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Yakima River Basin Phase II Fish Screen Evaluations, 2001

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Pacific Northwest National Laboratory
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Summary

In the summer and fall of 2001 the Pacific Northwest National Laboratory (PNNL) evaluated 23 Phase II fish screen sites in the Yakima River Basin as part of a multi-year study for the Bonneville Power Administration (BPA) on the effectiveness of fish screening devices. Data were collected to determine if velocities in front of the screens and in the bypasses met current National Marine Fisheries Service (NMFS) criteria to promote safe and timely fish passage and whether bypass outfall conditions allowed fish to safely return to the river.

Based on our studies in 2001, we concluded that

- in general, water velocity conditions at the screen sites met fish passage criteria set forth by the NMFS.
- most facilities efficiently protected juvenile fish from entrainment, impingement, or migration delay.
- automated cleaning brushes generally functioned properly; chains and other moving parts were well greased and operative.
- removal of sediment build-up and accumulated leafy and woody debris are areas that continue to improve.

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. 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 last 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.

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. 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 last 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.

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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 underway (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 Council's Columbia River Fish and Wildlife Program lists fish protection through 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. Changes in the regulations require that older, less-efficient screening facilities be updated or replaced. In addition, the BPA has established a monitoring and evaluation program to ensure that new and updated screening facilities meet current fish protection standards.

At the BPA's request, Pacific Northwest National Laboratory (PNNL) staff have conducted a number of fish screen evaluations in the Yakima Basin since 1985. Initially, staff 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, and 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).

Each year, more sites are added to the list of fish screening facilities surveyed by PNNL for the BPA. In 2000, 21 Phase II sites were evaluated. This year, twenty-two operating screen sites in the Yakima, Naches, and Tieton river basins were evaluated three times and one screen site was evaluated twice between May 11 and September 25, 2001 (Figure 1).

The evaluations of these facilities addressed three main questions:

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

2. Do velocities/flows meet NMFS criteria?
3. Are screens effective at protecting fish from injury and from unnecessary migration delay?

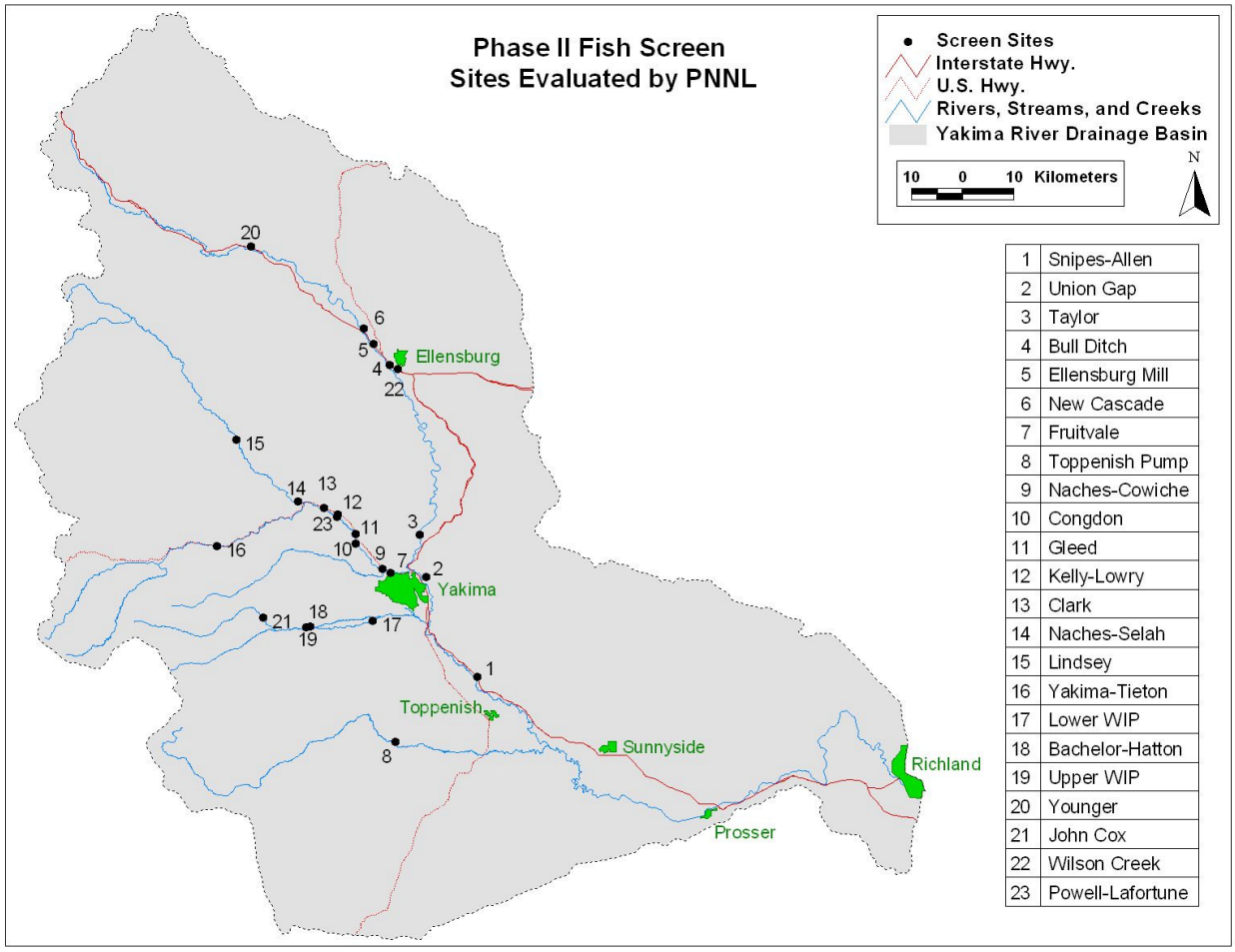

Figure 1. Yakima River Basin Phase II Fish Screen Facilities

2.0 Methods

The NMFS criteria define several conditions concerning velocity and general operation (NMFS 1995). These include:

- Maintaining a uniform flow distribution over the screen surface to minimize approach velocity
- Keeping approach velocities ≤0.4 ft/s
- Achieving sweep velocities that are greater than approach velocities
- Affecting a bypass flow greater than or equal to the maximum flow velocity vector resultant upstream of the screens
- A gradual and efficient acceleration of flow from the upstream end of the site into the bypass entrance to minimize delay by emigrating salmonids
- Screen submergence between 65 and 85% for drum screen sites.

To evaluate whether the sites are meeting these criteria, three types of data were collected at each site. Water velocity measurements allow a comparison of velocities near screen surfaces at a site with NMFS criteria concerning uniform flow distribution and flow velocities. The position and number of measurements are designed to provide data representative of conditions across each screen and site. Underwater video and general operational data collection (i.e., screen submergence, bypass conditions, fish presence, etc.) allows evaluation of screen submergence to NMFS criteria. They also allow evaluation of screen and site maintenance and other conditions that may affect juvenile fish passage. Specific methods are described in this section.

2.1 Water Velocity Measurements

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 toward 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 (approach, sweep, and vertical) at a point 10 cm below the probe. Figure 2 shows the ADV probe.

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 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 20 to 30 sec at a rate of 0.5 Hz and stored in a computer file. **Note:** we determined after the first two surveys that the ADV was not properly calibrated. Therefore, data taken with the ADV in May and June are not presented.

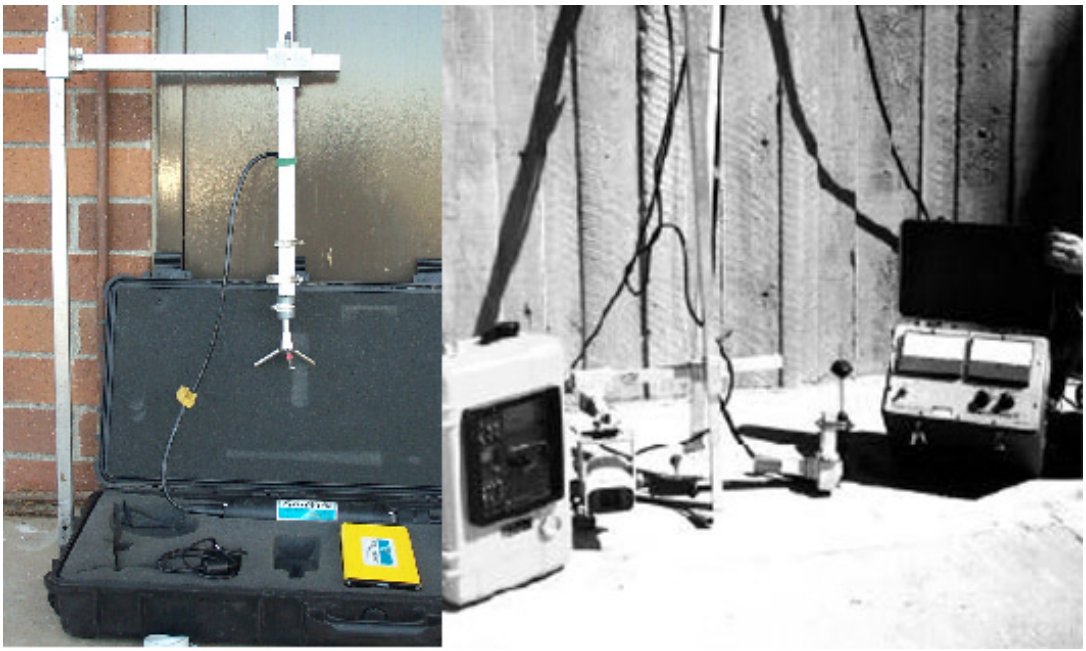

Figure 2. Acoustic Doppler Velocimeter (left) Underwater Video System (center), and Marsh-McBirney 511 Electromagnetic Velocity Meter (right)

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 flows in two directions (approach and sweep) simultaneously. Output was read visually from a panel gauge. Figure 2 shows the Marsh-McBirney probe on the right.

Measurements of water velocity were taken at several (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., one set of measurements was taken at 60 percent of depth from the surface. In cases where the forebay depth was greater than or equal to 48 in., measurements were taken at 20 and 80 percent of the water depth. Because the screens are constructed at an angle to the canal flow, all measurements were taken with the axes of the probe oriented to measure water flowing parallel (sweep) and perpendicular (approach) to the screen face, not to canal flow.

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 flowmeter. 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.

2.2 Underwater Video

An underwater video system was used to investigate screen seal condition and to monitor debris build up and fish presence. 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 internal battery power supply for the system. The underwater camera operates at extremely low light levels (<1 lux), so that artificial light sources were not necessary to obtain video images during daylight hours.

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. Written observations were made in the field when something of interest was seen with the camera (i.e., debris, gaps, fish).

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 flow conditions
- fish presence
- observations of debris or sediment on the screen sill or in the forebay or bypass
- presence or absence and condition of operator control aids such as water gauges and drum submergence marks on screen frames.

The NMFS criteria define several conditions concerning velocity and general operation (NMFS 1995). These include:

- Maintaining a uniform flow distribution over the screen surface to minimize approach velocity
- Keeping approach velocities ≤0.4 ft/s
- Achieving sweep velocities that are greater than approach velocities
- Affecting a bypass flow greater than or equal to the maximum flow velocity vector resultant upstream of the screens
- A gradual and efficient acceleration of flow from the upstream end of the site into the bypass entrance to minimize delay by emigrating salmonids
- Screen submergence between 65 and 85% for drum screen sites.

In addition, silt and debris accumulation should be kept to a minimum. For the purposes of 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. We generally compared our field measurements of water velocity, underwater video, and general data collection results for each screen site to the NMFS criteria. The following section contains the results of these comparisons for each site.

2.4 Data Analyses

Velocity data generated by the ADV system was downloaded and processed in the office after the field work was done. Data collected with the Marsh-McBirney system was entered manually into a spreadsheet. Once processed, the velocity data was plotted and compared to NMFS criteria for maximum flow and gradual increases in flow toward and into the bypass.

All videotapes were reviewed in detail in the office, and images of interest were digitally captured using Optimas software. Field notes were updated if anything of note was found during this later review. This information was used to evaluate screen maintenance and site conditions in areas that are otherwise difficult to observe.

The general operational data was used to evaluate whether NMFS screen submergence criteria were being met. They were also used to evaluate general site conditions that could affect the passage of juvenile salmonids. Poor screen or seal conditions could injure small fish or allow them to move into the aftbay. Bypass conditions may also injure small fish or provide habitat for predators. Excessive silt and debris accumulation can cause changes in flow patterns and velocities, and can cause excessive wear on screens and seals. For the purposes of this report, the accumulation of silt and/or debris was considered excessive if the intersection of the seal and the screen was buried. If any significant problems were identified as these data were being reviewed, the appropriate maintenance agency was notified so that the problem could be quickly fixed.

3.0 Results and Discussion

This section presents the overall results first, 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 Water Velocity Measurements

After the June evaluations, we discovered that we had been using the ADV with an improper calibration file, which introduced an unknown degree of error in the velocity data. Therefore, we will not present those data and will discuss only data recorded with the Marsh-McBirney probe from May and June and ADV data recorded after the problem was fixed in September. Unfortunately, because this was a low-water year, many sites were already closed down for the season before we could evaluate them in September. Because of this, we have no velocity data for five of the 23 sites, and data from only one survey for the majority of the rest (Table 1).

Table 1. List of Sites Done by Month and Equipment Used to Measure Water Velocities. Those listed in red are sites for which we have uncalibrated or no data (no water) for that month.

	May	June/July	Sept.
Bachelor-Hatton	ADV	ADV	no water
Clark	ADV	ADV	ADV
Congdon	ADV	ADV	ADV
John Cox	ADV	no water	no water
Kelly-Lowry	ADV	ADV	ADV
Lindsey	ADV	ADV	ADV
Lower WIP	ADV	ADV	no water
Naches-Cowiche	ADV	ADV	ADV
New Cascade	ADV	ADV	no water
Powell-Lafortune	not done	ADV	ADV, ADV
Snipes-Allen	ADV	MMB511	ADV
Taylor	MMB511	ADV	MMB511
Toppenish Pump	ADV	MMB511	ADV
Upper WIP	ADV	no water	no water
Wilson Creek	ADV	not done	MMB511
Bull Ditch	ADV	ADV	MMB511
Ellensburg Mill	ADV	ADV	ADV
Fruitvale	ADV	ADV	ADV
Naches-Selah	ADV	MMB511	ADV
Union Gap	MMB511	MMB511	ADV
Yakima-Tieton	ADV	ADV	ADV
Younger	ADV	ADV	ADV
Gleed	ADV	ADV	ADV

Although velocities often fluctuated from one sampling location to the next, 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 ≤0.4 ft/s (Table 3). 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) at Phase II Fish Screen Facilities in the Yakima River Basin in 2001

Site	Mean Sweep Velocity c S.D. *	Mean Approach Velocity ± S.D. *	Ratio of Sweep to Approach
Bachelor-Hatton	ND	ND	ND
Clark	0.53 ± 0.11	0.19 ± 0.09	2.83
Congdon	0.72 ± 0.15	0.35 ± 0.06	2.04
John Cox	ND	ND	ND
Kelly-Lowry	0.61 ± 0.23	0.29 ± 0.10	2.08
Lindsey	0.40 ± 0.05	0.21 ± 0.05	1.89
Lower WIP	ND	ND	ND
Naches-Cowiche	0.80 ± 0.49	0.14 ± 0.16	5.67
New Cascade	ND	ND	ND
Powell-LaFortune	0.37 ± 0.19	0.14 ± 0.06	2.72
Snipes-Allen	0.21 ± 0.11	0.18 ± 0.05	1.16
Taylor	0.41 ± .05	0.10 ± 0.07	4.13
Toppenish Pump	0.68 ± 0.22	0.11 ± 0.08	6.30
Upper WIP	ND	ND	ND
Wilson Creek	0.47 ± 0.12	0.13 ± 0.05	3.69
Bull Ditch	0.29 ± 0.29	0.08 ± 0.07	3.41
Ellensburg Mill	0.47 ± 0.18	0.09 ± 0.05	5.49
Fruitvale	0.31 ± 0.18	0.17 ± 0.03	1.77
Naches-Selah	1.18 ± 0.36	0.26 ± 0.12	4.57
Union Gap	1.27 ± 0.27	0.27 ± 0.12	4.66
Yakima-Tieton	1.76 ± 0.48	0.27 ± 0.08	6.44
Younger	0.02 ± 0.01	0.01 ± 0.01	2.76
Gleed	0.39 ± 0.17	0.27 ± 0.06	1.48

ND = No data

* Values are based on all surveys for which we have good velocity data (see Table 1).

Table 3. Percent of Approach Velocity Measurements that Exceeded the NMFS Criteria of 0.4 ft/s by Screen Site in 1997, 1998, 1999, 2000, and 2001

Screen Type	Screen Site	Percent of Approach Velocity Measurements >0.4 ft/s				
		1997	1998	1999	2000	2001(a)
Drum Screens	Bachelor-Hatton	12.5	34.1	0	15.4	(b)
	Clark	0	0	(c)	0	0
	Congdon	31.1	4.4	8.3	7.1	13.3
	John Cox	(d)	(d)	(d)	39.3	(b)
	Kelly-Lowry	3.3	0	0	0	20
	Lindsey	3.3	0	0	0	0
	Lower WIP	8.3	(e)	0	0	(b)
	Naches-Cowiche	6.6	0	12.5	2.6	5
	New Cascade	4.2	(c)	0	1.4	(b)
	Powell-LaFortune	(d)	(d)	(d)	(d)	0
	Snipes-Allen	3.3	0	0	0	0
	Taylor	4.2	0	0	0	0
	Toppenish Pump	43	60	25.4	9.4	3.33
	Upper WIP	17.5	9.4	2.5	3.3	(b)
	Wilson Creek	(d)	(d)	(d)	(d)	0
Vertical plate screens	Bull Ditch	36.1	2.9	14.7	22.2	0
	Ellensburg Mill	0	0	33.3	25.9	0
	Fruitvale	12.5	(c)	0	17.5	0
	Naches-Selah	5.5	2.8	27.8	28.7	8.33
	Union Gap	2.3	5	22.9	12.5	4.16
	Yakima-Tieton	10.5	5.2	2.1	1.4	2.06
	Younger	(d)	(d)	0	8.3	0
Vertical traveling screen	Gleed	(c)	(c)	14.3	17.5	0

(a) Based on September data only, except where other reliable data are available (see Table 1).
(b) No data; equipment problems in May and June, and site was dry in September.
(c) No data; electrical interference prevented velocity measurements.
(d) Not sampled.
(e) No data; flooded in May and nearly dry by July 1998.

Table 4. Summary of Problem Areas Identified at Yakima River Basin Phase II Screen Sites in 1999 (20 sites), 2000 (21 sites) and 2001 (23 sites)

Screen type	Site	≥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		
		1999	2000	2001 (a)	1999	2000	2001 (a)	1999	2000	2001	1999	2000	2001	1999	2000	2001	1999	2000	2001
Drum Screens	Bachelor-Hatton		∇	(b)		∇	(b)	■		✱	■	∇			∇				
	Clark											∇	✱						
	Congdon		∇	✱							■		✱						
	John Cox		∇	(b)			(b)			✱		∇						∇	✱
	Kelly-Lowry			✱			✱					∇	✱	■	∇	✱			
	Lindsey							■					✱						
	Lower WIP			(b)	■		(b)				■			■		✱			
	Naches-Cowiche	■					✱												
	New Cascade			(b)			(b)	■		✱	■	∇	✱		∇	✱			
	Powell-Lafortune						✱						✱						
	Snipes-Allen					∇	✱				■								
	Taylor												✱			✱			
	Toppenish Pump	■						■				∇	✱	■	∇	✱			
	Upper WIP			(b)			(b)	■						■	∇				✱
	Wilson Creek						✱						✱			✱			
Vertical Plate Screens	Bull Ditch	■														✱			
	Ellensburg Mill	■	∇		■		✱	■		✱				■		✱			
	Fruitvale		∇								■								
	Naches-Selah	■	∇			∇	✱	■											✱
	Union Gap	■	∇		■		✱	■											
	Yakima-Tieton					∇	✱			✱									✱
	Younger									✱									
Vertical traveling screen	Gleed	■	∇											■					

(a) Based on September data only, except in cases where other reliable data is available (see Table 1).
(b) No data; sites were dry in September.

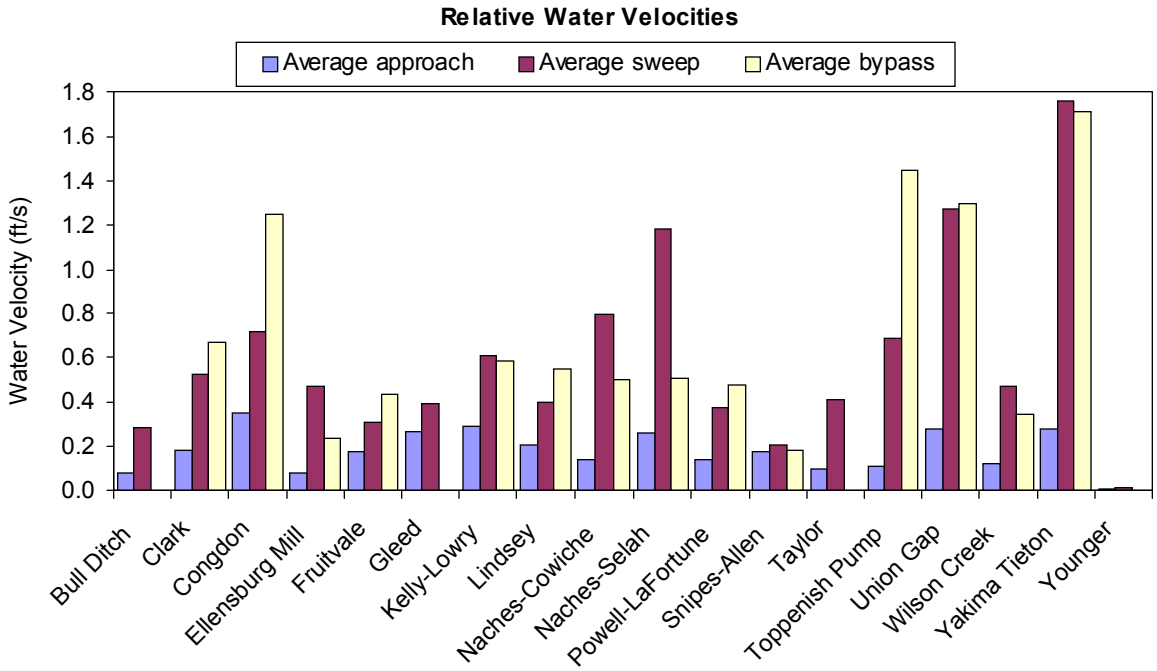

Figure 3. Mean Approach, Sweep, and Bypass Velocities at Phase II Fish Screen Facilities in the Yakima River Basin in 2001

Overall, 97% of all approach velocity measurements met the NMFS approach criteria of ≤0.4 ft/s (versus the 90% reported in 2000). However, the data from this year are an average of September's data only (except, see Table 1), which may not provide an accurate representation of the velocity conditions that were present earlier in the year. 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. Averaging velocities for each screen site for the whole year presented a clearer picture of the flows at these sites. 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).

3.2 Underwater Video

Underwater video was used to inspect the conditions of the seals, 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, record fish presence at the sites, and monitor and document sediment and debris accumulation in front of a screen. The latter is important because debris can severely decrease seal life, cause drag on screen motors, and provide cover for predator fish species. Most often, it is impossible 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 and how it affects water flow through or past the screen without a video survey. Eight sites were recorded as having excessive silt or debris at least once during the year (Table 4). Six of these were drum screen sites.

Most screens were properly sealed to prevent fish entrainment and injury, although some potential problems were identified in 2001 at several screen sites. Six sites had loose or damaged seals or caulking that might have allowed fish to be entrained or caused physical damage to them (Table 4).

Most visible screen seals were in good condition. Bottom frame seals were sometimes buried in debris or plants/algae and could not be evaluated. All drum screen seals that were classified as in "good condition" were tight against the screen and not cracked or punctured in any way. Many rubber seals were covered in algae, 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 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).

3.3 General Data

In 2001, most sites were operating in a manner that would be expected to provide safe passage for juvenile salmonids. Some sites, such as Lindsey, are well maintained, well designed, and rarely exceed criteria, while others such as Bachelor-Hatton have had various 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. Because this was a low-water year, and flows going through the screen sites were typically lower than in normal years, not as much water was available to bring in sediment and debris, and some sites had less debris than in previous years. At other sites where debris and sediment did accumulate, there was insufficient flow to flush them back out. Thirty-five percent of sites had excessive sediment/debris in 2001, compared with 24% in 2000 (Table 4). This is an area that will need special consideration in drought conditions.

Canal operating conditions are designed to provide water levels that cover between 65 and 85% of a drum screen's diameter. At higher water levels, fish may roll over the top of the screen and enter the canal. Lower water levels can prevent the screen from efficiently removing debris from the forebay area. In 2001, 60% of drum screens were outside submergence criteria. Most of these sites did not have enough water to affect appropriate submergence levels.

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 screen become completely submerged, fish can freely enter the irrigation canals by swimming over the top of the screen. Total screen

submergence was observed only at the Fruitvale screen; however, there were no reports of over-topping at the Fruitvale site in the operator's logbook.

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 in. (61 cm) and that the minimum depth of open-channel flow in the bypass conduit shall be greater than or equal to 9 in. (23 cm), 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 WIP, Taylor, Wilson Creek, and Younger are designed and built for diversion flows greater than 25 cfs. However, many sites had bypass pipes with diameters much smaller than the NMFS criteria. All sites appeared to normally meet the minimum requirements for in-pipe water depth.

Visual operator control aids, while not required, are extremely useful for maintenance and operations personnel periodically inspecting sites. They 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 due to the growth of algae. We recommend regular cleaning of these marks to facilitate operator adjustments and evaluation.

3.4 Rotary Drum Screens

3.4.1 Bachelor-Hatton

The Bachelor-Hatton site was evaluated 5/11/2001, 6/26/2001, and 9/12/2001. Water velocity was measured with the ADV using an improper calibration file in May and June, and the site was turned off for the season before our September inspection. Therefore, we present no velocity data for this site.

The gap noted in 1999 and 2000 between the seal and the bottom of screen 2 was no longer present in 2001. Video surveys in all three 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. A 1.5- to 2-in. gap between the metal screen frame and the concrete wall was noted in May. While fish

cannot move into the aftbay through this route, a gap of this size could entrain small fish. We recommend filling it with expanding foam insulation to prevent harm to migrating fish.

There were no operator control aids such as submergence marks painted on the screen frames or gauges for measuring water depth. However, submergence was calculated to be within criteria in May and June at 77 and 81%, respectively. The site was shut down for the season before our September inspection.

Approximately 2 in. of sediment had accumulated in front of screens 3 and 4 in May, which was nearly gone by June. A fair amount of twigs and other debris had accumulated in front of these same two screens and in the bypass in both May and June, though none was present in September. Bypass and bypass outfall conditions were conducive to safe fish passage in both May and June. In September, several small, unidentified fish were noticed in the forebay, but the weir was completely closed and there was no way for these fish to pass through the site.

3.4.2 Clark

The Clark screening facility was visited on 5/17/2001, 6/21/2001, 9/18/2001, and 9/25/2001. The water velocity was measured with the ADV using an improper calibration file in May and June; consequently, only velocity data from September are presented. In September water velocities at this site complied with NMFS criteria. All approach values were less than 0.4 ft/s and sweep velocities were always higher than approach velocities (Figure 4). The water velocity in the bypass was greater than the average sweep, which created a clear trajectory toward the bypass, and should help expedite fish movement through the site.

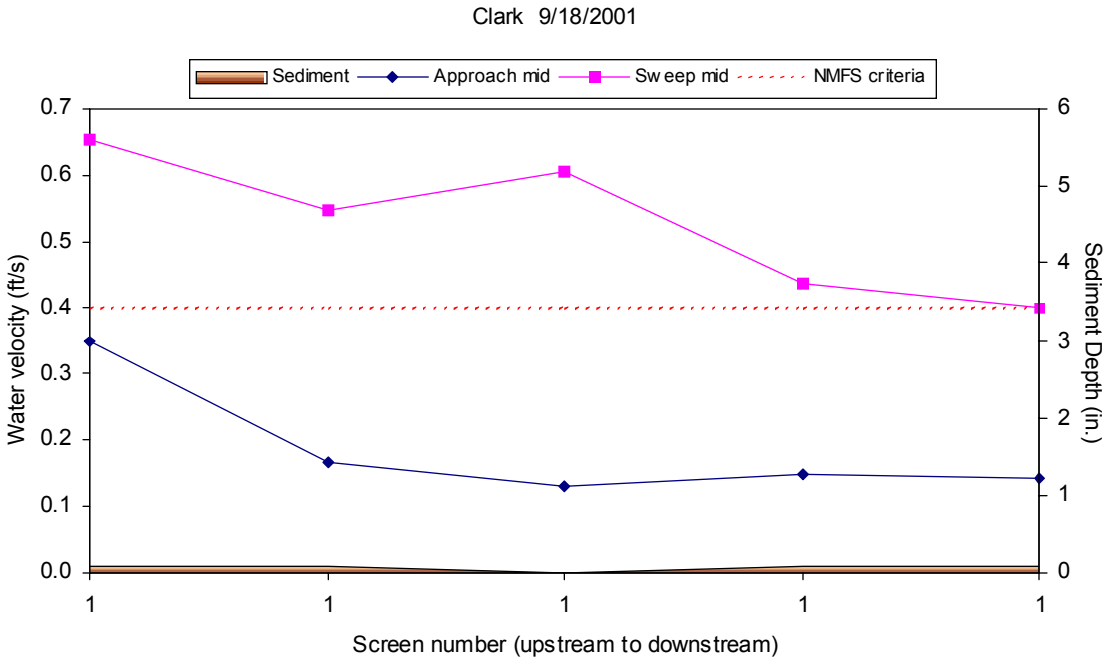

Figure 4. Water Velocities and Sediment Depths at Clark, 9/18/2001

In the past, there have been a lot of problems with beavers at this site, and this continued in 2001. In May, water was running from the downwell into the forebay, because of a beaver dam downstream of the outfall. This problem had been fixed by our June survey, and water was running freely through the bypass. However, in September, water levels were again very high in the channel leading to the site and in the canal downstream of the outfall, and submergence was outside of criteria at 93%. Water was running over the top of the head gates into the site. Bill Werst (WDFW) was notified on September 18, and the situation had improved by September 22 when we returned to check the site. The submergence level was down to 90%, and water was no longer running over the head gates. A combination of high river levels and renewed beaver activity may have caused the problems.

There were several small, unknown fish recorded in the forebay in May and June, though none appeared in the aftbay. In September there were too many plants growing in the forebay to see any fish. The condition of the seals was good throughout the survey period.

3.4.3 Congdon

The Congdon facility was evaluated on 5/17/2001, 6/22/2001, and 9/19/2001. The water velocity was measured with the ADV using an improper calibration file in May and June; consequently, only velocity data from September are presented. Thirteen percent of measured approach velocities exceeded NMFS criteria in September (Figure 5). Sweeps were always higher than approaches, and the velocity in the bypass was higher still, creating a clear trajectory towards the bypass in September.

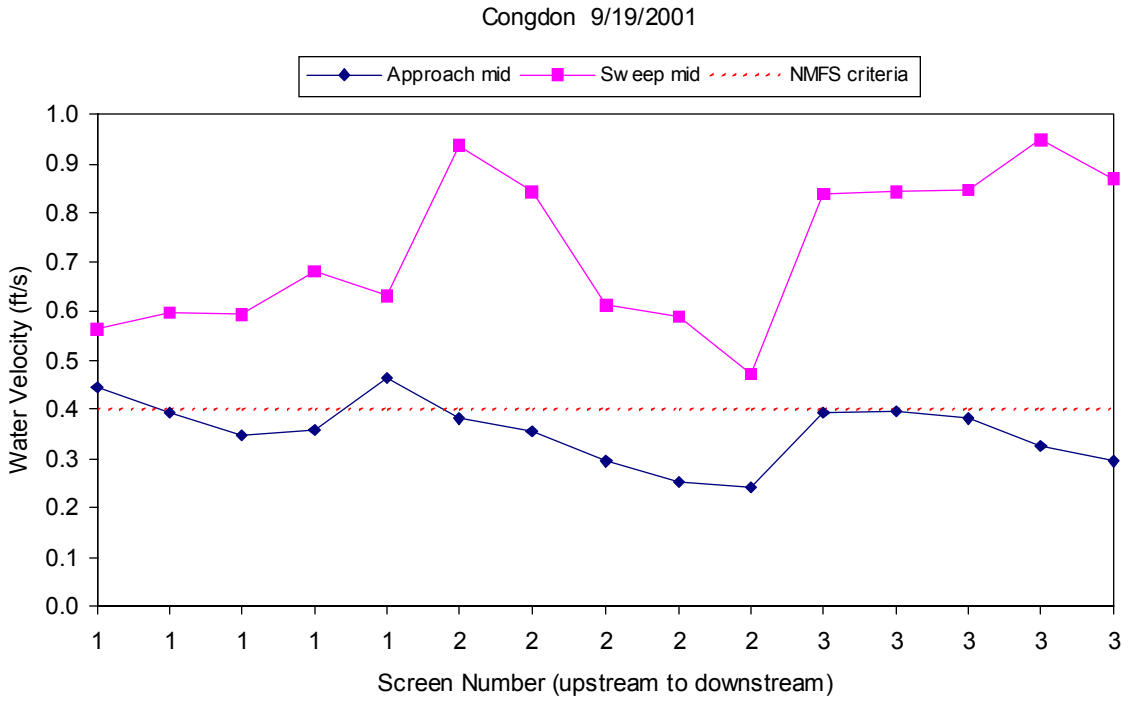

Figure 5. Water Velocities at Congdon, 9/19/2001

The screen seals were in good condition. There was only 2 in. of sediment built up in front of screen 2 in May, and there was none in June or September. Submergence was at the high end of the criteria range throughout the survey period at 87% in May and 85% in June and September. Water ran freely through the bypass, and bypass outfall conditions were conducive to safe fish passage in May and June. The depth of water flowing over the weir and through the outfall met NMFS criteria. In the past, it has been noted that water surged behind the bypass weir. This condition was particularly bad in September, with water spraying at least 1 ft above the outfall pipe housing. 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, and an air pressure release tube may need to be installed to prevent the surges.

3.4.4 John Cox

The John Cox site was evaluated on 5/11/2001, 6/26/2001, and 9/12/2001. The water velocity was measured with the ADV using an improper calibration file in May, and the site was dry in June and September; consequently, no velocity data are presented.

The screen seals appeared to be in good condition, although a gap was noted in May in the downstream corner of screen 2 (Figure 6). In May water flowed smoothly over the weir, though the water depth at the outfall was only 6 in. in the pipe and 3 in. over the concrete apron. Some small fish were noted in the forebay in June and September, though the water level was below the rubber seals on the screens and they could not get through the bypass.

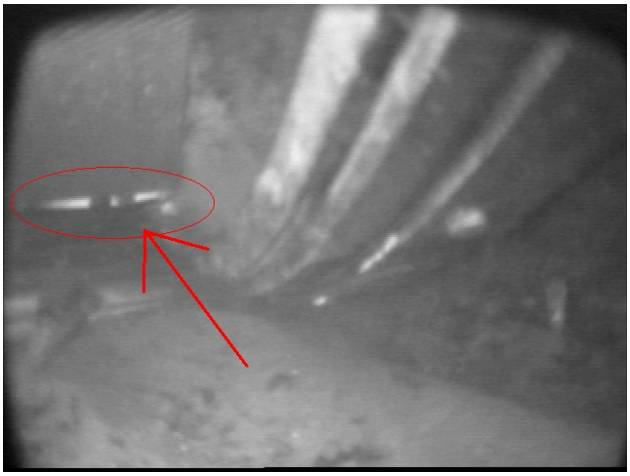

Figure 6. Gap in the Downstream Seal of Screen 2 at John Cox in May

3.4.5 Kelly-Lowry

The Kelly-Lowry site was evaluated on 5/11/2001, 6/21/2001, and 9/19/2001. The water velocity was measured with the ADV using an improper calibration file in May and June, so only velocity data from September are presented. Eighty percent of approach velocities met NMFS criteria in September (Figure 7). Sweep was generally higher than approach, though sweep did not increase toward the bypass, and the bypass velocity was slower than the average sweep.

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 our view of the seal in places. A significant amount of debris built up on the trashrack before our May survey, causing measurable headloss across the trashrack. Algae growth on the screens partially plugged them in May, but was cleaned by the WDFW before our June survey. There was no foam insulation between the screen frames and the cement.

Some fish were noted in the forebay in May and June, including one large trout. Bypass conditions were conducive to safe fish passage in all months. Water ran freely over the weir and we did not observe any accumulation of debris at the end of the outfall pipe. The depth of water at the outfall was always greater than 1 ft, and water discharge at the outfall was steady, though some turbulence and eddying was noted in June.

Operator control aids were present, though the submergence marks on the drum screen frame were faint even in May, and could benefit from being repainted.

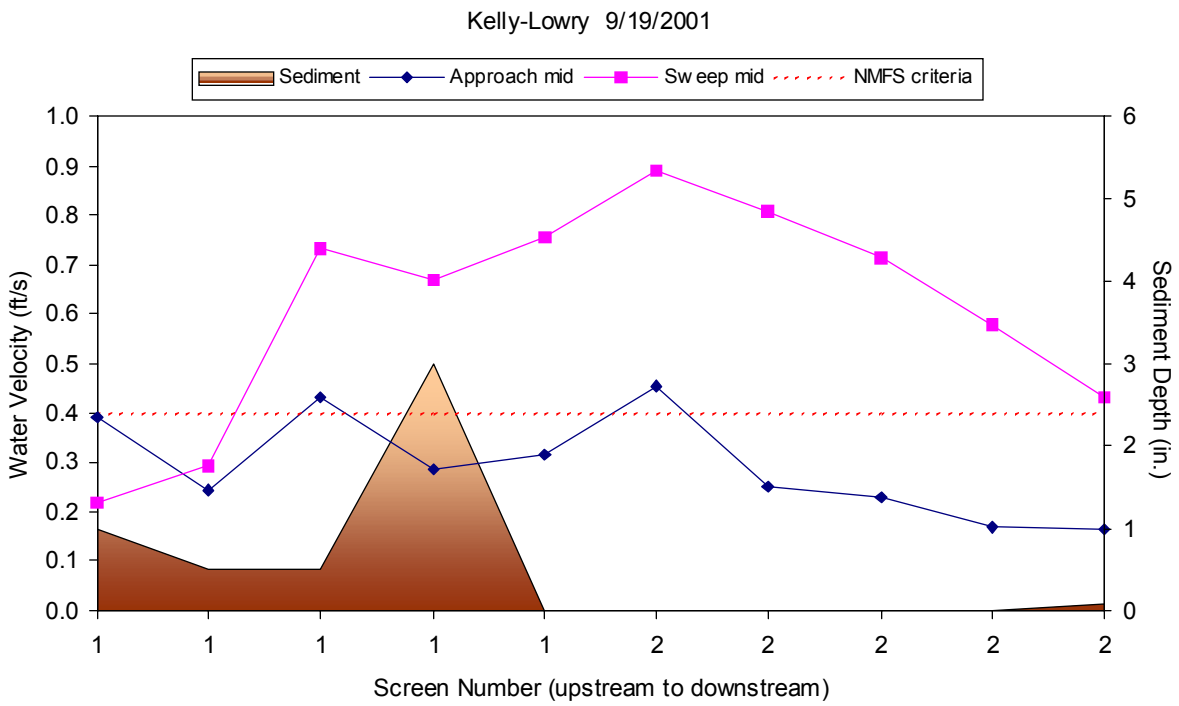

Figure 7. Water Velocities and Sediment Depths at Kelly-Lowry, 9/19/2001

3.4.6 Lindsey

The Lindsey site was evaluated on 5/16/2001, 6/21/2001, and 9/18/2001. The water velocity was measured with the ADV using an improper calibration file in May and June, so velocity data from those months are not presented here. In September, all approach values met NMFS criteria (Figure 8). All sweeps were greater than approaches, and the bypass velocity was greater than the average sweep. Sweep did not increase toward the bypass.

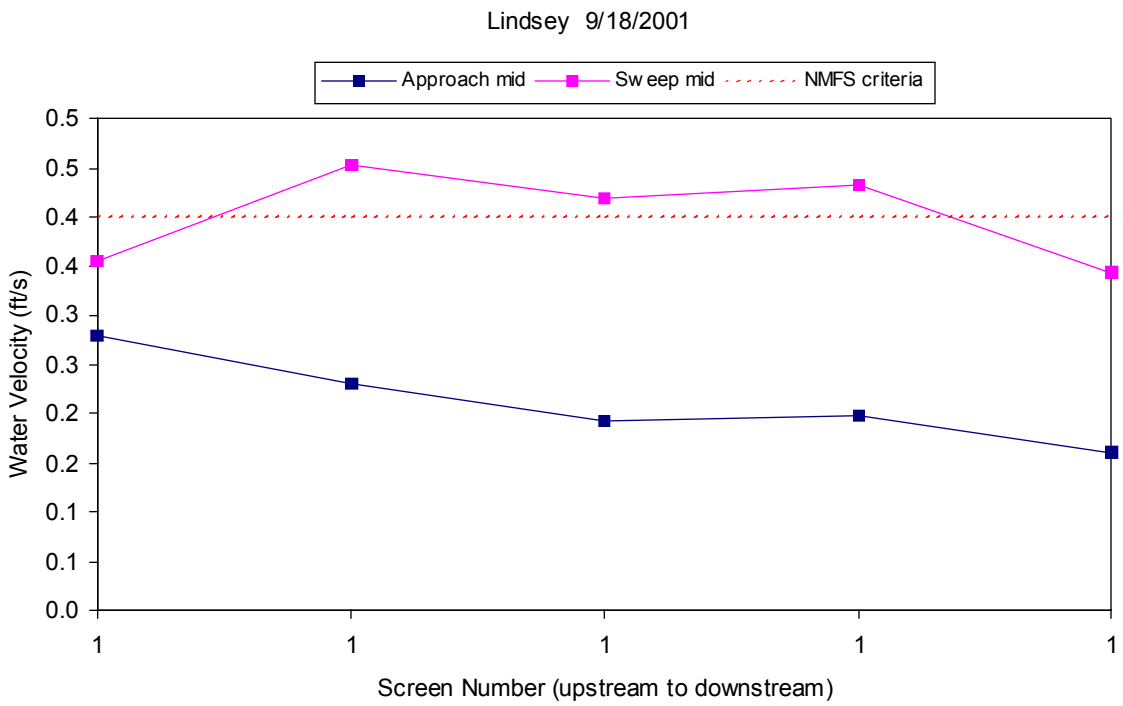

Figure 8. Water Velocities at Lindsey, 9/18/2001

The screen seals were in good condition, and the drum moved leaf matter and other floating debris into the canal effectively. On 4/27, submergence was noted at 10% in the logbook, although it was always within criteria during out visits.

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.

3.4.7 Lower WIP

The Lower WIP site was visited on 5/24/2001, 6/26/2001, and 9/12/2001. Water velocity was measured with the ADV using an improper calibration file in May and June, and the site was turned off for the year before our September inspection. Therefore, we present no velocity data for this site.

In May, murky water prevented an evaluation of the screen seals. In June, a significant amount of debris had built up in the bypass and appeared to partially block it. Sediment and debris were removed from the forebay and bypass in late August, and in September all seals were visible and appeared to be in good condition.

In both May and June, bypass conditions were conducive to safe fish passage. Water flowed smoothly over the weir and through the outfall. Water depth met criteria at the outfall pipe in both months. In June schools of tiny (1- to 2-in.) fish were noted in the forebay and aftbay.

3.4.8 Naches-Cowiche

The Naches-Cowiche site was evaluated on 5/17/2001, 6/22/2001, and 9/13/2001. Water velocity was measured with the ADV using an improper calibration file in May and June; therefore only velocity data from September are presented here. In September, 95% of all approach values met NMFS criteria (Figure 9). Sweeps were generally higher than approaches, but did not increase toward the bypass. The average bypass velocity was slower than the average sweep.

Two sets of stoplogs were placed in the forebay in an attempt to limit sediment accumulation against the screens. Twelve-inch-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, at the depth of the lower velocity measurements. Both the approach and sweep velocities at the lower depth were much lower than those observed at the higher position (Figure 9). The second set of stoplogs was placed in the forebay just upstream of screen bay one, angling slightly downstream (Figure 10).

During the September survey the water level in the river was relatively high. This high water level is reflected in the elevated approach velocities observed during this survey, which exceeded 0.6 ft/s in the upstream corner of screen one (Figure 9). It was hypothesized that the stoplogs might have accentuated this problem, and the WDFW removed the stoplogs 1 week later. We remeasured the velocities after the stoplogs were removed and found approaches to be lower than before, though the upstream corner of screen one still exceeded 0.4 ft/s. The water level in the river was lower than on our previous survey; therefore, we cannot conclude that the stoplogs were the cause of the high approaches. The WDFW is planning to move the stoplogs farther upstream in an attempt to minimize eddying and maintain some control over sediment buildup.

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 all surveys, sediment and/or debris were trapped in the space between the stoplogs and the screens. Submergence was within criteria during all visits, and bypass conditions were good for safe fish passage.

3.4.9 New Cascade

The New Cascade site was evaluated on 5/15/2001, 6/20/2001, and 9/17/2001. The water velocities were measured with the ADV using an improper calibration file in May and June, and the site was shut down for the season before our September visit, so no velocity data are presented. Submergence was outside criteria in May, at 86%. In June, the water level was down to 74%, and in September there was very little water at this site. This site had some problems with sediment buildup, especially in the corners of the screen bays, which obscured our view of the bottom seals in places. This is likely due to water eddying, which was clearly visible in our video surveys.

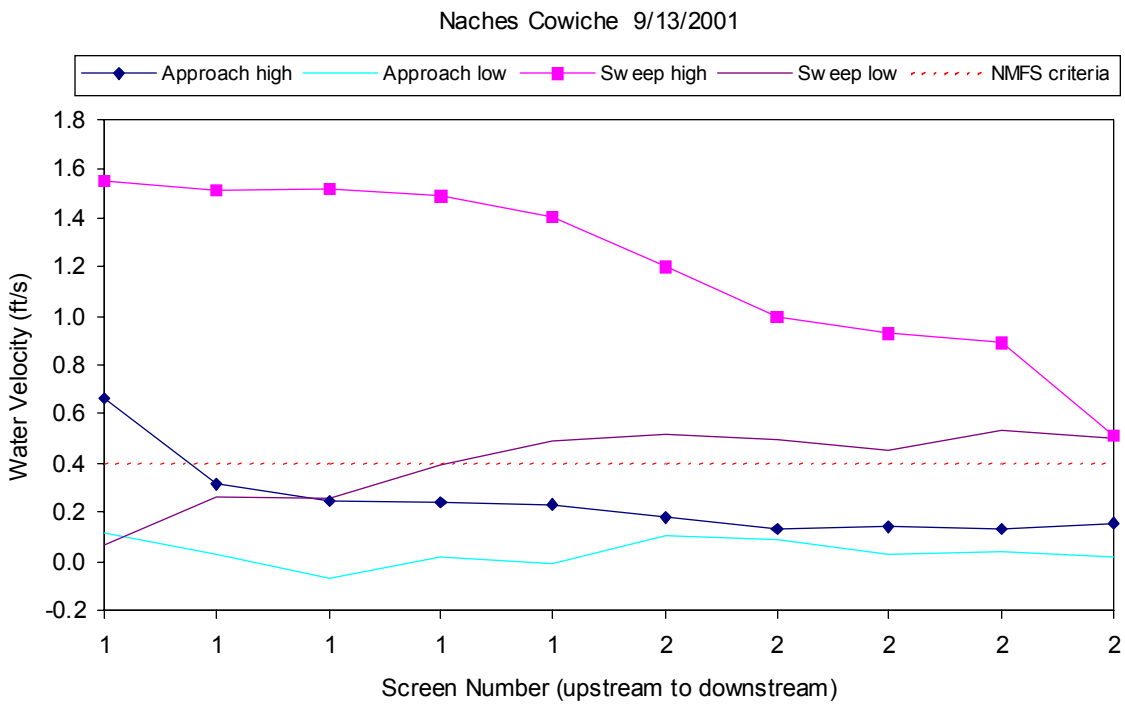

Figure 9. Water Velocities at Naches-Cowiche on 9/13/2001

Figure 10. 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 downstream side seal on screen 8 looked worn and some had notches in it. All cheeks were sealed with expanding foam insulation/caulking. The WDFW was concerned that gaps in the bottom seal allowed small fish to enter the aftbay. We have not observed any gaps in our video surveys.

Many fish were seen both in the forebay and in the aftbay of the canal during all surveys, including some large trout in September. Steelhead kelts were observed near the bypass ramp at this site on 5/15 (Figure 11). The ramp was up, but the flush gate was closed. The WDFW determined that this configuration discouraged the kelts from moving through the bypass. The WDFW decided to keep the ramps down during the migration period and to paint them a dark color to encourage fish movement through the bypass.

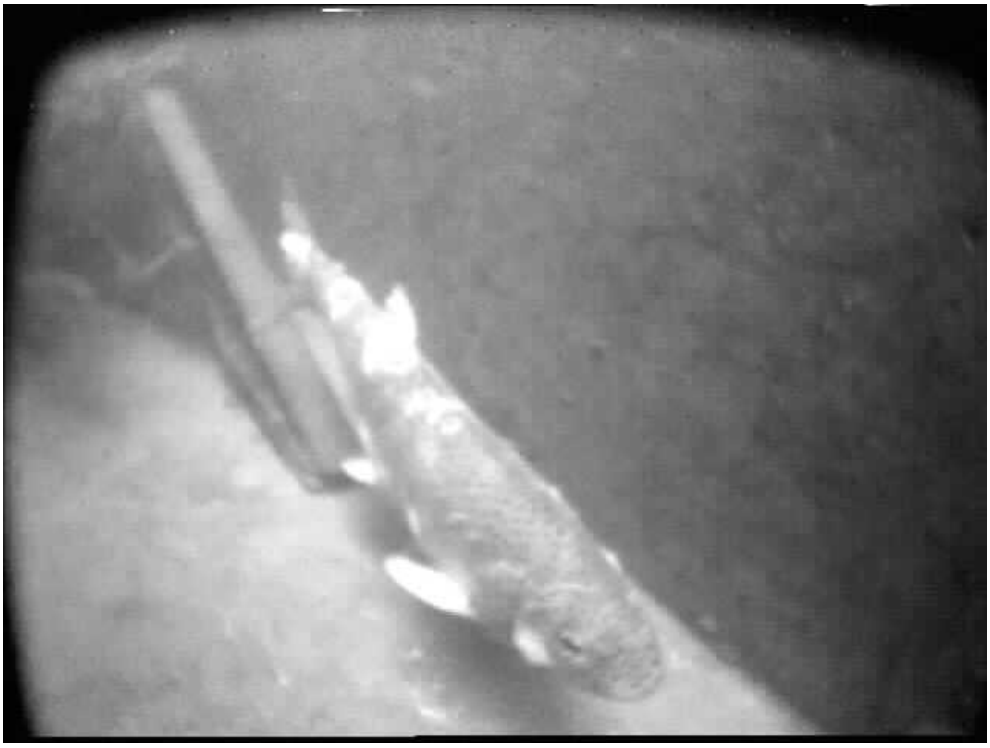

Figure 11. Steelhead Kelt in the Screen Forebay at New Cascade on May 15, 2001

3.4.10 Powell-LaFortune

Powell-LaFortune is a new site that was added to our itinerary after the May surveys. This site has four drum screens. It was evaluated on 6/27/2001, 9/19/2001, and 9/25/2001. Water velocity were measured with the ADV using an improper calibration file in June, so only velocity data from the two September surveys are presented. Approach velocities met NMFS criteria 100% of the time. Sweeps were generally higher than approach, and increased towards the bypass during the second survey in September (Figures 12 and 13). During the first survey in September, submergence was less than 40%, and no water flowed through the bypass, despite high flows in the river. Thus, the velocities measured during this inspection may not be characteristic of flows during normal conditions at this site. Following this visit, the WDFW

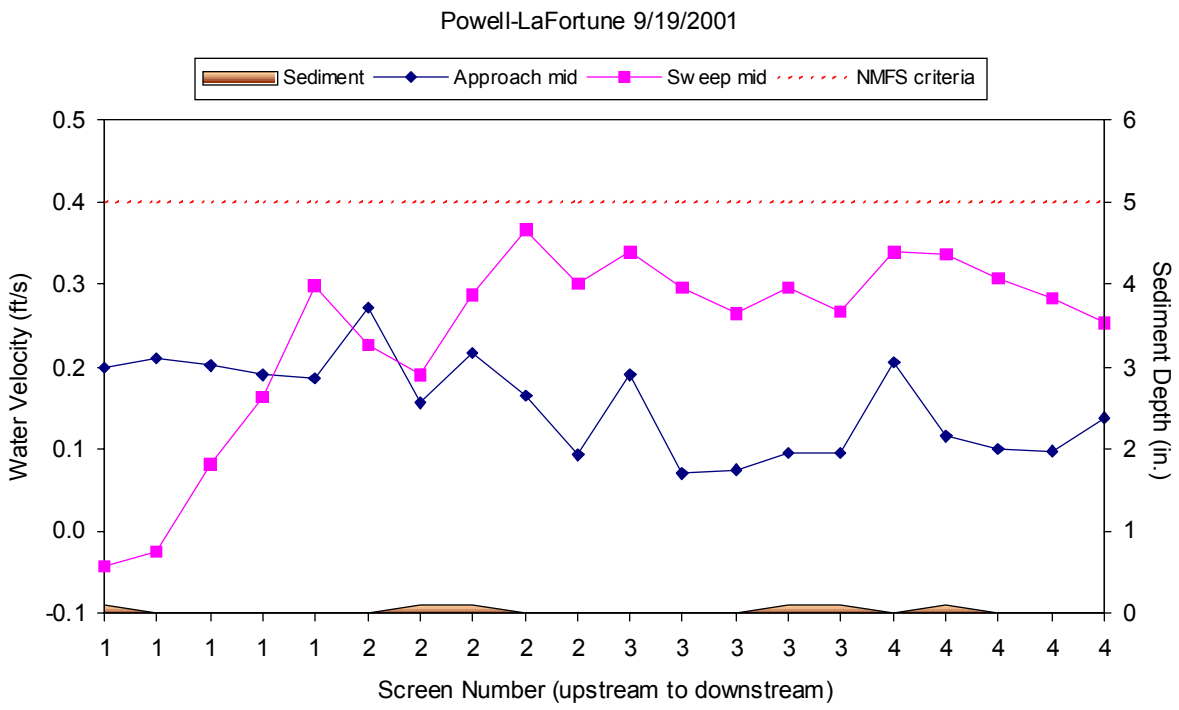

Figure 12. Water Velocities and Sediment Depths at Powell-LaFortune on 9/19/2001

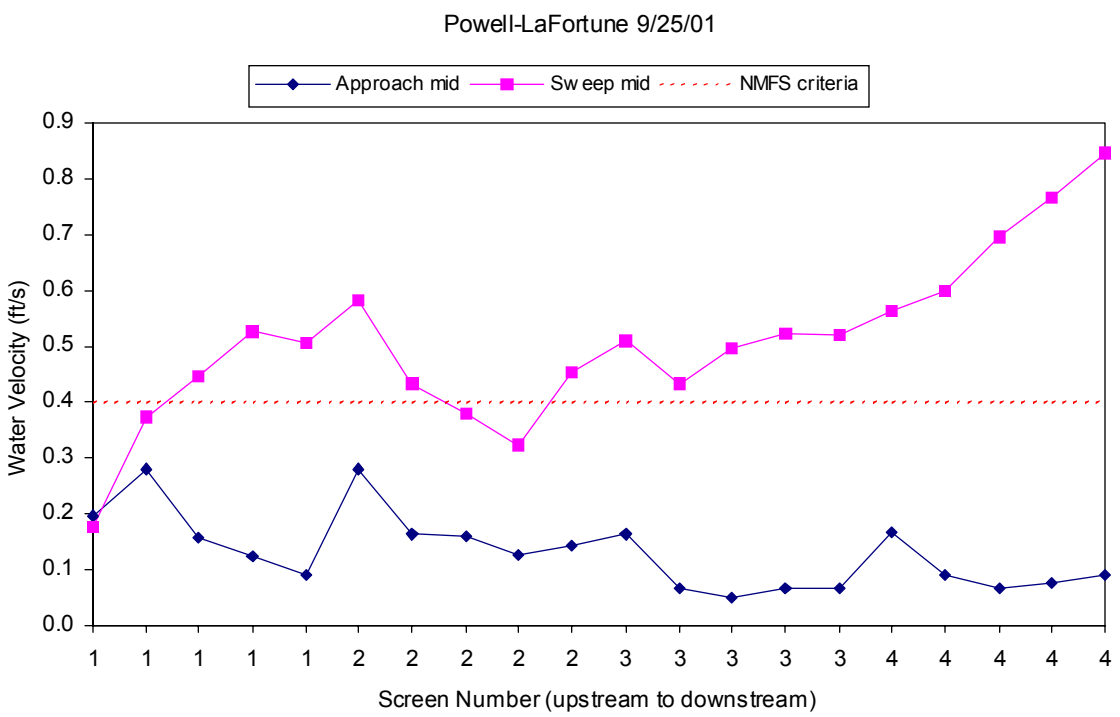

Figure 13. Water Velocities at Powell-LaFortune on 9/25/2001

found that the trashracks near the river were mostly plugged with debris. Once the debris was removed, we conducted a follow-up inspection of this site and found that submergence had returned to approximately 80%, and water flowed through the bypass (Figure 13).

Notes in the logbook state that submergence was low (38 to 50%) occasionally in April through June and that there was often little to no flow through the bypass at these times. In September, the logbook indicated that submergence was usually above criteria at 85 to 90%, and high water marks at the site revealed that the screens may have been over-topped at some point.

When water levels are high at this site there appears to be leakage into the neighboring field. As water levels drop, the pools in the field get smaller. If this leakage is coming from the facility or the channel leading to the facility, erosion of the surrounding sediments could cause failure of the channel or the facility. Efforts were planned to correct the problem.

Some small fish were noted in both the forebay and aftbay in June. All seals were in good condition, as was the screen material. There was some accumulation of sediment, though not enough to cover the seal. In September, the water was very murky, and it was difficult to see the seals, though some accumulation of debris under the bypass ramp was visible.

When the bypass was open, conditions appeared to be conducive to safe fish passage. The downwell at this site it unusually deep, and the water level in it is relatively shallow. The WDFW put stoplogs in the downwell to create a pool for fish to fall into safely. Water flowed freely over the weir and through the outfall. Water depth in the outfall pipe met NMFS criteria when the bypass was open and had water flowing through it.

3.4.11 Snipes-Allen

The Snipes-Allen site was evaluated on 5/24/2001, 6/25/2001, and 9/12/2001. The water velocity was measured with the ADV using an improper calibration file in May, so velocity data from that month are not discussed here. Velocities were measured using the Marsh-McBirney in June and the ADV in September. All approach velocities met NMFS criteria in June and September. Sweeps were generally higher than approaches, though in September we observed sweeps that were lower than approaches across the first screen (Figures 14 and 15). This is a pattern that is consistent with data from previous years (Chamness et al. 2001). Sweep did not increase toward the bypass, and the average bypass velocity was lower than the average sweep.

In the past, this site has had many problems with debris catching on the trashracks, and these problems continued in 2001. During all our surveys, a significant amount of trash was caught on the trashracks. The bypass became clogged sometime in April when roots grew into the outfall pipe. In June, flow through the bypass was being limited because fish could not get through the blockage in the outfall pipe. In June, we observed at least two dead fish floating in the forebay. Also at this time, we noticed a large amount of vegetation growing in the forebay and a lot of debris obstructing the entrance to the bypass. The blockage was cleaned out of the bypass on 8/13, and the system was flushed. Bypass conditions were again safe for fish passage in September.

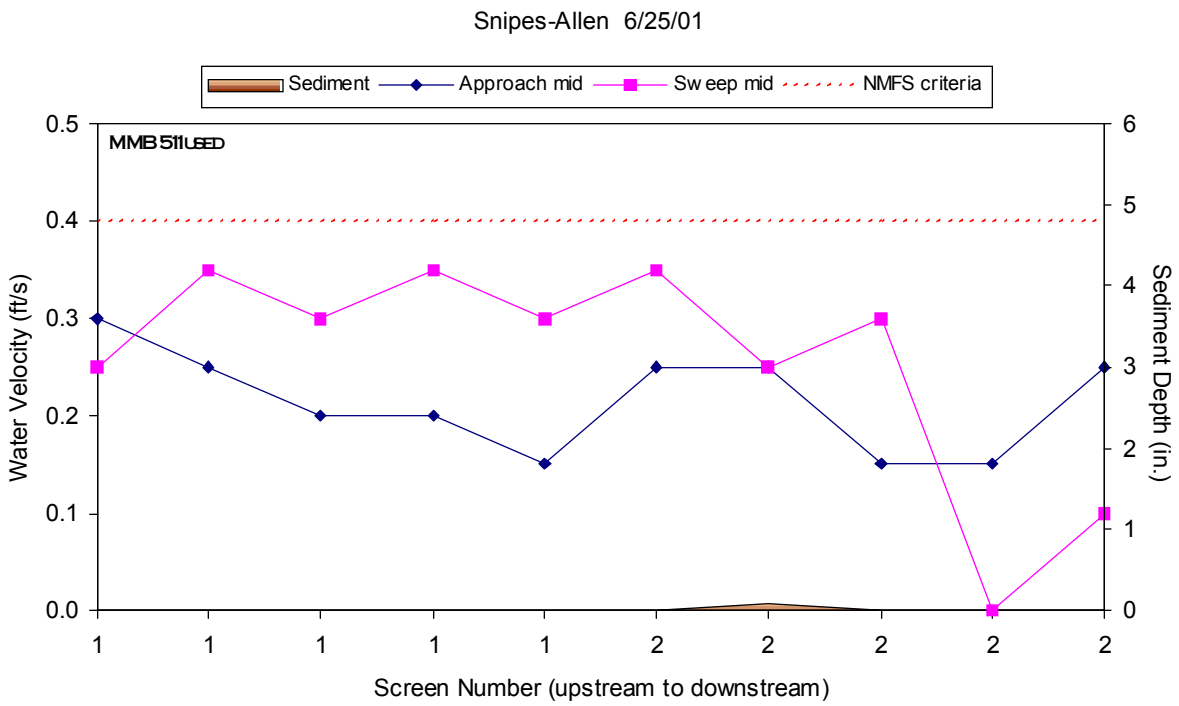

Figure 14. Water Velocities and Sediment Depths at Snipes-Allen on 6/25/2001

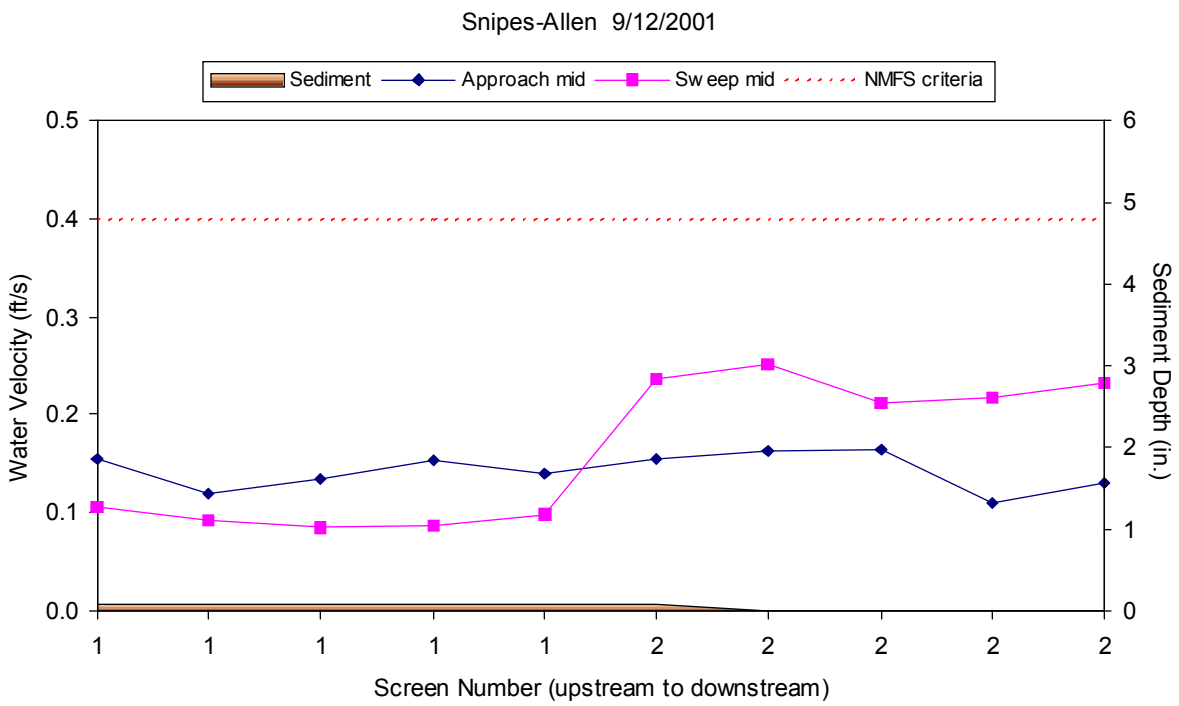

Figure 15. Water Velocities and Sediment Depths at Snipes-Allen on 9/12/2001

The screens and screen seals at this site were in good condition. Some fish were noted in the forebay in May that were possibly chislemouth bass or red-side shiners. In September, several larger fish were seen in the bypass, and small fish were noted upstream of the trashracks and just below the outfall pipe.

3.4.12 Taylor

The Taylor site was evaluated on 5/22/2001, 6/26/2001, and 9/17/2001. Water velocities were measured with the ADV using an improper calibration file in June; therefore, data from that month are not presented. In May and September, we attempted to measure water velocity with the Marsh-McBirney. The forebay depth was less than 9 in. however, making the readings invalid; these data are not presented. Submergence was very low in May and June (approximately 25 to 45%), and occasionally fell below 65% after June as well. By September, flows were again very low, and submergence was back down to about 25%.

In May, the downstream drum was turned off because of low flow, and it was collecting sediment and debris in the upstream corner and algae and twigs all over, which sometimes obscured the view of the seals. In May and June, there was a significant amount of sediment buildup such that there was only about 1 in. of water in some places in the forebay. The sediment problems were reduced when the flow was increased, just before our visit on 6/26. The bypass was almost completely shut off in September and was full of plants and debris.

3.4.13 Toppenish Pump

The Toppenish Pump site was visited on 5/24/2001, 6/25/2001, and 9/20/2001. The water velocity was measured with the ADV using an improper calibration file in May, so velocity data from that month are not discussed. Velocities were measured using the Marsh-McBirney in June and the ADV in September. Between June and September, 98% of approach velocities met NMFS criteria. Sweeps were always higher than approaches (Figures 16 and 17). Sweep did not generally increase toward the bypass, and bypass velocities were higher than sweeps. In September, the stoplogs were removed from screens 5 and 6, and flows increased in the downstream region of the site.

The screen seals that were visible looked to be in good condition. In May, the water was too murky to evaluate the bottom seals. There were piles of sediment and debris in the downstream corners of each screen bay. The conditions were much the same in June, though it appeared that the debris problem had worsened, and plant growth was abundant in the forebay. In September, a large pile of sediment was still present in front of the first two screens, which covered the bottom seal in places.

The outfall had relatively thick accumulations of sticks and debris extending from the surface of the water, and reaching down at least 6 in. Removal of this debris periodically will help to prevent blockage of the bypass pipe and possible injury to migrating fish.

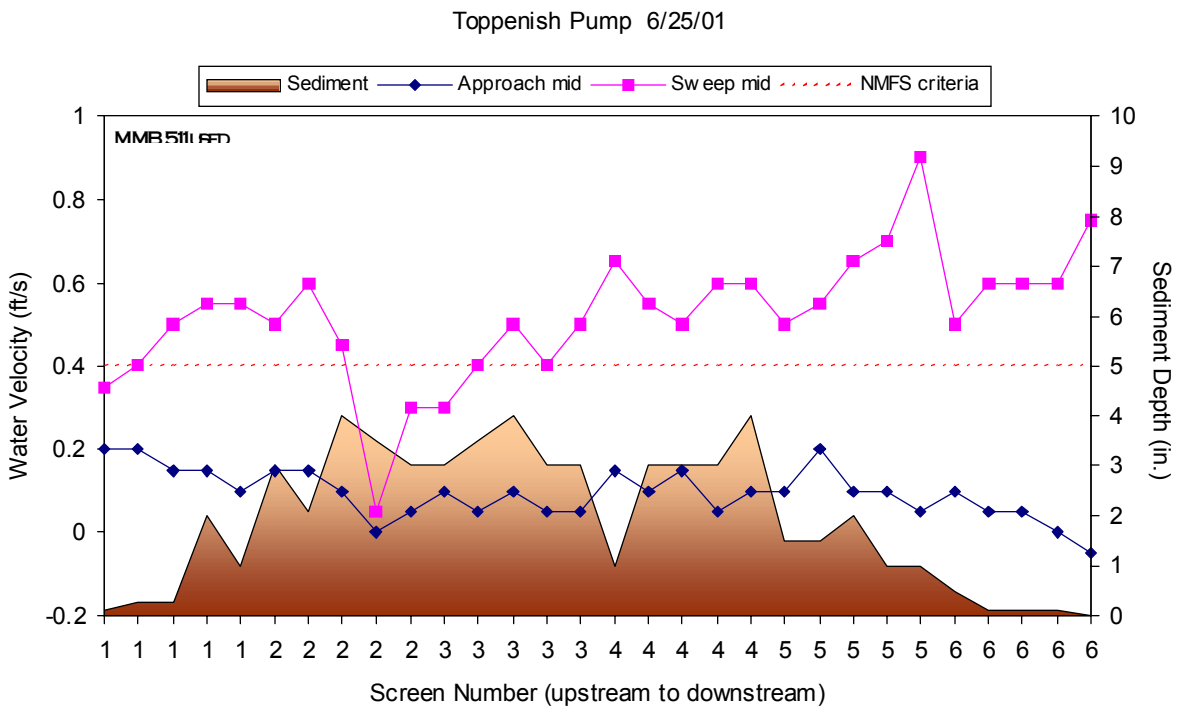

Figure 16. Water Velocities and Sediment Depths at Toppenish Pump on 6/25/2001

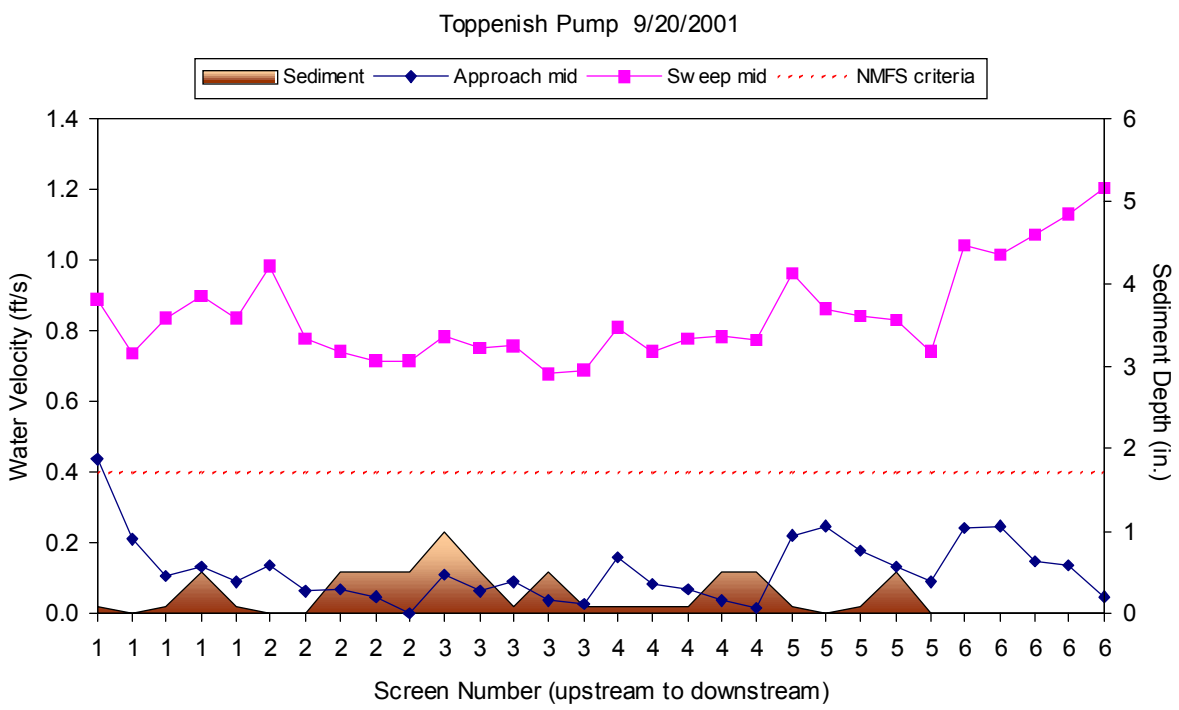

Figure 17. Water Velocities and Sediment Depths at Toppenish Pump on 9/20/2001

3.4.14 Upper WIP

The Upper WIP site was visited on 5/11/2001, 6/26/2001, and 9/12/2001. The water velocity was measured with the ADV using an improper calibration file in May, and the site was dry in June and September; therefore, no velocity data are presented.

In May, the site was operating relatively well. The submergence level was 81%. There was little buildup of sediment in front of the screens, the screens and seals were all in good condition, and water was flowing freely through the bypass and out the outfall. The water depth at the point of discharge was 10 in. in May, which meets NMFS criteria and provides sufficient water to allow for safe fish passage.

In June, the site was already shut down for the season because of the drought conditions and water rights, and screens 2 and 3 were pulled out for maintenance. In September, we could see that the seals on all of the screens had been replaced. Water depth was only 6 in. in much of the forebay. Quite a bit of sediment had accumulated in the bypass, though this will probably flush out once the site is watered up again.

3.4.15 Wilson Creek

The Wilson Creek site was visited on 5/22/2001 and 9/17/2001. This site has three drum screens and was constructed to replace Bull Ditch. In May, water velocities were measured with the ADV using an improper calibration file and those data are not presented here. In September, 100% of approach velocities met NMFS criteria (Figure 18). Sweeps were always greater than approaches. Sweep did not increase towards the bypass, and the average bypass velocity was slower than the average sweep.

All seals were in good condition. The first screen had a patch near the upstream seam. There was some buildup of sediment at the downstream end of screen 3 in May, and in September there was a lot of plant material in the forebay, some of which obscured the view of the seals and blocked the bypass. Some plastic debris and a large stick were present in the downwell of the bypass in May, though they were not obstructing water flow. In May, we could not find the outfall to evaluate it. In September, conditions at the outfall were good. The pipe was submerged, the water flowed smoothly, and the depth at the point of discharge was greater than 1 ft, all of which should help to contribute to safe fish passage.

According to notes in the logbook, and our own observations, submergence was at or near criteria all summer. In September it had fallen down to 62%, which does not meet NMFS submergence criteria but was probably not harmful for the fish in this small stream in a low-water year.

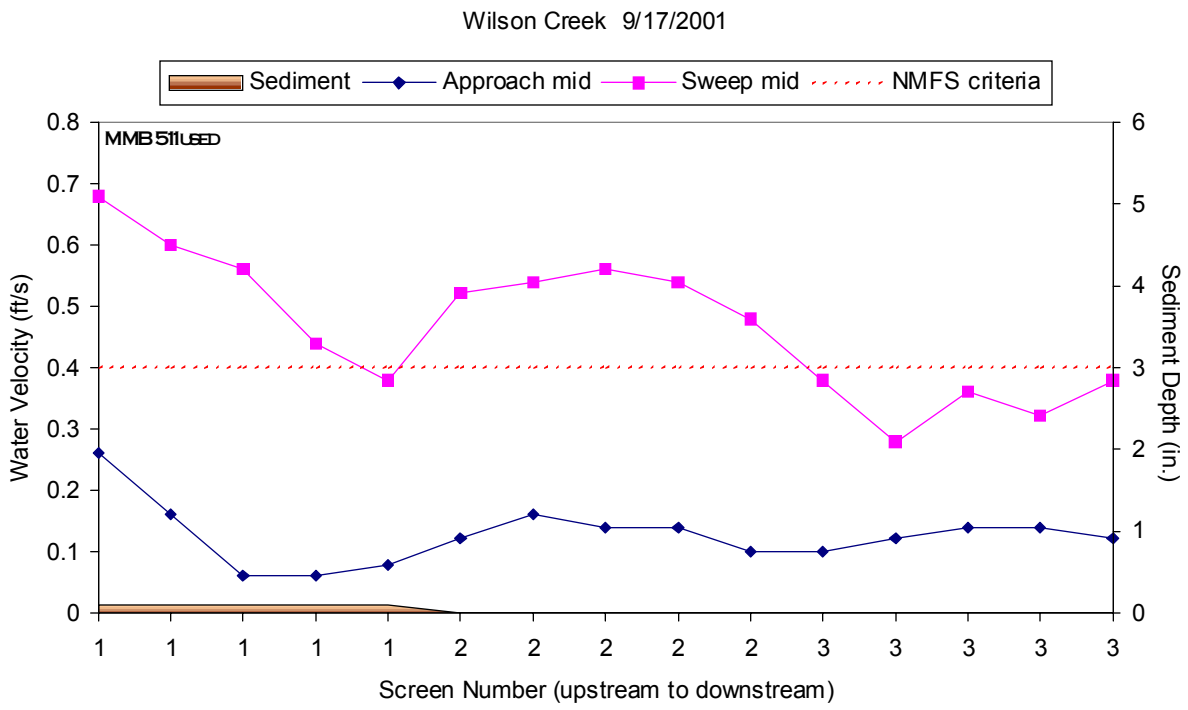

Figure 18. Water Velocities and Sediment Depths at Wilson Creek on 9/17/2001

3.5 Vertical Plate Screens

3.5.1 Bull Ditch

The Bull Ditch site was evaluated on 5/22/2001, 6/20/2001, and 9/17/2001. Water velocity was measured with the ADV using an improper calibration file in May and June, so only velocity data from September are presented here. In September, water velocity was measured with the March-McBirney velocimeter. All measured approach values met the NMFS established criteria of 0.4 ft/s (Figure 19). Sweep was not always higher than approach, in part because of the large amount of sediment and debris piled up in front of the screens. This caused visible surface eddies, some of which were likely present at our measuring depth.

The accumulation of sediment and debris is not unusual for this site, but during our September survey, we noticed that it was causing several problems. Sticks and leaves had built up on the upstream trashrack that runs perpendicular to the screens, which slowed the flow of water through the site. We estimated that there was 18 in. of debris in the downstream corner of the site, and this debris had caused one of the automatic cleaning brushes to break and bend away from the screen (Figure 3.20).

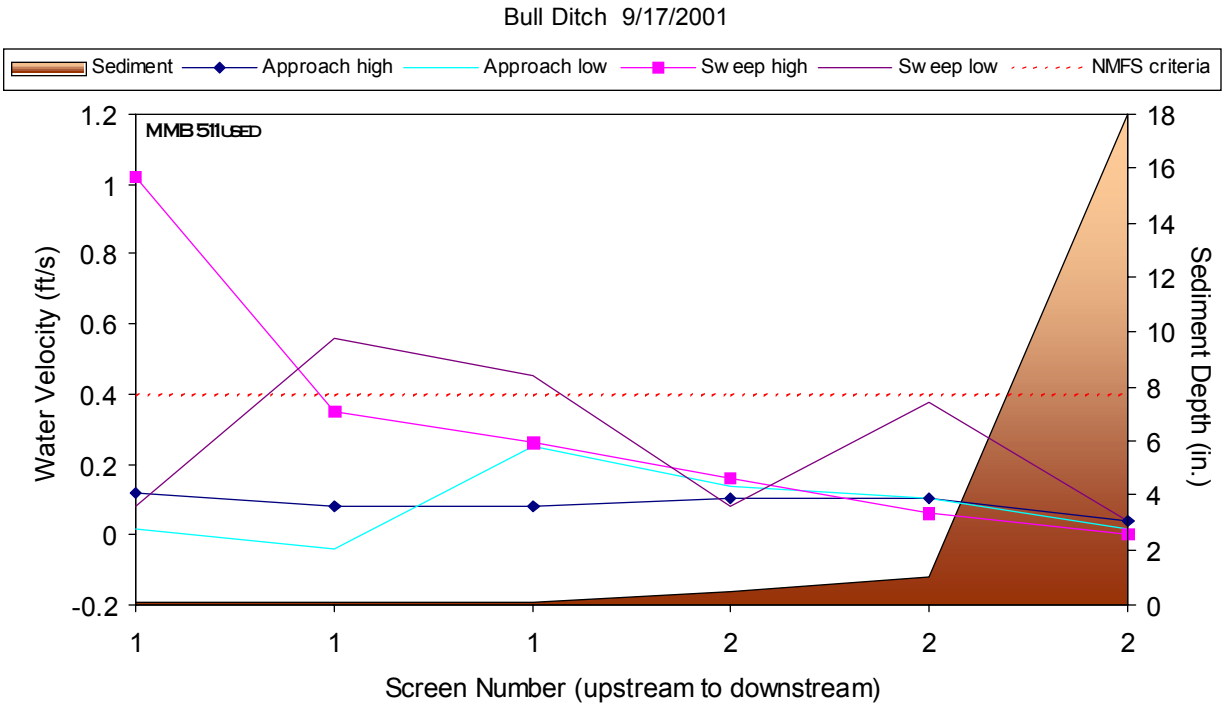

Figure 19. Water Velocities and Sediment Depths at Bull Ditch on 9/17/2001

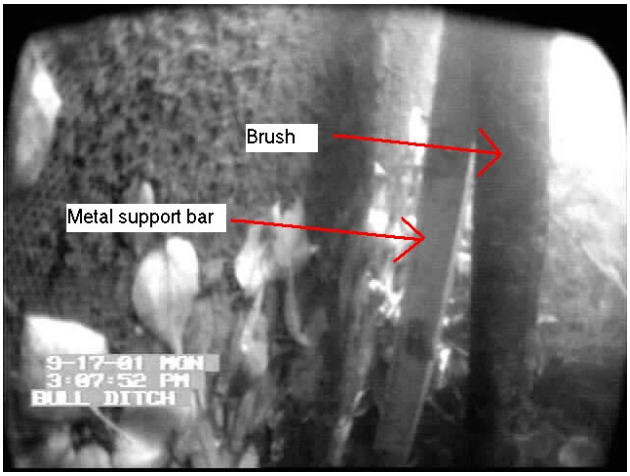

Figure 20. Looking Downstream Toward the Broken Brush at Bull Ditch. On the left is the screen covered with algae and leaves. In the background is the pile of sediment and debris that may have caused the brush to break.

The condition of the side seals on screen 1 was recorded as being poor in June. The insulation and/or caulking that was placed in between the screens and between the screens and the concrete walls of the facility is deteriorating and may need to be replaced if this site continues to operate. The rest of the seals were in good condition.

3.5.2 Ellensburg Mill

The Ellensburg Mill site was evaluated on 5/15/2001, 6/20/2001, and 9/17/2001. Water velocity was measured with the ADV using an improper calibration file in May and June; therefore, only velocity data from September are presented. In September, all approach values met NMFS criteria, and sweeps were always higher than approaches (Figure 21). Sweep did not generally increase toward the bypass, and bypass velocity was slower than the average sweep.

The bottom seals were in good condition, though there was little caulking between the screens or between the screens and the concrete walls of the forebay. Three inches of sediment had accumulated in front of the screens in May, coming down to 2 in. in June and reaching 4 in. in some spots in September. Also, lots of vegetation was growing in the forebay and in the aftbay.

In May, the brushes were being turned on only when the maintenance crew was there, and a significant amount of algae had built up on the screens. This caused a significant amount of headloss across the screens (13.5 in. during our survey). This was changed on 5/22 when the brushes were set to run continuously, which drastically reduced headloss.

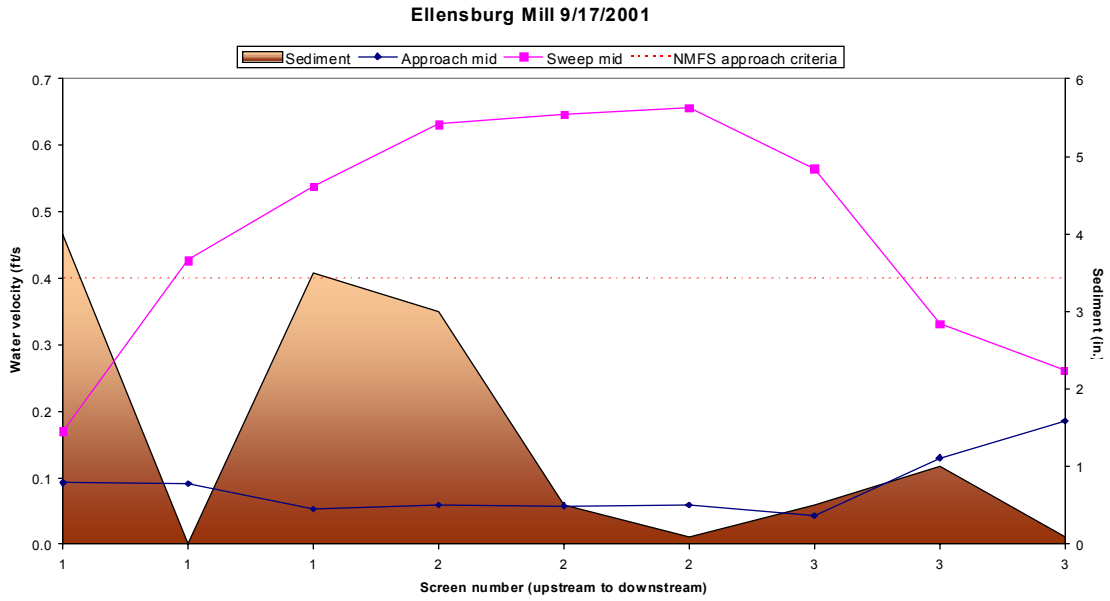

Figure 21. Water Velocities and Sediment Depths at Ellensburg Mill on 9/17/2001

The bypass was set in flush mode in May – water was not going over the weir, but being forced underneath instead. In June, the weir was open and had 14 in. of water flowing over the top. Water was running smoothly out the bypass outfall in May, but was backed up in June. In September, water was running smoothly out the bypass outfall, but the weir was closed and the ramp was up, and only 1.5 in. water ran over the top of the weir. There were several small unidentified fish noted in the forebay that probably could not have gone through the bypass in this configuration. Operator control aids were covered in algae and hard to read in September.

3.5.3 Fruitvale

The Fruitvale facility was evaluated on 5/17/2001, 6/27/2001, and 9/13/2001. Water velocity was measured with the ADV using an improper calibration file in May and June, so only velocity data from September are presented here. In September, all approach velocities complied with NMFS criteria, and sweep values were usually higher than approaches (Figure 22). Sweep velocities generally increased toward the bypass, and bypass velocities were higher than the average sweep, creating a clear trajectory toward the bypass.

Submergence levels fluctuated severely throughout the survey period. In May there were indications that the water level had been above the screen material, but not above the metal plate attached to the top of the screens. The submergence level was noted in the logbook as 50% on 7/2 and 7/9, and was up to 100% by 7/16. In September, the screen material was still completely submerged, though no water was flowing over the top.

The screens were missing caulking along the bottom and side seals during all surveys. In May, there were areas of the screen that the brushes were not cleaning. In June, the bypass was completely shut down, and no water flowed through it. The logbook revealed that the bypass was shut off for almost a month starting in mid-June, and that the operator had difficulties getting the bypass ramp up to flush it out because of silt accumulation. Bypass operation was restored on 7/16, though the fishway was blocked off until sometime after 7/30.

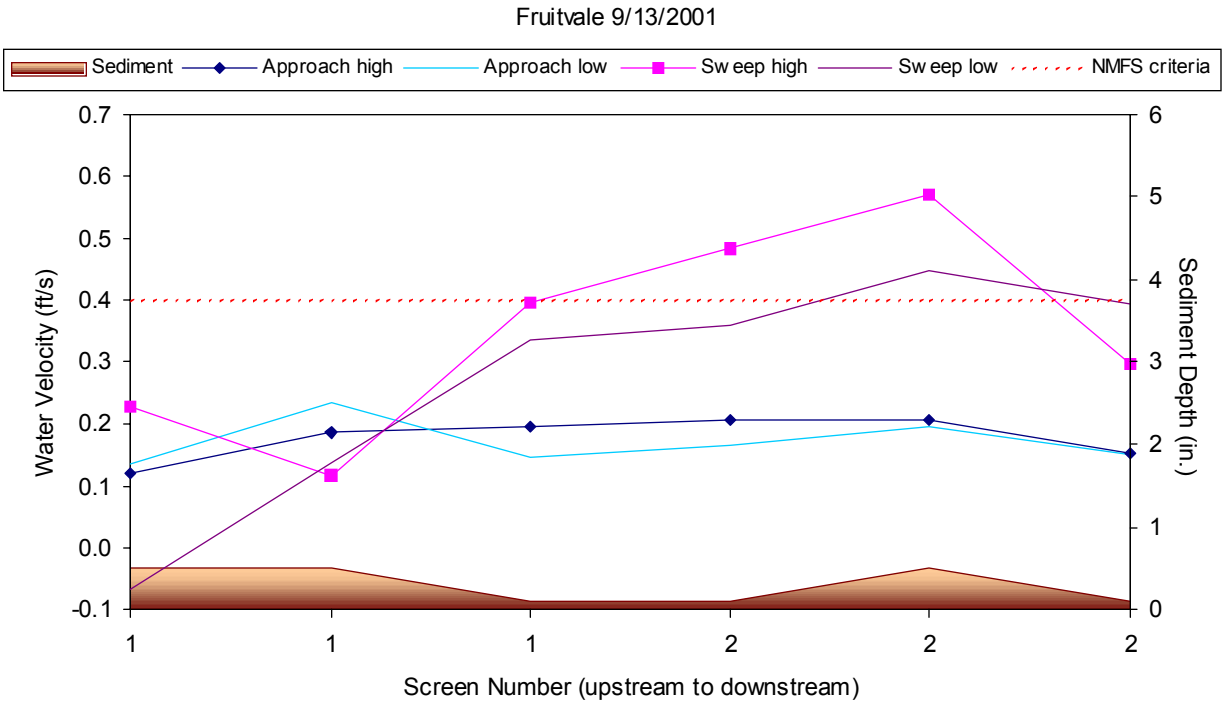

Figure 22. Water Velocities and Sediment Depths at Fruitvale on 9/13/2001

3.5.4 Naches-Selah

The Naches-Selah site was evaluated on 5/16/2001, 6/22/2001, 7/24/2001, and 9/19/2001. Water velocities were measured with the ADV using an improper calibration file in May and June, so velocity data from those months are not presented here. Water velocities were measured using the Marsh-McBirney in July and the ADV in September. In July and September, 97% and 92% of approach velocities met NMFS criteria, respectively (Figures 23 and 24). Sweeps were generally greater than approaches, though sweep did not increase toward the bypass, and the bypass velocity was slower than the average sweep both months. In September, vegetation growing near the bypass entrance caused sweep velocities at the downstream end of the site to be unusually low.

The seals between the metal screen and the concrete of the forebay and in between the screens were missing in places. We also noticed that the vertical bar screens had been patched with a perforated plate screen material that could affect the flows in those places. There were no sediment problems at this site, and the mechanical brushes worked properly throughout the survey period.

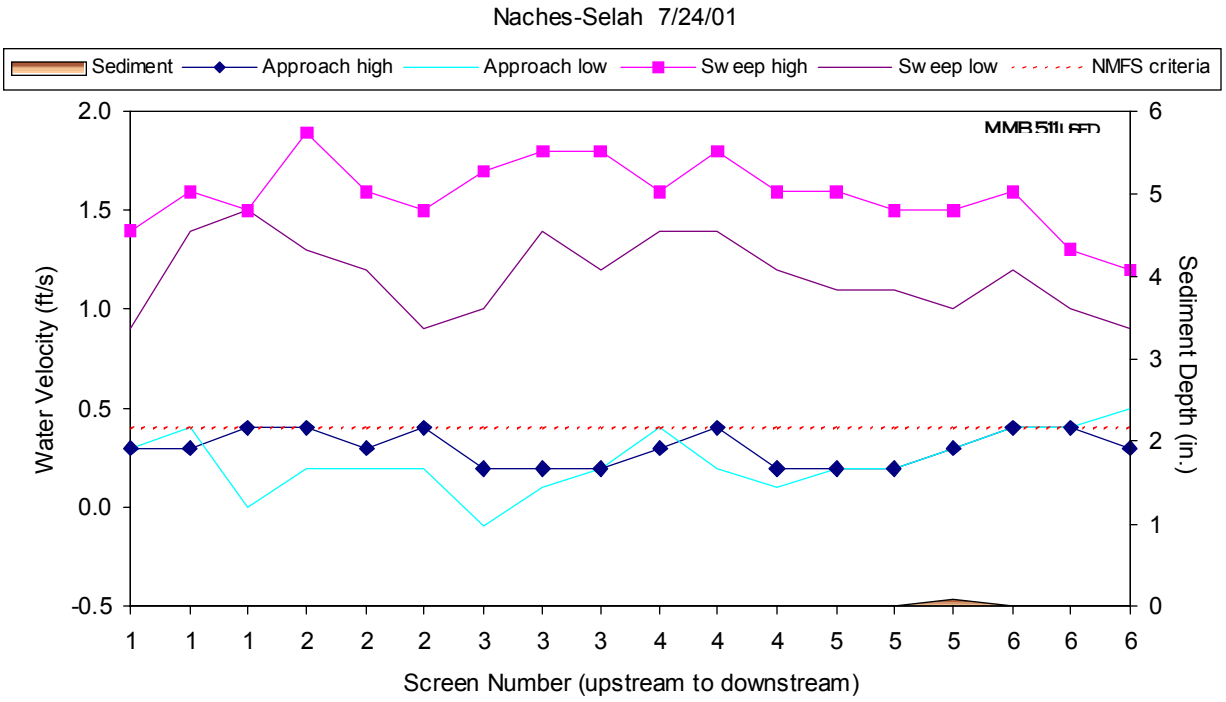

Figure 23. Water Velocities and Sediment Depths at Naches-Selah on 7/24/2001

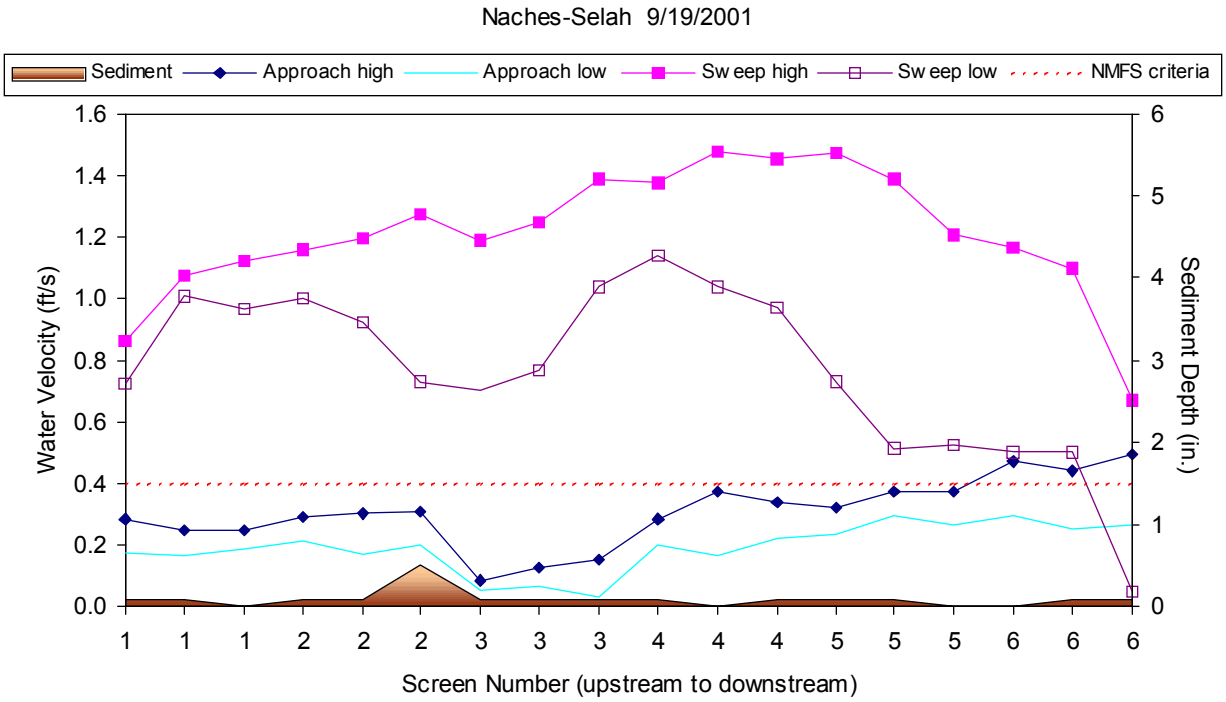

Figure 24. Water Velocities and Sediment Depths at Naches-Selah on 9/19/2001

3.5.5 Union Gap

The Union Gap site was evaluated on 5/22/2001, 6/27/2001, 7/24/2001, and 9/11/2001. Water velocities were measured with the Marsh-McBirney in May and July, and the ADV in September. Data from June are not presented as they were recorded with the ADV using the improper calibration file. Between the three surveys for which we have good data, 94% of approach velocities met NMFS criteria (Figures 25, 26, and 27). Sweeps were always higher than approaches. Sweep did not increase toward the bypass, and the average bypass velocity was slower than the average sweep.

The screen material was in good condition, though in our September survey we noticed that the upstream bottom corner of screen one had been patched with what appeared to be a solid metal plate. The seals on all screens were missing in places. In September, there was some buildup of algae on the screens and a lot of plant material and sediment in the forebay, especially near screen 3, which could account for the low sweep velocity at the downstream end of that screen (Figure 27).

Bypass conditions were good during all surveys. Because of lower flow volume, water did not surge through the bypass as it did in previous years. Water flowed freely over the weir and through the outfall. Water depth in the outfall pipe and at the point of discharge was always within criteria.

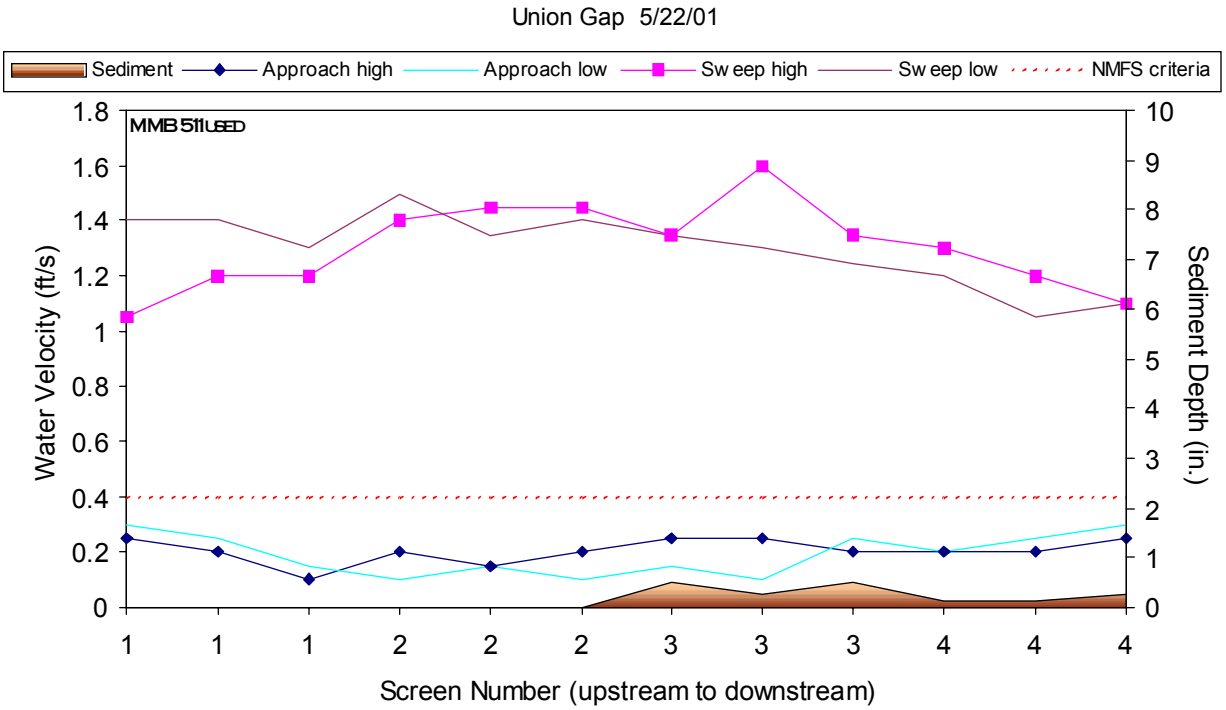

Figure 25. Water Velocities and Sediment Depths at Union Gap on 5/22/2001

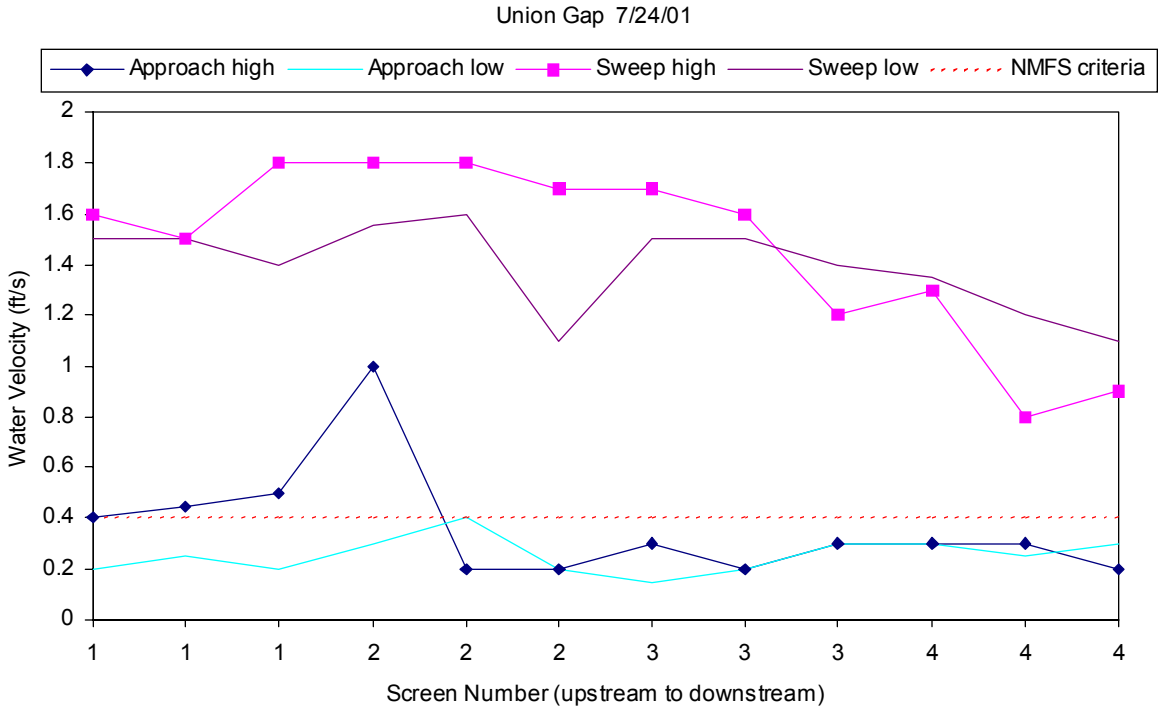

Figure 26. Water Velocities at Union Gap on 7/24/2001

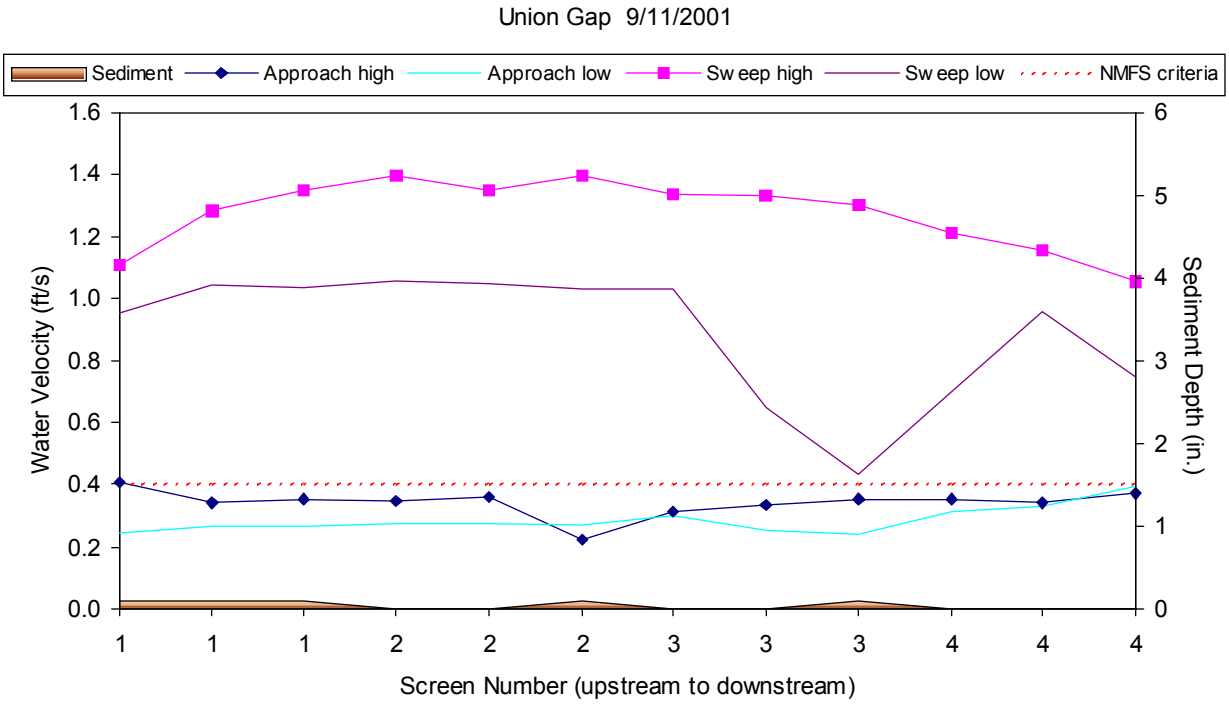

Figure 27. Water Velocities and Sediment Depths at Union Gap on 9/11/2001

3.5.6 Yakima-Tieton

The Yakima-Tieton site was evaluated on 5/16/2001, 6/21/2001, and 9/18/2001. The water velocities were measured with the ADV using an improper calibration file in May and June, so data from those months are not presented. In September, 97% of approach velocities met NMFS criteria (Figure 28). Sweeps were always higher than approaches. Sweep did not increase toward the bypass, and the average bypass velocity was slightly slower than the average sweep.

Several screen seals have missing or failing caulking and could benefit from re-caulking. In September, there was a big pile of debris in the bypass. During our visits, water was not flowing over the bypass weir. Instead, the flush gate was open to allow for easier fish and sediment movement through the bypass. In September, the water was very turbulent in the downwell. Water flowed freely through the bypass and out the outfall pipe. Water depth at the point of discharge was less than 1 ft in May, though once it cleared the cement apron the depth in the river was greater than 1 ft.

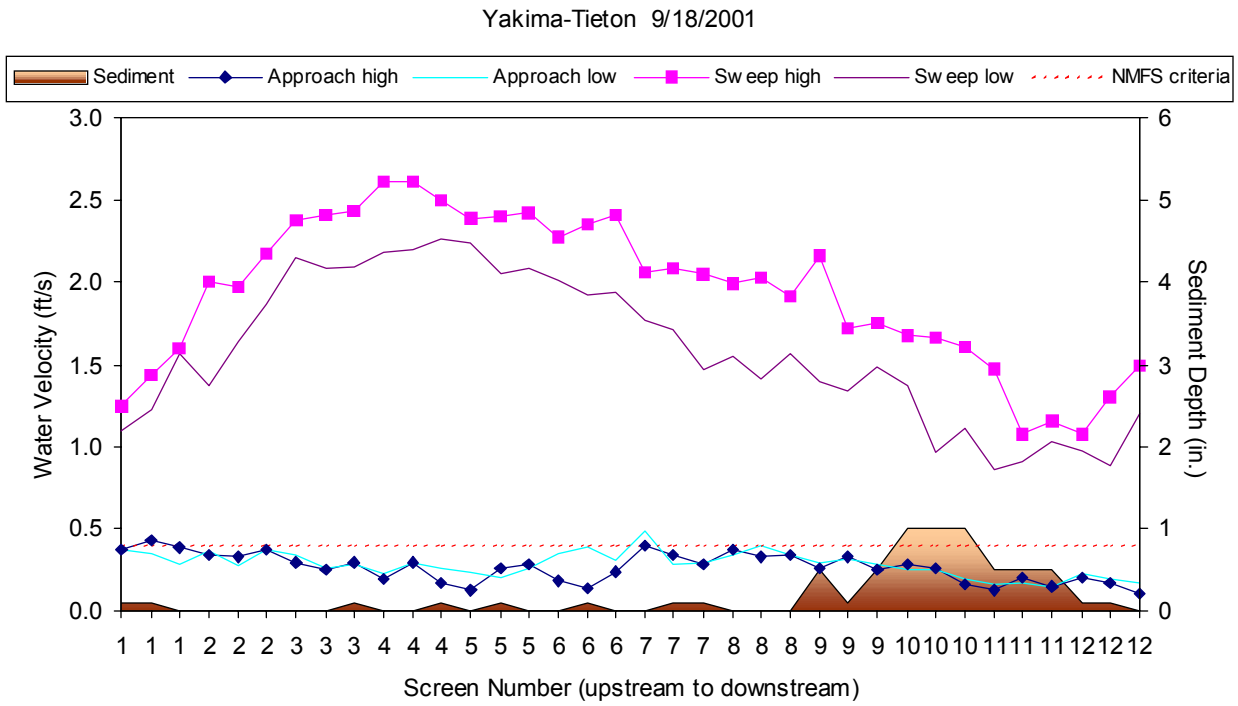

Figure 28. Water Velocities and Sediment Depths at Yakima-Tieton on 9/18/2001

3.5.7 Younger

The Younger site was visited on 5/15/2001, 6/20/2001, and 9/17/2001. The water velocities were measured with the ADV using an improper calibration file in May and June, so data from those months are not presented. All approach values met NMFS criteria in September. Sweeps were generally higher than approaches, though they did not increase toward the downstream end of the site (Figure 29).

Submergence was well below NMFS criteria during all surveys at 36, 34, and 30% for May, June, and September, respectively. Low water levels in the river and consequently at the site may account for the low recorded velocities in September (Figure 29). We also noticed that the turning of the paddlewheel was causing a swell or surge in the water in the forebay that raised the water levels approximately I in. We have never noticed this before and conclude it is likely due to low flow conditions.

The upstream seal on screen number 1 was lacking caulking in places. There was some evidence of sediment and a small amount of debris in June. The brushes seemed to be effective, and there was little buildup of algae. Several small, unidentified fish were noted in the canal and in the forebay in September.

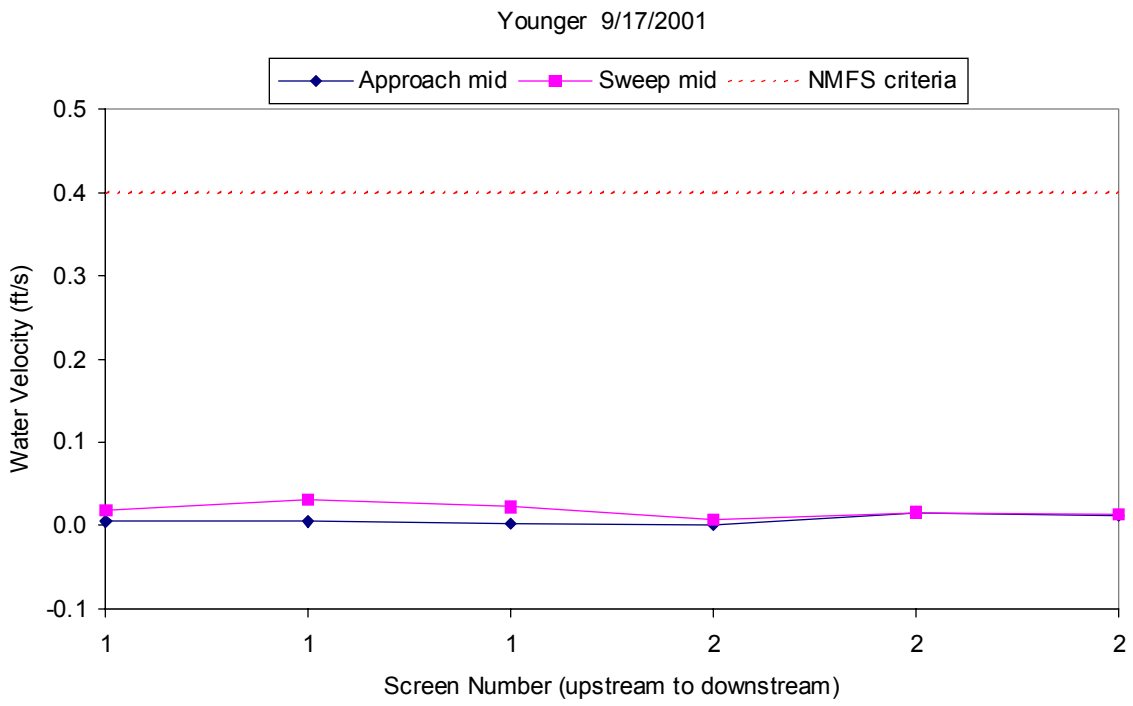

Figure 29. Water Velocities at Younger on 9/17/2001

3.6 Vertical Traveling Screens

3.6.1 Gleed

The Gleed site was evaluated on 5/17/2001, 6/27/2001, and 9/19/2001. Water velocity was measured with the ADV using an improper calibration file in May and June, so only velocity data from September are presented. In September, all approach values met NMFS criteria of ≤0.4 ft/s (Figure 30). Sweep was generally greater than approach and increased toward the downstream end of the site.

There were no problems with sediment buildup at this site, though in June there was some accumulation of sticks and other organic debris at the downstream end of the site. The screen material was in good condition, though in September the holes were partially plugged with algae, which caused 4 in. of headloss across the screens.

In May and June, small unidentified fish were seen jumping in the forebay, and there was a note in the logbook from 5/1 that fry were being carried over screens 3 and 4.

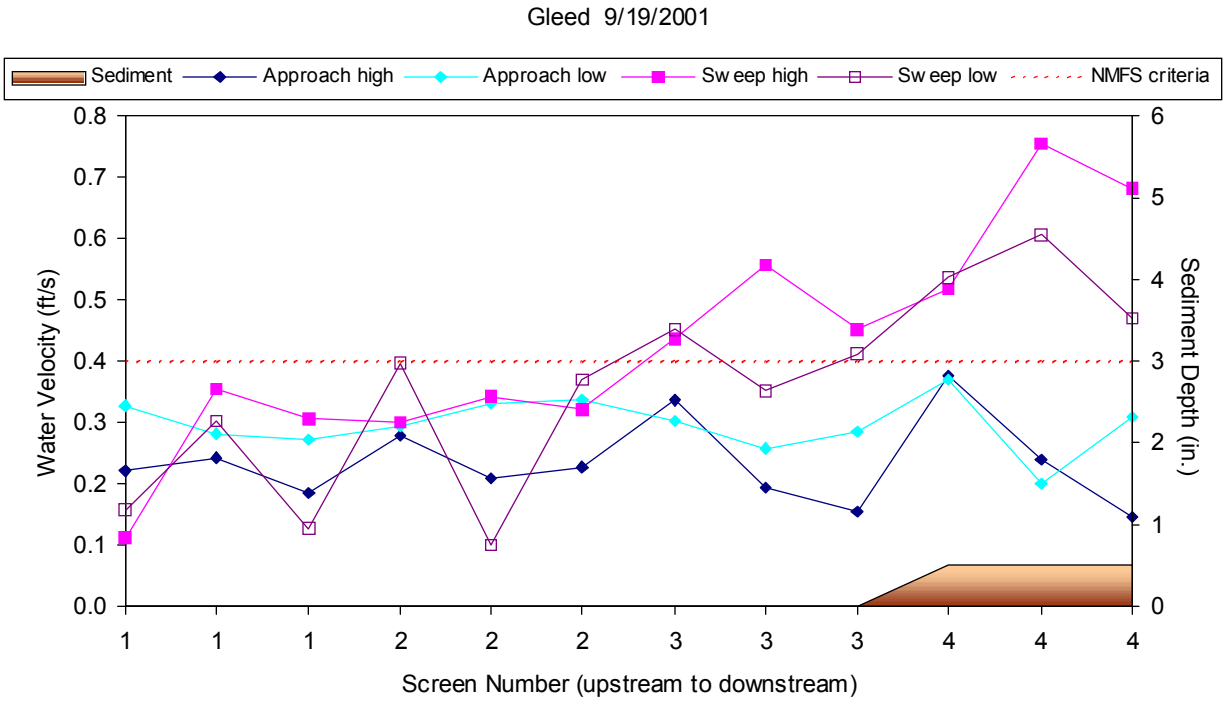

Figure 30. Water Velocities and Sediment Depths at Gleed on 9/19/2001

4.0 Conclusions

Our 2001 evaluations of 23 Phase II fish screen facilities in the Yakima River Basin indicate that they 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 for safe fish passage back out into the river without delays.

Because of the low water conditions in 2001, more sites were able to meet NMFS water velocity criteria. However, more sites had trouble meeting submergence criteria (i.e., they were below criteria), and special care should be taken so that fish are not trapped in low water (e.g., New Cascade). Care also should be taken to make sure sediment and debris are checked or removed more regularly because low flows may not flush them out of the forebay and bypass as well as in a normal flow year.

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 the bottom of the flat plate screens and excessive accumulation of debris at some sites (i.e., Bull Ditch and New Cascade). The lack of caulking creates gaps that could potentially harm fish or allow them to pass into the aftbay, 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.

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