# Effects of Protective Plates and Stoplogs on Water Flow Through the Gleed Fish Screen Facility

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# Summary

In 2007, Pacific Northwest National Laboratory was asked by the U.S. Bureau of Reclamation to provide additional velocity measurements at Gleed fish screens site to support decisions on mitigating extreme flow fluctuations near the screens. The site consistently has had extreme water velocities in places and a strong back eddy at the downstream end in spring and summer. With the help of Washington Department of Fish and Wildlife staff, we measured the effects of different stoplog configurations behind the screens in May and July 2007.

Protective metal plates in front of the trash racks were confirmed to be the cause of uneven and extreme water flow past the vertical traveling screens. Stoplogs were not sufficient to significantly reduce the effect of those metal plates on water velocities past and through the site. We provide a few suggestions including making it easier to raise and lower the metal plates and then adjusting them more often, constructing a new trash rack across the diversion entrance, and raising the control gate at the end of the site as long as possible in spring and during flood events.

# Contents



# Figures



# Table

# Introduction

Pacific Northwest National Laboratory (PNNL) has noted problems with water velocities and flows at the Gleed fish screen facility. In 2007, the U.S. Bureau of Reclamation (USBR) and Washington Department of Fish and Wildlife (WDFW) asked (PNNL) to provide additional velocity measurements at Gleed fish screens site to support decisions on correcting those problems. Bonneville Power Administration granted an extension to our contract, and with the help of WDFW staff we measured the effects of different stoplog configurations behind the screens in May and July 2007.

## Background

In 1993, the old Gleed fish screens located in the canal were removed and new fish screens installed along the north bank of the Naches River. The new site has four vertical traveling screens parallel to and in line with the shoreline. Heavy trash racks were installed approximately 3 ft in front of and parallel to the screens to keep large woody debris away from the screens. A large metal plate called the control gate is set perpendicular to the flow and controls the water level in front of the screens, allowing water to be diverted into the canal. A notch 18 in. wide and 18 in. deep in the upper part of the metal plate near the screens serves as the fish bypass, allowing fish to return to the river. Occasionally, additional boards are placed across the bypass notch to increase water levels and improve canal flow. No louvers or stoplogs are used behind the screens that control flow through the screens, although slots are present behind screens 3 and 4.

By 1997, seven heavy metal plates had been added to the outside face of the trash rack to provide the screens with additional protection from large woody debris in the winter and spring (Figure 1). The metal plates are each approximately 50 in. wide, with 6-in. gaps between them, and sit on the forebay floor and extend above the top of the screens. Although the plates are meant to be used in winter and spring, they have been left in place even later in the season, and one year remained in place the entire season.

**Figure 1**. View Downstream at Log Jam and Protective Metal Plates on May 1, 2006. Control gate is not raised.

PNNL has been evaluating the Gleed site since 1997. A strong back eddy has been noted at the downstream end of the site since the first evaluation performed in 1997 (shown by the negative sweep values at screens 3 and 4 in Figure 2). Sweep velocities at 80% of forebay depth are consistently upstream in the spring and early summer evaluations. Sweep velocities at 20% of forebay depth are less consistent and not as strong but follow the same trend. In addition, approach velocities have shown very erratic and abrupt changes, depending on measurement location relative to the gaps between the metal plates.

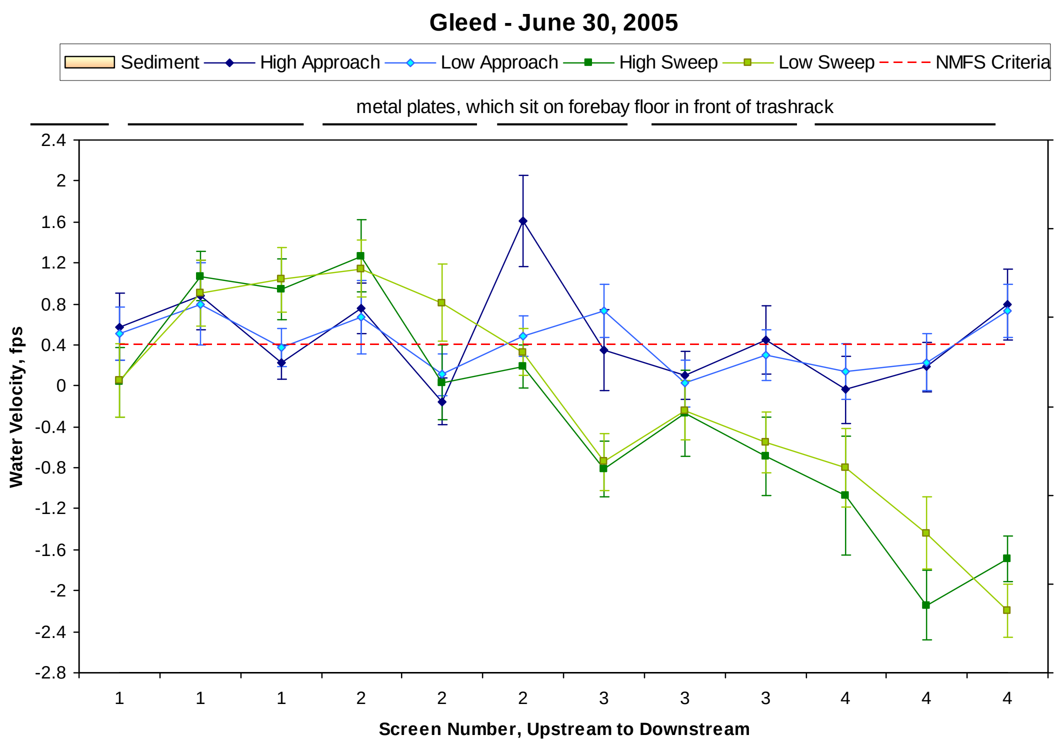


**Figure 2**. Water Velocity Measurements when Protective Metal Plates were Set on Forebay Floor. River discharge was approximately 335 cfs.

The apparent effects of the metal plates can be seen in plots of velocity measurements taken about 2 weeks apart at river levels between 335 and 355 cfs. In the June 2005 plot (Figure 2), the protective metal plates were down; in the July 2005 plot (Figure 3), the protective plates had been raised.

Flow into the canal is unknown. Setting the protective metal plates on the forebay floor appears to be the primary cause for the major perturbations in both sweep and approach velocities seen over the years. However, simply removing the plates is not a viable option, due to the heavy debris load in the river early in the irrigation season (Figure 1).

# Equipment and Methods

The following is a brief discussion of the equipment and techniques used. A more detailed description of the equipment and techniques is provided in Chamness and Tunnicliffe (2007). Underwater videography was accomplished using a digital deep-sea camera (DeepSea Power and Light, Inc., Model MULTI-SEACAM 1050) mounted on a long pole and 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). This setup allowed the operator to see in real time what the camera encountered and focus on areas of interest.

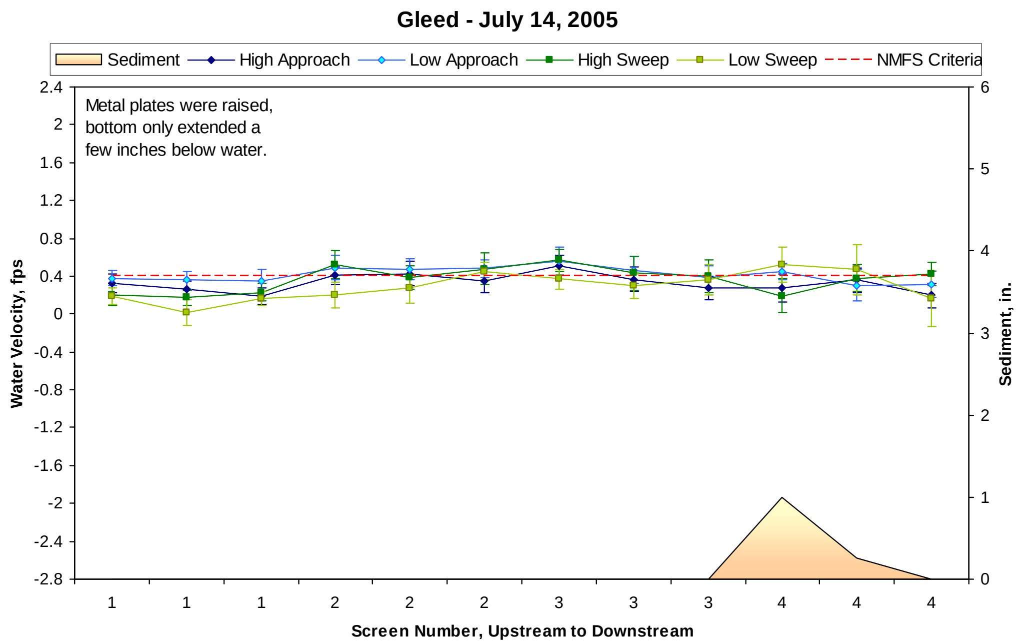


**Figure 3**. Water Velocity Measurements when Protective Metal Plates were Raised Above Water Level. River discharge was approximately 355 cfs.

Water velocities in front of the screen were measured using a SonTek acoustic Doppler velocimeter (ADV, SonTek/YSI, Inc., San Diego, California). The ADV probe emits sound at 10 kHz and measures the difference in the frequency of returning sound waves to determine the water velocity. Data were collected at each location for 30 seconds at a rate of two measurements]/second. These data were stored directly onto a computer. The probe was oriented to measure the velocity of water flowing past the screen face (sweep) and the velocity of water flowing perpendicular to the screen face (approach). Measurements were taken at both high and low positions, corresponding to 20% and 80% of forebay water depth, respectively.

# Results

Bureau of Reclamation staff did not have any specific requests or instructions regarding where they needed data or what operating conditions to modify. Consequently, PNNL and WDFW staff decided to set stoplogs behind the screens to try to smooth out sweep velocities and slow approach velocities. River discharge on May 10 was approximately 3,775 cfs. Water velocities were measured for three conditions:

1. a baseline with protective metal plates raised out of the water and no stoplogs.

2. protective metal plates raised out of the water and a 34-in. stack of stoplogs placed behind screen 4, set to allow 12 in. of water under and 11 in. of water over the boards.

3. protective metal plates set down on the forebay floor in conjunction with the same stoplog configuration as Condition 2.

Almost all of the approach velocities in the baseline measurements were below the National Marine Fisheries Service (NMFS 1995) draft criterion of 0.4 fps. Figure 4 shows sweep velocities comparing Conditions 2 and 3, in which the only change is whether or not the protective metal plates are set to the bottom of the forebay. Figure 5 shows the difference in approach velocities between the same two conditions. From the data shown in Figures 4 and 5, it is obvious that the metal plates cause the erratic approach velocities as well as the strong eddy at the downstream end of the site. The stoplogs did not affect flow significantly.

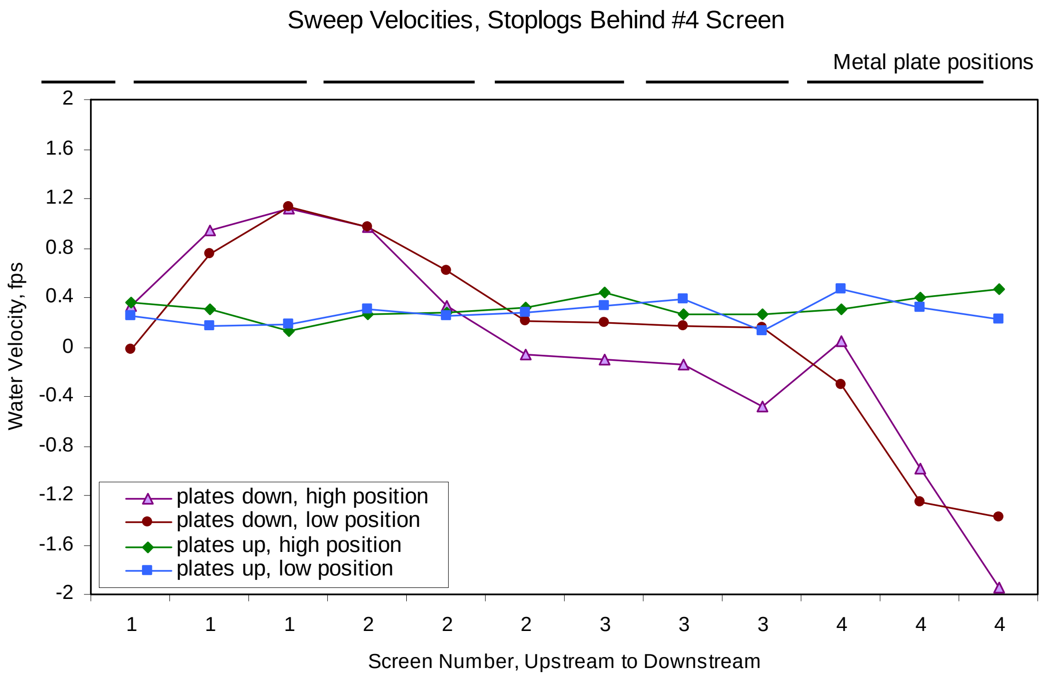


**Figure 4**. Sweep Velocity Measurements at High and Low Positions for Conditions 2 and 3 in May 2007

On July 24, water velocities at the site were measured to test the effect of a different stoplog configuration on approach velocities. Evaluations in previous years have often noted high approach velocities and WDFW and PNNL wanted to see if stoplogs could reduce the velocities to ≤0.4 fps. In May, a solid “wall” of stoplogs was placed behind screen 4. In July, horizontal wooden slats with openings between slats (Figure 6) were placed behind screens 3 and 4. Based on our May measurements, we suspected that no configuration of stoplogs would be able to moderate excessive flow fluctuations caused by the metal plates, so they remained raised for all measurements in July. The river discharge was consistently between 524 and 530 cfs. Again, three conditions were measured:

1. a baseline before any stoplogs were put in place.

2. stoplogs spaced as shown in Figure 6 were placed behind both screens 3 and 4.

3. stoplog slats behind screen 4 were spaced only 2 in. apart, and an extra board was set near the top, reducing flow over the top board to 3 in. Stoplogs behind screen 3 were raised to sit 6 in. off the bottom, and spacing between slats was left at 3 in.

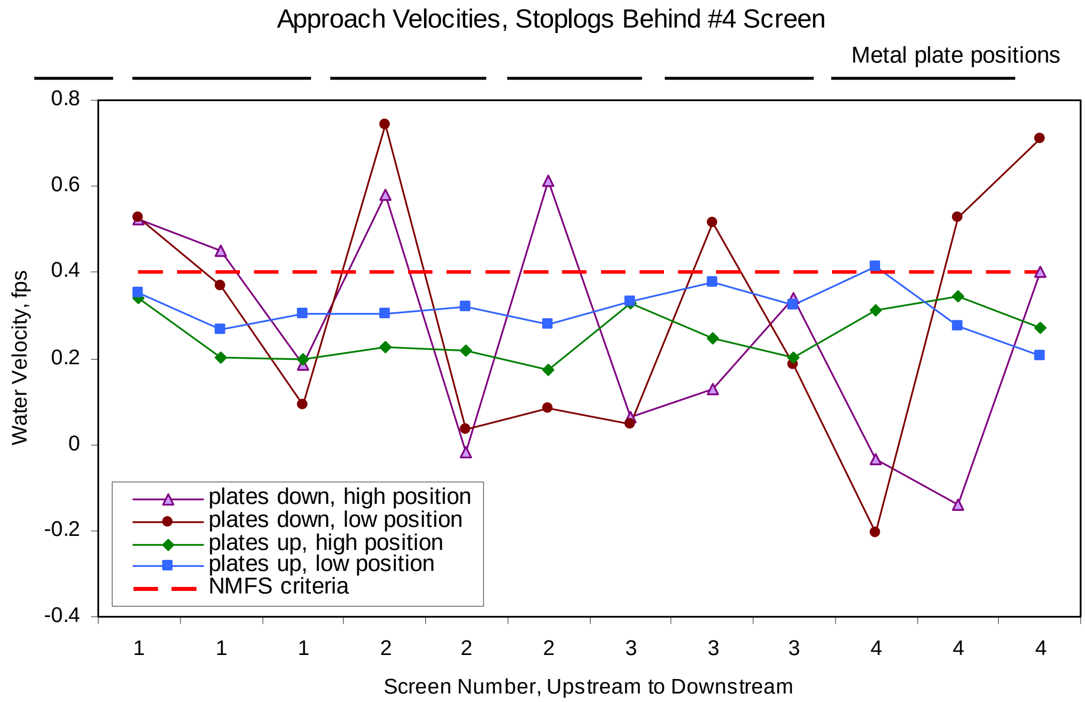


**Figure 5**. Approach Velocity Measurements at High and Low Positions for Conditions 2 and 3 in May 2007

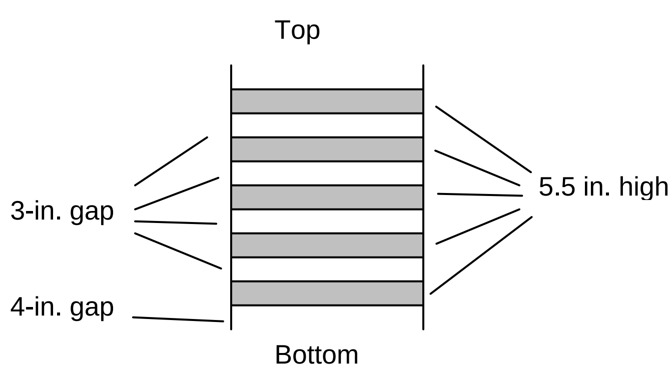


**Figure 6**. Stoplog Configuration Tested in July 2007 Behind Screens 3 and 4

During baseline measurements, only 4 of 24 approach velocities were below the NMFS criterion (Figure 7). With the stoplogs set for Condition 2, approach velocities improved slightly; with 6 of 24 velocities were ≤0.4 fps (Table 1). Under Condition 3, when the stoplogs were spaced more closely together behind screen 4, it appeared that more water was "pushed" through screens 1, 2, and 3 and that approach velocities at the upper three screens were increased. Stoplogs in the above configuration did not significantly moderate the high approach velocities.

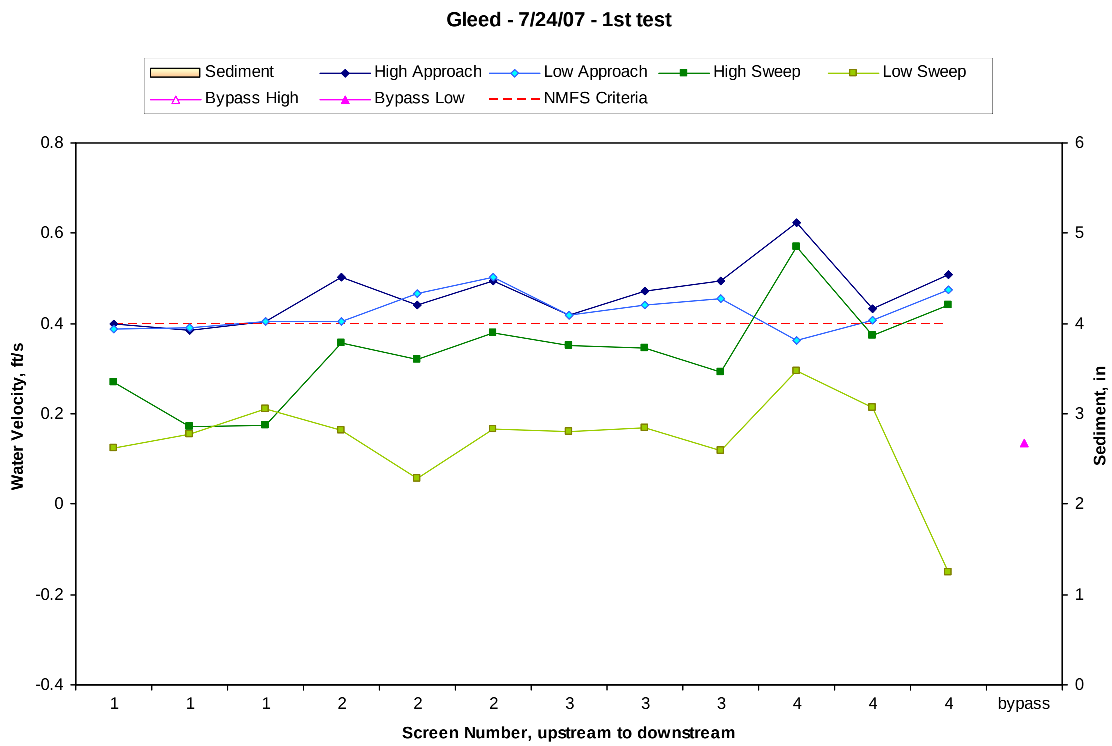


**Figure 7**. Baseline Measurements Before Stoplogs were Installed in July 2007

**Table 1**. Approach Velocities for Each of the Three Conditions Measured in July

| Screen and Position | Condition 1 | | Condition 2 | | Condition 3 | |
|---|---|---|---|---|---|---|
| | High | Low | High | Low | High | Low |
| 1-1 | 0.27 | 0.33 | 0.27 | 0.12 | 0.29 | 0.14 |
| 1-2 | 0.17 | 0.21 | 0.29 | 0.15 | 0.31 | 0.25 |
| 1-3 | 0.17 | 0.17 | 0.23 | 0.21 | 0.29 | 0.22 |
| 2-1 | 0.36 | 0.33 | 0.33 | 0.16 | 0.19 | 0.29 |
| 2-2 | 0.32 | 0.23 | 0.4 | 0.06 | 0.15 | 0.19 |
| 2-3 | 0.38 | 0.25 | 0.39 | 0.17 | 0.19 | 0.07 |
| 3-1 | 0.35 | 0.39 | 0.36 | 0.16 | 0.23 | 0.24 |
| 3-2 | 0.35 | 0.45 | 0.43 | 0.17 | 0.37 | 0.21 |
| 3-3 | 0.29 | 0.33 | 0.32 | 0.12 | 0.18 | 0.11 |
| 4-1 | 0.57 | 0.57 | 0.5 | 0.3 | 0.26 | 0.17 |
| 4-2 | 0.37 | 0.43 | 0.4 | 0.21 | 0.15 | 0.19 |
| 4-3 | 0.44 | 0.28 | 0.29 | -0.15 | 0.02 | -0.18 |
| Bypass | 0.96 | 1.18 | 1.21 | 0.14 | 0.05 | 0.15 |

## Conclusions and Recommendations

Problems at the Gleed fish screen facility are longstanding and appear to be related to the site configuration and design. The facility is located on the outside bend of the Naches River with water diverted to the site by rock dams pushed into place every year by the irrigation district. These push-up dams remain in place at the end of the season, eventually washed out by high river levels during flip-flop or in the winter and spring (Figures 8 and 9).


**Figure 8**. View Upstream from Gleed of Concrete Arm and Remnants of 2005 Push-Up Dam that Form the Gleed Diversion, May 2006


**Figure 9**. View Upstream from Gleed of Concrete Arm and New Push-Up Dam that Form the Gleed Diversion, July 2006

As seen in Figure 1, the Gleed site accumulates a lot of large woody debris every winter and spring when high river levels carry logs and root wads downstream. Because of the site's location on the outside of the river bend, much of the woody debris is funneled into the site, requiring additional protection for the screens in the form of the metal plates.

These metal plates were not part of the initial site design and cause significant perturbations to water flow patterns, creating sweep and approach velocities that greatly exceed NMFS criteria for protection of juvenile salmonids. However, it is recognized that the screens need more protection than the current trash rack can provide.

In addition to flow problems caused by the metal plates, some of the high approach values typically found in June and July may be due to river levels below the design criteria. The Gleed facility operating criterion identifies 60 in. as the normal low water level in the forebay. However, water depth in July 2007 was 47 in. in the forebay, with the bypass notch open to allow fish passage. Canal flow seems to be within the design criterion of 42 cfs, but the low forebay water levels may create a situation that increases the approach velocities. During summer, the bypass is often blocked to increase water levels.

Stoplogs behind the screens were ineffective at significantly reducing the erratic and excessive approach and sweep velocities caused by the metal plates. The quick partial remedy to smooth out flows would be to make it easier to raise and lower the metal plates and then do so more often as conditions change. The plates are very heavy and cumbersome to work with, so they are raised and lowered as infrequently. A more permanent solution is to install a primary trash rack upstream at the head end of the diversion, leaving the existing trash rack (without the metal plates) as secondary protection. The exact position of the new trash racks would need to be carefully chosen to facilitate debris removal without restricting irrigation district access for push-up dam construction. An alternative to this might be construction of a permanent wall with a head gate.

The following are suggestions that would potentially reduce the debris load near the screens but would not remove the need for the metal plates:

- Raise the control gate when flood events are anticipated. Washington Department of Fish and Wildlife personnel try to leave the control gate raised during winter and spring. During flood events, there is probably no shortage of head for the canal flows, even with the control gate raised. Figure 1 appears to show the control gate down in early May in this particular year.

- If the trash rack is not moved upstream, consider asking the irrigation district to push a dam across the entrance to the diversion at the end of the irrigation season, extending from the concrete "arm" to the shore. This would prevent most debris and fish from entering the site but might be difficult to remove later in the spring.

# References

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