Irrigation Diversion Structures

Applicability

Irrigation diversion structures are a key structural component of most irrigation systems on the upper and middle reaches of the Musselshell River. Many have been in-service for over a century. These structures provide a means of elevating and diverting water from the river into a canal that conveys water to fields, often miles away, for the purpose of irrigating cropland, hay land, and pasture. A major advantage of these structures is that they function without need of an external power source. The disadvantage is that they bottleneck the river causing long-term impacts to the physical and biological health of the river.

This Best Management Practice (BMP) reviews the major types of irrigation diversion structures found on the Musselshell River and similar rivers in Montana. On-site observations of irrigation diversion structures and discussions with Musselshell River water users are the basis for the information that follows.

Modifications or replacement of an existing irrigation diversion structure, including a change in the water volume diverted, change in location, and/or an alternative means of withdrawing water (i.e. pumps), will require an application and authorization process through the Montana Department of Natural Resources and Conservation, Water Resources, Lewistown Regional Office.

Figure 1: Irrigation diversion upstream from the town of Musselshell.
Photo Credit: Karin Boyd

Description

This Irrigation Diversion Structure BMP addresses the following items:

I. ***Site Location:*** Consideration of site characteristics when locating an in-channel diversion structure.
II. ***Checking Water to the Headgate:*** Attaining a water level that will provide a suitable amount of water to the headgate.
III. ***Fish Passage:*** Alternative ways to provide fish passage.
IV. ***Fish Entrainment:*** Options to reduce fish entrainment into the irrigation system.
V. ***Irrigation Diversion Alternative:*** Pumps are an alternative to in-channel diversion structures.
VI. ***Permitting:*** Permits are needed for irrigation diversion structure replacement or maintenance.

I. Irrigation Diversion Structure Location

Nearly all the irrigation diversion structures on the Musselshell River have been in-place for decades. When these structures require major maintenance or total replacement, it is unlikely that they will be relocated to a different place on the river. Diversion structures are typically associated with other permanent infrastructure (i.e. headgate and canal) so they need to remain near their original location, even if it isn't the most stable of sites. Upon the rare occasion when a new irrigation diversion structure is being built or an existing one is being relocated, the following items should be considered:

1) *Location:* Locate an irrigation diversion on the downstream arm of a river bend. The river current is greatest along the outside bend. The current will direct flows more effectively into the headgate and provide sufficient energy to keep woody debris away from the headgate (the configuration of the headgate is also important in that regard). When possible, tying the diversion to a hard point such as a bedrock bluff will add stability to the structure.
2) *Bank Stabilization:* Evaluate and determine whether bank stabilization measures are necessary on the upstream outside bend. The high-energy current along the outside bend may erode the bank; saturation and sloughing of the bank may also occur from diversion structure backwater. Without adequate protection, there is a danger of the diversion structure and headgate being flanked during high flow or ice events. There may also be concerns downstream if the diversion structure serves as a bottleneck and "fire hoses" the river towards a bank or canal buffer.

Figure 2: Irrigation diversion structure on downstream arm of bend.
Photo Credit: Kestrel Aerial Services, Inc.

3) *Floodplain Access:* Allow high water access to the floodplain, opposite the headgate, to reduce bottlenecking of the river and to relieve excessive pressure off the diversion structure, headgate, and outside bank. Careful design and periodic monitoring is required to minimize high water headcutting through the floodplain that could result in the river flanking the structure.

II. Checking Water to the Headgate

There are several ways that irrigation diversion structures can be designed to provide an adequate head of water at the headgate entrance.

1) **Permanent Check Structures:** Many of the irrigation diversion structures on the Musselshell River permanently check the river level year around. There are two types commonly seen in Montana:

1. *Concrete Diversions:* Common to the Musselshell River, they typically consist of concrete abutments, mass floor foundation, and a cross-channel concrete wall or sill that remains in-place year long.
   Advantages: The water is always checked up so water is readily available when needed; can lift water higher than other types of diversions; serves as a channel "hard point" that can prevent channel downcutting.
   Disadvantages: Subject to high water and ice damage; creates sedimentation behind the diversion and at the headgate that often requires periodic dredging; limits fish passage; and expensive to maintain.

Figure 3: Rock irrigation diversion.
Photo Credit: Warren Kellogg

2. *Rock Diversions:* These structures are not common on the Musselshell River, but they are more so on other Montana rivers. They are in-channel rock diversions that consist of large angular rocks carefully keyed into the channel bottom and both sides of the river.
   Advantages: Same as 1a above; can be designed to allow sediment to pass and accommodate fish passage; easier and less expensive to maintain.

Disadvantages: Subject to high water and ice damage; life span generally not as long as concrete structures; water level lift is usually less than 3 feet.

2) **Seasonal Check Structures:** These structures provide a low-flow seasonal check that raises the water level when needed. The check is removed when not needed, allowing the water level to return to normal river grade. There are two types of seasonal check structures:

1. *Permanent Seasonal Structures:* These structures typically have permanent abutments and a mass foundation fitted with anchors to accommodate the placement and removal of a seasonal check (jack legs, boards, inflatable pillow, etc.). There are a few such structures in the Musselshell River.
   Advantages: Less subject to high water and ice damage; allows sediment and bedload to pass most of the year; provides for fish passage most of the year; less expensive to maintain.
   Disadvantages: Need to place and remove the seasonal check every year.

2. *Temporary, Portable Structures:* Seasonal check structures that are placed in the channel when needed and removed at the end of the irrigation season (flat steel plates with jack legs, pre-cast concrete blocks, etc.).
   Advantages: Seldom impacted by high water; passes sediment and bedload; allows for fish passage; less expensive to maintain.
   Disadvantages: Need appropriate equipment and channel conditions to place and remove the portable structures every year.

III. Fish Passage

Barriers to fish passage, in the form of irrigation diversions, can reduce the distribution and habitat available to fish. Prairie fish (warm water species) are commonly found where most of the irrigation diversion structures in the Musselshell River are located. These fish evolved in low gradient systems so their swimming and jumping abilities are much less than that of migratory cold water salmonids (trout). Providing fish passage for prairie fish requires careful consideration of water velocities, water depths, resting habitats, and turbulent flows.

Figure 4: Tongue River fish by-pass channel. Photo Credit: USDA-NRCS.

There are two general approaches to allowing fish passage at an irrigation diversion structure:

1) **Permanent Irrigation Structures:** For these structures, there are generally two approaches.

1. *By-Pass Channel:* This is a low-gradient, constructed channel that circumvents the irrigation diversion. It is usually the best option for a high head diversion. The by-pass channel gradient, depth, and velocity are critical in assuring effectiveness.
2. *Fish Ladder:* This is a structure that can be either a constructed "ladder" or a rock ramp that provides passage over the diversion. Constructing fish ladders can be expensive with uncertain results, especially in regards to warm water fish species. They can also be more subject to high water and ice damage than by-pass channels.

2) **Seasonal Irrigation Structures:** These structures provide unobstructed passage for fish during the non-irrigation time of year. Proper design of these structures is important to assure there is sufficient water depth and low velocities over the floor of the structure. Any low-head drop off the structure's outlet apron could also be a detriment to fish movement upstream.

IV. Fish Entrainment

Fish losses in a canal system can have a significant impact on fish populations. Fish screens can be effective, but are costly to install and require regular maintenance. The costs and benefits of screening must be considered in comparison with other management actions that could enhance fish populations. Below are some factors to consider in regards to fish entrainment in canals:

1. Work cooperatively with Montana FWP to determine the significance of fish entrainment in a given irrigation canal and whether screening is worth the expense.
2. If fish entrainment is a serious issue, self-cleaning trash screens can be installed either at the headgate or a short distance down the canal. Screen design and selection need to fit the specific irrigation diversion and be adapted towards the targeted fish species.
3. Gradually reducing diverted flows over a period of several days has been shown to be an effective practice in signaling fish to move out of the ditch or canal before it is shut completely off for the season.

V. Pumps – Alternative to Irrigation Diversion Structures

Following the 2011 flood, several irrigation diversions were severely damaged. Some water users opted to go to pumps rather than pay the high cost of replacing the diversion structures.

Advantages: Not subject to high water and ice damage (portable pumps); allows sediment and bedload to pass; does not impede fish passage; less expensive to maintain; water use efficiency; increased crop production.

Disadvantages: Annual production expense – power; may require the purchase of new infrastructure: conveyance system (buried pipeline) and sprinklers.

Refer to the Irrigation Pump BMP for more information.

VI. Permit Requirements

Permits may be required for maintenance and relocation of irrigation diversion structures. Permits may be required from the Corps of Engineers (404), the Montana Department of Environmental Quality (318), the Montana Department of Natural Resources and Conservation, and the local Conservation District (310). For local contact information regarding applicable permits, see the Musselshell River Permit Contact Info Supplement available at your local conservation district office. Also see the Guide to Stream Permits at the Montana Department of Natural Resources and Conservation online at http://dnrc.mt.gov/permits/streampermitting/guide.asp.