Walla Walla River Basin Fish Screen Evaluations, 2001; Burlingame and Little Walla Walla Sites

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Summary

The Pacific Northwest National Laboratory (PNNL) evaluated 2 newly constructed fish screen sites in the Walla Walla River Basin during the spring of 2001. The fish screens facilities at the Little Walla Walla River in Milton-Freewater, Oregon and at Burlingame west of Walla Walla, Washington were examined to determine if they were being effectively operated and maintained to provide for safe fish passage. 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. Due to a calibration problem with the instrument used to measure water velocities during the spring evaluations, we re-evaluated the water velocities at both sites after the canals discharges were increased in the fall.

Based on the results of our studies in 2001, we concluded:

- Burlingame site:
    - The rotary-drum screen design appeared to be efficiently protecting juvenile fish from entrainment, impingement, and migration delay in May and June. However, sediment and debris accumulations in the screen forebay could result in screen seal wear (due to silt) and may increase mortality due to predation in the screen forebay (due to woody debris accumulations along the screen face).
    - All approach velocities were below the NMFS criteria of 0.4 feet per second in November. Sweep velocities were appreciably higher than approach velocities, however sweep velocities did not increase toward the bypass. Bypass velocity was greater than sweep velocities.
- Little Walla Walla:
    - The flat-plate screen design appeared to be efficiently protecting juvenile fish from entrainment, impingement, and migration delay in May and June.
    - All approach velocities were below the NMFS criteria of 0.4 feet per second in November. Sweep velocities were substantially higher than approach velocities and increased toward the bypass. Bypass velocity was greater than sweep velocities.
    - The automated cleaning brushes at the Little Walla Walla site generally functioned properly. However, there was a small (6 to 12 in.) band along the length of the facility at the bottom of the screen that was not being cleaned effectively by the brush. In addition, the cable that drives the

cleaning brush was showing signs of wear (cracks and frays) and should be replaced.

Acknowledgments

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1.0 Introduction

Over the years, 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, BPA has established a monitoring and evaluation program to ensure that new and updated screening facilities meet current fish protection standards.

The evaluation of newly constructed screen sites is important to ensure that the sites are performing their purpose of protecting fish from entrainment into the irrigation systems. Two relatively newly constructed screen sites in the Walla Walla River Basin were evaluated during the spring of 2001 to determine whether conditions at these sites

were conducive to safe fish passage and whether the sites were operating within criteria developed by the NMFS. The Burlingame diversion is located on the west bank (river left) of the Walla Walla River at river mile 36.9 (Figure 1). The fish screen facility is located on the canal, approximately 500 feet downstream of the diversion dam. The Burlingame fish screen site was remodeled to its present capacity in 1999 (Figure 2). This facility now consists of 8 rotary drum screens, the first, or most upstream of which is a blank metal bulkhead. Each screen is 4.0 feet in diameter and 14 feet long. The screens are constructed of 14-gage stainless steel perforated plate with 3/32-inch (0.094 inch) holes on 5/32 centers. This screen material has 34% open area, which will accommodate 16 cfs at 80% submergence or 17 cfs at 85% submergence for each screen.

The Little Walla Walla diversion is located at river mile 47 on the west bank of the Little Walla Walla River, within the city limits of Milton-Freewater, Oregon (Figure 1). The Little Walla Walla site was recently updated by the construction of a set of 11 flat plate screens of stainless steel wedgewire design with 0.069-inch openings, completed in 2000 (Figure 3).

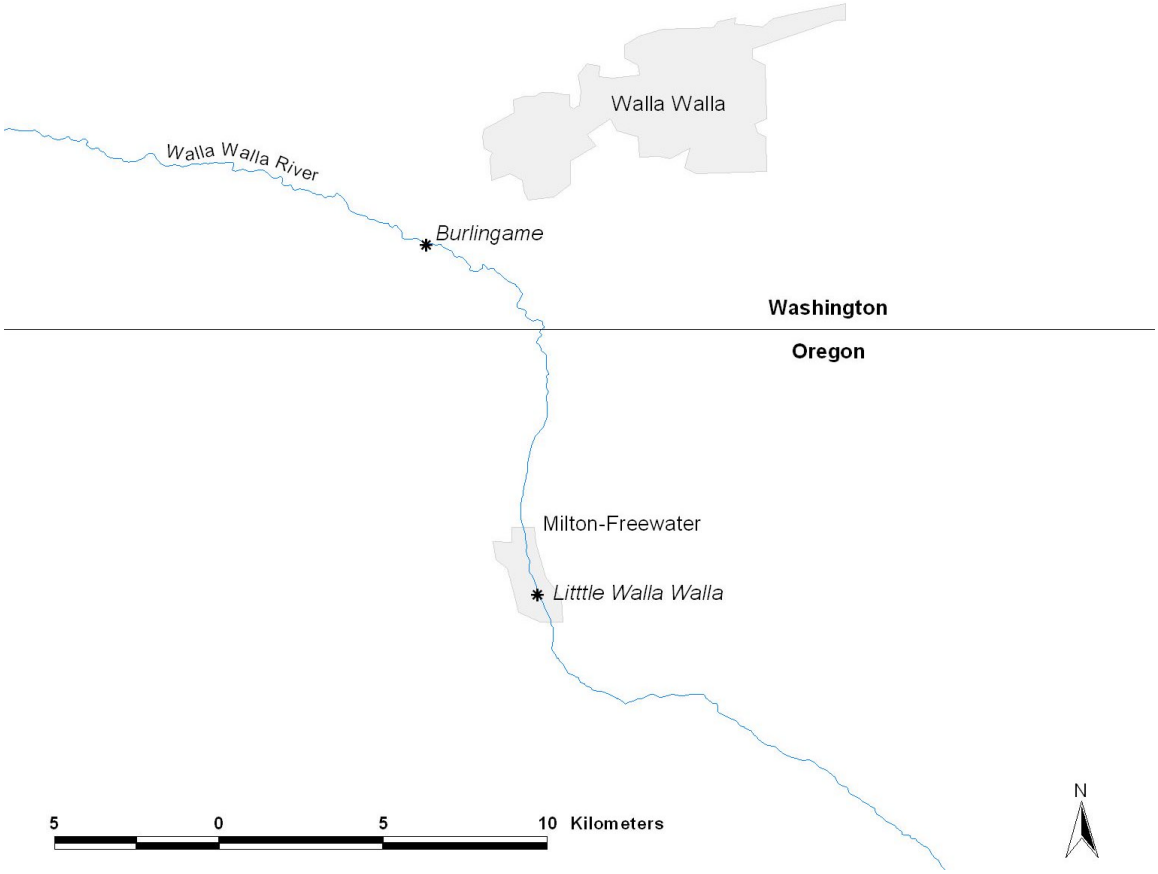

Figure 1. Map of study area in the Walla Walla River basin.

Each screen panel is 9 feet long, 11.75 inches wide and 5 feet tall. The site was designed to accommodate approximately 175 cfs at 80% submergence.

The methods currently used for evaluating screening facilities were developed while conducting similar studies at fish screen facilities in the Yakima River Basin (Blanton et al. 1998, 1999, Chamness et al. 2001). These evaluations 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 2. Burlingame fish screen facility.

Figure 3. Little Walla Walla fish screen facility.

2.0 Methods

Both operating screen sites were evaluated twice between May 3 and June 14, 2001. Additional velocity data were collected at both sites on November 2, 2001. Evaluators collected three types of data at each site. These included water velocity measurements, underwater video, and general operational data (i.e., screen submergence, bypass conditions, fish presence, etc.) as described below.

2.1 Water Velocity Measurements

Water velocity data from the May and June evaluations are not presented here because the instrument was later found to be out of calibration. After the instrument was correctly calibrated, we returned to both sites to measure water velocities. Water velocity data used in this report were collected on November 2, 2001.

2.1.1 Equipment

Water velocities at both sites 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 at a point 10 cm below the probe. Velocities were typically recorded at

each sampling point along the screen for 50 to 60 seconds at a rate of 0.5 Hz and stored in a computer file.

2.1.2 Probe Positioning

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 oriented in a down-looking orientation, with approach (X) and sweep (Y) velocities on the horizontal plane and turbulence (Z) on the vertical plane. Velocity measurements were recorded with the ADV probe 3 to 6 inches in front of the screen face. At Burlingame the bottom of the pole rested on the sill of the screen bay. 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 inches, one set of measurements was taken at 0.6 of depth from the surface. In cases where the forebay depth was greater than or equal to 48 inches, measurements were taken at two depths, 0.2 and 0.8 of depth, from the surface. 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 ("Y" or sweep) and perpendicular ("X" or approach) to the screen face, not to canal flow.

2.1.3 Data Collection and Analyses

Multiple velocity measurements were taken in front of every screen or panel. Drum screens were allowed to operate as normal during velocity measurements when possible. Cleaning brushes were turned off or only run occasionally during velocity measurements at the Little Walla Walla site. Average sweep and approach velocities were calculated for each site.

2.2 Underwater Video

2.2.1 Equipment

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. 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.

2.2.2 Camera Positioning

The camera was securely mounted on a vertical pole and adjusted as needed at each site. The camera was usually angled slightly downward to observe the area between the screen and the bottom seal where there was a potential for gaps to occur. The camera was usually moved from upstream to downstream, following the side and bottom seal/screen interfaces. The bypass was also viewed, looking both upstream and downstream. Where there were signs of excessive debris or fish, images were recorded showing the forebay area and/or bypass.

2.2.3 Data Collection and Analyses

Written observations were made in the field when something of interest was seen with the camera (i.e., debris, gaps, fish). All videotapes 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 headloss across the screen face
- bypass flow conditions
- bypass outfall flow conditions
- fish presence
- observations of debris in the forebay or bypass
- presence or absence of operator control aids such as water gauges and drum submergence marks on screen frames.

2.4 Data Analyses

The NMFS criteria define several conditions concerning velocity (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.

In addition, there should be a gradual and efficient acceleration of flow into the bypass entrance to minimize delay by emigrating salmonids. 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.

3.0 Results and Discussion

3.1 Burlingame

The Burlingame site was evaluated May 3, 2001 and June 4, 2001. Velocity data were collected on November 2, 2001. The Burlingame site was generally operating in a manner that would be expected to provide safe passage for emigrating salmonid smolts.

Velocity measurements indicated that all of the approach velocities met NMFS criteria on November 2 (Figure 4). Sweep velocities were always higher than approach velocities, and the water velocity in the bypass was higher than the sweep velocity in front of the screens (Table 1).

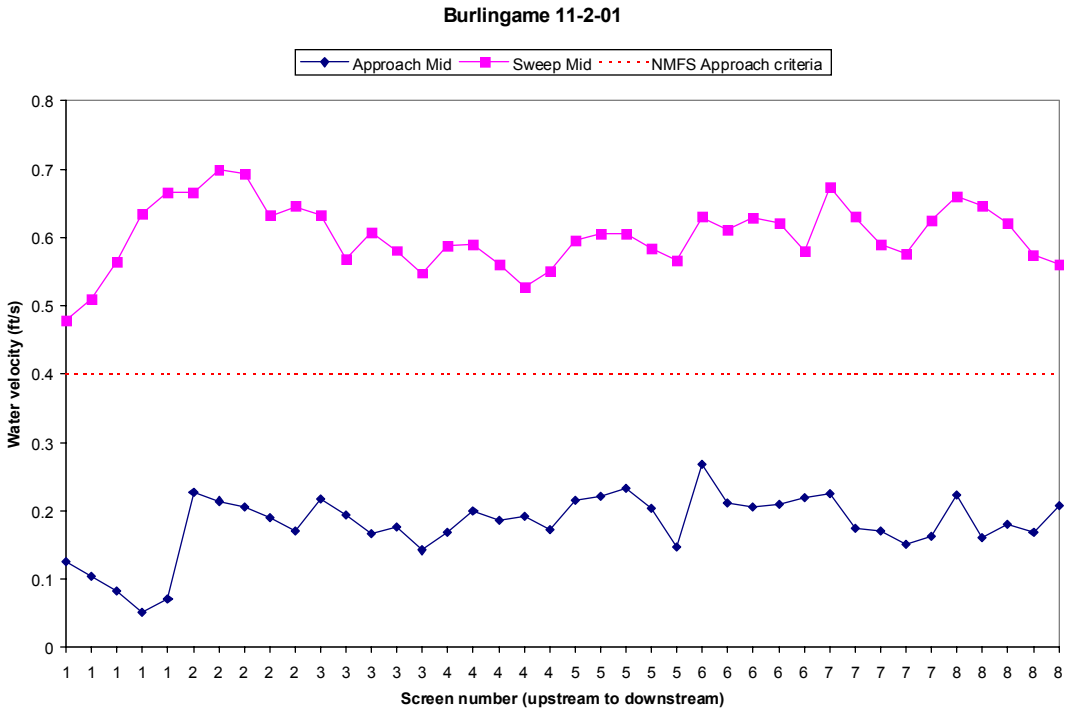

Figure 4. Approach and sweep velocities at the Burlingame fish screen site on November 2, 2001. Screen bay 1 is blocked and does not have a drum screen in it. The red line at 0.4 feet/sec denotes the NMFS criteria for fish screen approach velocities.

In June, sediments on the sill in front of the screens averaged 1.5 inches. During both surveys large piles of twigs, organic debris and other rubbish accumulated on many of the concrete structures between drums in the forebay (Table 2). This accumulation of

debris may provide foraging habitat for salmonid predators (e.g., northern pikeminnow) and/or become a problem in terms of wear and tear on the screen seals and motors.

Table 1. Summary fish screen water velocity data for the Burlingame and Little Walla Walla River sites on November 2, 2001.

Screen Site	% of Approach Velocities > 0.4 ft/s	Mean Sweep Velocity ± SD	Mean Approach Velocity ± SD	Ratio of Sweep to Approach
Burlingame	0.00	0.60 ± 0.05	0.18 ± 0.05	3.35
Little Walla Walla	0.00	1.27 ± 0.39	0.02 ± 0.09	52.71

Table 2. Summary fish screen evaluation information for the Burlingame and Little Walla Walla River sites in May and June, 2001.

Screen Site	Damaged Screen or Seal		Submergence Outside Criteria		Excessive Sand, Silt or Debris		Bypass Outfall < 1 ft Deep	
	May	June	May	June	May	June	May	June
Burlingame	no	no	no	no	yes	yes	no	no
Little Walla Walla	no	no	N/A	N/A	no	no	no	no

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 in front of the screen. Submergence marks on the drums were easy to read. Percent submergence was recorded at 80% in both May and June, which is within NMFS criteria. There was a negligible amount of headloss across the screens in both surveys.

The screen material was in good condition at Burlingame, as were all visible seals. 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. Some bottom seals were buried in debris or plants/algae and could not be evaluated. The screens seemed to be moving leaf matter and other floating debris over them and into the aftbay effectively. Expanding foam insulation had been 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.

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." The bypass outfall at Burlingame is an open channel with approximately five four-by-six boards installed to back up the outfall at the culvert and limit adult salmonid movement upstream into the screen forebay (Figure 5). Water ran freely over the bypass weir in both months, and the water level at the outfall discharge was greater than or equal to one foot in both months, which was well within NMFS criteria.

Figure 5. Bypass drop structure at the Burlingame fish screen facility.

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. The Burlingame site was equipped with gauges measuring water depths in the forebay and at the entrance to the bypass, and had submergence marks on the drum screens. Some of these operator control aids became more difficult to read later in the season due to algae growth. We recommend regular cleaning of these marks to facilitate operator adjustments and evaluation.

3.2 Little Walla Walla

The Little Walla Walla diversion site was evaluated May 3, 2001 and June 14, 2001. Velocity data were collected on November 2, 2001. The Little Walla Walla site was generally operating in a manner that would be expected to provide safe passage for emigrating salmonid smolts.

The flat plate screens at this site appeared to be in compliance with the NMFS approach velocity criteria (Table 1 and Figure 6); sweep velocities were always higher than approach velocities. Sweep velocity increased towards the bypass, and the bypass velocity was greater than sweep in front of screens.

Sediment buildup was not a problem at this site, nor was accumulation of debris. The use of underwater video allowed us to evaluate the effectiveness of the automatic cleaning brushes at the Little Walla Walla site. In both May and June, there was substantial algae growth on the bottom six to 12 inches of the screen, indicating that the brushes were not functioning to their full potential (Figure 7). In addition, the brush cable was showing signs of wear (fraying).

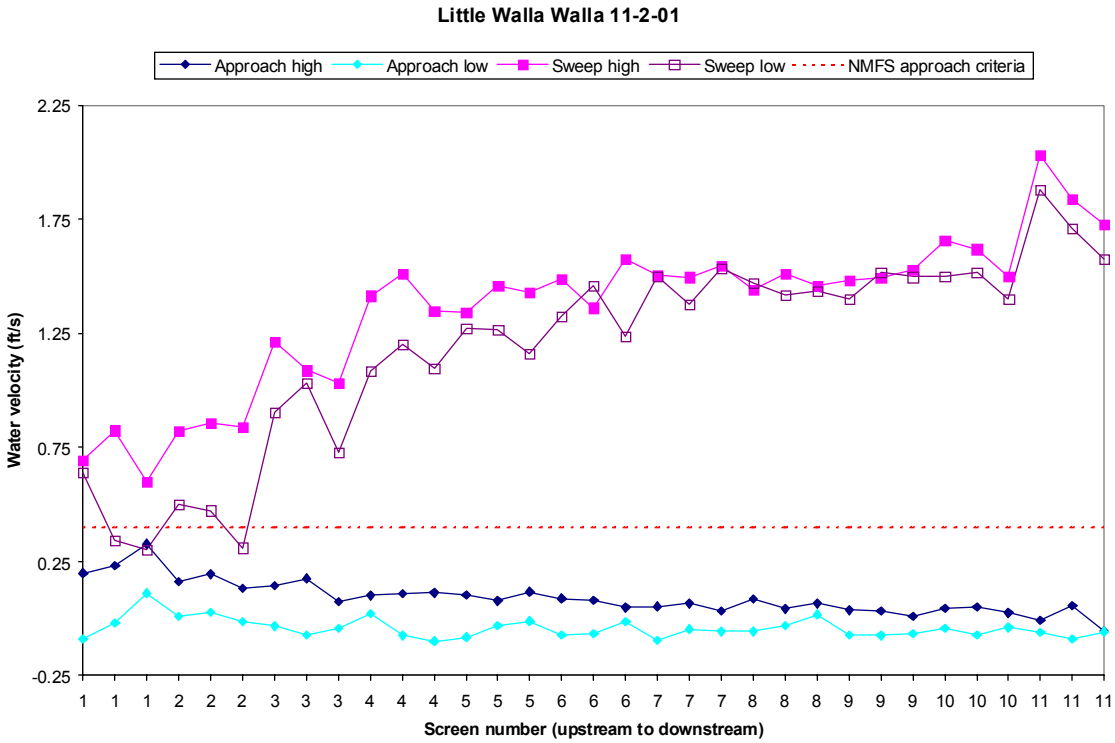

Figure 6. Approach and sweep velocities at the Little Walla Walla River fish screen site on November 2, 2001. The red line at 0.4 feet/sec denotes the NMFS criteria for fish screen approach velocities.

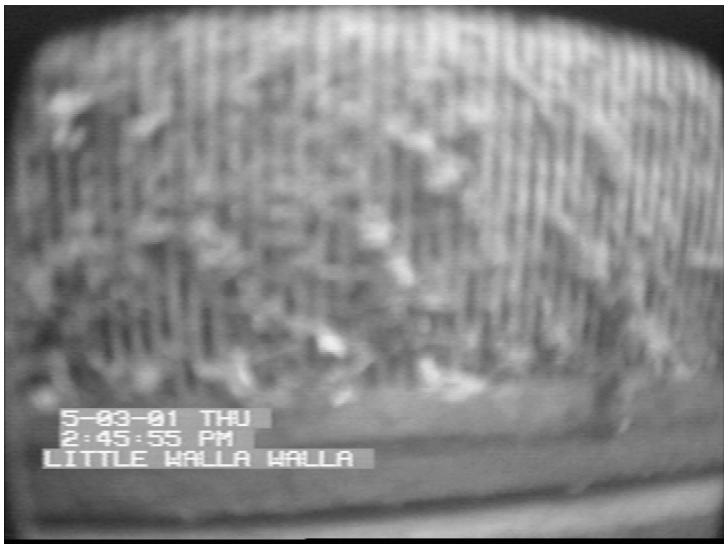

Figure 7. Algae buildup and lack of caulking at the bottom of screen panel 11 of the Little Walla Walla River screen site on May 5, 2001.

Flat plate screen sites do not have the same rollover debris removal issues to contend with as rotary drum screens. However, if a screen becomes completely submerged, fish can freely enter the irrigation canals by swimming over the top of the screen. Total screen submergence was never observed at the Little Walla Walla site.

The screen material seemed to be in good condition during both visits. There was some headloss (1.25 inches) across the screen in June, but virtually none in May (0.25 inches). Some of the vertical seams between the screens were lacking caulking which created gaps that could potentially harm fish (Figure 8).

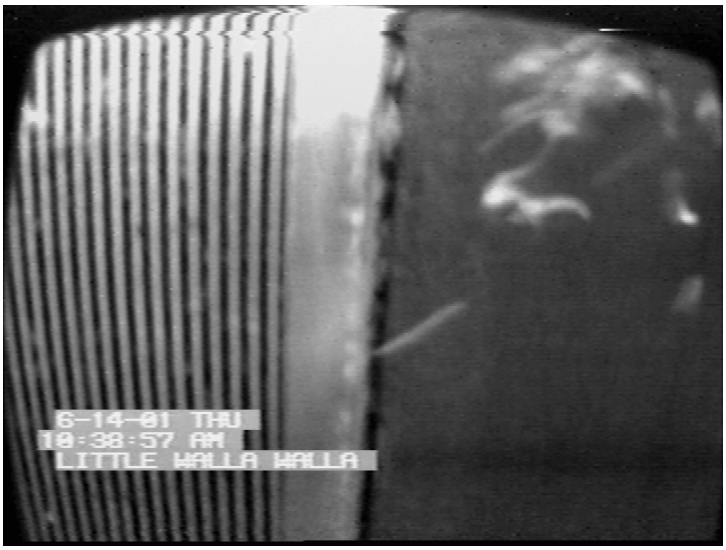

Figure 8. Gap at top of screen 3 upstream seal at Little Walla Walla.

The bypass weir was not completely open either month, but water flowed freely over the top. The upstream portion of the bypass outfall at Little Walla Walla is piped, while the lower portion is an open channel (Figure 9). This site appeared to meet the minimum requirements set by the NMFS for in-pipe water depth, although the water in the open channel portion of the outfall at Little Walla Walla was less than 9 inches in some places in June.

Figure 9. Open channel portion of the bypass at the Little Walla Walla fish screen facility.

Operator control aids at the Little Walla Walla screen site included gauges measuring water depths in the forebay, aftbay and downwell. Later in the season, some of these gauges became more difficult to read due to algae growth, and regular cleaning is recommended.

4.0 Conclusions

Our 2001 evaluations of two newly constructed screening facilities in the Walla Wall River Basin indicate that they were generally designed, constructed, operated and maintained to effectively provide fish a safe and efficient return to the river. All approach velocities measured at both sites on November 2001 were less than the NMFS criteria limit of 0.04 ft/s. Sweep velocities were higher than approach velocities and lower than bypass velocities, which should provide for safe fish passage back out 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 the bottom of the flat plate screens and excessive accumulation of debris at Burlingame. The lack of caulking creates gaps between the screen and the cement bottom of the forebay that could potentially harm fish, while debris build-up could create habitat for predators. The automated cleaning brushes at Little Walla Walla generally functioned properly; chains and other moving parts were well greased and operative. However, the cleaning brush was not effectively cleaning the lower portion of the screen surface at the Little Walla Walla site.

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 will be used to suggest means to better protect fish at screening facilities. There has been a progressive improvement in the design, construction, 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. The Walla Walla River Basin fish screening facilities could benefit from a similar program of evaluation and feedback.

5.0 References

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