# CONSERVATION INNOVATION GRANTS

Final Progress Report September, 2015

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| Grantee Name: Clark Fork Coalition | |
| Project Title: **Evaluation of Watson Horizontal Flat-Plate Fish Screen in Montana** | |
| Agreement Number: 69-3A75-12-211 | |
| Project Director: Will McDowell | |
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| Period Covered by Report: October 1, 2012 to August 31, 2015 | |
| Project End Date: August 31, 2015 | |

**A) Summarize the work performed during the project period covered by this report:**

The Clark Fork Coalition arranged for the Bureau of Reclamation Water Resources Research Laboratory in Denver ("Hydraulic Lab") to receive, install and test a Watson Fish Screen in November, 2013. Watson Irrigation fabricated a scale screen (3' wide by 8' long) and shipped it to the Bureau in Denver on 15 October, 2013. Once the Federal government shut-down was resolved, Bryan Heiner, P.E., of the BOR Hydraulic Lab installed the screen into a large flume within the Lab.

On 19 and 20 November, 2013, Clay Watson, Will McDowell and Casey Hackathorn from Montana travelled to Denver, to visit the BOR Hydraulic Lab and see the hydraulic and biological performance of the Watson screen. Bryan Heiner reviewed his preliminary work on the screen, explaining that the test screen's performance could be scaled up to a larger screen using simple mathematics.

After a presentation on the screen's initial hydraulic performance, the Montana group was able to watch the screen performance under varying hydraulic conditions in the laboratory flume. After discussing a number of options for improving the screen, Clay Watson made some modifications in the laboratory, so that the team could evaluate the effect of those improvements. By the end of 19 November, a set of improvements was in place that Clay was satisfied with, including an entrance ramp, smaller screen perforations (5/32") and three vertical baffles to improve water depth over the entire screen surface.

On 20 November, 2013, the BOR team (joined by Brent Mefford, a recently retired senior BOR engineer) introduced small trout (2-3" rainbow juveniles) to the flume, and the group was able to visualize the issues with fish crossing the screen at a series of different flow rates. A final meeting was held to review progress and detail what the BOR will include in their report, as well as discuss the workshop options in Montana for 2013. Will McDowell and Casey Hackathorn departed after lunch on 20 November, and Clay Watson returned to the laboratory to continue working on some modifications to the screen during the afternoon.

In winter 2013-2014, Will McDowell developed an outline for the small screen workshop, set dates for 6-7 August, 2014, and contacted all the key partner organizations to advertise the workshop opportunity. The BOR engineer, Bryan Heiner, and Brent Mefford of Wild Fish Engineering (formerly BOR), were recruited as the key presenters for the workshop.

The Clark Fork Coalition (CFC) coordinated the fish screen workshop on August 6 & 7, 2014, in Deer Lodge, MT. Fourteen agency professionals from the NRCS-Montana, including the State Engineer and Regional Engineer, NRCS biologists, and MT Fish Wildlife and Parks fish biologists attended the workshop. The BOR's engineer Bryan Heiner, and private consultant Brent Mefford (formerly of BOR) were the technical specialists leading the workshop. The BOR provided a "Small Scale Fish Screen Selection Guide" draft report, led two field tours to evaluate four distinct installed screens in the Deer Lodge-Anaconda area, and led an exercise with three inter-agency teams selecting a screen for a potential project site on Warm Springs Creek near Anaconda. Participant evaluations for the workshop were very positive.

In September, 2014, the CFC and TU inspected a new modified Watson screen installed in Gurney Creek, Broadwater County, Montana, using some of the design innovations developed during the flume tests. In winter 2015, the Trout Unlimited partner used the BOR engineer's report to develop guidelines for sizing and installing modified Watson screens for fish passage purposes (see GUIDELINES REPORT attached).

In spring 2015, Watson Irrigation installed eight (8) new screens on irrigation intakes in Broadwater, Madison, Gallatin and Wheatland counties, using the design modifications developed during the project. The incorporation of key fish passage design innovations into new screens being fabricated and installed by Watson Irrigation is a significant accomplishment for the project.

**B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:**

**Objective 1: Procure expert evaluation of the Watson screen's hydraulic performance in its current form, and provide recommendations for the fabricator to modify and improve his screen design.** **<u>Measurable outcome:</u> Professional analysis of hydraulics of existing screen and concrete proposals to improve the design.**

The Objective 1 result is "expert evaluation of the hydraulic performance of the Watson fish screen, with recommendations." The laboratory work in Denver was completed in November, 2013. Clay Watson made multiple modifications to the screen design in the laboratory, as he evaluated the performance of the screen in the BOR flume. The BOR personnel made a quantitative evaluation of hydraulic characteristics of the flume before and after the modifications were made. The BOR issued a draft report in January, 2014 of the existing screen and the modified design. The CFC, TU, and Watson made comments on the draft report, and a final BOR report on the screen and modifications was completed in April, 2014 (see attached).

The desired outcome, concrete recommendations for screen improvement, was accomplished and exceeded. The developer of the screen made three major modifications to the existing design: 1) install an entrance plate to force flow lines parallel to the perforated plate surface and prevent large quantities of water or debris—and small fish--- from being sucked into the screen at the entrance; 2) reduced the plate perforation size from 5/32" to 3/32", which is a smoother material; and 3) install three vertical baffles in sequence below the screen to equalize water levels over the screen and reduce localized "hotspots" of high screen entrance velocity.

These concrete improvements to the screen design make it function more efficiently from a hydraulic viewpoint, screen out more sizes of smaller fish, reduce screen entrance velocity, reduce fish impingement on the screen and increase fish survival.  The developer has incorporated these improvements into the model of screens he now provides for producers in western Montana.

**Objective 2:  Evaluate the biological performance of several variants of the Watson screen with fry and/or juvenile size Oncorhynchus trout, and incorporate biological criteria into modified designs.** **<u>Measurable outcome:</u>   New designs for Watson flat-plate screens adapted to meet or closely approach NMFS criteria for application on bull trout streams, and a less expensive design for westslope cutthroat streams.**

Objective 2 was "evaluate the biological performance of the Watson fish screen."  The laboratory biological evaluation was done in November, 2013, immediately after the hydraulic evaluation.  Clay Watson, Will McDowell (CFC) and Casey Hackathorn (TU) were present for two days and made modifications to the screen in response to hydraulic test results.  Then approximately 100 small rainbow trout (2"-3" with a few specimens of 4" to 5" length) were released into the flume, to test their response to the modified screen.  These trout were flushed over the screen in small groups of 10 or 20 as the flow characteristics and some screen characteristics were changed.  This response was videotaped by the BOR engineer, and the fish were held for two weeks after the test to measure mortality.  The modified Watson screen did not cause any fingerling mortality in the tests (zero fish mortality).

One important lesson learned was that the 3/32" screen performed nearly the same as the 5/32" screen hydraulically under the conditions tested, because the discharge flow rate of approximately 2 cfs (modeled, about 0.45 cfs actual) was controlled almost entirely by the hydraulic head over the inlet of the discharge pipe, and not by the flow rate through the screen. The 3/32" screen also has a smoother surface, much less inclined to abrade and damage the fish's  skin.  It also better excludes small fish (large fry and small fingerling size) and appears to be stronger/ more resistant to damage.

Clay Watson also tested the feasibility of setting three vertical baffles with vertical slot openings below the screen to maintain adequate water depth and flow distribution over the screen as the flow rates decline.  He set wooden baffles in place perpendicular to the flow direction, to model this effect. His initial take on the baffles was quite positive.  Experimentation with increasing tailwater by forming a weir at the screen outlet was not successful, because of the extreme hazard for small fish created by colliding with poorly seated weir blocks. There did not appear to be a simple, low maintenance way to increase tailwater.

The modified screen does not meet NMFS criteria, but the initial biological tests showed 100% survival of fingerling rainbow trout after two weeks of the fish used in the laboratory screen demonstration.

**Objective 3 is to "develop design and installation guidelines for new Watson screen and train engineers and conservationists in western Montana in their use."**  This objective was planned for April-December, 2013.  In actuality, TU and CFC developed the guidance in winter-spring 2015.  The guidance document builds off of the laboratory experience, the BOR report, and subsequent analysis of Watson and other screens in workshop and in the field.  The main limitation to the improved design Watson flat plate screen is that it requires relatively large quantities of bypass water to function efficiently.

**Objective 4 "promote the new screens through public outreach and support installation and maintenance of new screens."** The CFC and TU partners are working to promote the use of these improved design Watson screens in appropriate applications. Fish screens usually need to be custom-designed for a site. Therefore the improved Watson screen should be promoted in appropriate sites. The Watson Irrigation company is promoting the use of their screens with pivot sprinkler projects they are installing around western Montana. In spring, 2014, Watson installed one improved screen in Broadwater County. In spring, 2015, Watson installed eight (8) modified screens in Broadwater, Madison, Gallatin, and Wheatland counties, Montana. The successful incorporation of this improved, more fish-friendly design into the Watson Irrigation company's work is a significant accomplishment.

**C) Describe the work that you anticipate completing in the next six-month period:**
This is the final report, which accompanies final invoices and financial reports.

**D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:**

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

   The nine projects installed in fall, 2014, and spring, 2015, were all done without EQIP involvement. This was not intentional, but simply a result of the type of individuals demanding new screens for pipeline installations, and the robust current farm economy, in this part of western Montana, many of whom can afford to install these technologies without EQIP funding support.

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

   *N/A.*

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

   *N/A.*

# Guidelines for Use of Watson Irrigation Screens for Fish Screen Applications

Prepared by Trout Unlimited
For the Clark Fork Coalition
August 2015

**Background**

Over the last two decades, Watson Irrigation of Townsend, MT has developed a horizontal flat-plate debris screen to provide a cost effective and minimum-maintenance solution for screening debris from irrigation water at pipeline inlets. In recent years, this screen design has been installed experimentally as a fish screen on multiple irrigation diversions on Upper Clark Fork tributaries. Irrigators have been pleased with their performance and the screens appear to be protective of fish. Because of its promise as a low cost fish screen design alternative, the Clark Fork Coalition contracted with Trout Unlimited and the Bureau of Reclamation (BOR) to assist with evaluating the Watson Irrigation screen design for use as a fish screen. The purpose of this document is to summarize the findings of these evaluations and to provide practical guidance for irrigators and natural resource professionals considering use of the Watson Screen design as a fish screen.

**Discussion**

Based on the Bureau of Reclamation laboratory results summarized in the attached report, *Hydraulic Laboratory Technical Memorandum PAP-1085 Clark's Fork Coalition & Watson Irrigation Fish Screen Tests* and our field evaluations, the Watson screen design appears to function effectively to protect adult and juvenile salmonids from entrainment under certain conditions. Providing adequate bypass flow to maintain adequate water depth and sweeping velocities across the entire screen surface was the biggest factor in protecting fish moving over the screen. The original screen design had certain limitations in initial tests, in terms of its ability to successfully pass fish and debris without large proportions of bypass flow. However, modifications to the design that eliminated a hydraulic jump coming onto the screen and reduced velocities through the upper portions of screen were successful in reducing bypass water required to decrease the likelihood of fish contact with the screen surface and potential for impingement or injury. These modifications also improved the screen's performance in passing debris.

Bureau of Reclamation evaluation and performance testing of a screen prototype at the BOR Hydraulics Laboratory in Denver, CO resulted in some potential modifications to the Watson design that could improve its performance for passing both fish and debris over the screen. Clay Watson of Watson Irrigation participated in the testing and collaborated on modifications that included installing baffling under the screen (three baffles perpendicular to flow direction), adding a section of unscreened "guidance plate" at the leading edge of the screen surface, and reducing the hole size of the screen plate to 3/32 of an inch. The modified prototype was subsequently tested for hydraulic and biological performance in the Lab. The screen prototype with baffling, guidance plate, and reduced screen opening is referred to as the "modified" Watson design in the remainder of this document. Watson has since incorporated all of these elements into their standard screen box design.
In addition, when utilizing the Watson design for fish screen applications we recommend considering elimination of any obstructions to flow passing over the screen with which fish can collide such as "bull bars" on the downstream end of the screen over the bypass outlet which can potentially injure fish moving over the screen.

**Selection and Design Considerations**

The Watson Irrigation screen is most appropriate for fish screen applications that:

- Are not required to meet regulatory design criteria such as NOAA/NMFS
- Can provide for abundant bypass flow
- Will be periodically monitored and maintained to manage for conditions favorable for fish

The following hydraulic design guidelines should be considered when designing diversion systems incorporating a Watson screen as a fish screen:

- **Screen Size:** The Watson screens are currently built in two sizes: 3’x8’ for screens for pipelines up to 10” and irrigation flow rates up to approximately 2.5 CFS (1,100 GPM) and 3’x16’ for pipes up to 18” and irrigation flow rates up to approximately 9 CFS (4,000 GPM).

- **Bypass Flow:** Lab testing indicated that bypass flow of greater that approximately 75% of the screened flow was required to keep the screen wet with the unmodified 3’x8’design. With modified design including baffles, the bypass flow required to maintain some water over the entire screen could be reduced to as low as 10%. The Watson screen, like all horizontal flat plate screens, requires water flow over the entire screen to clear debris and avoid fish mortality. Bypass flow requirements should be considered with the desired water depth over the screen discussed below.

- **Water Depth:** NOAA criteria require maintaining one foot (1’) of water depth over the entire screen surface for horizontal screens. This depth does not appear to be a realistic goal for the Watson design, including the “modified” version, due to the quantity of bypass water that would be required to maintain it. Biological goals should be determined for each screening project for the water depth over the screen. Depth goals should be discussed with local fisheries managers to determine the design bypass flow required for your project. In the BOR flume tests, the 1” flow depth over the modified screen easily passed 2” to 4” length rainbow trout fingerlings, with a very good fish survival rate (see BOR report). Water depths greater than the body depth of the largest adult fish in the system would be ideal to pass adult fish while preventing them from contacting the screen and allowing them to maintain an upright orientation over the screen. The following table derived from the BOR lab testing provides an estimate of bypass flow required to maintain minimum water depths over the modified 3’x8’ screen design*.

| **Minimum Depth over Screen (in.)** | **Screened Flow (cfs)** | **Bypass Flow (cfs)** | **Total Flow Diverted (cfs)** |
|---|---|---|---|
| 0.33” | 2.0 | 0.2 | 2.2 |
| 0.75” | 2.0 | 0.9 | 2.9 |
| 1” | 2.0 | 1.6 | 3.6 |
| 2” | 2.0 | 3.1 | 5.1 |
| 3” | 2.0 | 5.2 | 7.2 |
| 4” | 2.0 | 7.2 | 9.2 |

*flows below one-inch depth are likely to be increasingly detrimental to fish survival.

**Optimizing Screen Performance**
After the screen and related irrigation infrastructure are installed, we recommend conducting performance testing of the screen to determine actual flows required to maintain the desired water depth over the screen and deliver the desired irrigation flow. Adjustments can then be made as conditions change over the irrigation season to maintain the desired conditions. A staff gauge can be installed on the screen box to assist in monitoring depth on the screen.  Extrapolation from the existing BOR test data with different flows or screen dimensions is not recommended, and cannot substitute for actual field tests.

**Monitoring and Maintenance**
Several environmental factors may affect the performance of a Watson screen that can change over the course of an irrigation season including streamflow and debris load.

**The dead-end conditions shown here, where no bypass water reaches the end of the screen, should be avoided**

Regular inspection and adjustment of the irrigation system are required to ensure the proper function of the screen to protect fish and deliver water through the changing conditions of an irrigation season. The following inspection and maintenance schedule is recommended:

Daily

- Inspect the headgate and remove any debris
- Inspect the screen surface and remove or brush off any debris
- Adjust headgate as necessary to maintain desired water depth over screen
- Inspect bypass pipe and remove any obstructions to free flow of water and return of fish

Annually

- Inspect screen surface. Should be smooth and free of sharp edges. Repair if necessary.

**Additional Information**

For additional information regarding these guidelines or Watson screens contact:

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