

Walla Walla River Basin Fish Screen Evaluations

Nursery Bridge Fishway, Garden City/Lowden II, and Little Walla Walla Sites

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**Walla Walla River Basin Fish Screen Evaluations,
2004: Nursery Bridge Fishway, Garden City/Lowden II
and Little Walla Walla**

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Summary

Pacific Northwest National Laboratory evaluated the fish screens at the Nursery Bridge Fishway, the Garden City/Lowden II site west of Walla Walla, Washington, and the Little Walla Walla site in Milton-Freewater, Oregon, in the Walla Walla River Basin during 2004. The fish-screen facilities were examined to determine if they were being effectively operated and maintained to provide for safe fish passage. At the Nursery Bridge Fishway, the screens were evaluated specifically to determine whether the louvers that aid in controlling water flow from behind the screens could be adjusted so that the screens would meet fish-protection criteria. Data were collected to determine whether velocities in front of the screens met current National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) (formerly NMFS) criteria to promote safe and timely fish passage before and after changing the louver settings. The Little Walla Walla screens were evaluated to determine how a build-up of algae on the screens affected water velocities.

The following conclusions are based on the results of the 2004 studies:

Nursery Bridge Fishway:

- 50% of the initial velocity measurements on the west screens exceeded NOAA Fisheries criteria of 0.4 ft/s for approach velocity
- After adjusting the louvers the percentage of velocity measurements on the west screens that exceeded 0.4 ft/s remained the same, while the percentage on the east screens dropped from 28% to 5%
- A simple adjustment of the existing louvers was not sufficient to put the site into compliance with NOAA Fisheries criteria

Garden City/Lowden II:

- The flat inclined-plate screen design appeared to be efficiently protecting juvenile fish from entrainment, impingement, and migration delay
- Approach velocities met NOAA Fisheries criteria of less than 0.4 ft/s in July, and no change in baffle settings was needed
- Sweep velocities were generally higher than approach velocities and increased slightly toward the downstream end of the site
- A change in the timing of the automated air-burst cleaning system at the Garden City/Lowden II improved its effectiveness for periods when sediment loads were high.

Little Walla Walla

- Approach velocities met NOAA Fisheries criteria
- The brushes appeared to be cleaning the outsides of the screens, but the algae build-up persisted in between the vertical bars causing approximately 7 inches of headloss across the screens.

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 was not 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).

More recently, 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 its plan to restore declining steelhead and salmon runs (NPPC 1984, 1987, 1994, 2000).

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 Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) (formerly 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 existing screen sites is important to ensure that the sites achieve the goal of protecting fish from entrainment into the irrigation systems (McMichael et al. 2004). The screens at the Nursery Bridge Fishway were evaluated during spring 2004 to determine whether conditions were conducive to safe fish passage and whether the site was operating within criteria developed by NOAA Fisheries. The Nursery Bridge Fishway is located on the east bank (river right) of the Walla Walla River near the town of Milton-Freewater, Oregon (Figure 1-1). The fish-screen facility is located at the upstream end of the ladder and is used to draw water through the auxiliary water supply (AWS) to increase attraction flow at the ladder entrances. This facility consists of two horizontal-bar screens facing each other with a channel in between (Figure 1-2).

The Garden City/Lowden II site is located about 2 mi east of the town of Lowden off Highway 12 (Figure 1-1). The site has an inclined plate screen with eight 6-ft high × 4-ft wide screen panels (Figure 1-3). The site was evaluated in July 2004 to determine whether conditions were conducive to safe fish passage and whether the site was operating within criteria developed by NOAA Fisheries and also to determine whether any changes in the baffle settings were needed, based on measurements, to put the site within NOAA Fisheries criteria.

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 1-1). The Little Walla Walla site was updated in 2000 by the construction of a set of 11 flat plate screens of stainless steel wedgewire design with 0.069-inch openings (Figure 1-4).

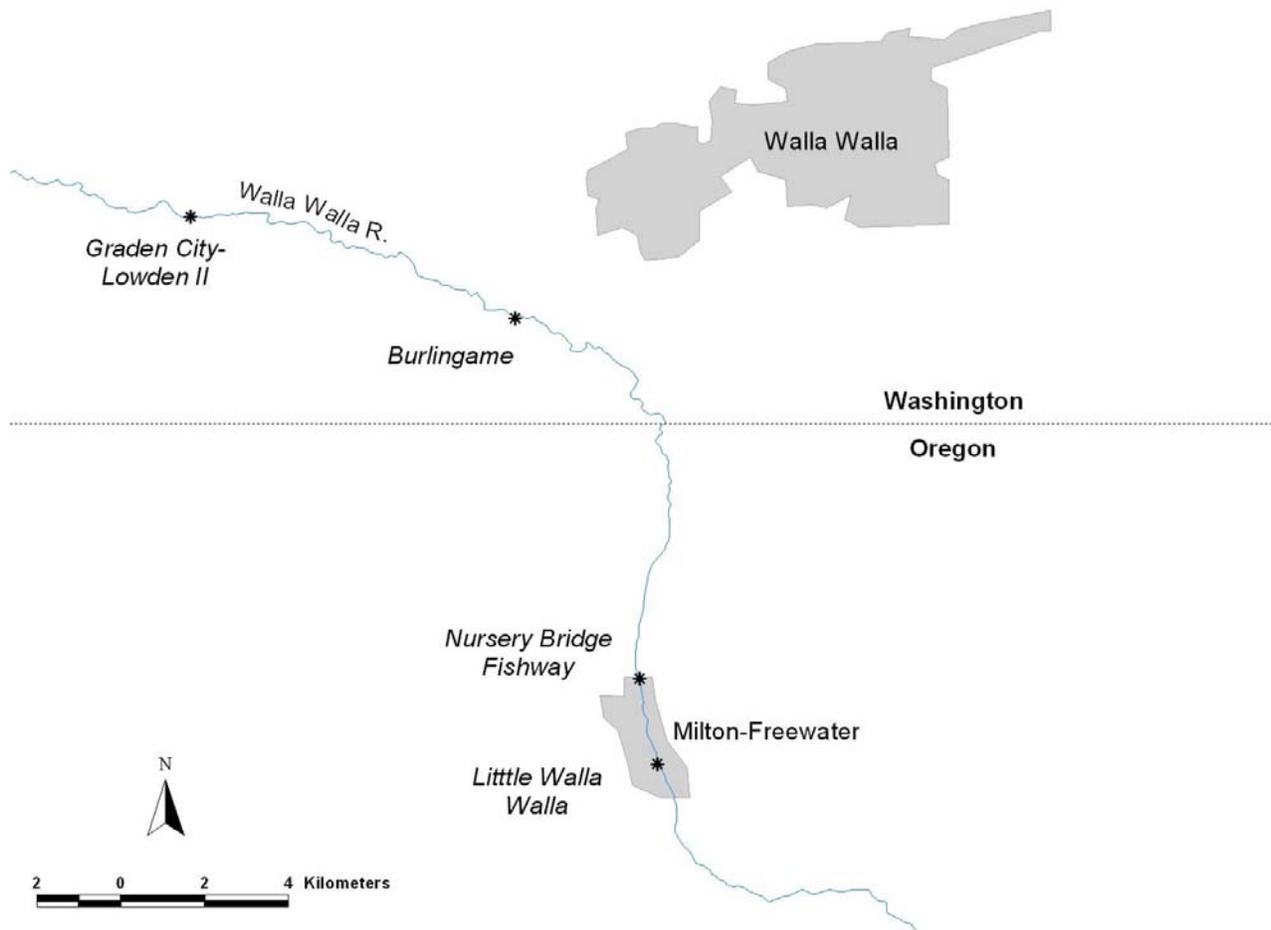


Figure 1-1. Map of Study Area in the Walla Walla River Basin

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; Carter et al. 2002, McMichael et al. 2004). These evaluations addressed three main questions:

1. Are screens designed, operated, and maintained to meet NOAA Fisheries criteria standards over a wide range of conditions?
2. Do velocities/flows meet NOAA Fisheries criteria?
3. Are screens effective at protecting fish from injury and from unnecessary migration delay?



Figure 1-2. Nursery Bridge Fishway auxiliary water supply (AWS) screens.
The red arrows show the direction of water flow.



Figure 1-3. Garden City/Lowden II fish screens. The red arrows show the direction of water flow.



Figure 1-4. Little Walla Walla Screens.

2.0 Methods

The Nursery Bridge site was evaluated and adjustments to the louvers were made on May 25, 2004. The Garden City/Lowden II site was evaluated July 19, 2004. Little Walla Walla was evaluated November 12, 2004. We collected water-velocity measurements, underwater video, and general operational data (e.g., screen submergence and fish presence) as described in the following sections.

2.1 Water-Velocity Measurements

2.1.1 Equipment

Water velocities were measured using a SonTek Acoustic Doppler Velocimeter^{®(1)} (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 3.9 in. below the probe. Velocities were typically recorded at each sampling point along the screen for 30 to 40 seconds at a rate of 2 Hz (2 recordings per second) and stored in a computer file.

2.1.2 Probe Positioning

Measurements of water velocity were taken at several (2 to 4) evenly spaced points along the front of each screen. The vertical pole was placed close to the front of the screen, but not allowed to come in contact with the screen surface. Velocity measurements were recorded with the ADV probe 3 to 6 in. in front of the screen face. The probe was oriented in a down-looking orientation, with sweep (X) and approach (Y) velocities on the horizontal plane and vertical velocity (Z) on the vertical plane. All measurements were taken with the axes of the probe oriented to measure water flowing parallel (sweep) and perpendicular (approach) to the screen face, regardless of the orientation of the screen. At the Garden City/Lowden II site, the pole on which the probe was mounted was held parallel to the screen surface, which is oriented at an angle 45° from vertical. 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% of depth from the surface. In cases where the forebay depth was greater than or equal to 48 in., measurements were taken at two depths, 20% and 80% of depth, from the surface.

2.1.3 Data Collection and Analyses

Multiple velocity measurements were taken in front of every screen or panel. Cleaning systems (brushes and air bursts) were turned off during velocity measurements. Average sweep and approach velocities were calculated for each position at each site.

(1) SonTek Acoustic Doppler Velocimeter is a registered trademark of SonTek/YSI, Inc., San Diego, California.

2.2 Underwater Video

2.2.1 Equipment

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

2.2.2 Data Collection and Analyses

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

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

2.3 General Data

Additional data collected during each evaluation included the following:

- General site descriptions and photographs
- Screen conditions
- Screen submergence levels
- Cleaning-system operation
- Fish presence
- Observations of debris in the forebay
- Presence or absence of operator control aids, such as water gauges and drum submergence marks on screen frames.

2.4 Data Analyses

NOAA Fisheries criteria define several conditions concerning velocity (NMFS 1995):

- Maintaining a uniform flow distribution over the screen surface to minimize approach velocity
- Keeping approach velocities ≤ 0.4 ft/s
- Achieving sweep velocities 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 compared our field measurements of water velocity and general data-collection results for each screen site to NOAA Fisheries criteria. The following section contains the results of these comparisons for each site.

3.0 Results and Discussion

3.1 Nursery Bridge Fishway Screens

3.1.1 Initial Velocity Measurements

The Nursery Bridge site was evaluated May 25, 2004 to determine whether changes in louver settings would result in lower approach velocities that would bring the site into compliance with NOAA Fisheries screen criteria. For the purpose of PNNL's evaluations, a site is considered to be in compliance with NOAA Fisheries criteria if less than 10 percent of the measured approach velocities exceed 0.4 ft/s (McMichael et al. 2004). An entire set of velocity measurements at 0.2 and 0.8 of depth, in front of both sets of AWS screens (east and west) was taken before the louvers were moved. A cursory, on-site examination of the data showed approach velocities exceeded NOAA Fisheries criteria of 0.4 ft/s on the east screens at 5 out of 18 locations, all at the most downstream screen, and on the west screens at 9 out of the 18 measured locations, mostly at the lower depth (Figures 3.1 and 3.2).

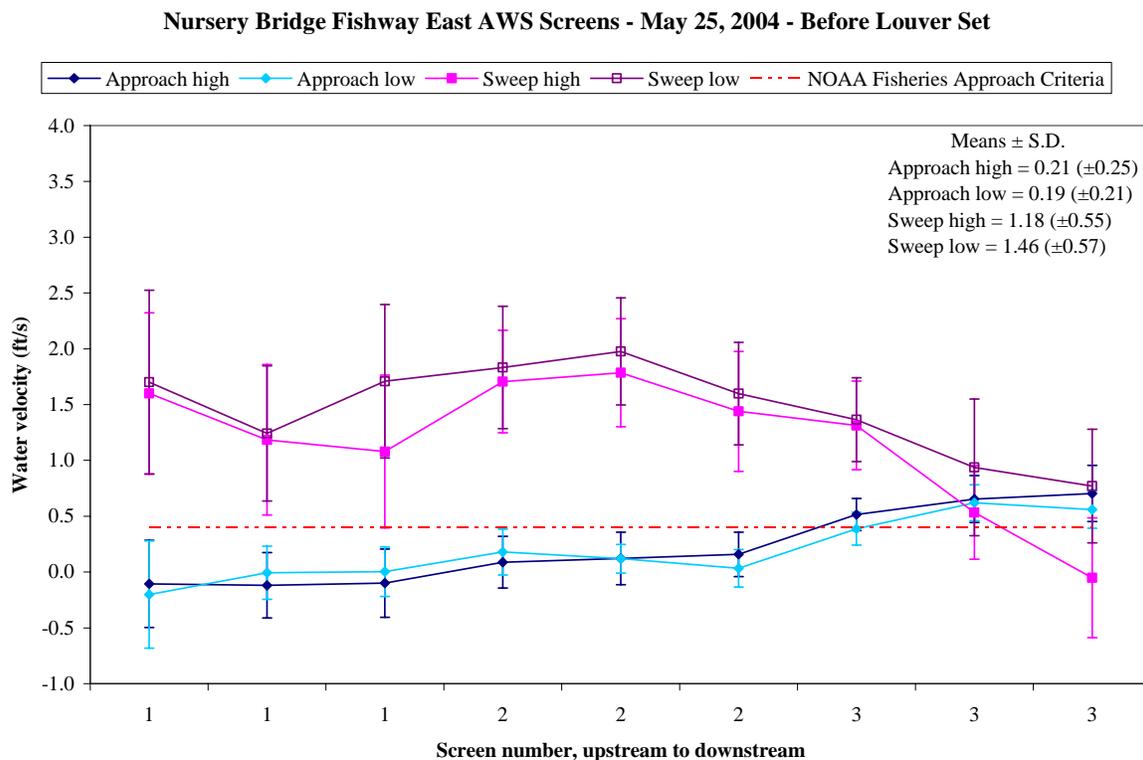


Figure 3-1. Initial approach and sweep velocity measurements at the Nursery Bridge Fishway east AWS screen on May 25, 2004. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The error bars (\pm the standard deviation) represent turbulence at each point. The text box shows the mean across all screens for the measured parameter.

Nursery Bridge Fishway West AWS Screens - May 25, 2004 - Before Louver Set

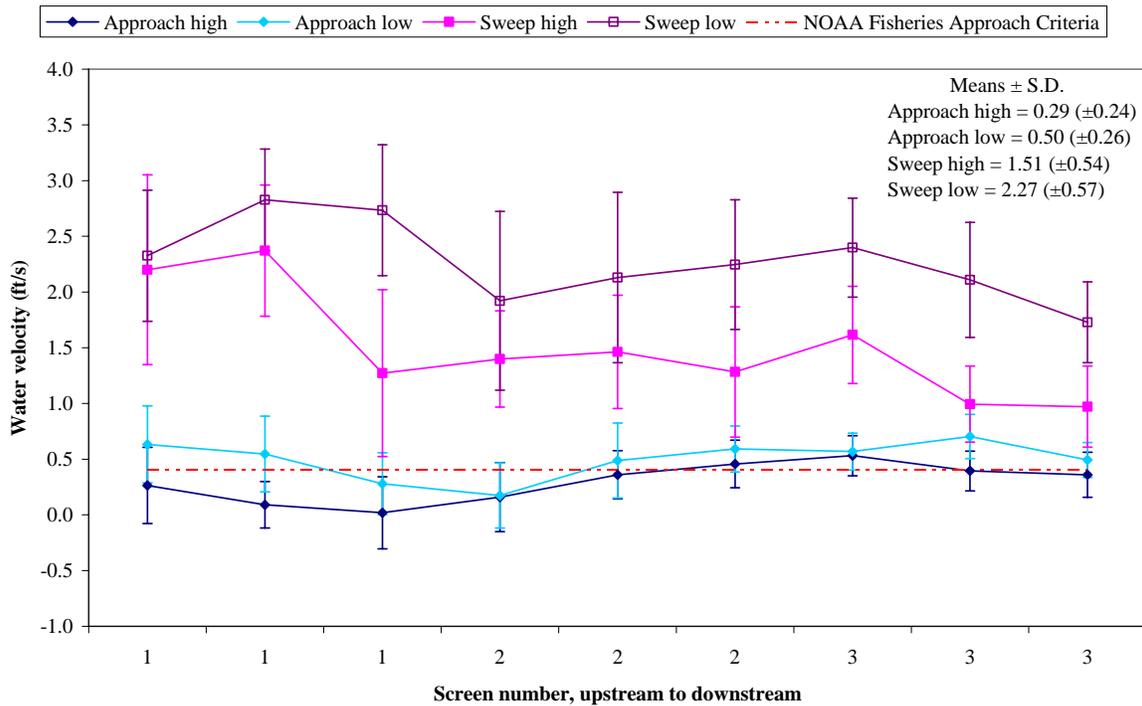


Figure 3-2. Initial approach and sweep velocity measurements at the Nursery Bridge Fishway west AWS screen on May 25, 2004. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The error bars (\pm the standard deviation) represent turbulence at each point. The text box shows the mean across all screens for the measured parameter.

3.1.2 Flow Measurements after Changing the Louver Settings

Based on an on-site review of the data, we decided to open up the louvers on the most upstream screen on the east side, and to partially close down the louvers on the most downstream screen on the east side in an attempt to draw more water towards the upper end of the east-side screens.

A second set of measurements was taken after the louvers were moved. The results showed that only one out of 18 measured locations on the east side exceeded 0.4 ft/s. On the west side, the number of points that exceeded criteria remained the same (Table 3.1, Figure 3-3, and Figure 3-4).

Changing the louver settings behind the screens did not change the flow patterns sufficiently to put the screens in compliance with NOAA Fisheries criteria for approach velocity, especially in front of the west screen. Two factors contribute to this problem. The first is the site design. The water enters the site at an angle toward the west screen, in essence hitting the west screen with more force (and higher velocities) than it would if the majority of the flow passing through the AWS screen area were parallel to the screen face. The second problem is the louver design/fabrication. Generally, louvers are designed to slightly overlap so that when completely closed, almost no water passes through them. The louvers at the Nursery Bridge Fishway do not overlap; they do not even meet. There is a gap approximately 0.9 in. wide (Figure

3-5) between the louvers when they are completely in the “closed” position. This gap allows water to flow through the screens even when the louvers are completely closed. Therefore, the approach velocity problems at this site cannot be fixed merely by closing the louvers. To conclude, the site was not constructed to operate within NOAA Fisheries criteria under all flow conditions, and to bring the site into compliance would require physical changes in the facility.

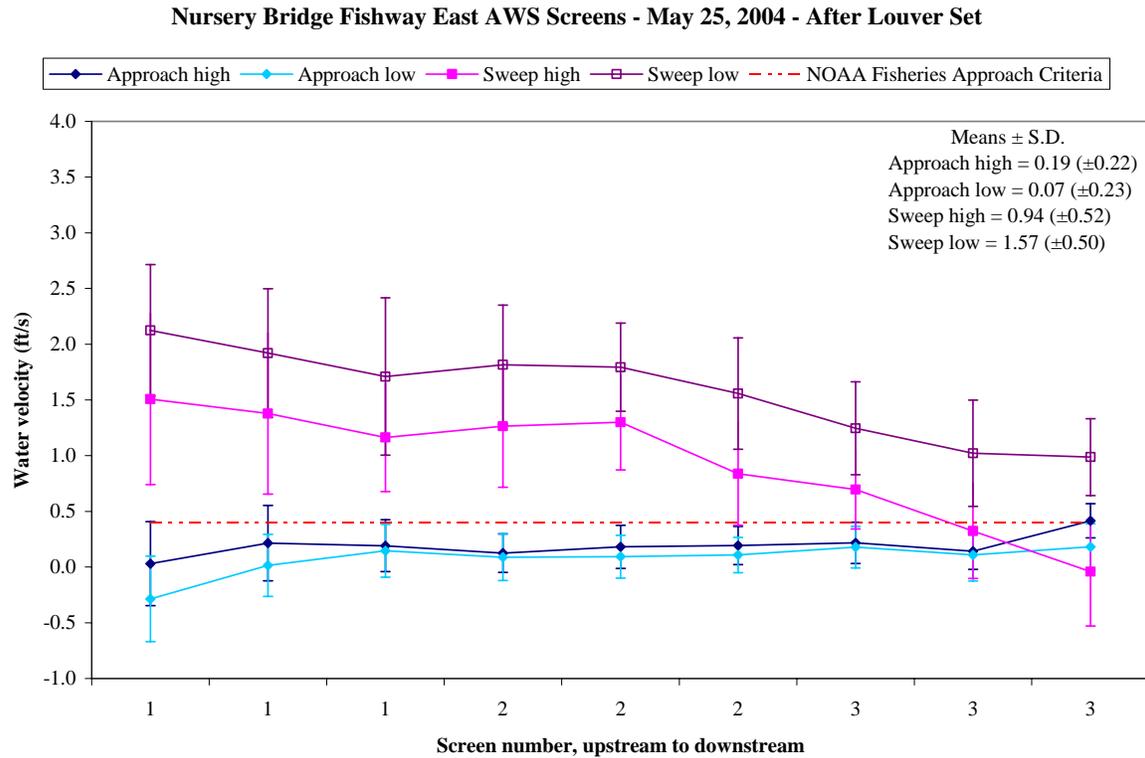


Figure 3-3. Approach and sweep velocity measurements at the Nursery Bridge Fishway east AWS screen after setting the louvers. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The error bars (\pm the standard deviation) represent turbulence at each point. The text box shows the mean across all screens for the measured parameter.

Nursery Bridge Fishway West AWS Screens - May 25, 2004 - After Louver Set

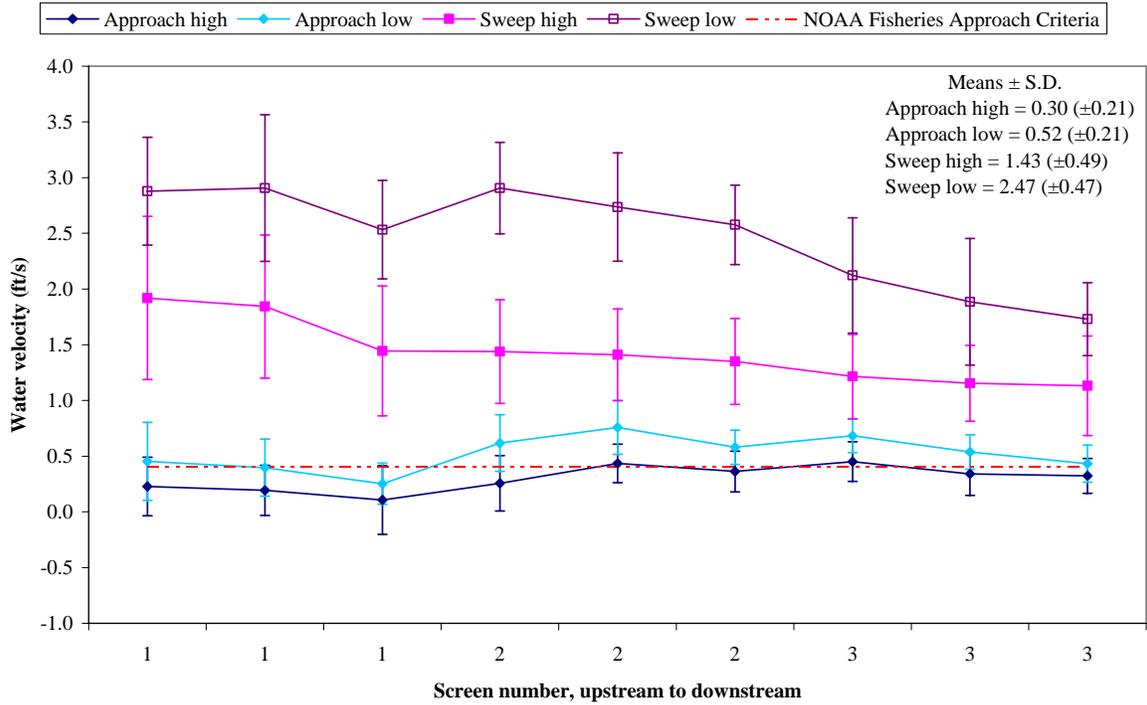


Figure 3-4. Approach and sweep velocity measurements at the Nursery Bridge Fishway west AWS screen after setting the louvers. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The error bars (\pm the standard deviation) represent turbulence at each point. The text box shows the mean across all screens for the measured parameter.

Table 3.1. Summary of water velocity data for east and west AWS screens at the Nursery Bridge Fishway, May 25, 2004

Nursery Bridge Fishway Screens		Mean Sweep (ft/s)	Mean Approach (ft/s)	% of Approach Values > 0.4 ft/s	Turbulence	
					Sweep	Approach
Before louver set	East	1.32	0.20	27.78	0.56	0.23
	West	1.89	0.40	50.00	0.55	0.25
After louver set	East	1.26	0.13	5.56	0.51	0.23
	West	1.95	0.41	50.00	0.48	0.21



Figure 3-5. The louvers at Nursery Bridge Fishway auxiliary water supply screens had a gap the size of a nickel (approximately 0.9 in.) between them when fully closed.

3.2 Garden City/Lowden II Fish Screens

The Garden City/Lowden II fish screens were evaluated on July 19, 2004. Approximately 15 cfs, or approximately 30% of the 49 cfs operating capacity was being taken through the site at the time of evaluation. The screens each have baffles and are equipped with an air-burst cleaning system. Water in the forebay covered slightly less than 54", leaving approximately 18" of screen exposed (measured parallel to the screen, not vertically).

Approach velocities were well within NOAA Fisheries approach criteria. Sweep velocities were generally greater than approach velocities (Figure 3-6). The sweep velocity increased slightly from upstream to downstream within the site, and velocities tended to be somewhat variable from point to point. The ratio of sweep to approach was 2.6, which should be sufficient to provide a clear direction for fish movement through the site.

There was no sediment accumulation, and there is no bypass to evaluate. Stuart Durfee said that he has changed the timing on the air burst cleaning system to make it more effective in times when there are heavier loads of algae in the river. The screens appeared sufficiently clean at the time of evaluation. The top 18 inches of the screens was much cleaner than the rest of the screens, possibly because the majority of the water goes through the top portion of the screens. The higher position velocity measurements seem to support that theory, as the difference in approach velocity between the high and low positions was statistically significant (t-test, $t=4.121$, $df=30$, $p<0.001$).

Garden City/Lowden II, July 19, 2004

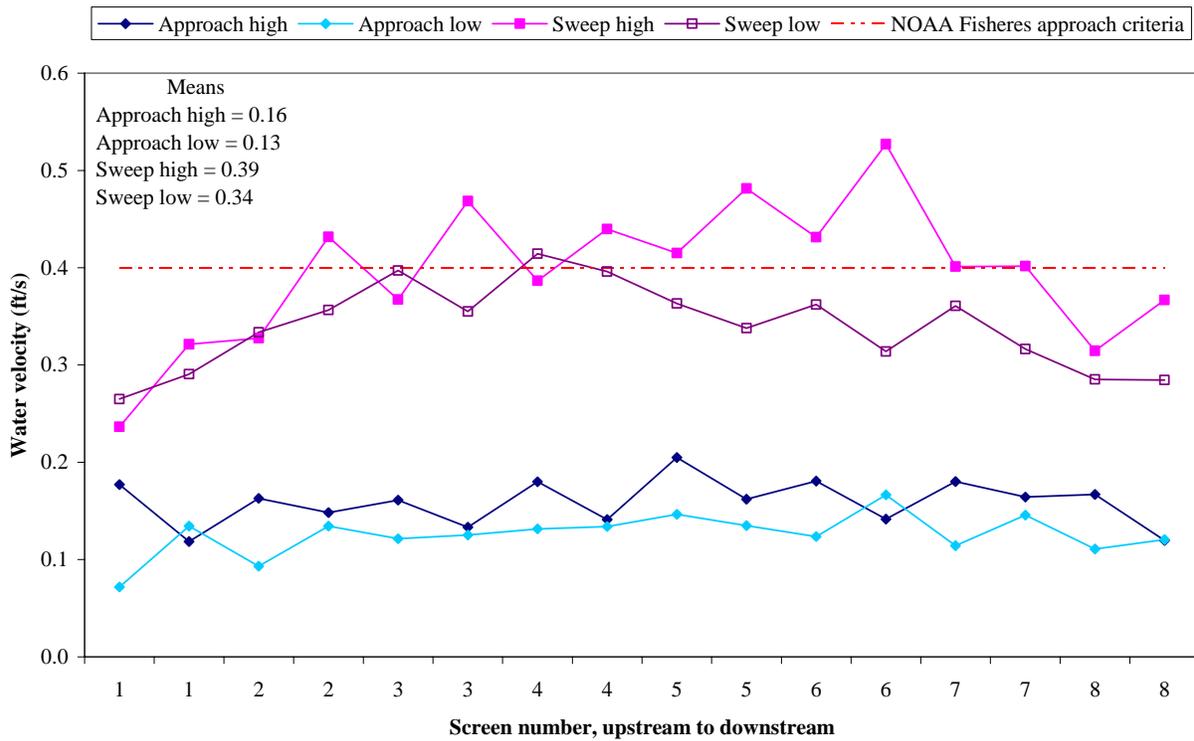


Figure 3-6. Approach and sweep velocities at Garden City/Lowden II fish screens on July 19, 2004. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The text box shows the mean across all screens for the measured parameter.

While further testing is needed to determine whether this site would meet NOAA Fisheries criteria when it is running closer to its capacity limit, preliminary calculations show that the site would be able to run at its design capacity (49 cfs) and maintain an average approach velocity lower than 0.4 ft/s providing that the screens are fully submerged. If the site was to draw 49 cfs at the current 75% submergence then the average approach velocity would likely exceed 0.4 ft/s (Table 3.2). This is an important consideration when operating the screens to meet NOAA Fisheries criteria.

Table 3.2. Calculations showing theoretical average approach velocity under two conditions (maximum water usage at two river levels) compared with measured conditions.

	Water usage (cfs)	Submergence (%)	Average approach velocity (ft/s)
Measured conditions	15	75	0.14
Theoretical operation	49	100	0.35
	49	75	0.46

3.3 Little Walla Walla

The Little Walla Walla fish screens were evaluated November 12, 2004 to determine how a buildup of algae on the screens affected water velocities. A visual examination of the screens did not reveal any indication of algae growth; in fact the screen surfaces appeared very clean. A video survey showed that the algae had built up in between the vertical bars of the screens where the brushes do not penetrate (Figure 3-7) and that the algae buildup in the screens was heavier at the bottom than at the top. At the time of the survey there was approximately 7 inches of headloss across the screens.

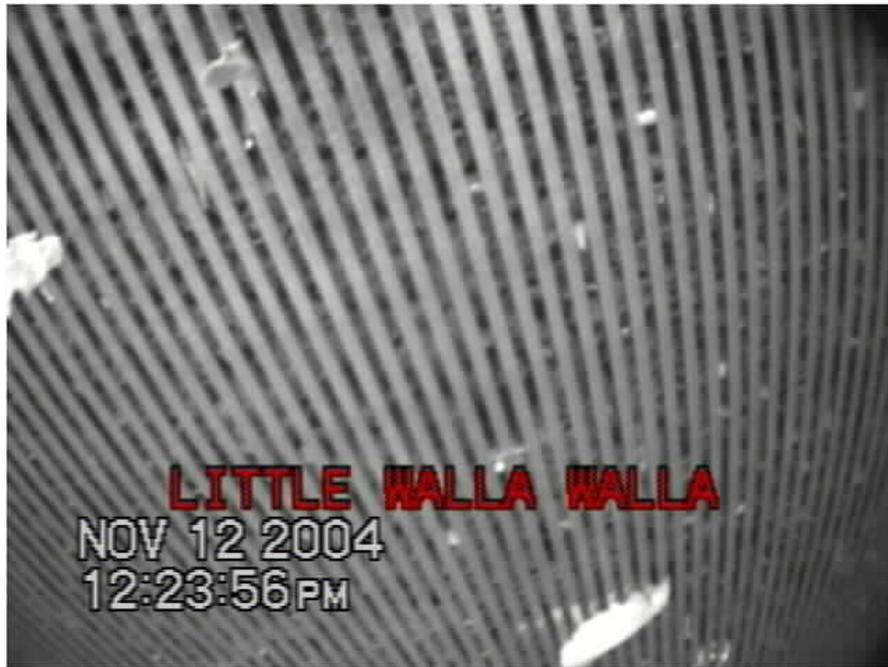


Figure 3-7. Little Walla Walla screens; note the clean exterior of the bars and the algae buildup in between the vertical bars.

All approach velocities met NOAA Fisheries criteria of < 0.4 ft/s (Figure 3-8). Sweep velocities were always higher than approach velocities. Sweep velocities increased slightly towards the bypass, although average bypass velocity was lower than the average sweep velocity. Based on these results, it appears that the algae growth and resulting head differential across the screens is a problem with potential consequences for irrigators, but not for fish. It is unclear from these results what the pattern of water velocities would be if the screens were cleaned out.

Little Walla Walla - November 12, 2004

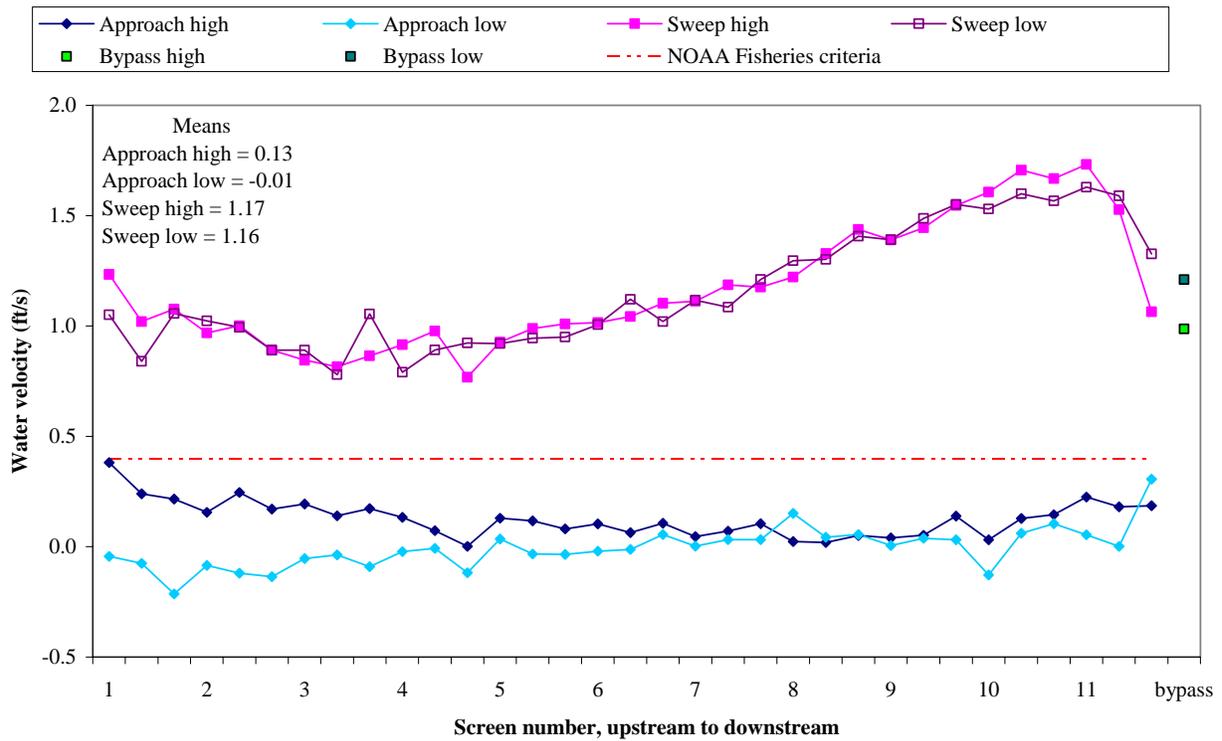


Figure 3-8. Approach and sweep velocities at the Little Walla Walla fish screens on November 12, 2004. The dashed line at 0.4 ft/s represents NOAA Fisheries criteria for approach velocities. The text box shows the mean across all screens for the measured parameter.

4.0 Conclusions

The 2004 evaluation of the Nursery Bridge Fishway AWS screens indicates that the site was not constructed to provide fish safe and efficient passage. Initial approach velocities exceeded NOAA Fisheries criteria at 39% of the measured positions. Physical changes to the louvers and/or the structure will need to be made to put the site into compliance with NOAA Fisheries criteria,

The Garden City/Lowden II site met NOAA Fisheries criteria for approach velocities and appeared to be designed, constructed, operated, and maintained to effectively provide fish safe and efficient passage through the site. Sweep velocities were higher than approach velocities and increased slightly toward the downstream end of the site, which should provide fish with safe passage without delays. A change in the timing of the automated air-burst cleaning system improved its effectiveness for periods when sediment loads were high.

The Little Walla Walla site met NOAA Fisheries criteria for approach velocities and appeared to be designed, constructed, and operated to effectively provide for safe fish passage through the site. The algae buildup in the screens did not appear to have any negative consequences in terms of fish passage.

Future work in the Walla Walla River basin may include evaluations at the Nursery Bridge Fishway if changes are made to the structure. We will continue to conduct periodic evaluations of the Garden City/Lowden II screens to collect water velocity data over a wider range of flows and operation conditions. These evaluations are aimed at increasing the effectiveness of screen operation and maintenance practices by confirming the effectiveness (or ineffectiveness) of screen operating procedures. We will also conduct any other relevant fish passage evaluations in the Walla Walla River basin that are identified by the Confederated Tribes of the Umatilla Indian Reservation.

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