution.

e) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Prioritize and correct fish passage barriers;
- Restore LWD presence in the channel;
- Restore functional riparian zones throughout watershed, including reestablishment of high density conifer presence in the riparian zone;
- Preserve and restore headwater wetlands; and,
- Identify sites with unrestricted livestock access to the channel; report to Thurston County Health Department for correction.

4. Woodland

Woodland Creek basin contains mostly level, glacially formed terrain south of Henderson Inlet. Most of the basin area lies less than 200' above sea level. The highest point of the basin is around 320' above sea level at an indistinct line of low hills south of Pattison Lake.

The Woodland Creek basin contains four lakes connected by extensive wetlands in a horseshoe-shaped chain at the head of Woodland Creek. Hicks Lake flows into Pattison Lake, which flows into Long Lake, and then Lake Lois. The creek flows through a narrow, steep-sided ravine through second growth forest on the St. Martin's College campus. Woodland Creek broadens and flattens somewhat as it continues flowing north through gently rolling hills before reaching the mud flats at the southern terminus of Henderson Inlet (Thurston County, 1995b).

Woodland Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 16,280 acres; urban growth area 81%; rural 19% • Total Impervious Area Estimate 1991: 14.4% 2006: 21.4% 2030: 26.4% Buildout: 28.6%	• Effective Impervious Area: 2006: 17.7% • Forest Cover: 40.1% • Unmodified Wetlands: 9.2% • Miles of Stream: 23.4 • Lakes: Long, 319.1 ac; Pattison 272.0 ac; Hicks, 169.6 ac; Goose, 13.6 ac; Lake Lois, 10.3 ac; Goose Pond, 3.7 ac; Lake Lois West, 2.2 ac • Areas of high ground water flooding: 0.6% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 16.6% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 81.3% 250 ft: 77.3% 1000 ft: 62.2% • # of road crossings per mile of creek: 2.1 • Riparian buffer somewhat impacted	• High water temperature • Lack of LWD • Bank stability is limiting factor • Excess fine sediment • Altered natural flow regime – increased winter flood flows and summer low flows • Reduced refuge habitat • Many wetlands have been filled • Estuary at mouth in good condition	Woodland Creek: • Monitoring results: fair water quality • Failed both parts of the fecal coliform standard. • Nitrate and total phosphorus high. • Urban stormwater impacting water quality. • Failing septic systems and livestock are a source of pollution in the rural watershed. • Improved water quality in the marine water resulted in an upgrade of 240 acres of commercial shellfish harvest area in 2010. • 303(d): temperature • Cat 4C, Impaired by non-pollutant: Low instream flow • Henderson TMDL for fecal coliform Fox Creek: • 303(d): dissolved oxygen • Henderson TMDL for fecal coliform Palm Creek • 303(d): dissolved oxygen Jorgerson Creek: • Henderson TMDL for fecal coliform Eagle Creek: • Henderson TMDL for fecal coliform	@ Pleasant Glade Road • B-IBI average 2002-2009: 33 • B-IBI range 2002-2009: 30-38 • Woodland Creek: coho, chum, Fall Chinook salmon, winter steelhead, coastal resident cutthroat trout, and largemouth bass. • Hicks and Pattison Lakes: rainbow trout.

Woodland Creek - Water Quality Continued				
Hick's Lake: • Monitoring results: good water quality • Low water levels in summer • Outlet is not maintained causing high lake levels and flooding in winter • High density residential land use, stormwater discharge, and non-point pollution could degrade water quality if not stopped. • Ecology Cat 4C, Impaired by non-pollutant: Invasive Exotic Species	Long Lake: • Monitoring results: fair water quality • Algal blooms due to phosphorus • 303(d): PCB, 2,3,7,8-TCDD, Total Phosphorus • Cat 4C, Impaired by non-pollutant: Invasive Exotic Species, Eurasian water milfoil, and fragrant waterlily.	Pattison Lake: • Monitoring results: fair water quality • Outlet channel is sometimes blocked, resulting in flooding • Algal blooms from abundant nutrients • 303(d): total phosphorus	Tanglewilde Outfall: • Monitoring results: poor water quality • Fails fecal coliform during storm events. • Stormwater at this outfall carries high bacterial and nutrient pollution to Woodland Creek. • Septics and other urban activities are contaminating shallow groundwater which is infiltrating into the stormwater system. • TC has project to reduce stormwater and improve water quality through bioswales and raingardens. • Very high nitrate concentrations.	Lois Lake: • Cat 4C, Impaired by non-pollutant: Invasive Exotic Species

a) **Basin Conditions**

Level of Urbanization

The primary land use in Woodland basin is urban and suburban residential with a small percentage in undeveloped forest cover primarily in wetland areas. Dense residential development exists along the shore of Long Lake (Thurston County, 2010). Residential development dominates the headwaters at the lake/wetland complex. Urban land uses within the City of Lacey dominate the central basin. The lower watershed becomes semi-rural residential as it drains to its mouth at Henderson Inlet. The final reach of the creek above the Henderson Inlet estuary is a habitat preserve owned by Thurston County (TCDLE, 2005).

Development throughout the watershed basin impacts the natural function of Woodland Creek (TCDLE, 2005). Problems associated with development in Woodland Creek basin include increased runoff, contaminated runoff, decreased ground water recharge, and encroachment into stream buffers resulting in water quality and habitat degradation (Thurston County, 1995b).

Hydrology

- Alteration of the natural flow regime resulting from rapid urbanization (Haring and Konovsky, 1999).

The characteristic hydrology of Woodland Creek includes very high peak flows during heavy rains and long low flow or dry periods in the summer. The peak flows are more extreme near the mouth of Woodland Creek; the dry reaches occur primarily between Lake Lois to just downstream of Martin Way (Thurston County, 1995b).

Woodland Creek flows out of a large wetland and lakes complex that includes Hicks, Pattison, and Long Lakes. The flat topography, soils, and lakes of this area absorb rainfall and help mitigate the impacts of development on the headwaters of the creek. The creek flows from Hicks Lake into Lake Lois which stores and detains most of the stream flow. The buffering effect of the wetlands in the headwaters results in peak flows at Long Lake and Martin Way that are only slightly larger than natural flows compared to downstream locations. The creek shows less response to summer droughts downstream (north) of Martin Way because groundwater-fed wetlands and a large, spring-fed tributary provide year round base flow to this area (Thurston County, 1995b).

Woodland Creek basin contains about 545 acres of mostly freshwater (Palustrine) wetlands, or about 2.9 percent of the basin. Major wetlands occur in areas around Hicks, Pattison, Long, and Lois Lakes, north of the Martin Way/Interstate 5 interchange, and at the creek mouth. The area is rapidly developing and many wetlands have already been lost to filling, however, wetland loss in the basin has slowed since Lacey adopted a wetland protection ordinance in 1992 (Thurston County, 1995b).

Hicks Lake lies at the upper end of the Woodland Creek basin and is fed primarily by groundwater seepage and surface flow. The lake discharges through a 38-acre Palustrine wetland located on the southwest border of the lake. A seasonally flooded, 162-acre palustrine wetland, characterized by shrub and emergent cover, lies between Pattison and Hicks Lakes. A 119-acre, seasonally flooded Palustrine wetland, characterized by shrub cover, lies between Pattison and Long Lakes. Many years ago, a ditch was constructed between Pattison and Long Lakes to float logs. The ditch still exists. The north end of Long Lake contains a permanently flooded 39-acre lacustrine wetland. From the north end of Long Lake, Woodland Creek flows north to a 70-acre Palustrine seasonally flooded wetland near the intersection of Martin Way and Interstate 5. Woodland Creek north of Martin Way Many is fed by many small, spring-fed wetlands. These wetlands are fed by groundwater which helps dilute creek water degraded by contaminated stormwater runoff from outfalls on Martin Way. Woodland Creek's mouth lies in an estuarine wetland, currently protected as a county-owned preserve. The slope within the creek mouth is mild and the tide influences the creek discharge (Thurston County, 1995b).

b) Riparian Corridor

Some native vegetation still surrounds the ditch connecting Pattison and Long Lakes. Between Long Lake and the Palustrine wetland north of the Martin Way/Interstate 5 interchange, the stream riparian area contains wetland plants. The riparian areas in the lower reaches of Woodland Creek consist of open farmland and rural residences, interspersed with coniferous and deciduous forest (Thurston County, 1995b).

c) In-Stream and Wetland Habitat Conditions

Physical

- Barriers to fish passage, and
- Water temperature/excess fine sediment/lack of large woody debris (LWD) (Haring and Konovsky, 1999).

Urbanization in Woodland Creek basin has lead to increased winter flood flows and summer low flows. Increased winter flood flows have significantly degraded fish habitat in some reaches of Woodland Creek. Increased stream flows cause significant erosion and sedimentation, scour out spawning channels, loss of large wood, elimination of redds, prevention of fish migration upstream to spawn, and reduce available refuge. Woodland Creek between Pleasant Glad Road and Draham Road showed a decline in all refuge habitat following increased winter flows. Woodland Creek has dried up completely between Lake Lois and Martin Way for up to six months, resulting in significantly reduced habitat and fish productivity in the creek. Extreme summer low flows in other areas have been shown to limit the ability of juvenile salmon to migrate to the sound, as well as prevent summer-run salmon from migrating up the stream (Thurston County, 1995b).

Woodland Creek has conditions in some of its reaches which provide good spawning and rearing habitat for anadromous fish, such as gentle to moderate gradient, good pool/riffle conditions, cold water, and gravelly beds. The lower reaches of Woodland Creek contain fairly pristine estuarine wetlands which offer good habitat for anadromous and resident fish (Thurston County, 1995b).

Approximately 5.6 miles of the mainstem of Woodland Creek are accessible to anadromous fish when flows are sufficient. A short spring-fed tributary enters the stream at mile 3.3 and provides most of the summer low flow for the lower stream. Woodland Creek between mile 3.3 and Lake Lois at mile 4.6 often goes dry between summer and fall. The reach between Long Lake (mile 5.6) and Lake Lois flows year-round. Chum, coho, and Chinook salmon primarily spawn below mile 3.3 in the spring fed tributary, however, chum, coho, steelhead, and sea-run cutthroat have been observed spawning as far upstream as mile 5.0. Juvenile chum and Chinook may use the entire 5.6 miles for seasonal rearing habitat (Thurston County, 1995b).

A study conducted in 1991 showed degraded habitat in Woodland Creek in the urbanizing area upstream of 21st Court NE. The habitat degradation appeared to be caused largely by the removal of large woody debris from the channel. The channel downstream of 21st Court was in fairly good condition. Woodland Creek contains a high percentage of sand which may be high due to soil erosion and increased stormwater runoff from urbanization.

Water Quality

Fecal coliform contamination of shellfish beds in Henderson Inlet is a significant issues. Studies have concluded that stormwater is the major contributor of fecal coliform contamination in Henderson Inlet. Stormwater analyses have also revealed high levels of heavy metals in the basin’s urban runoff (Thurston County, 1995b).

Woodland Creek - Fair - Failed both parts of the fecal coliform standard. Woodland Creek is listed on the 303d list for violations of fecal coliform, dissolved oxygen, and temperature in the upper reach. Nitrate and total phosphorus is high (Thurston County, 2010).

Issues — Woodland Creek — Urban stormwater discharges are contributing to water quality problems. Failing on-site sewage systems and poor livestock-keeping practices are a source of pollution in the rural part of the watershed. Improved water quality in the marine water resulted in an upgrade of 240 acres of commercial shellfish harvest area in Henderson Inlet in 2010 (Thurston County, 2010).

Good — Hicks Lake — The water quality is generally good and supports the beneficial uses of the lake. The phosphorus concentration is below state standards (Thurston County, 2010).

Issues for Hicks Lake: Low water levels occur during summer months, especially during periods of drought such as in 2001. High lake levels can also occur during higher than normal winter rainfall conditions. Extreme high lake levels cause flooding of some lakeshore structures. The outlet channel is on private property, is not maintained, and restricts the flow of water out of the lake. High-density residential land use, stormwater discharges, and other non-point pollution in this urban setting could degrade water quality if measures are not taken to prevent it (Thurston County, 2010).

Fair — Long Lake — The lake experiences nuisance bluegreen algae blooms and many areas of the lake have emergent aquatic plants that interfere with recreational activities. The north basin has better water quality than the south basin. The noxious aquatic plant, Eurasian water milfoil was discovered in the lake in the 1980s, and has been controlled through handpulling and bottom barriers. A second noxious plant, fragrant waterlily, is being treated with glyphosate and rhizome removal (Thurston County, 2010).

Issues for Long Lake: The Long Lake Steering Committee is implementing the Long Lake Integrated Management Plan to try to decrease phosphorus loading and elliminate noxious aquatic plant species (Thurston County, 2010).

Fair — Pattison Lake — Algae blooms, filamentous algae growth, and aquatic plant growth, at times, impair water clarity and fishing and boating activities, especially in the south basin (Thurston County, 2010).

Issues for Pattison Lake: Blockages in the outlet channel in past years have caused the lake level to rise, flooding docks and yards. Abundant nutrients often create algae blooms, which reduce water clarity. Nutrients also stimulate filamentous algae growth, especially in the south basin, which form floating mats on the surface that impair recreational uses (Thurston County, 2010). Tanglewild Outfall - Poor - Fails the fecal coliform standard during storm events. Nitrate concentrations are very high in the base flow due to shallow groundwater contamination (Thurston County, 2010).

Issues - Tanglewild Outfall - Stormwater discharged from this outfall is a major source of bacteria and nutrient pollution to Woodland Creek. On-site septic systems and other urban activities are contributing to contamination of the shallow ground water in the area, which is infiltrating into the stormwater system. Thurston County has a project underway to reduce the stormwater volume and improve water quality through rehabilitation of dry wells, restoration of lawns, and installation of bioswales and rain gardens in the Tanglewilde neighborhood (Thurston County, 2010).

Woodland Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for temperature (Ecology, 2008). Woodard Creek has a TMDL for fecal coliform. Woodland Creek is listed on Ecology's Cat 4C list of impaired by a non-pollutant for impaired by low instream flow.

Fox Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen (Ecology, 2008). Fox Creek has a TMDL for fecal coliform.

Long Lake is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for PCB, 2,3,7,8-TCDD, and total phosphorus (Ecology, 2008). Long Lake is listed on Ecology's Cat 4C list of impaired by a non-pollutant for invasive exotic species.
Palm Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen (Ecology, 2008).

Patterson Lake is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for total phosphorus (Ecology, 2008).

Jorgerson Creek has a TMDL for fecal coliform.

Eagle Creek has a TMDL for fecal coliform.

Hicks Lake is listed on Ecology's Cat 4C list of impaired by a non-pollutant for Invasive Exotic Species.

Lois Lake is listed on Ecology's Cat 4C list of impaired by a non-pollutant for Invasive Exotic Species.

d) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Woodland Creek contains coho, chum, fall Chinook salmon, winter steelhead, coastal resident cutthroat trout, and largemouth bass.

Hicks and Pattison Lakes contain rainbow trout.

Shellfish

Shellfish resources within Henderson Inlet at the mouth of Woodland Creek, include oysters, clams, mussels, and geoducks. Commercial shellfish harvest of oysters and clams began in Henderson Inlet in the mid 19th century. Henderson Inlet is one of Puget Sound's most productive shellfish harvesting areas; however, pollution from surface water runoff threatens this industry. Since 1983, 163-acres of commercial shellfish beds at the mouth of Henderson Inlet have been closed or conditionally closed due to pollution. Woodland Creek has been identified as the major source of fecal coliform contamination causing shellfish closures in Henderson Inlet (Thurston County, 1995b).

e) **Action Recommendations**

<u>(Haring and Konovsky, 1999)</u>

- Prioritize and correct fish passage barriers;
- Restore LWD presence in the channel, both in short-term and long-term;

- Restore functional riparian zones throughout watershed, including reestablishment of high density conifer presence in the riparian zone;
- Evaluate fine sediment impacts and develop plan to restore substrate function, if needed; and,
- Identify sites with unrestricted livestock access to the channel; report to Thurston County Health Department for correction.

(TCDLE, 2005)

- Restore riparian corridor to provide shade, stabilize streambanks and recruit LWD. Plant appropriate species (incorporate additional conifer in the riparian corridor).
    - Utilize the City of Lacey's riparian assessment to identify appropriate locations for riparian restoration actions.
- Increase LWD key piece abundance to encourage pool formation and sorting of sediments. Develop a strategy to place instream LWD for immediate benefits until riparian conditions improve to allow natural recruitment.

E. Totten Inlet Watershed

1. Burns/Pierre

Burns/Pierre					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 370 acres; 100% rural • Total Impervious Area Estimate 1991: 1.4% 2006: 2.5% 2030: 3.5% Buildout: 3.8%	• Effective Impervious Area: 2006: 1.7% • Forest Cover: 69.9% • Unmodified Wetlands: 0.1% • Miles of Stream: 1.0 • Miles of Marine Shoreline: 1.5 • Areas of high ground water flooding: 0.3% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 18.0% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 82.9% 250 ft: 79.9% 1000 ft: 80.8% • # of road crossings per mile of creek: 3.8	• No data	• Part of Totten TMDL	• Benthic levels unknown • Shellfish habitat

a) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

No fish use was noted.

Marine Mammals and Shellfish

The marine shoreline contains shellfish habitat.

b) Action Recommendations

<u>(Haring and Konovsky, 1999)</u>

None noted.

2. Kennedy Creek

Primary land use is rural residential, forestry, and some farming (Thurston County, 2010). There is commercial timber in the upper reaches. The valley floor through the middle reach contains private ownership with limited rural residential development, and the estuary is surrounded by the Department of Natural Resources Natural Area Preserve (MCDLE, 2004).

The headwaters of Kennedy Creek are dominated by commercially managed forestlands, transitioning to private land in deciduous forests and pasture lands along the valley floor. Portions of the basin are owned by Taylor Shellfish Company. In the middle stretch of the creek, there is some light rural residential. The lower half of the creek and its estuary where DNR owns and manages a Natural Areas Preserve are impacted by U.S. 101 and the Old Olympic Highway (MCDLE, 2004).

Kennedy Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 12,770 acres; 100% rural • Total Impervious Area Estimate 1991: 0.9% 2006: 1.5% 2030: 1.6% Buildout: 1.7%	• Effective Impervious Area: 2006: 1.0% • Forest Cover: 68.0% • Unmodified Wetlands: 5.4% • Miles of Stream: 79.6 • Lakes: Summit, 530.0 ac • Areas of high ground water flooding: 0.0% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 26.1% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 93.3% 250 ft: 92.6% 1000 ft: 91.4% • # of road crossings per mile of creek: 1.8	• Fair change in flow regime • Good biological processes • Poor canopy closure • Poor streambank condition due to high levels of streambank erosion • Poor key peice LWD abundance; good to fair total LWD abundance • Poor to good pool frequency and quality • Fair to poor substrate embeddedness • Anadromy is blocked at river mile 2.5 by a natural series of falls.	• Monitoring results: good water quality • Passed both parts of the bacteria standard. • Occasional dissolved oxygen violations during the summer low flow period. • Turbidity occasionally exceeds the standards during periods of high flow. • Part of Totten TMDL for fecal coliform	• B-IBI average 2002-2009: 41 • B-IBI range 2002-2009: 34-44 • Coho, chum, winter steelhead, coastal resident cutthroat trout.

a) In-Stream and Wetland Habitat Conditions

Physical

- Fair change in flow regime;
- Good biological processes;
- Fair to poor fish passage;
- Poor riparian canopy closure;

- Poor streambank condition due to high levels of streambank erosion;
- Poor to fair substrate embeddedness;
- Poor key piece LWD abundance; good to fair total LWD abundance;
- Poor to good pool frequency and quality; and,
- Data gaps: riparian condition; floodplain connectivity; width/depth stream ratio; off-channel habitat.

Anadromy is blocked at river mile 2.5 by a natural series of falls and cascades (Kuttel, 2002).

Water Quality

Good – Passed both parts of the bacteria standard. Occasional dissolved oxygen violations during summer low flow period. Turbidity occasionally exceeds the standard during periods of high flow.

Issues: A Washington Department of Ecology total maximum daily load study determined that fecal coliform bacteria levels during the late summer season in Kennedy Creek need to be reduced to ensure compliance with part 2 of the water quality standard. Investigation for potential sources was conducted in 2006 and 2007. A water quality implementation plan was completed in November 2007 and includes recommended actions for Kennedy Creek. The chum salmon run in Kennedy Creek continues to be a valued local resource. Various private and public entities worked together to build salmon spawning viewing areas for the public along a lower portion of the creek.

b) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Kennedy Creek contains coho, chum, winter steelhead, and coastal resident cutthroat trout.

c) **Action Recommendations**

<u>(Kuttel, 1999)</u>

- Replace culverts acting as fish barriers;
- Improve land use regulations and enforcement; replant native riparian vegetation, particularly conifers;
- Replant native riparian vegetation; follow guidelines in "Forest and Fish Report"; build fewer roads and maintain existing roads; prevent development on floodplains and along channel banks;
- Preserve large coniferous trees in riparian zones; place LWD in spawning and rearing reaches; restore meandering channels; leave LWD in channels and replant native riparian vegetation, particularly conifers.

(MCDLE, 2004)

- Restore the riparian corridor in the lower mile of Kennedy Creek. The lack of riparian cover in the lower reaches resulting in low LWD key piece recruitment is the primary problem. Planting and maintaining a functioning riparian zone and placing key pieces strategically along the banks to add complexity and recruit additional pieces to form log jams would be a solution. Alternatively, another solution would be an engineered log jam.

- Restore riparian corridor in the upper and middle reaches to stabilize streambanks, recruit LWD, and provide shade. Appropriate species should be planted including incorporating additional conifers into the riparian corridor. Restore riparian functions to upper Kennedy Creek by identifying and correcting areas where livestock have direct access to creek.

- Preserve areas within the Kennedy Creek watershed that are not already in a protective status and provide long-term conservation within the first 5 miles of the Kennedy Creek riparian corridor.

- Prioritize maintaining the upper watershed in managed forestry. If that status changes, propose acquisition along key areas.

- Off-channel assessment. There are data gaps on off-channel habitat, riparian condition and floodplain connectivity.

3. Schneider Creek (Totten)

Primary land use is rural residential, agriculture, and forestry (Thurston County, 2010). Schneider Creek's headwaters are primarily in timber production on land owned by the Department of Natural Resources. The valley floor is mostly under single ownership and is a mix of agricultural and forestry uses (MCDLE, 2004).

Schneider Creek					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 5,560 acres; 100% rural • Total Impervious Area Estimate 1991: 1.1% 2006: 1.8% 2030: 2.4% Buildout: 2.7%	• Effective Impervious Area: 2006: 1.3% • Forest Cover: 70.5% • Unmodified Wetlands: 3.3% • Miles of Stream: 28.1 • Miles of Marine Shoreline: 1.1 • Areas of high ground water flooding: 1.1% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 22.6% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 88.9% 250 ft: 87.5% 1000 ft: 86.2% • # of road crossings per mile of creek: 1.5	• Fair streambank condition • Fair floodplain connectivity • Good to fair pool quality • Fair water quantity/ dewatering • Fair change in flow regime • Good biological processes • Poor canopy closure • Poor substrate embeddedness • Good to poor LWD abundance; poor key piece abundance • Fair to poor pool frequency	• Monitoring results: good water quality • Often fails Part 2 of the fecal coliform standard. • There are summer dissolved oxygen violoations. • Other parameters are usually within standards. • Creek potentially impacted by animal keeping practices, logging practices, and stream-side development • 303(d): dissolved oxygen, fecal coliform • Part of Totten TMDL for fecal coliform	• B-IBI average 2002-2009: 41 • B-IBI range 2002-2009: 36-46 • Chum, coho, winter steelhead, coastal resident cutthroat.

a) In-Stream and Wetland Habitat Conditions

Physical

- Fair streambank condition;
- Fair floodplain connectivity;
- Good to fair pool quality;

- Fair water quantity/dewatering;
- Fair change in flow regime;
- Good biological processes;
- Poor canopy closure;
- Poor substrate embeddedness;
- Poor to good LWD abundance; poor key piece abundance;
- Poor to fair pool frequency;
- Water quality: 303d list fecal coliform;
- Data gaps: riparian condition; off-channel habitat; water temperature and dissolved oxygen data (Kuttel, 2002).

Water Quality

Good – Often fails Part 2 of the fecal coliform standard. There are summer dissolved oxygen violations. Other parameters usually with standards (Thurston County, 2010).

Issues: The creek has the potential to be impacted by animal-keeping practices, logging practices and stream-side development (Thurston County, 2010).

Schneider Creek is listed on Washington State's Clean Water Act Section 303(d) list of impaired water bodies for dissolved oxygen, fecal coliform (Ecology, 2008).

Schneider Creek also has a TMDL for fecal coliform.

b) **Aquatic Biota**

Benthic Macroinvertebrates

See Appendix B.

Fish

Schneider Creek contains chum, coho, winter steelhead, and coastal resident cutthroat.

c) **Action Recommendations**

<u>(Kuttel, 1999)</u>

- Improve land use regulations and enforcement;
- Replant native riparian vegetation, particularly conifers; follow guidelines in "Forests and Fish Report"; build fewer roads and maintain existing roads; prevent development on floodplains and along channel banks;
- Preserve coniferous trees in riparian zones; place LWD in spawning and rearing reaches; restore meandering channels; leave LSD in channels.

(MCDLE, 2004)

- Ensure the estuary and nearshore are protected (e.g., easement programs, and/or acquisition) by partnering with Thurston County;

- Restore the riparian corridor by planting appropriate species to provide shade, recruit LWD, and stabilize streambanks. Use the riparian assessment conducted by Thurston Conservation District to locate riparian restoration sites;

- Reduce runoff and erosion that lead to fine sediment deposition by maintaining vegetative cover;

- Increase LWD key piece abundance to encourage pool formation and sorting of sediments. Place LWD instream for immediate benefits until riparian conditions have improved to the point to allow natural recruitment;

- The riparian buffer above U.S. 101 is in poor condition, but is owned primarily by one cooperative landowner who has undertaken several revegetation projects. Partner with the primary landowner to develop an action plan for future revegetation projects.

4. Summit Lake

The majority of the basin is commercial forest with dense development concentrated along the shoreline. There are approximately 400 homes along the shoreline (Thurston County, 2010).

Summit Lake					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Included in Kennedy Creek information	• Included in Kennedy Creek information	• Included in Kennedy Creek information	• No data	• Monitoring results: excellent water quality • Low nutrient and chlorophyll *a* levels and high visibility. • High water quality is important because the majority of lakeshore residents use lake water as their domestic water supply and may not disinfect it. Steep slopes, shallow soils, and generally small lots sizes make siting and functioning of on-site sewage systems around the lake difficult. • High density residential uses along shoreline and forestry activities in upper watershed are a concern for water quality. • 303(d): PCB contamination in fish • Part of Totten Inlet TMDL	• Benthic levels unknown • Coastal resident cutthroat trout

a) In-Stream and Wetland Habitat Conditions

Water Quality

Excellent - The lake has low nutrient and chlorophyll levels and high visibility. The high water quality is important because the lake is the drinking water source for most of the lake residents. Uses are not impeded by aquatic weeds or algal growth.

Issues: Steep slopes, shallow soils, and generally small lots sizes make siting and functioning of on-site sewage systems around the lake difficult. A 1992-1997 sanitary survey of 330 on-site sewage systems around the lake perimeter found 58 systems were failing (18 percent). Nearly all of the 58 failing systems were repaired.

The majority of lakeshore residents use lake water as their domestic water supply, and many do not disinfect it prior to use. Surface waters cannot be adequately protected from contamination to be safely used as a domestic water supply without treatment. A public health advisory issued in 1987 advises against consumption of untreated lake water at Summit Lake.

The high-density residential activities along the shoreline and forestry activities in the upper watershed are a concern for water quality.

b) **Aquatic Biota**

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Summit Lake contains coastal resident cutthroat trout.

c) **Action Recommendations**

(WRIA 14, Salmonid Habitat Limiting Factors Report, 1999)

None noted.

5. Totten Inlet

Totten Inlet					
Current Aquatic Habitat Conditions					
Level of Urbanization	**Basin and Riparian Conditions**		**In-Stream and Wetland Habitat Conditions**		**Aquatic Biota**
	Hydrology	**Riparian Corridor**	**Physical Conditions**	**Water Quality**	
• Basin area 3,060 acres; 100% rural • Total Impervious Area Estimate 1991: 1.8% 2006: 2.9% 2030: 3.9% Buildout: 4.1%	• Effective Impervious Area: 2006: 2.0% • Forest Cover: 79.7% • Unmodified Wetlands: 3.0% • Miles of Stream: 4.5 • Miles of Marine Shoreline: 11.7 • Areas of high ground water flooding: 1.5% of basin	• Coniferous forest cover in 250 stream riparian corridor: 2006: 18.3% • Forest, scrub/shrub vegetation and wetlands in stream riparian corridor: 150 ft: 96.3% 250 ft: 93.0% 1000 ft: 85.5% • # of road crossings per mile of creek: 2.2	• No data	• Shellfish growing areas are approved.	• Benthic levels unknown • Coastal resident cutthroat • Marine shoreline: forage fish and shellfish habitat.

a) Aquatic Biota

Benthic Macroinvertebrates

Benthic Macroinvertebrates are not monitored in this basin.

Fish

Unnamed streams contain coastal resident cutthroat. The marine shoreline supports forage fish spawning.

Shellfish

The marine shoreline contains shellfish habitat.

b) Action Recommendations

(Haring and Konovsky, 1999)

None noted.

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Appendix I: Stakeholder Comments and Notes for Hydrologic Modeling

Basin	Notes for Hydrologic Modeling	Stakeholder Input
Budd/Deschutes		
Black Lake	Should also be evaluated as part of Percival Basin	Currently less than 10%TIA but expected to grow close to 10%, and still has salmon. East side of lake is in Tumwater's UGA. Flows into Percival Creek basin via Black Lake Ditch.
Capitol Lake		
Chambers		Contaminated groundwater and is impacted.
Deschutes River (Lower)	Possibly - part of basin is in the city. Also need to talk to hydrologist to see if could do only a portion of Deschutes.	LOTT Cleanwater Alliance has identified several areas important to recharge in this basin.
Deschutes River (Middle)	Need to talk to hydrologist to see if could do only a portion of Deschutes.	Deschutes has been studied extensively. Would focusing on the Deschutes teach us anything new? The middle Deschutes is in sensitive condition and expected to experience growth pressure. Despite the fact that there is a lot of TMDL information for the Deschutes, implementation of new land use would need additional modeling. The Squaxin Island Tribe has 50 years of stream gauge data at Rainier. The flow has gone from 72 cfs 50 years ago, to 14 cfs. There are many ongoing activities in this basin that would gain synergy from additional protective measures. Squaxin Island Tribe Suggested Basin for Top Consideration: Important to fishery. Not yet reached 5% impervious surface threshold, but moderate growth possible. Need to limit impervious surface to < 5% and increase forest cover to 65%.
Deschutes River (Upper)		
East Bay 1		
East Bay 2		Sensitive now, but projected to grow greater than 1% in TIA. Surrounds an important estuary at Gull Harbor. Capitol Land Trust is putting a lot of investment into acquisitions and conservation easements in Henderson 1 and East Bay 2 to create a habitat corridor. May not be an appropriate place to focus this project because so much will be protected already by the land trust that would leave little else to be done.
East Bay 3		
East Bay 4		In good condition now, but forecast to undergo development pressures
Ellis Creek		Sensitive now, but projected to grow greater than 1% in TIA. Could be considered impacted but also could be in good condition minus the fish passage barriers. Both barriers are under huge amounts of fill. Attempts at removal in the past have been unsuccessful.

Basin	Notes for Hydrologic Modeling	Stakeholder Input
Indian Creek		
Lake Lawrence		Likely to remain in current condition
McIntosh Lake		
Mission Creek		
Moxlie Creek		
Offut Lake		
Percival Creek		Location of salmon habitat restoration projects (Olympia, and Tumwater). Already extremely impacted, so not worthwhile to expend energy there.
Reichel Lake		
Schneider Creek (West Bay)		
Spurgeon Creek		In good condition now. Supports the Olympic Mud Minnow (a state sensitive species) and freshwater mussels. However, it is not under a lot of growth pressure. This is the most significant drainage of the Deschutes River for Tribal fisheries.
West Bay 1		
West Bay 2		There is a fish limitation at French Loop Road. TIA is already at 10%. Probably can't keep it below 10%. Currently under a county building moratorium.
West Bay 3		
Eld Inlet		
Eld Inlet 1		
Eld Inlet 2		
Eld Inlet 3		Squaxin Island Tribe: basin currently in good condition and expected to be impacted by growth
Eld Inlet 4		
Eld Inlet 5		
Eld Inlet 6		Currently less than 10%TIA but expected to grow close to 10%, and still has salmon.
Eld Inlet 7		Currently less than 10%TIA but expected to grow close to 10%, and still has salmon.

Basin	Notes for Hydrologic Modeling	Stakeholder Input
Eld Inlet 8		
Eld Inlet 9	Possibly - Much of growth is vested and/or in city boundaries	Most of the nearshore is already protected in conservation easements by Capitol Land Trust. Other parts of the basin are in the City of Olympia and its UGA. It already has a high TIA of 12.6% but Olympia commercial lands are there and it falls partially in the UGA. The City of Olympia says that it is a closed basin that does not drain to Eld Inlet. Much of growth is vested and/or in city boundaries. Squaxin Island Tribe Suggested Basin for Top Consideration: majority of shoreline already in conservation, but need to address upland development. Large potential increase in impervious surface. If development occurs, many of the benefits of shoreline protection will be lost.
Eld Inlet 10		
Eld Inlet 11		
Eld Inlet 12		
Eld Inlet 13		In good condition now, but forecast to undergo development pressures
Eld Inlet 14		
Green Cove Creek	Possibly - growth potential is likely vested.	Would be interesting to study for lessons learned.
McLane Creek	Many units potential. Possibly could look at subbasins separately.	Healthy, intact salmon runs. Great salmon creek basin but only low growth risk. Upper McLane is in Long Term Forestry and will not experience growth pressure. McLane 1 and a portion of McLane 2 support the primary salmon use. McLane is great for fish, but full buildout is only 1.6% TIA and it has a lot of A/B soils that are good for recharge. From a hydrology standpoint, the biggest problems are the golf course and the Alpine Hills Development.
Perry Creek		Healthy, intact salmon runs.
Squaxin Passage		Projected to grow, but all the lots are legacy lots so we wouldn't be able to affect the growth in that area through changes in zoning or development regulations.
Nisqually Reach		
Nisqually Reach 1		
Nisqually Reach 2		
Nisqually Reach 3		
Nisqually Reach 4		
Nisqually Reach 5		
Nisqually Reach 6		
Nisqually Reach 7		

Basin	Notes for Hydrologic Modeling	Stakeholder Input
Henderson Inlet		
Henderson 1		Surrounds an important estuary at Woodard Bay. Capitol Land Trust is putting a lot of investment into acquisitions and conservation easements in Henderson 1 and East Bay 2 to create a habitat corridor. May not be an appropriate place to focus this project because so much will be protected already by the land trust that would leave little else to be done.
Henderson 2		
Henderson 3		
Henderson 4		
Henderson 5		Likely to remain in current condition
Henderson 6		
Henderson 7		
Henderson 8		
Woodard Creek		Falls in UGA, flows to Henderson, but less work on it than Woodland, and looks like it will grow a lot. Mouth to mid-basin is still relatively intact (Olympia TC, and TRPC). Only mouth is in good condition and that rest is already degraded. Woodard not great for protecting fish because does not have a big salmon run. Has potential for future growth and is important for Henderson Inlet water quality, however, it is already above 10% TIA.
Woodland Creek		Water quality issues. Woodland Creek no longer provides good habitat for salmon. If it were chosen for further study, the focus would be on stormwater and groundwater, as well as how those affect shellfish. If everything was managed north of 1-5, could things be done to maintain the function in the lower reaches? Will never get significant biological function south of 1-5. Is it worth putting effort there? Maybe need to break up the basin for considering management tools. Lower Woodland Creek has different hydrology that southern Woodland Creek. It is more dependent on peak flows than base flows. Squaxin Island Tribe Suggested Basin for Top Consideration: Lower Woodland: cities taking action to protect habitat and improve streamflow in the creek; won't be helpful without additional landscape protection. Impervious surface < 15%, so not completely lost. Need to limit impervious surface to < 15%, but high potential for development. “Lower” refers to the basin downstream of the Top Foods wetland (aka Bette Springs). LOTT Cleanwater Alliance has identified several areas important to recharge in this basin.

Basin	Notes for Hydrologic Modeling	Stakeholder Input
Totten Inlet		
Burns/Pierre		
Kennedy Creek		Healthy, intact salmon runs. Primarily Long Term Forestry.
Schneider Creek (Totten)		
Totten 1		Adjacent to shellfish beds on Totten Inlet. Sensitive now and will experience moderate growth.
Totten 2		Adjacent to shellfish beds on Totten Inlet. Sensitive now and will experience moderate growth.
Totten 3		Adjacent to shellfish beds on Totten Inlet. Sensitive now and will experience moderate growth.
Totten 4		
Totten 5		