UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

September 3, 2009

Les Perkins
Farmers Conservation Alliance
14 Oak Street, Suite 302
Hood River, Oregon 97031

Re: Assessment of status of Farmers Conservation Alliance (FCA) Horizontal Screens as an Experimental Fish passage Technology

Dear Mr. Perkins:

In recent meetings and through correspondence with National Marine Fisheries Service (NMFS) staff, the FCA has requested assessment of the FCA screen as "conventional" fish passage technology. FCA has provided several documents for our consideration. The documents include; 1) undated document entitled The History and Development of the Farmers Screen, 2) an executive summary of a study conducted in 2009 by Matt Mesa and Liz Copeland of the United States Geological Survey (USGS), 3) some proposed criteria changes via e-mail and enclosed to this letter (Enclosure 1). We previously reviewed and responded by letter to the document entitled The History and Development of the Farmers Screen. This letter provides the results of our review of the executive summary and Enclosure 1. Our comments follow.

Acceptance of FCA screens as conventional technology

FCA request: A statement was made in a previous FCA submittal regarding the desire for a global approval letter for FCA screens similar to the one written for approval of the Intralox screen mesh.

NMFS reply: A key difference in these two situations is that Intralox Corporation developed a product that achieved criteria known to provide protection for fish. In contrast, FCA has developed a product that was outside known criteria that protect fish. In particular, the non-automated cleaning or cleaning through passive hydraulic action (a feature of the FCA screen), has caused fish to be killed and compromised screen protection at numerous sites throughout the Northwest. FCA seemed to have a good idea (based on boundary layer theory and demonstrated mathematically) that given the right combination of hydraulics on a horizontal screen, cleaning could be achieved through hydraulic action. This was further demonstrated in prototype construction, hydraulic lab study and in the Davenport Screen Facility installation, the initial horizontal screen constructed to special fish screen criteria (Enclosure 2, special criteria for FCA screens) collaboratively developed between many parties with considerable time and funding commitments from the Federal government. FCA's proposal to revise the collaboratively developed criteria would mean a repeat of this effort and expense, and, in our perspective, would not result in fish screens that provide fish protection equivalent to those built with existing special FCA criteria. Further, consideration of FCA screens used hydraulic design criteria other than what was agreed to by NMFS and is inconsistent with the screen design developed through the Experimental Technologies design process. Due to these changes, there have been problems identified with FCA screens such as cleaning issues, dewatering fish, and sediment capture (refer to later discussion and attached site visit memo, Enclosure 3).

<u>FCA adherence to collaboratively created FCA screen criteria</u>
FCA states: "During the past 6 years, 15 new screens have been installed…"

NMFS reply: How many of these screens were constructed using the collaboratively developed criteria (FCA criteria)? What biological basis permitted deviation from these criteria?

<u>Cost Savings with FCA screens</u>
FCA states that significant cost savings are available via use of FCA screens.

NMFS reply: Significant screen manufacturing and installation cost savings with FCA screens are not apparent, given statements from the three Northwest state screen shops at the recent Fish Screen Oversight Committee meeting, and using information from FCA.

FCA states that about $300,000 in grant money was used to construct the Lacomb FCA screen, a combo diversion for hydropower and irrigation. Per Oregon Department of Fish and Wildlife (ODFW), the total cost of the 65 cubic feet per second (cfs) Lacomb screen was nearly $700,000, or about $10,770 per cfs diverted. This is more than capitol costs for similar sized conventional screens, which are reported on the Washington Department of Fish and Wildlife (WDFW) website to cost about $5,837 per cfs in 1999 dollars, or about $7,850 per cfs in 2009 dollars, assuming 3 percent inflation per year.

In addition, WDFW reports that they installed a WDFW standard portable screen at a site for about one-third the bid amount for a FCA screen. All three states have portable screen designs (i.e. installed without pouring concrete, using a delivery truck and an excavator) available to screen flows from a fraction of a cfs up to 8 cfs.

<u>Maintenance issues with FCA screens</u>
FCA states that maintenance requirements are far reduced with FCA screens.

NMFS reply: A few direct quotes from operators (from the undated document entitled History and Development of the Farmer's Screen, submitted to us by FCA):

> May 26, 2006 – "High water had overtopped our diversion and the screen was plugged with debris."
>
> July 15, 2006 – " the screen was clean."
>
> August 6, 2006 – "The screen was partially clogged with algae and moss."
>
> August 25, 2006 - "The screen was again partially clogged."
>
> October 1, 2006 – "The screen was again partially clogged…."
>
> March 16, 2009 - "The screen must be cleaned when…not provide enough water for proper function … four or five times a calendar year."

All of these reports indicate that the FCA screen was being operated with less than 6 inches of depth (down to 3.5 inches). This reinforces our concern about the FCA screen not having sufficient bypass flow hydraulics (depth, velocity gradient, sweeping velocity and approach velocity) to move debris (and probably fish) very well when the criteria are revised without hydraulic justification. In the operator reports that FCA provided, screens were normally partially clogged with debris (this is further supported by Enclosure 3, which identifies significant issues with the Widow's Creek installations). Clogged screens have higher approach velocity, which can impinge and kill fish. Screen depths of less than one-foot likely cause delay or non-bypass of downstream migratory anadromous fish, although this has not been specifically tested with FCA screens.

In conventional screen systems, using annual Rocky Reach surface collection dewatering as an example, test fish (smolts) released upstream of the screens generally are captured within 10 minutes, nearly 1 mile away in an evaluation facility. Comparison of a large facility like the Rocky Reach collector (which has a very long bypass pipe) is significant as a contrast to the FCA screens as it is reasonable to expect that a smaller facility should have a recapture time that is less than that of the large facility. In this case it is not, which raises our level of concern.

With conventional screens, even if the bypass is shut off, the screen still operates to protect fish. Bypasses do not typically get shut off when there are migratory fish present, but they are often shut off when low flows occur, generally outside of the migration season. Non-migratory fish can survive in the ditch, depending on water quality conditions. Drum screens, belt screens and vertical panel screens constructed to conventional design criteria remove much of the debris even with the bypass shut off. In contrast, per field observations, when FCA bypass flow is reduced, the cleaning capabilities of the screen are impaired because the hydraulics required to move debris off the screen and keep it mobilized until it moves through the bypass are disrupted. With no place for debris to go, it impinges on the screen, blocks flow area and increases approach velocity, which can kill fish.

In addition, it has become apparent that screen operators have flexibility to increase diverted flow amounts thereby decreasing screen flow depth and bypass flows, adversely affecting fish safety. Multiple deaths of Endangered Species Act listed steelhead recently occurred on a FCA screen as a result of eliminating bypass flow.

FCA states: "Experience from these projects has shown some obvious issues with the current criteria that negatively affect both screen function and fish protection and add significant cost to projects with no correlating improvement in fish protection or screen function."

NMFS reply: Assuming that this statement refers to current criteria for FCA screens, again, how many of these sites were constructed to current FCA criteria that were collaboratively developed with NMFS and other agencies? Of the sites constructed to FCA criteria, what issues negatively affect fish protection or screen function?

FCA suggestion for bypass flow

*FCA suggested criterion change: "**Bypass Water:** Bypass flow must be available at all times for proper screen operation. Bypass flow must be sufficient to meet all other design criteria as bypass flow quantities are a function of screen design and operation."*

NMFS reply: A generic statement such as "Bypass flow must be available…" does not mean that the bypass and screen facility is being properly operated. The statement that an operator cannot alter the flow without altering other hydraulic parameters is obvious. However, the bypass flow percentage is a design criterion that was developed via iterative prototype design to provide hydraulics conducive to fish bypass, and is not an operational parameter. As such, this is not acceptable as a criterion change

FCA suggestion for approach velocity

*FCA suggested criterion change: "**Approach Velocity:** The Farmers Screen is considered an active screen due to a hydraulic cleaning mechanism. The approach velocity must not exceed 0.40 ft/s. Using this approach velocity will minimize screen contact and/or impingement of juvenile fish. For screen design, approach velocity is calculated by dividing the maximum screened flow by the vertical projection of the effective screen area. For measurement of approach velocity, see Section 15.2."*

NMFS reply: The Farmers Screen is by definition, not an active screen. An active screen has an automatic mechanical cleaning system, while a passive screen does not. The Farmers screen has no automatic cleaning system and relies totally on hydraulic action to move debris. If the hydraulics change, cleaning is not assured. This is the reason why particular sideboards were placed on the design criteria for the Farmers screen, and numerous field reports indicate that in fact cleaning is not always achieved automatically. This indicates a design and/or operational flaw that may further limit NMFS acceptance of these screens. Debris accumulations increase screen approach velocity and increase the potential take of listed fish, if present at the site. This is not acceptable as a criterion change.

On another note, using a "vertical projection of the effective screen area," as proposed by FCA above, would result in a zero denominator in the proposed calculation, because a vertical projection of a horizontal surface is zero.

FCA suggestion for sweeping velocity

*FCA suggested criterion change: "**Sweeping velocity (VS):** The water traveling parallel to the plane of the screen should have a minimum velocity of 10 times the approach velocity to achieve effective cleaning dynamics and fish protection."*

NMFS reply: We note that the combination of sweeping velocity and approach velocity criteria is of particular importance for accomplishing the stated FCA objectives, and is a critical aspect of screen design. However, of equal importance is the state of the hydraulics leading to the bypass. In particular, the sweeping velocity must gradually increase and not decrease as the flow approaches the bypass. There have been numerous demonstrations where abrupt velocity transitions or insufficient bypass depth have caused fish to reject bypass entry, subjecting fish to potential take. However, caution is urged to ensure that FCA changes do not induce inadvertent hydraulic conditions that cause fish to reject bypass entry.

FCA suggestion for bypass flow depth/depth over screens

*FCA suggested criterion change: "**Depth of water over screen:** The depth of water over the entire screen area should be a function of approach velocity and sweeping velocity criteria as well as input from local fish biologists regarding species present, timing, and life stages present. Water depth over the screen surface should not fall below 6 inches and typically should not exceed 18 inches.*

NMFS reply: As stated above, shallow depths approaching the bypass can cause fish to reject the bypass. In addition, a deviation in the water surface elevation in turn creates deviations in hydraulic conditions that produce an effective bypass. In reality, this occurs at many small screen sites throughout the Northwest, because design conditions cannot be achieved in operation because of low flow conditions. However, during the bulk of the out-migration design conditions are achieved because outmigration occurs during freshets and higher springtime flows. If this FCA design criterion is revised per the above suggestion, original design conditions may not ever be optimal for fish passage, because bypass operations have such a large design range and such a low minimum depth. Input from local fish biologists is of paramount importance for many aspects of general fish populations, but it is not clear how their input could affect screen design criteria.

FCA suggestion to change status of screen from experimental

*FCA suggested criterion change (to NMFS design document): "The 2008 version currently reads: "**11.6.1.7 Horizontal Screens:** Horizontal screens have been evaluated as an experimental technology, and may only be considered if the majority of flow passes over the end of the screen at a minimum depth of 1 foot........" We request that this section be removed.*

NMFS reply: There has not been biological success demonstrated with bypass depths less than one- foot for FCA screens.

As reported in Bonneville Power Administration (BPA) Contract Report DE-AI79-86BP62611, marginal bypass conditions (2-inch bypass orifice, 6-inch bypass orifice and 4.5-inch deep bypass weir) were tested with conventional screens in the Battelle Lab in 1996 to determine which low flow bypass worked the best. The results were that 69 percent to 77 percent of the 45-60 mm Chinook fry moved from the screen forebay and were bypassed within 24 hours. Similarly, 57 percent to 76 percent of the 90-110 mm Chinook sub-yearlings moved from the screen forebay and were bypassed within 24 hours. No significant difference was reported for the three bypass types tested.

In annual testing (2003 through 2008) of the Rocky Reach bypass designed with conventional screen design criteria, and operated as designed, nearly all of the test fish released in the screen forebay make it into the bypass, transit nearly a mile and are returned to the river in an average of about 9 minutes. Also, in 2004 tests at the Walterville canal with conventional screens, total mortality ranged from 0.2 percent to 1.0 percent for Chinook fry, with the combined mortality for all fish (Chinook fry and smolt) only 0.6 percent. Over 93 percent of the fry and over

94 percent of the smolts released upstream of the screens were recovered below the screen in the 4 hour test period.

The FCA screens have not demonstrated this level of passage. In the Jim Buell test of the prototype FCA screen, only 46 percent of the steelhead smolt moved into the bypass during the 17-hour test period. After the initial 6.5 hours of test operations, only 1 percent more of the test fish moved into the bypass, potentially indicating rejection of the bypass conditions by the remainder of the test population.

As noted in the 2002 United States Bureau of Reclamation (USBR) bull trout tests on a FCA screen (that did not comply with the current FCA criteria), up to 3.5 percent of 28 mm bull trout were entrained when bypass depths were a little over five inches. There was also consistently lower survival (1.5 percent) for fish that passed over the screen in comparison to the control. This indicates a minimum fry mortality of 5 percent, higher than the maximum mortality generally seen in conventional screen designs tests (less than 4 percent, often less than 2 percent). Entrainment is a function of exposure time, mesh opening size and approach velocity.

These comparisons of optimal conditions in the FCA screens (i.e. one foot bypass depth) versus the entire operational range of conditions (optimal and suboptimal) tested in a conventional screens suggests that current FCA screens do not exhibit equal performance to conventional screens.

Recent Screen Tests

We recently received a draft Summary and verbal description of recent testing of FCA screens (Mesa and Copeland in 2009). We are willing to review the entire study report; herein we provide the following commentary based on our review of the executive summary of the report.

1) Use of fluouroscein dye injury detection method as a metric for screen injury is not consistent with other screen evaluations done in the Northwest Region. It does not look at overall screen performance. This is because the magnitude of individual fish injury was recorded with the fluouroscein dye method, as opposed a more conventional release and recapture evaluation, which provides migration rates, mortality rates and injury rates of the population at large. The fluouroscein dye method revealed that nearly all fish were injured to some extent on the FCA screens, although some injuries were minor and probably negligible. However, this evaluation did not associate the degree of injury of an individual fish with its long-term survival. For example, a 1 percent injury of an individual fish could be negligible if it is a scale or two, but could cause eventual death if the injury was a distorted operculum.

2) The fluouroscein dye method probably could have utility in detecting de-scaling of smolts. Unfortunately, smolted fish were not tested.

3) There was no attempt to measure screen egress time. For this type of test, marked test fish (smolted) should be released well upstream of the screen and captured or detected downstream of the screen. Egress from the release point to the capture point should be through relatively uniform hydraulic conditions. To determine the extent of delay, egress time through the screen site should be compared with egress time through an equal length of flow conveyance just above

the screen site. Flat-plate Passive Integrated Transponder (PIT) tag arrays could be used to perform this test with PIT tagged fish. Radio telemetry or acoustic telemetry methods could also be employed. Mark and recapture techniques could also be used, but may present problems if recapture of the majority of the test fish does not occur.

Path Forward

Our recommendation is that the current FCA criteria screens remain in experimental technology status until:

1) Egress times for smolts placed in the canal are improved such that 75 percent or more of the test fish released upstream of the screen volitionally exit the bypass within 24 hours, for the entire range of hydraulic conditions that could exist at a prototype screen site. Alternatively, passage rates could be compared between a screened portion of the conveyance, and an equivalent length of the conveyance upstream of the screen. It is particularly important to test for the range of bypass depth. For this type of test, marked test fish (smolted) should be released well upstream of the screen and captured or detected downstream of the screen. Egress from the release point to the capture point should be through relatively uniform hydraulic conditions. To determine the extent of delay, egress time through the screen site should be compared with egress time through an equal length of flow conveyance just above the screen site. Flat-plate Passive Integrated Transponder (PIT) tag arrays could be used to perform this test with PIT tagged fish. Radio telemetry or acoustic telemetry methods could also be employed. Mark and recapture techniques could also be used, but may present problems if recapture of the majority of the test fish does not occur.

2) Debris testing should also be conducted to support the FCA assertion that cleaning can be accomplished with lower screen depths. The type of debris should be typical of debris found in many flow diversions (e.g. suspended sediment, tree leaves, pine needles, aquatic weeds, woody debris, sage brush, others). To be considered an active screen, no accumulations of debris on the screen face can occur under any type of operational condition.

3) The Fish Screen Oversight Committee (including NMFS), agrees that the current design criteria for FCA screens are acceptable for inclusion in regional juvenile fish screen criteria.

We also recommend that none of the changes proposed by FCA to the current FCA criteria are appropriate at this time.

We appreciate the effort that FCA has extended to expand the range of application for the FCA screens. However, as stated initially after the development of the original FCA prototype screen and its associated criteria, we remain skeptical that this style of screen can perform well with alternate criteria, especially a lesser depth of flow over the screens. NMFS recommends FCA only submit for our review, designs that comply with the collaboratively created special criteria for FCA screens.

We are interested in improvements in fish protection and are willing to explore design improvements that contribute to this goal. Please contact Keith Kirkendall (503-230-5431) to arrange for future review of test methods or test results by our staff.

Sincerely,

Bruce Suzumoto
Assistant Regional Administrator
Hydropower Division

Enclosures

cc: Dave Ward

ENCLOSURE 1

Farmers Screen

Submitted to NOAA Fisheries:
July 14, 2009

fca

Suggested Changes to the Farmers Screen Criteria:

The current Farmers Screen Criteria are based on one screen installation in one type of environment and do not reflect any information gained in the last 6 years of screen operation, new installations, and research. The original Farmers Screen criteria reflect a best guess as to what might be appropriate for future installations under varying sizes and site conditions. These criteria were created with an understandably conservative approach.

During the past 6 years, 15 new screens have been installed ranging from 0.5 CFS to 65 CFS with more screens to be installed in 2009. The new screens have been installed in a wide range of site conditions with varying types of conveyance attached to them. Sites have been monitored and hydraulic data have been gathered. Experience from these projects has shown some obvious issues with the current criteria that negatively affect both screen function and fish protection and add significant cost to projects with no correlating improvement in fish protection or screen function.

FCA is asking that the criteria for the Farmers Screen reflect current information based on testing and installations. The specific requests for changes to the current criteria are listed below. FCA would further request that the criteria for the Farmers Screen be periodically reviewed to assess any new data, testing, or information to ensure fish protection as well as optimum screen performance.

Requested Revisions:

The current criteria will be stated first and the suggested change will follow:

In the **Siting** section of the current Farmers Screen criteria:

Current:

- **Bypass Water:** Generally, for screens 100 cfs and smaller, a minimum of 15% of the total diverted flow must be maintained for transporting fish and debris across the plane of the screen. For screens 100 to 500 cfs, a minimum of 10% of the total diverted flow must be available for proper operation.

Suggested:

- **Bypass Water:** Bypass flow must be available at all times for proper screen operation. Bypass flow must be sufficient to meet all other design criteria as bypass flow quantities are a function of screen design and operation.

Rationale: The current by-pass water requirement was an estimate based on one screen installation. Obviously bypass flow quantities are a function of sweeping velocities, depth of water, and the opening at the distal end of the screen. As a percentage of flow, necessary bypass flow to maintain screen function and fish protection is quite low for large screens (5% for 65 cfs, for instance) and is quite high for small screens (50% for 0.5 CFS). An operator can not alter the by-pass water quantity without altering depth of water, approach velocity, and sweeping velocity. A statement that bypass flow must always be available in sufficient quantities to meet all other criteria provides protection without causing unnecessary design constraints. This would be consistent with NMFS criteria for bypass flow for other technologies.

In the **Design** section of the current Farmers Screen criteria:

Current:

- **Normal Velocity (V_N):** The velocity of flow throughout the entire plane of the screen (generally perpendicular to the plane of the screen), at any given point, should not exceed 0.25 ft/s after correcting for net open area (V_N in this case is the velocity through the open parts of the screen, AKA, through-slot-velocity is V_N).

Suggested:

- **Approach Velocity:** The Farmers Screen is considered an active screen due to a hydraulic cleaning mechanism. The approach velocity must not exceed 0.40 ft/s. Using this approach velocity will minimize screen contact and/or impingement of juvenile fish. For screen design, approach velocity is calculated by dividing the maximum screened flow by the vertical projection of the effective screen area. For measurement of approach velocity, see Section 15.2.

Rationale: The original Farmers Screen criteria were, again, based on one screen installation. Subsequent installations have allowed for more hydraulic testing where approach velocities were manipulated to observe operation at higher approach velocities. Impingement of debris was not observed in any installation until the approach velocities were above 0.7 ft/s and only when the sweeping velocity was less than 10 times the approach velocity. Biological testing has also shown no injury and no mortality to either Coho smolts or fry under varying approach velocity scenarios including those that exceed the above recommended criteria. The Farmers Screen should be held to an appropriate standard that protects fish, manages debris, and allows for cost effective screen design.

Current:

- **Sweeping velocity (V_S):** The water traveling parallel to the plane of the screen should have a sustained velocity throughout the entire length of the screen, averaging about 4 to 8 ft/s in order to achieve the maximum cleaning dynamics and fish protection. A taper wall is usually required to maintain correct velocity parameters.

Suggested:

- **Sweeping velocity (V_S)**. The water traveling parallel to the plane of the screen should have a minimum velocity of 10 times the approach velocity to achieve effective cleaning dynamics and fish protection.

Rationale: The sweeping velocity should be tied to the approach velocity. The potential to impinge debris or fish is dependent on both the approach velocity and the sweeping velocity. As the approach velocity increases, the sweeping velocity should be increasing as well to minimize the exposure time to the screen surface. Experience and observation has demonstrated that as approach velocities increase, there is a corresponding increase in sweeping velocity. Due to a much lower chance for the screen to foul, the sweeping velocity does not need to be as high when the approach velocity is relatively low. Recently completed in-situ biological testing supports this conclusion.

Current:

- **Depth of water over screen:** The depth of water over the entire screen area should be maintained at a uniform level between one and two feet. The actual depth will vary as a function of screen size and overall hydraulic conditions. A taper wall is usually required to maintain a uniform water surface elevation over the plane of the screen.

Suggested:

- **Depth of water over screen:** The depth of water over the entire screen area should be a function of approach velocity and sweeping velocity criteria as well as input from local fish biologists regarding species present, timing, and life stages present. Water depth over the screen surface should not fall below 6 inches and typically should not exceed 18 inches.

Rationale: The depth of water over the screen was set based on one screen installation. At the time of installation, that screen had a backwater issue that caused the water over the screen to be almost 24 inches deep. When the backwater influence was removed, the water depth over the screen was decreased to 12 inches, at which point the cleaning dynamics of the screen improved as did the sweeping velocities. Subsequent installations have shown that proper depth is a function of screen size and should not be based on the original Farmers Screen installation. Small screens lose cleaning dynamics when depths approach 12 inches. Small screens operating at depths of 6 to 9 inches have optimal cleaning dynamics and sweeping velocities. Biological testing has shown that depth of water has no relation to fish injury or mortality and therefore should not be set arbitrarily high.

Also, small screens are typically located on small tributaries with less total flow available which in turn limits bypass flow available. Historically, many small diversions have lacked cost effective solutions that fit within current criteria and therefore have gone unaddressed to date.

The above requests are purely for changes to the criteria covering the Farmers Screen. There are also changes needed in the current Anadromous Salmonid Passage Facility Design document. The 2008 version currently reads: "**11.6.1.7 Horizontal Screens:** Horizontal screens have been evaluated as an experimental technology, and may only be considered if the majority of flow passes over the end of the screen at a minimum depth of 1 foot……." We request that this section be removed.

There are very few recent studies or examples of published research that pertain directly to fish screen technologies. Studies of NOAA approved technologies, either in a laboratory or in situ, are very difficult to locate. Of the 144 listed Suggested Reading and References in the February 2008 published NMFS Anadromous Salmonid Passage Facility Design document, there are only 8 that are from 2000 or later and only one of those is related directly to fish screening. Therefore, the requirement that experimental technologies be shown to be at least as effective as current approved technologies before it will be considered is a difficult target to meet as the data showing how effective existing technologies are is not readily available. FCA and FID have collectively performed more testing and generated more data on screen performance than any other new screen technology and all of it has been performed in the past 8 years.

FCA respectfully requests that the suggested changes to the Farmers Screen criteria be accepted and included in the NMFS Anadromous Salmonid Passage Facility Design document. The accumulated research, testing, and in situ performance information all show a fish screening technology that protects fish, reduces operation and maintenance, and reduces initial project costs. Given NOAA Fisheries renewed commitment to decisions based on solid science, we request that the Farmers Screen be granted approved technology status.

Enclosure 2 - Operation, Siting, and Design Criteria[1]

Operation

The intended operation of the overshot horizontal fish screen (The Farmer's Screen) is to safely pass fish and effectively manage debris and sediment. Fish and debris are passed over the screen and off the end to the bypass channel. Diverted water passes through the screen and then flows from a sub-screen chamber over a uniform control weir to the attenuation chamber and then to the inlet of a water conveyance facility. The attenuation chamber functions to create separation between the weir and the water conduit such that any vortical flow at the water conduit entrance does not disrupt the flow dynamics at the weir or screen plane.

Water is introduced to the screen through an inlet transition section. Water flowing through the screen develops the following three velocity components:

- Sweeping velocity (V_S) is the average velocity of water moving directly across (parallel to) the screen from input to bypass output
- Boundary layer velocity (V_B) is the velocity of water in the non-diverted (bypass) flow at or very near the screen (as opposed to V_S which is the velocity of water **above** water layer traveling at V_B)
- Normal velocity (V_N) is the velocity of water passing through the screen approximately perpendicular to the plane of the screen material.

When constant inflow is available to submerge the control weir and screen, an elevated grade line is achieved, and steady-state operation begins. Water entering the screen either sweeps above the screen at V_S (substantially unaffected by the hydraulic condition at the screen) or becomes part of the near-screen hydraulic condition. Water in the near-screen hydraulic condition is diverted between a slower moving boundary layer component, V_B, and a component that passes through the screen at V_N. The V_N flow is the diverted water flow. Water traveling at V_S preferably achieves a relatively uniform fluid flow over water closer to the screen. To the extent that propagating waveforms appear at the water surface elevation over the screen, the V_N oscillates along the vertical axis. This phenomenon enhances screen self-cleaning.

The velocity of the water passing down through the screen (V_N) is relatively uniform across the entire plane of the screen due to the uniform control weir. This uniform velocity ensures that the screen operates without "hot spots," which are non-uniform areas of velocities greater then the acceptable V_N. The uniform control weir also ensures the screen is sufficiently submerged so that fish and debris pass over the screen with adequate water depth. The screen is typically designed with a taper wall to ensure that V_S remains sufficiently high throughout the length of the screen. Correct V_S also reduces the likelihood of trapping debris or delaying fish along the screen. The V_S is typically at

[1] This enclosure is adapted from criteria developed by the Farmer's Irrigation District listed at http://www.farmerscreen.org/tech-info.htm.

least fifteen times greater than V_N. Site-specific adjustments in design and operation are required to optimize system performance over a range of flow levels and site conditions.

Siting

The Farmer's Screen requires proper site conditions in order to function correctly and efficiently. The following information provides the minimum conditions required in order to reliably install the Farmer's Screen at a given site.

These criteria must be met in order for the Farmer's Screen to perform reliably:

- **Bypass water:** Generally, for screens 100 cfs and smaller, a minimum of 15% of the total diverted flow must be maintained for transporting fish and debris across the plane of the screen. For screens 100 to 500 cfs, a minimum of 10% of the total diverted flow must be available for proper operation.

- **Sediment type and load:** Site sediment - suspended and bed load - must be characterized. If sediment is present, then sediment management facilities must be included as an integral component of the screen project.

- **Backwater profile:** The influence of backwater from the water conveyance system must be taken into account when designing the screen system.

- **Debris type and load:** Generally, the Farmer's Screen manages even large volumes of debris in a highly effective manner. In instances where aquatic plants are present, lower V_N values, covers to block UV light, and upstream, fish-safe antifouling treatment might be required.

- **Footprint area:** Adequate area must be available to accommodate the screen structure.

Design

The Farmer's Screen requires proper flow parameters in order to function correctly and efficiently. The following information provides the minimum conditions required in order to realize optimum cleaning dynamics and fish protection from the Farmer's Screen.

The following criteria must be met in order for the Farmer's Screen to perform reliably:

- **Normal velocity (V_N):** The velocity of flow throughout the entire plane of the screen (generally perpendicular to the plane of the screen), at any given point, should not exceed 0.25 ft/s after correcting for net open area (V_N in this case is the velocity through the open parts of the screen, AKA, through-slot-velocity is V_N).

- **Sweeping velocity (V_S):** The water traveling parallel to the plane of the screen should have a sustained velocity throughout the entire length of the screen, averaging about 4 to 8 ft/s in order to achieve the maximum cleaning dynamics and fish protection. A taper wall is usually required to maintain correct velocity parameters.

- **Depth of water over screen:** The depth of water over the entire screen area should be maintained at a uniform level between one and two feet. The actual depth will vary as a function of screen size and overall hydraulic conditions. A taper wall is usually required to maintain a uniform water surface elevation over the plane of the screen.

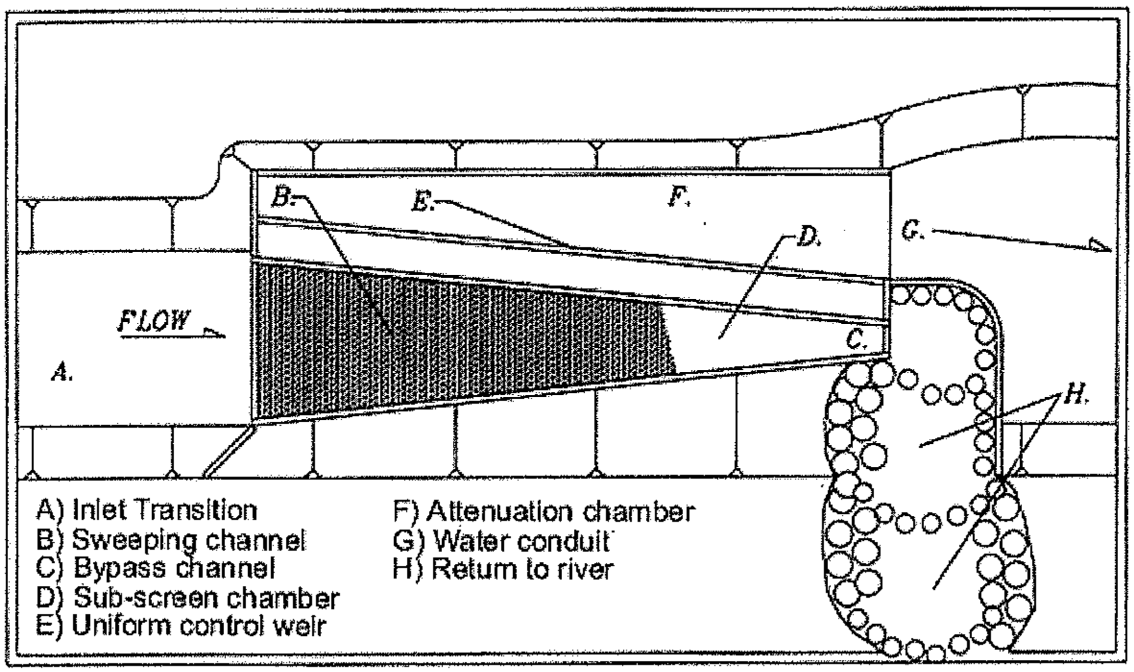
- **Screen area:** The total screen area must be large enough to achieve the correct V_N after correcting for net free area (calculated using through-slot-velocity).

- **Screen hole size:** Screen hole size, material, and open area should be in compliance with NMFS standards and allow for an appropriate footprint size and approach velocity.

- **Length to width ratio:** The length to width ratio must be correctly determined to avoid disruptive hydraulic conditions across the entire plane of the screen.

Features:

A. Inlet transition (from canal to screen)
B. Sweeping channel
C. Bypass (output) channel
D. Sub-screen chamber
E. Uniform control weir
F. Attenuation chamber
G. Water conduit
H. Return to river



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

August 31, 2009

ENCLOSURE 3

Memorandum for: Hydro files

From: Melissa Jundt

Reviewed by: Michelle Day and Keith Kirkendall

Subject: August 13, 2009, Widow's Creek Site Inspection

On August 13, 2009, Michelle Day and I traveled to the Widow's Creek Ranch, near Dayville, Oregon. The purpose of our visit was to inspect the recently installed Widow's Creek Fish Screens, located on Widow's Creek, a tributary to the John Day River. The Widow's Creek Fish Screens, three separate facilities in total, are each of the Farmer's Conservation Alliance (FCA) horizontal screen (these screens are also called "Farmer's Screens") design. We contacted Oregon Department of Fish and Wildlife (ODFW) personnel, Kelly Stokes and Mike Jensen, and arranged a tour of the three screens. In the text below, I will refer to the screens as the upstream, middle and downstream screen. These labels are simply applied in reference to flow from upstream to downstream. My observations from the trip are as follows:

Fish presence on and near the screen

During our tour of the downstream screen, I observed fish on the screen, maintaining location, which may indicate delay on top of the screen. In fact, my shadow caused these fish to move up and down the screen. The water surface was maintained between 0.4 feet (4.8 inches) and 0.55 feet (6.6 inches) (varying between the different screens, with the upstream screen operating at 0.4 foot (4.8 inches) and the middle screen at 0.4 foot (4.8 inches) and the lowest screen at 0.55 foot (6.6 inches, with the lowest screen operating in an unusual mode, see the discussion below). This illustrated an opportunity for fish to hold up on the screen. The fish were readily visible to and could be spotted by a predator.

Sediment and debris conveyance

Typical of most northwest stream and river systems, inflow from Widow's Creek conveys a significant sediment and debris load. During this visit I noted that each of the three screens had some degree of debris occlusion comprised of a mixture of inorganic and organic debris (Caddis Fly, organisms that may have been Western Brook Lamprey ammocoetes or aquatic insects, small gravels, algae, and various forms of other organic materials, see Image 1). Regular fouling occurs and is documented as significant at times (see Image 2). ODFW and the ranch manager stated that the screens require cleaning at least one time per day.

Image 1, organisms found on the screen

Image 2, fouling on the screens

ODFW stated that within one week of installation of the fish screen, operation of the screen was impaired and ODFW reported that the entire screen bay under the screen was full of deposited sediment. In order to perform this sediment removal, ODFW dismantled each weir wall in each screen and shoveled out of the material from the bay under each of the screens. On my August 13 inspection, I observed that a wedge of sediment was forming in the bay under the upstream screen. ODFW states that FCA modified the screens and installed a sluice mechanism. ODFW reported that fish were killed during the operation of the sluice.

In addition to sediment settling out and filling in the bay below the screen, it also settles out on top of the screens and at times can occlude 50 percent of the surface, or more. ODFW stated that one week prior to my inspection the top of the downstream screen was occluded by at least 50 percent with deposition of bedload material. This is a significant observance as ODFW and the ranch manager stated that the screen is cleaned at least one time per day. During my inspection, I found the screen material (perforated plate) occluded with bedload material (small gravel). This material was just the exact size to fit within the screen holes and provide a rough surface to the touch. As part of my inspection, I ran my hand down portions of each screen and forcibly removed five pieces of this material from the upstream screen, see Image 3, below.

Image 3, the material removed from the screen face of the upstream screen. Note the angularity of the small gravel (nearly small enough to classify as coarse sand).

<u>Operating water depth</u>

I observed the upstream screen and the middle screen operating below the "design" condition of 6 inches (the design parameter stated to us by FCA prior to installation of the Widow's Creek project). In Images 4, 5, and 6, below, Image 4 represents the upstream screen and documents the operating depth of 0.4 foot (4.8 inches), Image 5 represents the middle screen and documents the operating depth of 0.4 foot (4.8 inches) and Image 6 represents the downstream screen and documents the operating depth of 0.55 foot (6.6 inches). ODFW stated that the downstream screen was operating in an abnormal way and when I observed the screen, I noted that a large amount of return flow was conveyed in the diverted water bay, which caused the screen to backwater (Image 7). Therefore, my observation of the water depth over this screen was that it exceeded the 0.5 foot of water depth planned for by the designer, but that it likely did not represent normal operating conditions.

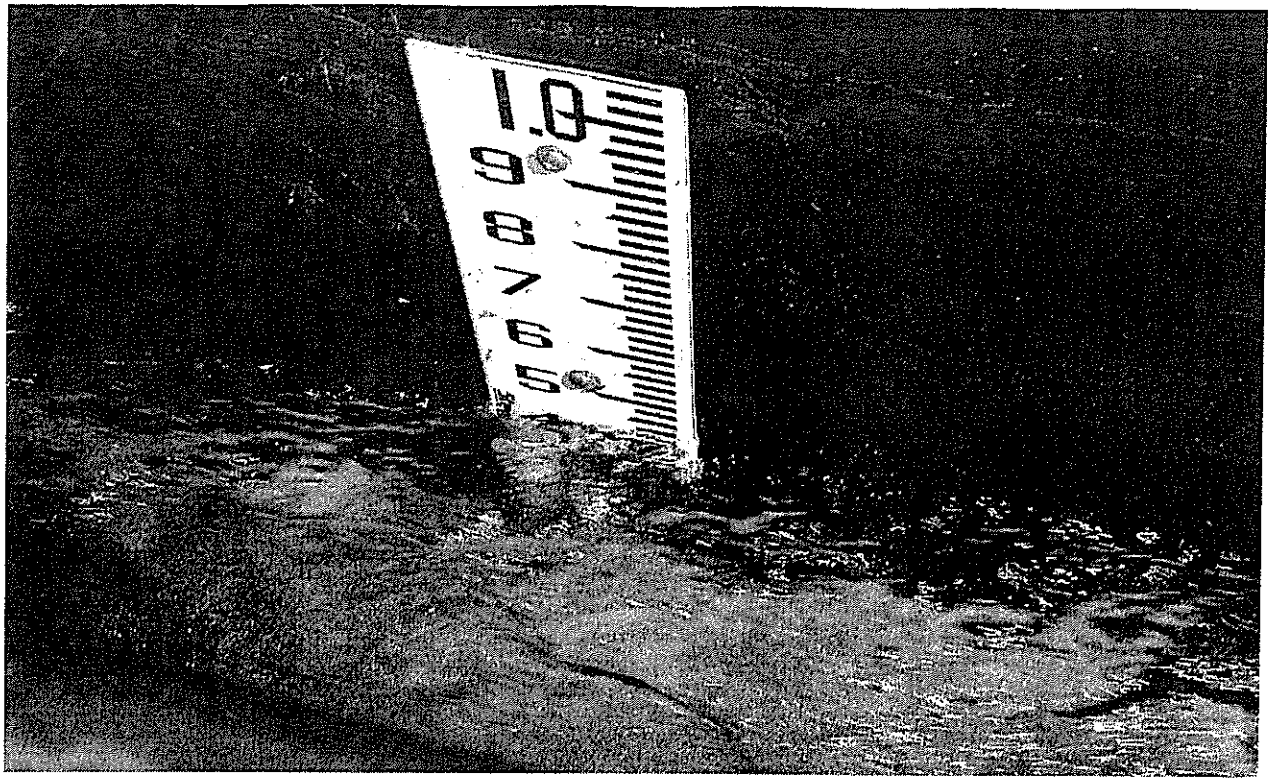


Image 4, upstream screen operating water depth

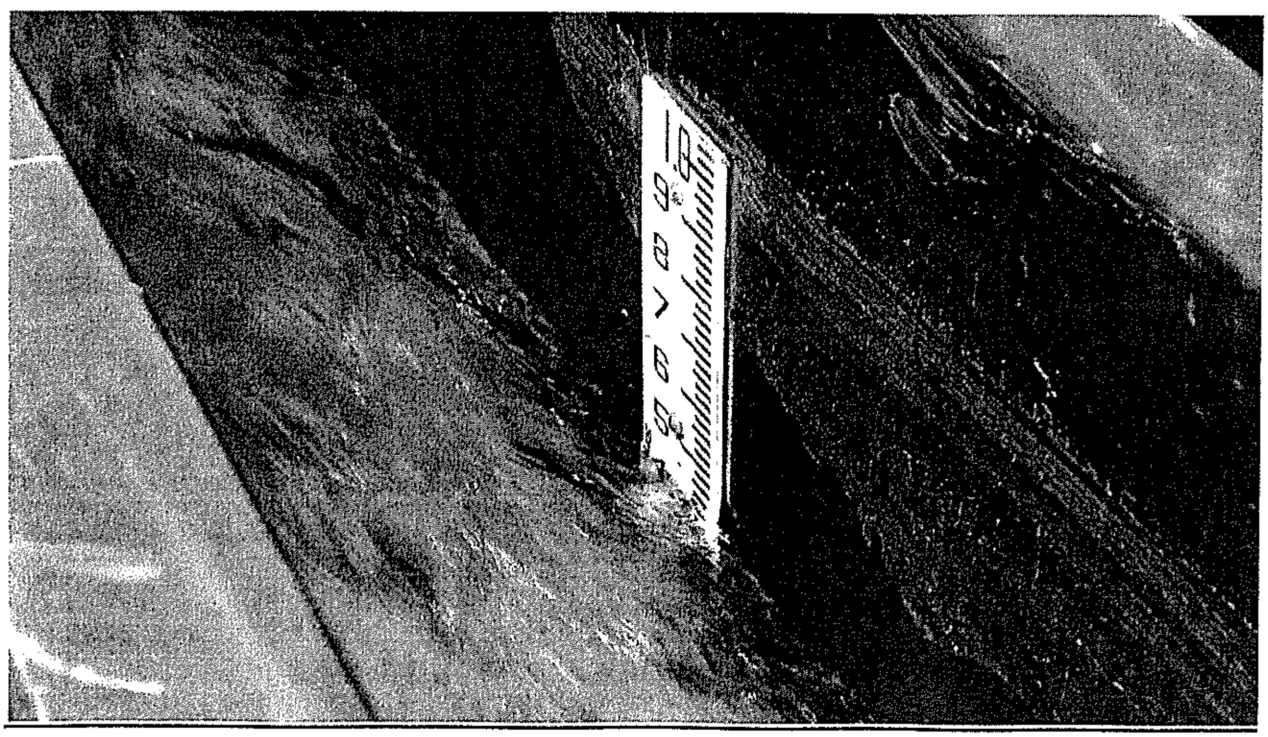


Image 5, middle screen operating water depth

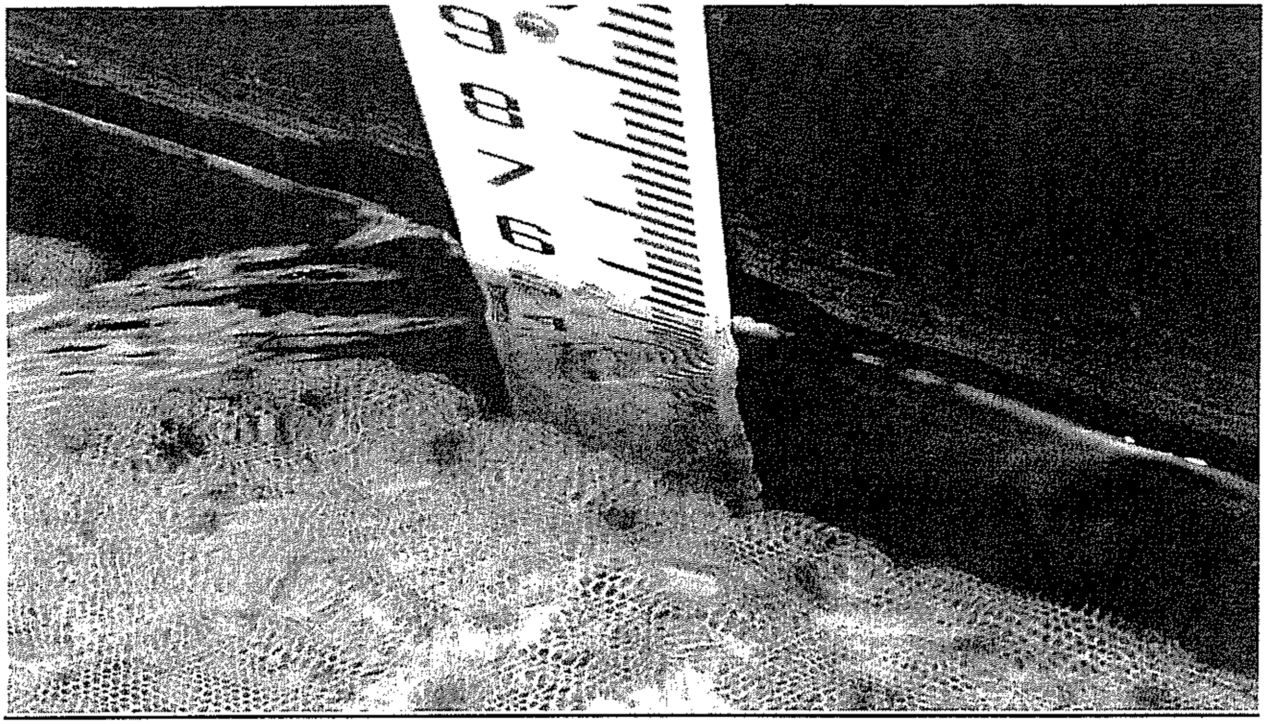


Image 6, downstream screen operating water depth

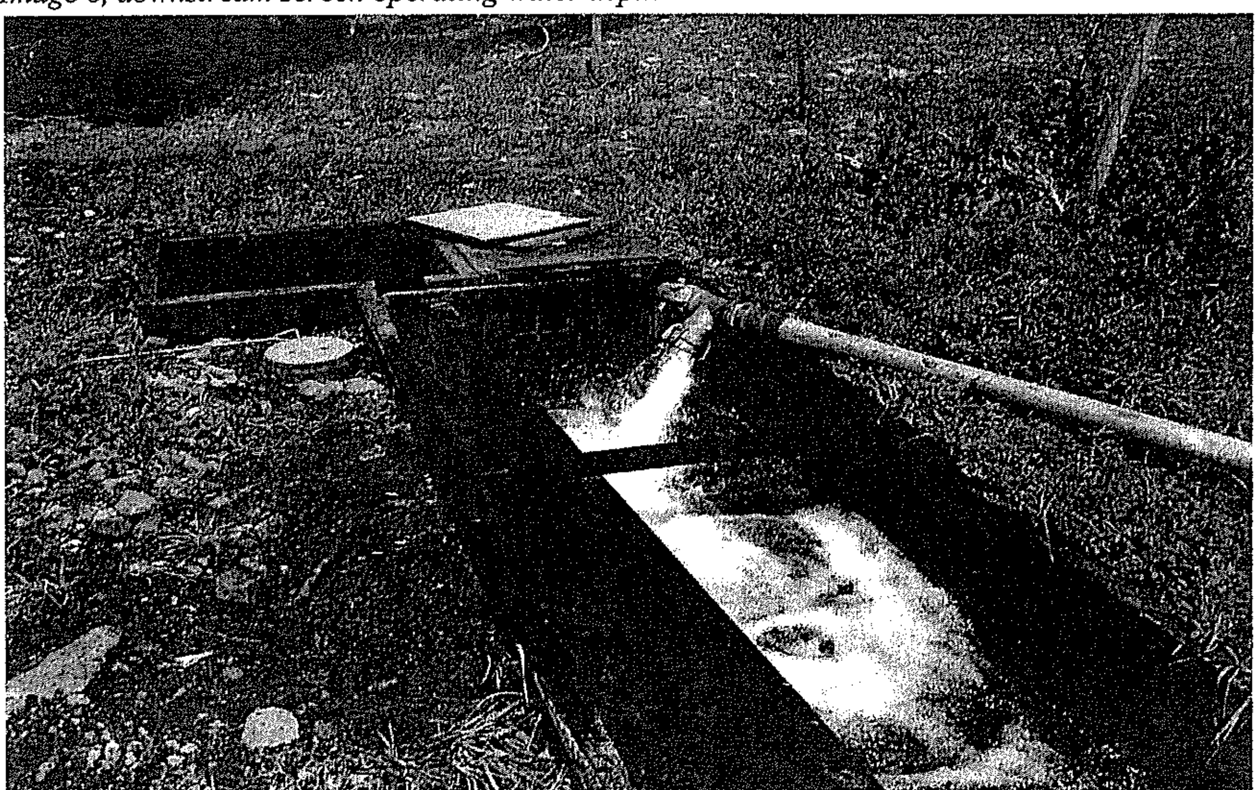


Image 7, downstream screen unusual operation with return flow to diverted water bay backwatering screen

Bypass flow

Two issues related to the bypass operation were reported by ODFW. Late in the operating season, no flow in excess of the diverted flow will be available for bypass, meaning that the bypass will be closed. This is a concern and violates the criteria the special FCA screen criteria. Also, I observed that even with flow available for bypass, fish are routed directly below the screens. I observed fish below the diversion structures. The three diversions provide a complete passage barrier to any fish interested in passing upstream (image 8).

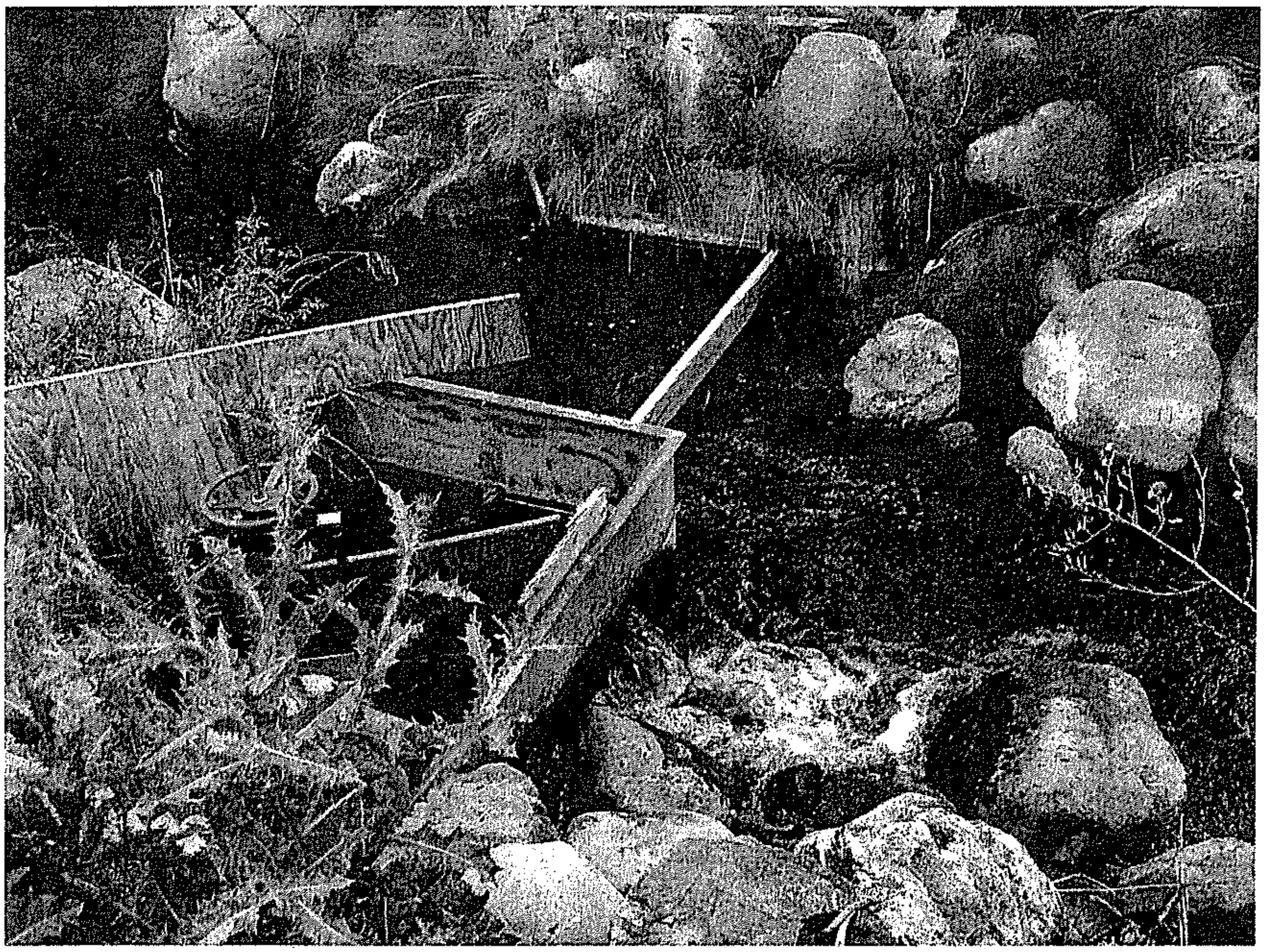


Image 8, upstream passage barrier