PNNL-14205

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Yakima River Basin Phase II Fish Screen Evaluations, 2002

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January 2003

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RL01830

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Bonneville Power Administration
under Project 1985-06200

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

In 2002, the Pacific Northwest National Laboratory evaluated 23 Phase II fish screen sites in the Yakima River Basin as part of a multi-year project for the Bonneville Power Administration on the effectiveness of fish screening devices. Pacific Northwest National Laboratory collected data to determine whether velocities in front of the screens and in the bypasses met National Marine Fisheries Service criteria to promote safe and timely fish passage and whether bypass outfall conditions allowed fish to safely return to the river. In addition, Pacific Northwest National Laboratory conducted underwater video surveys to evaluate the environmental and operational conditions of the screen sites with respect to fish passage.

Based on evaluations in 2002, PNNL concluded that

- In general, water velocity conditions at the screen sites met fish passage criteria set by the National Marine Fisheries Service.
- Conditions at most facilities would be expected to provide for safe juvenile fish passage.
- Conditions at some facilities indicate that operation and/or maintenance should be modified to increase safe juvenile fish passage.
- Automated cleaning brushes generally functioned properly; chains and other moving parts were typically well greased and operative.
- Removal of sediment buildup and accumulated leafy and woody debris should be improved at some sites.

Acknowledgments

The successful completion of this project depended on the involvement and cooperation of many people. David Byrnes, Bonneville Power Administration, directed the project. John Easterbrooks, Ray Gilmour, Bill Werst, and Pat Schille of the Washington Department of Fish and Wildlife, and Tom Leonard of the U.S. Bureau of Reclamation provided valuable background information on the sites and also comments on the operation and maintenance of individual sites. Adam Sealock and Ann Veitz, PNNL Office of Fellowship Programs Fellows, assisted with the field work.

Acronym List

ADV	acoustic Doppler velocimeter
BPA	Bonneville Power Administration
cfs	cubic feet per second
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
PNNL	Pacific Northwest National Laboratory
RMS	root-mean-square
USBR	U.S. Bureau of Reclamation
WDFW	Washington Department of Fish and Wildlife
WIP	Wapato Irrigation Project

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1.0 Introduction

Irrigation has played an important role in the development of the middle Columbia River Basin. Water has been diverted from western rivers since the mid-1850s to irrigate crops. During the 1920s, some of these diversions were equipped with fish protection devices, but it wasn't until the Mitchell Act of 1938 provided funding to protect fish that screening irrigation diversions and evaluating their effectiveness truly got under way (Bryant and Parkhurst 1950).

In more recent history, the Bonneville Power Administration (BPA) and the Northwest Power Planning Council (NPPC) expanded screening efforts to protect and enhance fish populations. The NPPC's Columbia River Fish and Wildlife Program lists effective screening of irrigation diversions as an essential element in their plan to restore declining steelhead and salmon runs (NPPC 1984, 1987, 1994).

Research on the effectiveness of fish screening devices initiated changes in design and operating procedures of screening facilities over the years. For example, maximum allowable screen size openings decreased as protecting fish at their earliest developmental stages became a concern. These and other new requirements for fish protection are developed by the National Marine Fisheries Service (NMFS) and adopted by individual state agencies. In addition, the BPA has established a monitoring and evaluation program to ensure that new and updated screening facilities meet current fish protection standards.

With funding from the BPA, Pacific Northwest National Laboratory (PNNL) researchers have conducted fish screen evaluations in the Yakima Basin since 1985. Initially, PNNL monitored Phase I screening facilities to determine whether fish that entered irrigation canals were diverted back to the river safely (Neitzel et al. 1985, 1986, 1988, 1990a, 1990b). Additional studies examined water velocities in front of the screens to determine whether NMFS criteria were being met (Abernethy et al. 1990). Two studies conducted at PNNL's Aquatic Laboratory in Richland, Washington, used modular drum screens constructed by the Washington Department of Fish and Wildlife (WDFW) to determine fish survival through submerged orifices and the relative effectiveness of two screen configurations at bypassing fish (Abernethy et al. 1996; Neitzel et al. 1997). The methods currently used for evaluating screening facilities were developed while conducting these earlier studies (Blanton et al. 1998, 1999; Chamness et al. 2001; Carter et al. 2002).

As the Phase II screens program continued, more sites were evaluated by PNNL for the BPA. In 2000, 21 Phase II sites were evaluated. The Powell-LaFortune and Wilson Creek sites were added in 2001 for a total of 23 sites. No sites were added in 2002. The evaluations of these sites addressed two main questions:

1. Are screens designed, operated, and maintained to meet NMFS criteria over a wide range of conditions?

2. Are screen sites effective at protecting fish from injury and from unnecessary migration delay?

2.0 Methods

Twenty-three operating screen sites in the Yakima, Naches, and Tieton River basins were evaluated three times between May 13 and September 19, 2002 (Figure 1). PNNL researchers collected three types of data at each site, based on criteria set by the National Marine Fisheries Service (NMFS) for Phase II fish screen facilities. The types of data collected include water velocity measurements, underwater video, and general operational data (e.g., screen submergence, bypass conditions, fish presence).

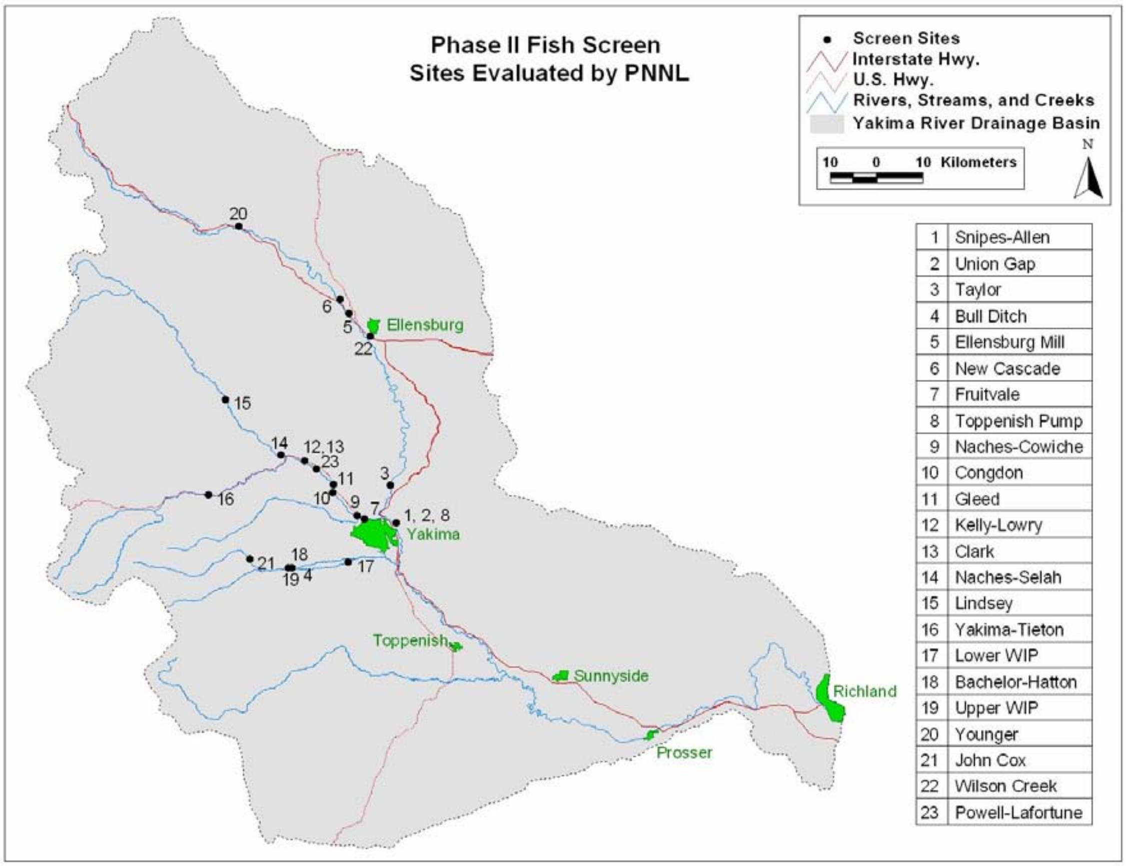

Figure 1. Yakima River Basin Phase II Fish Screen Facilities

The NMFS criteria for Phase II fish screen sites define velocity and general operational conditions that would be expected to promote safe fish passage through Phase II screen sites (NMFS 1995). These include the following:

- A uniform flow distribution over the screen surface to minimize approach velocity
- Approach velocities less than or equal to 0.4 ft/s
- Sweep velocities that are greater than approach velocities

- A bypass flow greater than or equal to the maximum flow velocity vector resultant upstream of the screens (generally the sweep velocity)

- A gradual and efficient acceleration of flow from the upstream end of the site into the bypass entrance to minimize delay of emigrating salmonids

- Screen submergence between 65 and 85% for drum screen sites.

In addition, the NMFS states that silt and debris accumulation should be kept to a minimum. For this report, the accumulation of silt and/or debris was considered excessive if the intersection of the seal and the screen was buried. Screen operators should try to achieve these criteria at all sites throughout the year. In this report, PNNL generally compared the field measurements of water velocity, underwater video, and general data collection results for each screen site to the NMFS criteria. The following sections detail how each type of data was collected, and Section 3 contains the results of the comparisons for each site.

2.1 Water Velocity Measurements

2.1.1 Equipment

With the exception of a few sites, water velocities in front of the screens and in the bypass were measured using a SonTek acoustic Doppler velocimeter (ADV). The ADV emits sound at 10 kHz. The frequency of the returning sound waves increases or decreases depending on whether the water is flowing towards or away from the ADV receiver. The difference between the emitted frequency and the received frequency is used to calculate the velocity of the water. The probe uses three receivers extending out at an angle from the transmitter to calculate the three-dimensional water velocity at a point 10 cm below the probe. Figure 2 shows the ADV probe on the left.

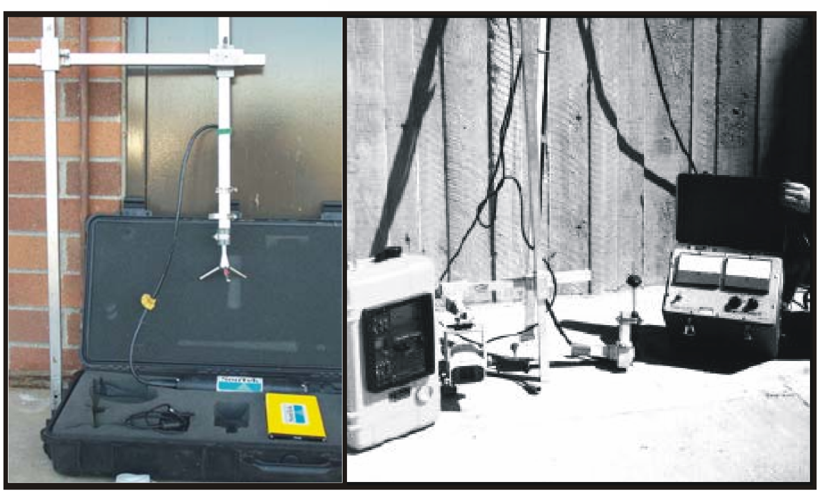

Figure 2. Acoustic Doppler Velocimeter Probe Equipment (left) and the Underwater Video Camera (middle) and Marsh-McBirney 511® Velocity Meter (right)

The ADV probe was securely mounted to a horizontal metal arm that extended approximately 12 in. from a vertical pole. The probe was oriented into the current with the support assembly downstream or off to the side to minimize interference from the vertical pole when taking velocity readings. The length of the horizontal arm and its position on the vertical pole were adjustable. Velocities were typically recorded at each sampling point along the screen for 40 s at a rate of 2 Hz and stored in a computer file.

When the water was too shallow or there was too much vegetation or debris in the forebay, water velocities were measured using a Marsh-McBirney Model 511® electromagnetic water current meter. The meter uses a bi-directional probe that allows measurement of velocities in two directions (approach and sweep) simultaneously. Output was read visually from a panel gauge and recorded. Figure 2 shows the Marsh-McBirney probe on the right.

2.1.2 Data Collection and Analyses

Measurements of water velocity were taken at 3 to 5 evenly spaced points along the front of each screen and in the entrance to the bypass. The vertical pole was placed close to the front of the screen but not allowed to come in contact with the screen surface. The probe was positioned as close to the screen surface as possible, usually about 3 in., though it was impossible to get that close in some cases. The height that the probe was set from the bottom depended on the depth of water in the forebay. In cases where the forebay depth was less than 48 in., measurements were taken at one depth (0.6 x depth from the surface). In cases where the forebay depth was greater than or equal to 48 in., measurements were taken at two depths (0.2 x depth from the surface and 0.8 x depth from the surface). All measurements were taken with the axes of the probe oriented to measure water flowing parallel (sweep) and perpendicular (approach) to the screen face.

Flow measurements were taken in front of every screen during site visits. Automatic cleaning brushes were usually turned off during velocity measurements, while drum screens were allowed to operate as normal during measuring, except when this caused significant electrical interference with the Marsh-McBirney velocimeter. In such cases, the drums were turned off. Average sweep and approach velocities were calculated for each visit to each site, and seasonal averages were calculated at the end of all surveys.

Graphical representations of velocity data include lines for mean sweep and approach velocity measurements, a reference line at 0.4 ft/s (which represents the NMFS criteria for approach velocity), and a shaded area representing sediment accumulation in front of the screens as estimated with the support pole for the velocity probe, where the pole came to rest on the sill and in the bypass. The error bars on the velocity graphs represent the root-mean-square (RMS) of the turbulent velocity fluctuations about the mean velocity. The RMS value is equal to the standard deviation of the individual velocity measurements.

2.2 Underwater Video

2.2.1 Equipment

An underwater video system was used to investigate screen seal condition and to monitor debris buildup and fish presence. For the first part of May, the system consisted of a high-sensitivity remote camera (Sony, model HVM-352®) connected by 66 ft of quadraxial cable to an 8-mm camcorder (Sony, model CCD-FX710 Handycam Hi-8®) in a weatherproof housing (Figure 2). The case was fitted with external weatherproof controls, a 4-in. black and white monitor, and an internal battery power supply for the system. The underwater camera operates at extremely low light levels (<1 lux), so artificial light sources were not necessary to obtain video images during daylight hours.

For the remainder of the evaluations, the video system consisted of a digital deep-sea camera (DeepSea Power and Light, Inc., model MULTI-SEACAM 1050) connected to a digital video recorder (Sony Video Walkman, model GV-D800), which in turn was connected to a pair of video glasses (Olympus Eye-Trek, model FMD-200). The advantage of this system was that it allowed the person operating the camera to see what they were recording while in the field, thus providing better video quality and a greater potential for problem identification. In addition the end product of this system was digital video which greatly improved the quality of still pictures captured from the video.

2.2.2 Data Collection and Analyses

The camera was securely mounted on a vertical pole and adjusted as needed at each site. The camera was usually angled slightly downward to look for potential gaps between the screen and the bottom seal. The camera was usually moved from upstream to downstream, following the side and bottom seal/screen interfaces. The bypass was also inspected, looking both upstream and downstream for signs of excessive debris or fish presence.

Written observations were made in the field when something of interest was seen with the camera (i.e., debris, gaps, and fish). All videos were later reviewed in detail, and images of interest were digitally captured using Optimas™ software.

2.3 General Data

Additional data collected during each evaluation included the following:

- General site descriptions and photographs
- Screen and seal conditions
- Screen submergence levels
- Cleaning system operation and the incidence of head loss across the screen face
- Bypass flow conditions
- Bypass outfall conditions
- Fish presence

- Observations of debris in the forebay, bypass, or outfall
- Presence or absence and condition of operator control aids such as water gauges and drum submergence marks on screen frames.

2.4 Problem Tracking

For the 2002 evaluations, PNNL implemented a new problem identification and tracking program in response to comments from the Independent Scientific Review Panel. The purpose of this program was to increase accountability of operations and maintenance and to better serve fish passage and protection goals. When a problem such as a blocked bypass or excessive debris was identified at a screen site, the responsible agency (Table 1) was notified immediately by the field personnel and asked to report back to PNNL when the issue was rectified or when a repair schedule was implemented. When PNNL received notice that a problem had been fixed, a team was sent to the site to reevaluate whether operating conditions met NMFS criteria for safe fish passage.

Table 1. Agency Responsible for the Operation and Maintenance of Each Fish Screen Facility. WIP = Wapato Irrigation Project; USBR = U.S. Bureau of Reclamation; WDFW = Washington Department of Fish and Wildlife.

Fish Screen Facility	Responsible Agency
Bachelor-Hatton	USBR
Bull Ditch	WDFW
Clark	WDFW
Congdon	WDFW
Ellensburg Mill	WDFW
Fruitvale	WDFW
Gleed	WDFW
John Cox	USBR
Kelly-Lowry	WDFW
Lindsey	WDFW
Lower WIP	USBR
Naches-Cowiche	WDFW
Naches-Selah	WDFW
New Cascade	WDFW
Powell-LaFortune	WDFW
Snipes-Allen	WDFW
Taylor	WDFW
Toppenish Pump	USBR
Union Gap	WDFW
Upper WIP	USBR
Wilson Creek	USBR
Yakima-Tieton	USBR
Younger	WDFW

3.0 Results and Discussion

This section presents the overall results first and then describes each site in more detail. The site-by-site descriptions are organized into three groups: rotary drum screens, flat-plate screens, and vertical traveling screens.

3.1 Overall Results

3.1.1 Water Velocity Measurements

Although velocities often fluctuated widely from site to site and over time, average sweep velocities for the year typically exceeded average approach velocities for the year (Table 2). Mean approach velocities were generally below the NMFS criteria of less than or equal to 0.4 ft/s (Table 3). However, many of the sites had bypass velocities that were slower than sweep velocities (Table 4, Figure 3).

Table 2. Mean Sweep and Approach Velocities (± standard deviation (S.D.) at Phase II Fish Screen Facilities in the Yakima River Basin in 2002. WIP = Wapato Irrigation Project.

Screen Type	Site	Mean Sweep Velocity ± S.D.	Mean Approach Velocity ± S.D.	Ratio of Sweep to Approach
Drum screens	Bachelor-Hatton	0.51 ± 0.33	0.14 ± 0.10	4.32
	Clark	0.16 ± 0.04	0.10 ± 0.03	1.65
	Congdon	0.69 ± 0.13	0.35 ± 0.05	1.97
	John Cox	0.67 ± 0.21	0.36 ± 0.07	1.83
	Kelly-Lowry	0.64 ± 0.14	0.25 ± 0.08	2.59
	Lindsey	0.33 ± 0.09	0.17 ± 0.05	1.97
	Lower WIP	0.38 ± 0.16	0.37 ± 0.08	1.01
	Naches-Cowiche	0.63 ± 0.16	0.23 ± 0.07	2.80
	New Cascade	0.76 ± 0.22	0.21 ± 0.10	4.09
	Powell-LaFortune	0.47 ± 0.14	0.17 ± 0.06	2.87
	Snipes-Allen	0.25 ± 0.17	0.19 ± 0.04	1.28
	Taylor	0.23 ± 0.14	0.10 ± 0.04	2.16
	Toppenish Pump	1.00 ± 0.52	0.32 ± 0.15	3.13
	Upper WIP	1.44 ± 0.57	0.24 ± 0.10	5.92
	Wilson Creek	0.69 ± 0.10	0.25 ± 0.07	2.82
Vertical plate screens	Bull Ditch	0.65 ± 0.59	0.19 ± 0.16	3.56
	Ellensburg Mill	0.18 ± 0.13	0.07 ± 0.06	2.46
	Fruitvale	0.63 ± 0.37	0.19 ± 0.10	3.60
	Naches-Selah	1.19 ± 0.43	0.32 ± 0.17	4.03
	Union Gap	1.32 ± 0.31	0.25 ± 0.08	5.39
	Yakima-Tieton	1.85 ± 0.46	0.22 ± 0.17	10.03
	Younger	2.26 ± 1.36	0.47 ± 0.30	4.86
Vertical travelling screen	Gleed	0.52 ± 0.49	0.23 ± 0.22	2.21

Table 3. Annual Percent of Approach Velocity Measurements that Were in Excess of the NMFS Criteria of Less than or Equal to 0.4 ft/s by Screen Site by Year. The shaded numbers represent sites for which greater than 10% of the approach velocities for the year were in excess of 0.4 ft/s.

Screen Type	Screen Site	Percent of Approach Velocity Measurements >0.4 ft/s					
		1997	1998	1999	2000	2001(d)	2002
Drum screens	Bachelor-Hatton	12.5	34.1	0	15.4	(e)	2.5
	Clark	0	0	(a)	0	0	0
	Congdon	31.1	4.4	8.3	7.1	13.3	11.1
	John Cox	(c)	(c)	(c)	39.3	(e)	27.5
	Kelly-Lowry	3.3	0	0	0	20.0	0
	Lindsey	3.3	0	0	0	0	0
	Lower WIP	8.3	(b)	0	0	(e)	38.9
	Naches-Cowiche	6.6	0	12.5	2.6	5.0	1.7
	New Cascade	4.2	(a)	0	1.4	(e)	2.5
	Powell-LaFortune	(c)	(c)	(c)	(c)	0	0
	Snipes-Allen	3.3	0	0	0	0	0
	Taylor	4.2	0	0	0	0	0
	Toppenish Pump	43.0	60.0	25.4	9.4	3.3	31.1
	Upper WIP	17.5	9.4	2.5	3.3	(e)	5
	Wilson Creek	(c)	(c)	(c)	(c)	0	4.4
Vertical plate screens	Bull Ditch	36.1	2.9	14.7	22.2	0	12.5
	Ellensburg Mill	0	0	33.3	25.9	0	0
	Fruitvale	12.5	(a)	0	17.5	0	5.6
	Naches-Selah	5.5	2.8	27.8	28.7	8.3	29.6
	Union Gap	2.3	5.0	22.9	12.5	4.2	2.8
	Yakima-Tieton	10.5	5.2	2.1	1.4	2.1	14.4
	Younger	(c)	(c)	0	8.3	0	33.3
Vertical travelling screen	Gleed	(a)	(a)	14.3	17.5	0	17.4

(a) No data; electrical interference prevented velocity measurements.
(b) No data; flooded in May and nearly dry by July 1998.
(c) Not sampled.
(d) Based on September data only, except Snipes-Allen, Taylor, Toppenish Pump, Naches-Selah, and Union Gap.
(e) No data; equipment problems in May and June, and site was dry in September.

Table 4. Summary of Problem Areas Identified at Yakima River Basin Phase II Screen Sites in 1999, 2000, 2001, and 2002. The different symbols represent different years. John Cox was not evaluated in 1999, and Powell-LaFortune and Wilson Creek were not evaluated in 1999 or 2000.

		≥10% of Approach Velocities > 0.4 ft/s				Bypass Velocities Slower than Sweep Velocities at Least Once				Damaged Screen or Seal				Submergence Outside Criteria at Least Once				Excessive Silt or Debris at Least Once				Bypass Outfall < 1 ft at Least Once			
Screen Type	Site	1999	2000	2001 [a,b]	2002	1999	2000	2001 [a,b]	2002	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002
Drum screens	Bachelor-Hatton		▽				▽			■		✱		■	▽		⋏		▽		⋏				
	Clark														▽	✱									
	Congdon		▽	✱	⋏									■		✱									
	John Cox		▽		⋏				⋏			✱			▽								▽	✱	
	Kelly-Lowry			✱				✱	⋏						▽	✱		■	▽	✱	⋏				
	Lindsey									■						✱									
	Lower WIP				⋏	■			⋏					■				■		✱	⋏				
	Naches-Cowiche	■						✱													⋏				
	New Cascade									■		✱	⋏	■	▽	✱			▽	✱	⋏				
	Powell-LaFortune							✱	⋏							✱	⋏				⋏				
	Snipes-Allen						▽	✱	⋏					■											
	Taylor															✱				✱	⋏				
	Toppenish Pump	■			⋏					■					▽	✱	⋏	■	▽	✱	⋏				
	Upper WIP								⋏	■			⋏					■	▽		⋏			✱	
	Wilson Creek							✱	⋏				⋏			✱				✱					
Vertical plate screens	Bull Ditch	■			⋏															✱					
	Ellensburg Mill	■	▽			■		✱		■		✱						■		✱	⋏				
	Fruitvale		▽											■		✱									
	Naches-Selah	■	▽		⋏		▽	✱	⋏	■											⋏			✱	
	Union Gap	■	▽			■		✱	⋏	■											⋏				
	Yakima-Tieton				⋏		▽	✱				✱	⋏											✱	
	Younger				⋏							✱													
Vertical traveling screens	Gleed	■	▽		⋏													■							

a) Based on September data only, except Snipes-Allen, Taylor, Toppenish Pump, Naches-Selah, and Union Gap.

b) No data available for Bachelor-Hatton, John Cox, Lower WIP, New Cascade, or Upper WIP.

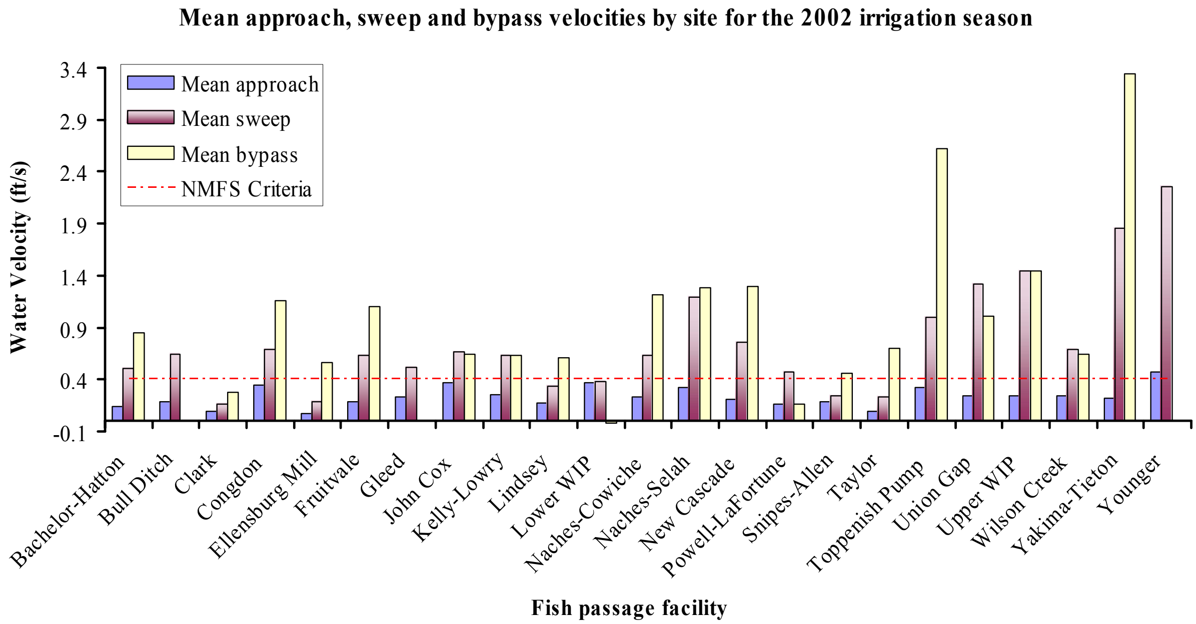

Figure 3. Mean Approach, Sweep, and Bypass Velocities at Phase II Fish Screen Facilities in the Yakima River Basin in 2002 Shown Against a Reference Line for the NMFS Approach Criteria (less than or equal to 0.4 ft/s)

Overall, 90% of all approach velocity measurements met the NMFS approach criteria of less than or equal to 0.4 ft/s (the same as was reported in 2000). This is much lower than the 97% reported in 2001; however, 2001 was an exceptionally low-water year, and many sites did not have enough water to meet other criteria, such as submergence and bypass flow. Areas of the screen (i.e., top, bottom, upstream, downstream) that exceeded these criteria were dependent on factors at the individual sites.

Water velocities at each site were often highly variable, both spatially and temporally. Flows were typically not uniform over screen surfaces. Often, there were distinct differences between top and bottom approach velocity values, but there was no obvious pattern associated with those differences. To standardize problem reporting, PNNL calculated average velocities for each screen site for the whole year. Sites with greater than 10% of approach velocities greater than 0.4 ft/s were considered to be in violation of NMFS criteria (Table 4). Also, considering only averages, sweep velocity was greater than approach velocity at all sites (Table 2, Figure 3). However, many sites had bypass velocities that were slower than the average sweep (Table 4, Figure 3). This is similar to patterns observed last year and is an area of concern because slow bypass velocities relative to sweep velocities could result in migration delay.

3.1.2 Underwater Video

Underwater video was used to inspect the conditions of the seals, to look for gaps between the seals and the screens that could allow small fish to pass through the site into the canal or be entrained or otherwise harmed, to record fish presence at the sites, and to monitor and document sediment and debris accumulation in front of the screens. The latter is important because debris can severely decrease seal life, cause drag on screen motors, and provide cover for fish predator species. Most often, it is difficult to see this debris from above the water's surface. Although a pole can be placed in the water to gauge the depth of accumulated sediments, one cannot determine exactly the kind of debris present, the proximity to the screen seal, and how it affects water flow through or past the screen without a video survey. Twelve sites were recorded as having excessive silt or debris at least once during 2002 (Table 4). Nine of these were drum screen sites. A much higher percentage of sites in 2002 had sediment or debris problems as compared with 2001, but, again, because 2001 was a low-water year and the water velocities were slower, the sediment carrying capacity of the water was diminished.

Most screens were properly sealed to prevent fish entrainment and injury, although potential problems were identified in 2002 at several screen sites. Four sites had loose or damaged seals or caulking that might have allowed fish to be entrained or caused physical damage to them (Table 4). Many of these problems were carry-overs from previous years that have not been remedied; however, some were new and were processed through the new problem-tracking protocol.

Most of the visible screen seals were in good condition. Bottom frame seals were sometimes buried in debris or aquatic plants and could not be evaluated. All drum screen seals that were classified as in "good condition" were tight against the screen and not cracked, warped, or punctured in any way. Many rubber seals were covered in algae or other growths, but this was not considered a problem. A number of the drum screen sites had expanding foam insulation placed between the concrete sides of the facility and the metal "cheeks" of the drum frame. This blocked off an area that could have entrained small fish, although they could not normally have moved into the aftbay (canal) through this route. Flat-plate screen seals were generally in good condition with the exception of some panels showing loose or missing caulking (e.g., Yakima-Tieton and Union Gap). Again, many of the flat-plate sites with loose or missing caulking were in poor condition in previous years.

3.1.3 General Data

In 2002, most sites were operating in a manner that would be expected to provide safe passage for juvenile salmonids. Some sites, such as Lindsey, were well maintained, well designed, and rarely exceeded criteria; while others, such as Bachelor-Hatton, have had problems over the past several years.

Automated cleaning brushes generally functioned properly; chains and other moving parts were well greased and operative. The WDFW's screen shop staff were generally prompt in repairing and/or cleaning screens. The percent of sites with excessive debris problems has been on the rise over the past several years. In 2002, 52% of sites had accumulated an excessive amount of sediment or debris, compared with 35% in 2001 and 24% in 2000 (Table 4). This is a concern because sediment and debris can create habitat for predators and cause mechanical brushes or drums to become less effective or even cease functioning (e.g., Naches-Selah in 2002).

3.1.3.1 Screen Submergence Levels

Phase II rotary drum screens are designed to be operated at submergence levels between 65 and 85%. At higher submergence levels, fish may roll over the top of the screen and enter the canal. Lower submergence levels can prevent the screen from efficiently removing debris from the forebay area. In 2001, 60% of drum screens were outside submergence criteria at least once. Most of these sites did not have enough water to effect appropriate submergence levels. In 2002, the percentage of drum screen sites that were outside submergence criteria at least once dropped to 20%.

Flat-plate screen sites do not have the same roll over and debris removal issues to contend with as rotary drum screens. However, should a flat-plate screen become completely submerged, fish can freely enter the irrigation canals by swimming over the top of the screen. Therefore, for 2001 and 2002, flat-plate screen sites were marked in Table 3 only if screens were completely submerged at any point during the irrigation season. Total screen submergence was not observed in 2002.

3.1.3.2 Bypass Outfall Conditions

The NMFS established a number of guidelines and criteria concerning bypass conduit design and outfall conditions (NMFS 1995). These criteria state that, "for diversions 25 cfs and greater, the required pipe diameter shall be greater than or equal to 24 inches and that the minimum depth of open-channel flow in the bypass conduit shall be greater than or equal to 9 inches, unless otherwise approved by the NMFS." Pipe diameter criteria exist primarily to minimize debris clogging and sediment deposition and to facilitate cleaning. For screens with a diversion flow of less than 25 cubic feet per second (cfs), the requirements are a 10-in.-diameter pipe and a minimum allowable water depth in the pipe of 1.8 in. All screens with bypasses that were evaluated with the exception of Bull Ditch, Clark, John Cox, Lindsey, Lower Wapato Irrigation Project (WIP), Taylor, Wilson Creek, and Younger are designed and built for diversion flows greater than 25 cfs. Many sites had bypass pipes with diameters much smaller than the NMFS criteria. However, all sites appeared to meet the minimum requirements for in-pipe water depth, with the exception of Naches-Selah, which was below the minimum requirement in May and June 2002.

3.1.3.3 Operator Control Aids

Visual operator control aids, while not required, are extremely useful for the maintenance and operations personnel who inspect the sites. Operator aids complement the operating criteria and help "flag" operational or procedural problems. Operator aids include marks indicating submergence level on drum screen frames; water depth or elevation gauges in the forebay, aftbay, and irrigation canal; and marks indicating how far headgate, bypass weir, or canal intakes are open. Providing highly visible indicators of screen system operation as it relates to NMFS criteria or of proper water diversion to the canal can save time and reduce incidences of operator error that may result in fish impingement, entrainment, or stranding at a site.

Most sites were equipped with gauges measuring elevation or water depth, although gauges were not always present both in front of and behind the screens. Drum screen submergence marks were present at most sites but were difficult to read later in the season because of the growth of algae and weather fading of some marks. As a result of this study, PNNL recommends regular cleaning and repainting of these marks to facilitate operator adjustments and evaluation.

3.2 Rotary Drum Screens

3.2.1 Bachelor-Hatton

The Bachelor-Hatton site was evaluated May 13, 2002; June 17, 2002; and September 10, 2002; although no water was present at the site in September. In May and June, 95 and 100% of approach velocities met NMFS criteria, respectively (Figures 4 and 5). Water velocities approaching screen 1 were more variable in June, and sweep velocity did not generally increase from the upstream screens to the downstream end of the site, although the bypass velocities were generally greater than the average sweep velocity.

No operator control aids such as submergence marks painted on the screen frames or gauges for measuring water depth have been installed at this site. However, submergence calculations revealed that the site exceeded criteria in May (93% submergence) but met criteria in June (81% submergence).

Video surveys in all 3 months showed that the seals were in good condition, with the exception of a bulge at the top of the upstream side seal on drum 4. However, this bulge was never submerged and could not have caused problems for fish. The gaps between the metal screen frames and the concrete wall noted in 2001 were still present in 2002. While fish cannot move into the aftbay through this route, a gap of this size could entrain small fish. The PNNL researchers recommend filling these gaps with expanding foam insulation to prevent harm to migrating fish.

Approximately 4 in. of sediment had accumulated in front of screens 3 and 4 in May, which increased to 5 in. in June and was still present in September. A fair amount of twigs and other debris were present in front of screen 4 and in the bypass during all surveys. Bypass conditions were good in May, but in June the bypass appeared to be backed up and did not drop into the downwell. Bypass outfall conditions met standards for safe fish passage in May and June. A juvenile salmonid was observed in front of screen 2 in June, and several small, unidentified fish were seen in the forebay in September.

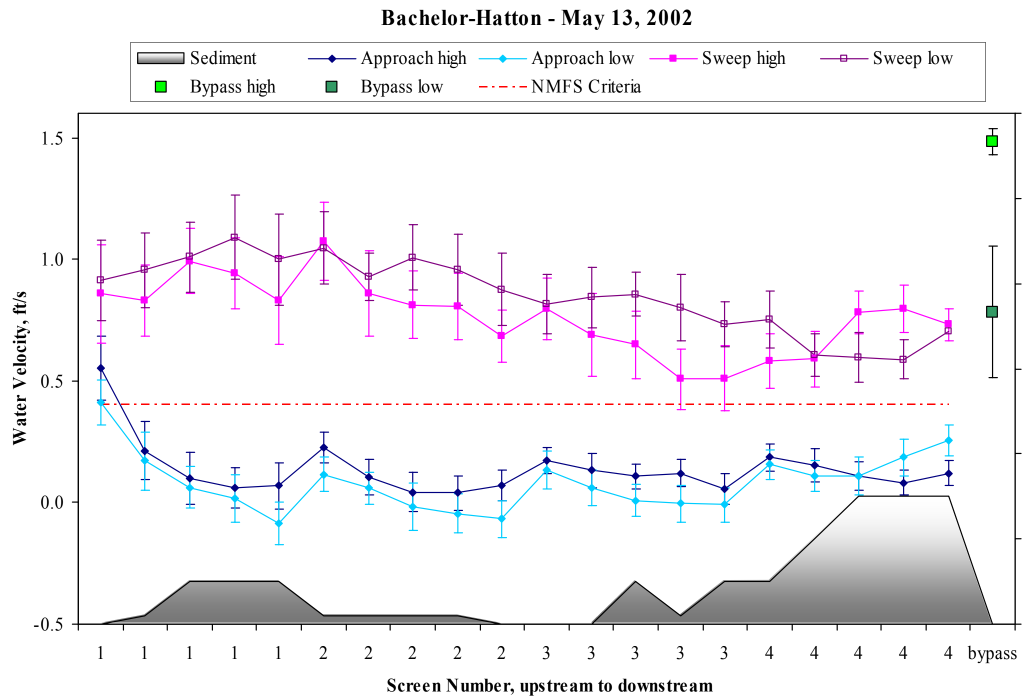

Figure 4. Water Velocities and Sediment Accumulation at Bachelor-Hatton in May 2002. Error bars (± the root-mean-squared [RMS]) represent turbulence at each point.

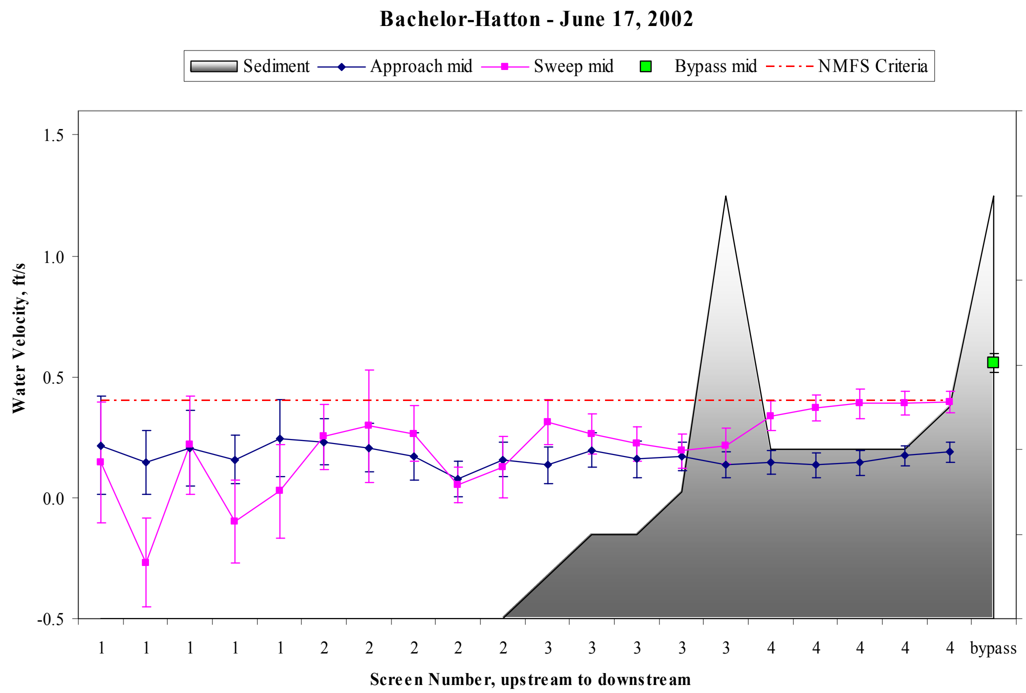

Figure 5. Water Velocities and Sediment Accumulations at Bachelor-Hatton in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.2 Clark

The Clark screening facility was visited on May 16, 2002; June 25, 2002; and September 19, 2002. Water velocities at this site complied with NMFS criteria during all surveys. All approach values were less than 0.4 ft/s, and sweep velocities were generally higher than approach velocities (Figures 6, 7, and 8). The water velocity in the bypass was always greater than the average sweep velocity, and in September, there was a clear increase in sweep velocity from upstream to downstream within the site. These conditions created a clear trajectory towards the bypass and would be expected to expedite fish passage through the site.

In the past, there have been many problems with beavers at this site. These issues appear to have been resolved for the 2002 irrigation season. There was some accumulation of leaves and branches at the trashrack, but they did not seem to affect operating conditions. Screen submergence met criteria during all site visits. No water was observed flowing over the headgates, and water always flowed freely over the weir and through the bypass outfall.

The condition of the screen and seals was good throughout all surveys. In June, three juvenile salmonids were observed in the forebay.

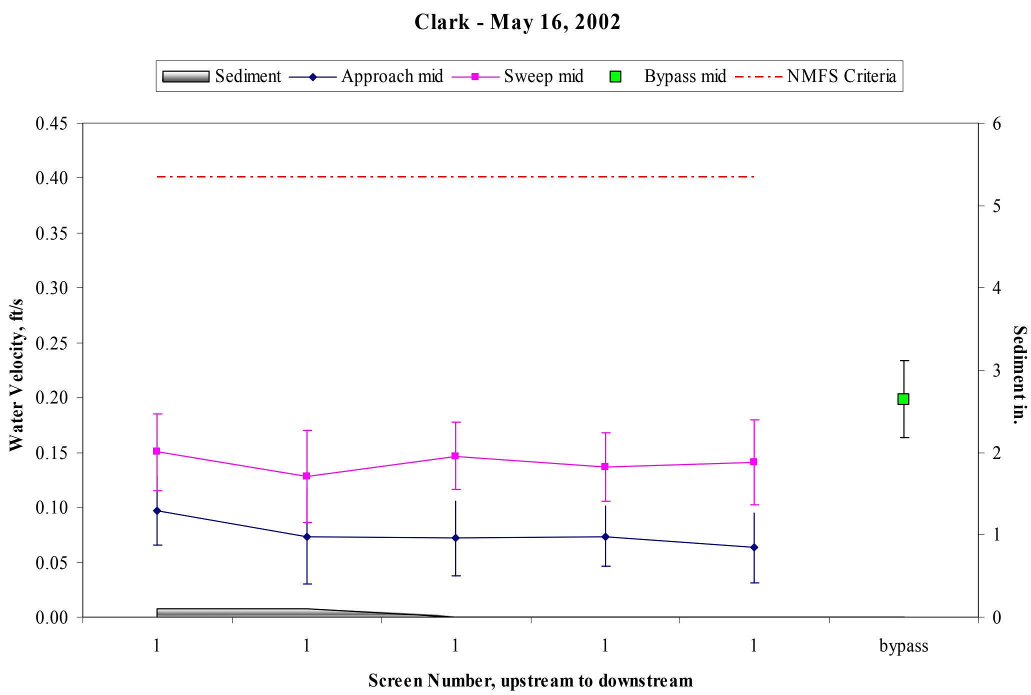

Figure 6. Water Velocities and Sediment Depths at Clark in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

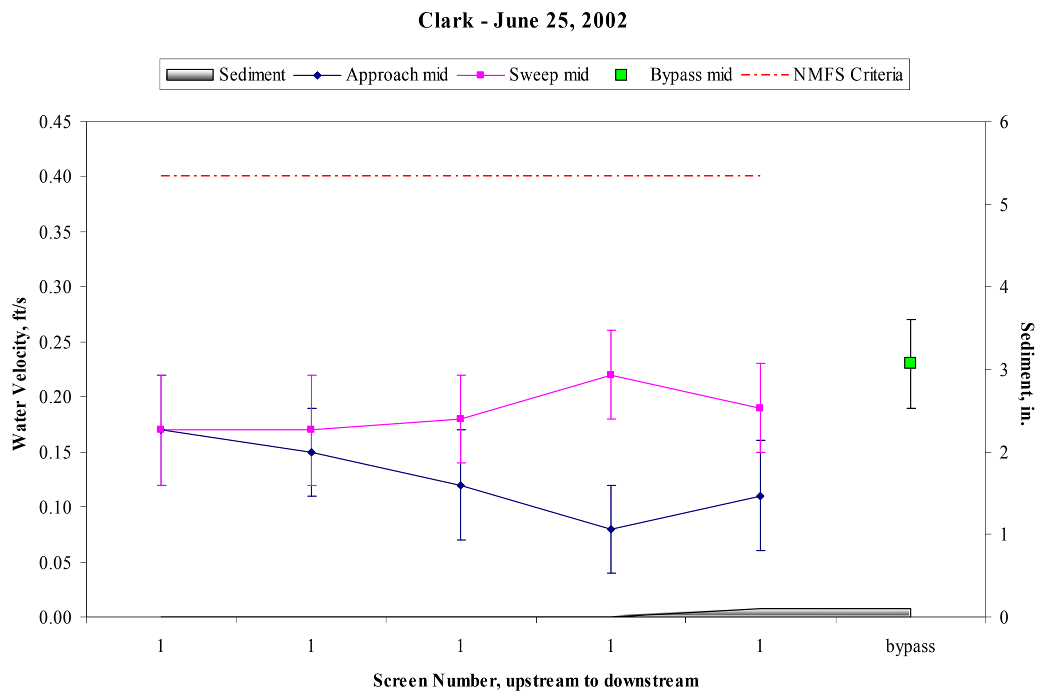

Figure 7. Water Velocities and Sediment Depths at Clark in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

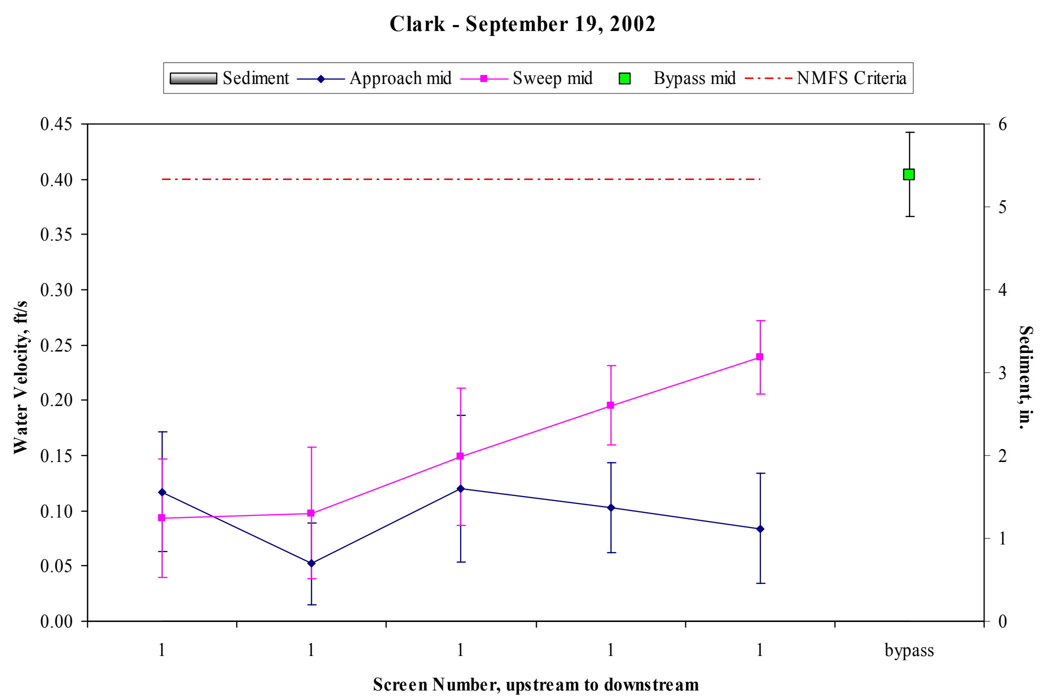

Figure 8. Water Velocities and Sediment Depths at Clark in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.3 Congdon

The Congdon facility was evaluated on May 20, 2002; June 20, 2002; and September 17, 2002. During the May evaluation, 67% of approach velocities exceeded NMFS criteria. This figure had greatly improved by June, and all approach velocities met NMFS criteria in June and September (Figures 9, 10, and 11). Sweep velocities were always higher than approach velocities, and the velocity in the bypass was always higher still, creating a clear trajectory towards the bypass during all surveys.

The screen seals were in good condition. There was no sediment in front of the screens during any of the surveys. Submergence was at the high end of the criteria range throughout the survey period: 85% during May and June, and 83% in September. The depth of water flowing over the weir and through the outfall met NMFS criteria. Water ran freely through the bypass, though, as in previous years, water surged at the bypass outfall. This condition was not as severe as in 2001 when PNNL researchers observed water spraying at least a foot above the outfall pipe. A test conducted in 2000 concluded that the surging was not caused by an obstruction of the bypass. This surging water could be harmful to fish moving through the bypass; the PNNL researchers recommend the installation of an air pressure release tube to prevent the surges.

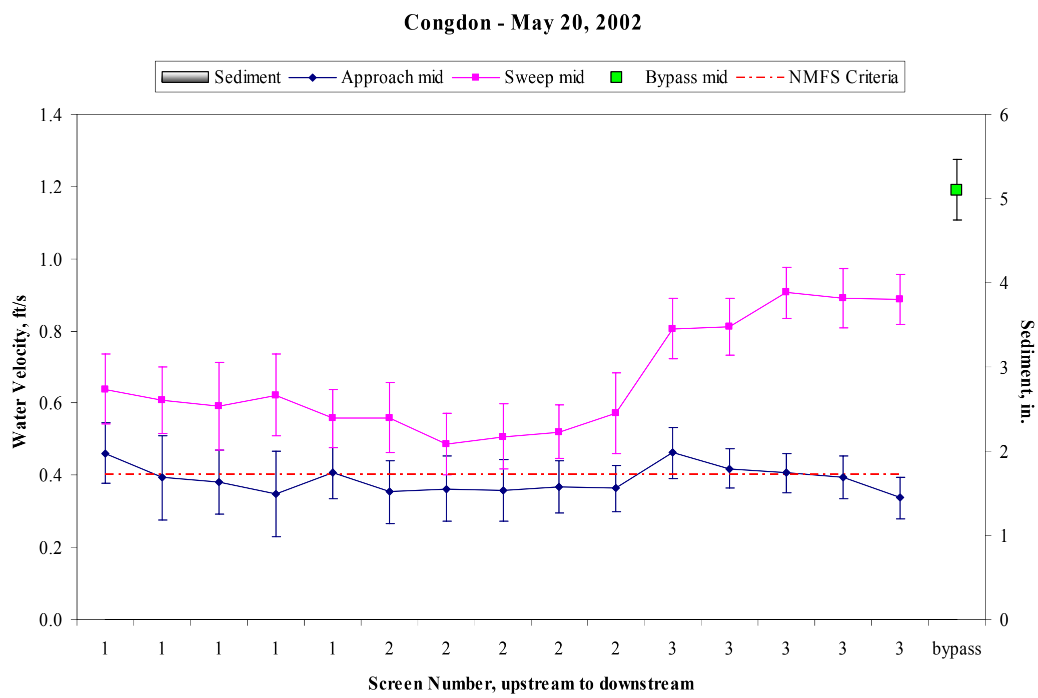

Figure 9. Water Velocities and Sediment Levels at Congdon in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

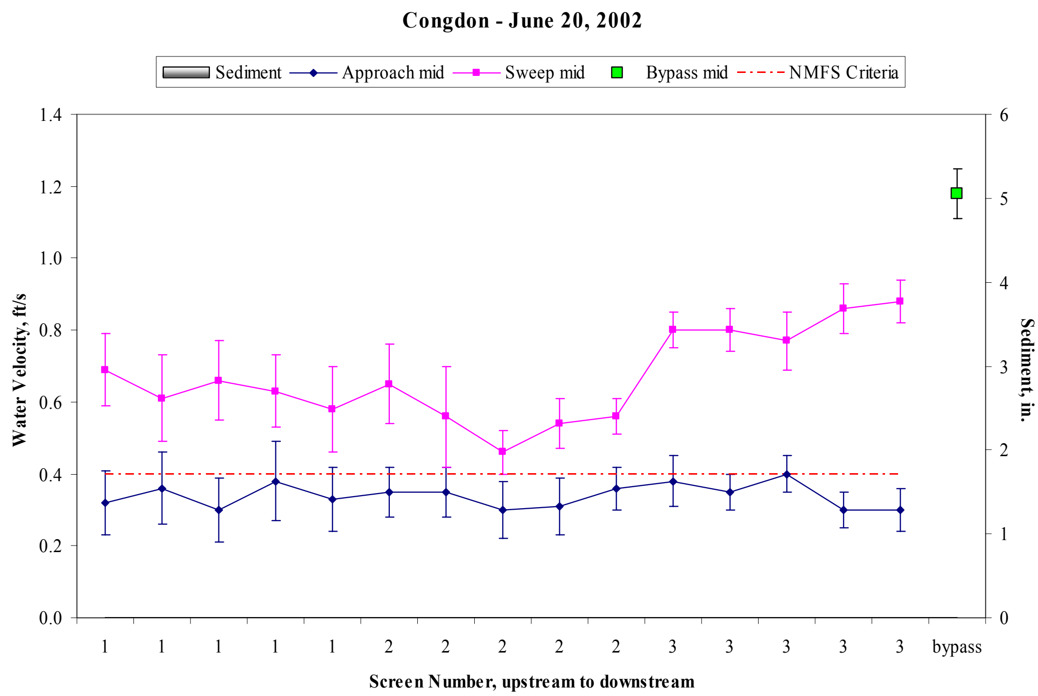

Figure 10. Water Velocities and Sediment Depths at Congdon in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

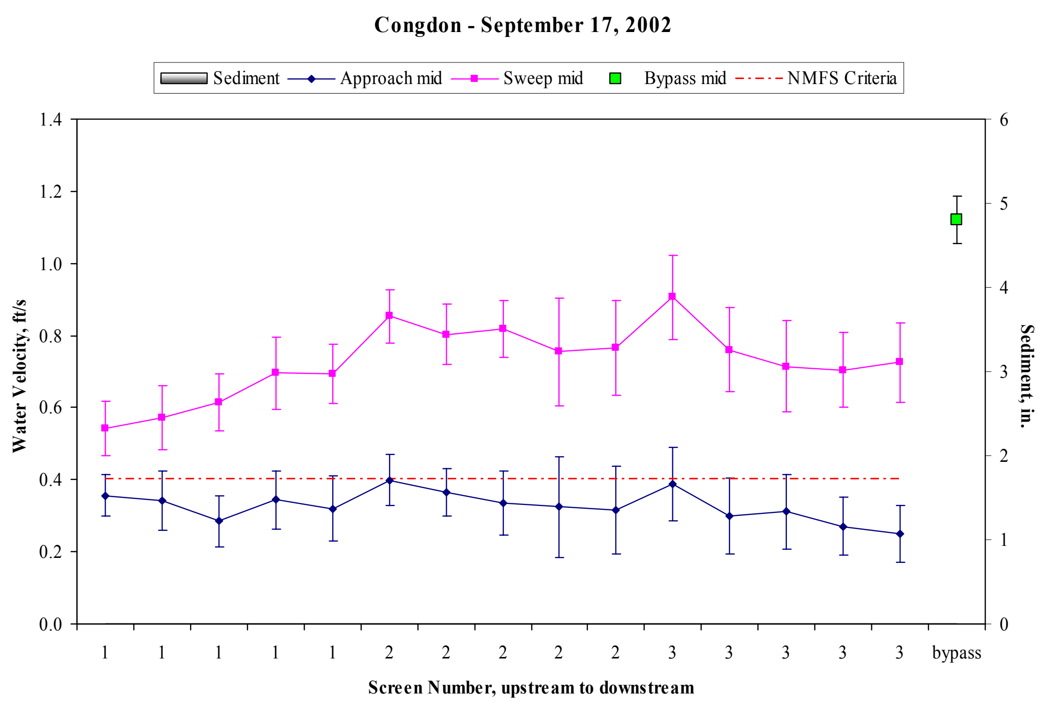

Figure 11. Water Velocities and Sediment Depths at Congdon in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.4 John Cox

The John Cox site was evaluated on May 13, 2002; June 17, 2002; and September 10, 2002, although the site was shut down for the season before the September survey. In May and June, 75 and 70% of approach velocities met NMFS criteria, respectively (Figures 12 and 13). However, there was a clear trend of decreasing approach velocity and increasing sweep velocity towards the downstream end of the site during both May and June. The bypass velocity was slower than the average sweep velocity in May, which led the PNNL researchers to believe that there was a blockage in the bypass. The PNNL researchers left a message for John Dyson (U.S. Bureau of Reclamation (USBR) concerning this issue on May 13, 2002. Tom Leonard (USBR) replied that there was no blockage. The PNNL researchers followed up on May 21, 2002, with a visit to the site. After passing a neutrally buoyant object through the bypass, the researchers concurred that the bypass was not blocked, but that it was backed up for some reason. This situation was remedied before the June survey, and in June, the bypass velocity was greater than the average sweep, and water ran freely over the weir and out the outfall.

The screens were vandalized sometime before the 2002 irrigation season and small holes in screen 2 were covered or filled with a black sealant. The screen seals appeared to be in good condition throughout the survey period, and the gap between the bottom seal and screen 2 noted in 2001 was not present in 2002. Submergence met NMFS criteria in May and June, and sediment accumulation was not a problem. Some small fish (~1 in.) were noted in the forebay in September. However, because the water level was below the rubber seals on the screens, they could not get through the bypass.

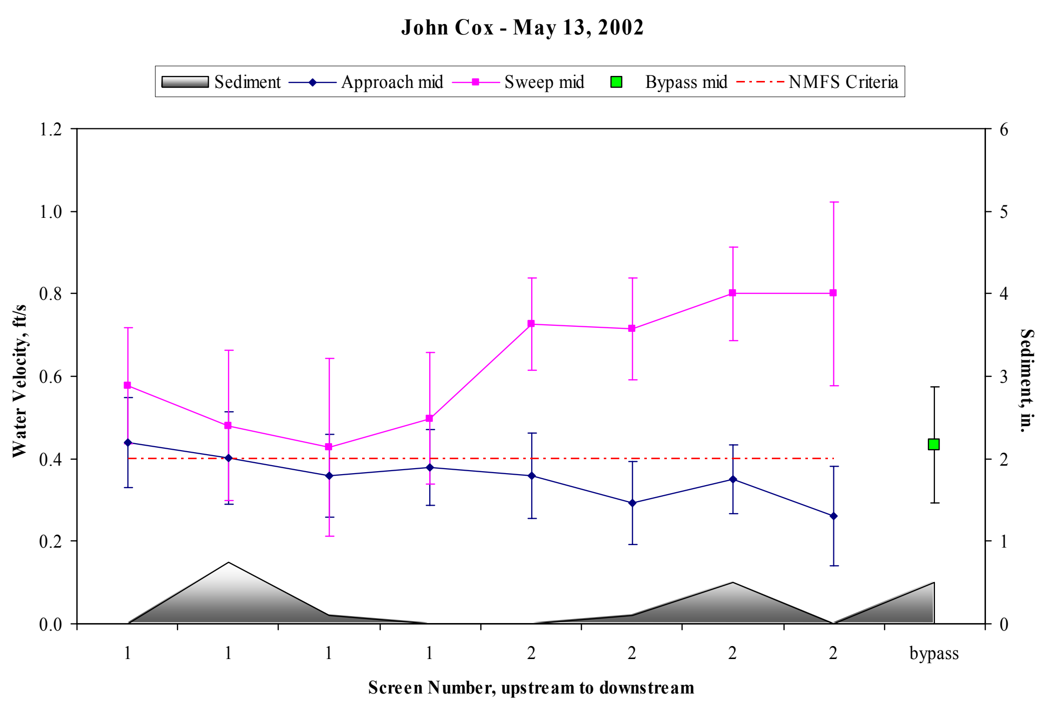

Figure 12. Water Velocities and Sediment Depths at John Cox in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Figure 13. Water Velocities and Sediment Depths at John Cox in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.5 Kelly-Lowry

The Kelly-Lowry site was evaluated on May 22, 2002; June 20, 2002; and September 17, 2002. All approach velocities met NMFS criteria during all surveys (Figures 14, 15, and 16). Sweep velocities were always higher than approach velocities, though sweep velocities did not increase towards the bypass. The bypass velocity was slower than the average sweep velocity in May and faster in June and September.

The screen seals all looked to be in good condition, though the site had some problems with sediment and debris building up in front of the screens throughout the year, which obscured the view of the seal in places. Overall, the site was somewhat cleaner than in 2001. A significant amount of debris had built up on the trashrack before the May survey, though there was no head loss across the trashrack. The gaps between the metal screen frames and the concrete wall noted in 2001 were still present in 2002. While fish cannot move into the aftbay through this route, a gap of this size could entrain small fish. The PNNL researchers recommend filling these gaps with expanding foam insulation to prevent harm to migrating fish.

One 8- to 10-in. juvenile coho salmon was noted in the forebay in May, and a similar-sized non-salmonid fish was noted in the bypass in June. Bypass conditions were conducive to safe fish passage in all surveys. Water ran freely over the weir, and the PNNL researchers did not observe any accumulation of debris at the outfall pipe until September, when some small twigs and grasses were present. The depth of water at the outfall was always greater than 1 ft, and water discharge at the outfall was smooth.

Operator control aids were present, though the submergence marks on the drum screen frame were faint even in May and should be repainted.

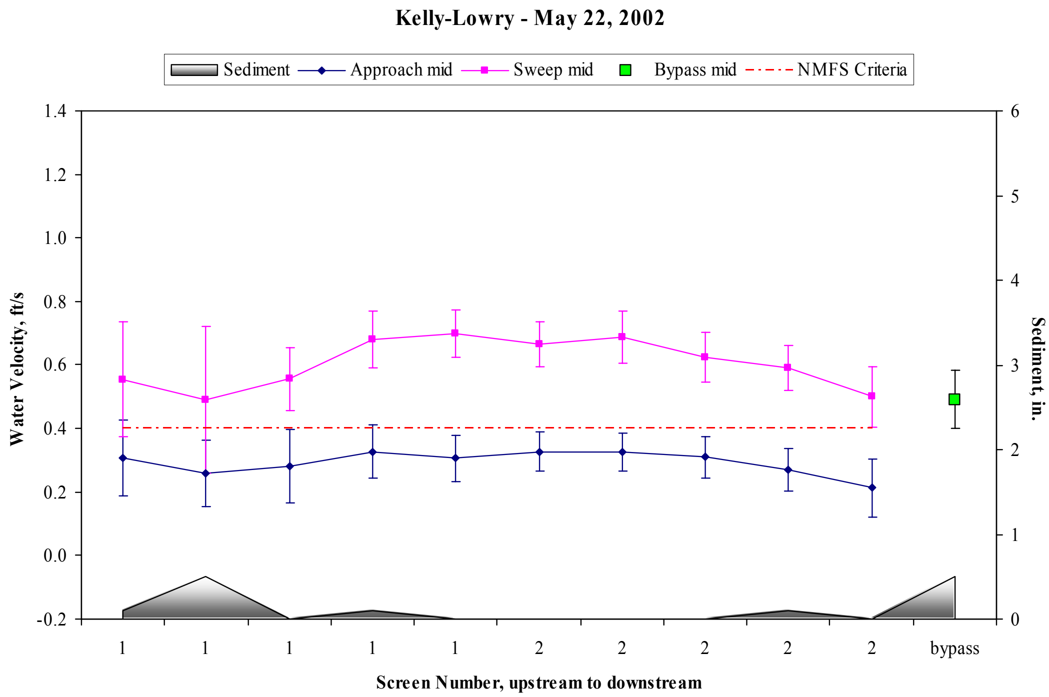

Figure 14. Water Velocities and Sediment Depths at Kelly-Lowry in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

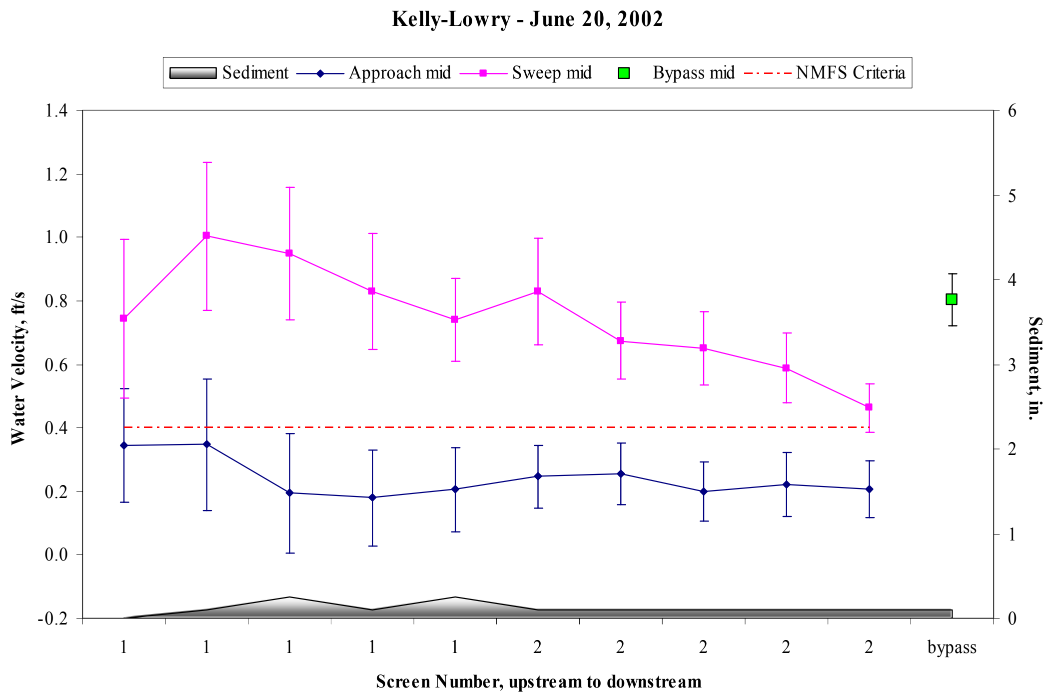

Figure 15. Water Velocities and Sediment Depths at Kelly-Lowry in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

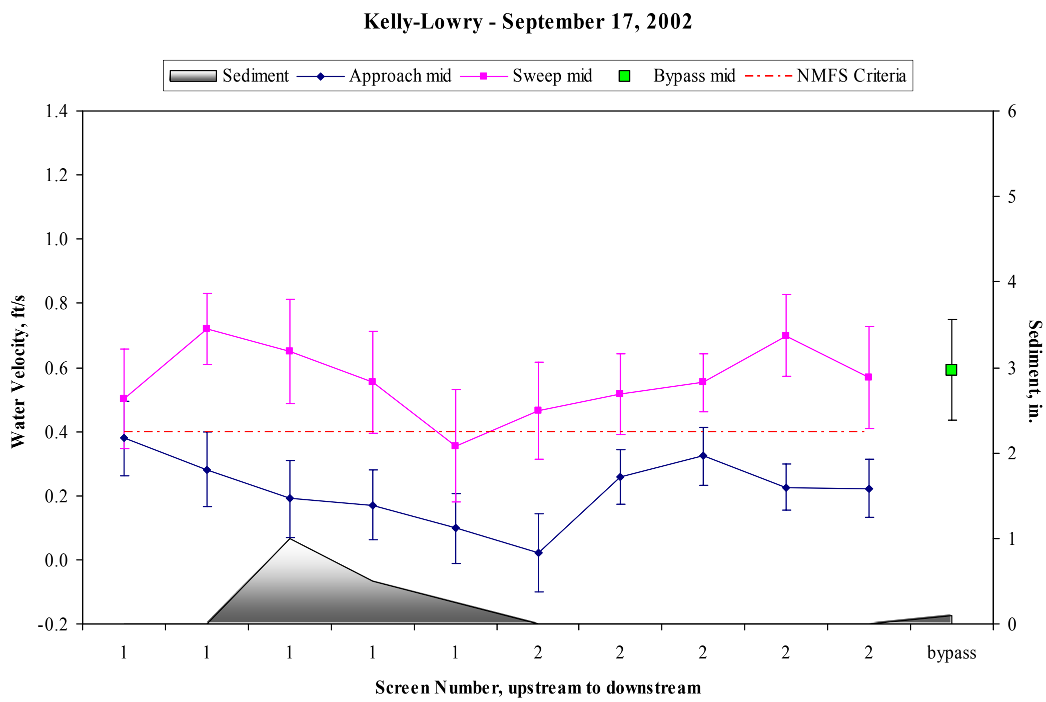

Figure 16. Water Velocities and Sediment Depths at Kelly-Lowry in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.6 Lindsey

The Lindsey site was evaluated on May 16, 2002; June 25, 2002; and September 18, 2002. During all surveys, 100% of approach velocity values met NMFS criteria (Figures 17, 18, and 19). All sweep velocities were greater than approach velocities, and the bypass velocity was greater than the average sweep velocity, except in September. In June, sweep increased from the upstream end of the site towards the bypass.

The screen seals were in good condition, and the drum moved leaf matter and other floating debris into the canal effectively. Submergence was always within criteria. The gaps between the metal frame of the screen and the cement wall were filled with expanding foam insulation that will prevent entrainment of small fish in these gaps.

In June, many 2- to 3-in. fish were noted in the forebay. Bypass conditions were conducive to safe fish passage. Water flowed freely over the weir and through the outfall, where the depth was always greater than 1 ft.

This site has always been maintained and operated to meet NMFS criteria and has had very few problems over the last several years. Because of the increasing number of requests to evaluate new sites each year, the PNNL researchers believe that it would be appropriate to inspect Lindsey only once a year.

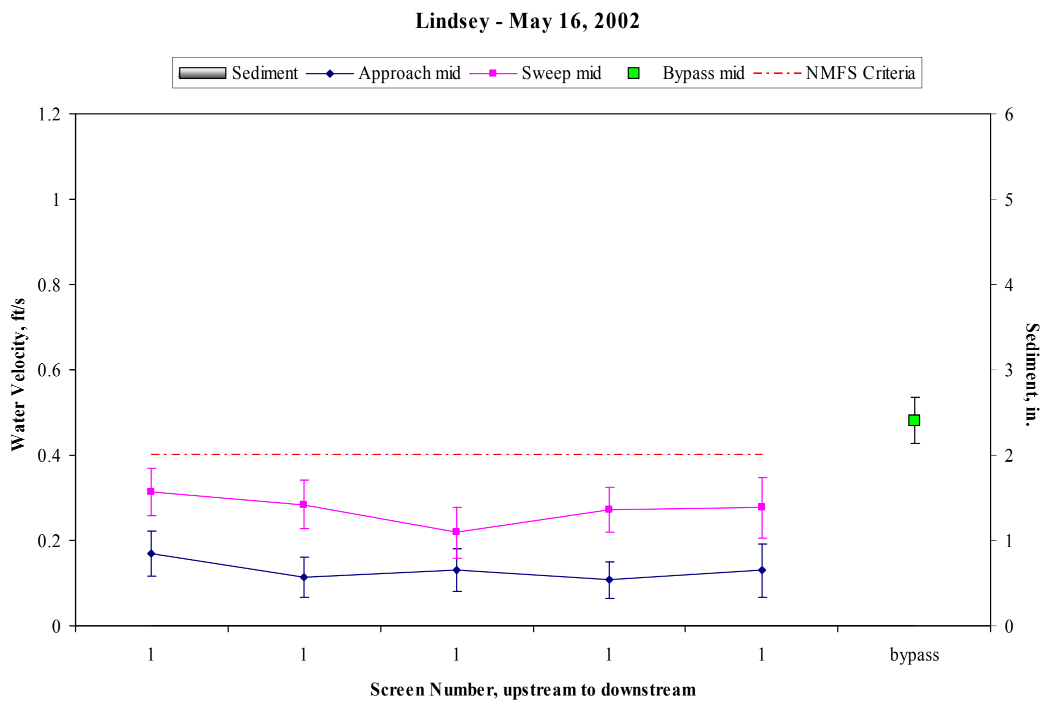

Figure 17. Water Velocities and Sediment Depths at Lindsey in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

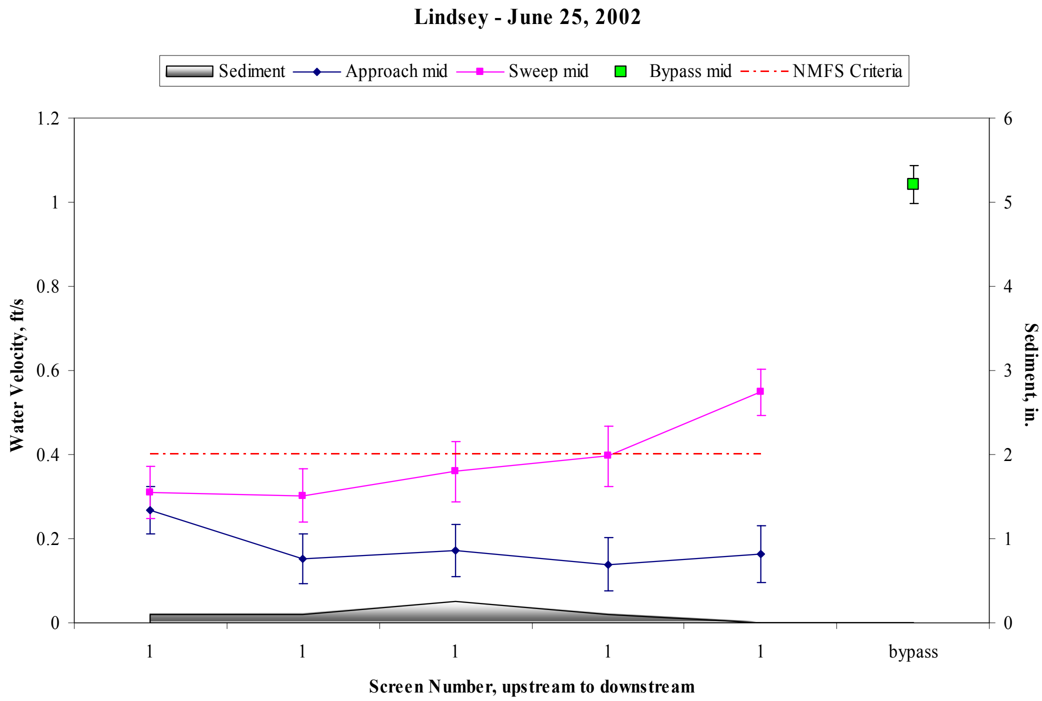

Figure 18. Water Velocities and Sediment Depths at Lindsey in June 2002. Error bars show turbulence (± the root-mean-squared [RMS] at each point.

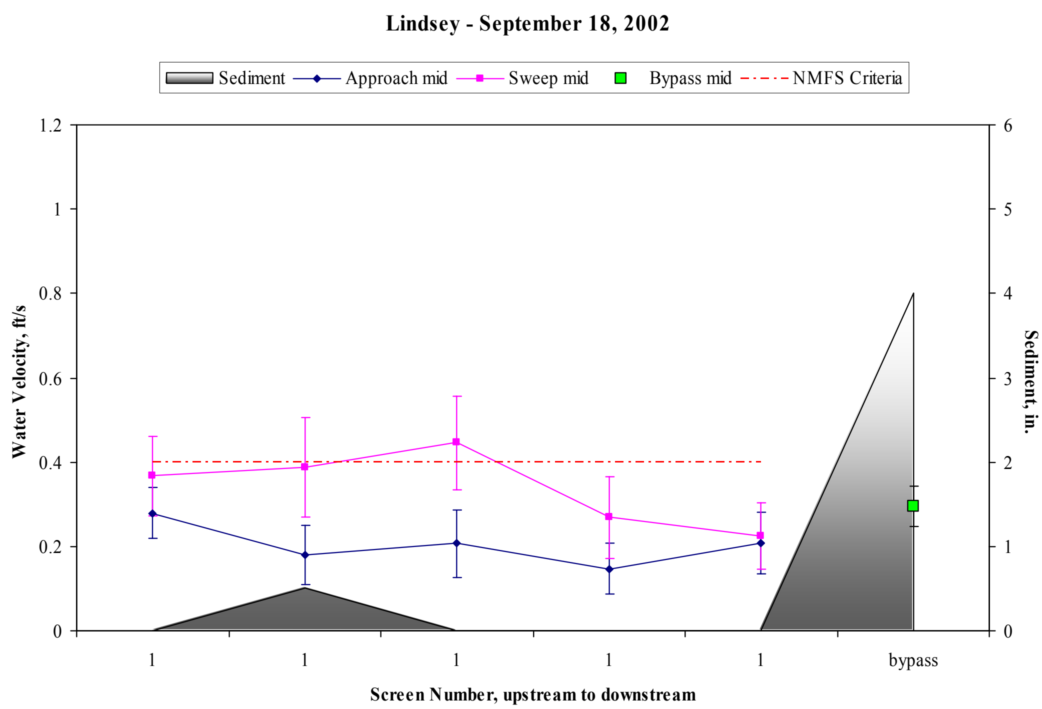

Figure 19. Water Velocities and Sediment Depths at Lindsey in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.7 Lower Wapato Irrigation Project (WIP)

The Lower WIP site was visited on May 21, 2002; June 18, 2002; and September 10, 2002. In May, all approach velocities met NMFS criteria. That figure decreased to 67% in June and 17% in September. In May, approach velocities were greater than sweep velocities. Sweep velocities did not generally increase towards the downstream end of the site, and bypass velocities were slower than the average sweep velocity (Figures 20, 21, and 22). This set of conditions could lead to delay for migrating fish.

During all surveys, an excessive amount of sand was present in the forebay, in front of the screens, and in the bypass. Submergence was below criteria in May at 60%. In June and September, submergence met criteria with 65 and 80%, respectively. In May, water flowed backwards from the downwell into the bypass, possibly because of high river flows. In June, sand had penetrated into the downwell and caused water to back up behind the weir. In September, the bypass pipe was plugged with sticks, again causing water to back up in the downwell. Bypass outfall conditions met NMFS criteria during all surveys. Those seals that were visible (i.e., not obstructed by sediment or debris) appeared to be in good condition.

In addition to the velocity and sediment problems, an oil leak from screen 1 was noted in the site operator's logbook on April 29, 2002, and was still present during the September survey. Large dents that nearly broke the screen material were noted on screen 1 in September.

The USBR, which is responsible for the operation and maintenance of this site, was notified May 21, June 18, and September 10, 2002, concerning the non-compliance of the site to NMFS criteria and the other maintenance concerns mentioned earlier. The USBR did not respond to any of these notifications. Velocity and sediment conditions such as these could lead to injury or delay of migrating fish. The PNNL researchers recommend removal of sediment deposits from the screen site, as well as monitoring facility operations more closely in an attempt to meet NMFS criteria.

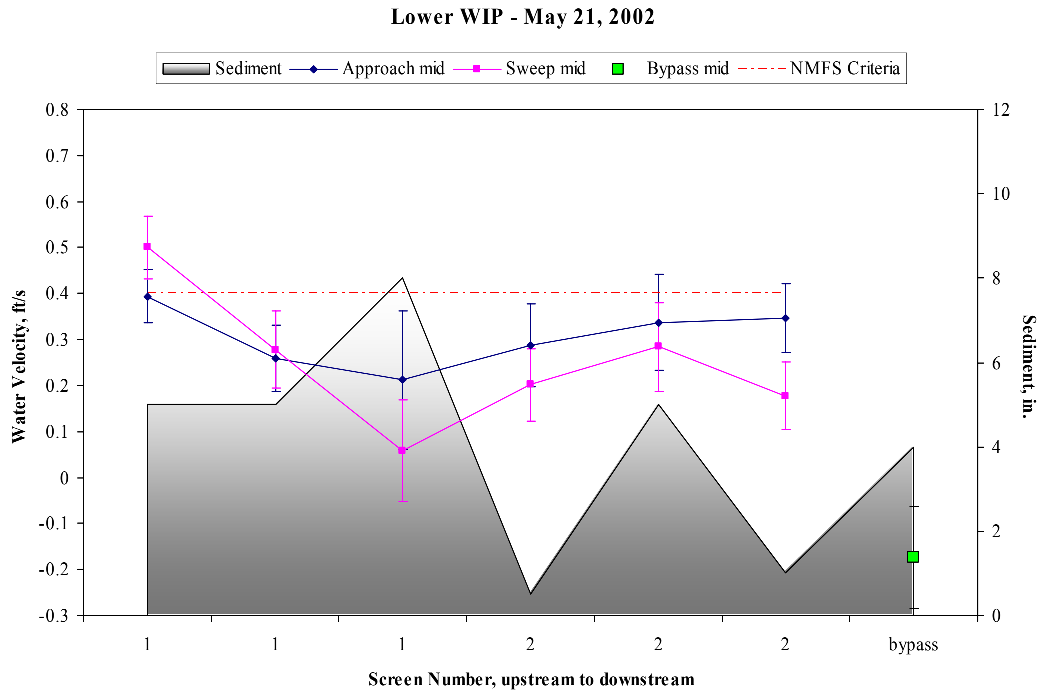

Figure 20. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

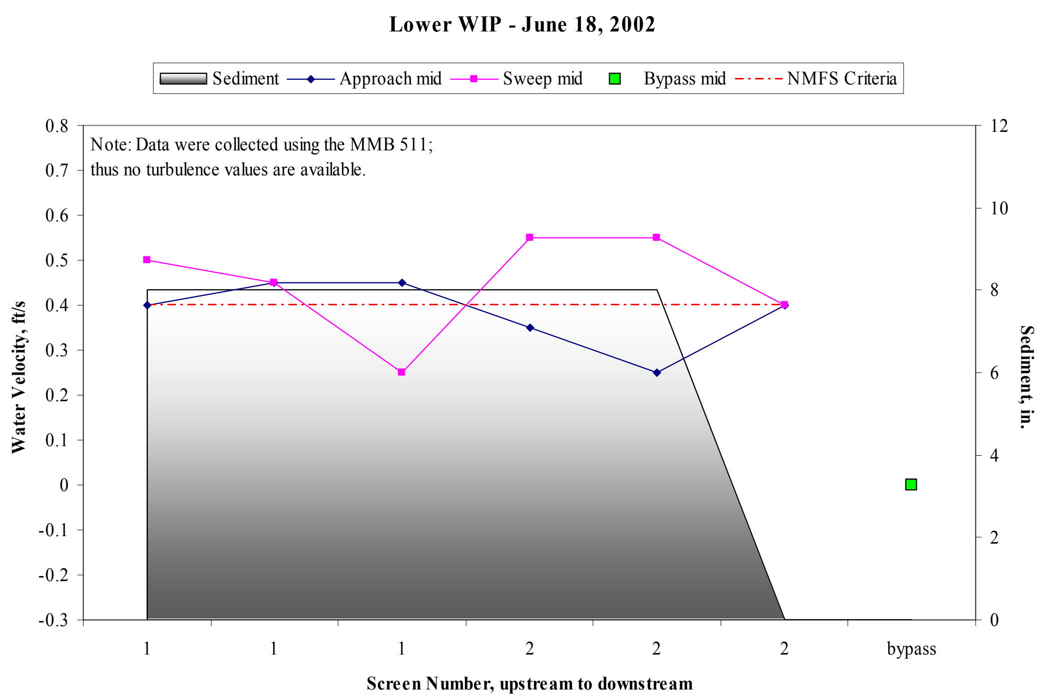

Figure 21. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in June 2002

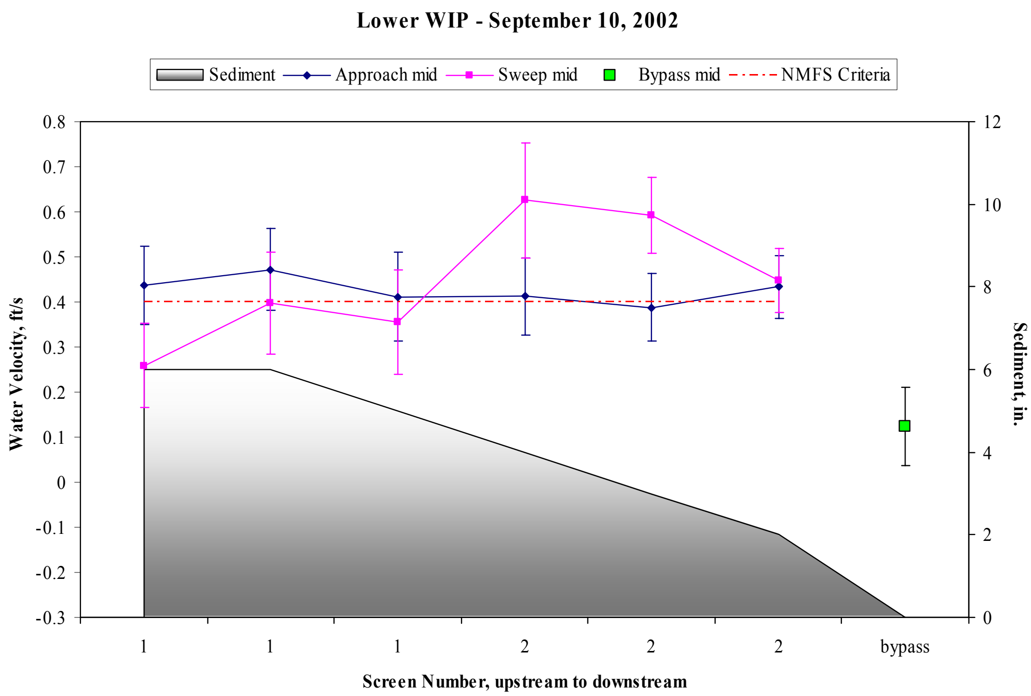

Figure 22. Water Velocities and Sediment Depths at Lower Wapato Irrigation Project (WIP) in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.8 Naches-Cowiche

The Naches-Cowiche site was evaluated on May 20, 2002; June 19, 2002; and September 11, 2002. In May, 95% of all approach values met NMFS criteria (Figure 23). This figure increased to 100% for June and September (Figures 24 and 25). Sweep velocities were generally higher than approach velocities but did not increase towards the bypass in May or June. The average bypass velocity was faster than the average sweep velocity during all surveys.

In 2001, two sets of stoplogs were placed in the forebay in an attempt to limit sediment accumulation against the screens. The 12-in. high stoplogs were placed on the concrete sill directly in front of the screens. These may have caused atypical flow patterns just above the stoplogs, so the PNNL researchers adjusted the measurement depths to account for this. The second set of stoplogs was placed in the forebay just upstream of screen bay 1, angling slightly downstream (Figure 26). In 2002, this set was moved farther upstream in an attempt to prevent the high water velocities seen at the head end of the site in 2001, but when the water increased in the spring these boards were blown out of place. Consequently there were no checkboards upstream of the screens during the 2002 irrigation season, although the stoplogs in front of the screens remained in place.

The stoplogs in front of the screens prevented an evaluation of the bottom seals with the video camera. All other visible seals were in good condition. During the June evaluation it was evident that debris had built up between the checkboards and the screens. Submergence was within criteria during all visits and bypass conditions were good for safe fish passage. There was some concern that the design of the bypass outfall did not compensate enough for the shifting riverbed because it became filled with rock when flows were high. The outfall channel has been dug out several times in the past, only to get filled in again when the river level rose. On August 16, 2002, PNNL researchers visited the site to confirm that the bypass was not obstructed by debris, and found it to be passable. That being said, the PNNL researchers recommend the design of the bypass and outfall be reevaluated. If the design of the bypass and outfall cannot be modified to prevent it from becoming filled with rock, then maintenance plans for the site will need to include regular clean-outs of the outfall channel.

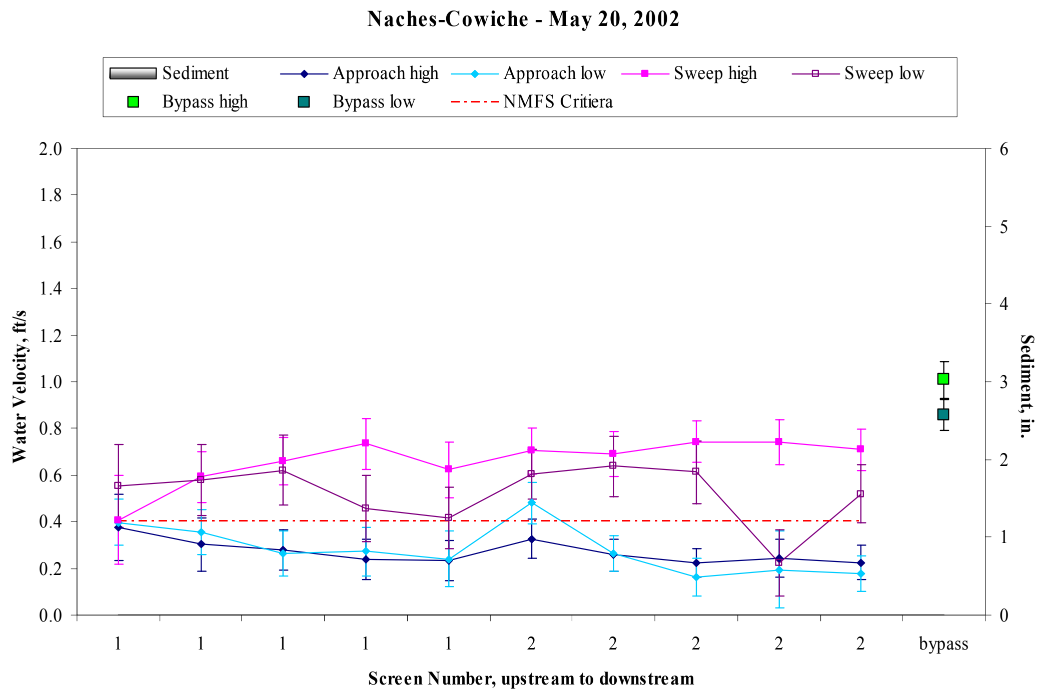

Figure 23. Water Velocities and Sediment Depths at Naches-Cowiche in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

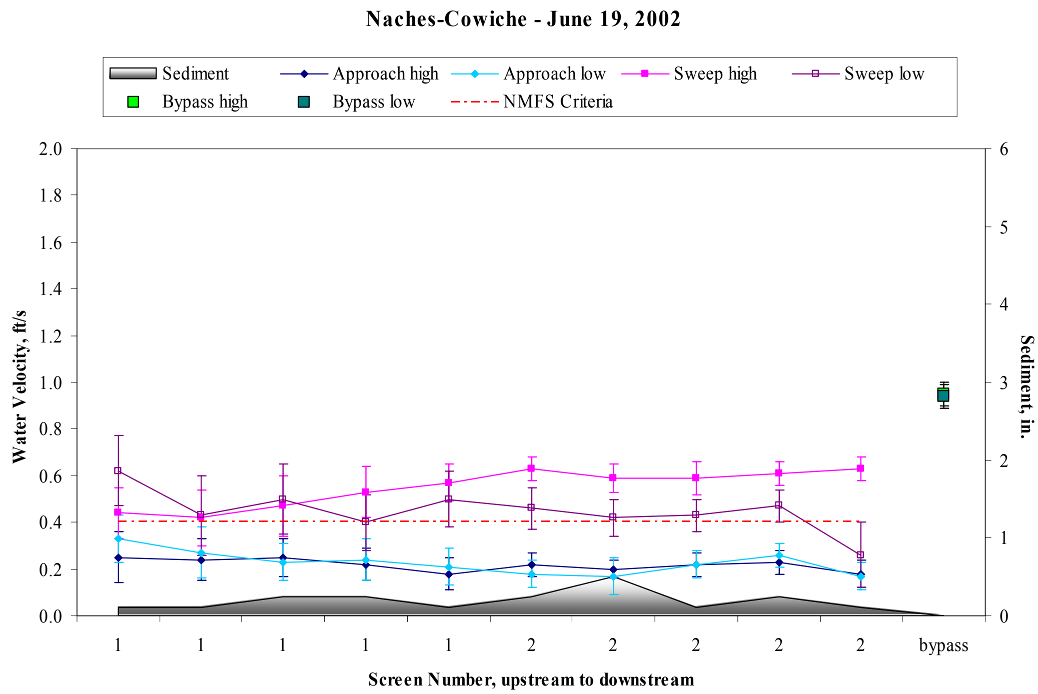

Figure 24. Water Velocities and Sediment Depths at Naches-Cowiche in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

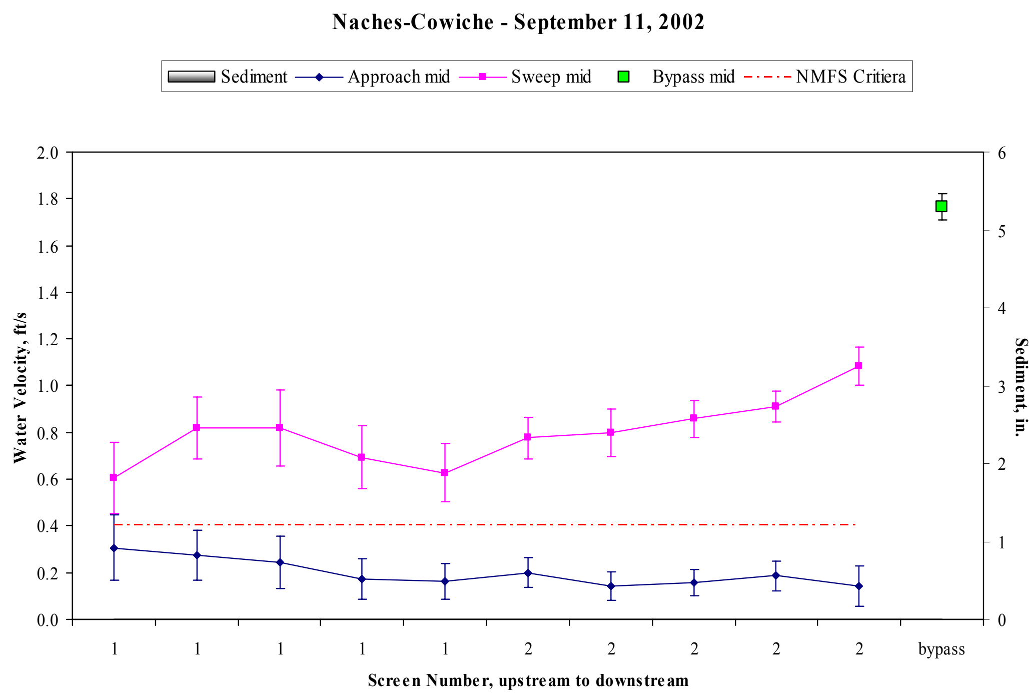

Figure 25. Water Velocities and Sediment Depths at Naches-Cowiche in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Figure 26. Screen 1 at Naches-Cowiche with Stoplogs in Front of the Screen (parallel) and Upstream of the Screen Bays (perpendicular to the direction of water flow). The upstream stoplogs were blown out by high flows early in the irrigation season.

3.2.9 New Cascade

The New Cascade site was evaluated on May 15, 2002; July 1, 2002; and September 16, 2002. Growth of aquatic plants in the forebay in September forced researchers to use the Marsh-McBirney flow meter, so turbulence values are not available for that survey. In May, July, and September 100, 93, and 100% of approach velocities met NMFS criteria, respectively (Figures 27, 28, and 29). Sweep velocities were generally faster than approach velocities, and sweep velocities increased slightly towards the bypass. Bypass velocities were faster than the average sweep velocity during all surveys.

Submergence slightly exceeded criteria in May and July, at 86 and 88%, respectively. In September, submergence was 82%. This site had some problems with sediment buildup, especially in the downstream corners of the screen bays, which obscured the view of the bottom seals in places. This is likely due to water eddying, which was clearly visible in the video surveys. Aquatic plant growth in September blocked the view of the bottom seal in places. The notches noted on the downstream side seal of screen 8 in 2001 were still present in 2002 (Figure 30). Except for the side seal on screen 8, all visible seals appeared to be in good condition, and all cheeks were sealed with expanding foam insulation.

Many fish were observed in the forebay during all surveys. In June, two 8-in. rainbow trout were observed in front of the screens, along with two similar-sized northern pikeminnow and several smaller juvenile salmon and other unidentified fish.

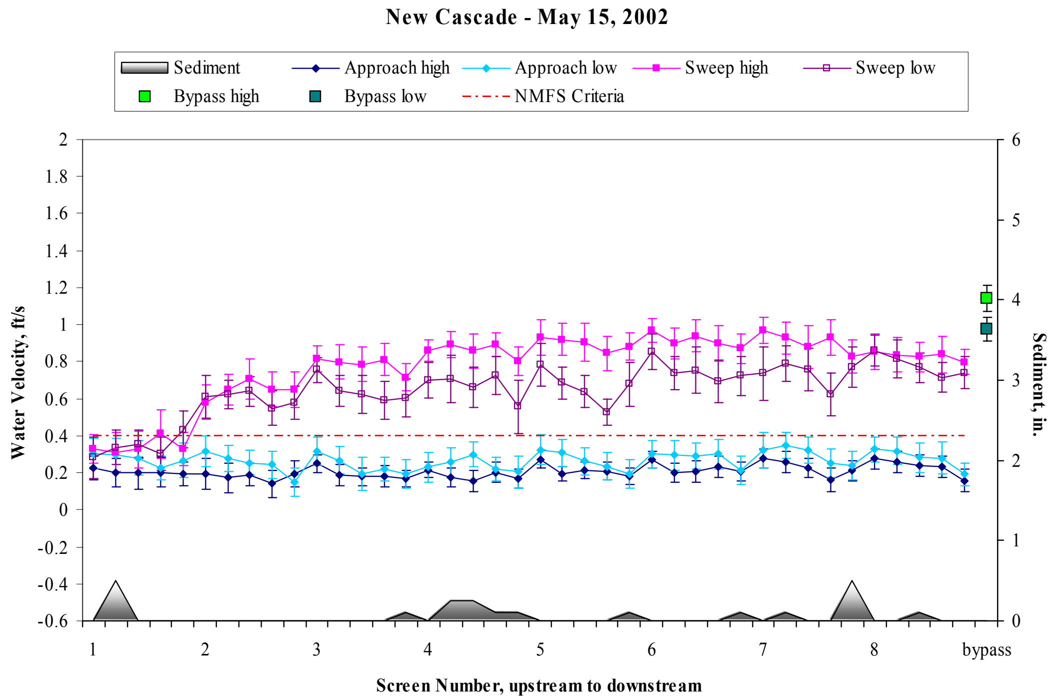

Figure 27. Water Velocities and Sediment Depths at New Cascade in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

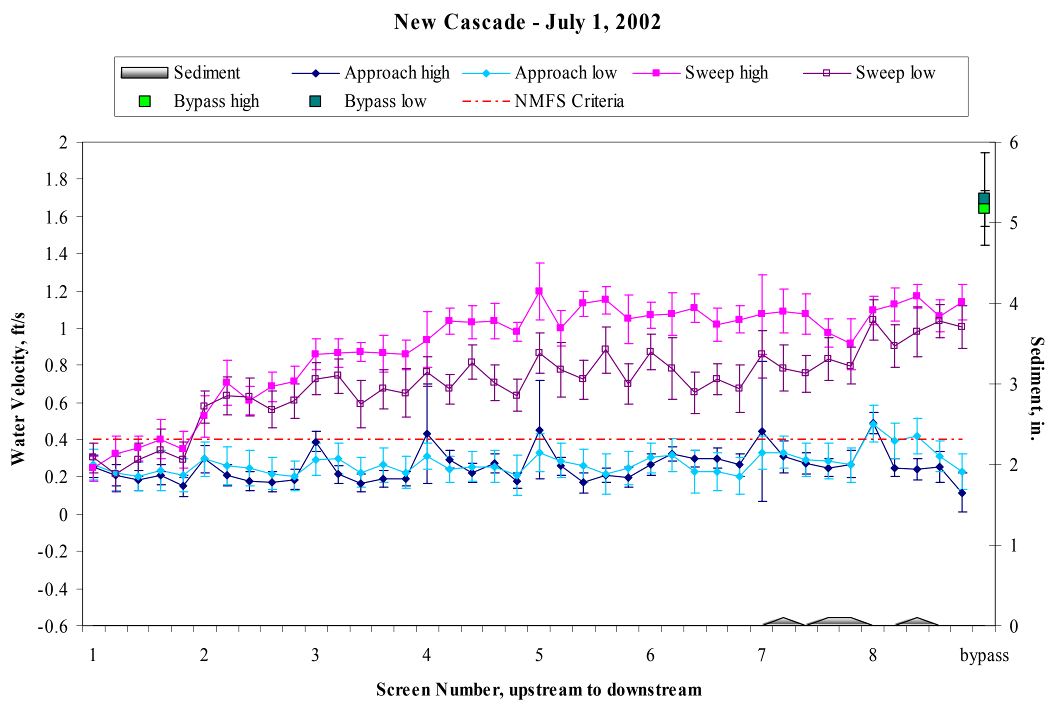

Figure 28. Water Velocities and Sediment Depths at New Cascade in July 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

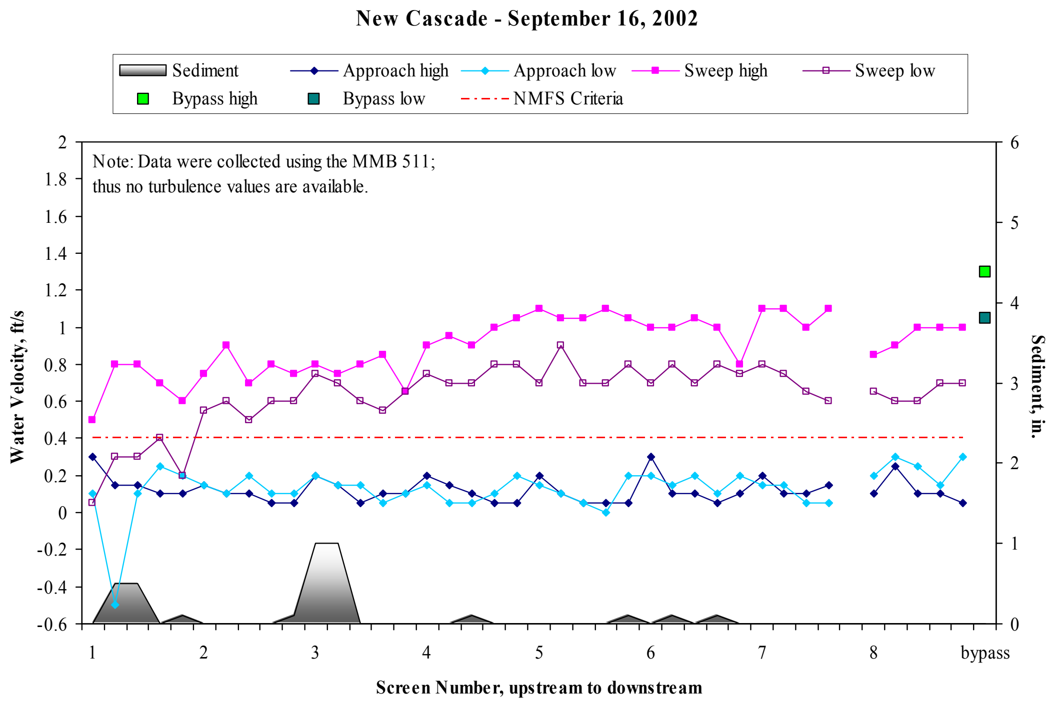

Figure 29. Water Velocities and Sediment Depths at New Cascade in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Figure 30. Damaged Seal at New Cascade, Downstream on Screen 8

3.2.10 Powell-LaFortune

Powell-LaFortune was evaluated on May 22, 2002; June 20, 2002; and September 17, 2002. Approach velocities met NMFS criteria 100% of the time. Sweep velocities were generally higher than approach velocities but did not increase towards the bypass (Figures 31, 32, and 33). Bypass velocities were slower than the average sweep velocity. Percent submergence fell below NMFS criteria in May and September at 63 and 50%, respectively. Submergence was 72% in June.

In the past, this site has had problems meeting NMFS criteria for submergence, and these problems continued during the 2002 irrigation season. Notes in the site operator's logbook state that submergence was low (28 to 60%) almost every time the site was visited by WDFW staff May through September, and there was often little to no flow through the bypass at these times (Figure 33). The Powell-LaFortune site has two trashracks: one on the canal leading to the site and the other at the head gates, farther upstream. The trashracks at the head gate often plug with excessive debris and are not cleaned regularly. During the PNNL researchers' visit to the site in June, enough debris had built up on the head-end trashrack to cause more than 1 ft of head loss across the debris. The PNNL researchers recommend that the upper trashrack be cleared of debris by the water users as a part of their daily operations procedures.

The leakage into the neighboring field noted in 2001 that occurred when water levels were high appeared to have been fixed by 2002.

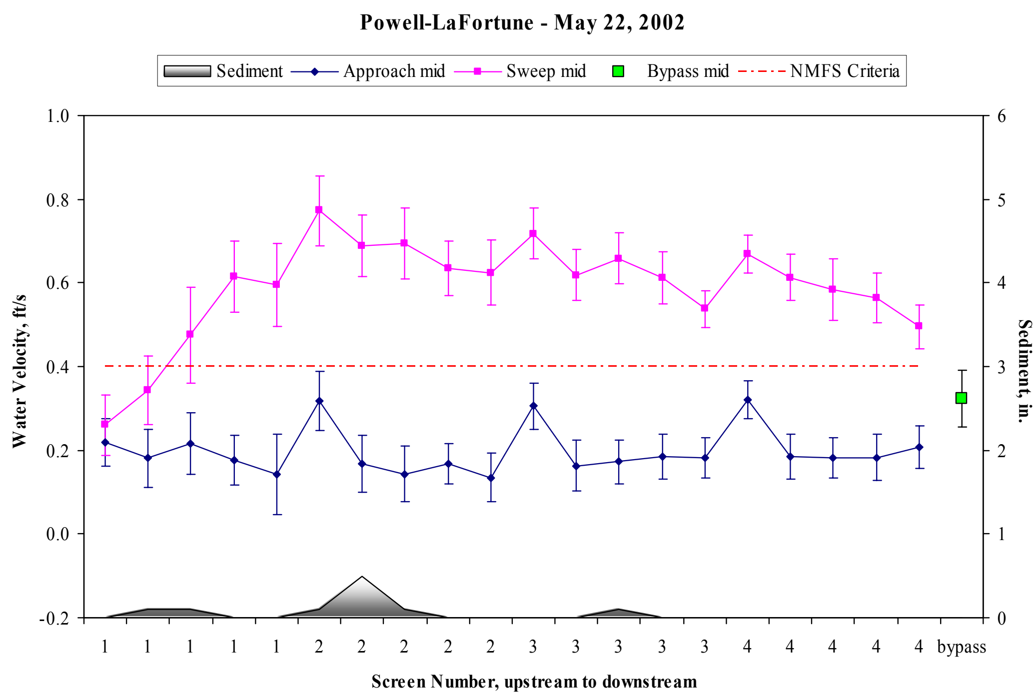

Figure 31. Water Velocities and Sediment Depths at Powell-LaFortune in May 2002. Error bars show turbulence (± the root-mean-squared [RMS] at each point.

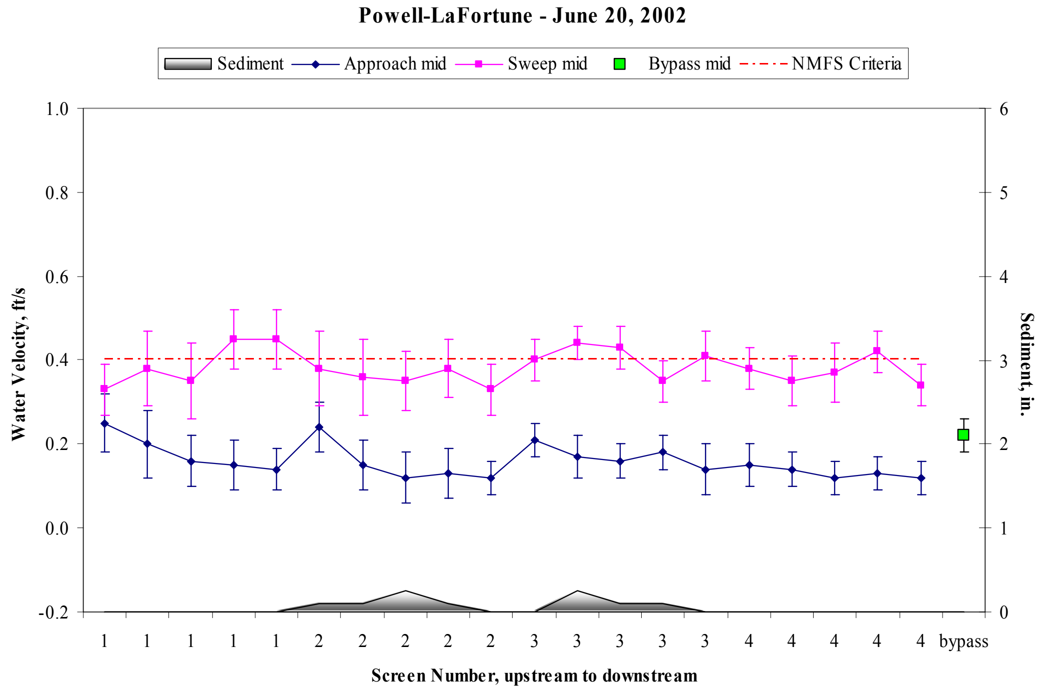

Figure 32. Water Velocities and Sediment Depths at Powell-LaFortune in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

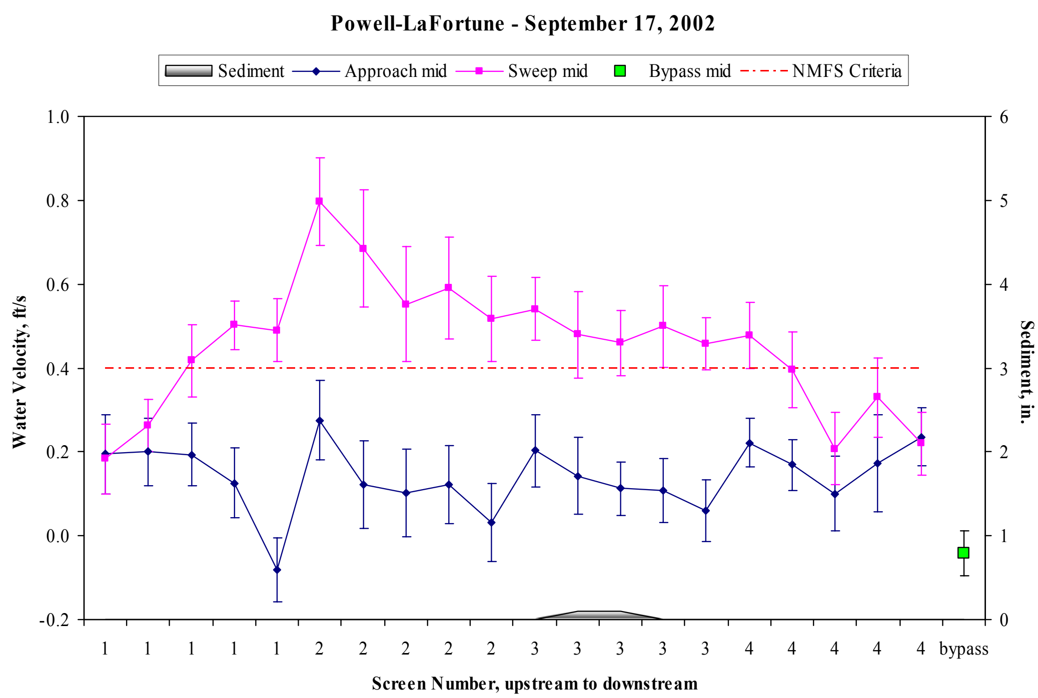

Figure 33. Water Velocities and Sediment Depths at Powell-LaFortune in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Some small 2- to 3-in. fish were seen in the forebay and the bypass entrance in May and June, and four 4- to 6-in. fish were seen in front of the screens and in the bypass in September. All visible seals were in good condition, as was the screen material. An accumulation of sediment covered some of the bottom seals in May, and a log was jammed underneath the open bypass ramp. Also in May, the video survey revealed what appeared to be a seed or rock trapped between the screen and bottom seal creating a small gap. After a few seconds, the obstruction was rolled out by the movement of the screen.

When there was enough water in the canal to create bypass flow, bypass conditions appeared to be conducive to safe fish passage. The downwell at this site is unusually deep, and the water level in it is relatively shallow. To mitigate for these conditions, the WDFW installed boards in the downwell to create a pool for fish to fall into safely. These boards apparently wash out occasionally and have to be reinstalled. In May and June, water flowed freely over the weir and through the outfall, and water depth in the outfall pipe met NMFS criteria. In September, no water flowed over the weir or through the outfall. In May, the lower canal outlet surges, though this was not considered a problem by the PNNL researchers.

3.2.11 Snipes-Allen

The Snipes-Allen site was evaluated on May 14, 2002; May 23, 2002; June 21, 2002; and September 12, 2002. All approach velocities met NMFS during all surveys (Figures 34, 35, 36, and 37). Sweep velocities were higher than approach velocities in late May and June, though in early May and September, sweep velocities were sometimes lower than approach velocities (Figures 34, 35, 36, and 37). Sweep velocities did not increase towards the bypass, and the average bypass velocity was slower than the average sweep velocity.

Screen submergence at Snipes-Allen met NMFS criteria during all surveys except in early May when the submergence was slightly higher (86%). In the past, this site has had many problems with debris catching on the trashracks, and while this problem was not as severe in 2002, there was still an accumulation of debris in the space behind the trashrack that could have provided cover for predator species or disrupted water flow through the site. In June and September, growth of aquatic plants in the forebay was noted. These plants also could provide shelter for predator species. The PNNL researchers recommend the site be regularly cleared of debris and vegetation to prevent harm to migrating fish.

This site has had many problems in the past with bypass obstructions, and these problems continued in 2002. During the survey in early May, water was backed up behind the weir and didn't appear to be flowing out the outfall. PNNL researchers notified Pat Schille (WDFW) about the problem. Pat Schille responded to PNNL early the next week. The bypass was cleaned out, and in late May the water was surging strongly behind the weir, and the water at the outfall surged also. Bill Werst (WDFW) commented that he thought the surging would settle out. In June, water ran freely behind the weir and out the outfall. As a test to determine whether the bypass was obstructed, PNNL researchers sent a neutrally buoyant object through the bypass pipe in June. It passed with no problems. Notes in the site operator's logbook mention additional problems with bypass blockage in August, and during the September survey, PNNL researchers noticed that the downwell was full of sticks, the bypass pipe was half full of debris, and less than 1 in. of water flowed over the weir. PNNL researchers notified Ray Gilmour (WDFW) of the blockage on September 13, 2002. He cleared out the bypass on September 17, 2002. The PNNL researchers followed up on September 19, 2002, and found submergence to be back up to 80%, and 6 in. of water flowed over the weir.

The screens and screen seals at this site were in good condition during all surveys. A 7-in. salmonid was seen in the forebay in early May, along with some other small fish. Some fish were noted in the forebay in May that were possibly chiselmouth or redside shiners. In September, several larger fish were seen in the bypass, and small fish were observed upstream of the trashracks and just below the outfall pipe.

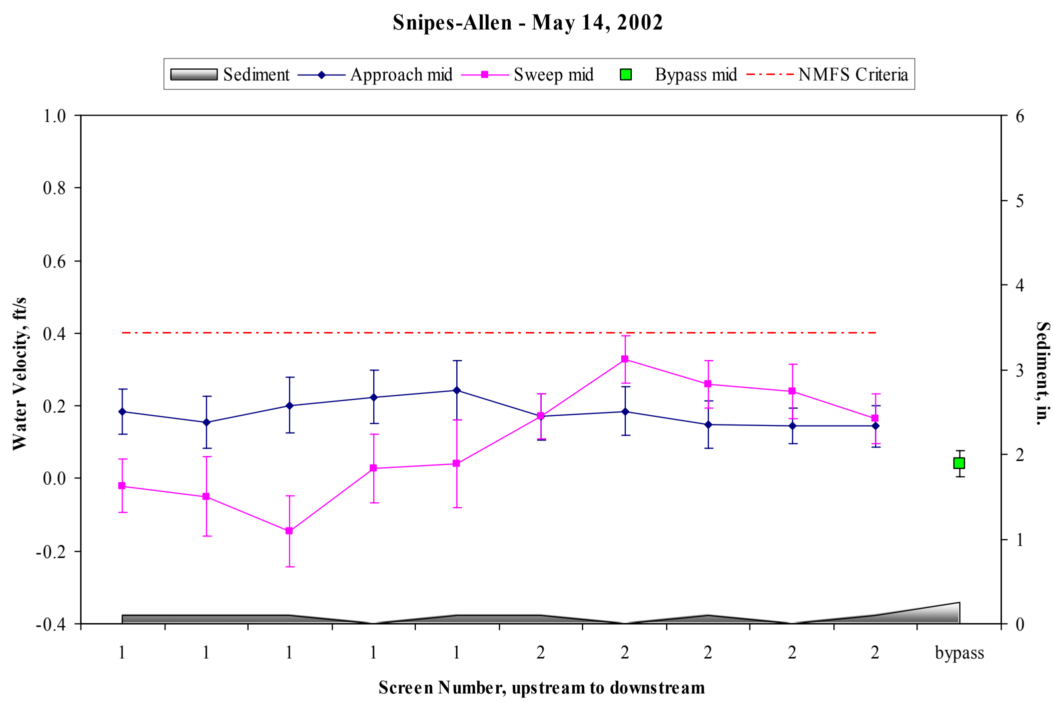

Figure 34. Water Velocities and Sediment Depths at Snipes-Allen, May 14, 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

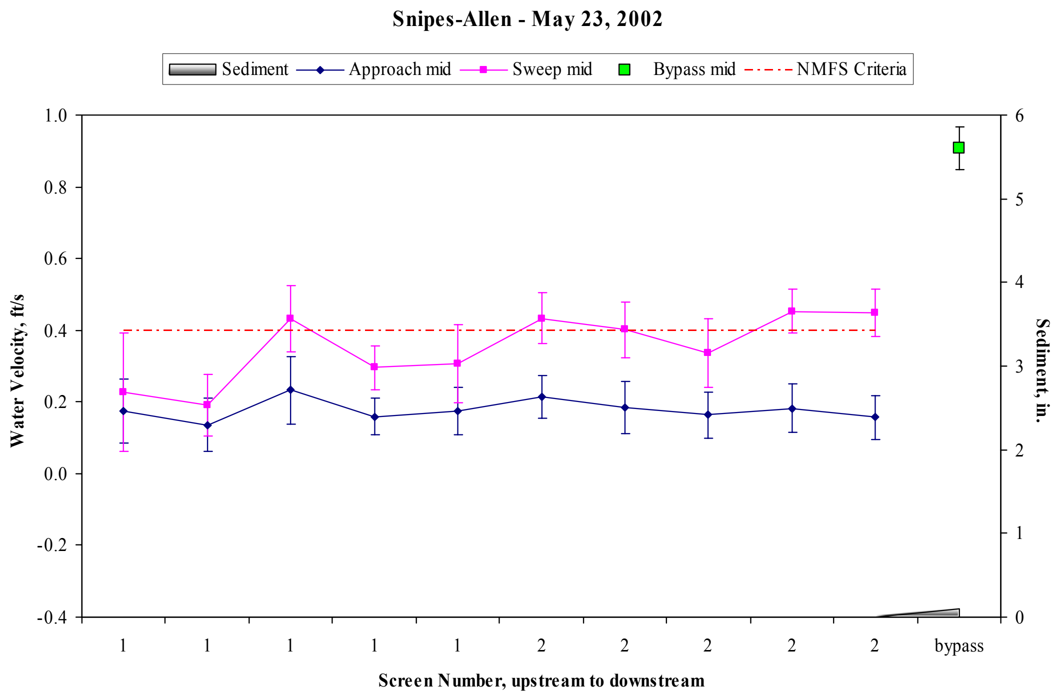

Figure 35. Water Velocities and Sediment Depths at Snipes-Allen, May 23, 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

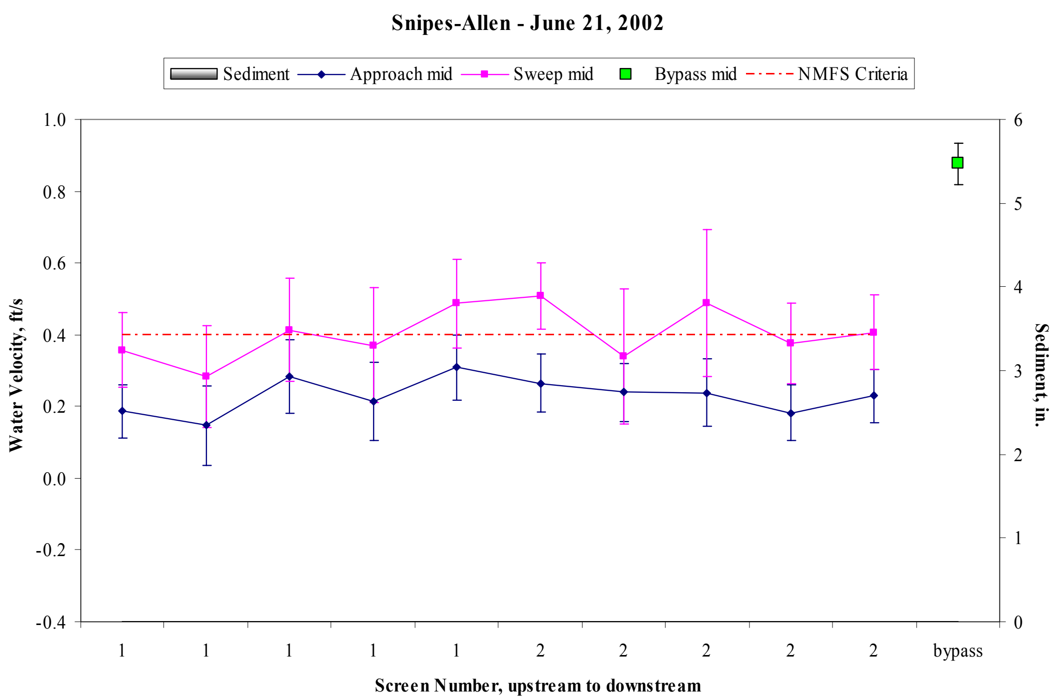

Figure 36. Water Velocities and Sediment Depths at Snipes-Allen in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

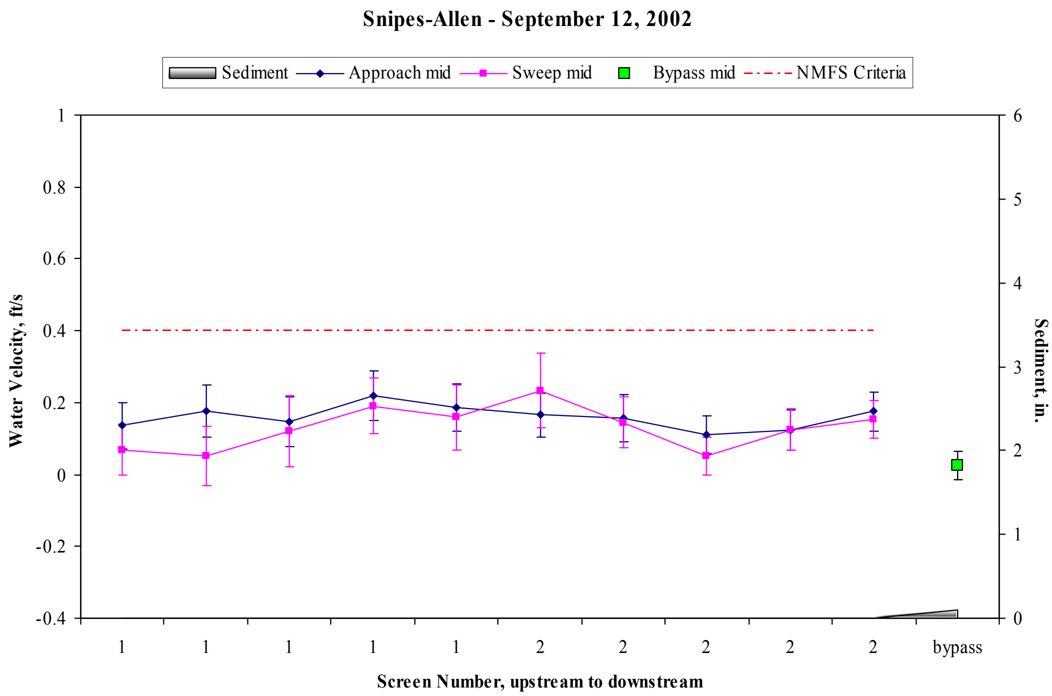

Figure 37. Water Velocities and Sediment Depths at Snipes-Allen in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.12 Taylor

The Taylor site was evaluated on May 22, 2002; June 25, 2002; and September 17, 2002. All approach velocities met NMFS criteria in May and June, and the site was effectively shut down for the season before the September evaluation (Figures 38 and 39). Sweep velocities were always greater than approach velocities, and the bypass velocity was always greater than the average sweep velocity. Percent submergence met criteria during the surveys in May and June.

Screen and seal condition appeared to be fine, and the gaps between the metal frame of the screens and the cement walls were filled with expanding foam insulation. In May, water flowed freely under the bypass ramp, which was lifted completely up, and through the weir into the downwell. In June, the ramp was closed, and water flowed freely over the weir. Outfall conditions were within all criteria limits in May and could not be evaluated in June because the area was overgrown.

In September, there was only 6 in. of water in the forebay, and the first drum screen was turned off. The bypass was blocked off by checkboards that were installed in front of the ramp on September 4, 2002. There was no flow through the bypass, and the point of discharge at the outfall appeared to be less than 12 in. deep, though the researchers could not get to it to measure it because the area was too overgrown. Notes in the site operator's logbook show that this site had difficulties maintaining submergence to within criteria and that flows have been very inconsistent throughout the irrigation season. Submergence was below criteria for most of September.

According to the PNNL's problem-tracking protocol, researchers contacted WDFW staff concerning the issues of low submergence and blocked bypass on September 17, 2002, and September 18, 2002. Bill Werst (WDFW) responded on October 3, 2002, with the comment that not much could be done because the amount of water coming through the headgates was low and the water user had a right to the water. Werst said that once a week he lifted the checkboards out of the bypass and flushed it and that he would continue to do so until the water level rose.

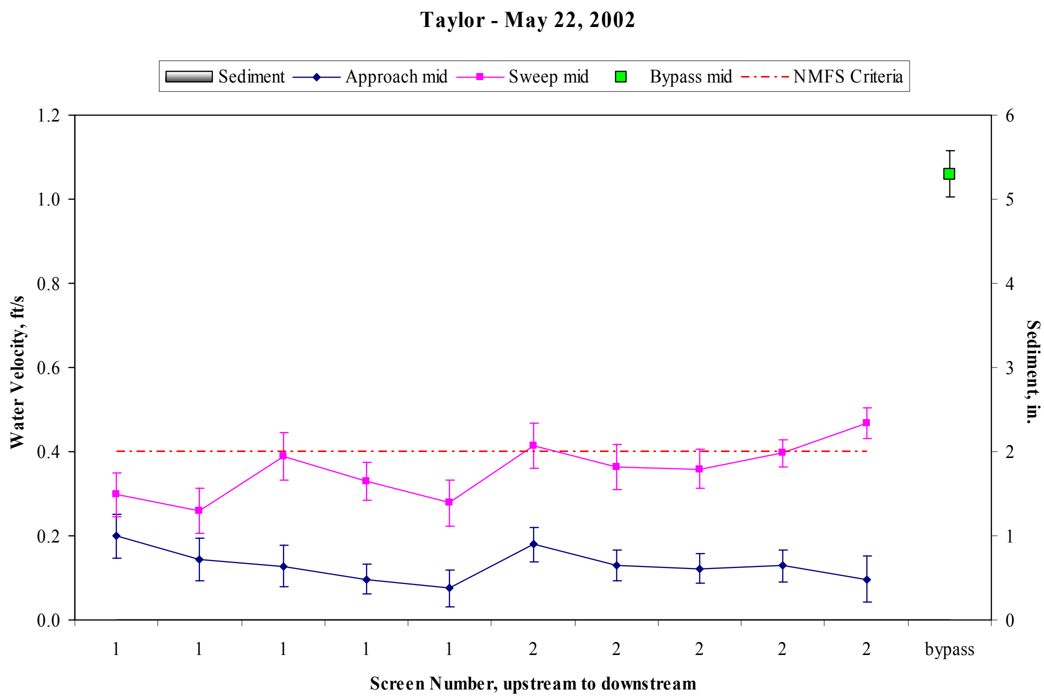

Figure 38. Water Velocities and Sediment Depths at Taylor in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

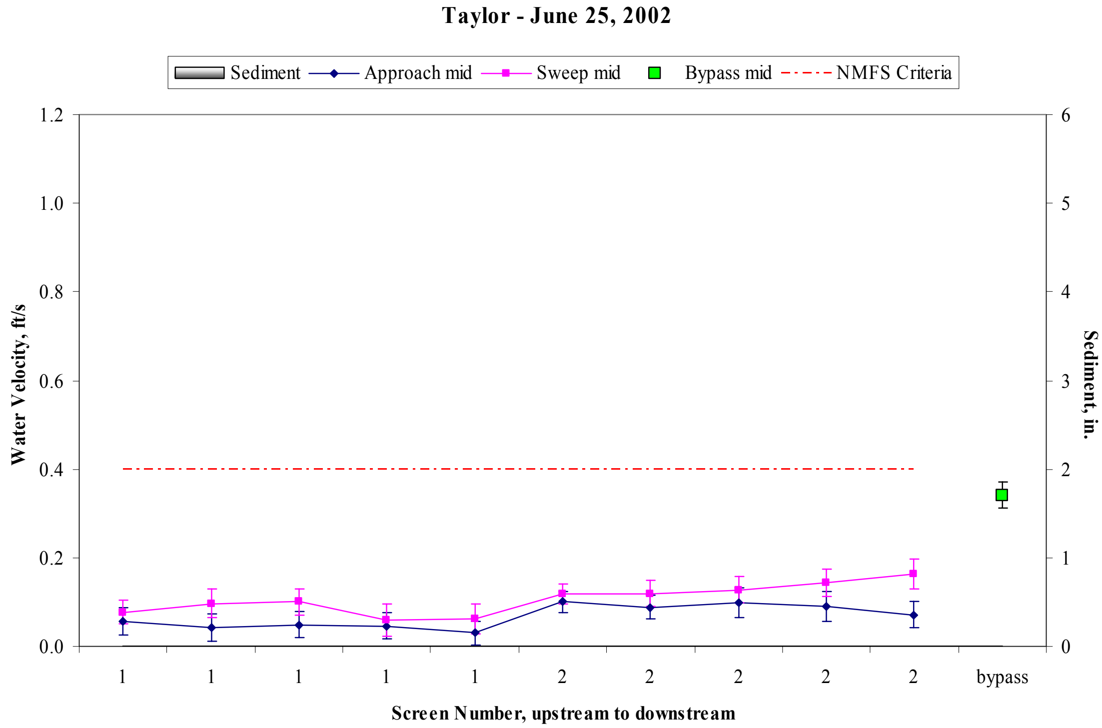

Figure 39. Water Velocities and Sediment Depths at Taylor in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.13 Toppenish Pump

The Toppenish Pump site was visited on May 14, 2002; June 20, 2002; and September 12, 2002. In May, June, and September, 33, 73, and 100% of approach velocities met NMFS criteria, respectively. Sweep velocities were generally higher than approach velocities (Figures 40, 41, and 42). Sweep velocities generally increased towards the bypass, and bypass velocities were higher than sweep velocities. Submergence was calculated to be slightly low in May at 60% and met criteria in June and September. A major cleanout of the main channel and installation of checkboards upstream of the trashracks was happening during the May evaluation, and water levels continued to rise, which may account for the slightly low submergence.

Visible seals appeared to be in good condition during all surveys. In May, some debris was observed on the trashrack, and the middle section of the trashrack had separated approximately 1 ft from the concrete wall (Figure 43). During all surveys, sediment and debris covered nearly all of the bottom seals.

The gaps between the metal frames of the drums and the cement walls of the site were not caulked. Bypass conditions were favorable during all surveys, though there was a small amount of debris floating above the outfall, and in September the outfall surged.

Notes in the logbook show that the bypass was plugged with debris twice between the May and June visits and several times in July.

The USBR, which is responsible for the operation and maintenance of the Toppenish Pump facility, was notified on May 21, 2002, concerning the high approach velocities noted during the May survey. Tom Leonard (USBR) estimated that it would be a couple of weeks or more before this would be fixed. On May 23, 2002, the PNNL researchers left a message asking to be notified when something was done about this. The USBR never responded.

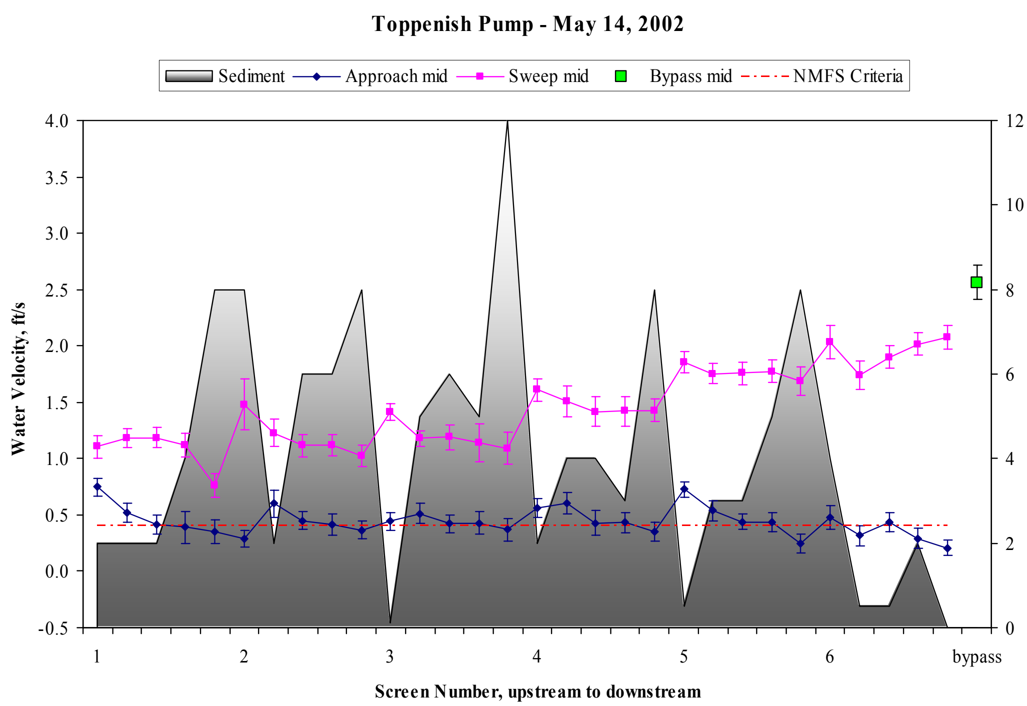

Figure 40. Water Velocities and Sediment Depths at Toppenish Pump in May 2002. Error bars show turbulence (± the root-mean-squared [RMS] at each point.

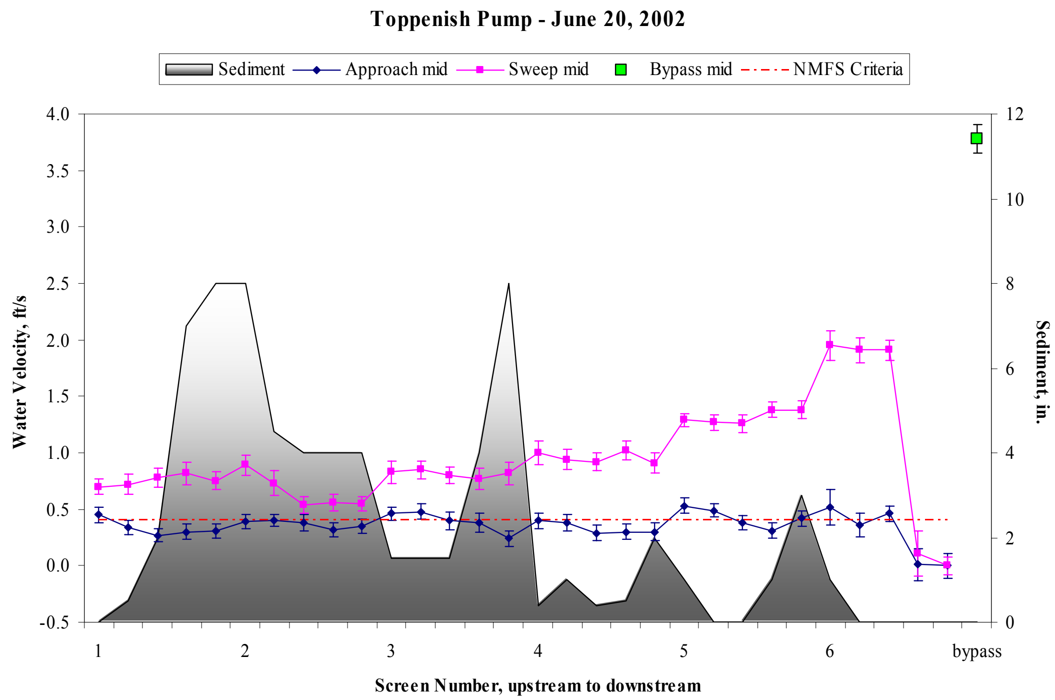

Figure 41. Water Velocities and Sediment Depths at Toppenish Pump in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

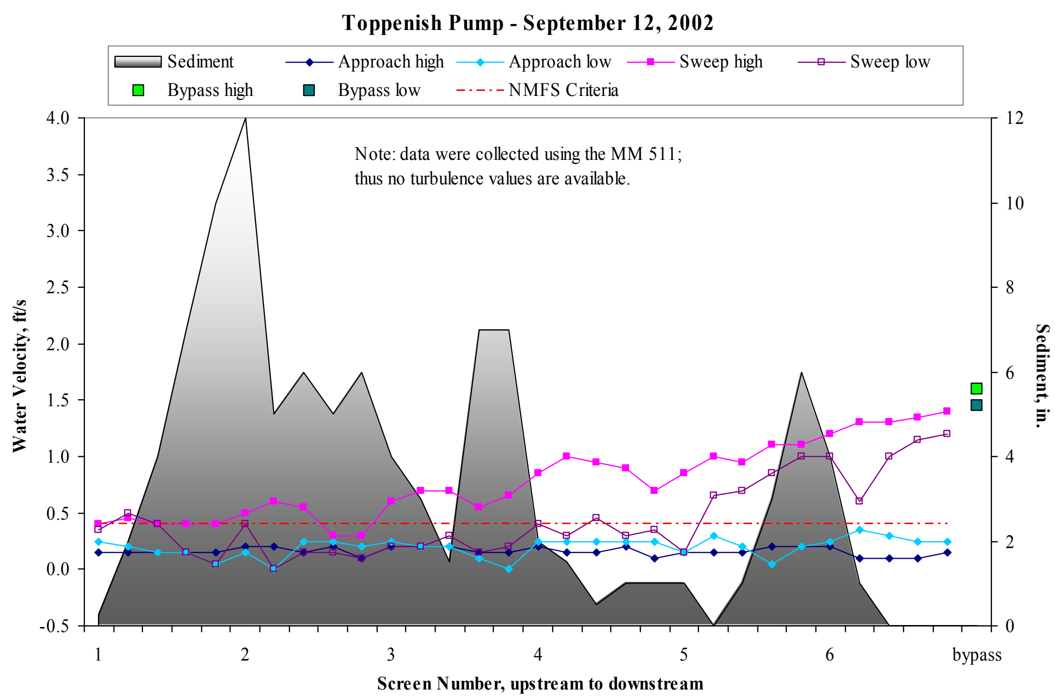

Figure 42. Water Velocities and Sediment Depths at Toppenish Pump in September 2002

Figure 43. The Trashrack at Toppenish Pump was Partially Separated from the Concrete Wall in May 2002

3.2.14 Upper Wapato Irrigation Project (WIP)

The Upper WIP site was visited on May 21, 2002; June 18, 2002; and September 10, 2002. The site was shut down for the season before the survey in September. All approach velocities met NMFS criteria in May, while only 90% of approach velocities met NMFS criteria in June (Figures 44 and 45). Those points that exceeded 0.4 ft/s were located at the upstream end of the site. During both surveys, sweep velocities were much more turbulent than approach velocities. Sweep velocities did not increase towards the bypass, and in June, the bypass velocity was less than the average sweep velocity.

In May, debris buildup on the trashracks caused approximately 1 in. of head loss across the racks. This did not appear to affect screen submergence, which met NMFS criteria at 80% submergence in May and June. The screens seals were replaced in 2001 and appeared to be in good condition in 2002. Water ran freely behind the weir and out the outfall. The water depth at the point of discharge was greater than 12 in. in May and June, which satisfied NMFS criteria and should be expected to provide sufficient water to allow for safe fish passage.

The gaps between the metal frames of the drums and the cement walls of the forebay were not caulked. The PNNL researchers recommend that these be filled with expanding foam insulation to prevent harm to migrating fish.

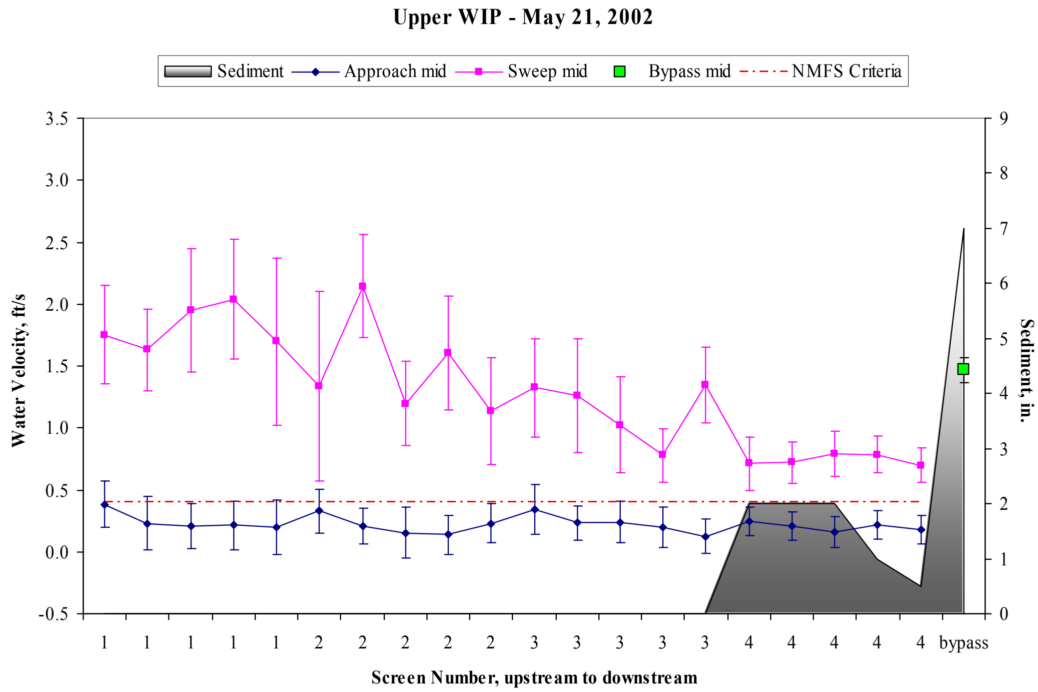

Figure 44. Water Velocities and Sediment Depths at Upper Wapato Irrigation Project (WIP) in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

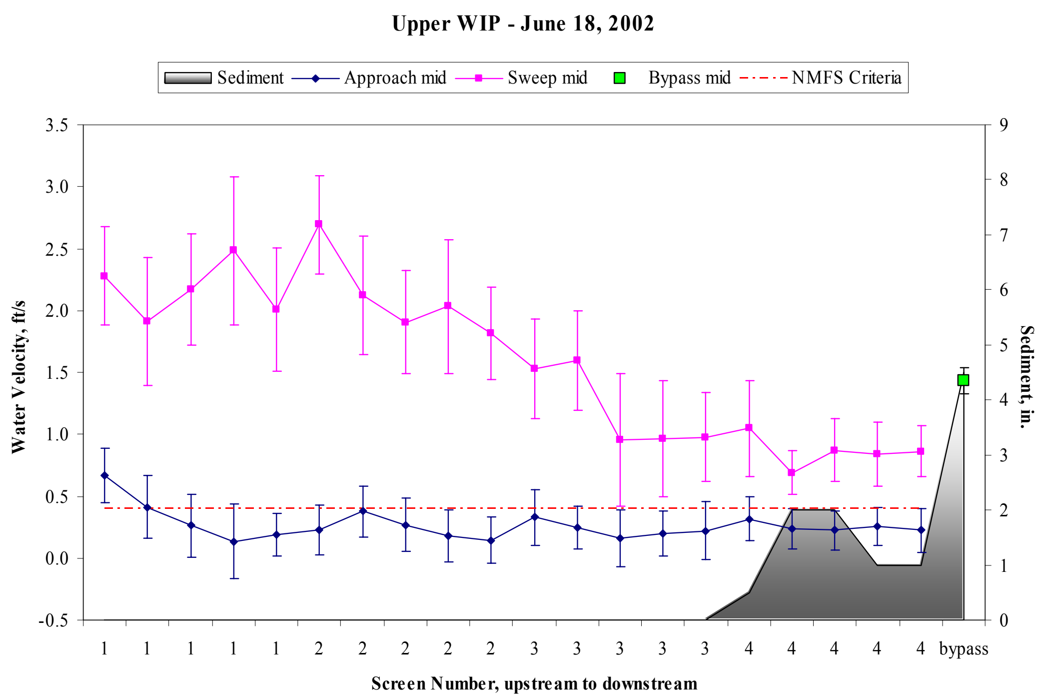

Figure 45. Water Velocities and Sediment Depths at Upper Wapato Irrigation Project (WIP) in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.2.15 Wilson Creek

The Wilson Creek site was visited on May 17, 2002; July 2, 2002; and September 16, 2002. Because of excessive growth of aquatic plants in the forebay in July, the Marsh-McBirney 511® velocity meter was used, so no turbulence values are available. In May, July, and September, 87, 100 and 100% of approach velocities met NMFS criteria, respectively (Figures 46, 47, and 48). Sweep velocities were always greater than approach velocities. Sweep velocities did not increase towards the bypass, and the average bypass velocity was slower than the average sweep velocity in May and July.

Submergence met criteria during all surveys. There was 3 in. of head loss over the screens in May and 1.5 in. in June. This was probably due to growth of algae on the screens, which tends to partially or fully plug the screen holes. The screen material was in good condition during all surveys, as were all seals. In June, there were small gaps between the bottom seal and both screens (for example Figure 49). These gaps were likely caused by debris that was rolled into that space by the turning of the drum, as was observed at Powell-LaFortune in May. This problem probably took care of itself shortly as no gaps were observed in September. The gaps between the metal frames of the drums and the concrete walls of the forebay were filled with expanding foam insulation to prevent harm to migrating fish.

Drums turned freely and evenly during all surveys and rolled leaf matter into the aftbay. Water flowed freely over the weir and out the outfall in May and July. In September, the outfall pipe surged, which may have been caused by a partial plug in the downwell or in the bypass pipe. Ray Gilmour (WDFW) believes that this may have been caused by taking too much water into the site. The outfall pipe was submerged during all surveys and the depth at the point of discharge was greater than 1 ft.

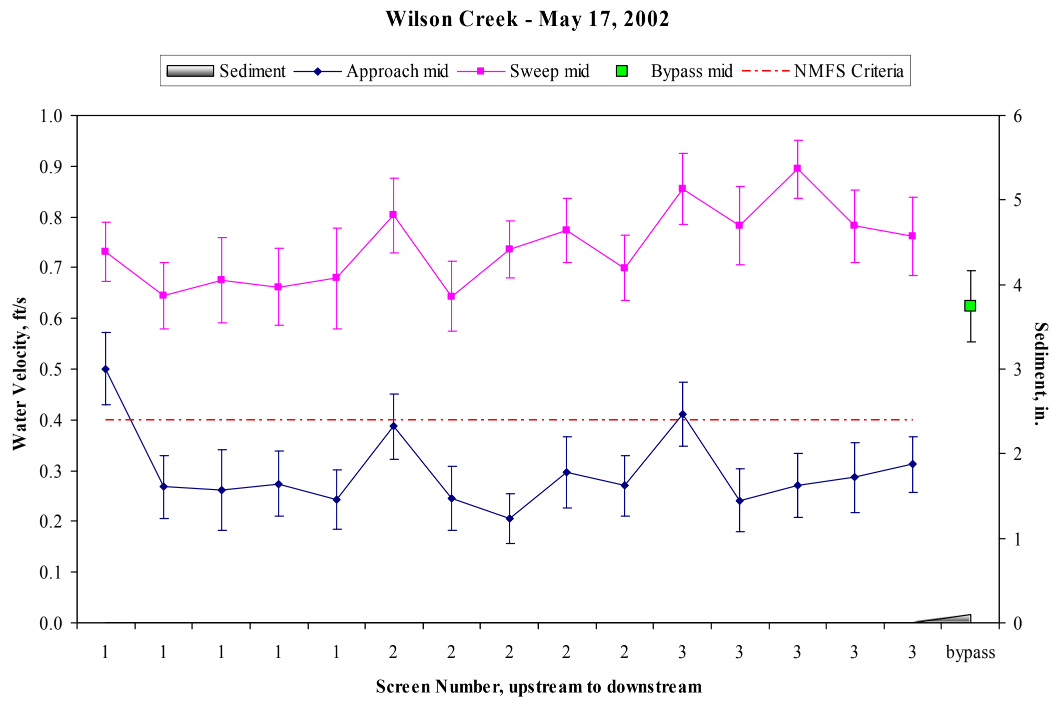

Figure 46. Water Velocities and Sediment Depths at Wilson Creek in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

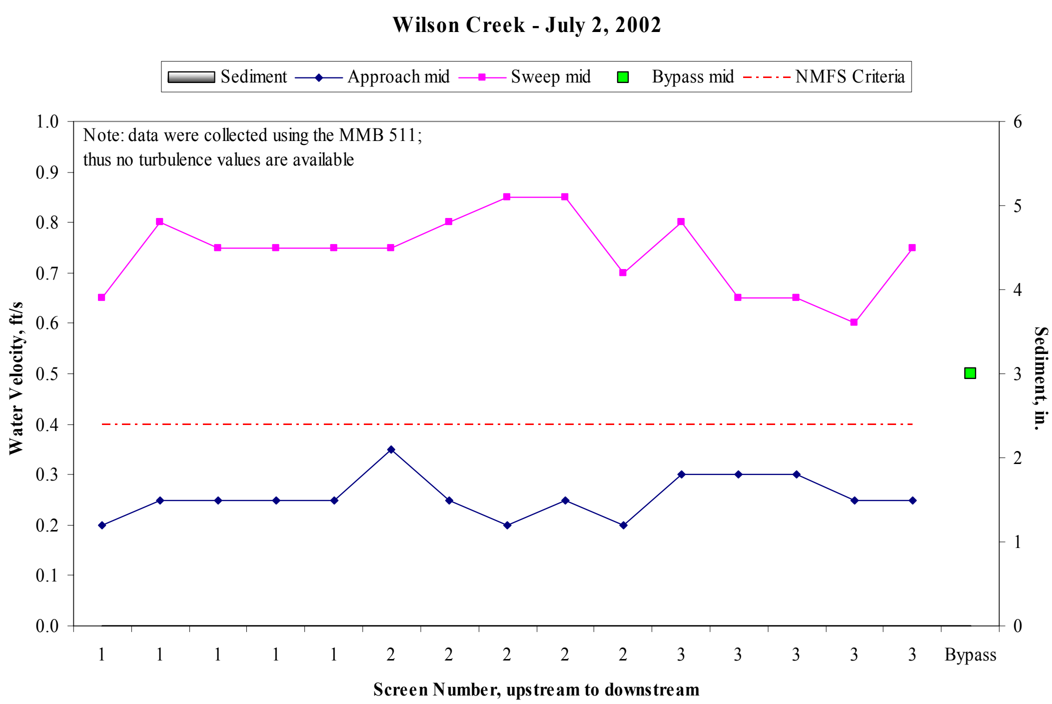

Figure 47. Water Velocities and Sediment Depths at Wilson Creek in July 2002

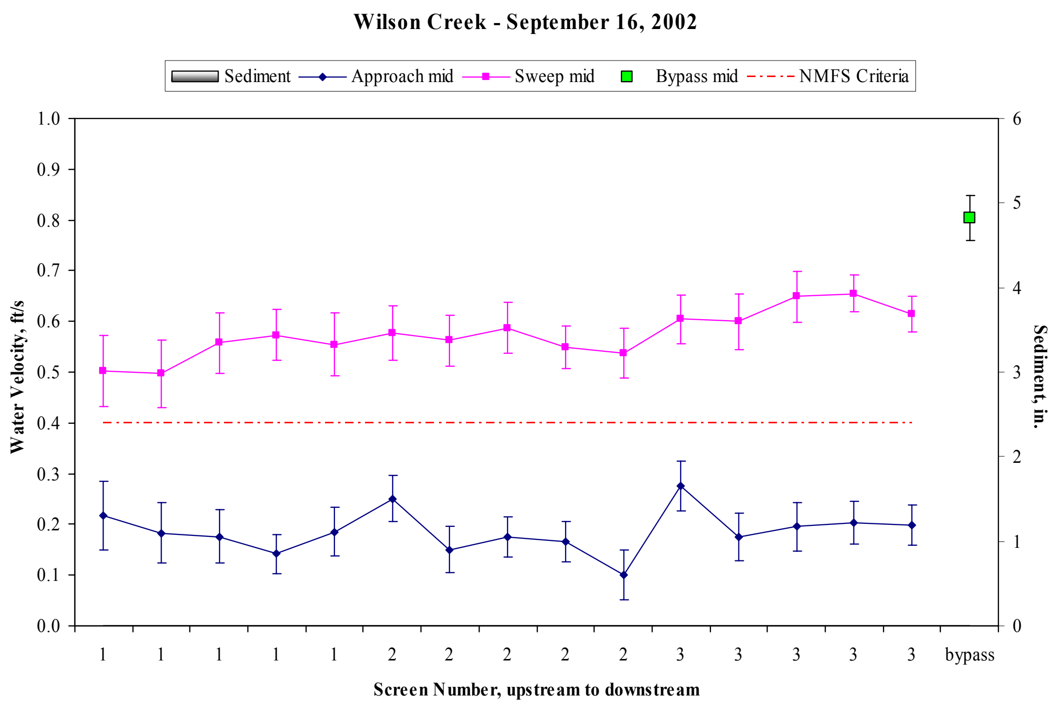

Figure 48. Water Velocities and Sediment Depths at Wilson Creek in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Figure 49. Gap Between the Bottom Seal and the Screen Observed at Wilson Creek in June 2002

3.3 Vertical Plate Screens

3.3.1 Bull Ditch

The Bull Ditch site was evaluated on May 17, 2002; July 2, 2002; and September 17, 2002. Sweep velocities were generally higher than approach velocities in May but not in July or September (Figures 50, 51, and 52). Approach velocities met NMFS criteria 100, 63, and 100% of the time in May, July, and September, respectively. Sweep velocities tended to decrease over the length of the site, and in September, both sweep and approach velocities at the downstream end of the site were approximately zero.

All screens and seals appeared to be in good condition during the surveys. The debris noted at the downstream end of the site in 2001 was cleaned out in 2002, and there was little debris present during any of the surveys in 2002. A log was installed upstream of the upstream trashrack to prevent further accumulation of sediment. The downstream brush that had broken because of this debris was fixed, and the brushes operated effectively to remove debris from the screen face.

In May and July, leafy branches were caught on the upstream trashrack, and in September, some debris was observed underneath the metal plates that cover the parallel trashracks. A large Northern pikeminnow was observed in this foliage in May. Several juvenile salmonids were observed in the forebay in May and September.

Low sweeping velocities at the downstream end of the site combined with the presence of predator habitat may result in the delay of and predation on migrating salmonids. The slower water may also cause sediment accumulation at the downstream end of the site. The PNNL researchers recommend that procedures be evaluated to increase sweep velocities and minimize predator habitat growth and sediment accumulation.

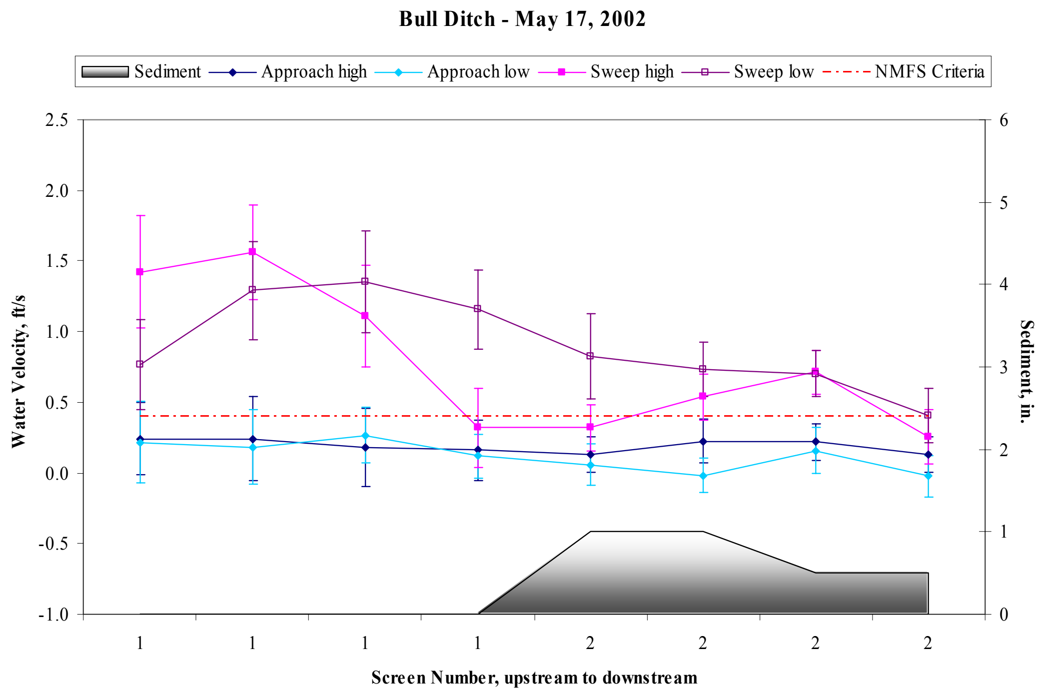

Figure 50. Water Velocities and Sediment Depths at Bull Ditch in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

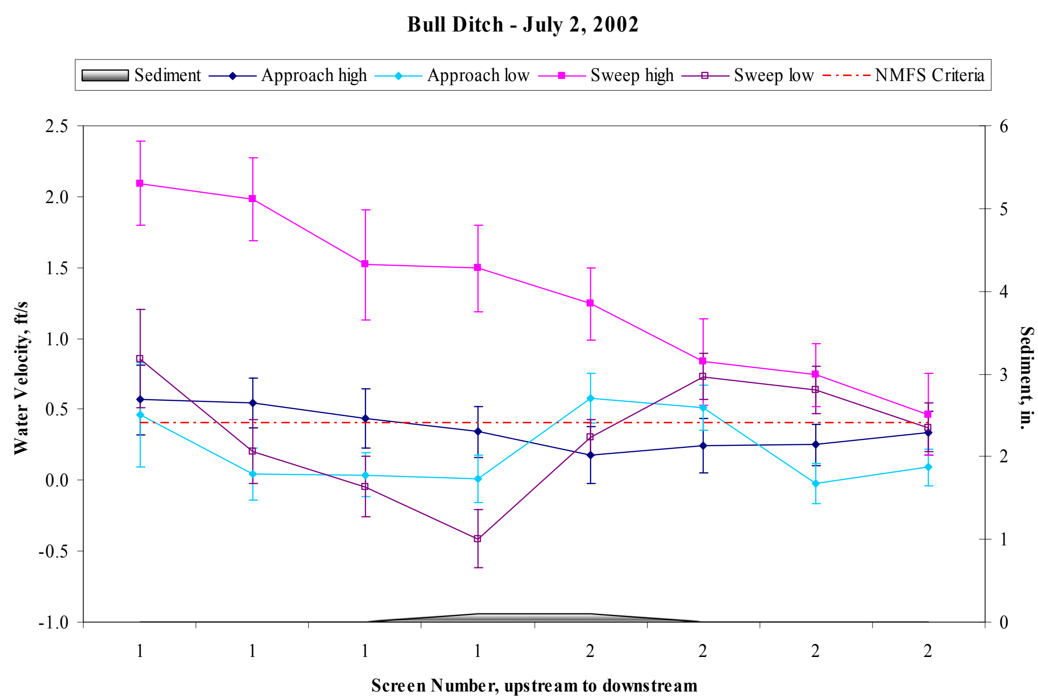

Figure 51. Water Velocities and Sediment Depths at Bull Ditch in July 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

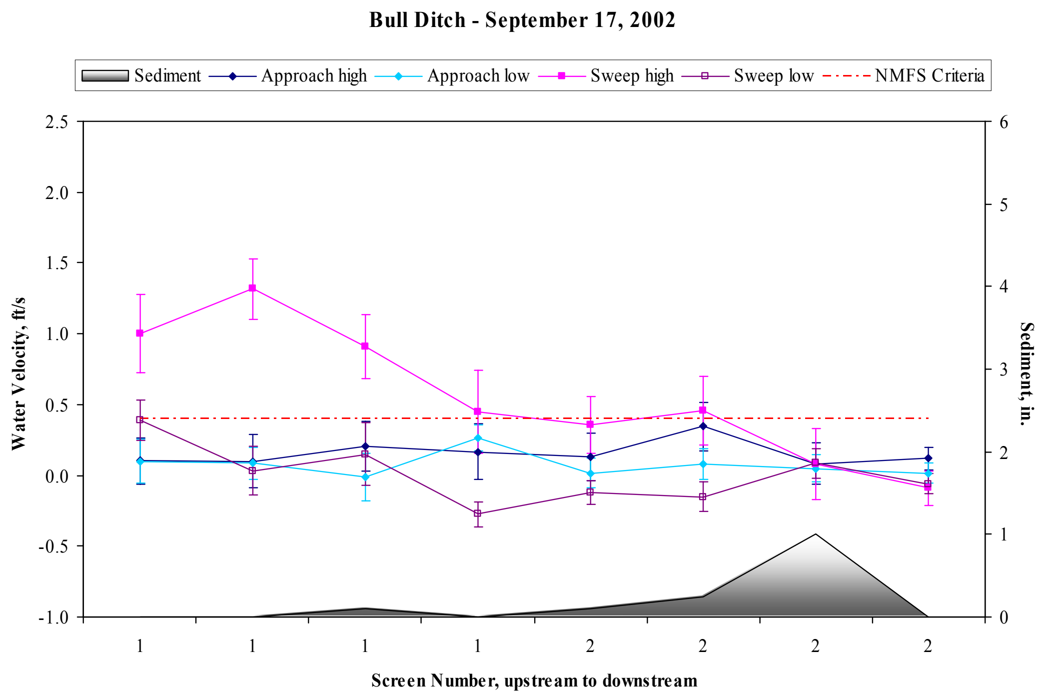

Figure 52. Water Velocities and Sediment Depths at Bull Ditch in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.2 Ellensburg Mill

The Ellensburg Mill site was visited on May 17, 2002; July 1, 2002; and September 16, 2002. Because of aquatic vegetation growth in the forebay, the Marsh-McBirney 511® flow meter was used to measure velocity at the low position in May and June, so turbulence values are not available for those measurements. All approach velocities met NMFS criteria during all surveys (Figures 53, 54, and 55). Sweep velocities were not always higher than approach velocities, especially at the low position. This was probably due to the presence of aquatic plants in the forebay and near the screen surfaces. Sweep velocities did not increase towards the bypass, although the bypass velocity was greater than the average sweep velocity in May and September.

The screens appeared to be in good condition during all surveys, but the seals between the screens were partially missing and may need to be replaced. In May and July, bottom seals were not evaluated due to growth of aquatic plants in the forebay. The September video survey revealed that the bottom seals may also need to be replaced as the caulking is missing in places. The mechanical brushes effectively removed algae and debris from most of the screen surfaces, though there were patches, especially towards the bottoms of the screens, that remained covered with algae.

In May, the bypass might have been partially blocked. In July, PNNL researchers tested the bypass by attempting to pass a neutrally buoyant object through it and determined that it was blocked. The researchers notified Ray Gilmour (WDFW) of the blockage on July 2, 2002. The researchers were informed on July 11, 2002 that the blockage was no longer present. Outfall conditions were good for safe fish passage during all surveys.

Notes in the site operator's logbook show that the bypass was cleaned, and milfoil was removed from the forebay on July 31, 2002. The next day, silt was removed from the forebay. In the future, the researchers recommend a more aggressive cleaning schedule that allows silt and plants to be removed before they begin to affect the operation of the site.

Many fish were observed at this site during all of the surveys. In May, there was a large fish near the bypass ramp that was likely a pikeminnow. In July, there were 15 or more 3- to 4- in. fish that were possibly salmonids, as well as three or four 8-in. fish. In September, there were about 10 suckers on the screen and a few 8-in. fish that were not suckers.

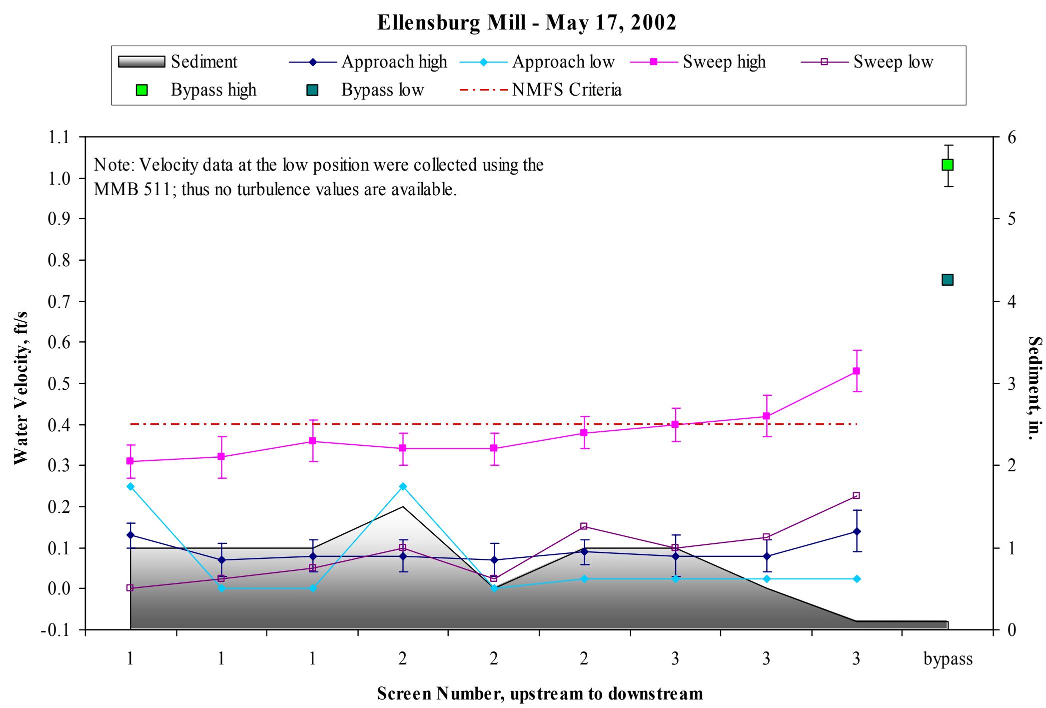

Figure 53. Water Velocities and Sediment Depths at Ellensburg Mill in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

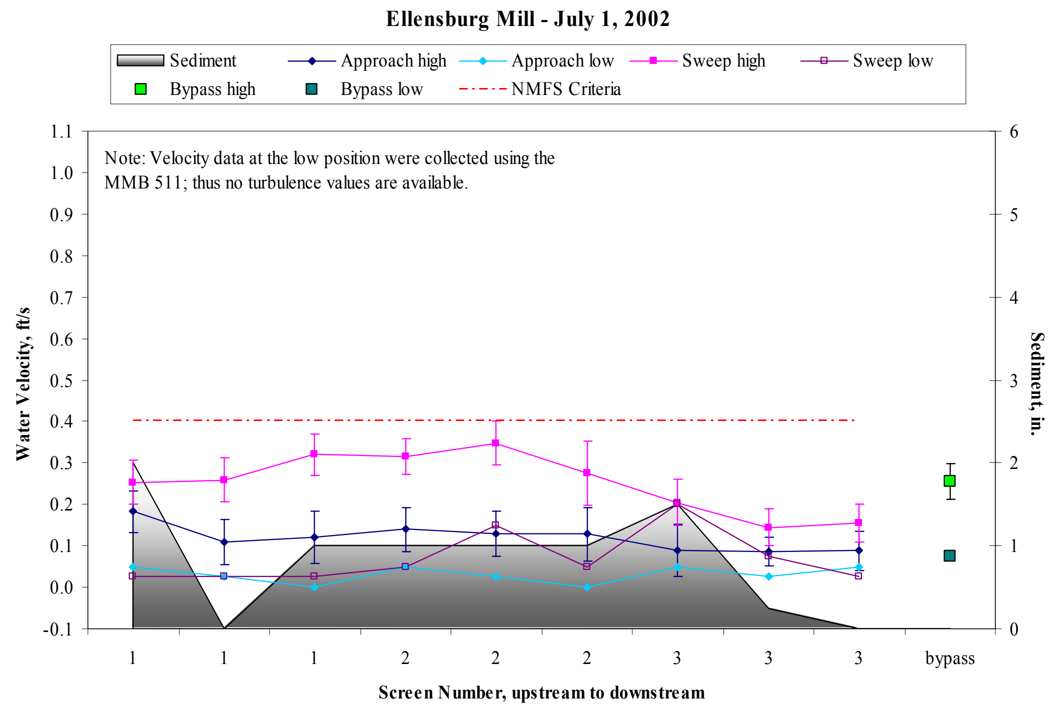

Figure 54. Water Velocities and Sediment Depths at Ellensburg Mill in July 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

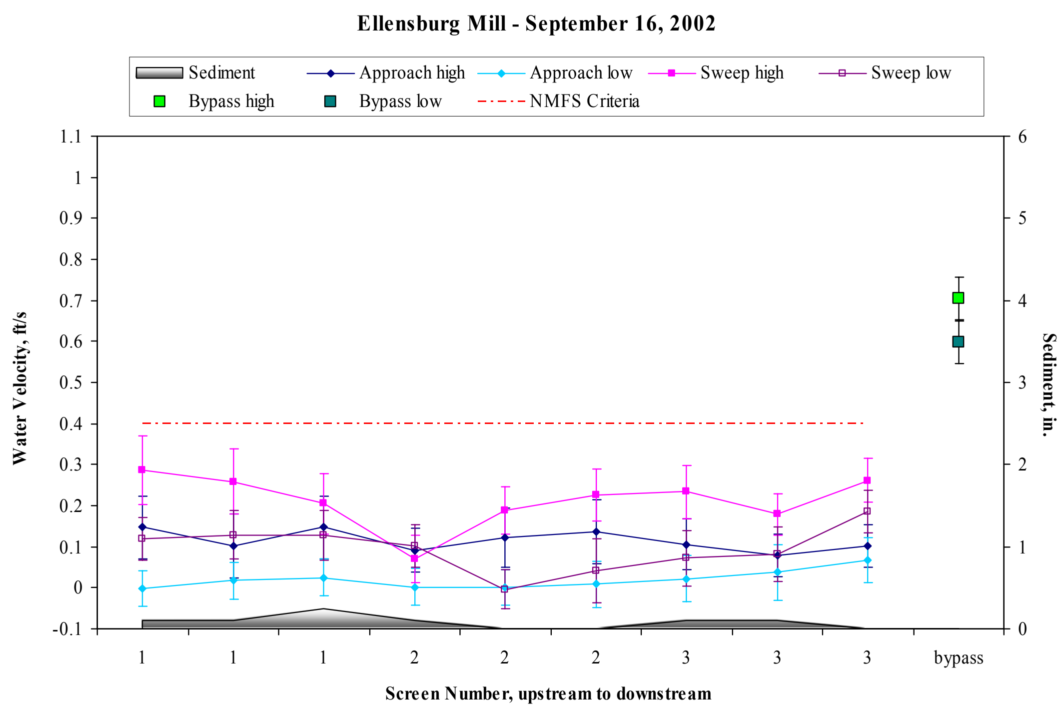

Figure 55. Water Velocities and Sediment Depths at Ellensburg Mill in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.3 Fruitvale

The Fruitvale site was visited on May 20, 2002; June 19, 2002; and September 11, 2002. In May, June, and September, 100, 83, and 100% of approach velocities met NMFS criteria, respectively (Figures 56, 57, and 58). Sweep velocities were not always higher than approach velocities and did not increase towards the bypass. Bypass velocities were higher than the average sweep velocity during all surveys.

Notes in the logbook indicated low flow and no bypass or fishway flow from late July through early September. This is similar to what happened in 2001, when the bypass was shut off completely for almost a month. Because smolts are not expected to migrate during this period, as long as there was enough water movement to maintain oxygen levels in the water, the flow conditions would not be expected to be a problem. However, if the bypass were to become blocked during a smolt migration period, it could kill any smolts that were trapped in the forebay. The PNNL researchers recommend that operational procedures be evaluated to minimize these conditions, especially during smolt migration periods.

The mechanical brushes operated effectively to remove debris from the screens during all surveys. The screens appeared to be in good condition, with the exception of a spot marked in red near the surface of screen 1 where the screen material pulled loose from the frame. This was fixed sometime before the September survey. It is unlikely that this portion of the screen was submerged during this time and should not have caused a problem for fish. The seals on the upper parts of the screens appeared somewhat weathered, and the video survey revealed that the caulking along the bottom of the screens was loose or missing in places.

There was no debris present in the forebay or on the trashrack during any of the surveys. In all months, water ran freely over the weir and out the outfall, and outfall conditions met NMFS criteria for safe fish passage. In September, the outfall surged.

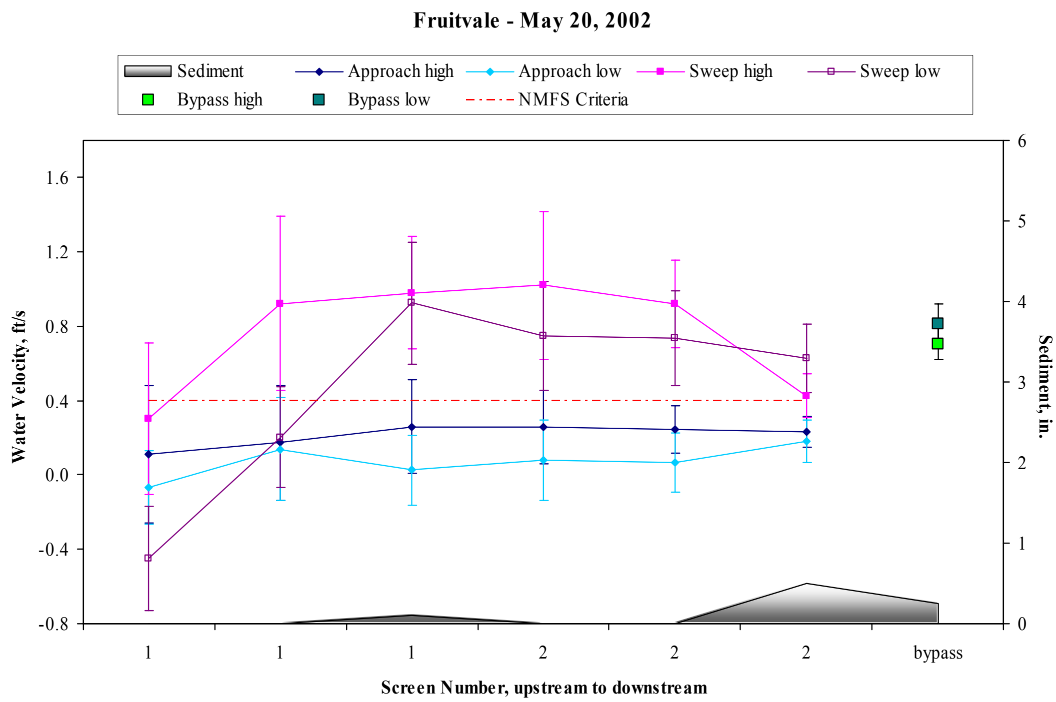

Figure 56. Water Velocities and Sediment Depths at Fruitvale in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

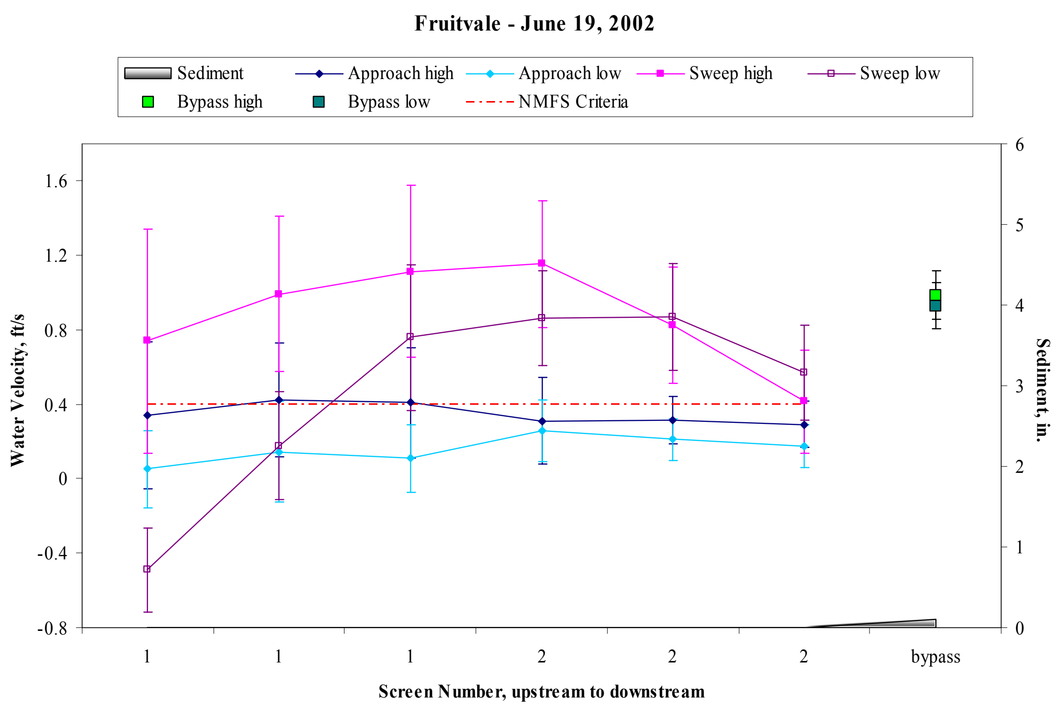

Figure 57. Water Velocities and Sediment Depths at Fruitvale in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

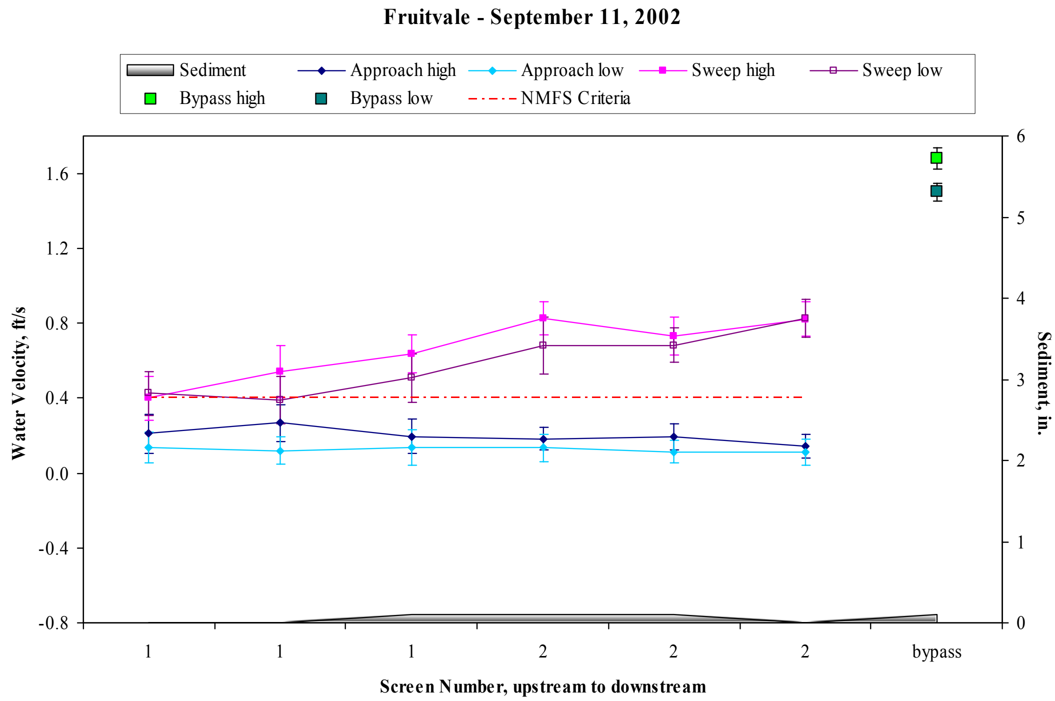

Figure 58. Water Velocities and Sediment Depths at Fruitvale in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.4 Naches-Selah

The Naches-Selah site was visited on May 16, 2002; June 25, 2002; and September 19, 2002. In May, June, and September, 72, 89, and 50% of approach velocities met NMFS criteria, respectively (Figures 59, 60, and 61). Sweeping velocities were greater than approach velocities and increased towards the bypass only in May. The average bypass velocity was greater than the average sweep velocity in May. In June and September, sweep velocities were usually greater than approach velocities but did not increase towards the bypass, and bypass velocities were slower than the average sweep velocity. This site has one of the worst records as far as meeting NMFS velocity criteria (Table 4). The PNNL researchers recommend that site operating procedures be evaluated to attempt to protect migrating fish from injury as they pass through this site.

The screens were patched in places, but they appeared to be in good condition during all surveys. The caulking between the screens and under the screens was missing in places. In May, the bypass was approximately half filled with sand underneath the ramp. In June, sand and debris had built up near screen 6 to the point that it covered all of the bottom seal and prevented the brush from cleaning the screen (Figure 62), and the bypass ramp was completely plugged with sand and debris. The PNNL researchers notified Bill Werst (WDFW) on June 25, 2002. The problems were fixed on June 26, 2002.

Water flowed freely over the weir and out the outfall in May. The depth of the water in the outfall pipe was only 6 in. in May. In June, the flush gate was set open, but because the bypass was full of sand, no water was going through it, and although plenty of water flowed over the weir, the depth of water in the outfall pipe was only 4 in., which is 5 in. below the minimum criteria set by NMFS. In September, the bypass water flowed freely through the cleaned-out weir and out the outfall. The depth of water in the outfall pipe was 10 in., and the depth of water at the point of discharge was greater than 12 in. during all surveys.

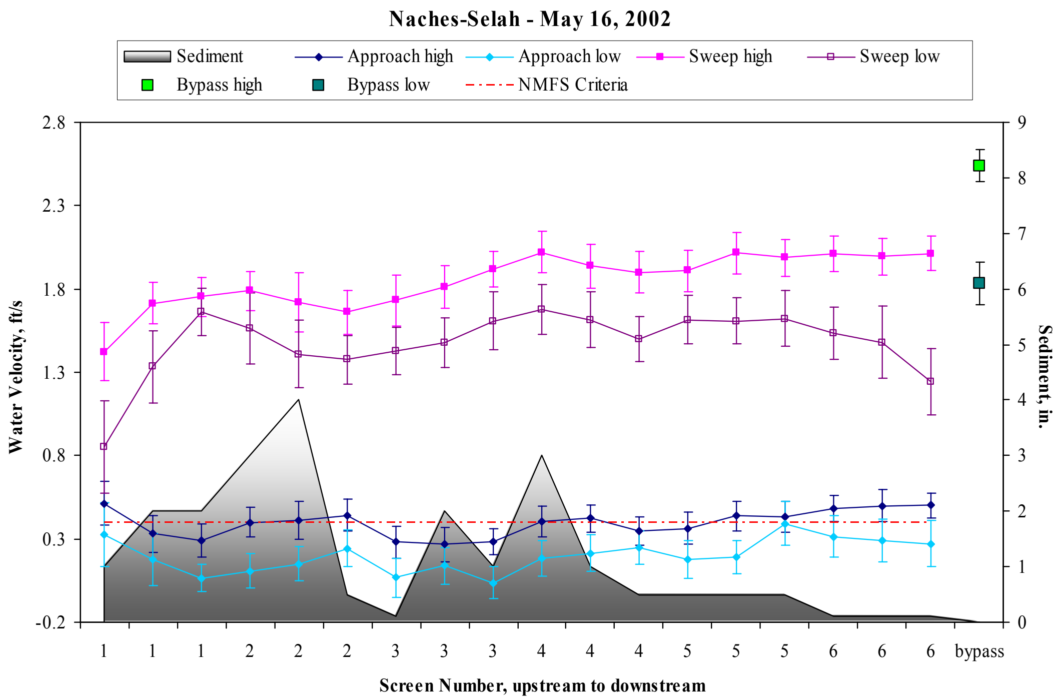

Figure 59. Water Velocities and Sediment Depths at Naches-Selah in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

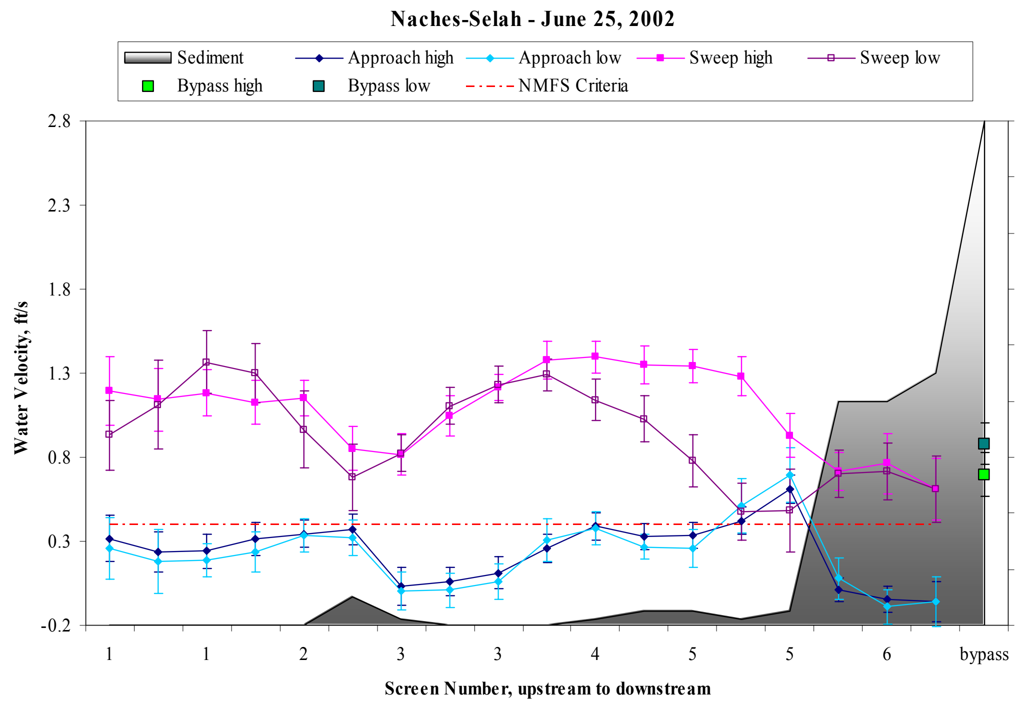

Figure 60. Water Velocities and Sediment Depths at Naches-Selah in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

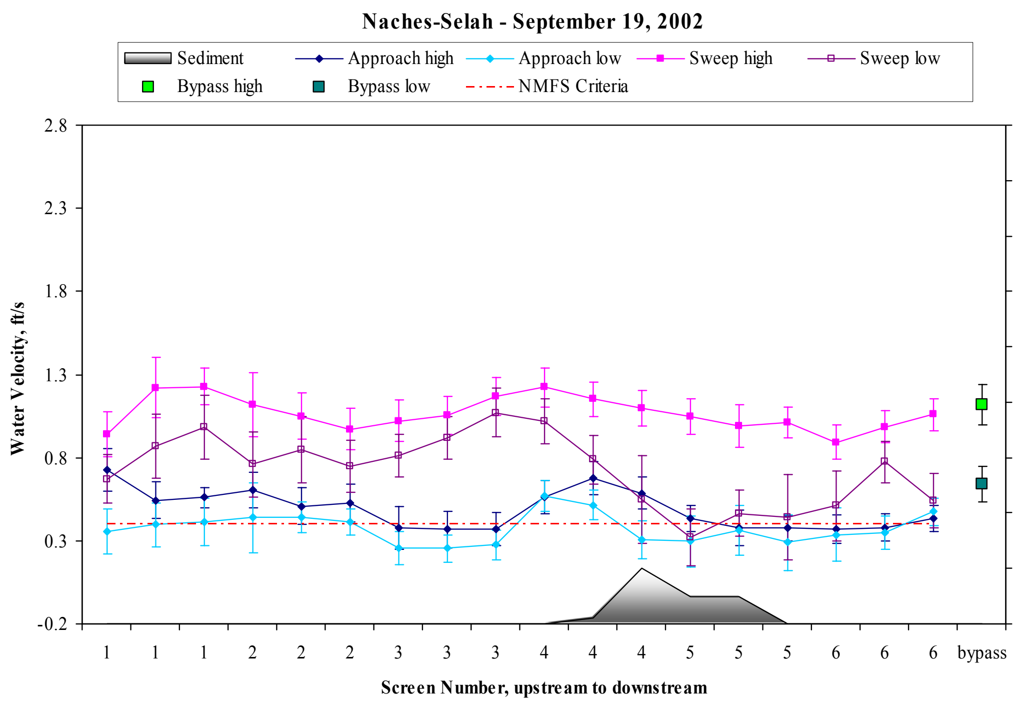

Figure 61. Water Velocity and Sediment Depths at Naches-Selah in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

Figure 62. Sediment Accumulation and Debris on Screen 6 at Naches-Selah in June 2002

3.3.5 Union Gap

The Union Gap site was evaluated on May 23, 2002; June 19, 2002; and September 11, 2002. In May, June, and September, 100, 92, and 100% of approach velocities met NMFS criteria, respectively (Figures 63, 64, and 65). Sweep velocities were almost always higher than approach velocities. Sweep velocities did not increase towards the bypass, and the average bypass velocity was slower than the average sweep velocity.

The screen material was in good condition during all surveys. The seals on all screens were missing in places, as they have been for the past several years. No algae or aquatic plant growth was observed in the forebay during 2002.

Water ran freely behind the weir and through the outfall pipe in May and September. In June, the bypass was filled with sticks underneath the ramp and water appeared to be backed up in the downwell, though conditions at the outfall pipe were still good. Based on the problem-tracking protocol, the PNNL researchers notified Bill Werst (WDFW) of the conditions on June 19, 2002, and he cleaned out the bypass the same day. When the researchers returned to the site on June 20, 2002, the situation was greatly improved. The bypass velocity was greater (though still slower than the average sweep velocity), the water dropped into the downwell, and the depth of water in the outfall pipe was greater.

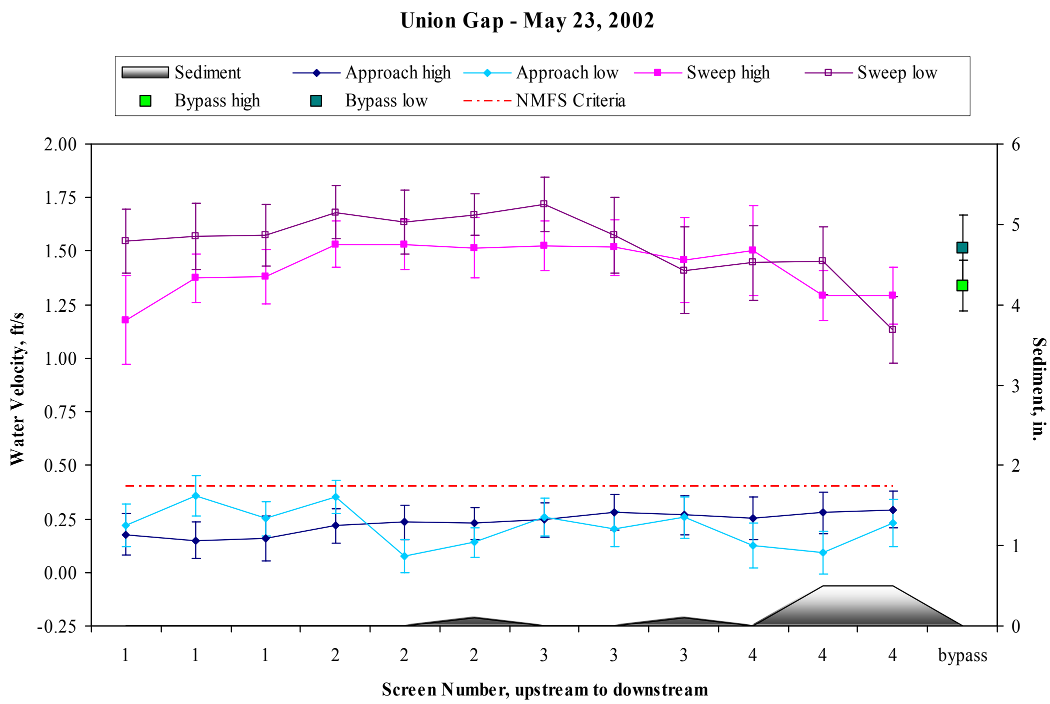

Figure 63. Water Velocities and Sediment Depths at Union Gap in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

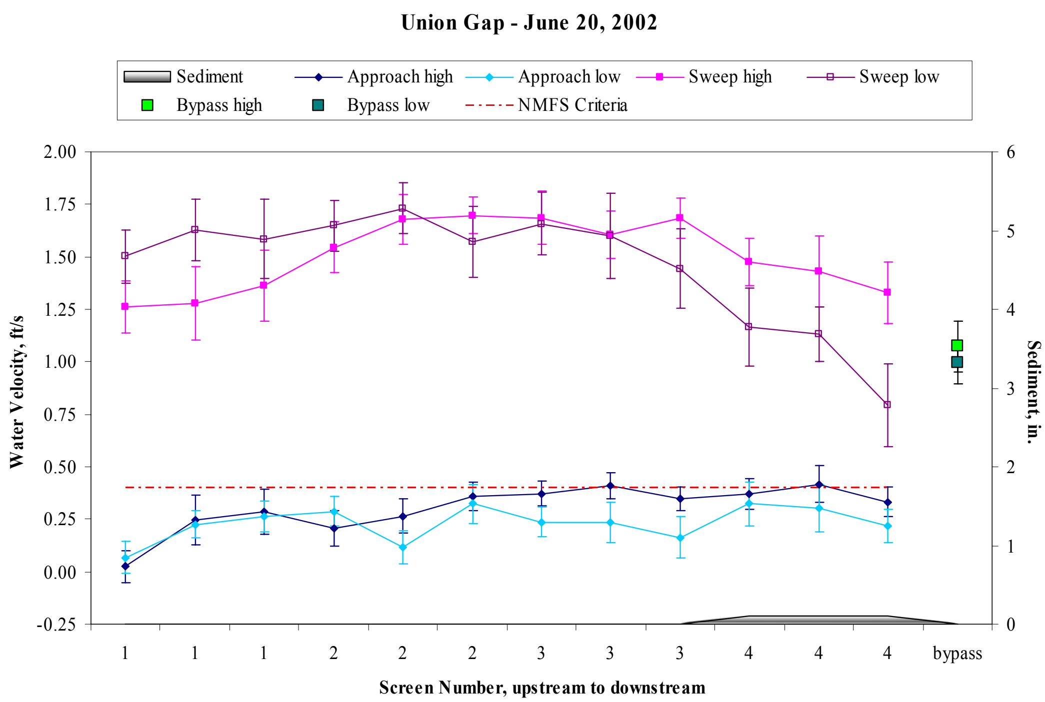

Figure 64. Water Velocities and Sediment Depths at Union Gap in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

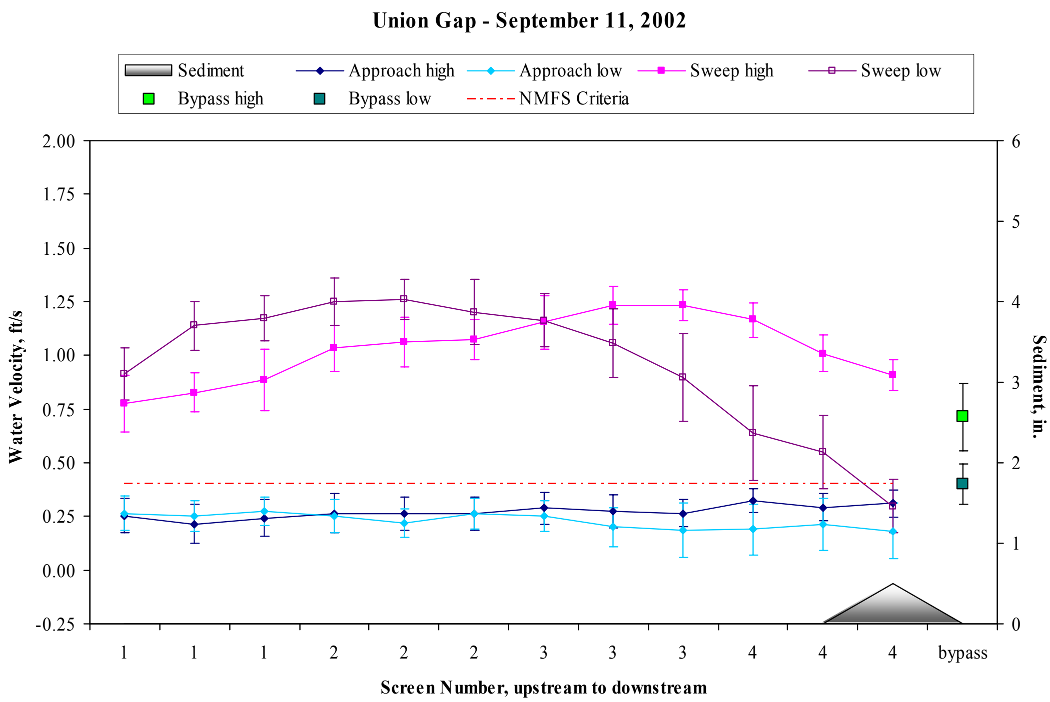

Figure 65. Water Velocities and Sediment Depths at Union Gap in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.6 Yakima-Tieton

The Yakima-Tieton site was evaluated on May 16, 2002; June 26, 2002; and September 18, 2002. In May, June, and September, 100, 57, and 100% of approach velocities met NMFS criteria, respectively (Figures 66, 67, and 68). Sweep velocities were always higher than approach velocities. Sweep velocities did not increase towards the bypass, and the average bypass velocity was always higher than the average sweep velocity.

The screens appeared to be in good condition during all surveys. Several of the screen seals have missing or failing caulking and have been in a similar condition for the past several years. These screens should be re-caulked.

Bypass and outfall conditions met NMFS criteria during all surveys in 2002. In June, outfall flows were very turbulent, and water from the outfall pipe splashed up on top of the cement apron. Under high flow conditions, a flapper may need to be installed to prevent fish from being forced out of the water and stranded.

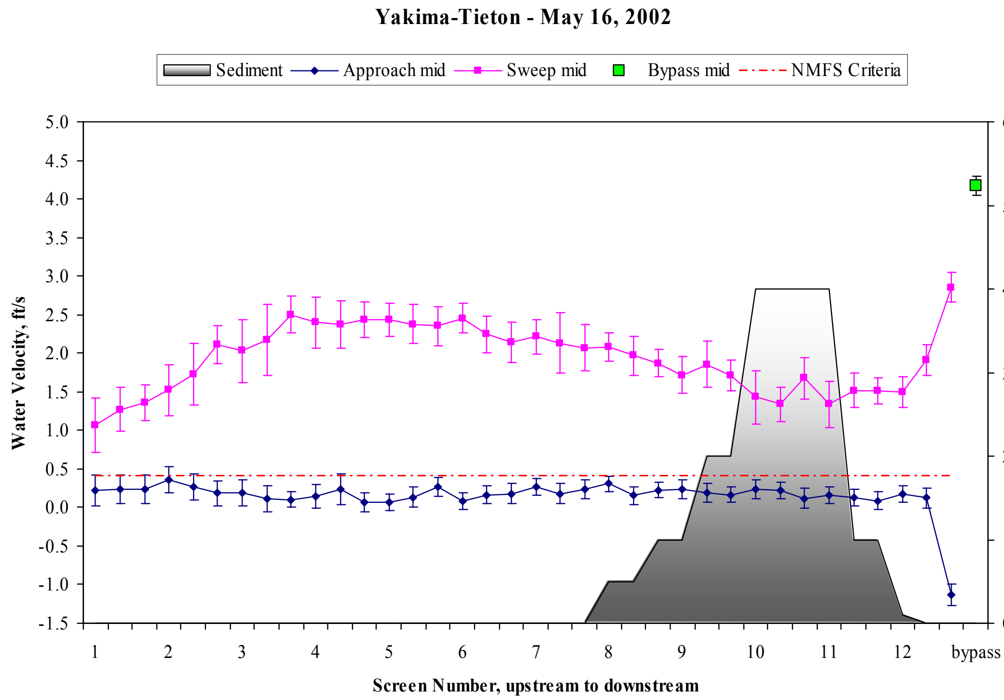

Figure 66. Water Velocities and Sediment Depths at Yakima-Tieton in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

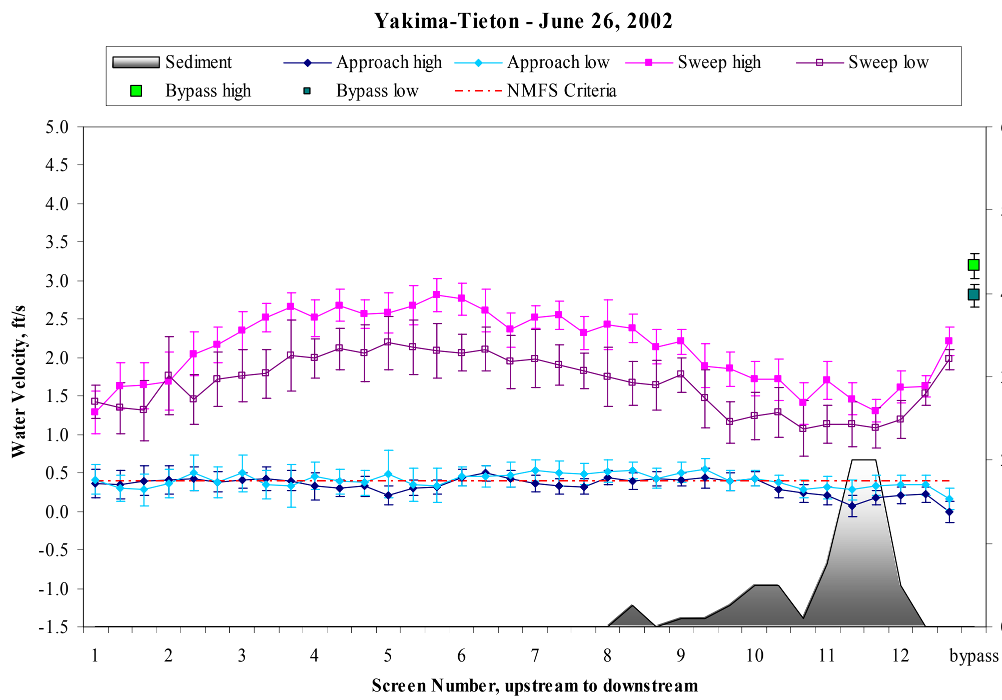

Figure 67. Water Velocities and Sediment Depths at Yakima-Tieton in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

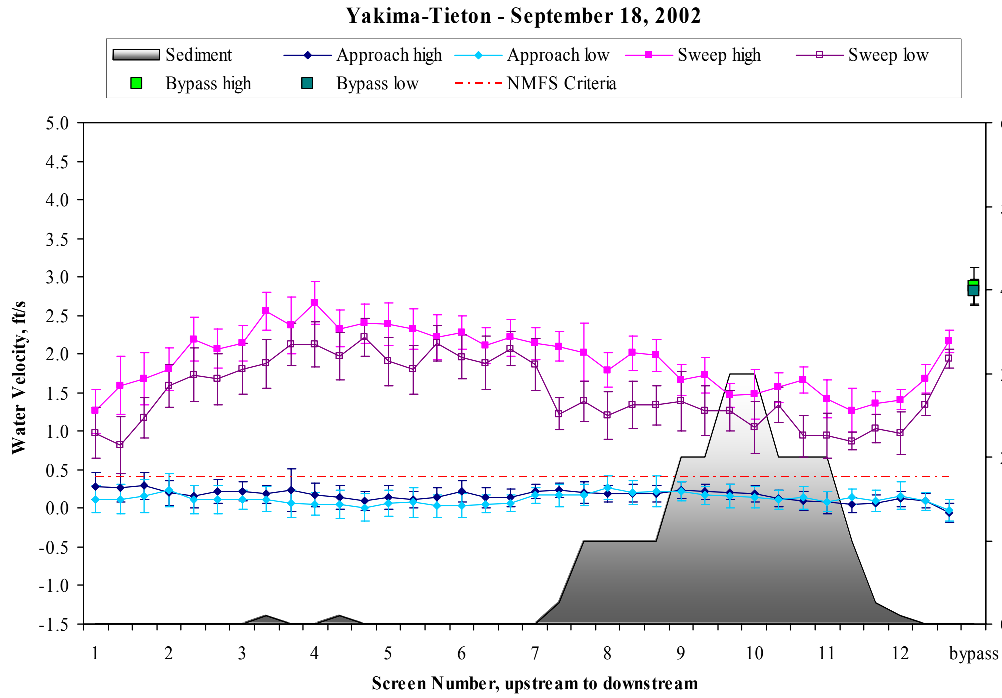

Figure 68. Water Velocities and Sediment Depths at Yakima-Tieton in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.3.7 Younger

The Younger site was visited on May 15, 2002; July 1, 2002; August 1, 2002; and September 16, 2002. In May, July, and August, 83, 0 and 50% of approach values met NMFS criteria, respectively (Figures 69, 70, and 71). The site was shut down before the September survey. Sweep velocities were generally higher than approach velocities, though they did not increase towards the downstream end of the site. Because none of the approach values met NMFS criteria in July, Jose Molano (WDFW) was notified on July 1, 2002, and Ray Gilmour (WDFW) was notified on July 2, 2002. Molano said that he would check the site on July 2, 2002, and fix it the week of July 8, 2002. The researchers followed up with Molano on July 11, 2002, and he said that it had been fixed. The researchers revisited the site on August 1, 2002, and found that while approach velocities were still high in places, the site average was below 0.4 ft/s.

In May, the researchers noticed that checkboards had been installed in the forebay that appeared to block passage through the site. Juvenile salmonids were also present in the forebay. Ray Gilmour was notified about the blockage on May 24, 2002, and he said that the problem would be remedied in 2 days.

The researchers followed up on May 29, 2002 with a phone call to Gilmour, who said he had visited the site and trained a new ditch rider on correct operation of the site. On May 30, 2002 Gilmour returned to the site and took photos, which he sent to PNNL as evidence that the problems had been resolved.

The upstream seal on screen 1 and the downstream seal on screen 2 were lacking caulking in places. Sediment and debris were not an issue at this site in 2002. The brushes seemed to be effective, and there was little buildup of algae. Many small, unidentified fish were noted in the canal and in the forebay in May.

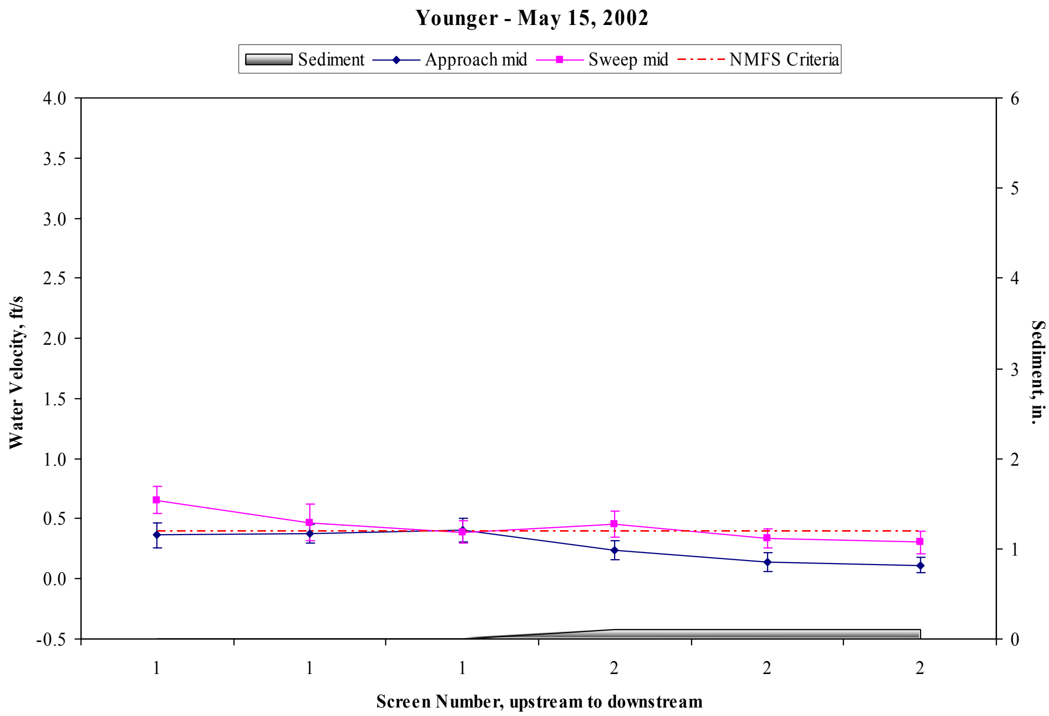

Figure 69. Water Velocities and Sediment Depths at Younger in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

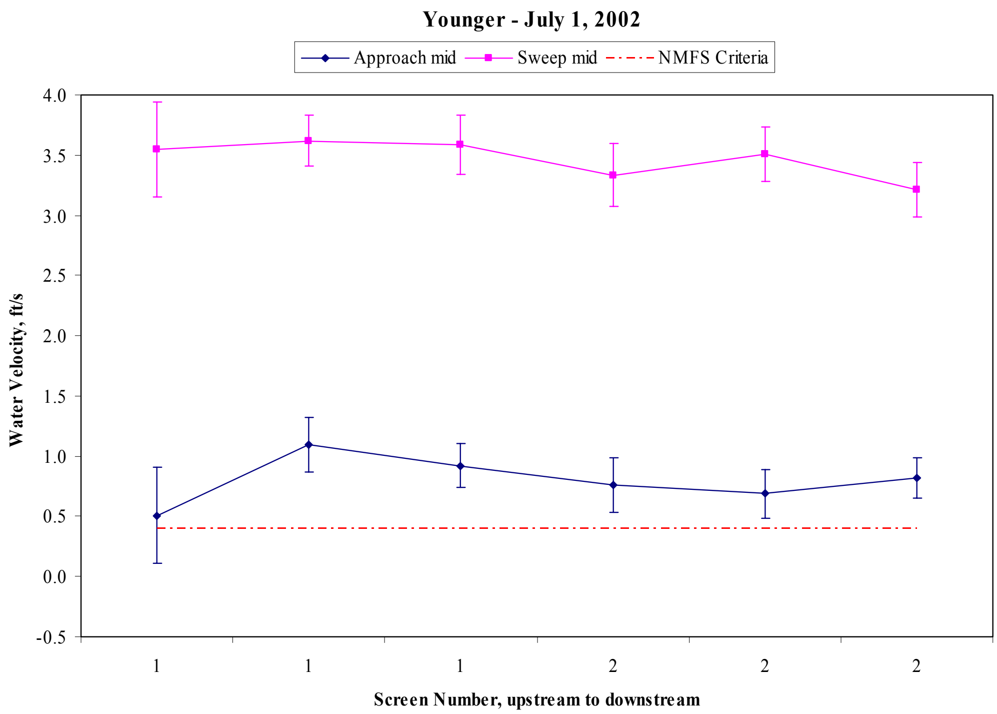

Figure 70. Water Velocities at Younger in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

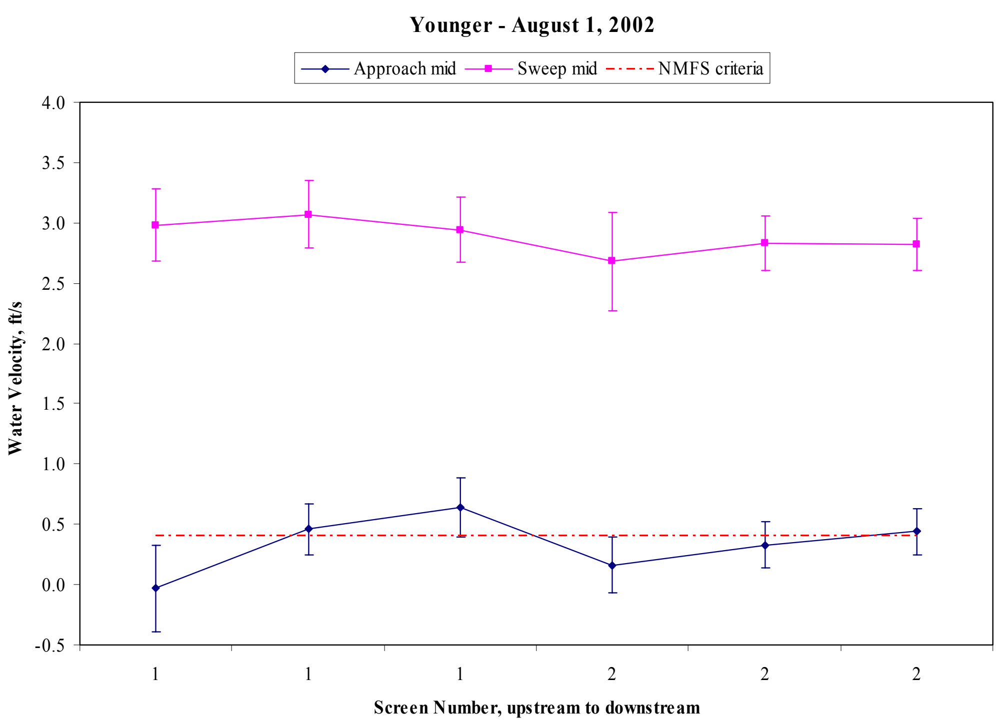

Figure 71. Water Velocities at Younger in August 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

3.4 Vertical Traveling Screen

3.4.1 Gleed

The Gleed site was evaluated on May 22, 2002; June 25, 2002; and September 19, 2002. In May, June, and September, 81, 79, and 88% of approach values met NMFS criteria of less than or equal to 0.4 ft/s, respectively (Figures 72, 73, and 74). Aside from fast water, fish encountering this site also had to deal with highly turbulent water, without a clear trajectory. Sweep velocities were not always greater than approach velocities and did not increase towards the downstream end of the site.

There were no problems with sediment buildup at this site. The screen material was in good condition, except for a gap between the screen sections in screen 3 that was fixed in mid-August. In June, one small, unidentified fish was observed in the forebay.

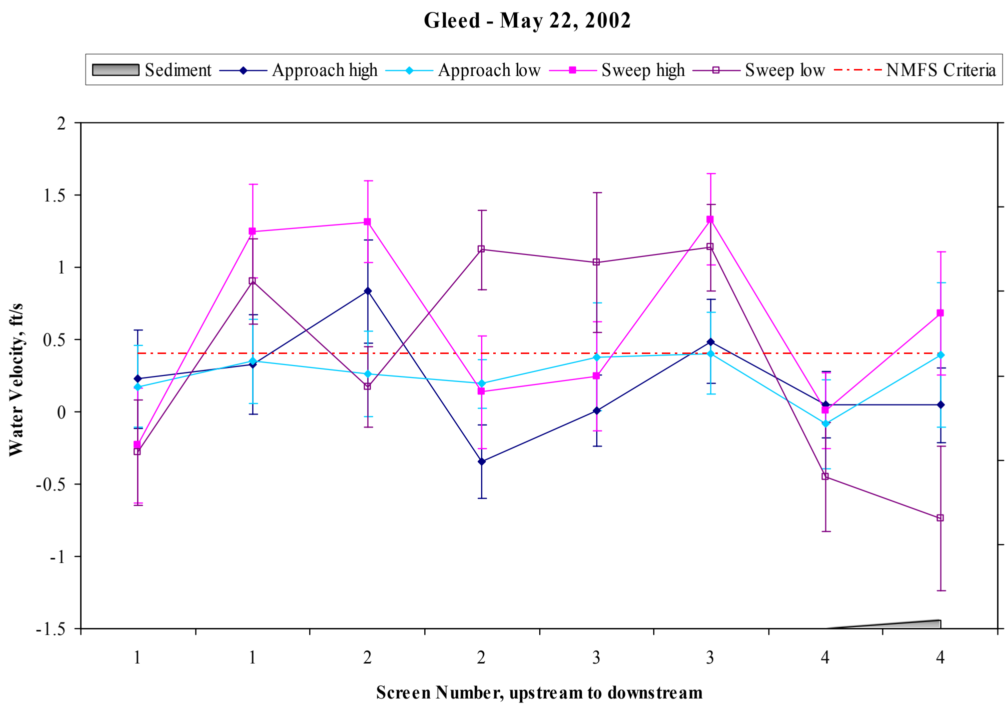

Figure 72. Water Velocities and Sediment Depths at Gleed in May 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

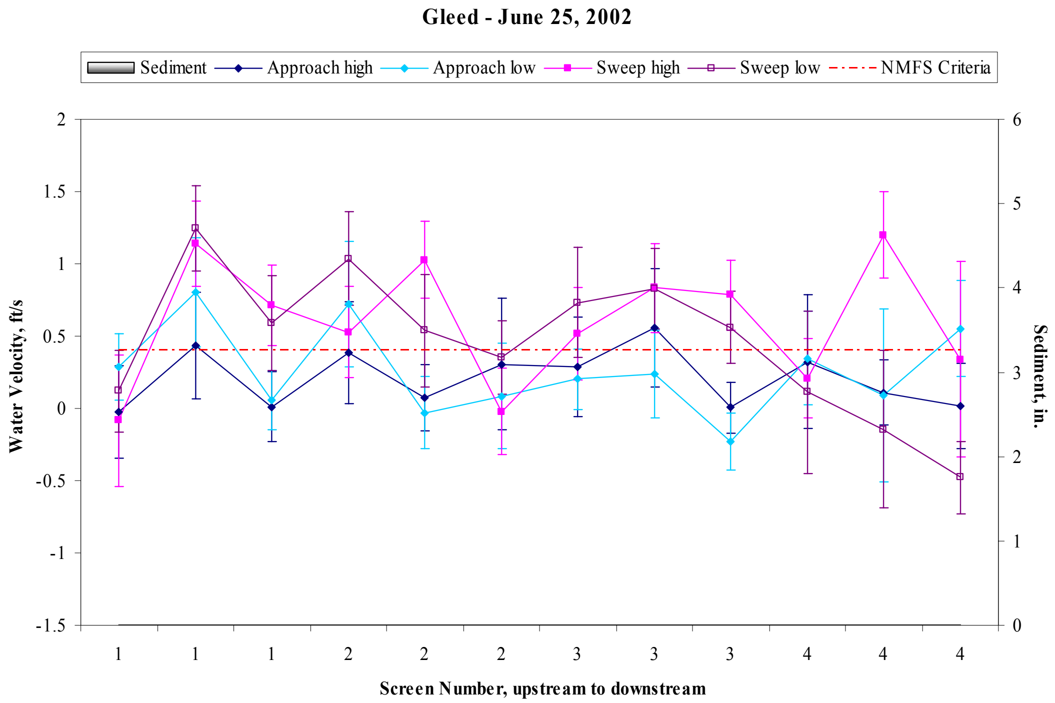

Figure 73. Water Velocities and Sediment Depths at Gleed in June 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

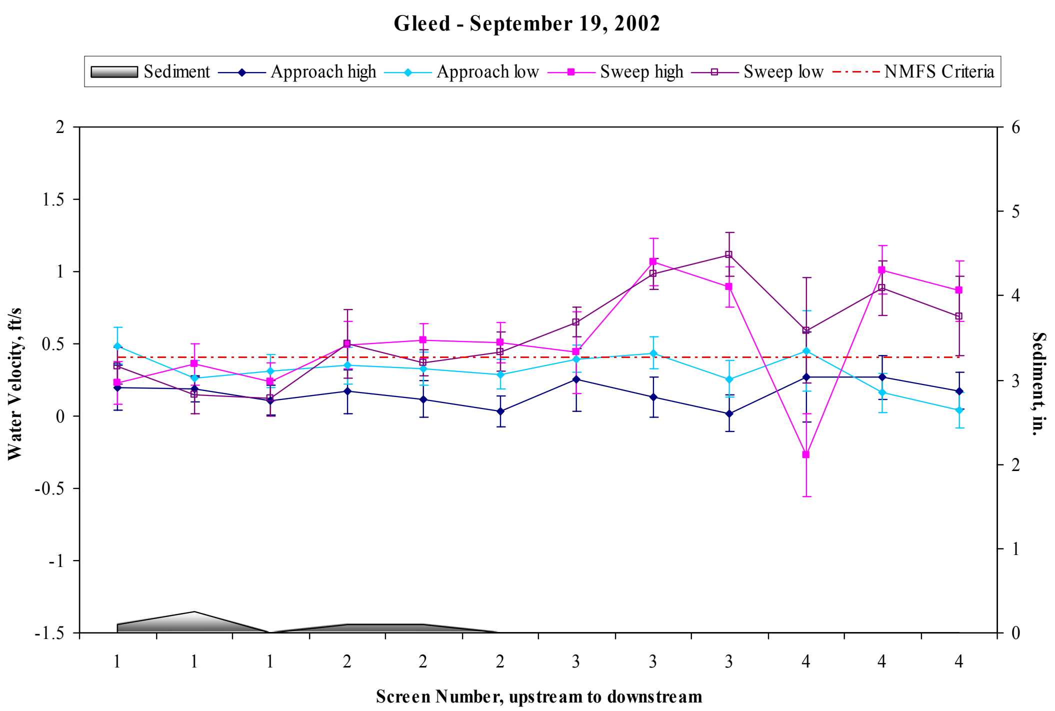

Figure 74. Water Velocities and Sediment Depths at Gleed in September 2002. Error bars show turbulence (± the root-mean-squared [RMS]) at each point.

4.0 Conclusions

The 2002 evaluations of 23 Phase II fish screen facilities in the Yakima River Basin by PNNL indicate that the facilities were generally designed, constructed, operated, and maintained to effectively provide fish a safe and efficient return to the river. Sweep velocities were generally higher than approach velocities and lower than bypass velocities, which should provide fish with safe passage back into the river without delays.

Most screens were well maintained and properly sealed to prevent fish entrainment and injury, although some potential problems were identified at each screen site. These included lack of caulking at flat-plate screens and excessive accumulation of debris at some of the sites (e.g., Toppenish Pump). The lack of caulking creates gaps that could potentially entrain fish, while debris buildup could create habitat for predators and, in some cases, inhibit the ability of the site to function properly. The automated cleaning brushes at flat-plate screen sites generally functioned properly; chains and other moving parts were well greased and operative. Drum screen sites generally functioned properly to roll debris into the aftbay.

Continued periodic screen evaluations will increase the effectiveness of screen operation and maintenance practices by confirming the effectiveness (or ineffectiveness) of screen operating procedures at individual sites. The new problem-tracking protocol can assist in this process by making the agencies responsible for operations and maintenance more accountable for proper maintenance and operation of the sites and by allowing the researchers to more easily ascertain which sites may need more attention. Where procedures are being followed and problems still occur, evaluation results can be used to suggest means to better protect fish at screening facilities. There has been a progressive improvement in the maintenance and effectiveness of fish screen facilities in the Yakima River Basin during the past several years, in part, as a result of regular screen evaluations and the rapid feedback of information necessary to improve operations and design of these important fish protection devices.

Because of an increase in the number of sites evaluated by PNNL each year (without an increase in funding) and the good performance of some of the sites over the past several years, PNNL has proposed reducing site visits for the 2003 irrigation season at some of the sites with better records. Based on a point system that places approach velocity criteria ahead of other criteria, Clark, Lindsey, Naches-Cowiche, Snipes-Allen, Taylor, Fruitvale, and Younger could be evaluated once a year as opposed to the current three times a year.

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