Date: November 9, 2006

BUREAU OF RECLAMATION
TECHNICAL SERVICE CENTER
DENVER, COLORADO

TRAVEL REPORT

RES-3.50

Code: 86-68560 **Date**: November 9, 2006

To: Tim Randle, Manager, Sedimentation and River Hydraulics Group
Clifford A. Pugh, Manager, Water Resources Research Laboratory Group
Robert Einhellig, Acting Manager, WRRL

From: Tom Gill, 86-68560 Hydraulic Engineer;
Kent Collins, 86-68540 Hydraulic Engineer

Subject: Travel to North Dakota to view Missouri River pump intake sites

1. Travel period: October 16-20, 2006

2. Places or offices visited: Dakota Area Office (DKAO), Fort Yates Municipal Intake, Fort Yates Irrigation Pump Intake, Cannonball Irrigation Intake, sites along the Heart River, Horsehead Irrigation (Parts 1, 2, 3, & 5) pump intake sites, Fort Clark Irrigation District pump intake, and Buford-Trenton Irrigation District pump intake and delivery system.

3. Purpose of trip: The primary objectives of this trip were to view sites where various issues are impacting the ability to pump water from the Missouri River, and to view erosion problems being experienced along the Heart River, below Heart Butte Dam. A secondary issue that was addressed as part of the trip was viewing sites along the Buford-Trenton delivery system that may be candidates for demonstrating canal modernization technologies.

4. Synopsis of trip: We arrived mid-day at the DKAO in Bismark ND on Monday, Oct. 16. We spent that afternoon reviewing aerial photo maps of sites we would be visiting during the week with DKAO staff, including Jim Weigel (DK 600), Ryan Waters (DK 400), and Randy Ehlis (DK 372). The DKAO staff provided a background on recent efforts that the respective diverters at the various Missouri River intake sites have undertaken.

The Fort Yates sites, Cannonball, and Horsehead Parts 1, 2, 3, and 5 all divert from a reach of the Missouri between Bismark and the North Dakota – South Dakota state line that, over the past three to four years has reverted from reservoir conditions to river conditions as the level of Lake Oahe has dropped on the order of 50 feet due to a prolonged period of low precipitation experienced in the region in recent years. At all sites, the reversion to river conditions has resulted in water receding away from the pump sites that had previously been used for pumping water from Lake Oahe. The distance from the reservoir pump sites to the current river channel varies significantly from site to site.

The Fort Clark and Buford-Trenton pump sites are at locations along the river that are upstream of the capacity reservoir elevations of Lake Oahe and Lake Sakakawea, respectively. The issues faced at each of these pump sites is a high rate of sediment diversion, as well as sand bars that are approaching pump intake channels at each of the sites.

The Heart River features extensive meander bends with active erosion along the outer bank at most bends that is encroaching on farmlands, roads, and any structures along the bends. In the opinion of some area land owners, the rate of meander erosion seems to have increased since construction of Heart Butte Dam.

Our site visit schedule included: Fort Yates municipal and irrigation intake sites, Cannonball irrigation intake, and the Heart River on Tuesday, (Oct. 17); Horsehead Irrigation Parts 1, 2, 3, and 5 on Wednesday, (Oct. 18); Fort Clark on Thursday morning, (Oct. 19); and Buford-Trenton on Thursday afternoon & Friday morning , (Oct. 19 & 20). We traveled from Buford-Trenton to Bismark, then flew from Bismark back to Denver on Friday, (Oct. 20).

A more detailed account of the site visits, plus follow-up discussions after the trip are included in Attachments A, B & C, being transmitted with this report. Attachment A includes discussion of Horsehead Parts 1, 2, 3, and 5, pump sites, of the Fort Clark pump intake, and of the Buford-Trenton pump intake. Jim Weigel has asked that the TSC prepare a scope of work for investigating alternatives for addressing the issues being faced at these sites. Attachment B includes discussion of the Fort Yates municipal and irrigation, and the Cannonball irrigation pump intakes. Jim Weigel has indicated that while further work on these sites will not be included in the requested scope of work, he would like a summary of our comments/ideas regarding potential alternatives, after having viewed these sites. Attachment C is a summary of the demonstration canal modernization discussions with Buford-Trenton. A demonstration canal modernization project would also be separate from the requested Scope of Work.

5. Conclusions: Water users diverting from the Missouri River between Bismark and the North Dakota – South Dakota state line face challenging issues. Identifying long-term solutions that are technically feasible, cost-effective, and that can receive all regulatory approvals required will entail creative thinking among a diverse stakeholder group. Sediment diversion mitigation at Fort Clark and at Buford-Trenton may be accomplished through application of existing technologies that are being utilized for similar river diversion structures. Ice conditions are an additional factor that must be accounted for at these sites that may not be a factor at other sites where sediment diversion limiting technologies are being used.

6. Action correspondence initiated: Development of a Scope of Work to investigate alternatives the Horsehead, Fort Clark, and Buford-Trenton pump intake issues is pending with a target getting it transmitted to DKAO before the end of November.

cc: Jim Weigel (DK 600)

SIGNATURES AND SURNAMES FOR:

Travel to: North Dakota, Missouri River and Heart River sites

Date or Dates of Travel: October 16-20, 2006

Names and Codes of Travelers: Tom Gill, 86-68560; Kent Collins, 86-68540

Traveler: ______________________ ______________________
Tom Gill, 86-68560 **Date**

Traveler: ______________________ ______________________
Kent Collins, 86-68540 **Date**

Noted and Dated by:

___________________________________ ________________________
Timothy Randle, Manager 86-68540 **Date**

___________________________________ ________________________
Clifford A. Pugh, Manager 86-68560 **Date**
(Robert Einhellig, Acting Manager 86-68560)

DKAO Pump Intake Project
Discussion Notes from 10/16-20/06 Site Visit
And from Post-Visit 10/31/06 Staff Meeting:
Attachment A to Travel Report for October 16-20, 2006 Site Visit

Post-Visit Meeting Participants: Kent Collins, 86-68540 Hydraulic Engineer; Tim Randle, 86-68540 Group Manager; Bob Strand, consultant (retired from USBR – former 86-68540 Group Manager); Tom Gill, 86-68560 Hydraulic Engineer

Background: This meeting follows a site visit by Kent and Tom to North Dakota to view many of the problem pump intake sites. Following this trip, the TSC has agreed to develop a Scope of Work for examining possible alternatives for addressing the pump intake issues. At the outset of this meeting, Kent noted that subsequent to the site visit, Jim Weigel (DK 600, Bismark Office) has indicated that three priority concerns will be included in the current scope of work. These include: Parts 1, 2, 3, and 5 of the Horsehead irrigation unit, the Fort Clark pump intake of the Fort Clark irrigation unit; and the Buford-Trenton pump intake of the Buford-Trenton Irrigation District.

Discussions:

Horsehead Irrigation Project

Part 1: Three pumping sites were visited at Horsehead Part 1. The northern-most site was adjacent to the Hazelton boat ramp. As this reach of the Missouri has reverted from reservoir to river conditions, a diversion previously located farther upstream was relocated to this boat ramp site. Since reverting to river conditions, the managed river discharge has typically ranged from about ~12,000 ft^3/s to ~35,000 ft^3/s during the year.

At the lower discharge – as viewed on our site visit – water adjacent this site becomes a back-fed channel. (This channel is shown at right in a view looking downstream.) During irrigation season, a portable pump is positioned in the channel. Water is conveyed via surface pipe up to a point at the bench lands where it is connected to the irrigation distribution pipe system.

At the time of our visit, the USACE had excavation equipment on-site in an effort to maintain sufficient depth in this back-fed channel to provide boat access to the main river channel. This appears to be one of the most favorable pump sites along Horsehead Project under the current river conditions. As long as the USACE continues to maintain boating access at this point, pumping should remain viable. The back-fed conditions should be a limiting factor in sediment transport near pumping operations, and hence should tend to limit sediment intake by the pump.

A point to note in connection with the excavation of the channel near the Hazelton boat ramp is the description of the excavated materials provided by the irrigator. He indicated that the materials from the channel bed contained a significant amount of coarse grained sands that he was having stockpiled for use as fill at a near-by site on the upper bench where he was planning to erect a building. The bank material near the boat ramp consisted of fine sands and silts intermixed with ½" to 1" gravel particles.

The second pump site visited in Horsehead Part 1 is approximately a mile downstream of the Hazelton boat ramp. At this site, the river is accessed via a cut through the approximately 20 ft vertical wall at the edge of the river bottomland. At this site, (seen in the photo at right), the pump site where water was previously drawn from Lake Oahe is 1500 ft to 2000 ft back from the edge of the river channel as it currently flows.

As an adjustment to river operating conditions, the land owner at this site installed a wet well (just out of view to the right of the cut in the photo) connected to the river channel by a horizontal pipe. Apparently during construction of the wet well, a "blue" sand layer was encountered from which a considerable amount of water flowed into the wet well. North Dakota State Water Commission staff that accompanied us on the site visit stated that this "blue" sand zone in that vicinity is typically suitable as a domestic water source, but insufficient for irrigation.

Functioning of the wet well/horizontal pipe system has apparently been impacted by excessive sediment diversion which resulted in failure of a water-cooled vertical turbine pump installed in the wet well after only a partial season of operation. After this pump failed, the irrigator utilized a portable pump system with a capacity suitable for only a fraction of his acreage to finish the 2006 season.

The third Horsehead Part 1 pump site visited is approximately 2.5 miles downstream from the second Part 1 site. Transition from the upper bench lands to the river/reservoir bottomland is more gradual at this location. Presently, the river channel is approximately

1500 ft from the "reservoir conditions" pump site near the Lake Oahe high water line. A portable pump and overland pipe is being utilized to get water from the river channel to the reservoir conditions pump site and into the irrigation distribution system.

At higher river discharges, land near the portable pump location becomes damp and provides limited support. This site is not close to electric power access. It is being operated by a diesel engine. The soft ground necessitates piping fuel several hundred feet to a small on-site fuel tank that must be refilled twice daily. The irrigator cited high cost of operations as reason for current pumping operations at a capacity that serves about half his irrigated acreage.

Access to water at this site (seen in the photo at right) has been maintained, but under conditions that are clearly marginal at best. While these conditions are superior to some seen at other Horsehead sites discussed below, current operating conditions may not be viable over any significant period of time.

In the 10/31/06 meeting discussions, it was noted that the pump site at the Hazelton boat dock may offer as favorable pumping conditions as may be found in association with any of the sites affected by the reversion from reservoir to river conditions. The description of the excavated bed material would indicate that zones of coarse alluvium – which are typically present in a mature river system – may exist as part of the bottomland depositions. Apparently recent ground-penetrating radar tests conducted from a boat that traveled much of the main channel in the areas visited did not provide information to indicate that high transmissivity zones of coarse materials exist.

Comments/discussion raised in the 10/31/06 meeting included:

- Consider the viability of establishing a single pumping plant at the Hazelton boat dock along with any necessary improvements to a pipe distribution system to serve all Part 1 irrigated lands from this single site.
- Investigate the viability of excavating pits at other pumping sites that would intercept water bearing coarse alluvium zones – if they exist. If such pits could be constructed in areas near the edge of the reservoir footprint that could remain readily accessible from the adjacent shorelines, pumping from these pits may be a cost-effective and reliable alternative.

- Pump intake designs that might limit sediment intake would be beneficial for existing operations and would likely be helpful for any potential alternatives.

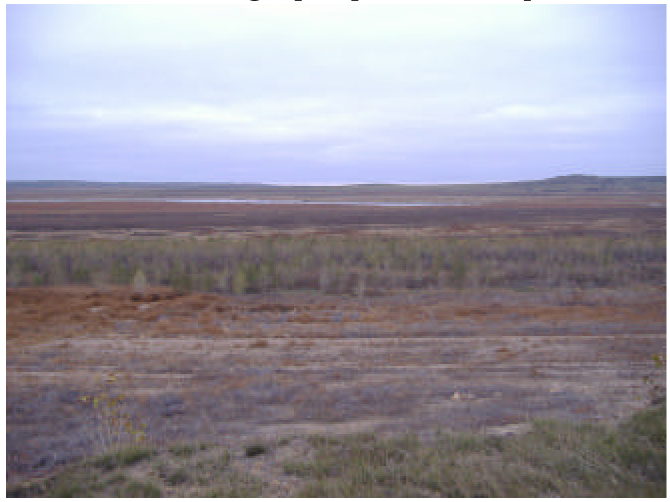
Part 2: Horsehead Part 2 features a single pump site. Since reverting to river conditions, the main channel at this site has been located approximately 1000 ft out from the “reservoir conditions” pump site. Up to 2006, a smaller channel had continued to flow at the toe of the slope about 200 ft from the reservoir pump. (This side channel is seen in the photo at right as viewed from the reservoir pump site.)

During 2006 the upper connection to this side channel apparently silted in. The side channel is currently backwatered from the lower connection to the main channel which is some 3000 ft downstream from the pump site. During the site visit, possible means of re-establishing the upper connection were discussed, including use of a floating dredge that jets dredged material out a good distance (~ 100 ft) from the channel being dredged. Access to the side channel from the upper bench lands at this site has been enhanced by a pavement of concrete slabs the land owner has placed to form a ramp that extends about 200 ft down to the channel.

In the 10/31/06 meeting suggestions/comments offered by Bob and Tim included:

- The closure of the upper connection to this side channel may actually be beneficial in that sediment transport past the pumps would be significantly diminished.
- As long as the backwater connection remains viable, pumping conditions at this site may be as favorable as can be developed. Identifying potential means of maintaining/improving this backwater connection (i.e. a “thumb” dike at the lower bar point at the backwater connection may serve to keep sediments moving past the connection and keep it from getting choked off.)

Part 3: Horsehead Part 3 irrigators face highly unfavorable conditions in that the main channel of the river is currently in excess of mile away from their “reservoir conditions” pump sites. As Lake Oahe receded, most were able to extend operations for at least part of an additional season by pumping out of shallow basins on the near side of the bottomlands. Over the past few seasons, a limited amount ongoing irrigation in Horsehead Part 3 has been fed by groundwater supplies. A potential course of action discussed during the site visit would be to establish a single pump station at a point approximately 1.5 miles in the upstream direction from the northern-most irrigated field in Horsehead Part 3, where the main channel is closer to the eastern boundary of the bottomlands. The photo at right is taken from near the northern-most irrigated field in Part 3. The open water seen in the background was suggested as a potential site for a single pumping station to serve all of the Part 3 lands.



The lower photo at right shows two floating pumps at a now-idle Part 3 pumping plant. Irrigators that participated in the site visit suggested that a channel along the left side of the bottomlands may be an old path of the river. They expressed interest in investigating the viability of dredging a connection at the upper end of this channel to the existing flow to see if water could be induced to follow this path which is much nearer their pump stations than the current main channel. This channel apparently runs near the tree line that can be seen near the middle (top to bottom) across both the above photos.

Some lands in the more southern section of Horsehead Part 3 were irrigated early in the 2006 season from a shallow backfilled basin that is wetted under high river flow and/or backwater influence of Lake Oahe at recent higher storage levels. Once this basin drained, there was no other open water source “in reach” for continued irrigation through the season.

Comments/discussion raised in the 10/31/06 meeting included:

- The idea of inducing flow to come down the channel on the left side of the bottomlands – even if initially feasible with a limited amount of excavation – would likely be subject to re-filling with sediment within a limited time frame.
- If it could be shown that zones of streambed alluvium exist that are capable of delivering water in the amounts needed for irrigation pumping, then excavation of

pits in the proximity of existing “reservoir conditions” pumping plants may be a promising alternative for Part 3 lands.

- If pumping from excavated pits is not viable, the single-upriver pumping site may be the most technically feasible alternative. The significant acreage that would need to be served dictates that this alternative would include significant and costly infrastructure including pump facilities and distribution system, possibly including storage facilities.

Part 5: Horsehead Part 5 lands lie along a reach where during part of the year backwater effects of Lake Oahe may result in the filling of shallow basins. Some early-season shallow pumping was possible during 2006 before the lake dropped to levels that dried the basins up. The dark area at mid right of the photo at right is a now-dry basin which contained 8” – 12” of water in early summer 2006. This source was utilized for limited acreage in Horsehead Part 5 during the past season.

A side note in regard to the pump site which has been accessing this shallow bay: The irrigator stated that as part of system modifications for river conditions pumping, he had constructed a wet well near the location of his “reservoir conditions” pump site near the edge of the bench lands. Water is pumped by portable pump from the shallow basin to the wet well. It is then lifted by a vertical turbine pump to the irrigation distribution system. The irrigator reported that the wet well was dug to a depth of 30 ft, at which point bedrock was encountered, with no evidence of groundwater.

Langeliers Bay lies adjacent in the upstream direction to the northern-most irrigated land in Part 5. A possibility that has been raised is a joint effort to serve both irrigators and recreational interests that would involve excavation of a channel from the Langeliers bay boat dock out to the current channel location. This channel could provide access to water for a single-site pumping system for Horsehead Part 5 and also provide boating access to the river channel. An irrigation distribution system might be expanded beyond Horsehead Part 5 to include lands in South Dakota located adjacent to the southern edge of Part 5 lands.

The photo at right is a view looking north across the mouth of Langeliers Bay. An excavated route from the Langeliers Bay boat dock (located to the right of the photo) to the current river channel location (seen in the background moving off to the left of the photo) would be a channel on the order of one mile in length.

Comments/discussion raised in the 10/31/06 meeting included:

- Again, excavated pits fed by alluvium with suitable high transmissivity may be the most viable option – provided such pits are feasible.
- The excavated channel into Langeliers Bay under discussion may be subject to filling in under delta depositional conditions as Lake Oahe fills to higher-than-recent storage levels. If costs of establishing and maintaining such a channel can be shared with recreational interests, this would enhance the cost-effectiveness of what may otherwise represent significant economic risk for agricultural benefits only

Horsehead summary comments:

Current pumping conditions at the various Horsehead locations vary from being about as favorable as can be realistically achieved under river conditions (i.e. Hazelton Boat Ramp of Part 1 and the Part 2 pump site), to situations where identifying technically viable solutions for river-conditions pumping that are economically realistic represent a challenge (the bulk of Part 3 and Part 5 sites). For the challenging areas, the idea of pits excavated into water-bearing high-transmissivity materials in hydraulic connection with the river channel – if possible and permissible – may be the most conceptually promising prospect that has been identified to date. An affordable means of investigating this possibility might be an appropriate priority, particularly in light of the lack of positive feedback from the ground-penetrating radar tests. For the sites where pumping operations have remained on-going, mechanisms and technologies to enhance sediment management could simplify some of the key issues being faced.

Fort Clark Irrigation Pump Intake: The Fort Clark Irrigation intake is located in what would seemingly be desirable location along the outside of a channel bend. The photo at right is a view of the pump site looking upstream. A factor which complicates river geomorphology at this location is that the Knife River feeds into the Missouri River upstream from this point, on the outside of the same river bend.

The Knife River sediment load is carried along the outside of the bend. Impacts on pumping operations include a high rate of sediment intake at the pumping plant, and formation of a point bar (visible near the left-center of the photo) which is pushing the river thalweg away from the pump location. Apparently, recently collected river bathymetric data suggests a significant back-fed component of the water entering the pump intake.

Comments/discussion raised in the 10/31/06 meeting included:

- The width of the river in this reach would likely render any opposite-bank mechanisms (i.e. spur dikes designed to deflect the main current to the opposite side of the channel) to be of limited effect.
- Submerged or "Iowa" vanes have been used to effectively limit bed-load sediment diversion at river intakes through creation of secondary currents that direct the bed-load carrying lower segment of the stream profile away from the diversion while the upper segment of the stream profile with lower sediment concentration is directed toward the pump intake. Uncertainties with submerged vanes at this location would include impacts of ice and ice jams, and impacts and/or hazards that may impact river navigation.
- It may be feasible to dredge a back-watered channel with a riprap protected wall starting at the bank just upstream of the intake and angling gradually outward in the downstream direction. The back watered channel would be subject to minimal bed-load transport. Potential for bed-load transport could be further limited by adding a short wing angling more sharply into the stream at the downstream end of the channel wall.
- Limiting sediment diversion might be achieved by constructing an elongated entrance structure to the existing diversion that is controlled by an overshot gate. This gate could be automated to adjust to river stage and/or pumping demand to divert water from the upper part of the flow profile containing the least sediment concentrations.

Buford-Trenton Irrigation District Pump Intake: The Buford-Trenton Irrigation District pump intake site on the Missouri River is seen in the view at right looking upstream. Issues with excessive sediment diversion led to a project undertaken by the USACE in recent years to direct the main current toward the pump intake by installing three spur dikes upstream on the opposite side of the river.

Irrigation district personnel report that for the first two to three years after the spur dikes were installed, they appeared to create the desired effect. In recent seasons however a point bar has formed atop the spur dikes (at the location of the arrow in the above photo). Subsequent to the formation of the point bar over the spur dikes, the bar that is seen on the near side of the channel upstream from the pump intake began to form. As a result, the main channel has now been moved out from the intake location. The District has seen a significant increase in diverted bed-load sediments that coincided bar formation over the spur dikes and appearance of the bar on the near side of the channel.

An item of note is in regard to the riprap material utilized for spur dike constructions: During our site visit, we were taken to view the spur dikes from the adjacent bank. A short distance from the dike location, we were shown a pile of excess riprap that was left over from the dike construction. Irrigation district personnel indicated that the land owner has notified the USACE that this remaining material must be removed from the property.

Comments/discussion raised in the 10/31/06 meeting included:

- Accounts of behavior of the river subsequent to installation of the spur dikes on the opposite bank are evidence that the spur dikes were initially effective at influencing the channel path in the desired manner. The short-lived success experienced would seem to indicate that, while the spur dikes were initially effective, they are located too far upstream. Construction of one or two additional spur dikes farther down-river may be effective in getting the main channel redirected back toward the pump intake. The fact that additional riprap is available on-site would simplify this alternative.
- The submerged or "Iowa" vane technology might also be a consideration at the Buford-Trenton intake. Concerns with impacts of ice and navigation expressed above in the Fort Clark intake discussions would also be uncertainties at this site.

Standing Rock Tribal Intakes
Thoughts and Discussion
Reclamation Technical Service Center, Denver CO

Attachment B to Travel Report for October 16-20, 2006 Site Visit

Reclamation Technical Service Center (TSC) personnel visited the Standing Rock tribal intakes on the Missouri river in southern North Dakota between October 16 and 20, 2006. After returning from the site visit, the DKAO asked the TSC hydraulic engineers to summarize potential options discussed during the site visit and subsequent meetings.

Standing Rock MR&I Intake – Fort Yates Unit (Irrigation Intake)

Reclamation's DKAO (Weigel, 2006) stated the problem and objective at this site are as follows:

> Problem: The fixed intake failed when the river channel shifted due to declining reservoir levels which moved sediment downstream. An off-channel sump was constructed and is being used as the intake for the MR&I water system. The channel is unstable and shifting due to fluctuating water levels (Oahe reservoir to Missouri river system), shifting river channels, sedimentation of intake sites, and low water levels.
>
> Objective: To identify and explore options for a more reliable access to water in both high (reservoir) and low water (river channel) conditions. Explore innovative options for accessing surface water and/or groundwater under the influence of surface water.

A tribal irrigation intake (referred to as the Fort Yates Unit) also exists south of the town of Fort Yates along the west (right) bank with similar problems to those stated above for the MR&I site. Figure 1 is an aerial photo of the reach of the Missouri River containing the Fort Yates municipal and irrigation intakes.

Figure 1. Aerial photo of Fort Yates municipal and irrigation intakes (courtesy Google).

The Figure 1 photo was likely taken in the late 1990's before Lake Oahe dropped below this location. Although it is outdated, the photo was simply intended to show the intakes and surrounding area.

At the Fort Yates municipal intake (Figure 2), historical aerial photos indicate the downstream migration of river bends in the area. As the river meanders progress downstream, the large point bar along the right bank is moving in front of the existing intake, threatening to cut off river flow into the sump. Currently, the leading edge of the point bar is downstream of the sump, resulting in a backwater area along the face of the intake at low flows. Figure 2 shows the existing sump and point bar.

Figure 2. Fort Yates MR&I intake sump, October 17, 2006 (photo courtesy Tom Gill).

Approximately 1,200 to 1,400 gpm year-round is required for municipal use at this site. Sediment deposits in front of the existing intake could eventually prevent adequate water supply from flowing into the sump.

Rising reservoir levels would bring the pool close to the sump, but may cause further sediment deposit until the reservoir delta is a significant distance upstream. Even if the reservoir fills over the next several years, the same low flow problems would likely occur at this site during the next drought period.

The Fort Yates Unit currently consists of a 3,500 gpm pump drawing water from the river through 2600 feet of 12-inch aluminum pipe to a wet well. Water from the wet well is sufficient to irrigate about one half of the Tribe's irrigated land at this site. During irrigation season, the current system is pumping large amounts of sediment from the river. The Tribe is considering the installation of floating intakes to eliminate most of the sediment being pumped. Figure 3 was taken from the right bank, near the wet well and shows the distance from to the river.


Figure 3. Fort Yates Unit irrigation intake site, October 17, 2006 (photo courtesy Tom Gill).

River migration during low flows and sediment deposit at the intakes are the primary issues at this site as well.

Following the October site visits, TSC personnel (along with consultant Bob Strand) reviewed and evaluated existing data at the sites. Evaluation of data from North Dakota State Water Commission sources indicated the possibility of accessing existing ground water resources. In the area of the Standing Rock MR&I intake and the Fort Yates Unit, historical drill logs recorded between 1971 and 1998 identified sand and gravel layers from 15 to 85 feet thick (Randich, 1975 and NDSWC, 2006).

The locations of some of the wells and test holes are plotted on Figure 4. Not all of the drill logs evaluated are plotted on Figure 4, but it shows the proximity of the intakes to the historical river channel and reservoir boundaries.

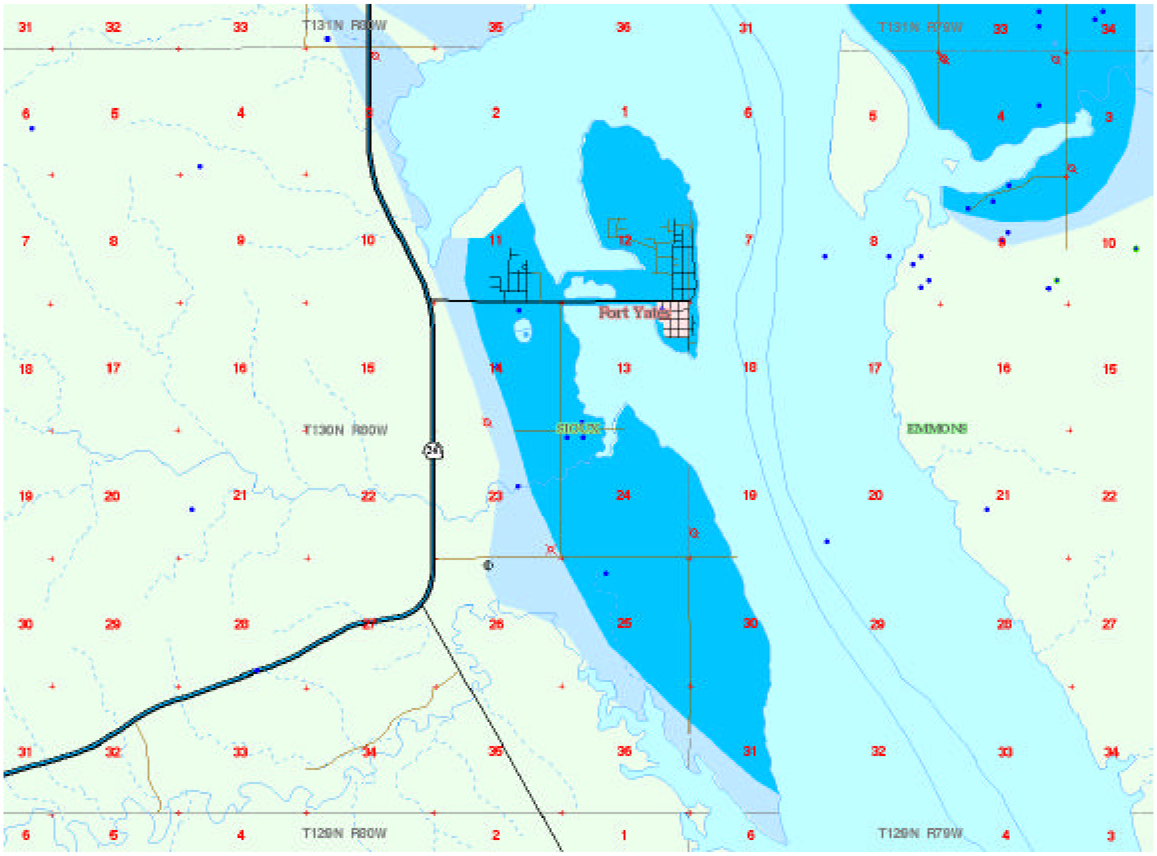


Figure 4. NDSWC map of Fort Yates area showing well locations (courtesy NDSWC).

Open borrow pits on historical aerial photos appear to fill and drain as Lake Oahe rises and falls, suggesting hydraulic connectivity to the Missouri River. Historical drill logs from NDSWC groundwater studies (NDSWC, 1975) and from the NDSWC website (www.mapservice.swc.state.nd.us/index.html; NDSWC, 2006) were compared to Lake Oahe water surface elevations recorded at USGS gage No. 06439980 (Lake Oahe Near Pierre SD) during the same time period to determine the relationship between lake and groundwater elevations in the Fort Yates area. Table 1 and Table 2 list the water surface elevations over time at two of the wells drilled and monitored during the early 1970's.

Table 1. Well No. 130-079-19CCD water level monitoring record.

Well No./Loc.: 130-079-19CCB Land Elev. = 1625 ft (NGVD29)

Well Water Level Observation Date (dd-mmm-yy)	Well Water Level (ft below land)	Well Water Elev. (ft-NGVD29)	Lake Oahe Elev. (ft-NGVD29)	Lake Elev. Record Date (dd-mmm-yy)
09-Sep-71	17.37	1607.63	1610.5 1607.2	31-Aug-71 30-Sep-71
07-Oct-71	20.4	1604.6	1607.2 1604.9	30-Sep-71 31-Oct-71
04-Nov-71	22.44	1602.56	1604.9 1602.2	31-Oct-71 30-Nov-71
05-Jan-72	25.99	1599.01	1601.2 1602.4	31-Dec-71 31-Jan-72
09-Feb-72	24.88	1600.12	1602.4 1603.9	31-Jan-72 29-Feb-72
15-Mar-72	21.43	1603.57	1603.9 1609	29-Feb-72 31-Mar-72
19-Apr-72	18.07	1606.93	1609 1609.8	31-Mar-72 30-Apr-72
16-May-72	15.62	1609.38	1609.8 1614.4	30-Apr-72 31-May-72
20-Jun-72	12.27	1612.73	1614.4 1615.8	31-May-72 30-Jun-72
12-Jul-72	12.3	1612.7	1615.8 1614.4	30-Jun-72 31-Jul-72
09-Aug-72	13.66	1611.34	1614.4 1610.9	31-Jul-72 31-Aug-72
13-Sep-72	18.2	1606.8	1610.9 1606.4	31-Aug-72 30-Sep-72
16-Nov-72	23.33	1601.67	1602.6 1601 1599.9	31-Oct-72 30-Nov-72 31-Dec-72
21-Feb-73	24.65	1600.35	1602.3 1603.1	31-Jan-73 28-Feb-73
27-Mar-73	20.91	1604.09	1603.1 1607.3	28-Feb-73 31-Mar-73
05-Apr-73 06-Apr-73 10-Apr-73 12-Apr-73 16-Apr-73 19-Apr-73	20.17 20.16 19.82 19.73 19.38 19.05	1604.83 1604.84 1605.18 1605.27 1605.62 1605.95	1607.3 1608.8 1608.5	31-Mar-73 30-Apr-73 31-May-73
05-Jul-73 17-Jul-73	19.77 20.89	1605.23 1604.11	1607.8 1606.1	30-Jun-73 31-Jul-73
16-Aug-73	22.31	1602.69	1606.1 1603.4	31-Jul-73 31-Aug-73
09-Oct-73	25.51	1599.49	1602.4 1602.2	30-Sep-73 31-Oct-73
03-Dec-73	24.35	1600.65	1603.8 1604.4	30-Nov-73 31-Dec-73
26-Feb-74	20.5	1604.5	1605.7 1607.2 1609.2 1608.9	31-Jan-74 28-Feb-74 31-Mar-74 30-Apr-74
25-Jun-74	18.9	1606.1	1608.6 1608	31-May-74 30-Jun-74
26-Aug-74	22.58	1602.42	1606.1 1604.5	31-Jul-74 31-Aug-74

Table 2. Well No. 130-080-14CCD water level monitoring record.

Well No./Loc.: 130-080-14CCD			Land Elev. = 1636 ft (NGVD29)	
Well Water Level Observation Date (dd-mmm-yy)	Well Water Level (ft below land)	Well Water Elev. (ft-NGVD29)	Lake Oahe Elev. (ft-NGVD29)	Lake Elev. Record Date (dd-mmm-yy)
18-May-73	27.63	1608.37	1608.8 1608.5	30-Apr-73 31-May-73
05-Jul-73 17-Jul-73	28.16 28.94	1607.84 1607.06	1607.8 1606.1	30-Jun-73 31-Jul-73
01-Aug-73 15-Aug-73	29.31 29.32	1606.69 1606.68	1603.4 1602.4	31-Aug-73 30-Sep-73
09-Oct-73	32.59	1603.41	1602.4 1602.2	30-Sep-73 31-Oct-73
03-Dec-73	31.44	1604.56	1603.8 1604.4	30-Nov-73 31-Dec-73
26-Feb-74	28.88	1607.12	1605.7 1607.2	31-Jan-74 28-Feb-74
25-Jun-74	27.25	1608.75	1608.6 1608	31-May-74 30-Jun-74
26-Aug-74	30.25	1605.75	1606.1 1604.5	31-Jul-74 31-Aug-74

The well water elevations in Table 1 and Table 2 match closely with recorded Lake Oahe elevations. The groundwater at these locations appears to be hydraulically connected to the surface water, rising and falling with the adjacent reservoir/river elevations.

In their 2004 report on resistivity testing they conducted in the Fort Yates and Cannonball areas, N.S. Nettles & Associates described a layer of "…gravely sand approximately 15 feet thick…" at Fort Yates, but then stated, "The thin lens of gravely sands do not have a sufficient thickness of saturated sediments to serve as a water supply source." (N.S. Nettles & Associates, Inc., 2004). Later in the same report, N.S. Nettles & Associates discuss possible clean gravel deposits near the Fort Yates Unit that "…have excellent potential for development as a water source" and "…suggest a hydraulic connection with the overlying lake waters." Most importantly, the 2004 resistivity testing did record the presence of sand/gravel layers in the Fort Yates vicinity with the potential for development as a groundwater source. Historical drill logs identifying sand/gravel layers and the presence of standing water in low lying areas when Lake Oahe is high indicate that a continuous hydraulic connection between the river and groundwater may exist and should be explored further.

Fort Yates Sites Recommendations

TSC personnel and consultant Bob Strand met to review the information and discuss possible solutions at the Standing Rock tribal intakes. From those discussions, a list of recommendations for further study was compiled:

- Further exploration of groundwater in the Fort Yates area is warranted. Preliminary examination of existing data indicates potential for developing groundwater sources for municipal and irrigation water supply. Tapping into existing groundwater sources could provide a reliable water supply in high and low water conditions and eliminate most concerns associated with sediment deposition and ice flow. Several methods of accessing, testing, and collecting groundwater could be considered.

- Test wells could be drilled or test pits could be excavated and pumped to determine the potential yield of some of the groundwater sources. Test sites closer to the river would likely provide the cleanest water (lowest sodium content) and strongest connection to the surface water.
- At the municipal water intake, an infiltration gallery should be considered. Historical drill logs indicate that there may be an existing sand/gravel layer sufficient to provide groundwater flow. Several options are available for infiltration galleries to improve their production. If placing gallery pipe in sand and gravel layers is not feasible, then gallery pipe can be placed in open cut trenches, then backfilled with appropriately sized gravel and sand to allow groundwater flow and provide a base level of filtration. Multiple gallery pipes could be extended underneath the river from a central collection well, providing backup sources and increasing gallery production. Whether a directionally drilled or cut and fill placement method is used, fine sediments (silts and clays) can deposit in the sand/gravel surrounding the gallery pipe over time, choking the water inflow. To maintain sufficient inflow, an infiltration gallery can be designed with back-flushing capability to periodically remove fine sediment from the filter layer surrounding the pipe. The water demand for Fort Yates is relatively low (1,200 to 1,400 gpm; 2.7 to 3.2 cfs), increasing the potential of an infiltration gallery as a reliable and consistent water supply.
- An excavated pit in the low lying floodplain between the wet well and river to collect groundwater might be sufficient to supply irrigation water at the Fort Yates Unit irrigation site. If test wells or pits produce water at a usable rate, the depth and size of the pit could be computed based on demand. Spoil material from the excavation could be used to build a protective berm surrounding the pit to prevent it from filling with surface water and sediment when the reservoir rises.

- If the groundwater investigations eliminate it as a supply option, surface water solutions must be examined. A backwater channel could be dredged or excavated along the right river bank from the downstream end of the point bar upstream to the existing municipal intake sump. Periodic dredging of the backwater channel would likely be necessary to maintain an open connection to the river. A protective dike could be constructed along the left top bank of the backwater channel to limit sediment deposition there. A similar backwater channel could be considered at the Fort Yates Unit irrigation intake as well.
- The current 3,500 gpm pump at the Fort Yates Unit supplies enough water for about one half of the irrigated farm land at that site. A second intake, pipeline, and 3,500 gpm pump could be installed parallel to the existing system, effectively doubling water production to the wet well and providing sufficient water to irrigate the other half of the land.

- Various intakes have been designed with the intent of limiting sediment inflow and could be studied for implementation at this site. Reducing approach velocity, redirecting bedload at the intake, or drawing relatively clean water closer to the surface are the most common solutions. The Tribe is considering the installation of floating intakes at this site. Floating intakes would be maximum mobility and this site and would not be threatened by ice flows during irrigation season. Excavation of a pit to pump from would eliminate sediment intake issues.

Cannonball Unit Irrigation Intake

Unlike the Fort Yates sites discussed above, the Cannonball intake site is close to a relatively stable portion of the Missouri River. The river channel here is relatively straight, deep, and close to the right bank. Even under the current low flow conditions, water access is against the right bank, near the Cannonball Irrigation Unit intake (Figure 5).

Currently, a 3,500 gpm Crisafulli pump draws water from the river through a portable intake for irrigation. A total intake of 7,000 gpm is desired to develop and irrigate potential farmland at the site.

Figure 5. Cannonball Irrigation Unit intake, October 17, 2006 (photo courtesy Tom Gill).

Reclamation's DKAO described the problem and objective at this site in an October 2006 email communication:

> Problem: The fixed intake failed when the river channel shifted due to declining reservoir levels which moved sediment downstream. The Tribe is currently using a portable pump as the main river channel is close to the pumping plant. The Tribe would like to construct one intake which will operate in both high and low water conditions. Their consultant has proposed constructing an expensive H structure in the channel which will allow the intake to be moved vertically but not horizontally.
>
> Objective: To identify and explore options for a more reliable access to water in both high (reservoir) and low water (river channel) conditions. Explore innovative options for accessing surface water and/or groundwater under the influence of surface water. Review and comment on the consultants proposal and identify other more feasible options to present to the Tribe.

Figure 6 and Figure 7 provide aerial views of the Cannonball intake site and surrounding area. The Missouri River narrows at the upstream end of the straight reach containing the intake, increasing flow velocity and depth, and raising sediment transport capacity there.

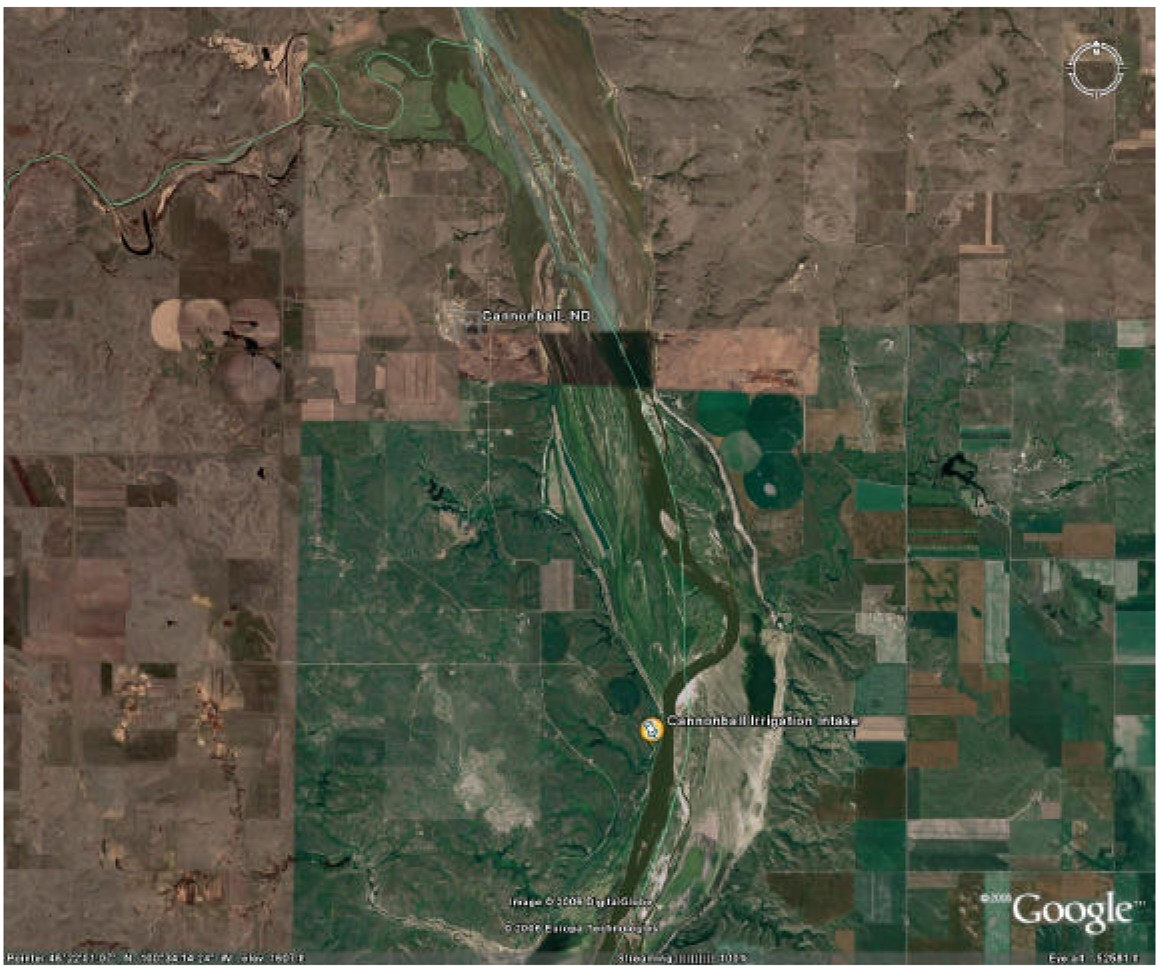


Figure 6. Aerial photo of Cannonball Irrigation Unit intake site (courtesy Google).

Figure 7 maps the original Missouri River channel before Oahe Dam closed. The historical channel was straight and against the right bank at the current Cannonball Intake site. When Lake Oahe dropped, the river returned to the historical channel. Upstream of the intake, a sharp bend has developed and the river has migrated away from the historical channel, but the channel at the intake appears to be relatively stable. Recent aerial photos do not show significant downstream migration of the bend since 1995 and show additional vegetation growth in the floodplains, further stabilizing the low flow channel.

Assuming the low flow river channel remains close to the bank, the best method of developing a reliable water supply is to access the surface water directly. Limited groundwater investigations have been performed in this area and do not appear to be necessary at this time. However, should access to surface water become unfeasible or impossible, the potential for development of groundwater sources does exist. According to the N.S. Nettles & Associates 2004 resistivity testing report, a sand and gravel layer was identified in the Missouri River bed at the Cannonball site (N.S. Nettles & Associates, Inc., 2004). N.S. Nettles & Associates go on to say, "Development of a groundwater supply from these sediments may be feasible." (N.S. Nettles & Associates, Inc., 2004). The NDSWC website showed limited well records available in the Cannonball area (wells are blue dots in Figure 7). If development of groundwater supply becomes necessary in the future further investigation examination to locate the best sources would be required.

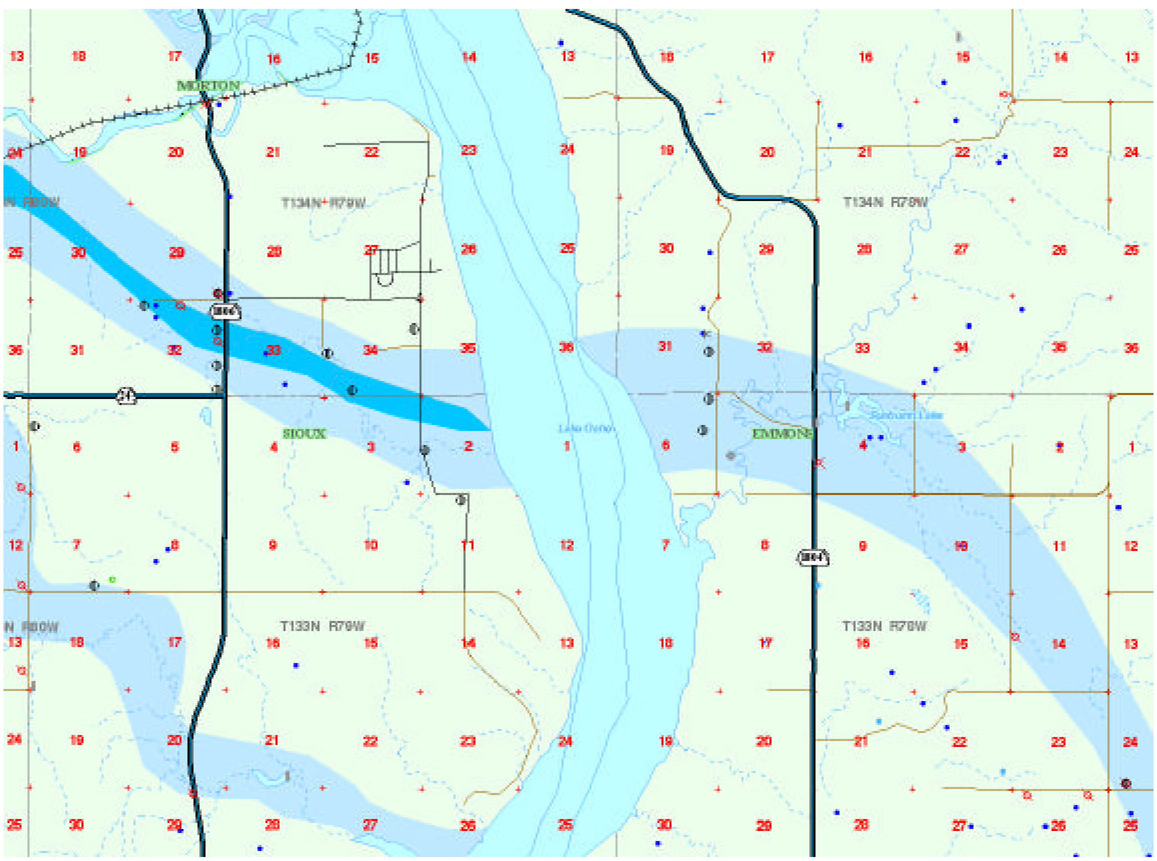


Figure 7. NDSWC map of Cannonball Irrigation Unit intake area showing historical channel.

As the reservoir level rises and falls, the delta location changes with the head of the pool. If the upstream end of the pool stalls in the Cannonball area due to hydrological conditions or dam operation, there is potential for significant sediment deposit to occur at the intake site. Delta deposition could burry a permanent, stationary intake.

Conversely, dropping reservoir levels can result in erosion of the river channel through reservoir deposits. Erosion of the channel bed at the intake could undermine Cannonball Irrigation Unit infrastructure, causing structural failure of the intake.

Consultants Morrison and Maierle designed an H-pile intake structure approximately 150 ft out in the channel with a vertically adjustable intake manifold platform to accommodate low and high water conditions (Morrison and Maierle, Inc., 2006). While the proposed design would likely solve the problem of changing water levels and potential sediment deposits, it may be unnecessarily expensive. Other options for mobile intakes should be considered.

Cannonball Irrigation Unit Recommendations

TSC personnel and consultant Bob Strand evaluated the existing data at this site. Potential solutions at the Cannonball Irrigation were discussed:

- Although further groundwater investigation seems unwarranted at this time, data indicates that potential groundwater sources do exist and could be considered as a future option if necessary.
- To achieve the desired 7,000 gpm intake capacity, a second intake, similar to the existing intake could be added. This would essentially double the pumping capacity of the Cannonball Irrigation Unit.
- If the river remains in its current low flow channel along the right bank, portable intakes appear to be the best option here. The river at this site is relatively stable and close to the irrigation pumps. While the vertically adjustable intake proposed by Morrison and Maierle may solve most of the problems at this site, the estimated $1,000,000 price tag seems excessive. Perhaps a less expensive solution could be found that would be just as effective. During discussions of potential alternatives, the possibility of installing an inclined intake on the existing concrete ramp at the Cannonball site (Figure 5) was presented. Inclined rails or a track system could be installed on the concrete slope. A portable intake could travel up and down the rails, following the water surface as it rises and falls. Flexible pipe would be connected to the intake to maintain a connection to the pumps while the intakes were adjusted.

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Buford-Trenton Irrigation District
Radio/Control Demonstration Project
10/19/16 Site Visit Notes
Attachment C to Travel Report for October 16-20, 2006 Site Visit

Background: In connection with work on a Radio/Control demonstration project being established in South Dakota at the Angostura Irrigation District, staff of Reclamation's Hydraulic Investigations & Laboratory group (86-68560) has had preliminary discussions with staff of the Dakota Area Office (DKAO) regarding initiating a similar demonstration project at the Buford-Trenton Irrigation District (BTID) in North Dakota during FY07. An on-site visit and initial conversations with BTID regarding this project were included in conjunction with a visit to discuss river pump intake issues at BTID during an October 19-20 site visit to BTID.

BTID Demonstration Project Discussions: During the site visit, two sites were suggested by BFID Manager Monte Hininger for consideration for establishing automated control and flow monitoring. The uppermost of these sites is the 3.8 check structure where the uppermost major lateral takes off from the main canal. The 3.8 check is shown in the Figure 1 below.

Figure 1: BTID 3.8 check structure

As seen in the Figure 1 above, the 3.8 check is a three bay structure that currently features stop-log control in each bay. Automation at this site would require installation of some type of gate structure in one of the bays (likely the center bay) that could be motorized. Possible gate options would include construction of a vertical slide gate. BTID has recently constructed and installed a similar gate in the check at a site lower in the delivery system, (shown in the Figure 2 below).

A second option would be modification and installation of an "accordion fold" overshot gate BTID constructed a few years ago, but have had problems getting to function properly. This gate was examined at the BTID office yard during the site visit. Apparently the operational issues experienced with the gate were related large forces needed to lower the gate. This problem appears to be related to be the near vertical orientation of the two gate sections when the gate is fully raised. A similar commercially produced gate functions such that when the gate is at its maximum operational height, the two gate sections are at approximately a 45^o angle to either horizontal or vertical and are hence at approximately a 90^o angle to each other. The BTID gate could be readily modified by lengthening both gate sections and by extending the wings extending upstream at either side of the gate. With these modifications, installation of gearing needed for operation with a 12 volt solar-charged system would be a straight-forward task.

There is currently no flow measurement at the 3.8 site, either in the main canal or in the lateral. With no flow measurement, the check could be automated to maintain a target upstream level, which would result in steady flow delivery rate to the lateral. If measurements of flow are desired, it may be feasible to develop ratings for flow passing a gate in the check, as well as for flow passing the lateral headworks gate that could yield measurement accuracies suitable for system administration uses.

The second site suggested by Monte during the site visit is the end-of-project spill. Monte was particularly interested in the possibility of automating the spill control. This site is seen in Figure 2 below. As noted above, a vertical slide gate constructed by the BTID staff has recently been stalled in one bay of the two-bay check structure. The spill off-take may be seen at the right of the structure. There is a vertical slide gate that has long been in place to control flow into the spill. (The stem and upper hardware for this gate can be seen atop the concrete wall at right in the photo.) In recent years, BTID has installed angle irons on the walls of the approach to the spill control gate that form stop-log slots. By passing spill over the stop logs, it has prevented the canal from draining when operational problems are encountered with upstream pumps – a problem apparently experienced on repeated occasions when the vertical slide gate was used to control flow into the spill.


Figure 2: BTID end-of-project spill

Alternatives discussed for automating the spill control included motorization and control of the existing gate or construction of an adjustable weir which could be placed in the stop-log slots. Automation of the existing gate should address the issue of preventing draining of the canal when pump problems occur. This site would also be a candidate for additional functions similar to items discussed in association with the 3.8 check with regard to making flow measurements passing the gates.

In a follow-up phone conversation on 11/02/16, Monte Hininger indicated that after having time to reflect on the project, he would like to consider the 4.8 check site for inclusion in the project. The lateral that branches off the main canal at this site has a Cipoletti weir near the headworks. Monitoring flow over this weir – along with possibly automating the lateral headworks control gate to maintain a target flow at the weir – are functions Monte feels would provide the BTID Board with good sense of the utility that could be realized from the radio/control technology. Thus the BTID's current thinking is that the 4.8 check and the end-of-project spill would be the priority field sites for the demonstration project. The 3.8 check would be a desired field site if the project scope could include three field sites.

At this juncture, consideration of a BTID radio/control demonstration project remains in the concept stage. With further discussions, other sites may well come into focus that may ultimately be seen as more appropriate sites for initial installations. The sites discussed above would offer opportunities for performing functions that can enable BTID to develop a sense for how the technologies can provide benefits for their operations.