

# RECLAMATION

*Managing Water in the West*

## Intake Diversion Dam

Trashrack Appraisal Study for Intake Headworks

Lower Yellowstone Project – Montana – North Dakota



## **MISSION STATEMENTS**

### **U.S. DEPARTMENT OF THE INTERIOR**

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

### **BUREAU OF RECLAMATION**

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION

Date: February 05, 2008

---

**Region: Great Plains Region, Montana Area Office**

**Project: Lower Yellowstone Intake Diversion**

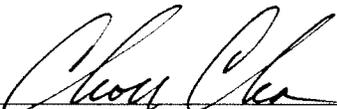
**Feature: Intake Diversion Headworks**

---

**Subject: Trashrack Appraisal Study**

---

*Prepared by:*

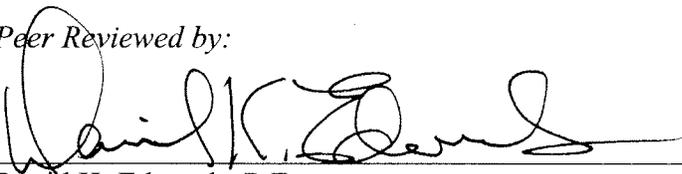
  
\_\_\_\_\_  
Chou Cha, P.E.  
Water Conveyance Group (86-68140)

2/5/08  
Date

  
\_\_\_\_\_  
Rick Christensen  
Mechanical Equipment Group (86-68410)

2/5/08  
Date

*Peer Reviewed by:*

  
\_\_\_\_\_  
David K. Edwards, P.E.  
Manager  
Water Conveyance Group (86-68140)

2/5/08  
Date

# Table of Contents

Table of Contents	i
Table of Figures	ii
Executive Summary	iii
Introduction	1
Purpose	1
Project Location and Background	1
Trashrack Concept	2
Design Consideration	3
Hydraulics	3
Velocities	3
Operations and Maintenance	5
Operation Access	5
Trashrack cleaning system and trash removal	5
New gate controls and operators	6
Structural Design	6
Access decks design	6
Foundation supports	7
Ice loading	7
Electrical Power	7
Construction Consideration	7
Cost Estimate	8
Construction Assumptions and Costs	9
Operation & Maintenance Assumptions and Costs	10
Bypass Hydraulics	12

# Table of Figures

Figure 1 - Existing Intake headworks section shown in old elevation datum	4
Figure 2 - Trash rake system (from Atlas Polar website)	6
Figure 3 – New trashrack concept plan and elevation	Appendix A
Figure 4 – New trashrack concept sections	Appendix A
Figure 5 – Protective cofferdam and construction sequence	Appendix A

# Executive Summary

This Appraisal Study addresses the Biological Review Team's recommendation to "install a removable 2 inch bar mesh trashrack and self cleaning mechanism on the riverside of the canal intake to prevent initial entrainment." The concept presented would meet the needs of the recommendation. The concept includes a new trashrack structure with ten bays constructed in front of the existing headworks. Left and right transition abutment cells would be needed to make a smoother hydraulic transition and to protect the trashrack structure from ice flow. The trashracks are removable steel panels that can be pulled from above with a monorail hoist. The west abutment deck is wider for vehicle access. The deck on top of the trashrack structure is provided for maintenance crew access, but not designed for vehicle access.

This concept includes discussions on design considerations, construction considerations, and the cost estimates. The design considerations address hydraulics, operations and maintenance, structural design, and electrical power needs. The construction considerations address possible water diversion schemes and potential collaboration with other parts of the whole project. The cost estimate includes construction costs and associated operation and maintenance costs.

Velocities through the trashrack would be kept below 2 ft/s. At the low water surface obtained from the referenced report for future repair to the diversion dam, the velocity would be 1.5 ft/s.

Operation and maintenance would be improved with better access both by vehicle and by foot. An automated trash rake and conveyor systems for cleaning the trashracks would reduce maintenance efforts. Trash removal would be done on preselected time increments based on trash load. A monorail hoist would allow seasonal installation and removal of the trashrack panels with minimal manual lifting. New gate controls and operators would allow for future automation of flow diversion. This would reduce on site supervision along with better control of the flow velocities through the trashrack preventing high flow hot spots. New operating criteria would need to be developed.

Structural design would address live loads on access decks, foundation stability, floatation, and ice loads for the trashrack and abutment cells. The vehicle access deck would be designed to a limited loading. An access deck for maintenance crews would be designed to an appropriate live load. Foundation stability would be designed to prevent the structure from settling and to allow for lateral ice flow loadings. Ice flow pressure would need to be determined and the structure be designed in accordance with existing codes and standards.

Three phase electrical power would be required on site to operate the trash rake, conveyor, monorail crane, and new gate operators.

Construction considerations include protective cofferdam and dewatering scenarios. Cofferdams would protect one half of the trashrack structure at a time. This would allow flow to be bypassed for irrigation while construction efforts proceed. The cofferdams would then be pulled upon completion of the first construction season and be driven for the second construction season. Cofferdams could range from different types of sheet pile cells filled with free draining material to sheet piles driven in front of the concept structure with braces extending back against the existing structure. Combining cofferdams for the proposed trashrack structure with water diversion for the diversion dam construction project could be done to save costs. Coordination and scheduling would be required if there are different contracts and Contractors.

Other construction consideration would be irrigation bypass flow if construction occurs during the irrigation season. Bypass diversion would have to be evaluated for full flow of 1,400 ft<sup>3</sup>/s. Winter construction could be considered; however, for this appraisal study, construction was assumed to be conducted during the summer season and would likely be done over two irrigation seasons. Approximately five of the eleven existing gates would be used for the first year construction for irrigation bypass diversion. Once the first half of the structure is constructed and cofferdam sheet piles pulled and driven for the second half, the new trashrack and existing gates would be used to bypass the irrigation diversion for the second construction season. Preliminary hydraulic evaluation demonstrated that irrigation bypass flows of 1,400 ft<sup>3</sup>/s could be achieved with three feet of hydraulic head. Further hydraulic analysis would need to be investigated in the Feasibility Design and Final Design phases.

The cost estimate for the project includes two components. The first would be the construction costs of the facility and the second would be the annual operation and maintenance costs. The construction cost of the trashrack structure and its appurtenances is estimated at \$12,500,000. This cost is based on preliminary design, assumed equipment needs, and an assumed construction methodology. Cost associated with the operation and maintenance at present value is estimated at \$3,000 annually. This is based only on electrical power consumption from operating the facility. Additional labor is required during the removal and installation of the trashrack panels and disposal of the trash. The new gate motor operators would be pushbutton controlled and the gates positioned similarly to existing operations. The labor requirements for future operations are assumed to cost the same as the labor requirements for existing operations.

# Introduction

In April, 2004, the Bureau of Reclamation expanded on a fish protection and passage concept with a Feasibility Report (Reference 2) that included the following: 1) a positive barrier screen to exclude /divert fish from the canal; 2) upstream fish passage; and 3) replacement of the existing diversion dam spillway. In September, 2006, the Fish and Wildlife Service prepared a summary of the Biological Review Team's comments on this report. One recommendation was to "install a removable 2 inch bar mesh trashrack and self cleaning mechanism on the riverside of the canal intake to prevent initial entrainment."

## Purpose

The purpose of this study is to develop concept designs and appraisal level cost estimates for a trashrack structure that will prevent the entrainment of adult and sub-adult Pallid Sturgeon into the canal diversion.

## Project Location and Background

Intake Diversion Dam and the diversion headworks for the Lower Yellowstone Irrigation District's Main Canal are located on the Yellowstone River about 17 miles northeast of Glendive, Montana.

The Reclamation Service began investigating the project in 1903. A report by a board of consulting engineers, dated April 23, 1904, served as a basis for authorization of the project. The project was authorized by the Secretary of the Interior on May 10, 1904, under the Reclamation Act of June 17, 1902. Construction of a diversion dam, canal headworks and delivery canals began on July 22, 1905. Water was available for irrigation during the season of 1909.

The Lower Yellowstone Irrigation Project lies in east-central Montana and western North Dakota. The project includes the Lower Yellowstone Diversion Dam, Thomas Point Pumping Plant, the Main Canal, 225 miles of laterals, and 118 miles of drains. The purpose of the project is to furnish a dependable supply of irrigation water for 52,133 acres of fertile land along the west bank of the Yellowstone River. About one-third of the project lands are in North Dakota and two-thirds in Montana.

Water is diverted from the Yellowstone River into the Main Canal by the Lower Yellowstone Diversion Dam near Intake, Montana. The water is carried by gravity to the greater portion of the project lands. About 2,300 acres of benchland are irrigated by water pumped from the canal by the Thomas Point Pumping Plant.

Intake Dam was originally constructed as a rock-filled timber crib weir about 12 ft high and 700 ft long. The original dam contained 23,000 cubic yards of material. The dam raises the upstream water elevation from about three to five feet depending on river flows. Since the construction of Intake Dam, the structure has required frequent repair to maintain the needed upstream head to divert flow into the canal. Heavy ice and large flood flows work to progressively move riprap material from the dam downstream. A cableway that crosses the river over the crest of the dam is used to place riprap along the dam crest when repairs are required. Over the years, large quantities of rock have been added to the dam to replace rock displaced by the river. Riprap now extends several hundred feet downstream of the dam across the width of the river.

The Main Canal diverts to the west side of the Yellowstone River at Intake and extends down the valley to the confluence of the Yellowstone and Missouri Rivers. The canal is 71.6 miles long, unlined and has an initial capacity of about 1400 ft<sup>3</sup>/s. The canal headworks is a concrete structure with eleven 5-ft-diameter sluice gates. There are no trashracks in front of the intake gates. The canal was originally designed with a 30 ft bottom width with 1.5:1 side slopes. The canal is designed to convey its full capacity at a flow depth of about 10 ft. The canal operates from late April through October of each year.

## **Trashrack Concept**

The trashrack concept is shown in Figures 3 and 4 in Plan and Section views in Appendix A. The trashrack structure would be constructed of cast-in-place concrete. The concept designs for the trashrack structure consist of two parts: 1) the main structure housing the trashracks, and; 2) the transition abutment cells on either side.

The main trashrack structure includes a floor slab, 5 feet thick, with vertical pier walls and an access deck. The structure floor thickness matches the existing concrete headworks. There are ten bays with 8-foot wide openings, separated by two feet wide piers with rounded pier noses. The cast-in-place access deck will allow maintenance personnel to remove trash, and will also allow for the removal of the trashrack after the irrigation season. Removal of the trashracks is necessary to prevent ice damage during the winter and early spring. Canal diversions will not be made during these times, so there will not be any entrainment of sturgeon.

The trashracks will be removable and stackable panels with vertical bars having 2 inch clear openings. The concept shows each panel approximately 8 feet high by 9 feet wide, weighing approximately 3,000 pounds each. The depth from the top of the deck to the bottom of the structure is 36 feet 6 inches. Therefore, trashrack panels or a combination of trashrack panels and barrier panels will be required for the full height to allow trash to be brought to the top deck by an automatic trash rake. There will be dual trashrack guides allowing for maintenance and repair of the front racks by inserting temporary racks behind.

The primary rack will be installed in front. A monorail hoist at the top of the structure will be used to pull the trashrack panels. The monorail hoist system will be sized to pull one trashrack panel with a lifting beam plus additional load capacity to overcome friction and water pressure loading.

The concrete transition cells are another component of the trashrack structure. These serve several purposes. The first is to make a smoother hydraulic transition at the trashrack approach. The second is to deflect and brace the main trashrack structure from ice flow loading. These structures can be constructed as mass concrete; however, this concept shows cast-in-place floors, walls, and decks containing gravel or soil fill to counteract any buoyant forces. Having cells filled with gravel or soil would have potential for cost savings over mass concrete. Cost should be evaluated to confirm the comparison between filled cells and mass concrete.

The concrete transition cells would be designed as fully enclosed structures to prevent water from filling the cell. If water fills the cell, expanding ice forces from the frozen water inside the cells could cause structural wall failure. This ice force eliminates the possibility of retaining wall like transition structures where water could be trapped behind the structure.

## **Design Considerations**

### **Hydraulics**

Although the Biological Review Team recommended a velocity of 4 feet per second through the trashrack, Reclamation design guidelines limit trashrack velocities to 2 ft/s. A maximum 2 ft/s velocity will be provided at the lowest diversion water surface while still diverting the full flow of 1400 ft<sup>3</sup>/s. This calculation assumes all gates are operated at equal settings to achieve the full flow. There are several reasons for maintaining a velocity at or below 2 ft/s. One is to minimize the head loss through the trashracks. Canal operations and a proposed future fish screen bypass would benefit from this minimum headloss. In addition to increased headloss, high velocities can cause potential vibration and fatigue failure of the trashrack bars. Higher velocities also make trash removal more difficult. Velocities and methods of their computation are described below.

### **Velocities**

The existing intake structure initial design was based on a velocity of 2.5 ft/s at the front face of the structure for each bay at the minimum water surface. From Figure 1, the velocity is computed by the depth to the bottom of the concrete floor from the minimum water surface multiplied by the width in front of each slide gate. The maximum flow of 1,400 ft<sup>3</sup>/s is divided by the eleven gates for a 127.3 ft<sup>3</sup>/s per gate or a 6.5 ft/s velocity through each gate opening. This velocity



calculated at 1.5 ft/s. The elevations given are with respect to the North America Vertical Datum of 1988 (NAVD88).

An assumption for this velocity computation is that all gates are going to be operated uniformly allowing an even flow distribution across the trashrack. However, operations of the canal with the minimum water surface elevation and maximum water diversion allowed can change this assumption and lead to higher velocity or “hot spots” areas in front of the trashrack. Such scenarios could exist and perhaps even exceed the maximum velocity recommended by the Biological Review Team. To minimize this potential occurrence, new operation criteria along with retrofits to the gate operators would be required. The gate motor operator retrofit will be discussed later.

## **Operations and Maintenance**

The Biological Review Team recommended a self cleaning mechanism for the trashrack to reduce maintenance effort. To achieve the goal of reduced operations and maintenance, the following features were included:

### **Operation Access**

Currently, access to the gate operators is by foot on the wooden decking. The wood deck is wide enough for vehicle access; however, the District does not drive on the wooden deck because the loading capacity is unknown.

The trashrack concept will allow vehicle access to the west side of the headworks. This will allow for the removal and transport of the trashrack panels from an offsite storage and maintenance area. The west abutment transition cells will add an additional 8 feet width to the top of the existing structure. The combined width will be 15 feet. W-beam guardrails with safety guardrails will be incorporated for vehicle and human safety. New chain link fencing and gates would need to be installed to limit public access. Removal of the existing wooden deck would be required up to the end of the required vehicle access. The top deck of the trashrack structure would not be designed for vehicle access.

The monorail crane will be designed to bring the trashrack panels to a location where they can be loaded onto a flat bed truck for transport. The monorail hoist will need to be approximately 25 feet vertically above the access deck so that it will not interfere with the trash cleaning system.

### **Trashrack cleaning system and trash removal**

A self cleaning trashrack would require an automated trash rake. This concept assumes a rake system similar to Atlas Polar hydrorake system (see Figure 2). This type of trash rake system has been designed and used by Reclamation in other projects. There are other types of rakes that could be considered; however,

lateral loads from the river flows should be considered when selecting the type of rake system to use.



**Figure 2 - Trash rake system (from Atlas Polar website)**

In any system, the rake should rake the trash to the top of the trashrack deck and onto a conveyor system. A trash buckets or trash bins could also be considered. The type, size, and quantity of debris need to be determined before final design.

### **New gate controls and operators**

As previously mentioned avoiding high velocity “hot spots” through the trashracks would require new gate operators and new operating criteria. The current operation is by manually positioning and connecting an engine and power takeoff shaft to drive the gate stem gears to open and close the slide gates. The single power unit rolls on tracks from gate to gate. By providing new electrical operators and control panels, the gates can be operated locally using push button stations and automation of the gates would allow for remote operation. Coupled with new operating criteria, concentrated high velocity would be minimized along the trashrack.

## **Structural Design**

### **Access deck design**

The vehicle access deck would be designed for a limited vehicle load. Because of limited area for vehicle turnaround, the access deck will not be designed for a highway HS20 loading which considers large tractor trailer vehicles. Vehicle access will be limited to the area as shown in Figure 3. The maintenance access deck on top of the trashrack structure will be designed to the appropriate live loads.

## **Foundation supports**

The existing structure was built on foundation piles to prevent settlement. Piling would likely be required for this concept trashrack structure as well. The foundation piles would prevent the structure from settling and resist lateral loads from water pressure and ice flows in the river during early spring. The site should be geologically investigated with drill holes with the use of a barge to retrieve such design data. Since piles were driven at the existing structure, any future pile driving would probably be achievable. However, information such as depth of piles to support the weight of the structure should be determined.

## **Ice Loads**

Ice loads would exist during the winter months to early spring. Ice loadings were considered for this study, and provisions were made to deflect the ice flows with the transition abutment cells. Ice loading on the structure would be designed similar to those used for bridge piers per American Association of State Highway and Transportation Officials (AASHTO) design specifications. Design data such as extreme low temperature data as well as ice thickness and composition data would need to be collected for structure design. As assumed in the construction cost estimate, construction is assumed to be done during the summer. Ice loads will need to be considered for construction loads should winter construction become an option.

Ice load is a surprisingly high pressure load. Structures with ice load differential on one side should be avoided if possible. The current concept layout is designed to avoid this differential ice pressure loading.

## **Electrical Power**

Existing single phase power is available at the site. The power is used to help light the existing facility. Three phase power will be necessary for the equipment that will be required to operate the gates as well as operate the trashrack cleaning system and monorail hoist. Three phase power is available within a half mile and is provided by Montana-Dakota Utilities Company (MDU). New equipment should be designed to not exceed the existing three phase power capacity. Total load demand from the existing power should be the combined loads of the trashrack structure and the proposed in canal fish protection facility.

## **Construction Considerations**

Cofferdams and dewatering would be required during construction. These components should be part of the design and all associated costs should be considered for future cost estimates. Several possible cofferdam scheme are

presented in the study because of the possible depth of water in the river that could exceed 20 feet during construction.

One possible cofferdam system would be cellular cofferdams. Traditional cellular cofferdams are a unique form of retaining wall that combine flat sheet piling and special connections loaded in tension with free-draining cohesionless fill to produce a wall suitable for very high cofferdams. A modified cellular cofferdam system may also be considered. The modified cellular system is rectangular in shape and uses “Z” sheet piling. The modified cellular system is suitable for medium to large cofferdam heights. Both types of cellular cofferdam systems would be temporary and be removed after construction efforts have been completed.

Another possible cofferdam system would be the construction of a single “Z” sheet pile wall driven just in front of the proposed structure. The sheet piles would be braced back against the existing headworks using walers and struts. The single cofferdam sheet piles would also serve as a form for the concrete foundation base slab and serve as a cutoff for erosion protection. Once construction is done, the sheet piles would be cut at the top face of the foundation concrete floor. This cofferdam system is considered viable for the trashrack structure since the bracing could go through the open bays. Some modification to the braces would be required for the transition abutment cells as they have no through openings.

Because of multiple construction contracts that could happen at this project site, cofferdam construction could be coordinated with the other parts of the project such as the diversion dam construction. Construction sequencing and scheduling would need to be coordinated closely and clear definition of work limits would need to be established in the case of having different contracts and Contractors.

Another dewatering consideration would be the possible back loading of the gates from water in the canal downstream of the headworks.

If construction is to occur during the irrigation season, a bypass system for the irrigation water would need to be considered. The bypass would need to accommodate the full diversion flow of 1,400 ft<sup>3</sup>/s. To cost estimate this concept, a bypass system is assumed and will be presented in the cost estimate section. Winter construction could be considered avoiding the irrigation season all together. Costs associated with cold weather construction should be evaluated and compared to a bypass system.

## **Cost Estimate**

The estimates included in this section cover two cost components. The first component will be the construction cost of the structure. The second would be the operation and maintenance cost. These costs are preliminary and are

presented so decision can be made as to whether this is a preferred alternative when combined with the in canal fish protection facilities. If this is a preferred alternative, the design concept would be elevated to Feasibility Design. Feasibility Design process can be referenced in the Reclamation Design Guidelines.

## **Construction Assumptions and Costs**

To estimate the cost of this structure, some assumptions are made about the construction window and the cofferdam method so it can be constructed in the dry. The construction would occur over two summers through the irrigation seasons. The structure would be constructed in two parts. The first half would be the upriver portion to include about five bays of the new structure and cover six gates of the existing structure. This would allow five intake gates of the existing structure downriver available to bypass irrigation diversion flows. In the second season, the downriver half of the structure would be constructed and the upriver existing six gates through the portion of the newly constructed trashrack would be made available for a second year bypass irrigation diversion.

The cofferdam would include AZ26 sheet piles driven from the bank towards the thalweg of the river in front of the existing structure. The sheet piles would be located approximately 12-15 feet paralleling the front and be braced against the existing headworks structure as seen in Figure 5 in Appendix A. At the existing structure pier nose, special connection sections would be anchored onto the concrete vertically so sheet piles can be connected for a watertight seal at a later date. This would require divers working under water.

Mobilization and construction of the water diversion cofferdam could start in October after the irrigation season. This would take advantage of the low river water surface and not interfere with irrigation operation. Sheet piles for the cofferdam would be driven from a barge with a crane. The barge would also be used to drive the foundation piles for the structure as well. In the second construction season after the first half is completed or constructed to an elevation above the normal water surface, the cofferdam sheet piles would be pulled and re-driven for the second half of trashrack structure construction. Water within the sheet pile cofferdam will be pumped out and a dewatering system would need to be in place to maintain a dry work area. The dewatering system would need to be operated continuously for the duration of the two halves construction. During the winter months, the dewatering system would be discontinued for cost savings. Mobilization and demobilization of large equipment such as the barge and cranes would only be required once which would be at the beginning and upon construction completion.

The following equipment will be required for the trashrack structure:

- Overhead monorail with two ton hoist,
- A trash rake,
- A trash conveyor, and
- New gate motor operators.

The above equipment would require three phase power to be brought to the site. The power line extension would be within a half mile distance and be provided by MDU. A backup generator was not included in the cost estimate because the gate can be manually operated in a power outage. Trash rake and trash conveyor system operation could be impacted by a power outage; however, down times between cleaning was assumed to not be critical in the water diversion operation.

With these equipment assumptions included with the structure and under the assumed method of construction, the cost of the trashrack concept is estimated at \$12,500,000. Some estimating assumptions at this level of costs include a design contingency percentage of 15 percent and a construction contingency of 25 percent. As the design is refined, these contingencies would be lowered or possibly eliminated. The cost worksheets and estimate can be referenced in Appendix B.

## **Operation & Maintenance Assumptions and Costs**

Current operations require one operator to physically make gate adjustments. The gate adjustment frequency varies throughout the year; however, the average gate setting would occur once a day with one gate and takes approximately five minutes to adjust. The sequence of gate setting starts with initial filling of the canal where half of the gates are opened to a set gate opening. Then each gate is incremented at 2 to 3 tenths of a foot until the gate reaches the halfway opened position. The gates are singularly set to the half opened position from one end of the headworks to the other. When approximately nine of the gates are fully opened and diversion flows have not been met, the District would add riprap to the diversion dam to increase the river water surface. This then provides the additional hydraulic head to drive higher flows through the gates meeting the diversion demands. Riprap is added to the diversion dam due to loss or settling of the riprap over the year. Besides regular water operation, additional District staff is required for annual debris and logjam removal in front of the headworks after the spring runoff.

The trashrack panels would be removed after the irrigation season and then installed in the spring before diversion. This removal and installation would require additional labor for an estimated time frame of 20 days annually. Conservatively estimating, removing the trashrack panels and handling to an offsite storage area would take one day per bay for a total of ten working days. Likewise for installation, ten days would also be required. Water operation with

gate settings during the irrigation season would be similar to existing practice. With the new operator motors, gate operation would be done by pushed button controls on site. The operation of the trash rake and trash conveyor system would be automated requiring minimal labor. The trash rake would rake debris from in front of the trashracks to the conveyor system. The conveyor would feed into a dumpster, dump trailer, or dump truck parked at the west end of the structure vehicle access. Added labor required in the trash rake process would be the disposal of the trash off site. The gate operators, trash rake, and conveyor would require routine maintenance.

Power consumption required for the operation of the new trashrack would be for the hoist removing/installing the trashrack panels, the trash rake operation, the conveyor system operation, and operating the new gate motors. Table 1 lists the equipment, the power required, assumed duration of operation, and the total power consumed. The crane hoist is assumed to operate for four hours per day for the 20 days required to install and remove the trashrack panels. The trash cleaning system is assumed that both the trash rake and conveyor would be operated three times a day throughout the five months irrigation season. The trash rake would operate for 90 minutes per cleaning cycle or for a total of four and a half hours per day. The conveyor system would operate five minutes before and 15 minutes after the trash rake starts and stops. The gate operators would be operated for five minutes per day throughout the irrigation season similar to the existing operation. Maximum power consumption for the structure would be a combination of several pieces of equipment. The maximum power demand scenario would occur due to the simultaneous operation of the trash rake, the conveyor, and one gate motor operator. This peak power would be approximately 19 horsepower (hp) or 14.2 kilowatts (kW).

**Table 1 Annual estimated electrical power consumption**

Equipment	Power (hp)	Power (kW)	Duration (hr)	Annual Power Consumed (kW-hr)
Monorail hoist	5	3.73	80	300
Trash rake	7.5	5.59	689	3,852
Conveyor	10	7.45	842	6,273
Gate operators	1.5	1.11	13	14
Total Annual Power Consumed				10,439

The wear and tear on the structure and equipments could not be estimated. This is a cost that is dependent on variables such as types of repair or replacement scenarios. Some depreciation value could be used to estimate the wear and tear costs of the facility. However, this is beyond the scope of this report.

The cost for operating the facility at the current December 6, 2007 power rate from MDU is estimated approximately at \$3,000 annually. The cost is estimated from MDU's Irrigation Power Service Rate 25. This cost includes a monthly base rate of \$8.75, an energy usage rate of \$0.0274 per kW-hr, a monthly demand

charge of \$2.90 per horsepower of connected load, and a minimum seasonal charge base rate of \$22.72 per horse power of connected load. Future rate increases by MDU would affect the annual cost. However, this cost does not reflect the additional labor required as part of the installation and removal of the trashrack panels, trash removal, and gate operation. The labor required is assumed to be offsetting with the existing operation of the headworks.

## **Bypass Hydraulics**

This section discusses hydraulics that would allow construction bypass diversions during the irrigation season using the existing gates. The discussion here is theoretical and would require further hydraulic evaluation of the river hydrology, headworks operation, and canal backwater. This evaluation would be expanded in the Feasibility Design and Final Design phases.

The fundamental hydraulic equation for submerged tube relating the hydraulic head, friction coefficient, and flow velocity is as shown in the following equation.

$$V = C(2 * g * h)^{.5}$$

The “C” value is the headloss coefficient and can be assumed at 0.80 as unitless from Reference 3. The “g” is acceleration of gravity given at 32.2 ft/sec<sup>2</sup>. The hydraulic head is “h” in feet. “V” is the velocity of the water in feet per second (ft/s).

Under a hydraulic head of three feet between the upstream and downstream sides of the headworks, the flow velocity would be 13.9 ft/s. With a five feet diameter gate fully opened, the diversion through each gate is approximately 273 ft<sup>3</sup>/s flow. With five gates fully opened for construction bypass diversion, the combined flow would be approximately 1,365 ft<sup>3</sup>/s. If additional hydraulic head is made available, the flow increases. Therefore a potential minimum hydraulic head of 3 feet would divert close to the 1,400 ft<sup>3</sup>/s flows as needed for irrigation. With the flexibility of the District adding riprap as part of their maintenance routine to raise the river water surface, adding riprap during construction would increase the hydraulic head and provide the bypass diversion flow needed.

# References

1. Jordan, George, September 5, 2006. Summary of the Biological Review Team's comments on Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report.
2. Technical Service Center, Bureau of Reclamation, "Intake Diversion Dam Fish Protection and Passage Concept Study Report II, Lower Yellowstone Project Yellowstone River, Montana," April 2004.
3. Office of Chief Engineer Denver, Colorado, Bureau of Reclamation, "Design Standards No. 3 Canals and Related Structures," December, 1967.

# Appendix A

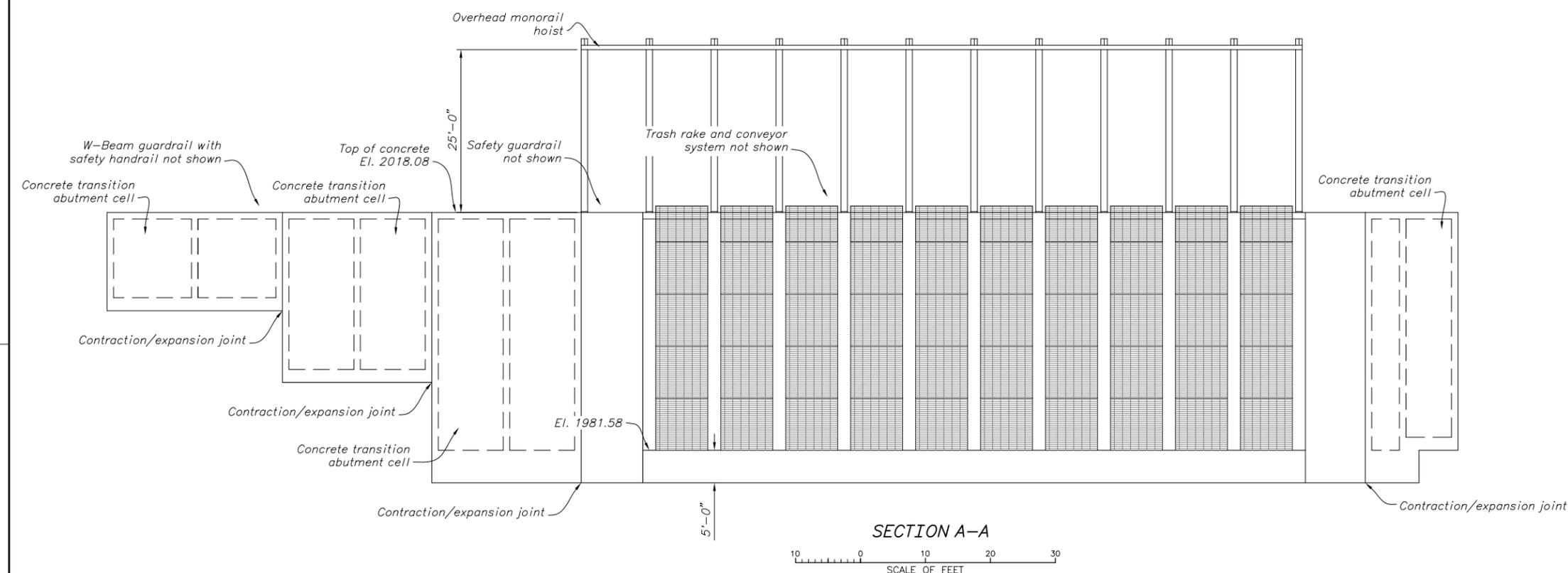
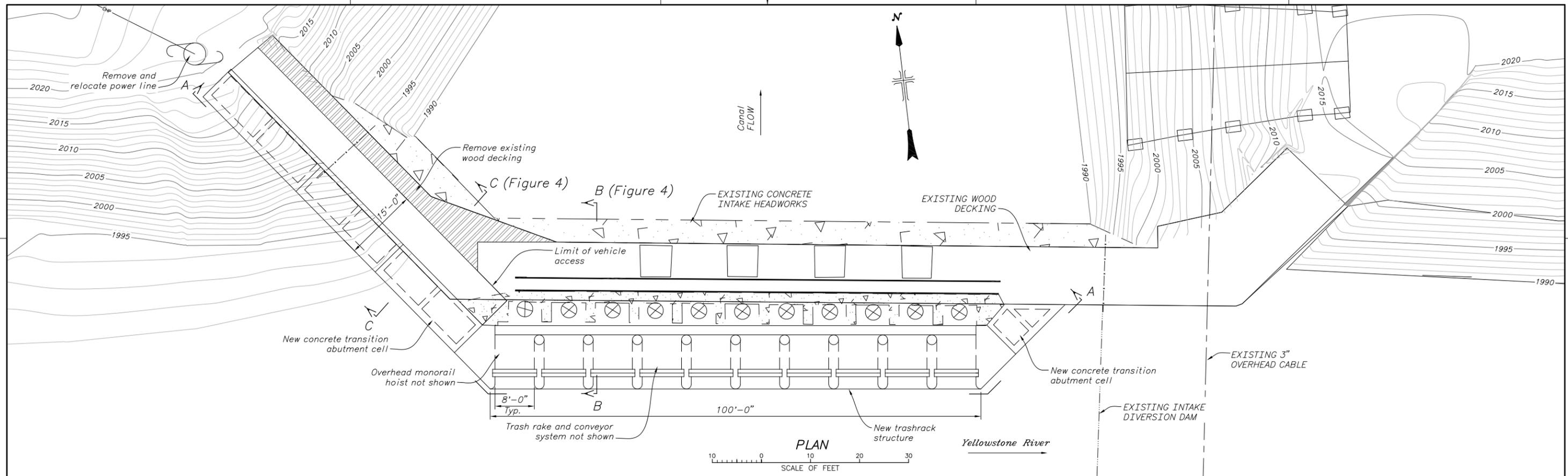
5

4

3

2

1



**NOTE**

- 1. Elevation in NAVD88 Datum.
- 2. Foundation piles for new trashrack structure and transition abutments not shown.
- 3. Trashracks are 8 feet high by 9 feet wide removable panels.

**ALWAYS THINK SAFETY**

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION  
INTAKE PROJECT - MONTANA

**FISH PROTECTION CONCEPT STUDY**  
TRASHRACK STRUCTURE  
CONCEPT DESIGN  
PLAN AND SECTION

**FIGURE 3**

CADD SYSTEM AutoCAD Rev. 16.2s	CADD FILENAME NEW TRASHRACK WITH RAKE.DWG
-----------------------------------	----------------------------------------------

FILE PATH: O:\Lower Yellowstone Project\Intake Diversion Dam\Trashrack Structure Appraisal Design\Draw  
 PLOTTED BY: CCHA  
 FEBRUARY 1, 2008 08:44

5

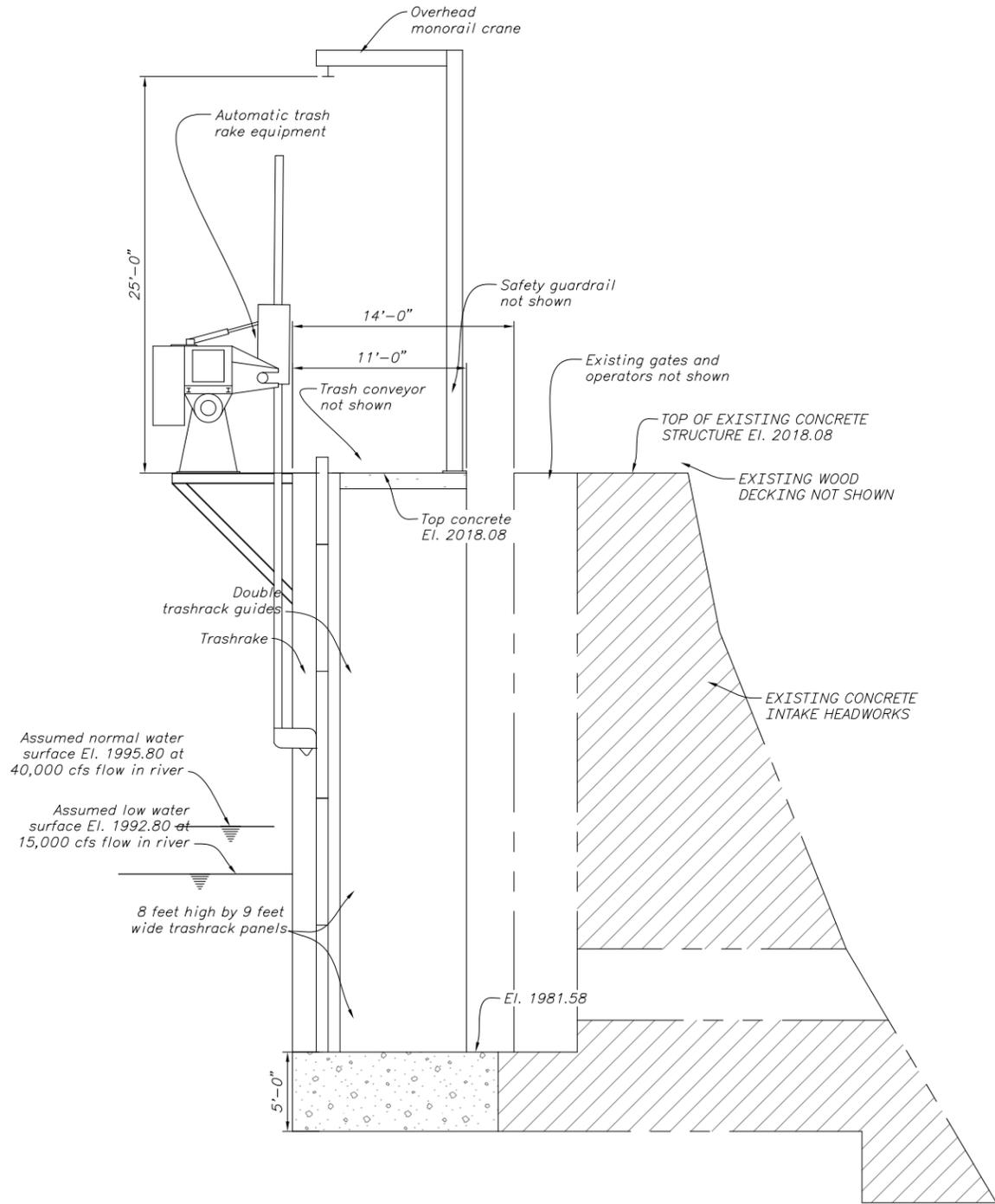
4

3

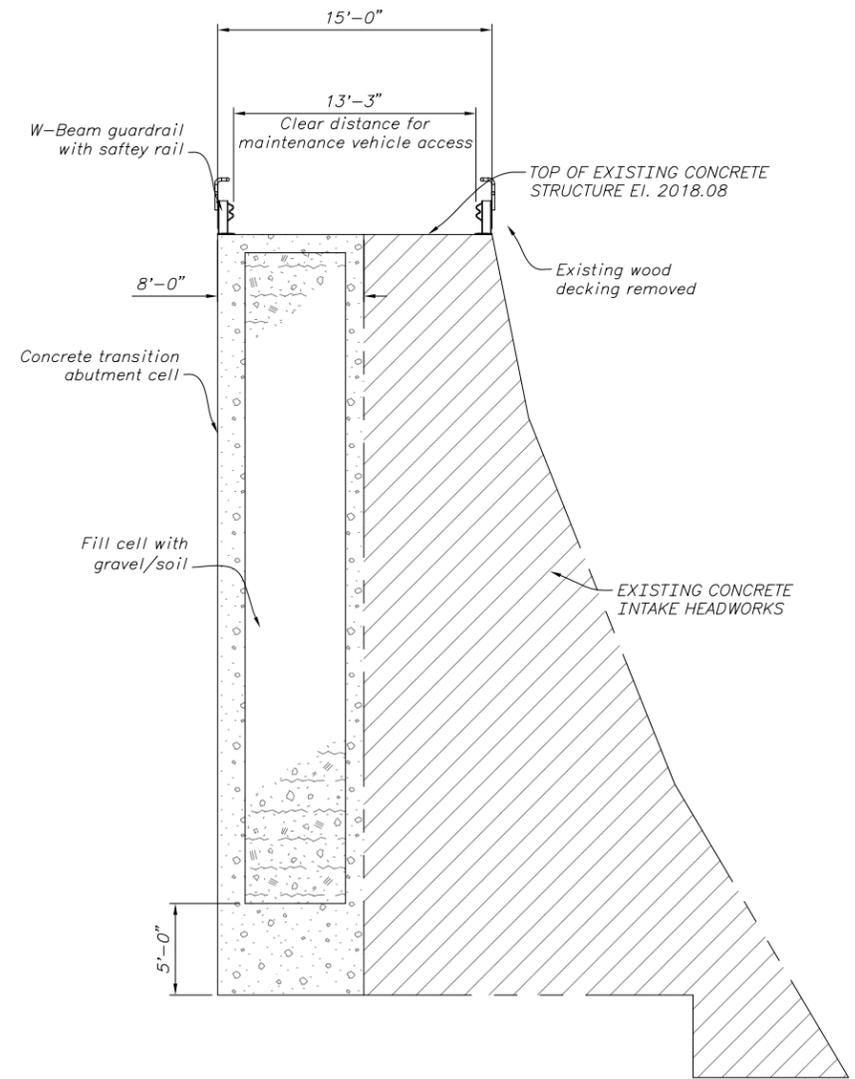
2

1

FILE PATH: O:\Lower Yellowstone Project\Intake Diversion Dam\Trashrack Structure Appraisal Design (Dwg)  
 PLOTTED BY: CCHA  
 FEBRUARY 1, 2008 08:44



SECTION B-B (Figure 3)  
 No Scale



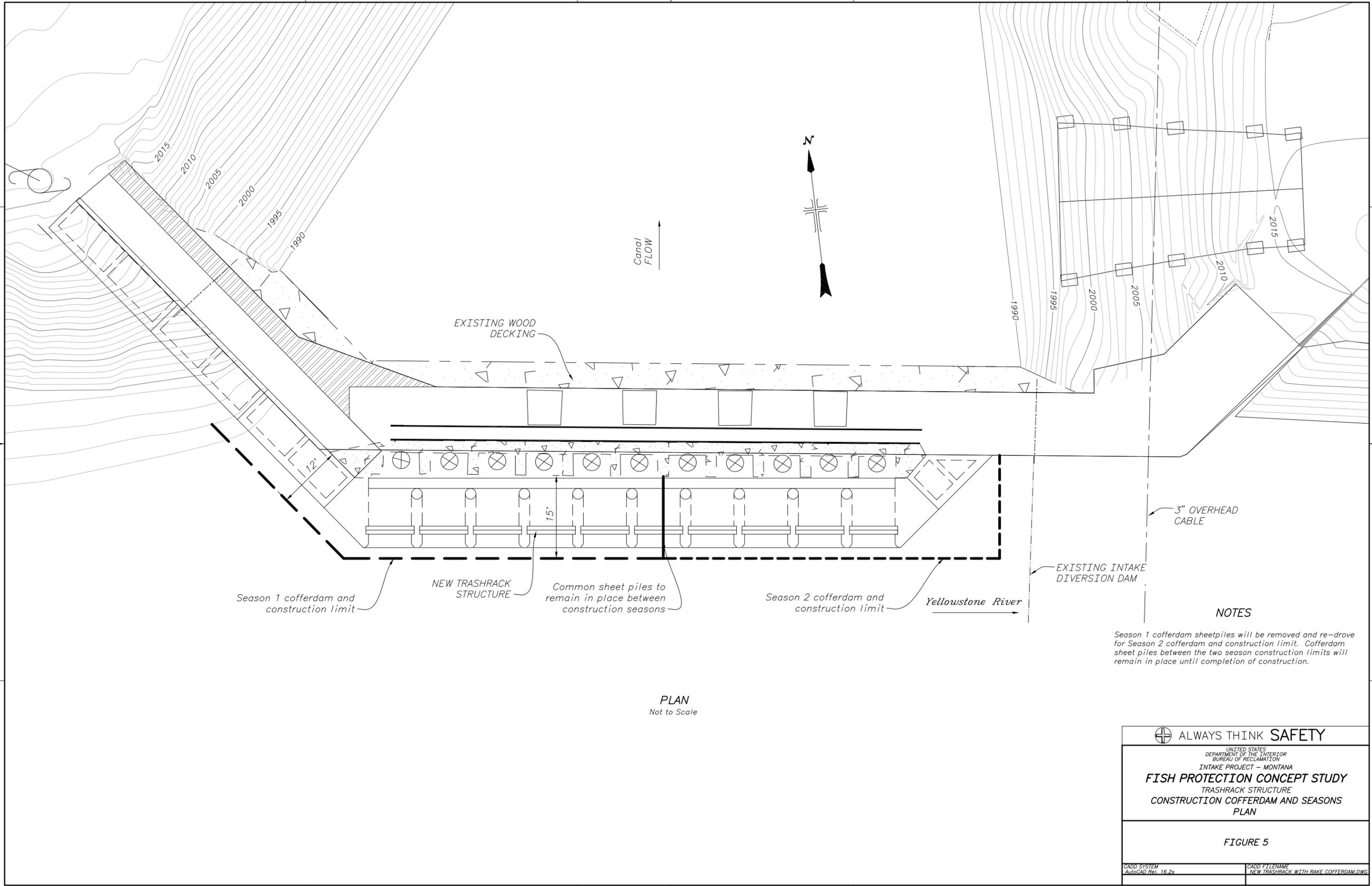
SECTION C-C (Figure 3)  
 No Scale

**NOTE**

1. Elevation in NAVD88 Datum.
2. Foundation piles for new trashrack structure and abutments not shown.
3. Water surface elevations is based on Intake Diversion Dam Fish Protection and Passage Concept Study Report II HEC RAS hydraulic modeling.
4. At low water surface elevation, 1,400 cfs is still being diverted through Intake Diversion.

<b>ALWAYS THINK SAFETY</b>	
<small>UNITED STATES          DEPARTMENT OF THE INTERIOR          BUREAU OF RECLAMATION</small> <b>FISH PROTECTION CONCEPT STUDY</b> <small>TRASHRACK STRUCTURE          CONCEPT DESIGN          SECTIONS</small>	
<b>FIGURE 4</b>	
<small>CADD SYSTEM AutoCAD Rev. 16.2s</small>	<small>CADD FILENAME NEW_TRASHRACK_WITH_RAKE.DWG</small>

FILE PATH: O:\Lower Yellowstone Project\Intake Diversion Dam\Trashrack Structure Appraisal Design\Drawn  
 PLOTTED BY: CCHA  
 FEBRUARY 1, 2008 09:16



# Appendix B

# ESTIMATE WORKSHEET

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept	<b>PROJECT:</b> Lower Yellowstone Project
	<b>REGION:</b> GP <b>ESTIMATE LEVEL:</b> Appraisal <b>WOID:</b> 6B921 <b>PRICE LEVEL:</b> Oct - 07
	<b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary

**Summary**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>SUMMARY:</b>					
		86-68120 Sheet (Structural Steel and Miscellaneous Metals)					\$397,200.00
		86-68140 Sheet (Concrete, Excavation, Backfill)					\$1,609,540.00
		86-68312 Sheet (Cofferdam and Water Control)					\$2,830,400.00
		86-68312 Sheet (Foundation Piles)					\$240,000.00
		86-68410 Sheet (Mechanical)					\$2,220,000.00
		86-68420 Sheet (Motor Operators)					\$390,000.00
		86-68430 Sheet (Electrical)					\$68,800.00
		<b>Subtotal</b>					<b>\$7,755,940.00</b>
		Mobilization				10%	\$780,000.00
		<b>Subtotal w/ Mobilization</b>					<b>\$8,535,940.00</b>
		Design Contingencies				15%	\$1,264,060.00
		Allowance for Procurement Strategy (assumed unrestricted sealed, competitive bid)				0%	--
		<b>CONTRACT COST</b>					<b>\$9,800,000.00</b>
		Construction Contingencies				25%	\$2,700,000.00
		<b>FIELD COST</b>					<b>\$12,500,000.00</b>
		<b>Notes:</b>					
		Non-contract costs are to be provided by others. This estimate does not include non-contract costs at this time, and therefore should not be used for funding purposes.					
		Reference documents RM D&S Cost Estimate (FAC 09-01) and RM D&S CCE and PCE (FAC 09-02)					

QUANTITIES		PRICES	
<b>BY</b> See Group Sheets	<b>CHECKED</b> See Group Sheets	<b>BY</b> T Hanke	<b>CHECKED</b>
<b>DATE PREPARED</b> ---	<b>PEER REVIEW</b> See Group Sheets	<b>DATE PREPARED</b> 02/04/08	<b>PEER REVIEW</b>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Structural Steel and Misc. Metalwork)  <b>86-68120</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%;"><b>REGION:</b> GP</td> <td style="width:50%;"><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack(Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls) Summary	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal				
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07				

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	<b>1</b>	<b>Structural Steel (monorail beam @ 25' high and frame supports for 2-ton hoist)</b>					
		Monorail beam, baseplates, anchor bolts, and tension-only rods (ASTM A36, Fy=36 ksi)	8120	6,100	LBS	\$8.00	\$48,800.00
		Frame supports (ASTM A992, Fy=50 ksi)	8120	40,300	LBS	\$8.00	\$322,400.00
	<b>2</b>	<b>Miscellaneous Metalwork (ASTM A36, Fy=36 ksi)</b>					
		Steel pipe guardrails	8120	1,800	LBS	\$10.00	\$18,000.00
		a. 1-1/2" Std. pipe, 3-rail, 42 inches high					
		b. Top-mounted with kickplate					
		Removable posts and chain	8120	800	LBS	\$10.00	\$8,000.00
		a. 1-1/2" Std. pipe posts, 42 inches high					
		b. Embedded pipe sockets, 3 rows of chain					
		c. Max. post spacing = 5 feet					
		<b>NOTE:</b> Quantities for W-beam guardrails w/ pipe guardrails are provided by 8140.					
<b>This Sheet and Total 86-68120 =&gt;</b>							<b>\$397,200.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY Olaff G. Huerta	CHECKED B. VanOtterloo	BY <i>TH</i> T. Hanke	CHECKED <i>[Signature]</i>
DATE PREPARED 1/16/2008	PEER REVIEW R. W. LaFond	DATE PREPARED 02/04/08	PEER REVIEW <i>[Signature]</i>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept  <b>86-68140</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:25%;"><b>REGION:</b></td> <td style="width:25%;">GP</td> <td style="width:25%;"><b>ESTIMATE LEVEL:</b></td> <td style="width:25%;">Appraisal</td> </tr> <tr> <td><b>WOID:</b></td> <td>6B921</td> <td><b>PRICE LEVEL:</b></td> <td>Oct - 07</td> </tr> <tr> <td><b>FILE:</b></td> <td colspan="3">J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\ [Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls] Summary</td> </tr> </table>	<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal	<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07	<b>FILE:</b>	J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\ [Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls] Summary		
<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal										
<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07										
<b>FILE:</b>	J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\ [Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls] Summary												

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Removal of existing wooden deck 2"x6" timber deck	8140	94	sy	\$40.00	\$3,760.00
	2	Concrete 4,000 psi	8140	1,060	cy	\$1,100.00	\$1,166,000.00
	3	Cementious material	8140	300	tons	\$240.00	\$72,000.00
	4	Reinforcement 60 ksi yield strength	8140	159,000	lbs	\$1.95	\$310,050.00
	5	Excavation for left abutment cells	8140	340	cy	\$17.00	\$5,780.00
	6	Backfill about left abutment cells	8140	270	cy	\$20.00	\$5,400.00
	7	Compacted backfill about left abutment cell	8140	270	cy	\$15.00	\$4,050.00
	8	W-Beam guardrails with safety guardrails attached (Similar to Chiloquin Dam Removal Fshscm Struct.)	8140	155	lf	\$150.00	\$23,250.00
	9	Backfill inside abutment cell with gravel fill	8140	350	cy	\$55.00	\$19,250.00
<b>This Sheet and Total 86-68140 =&gt;</b>							<b>\$1,609,540.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY Chou Cha	CHECKED Nick Clough	BY <i>TH</i> T. Hanke	CHECKED <i>TH</i>
DATE PREPARED 1/16/2008	PEER REVIEW Chou Cha	DATE PREPARED 02/04/08	PEER REVIEW <i>ACD</i>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Cofferdam & Water Control)  <b>86-68312</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;"><b>REGION:</b> GP</td> <td style="width:30%;"><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal				
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07				

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>Assumption: Maximum water elevation EI 1995.8</b>					
		<b>Cofferdam will be flip-floped, one half at a time</b>					
		<b>All sheet pile placed by river barge</b>					
		<b>First half of cofferdam</b>					
	1	Furnish and install sheetpile (over 6 bays) Use AZ26 sheet piles - Section Modulus = 48.4 in <sup>3</sup> /ft 41 piles @ 43 ft long (≈ 116,200 lbs) Drive piles 20 ft deep 11 piles @ 23 ft long (≈ 16,500 lbs) Drive piles 10 ft deep	8312	1	LS	\$260,000.00	\$260,000.00
	2	Use W14X90 for walers and brace struts 105 ft waler = 9,450 lbs 10 struts @ 30 ft ≈ 27,000 lbs	8312	1	LS	\$132,000.00	\$132,000.00
	3	Dewatering/Unwatering Assume 1 month use (before base slab placement) 10 wellpoints (induction wells 10 ft deep) 2 - 20 hp - 3-inch dia line sump pumps to unwater construction area  Pump operation assumed @ 5 months (24/7)	8312	1	LS	\$1,140,000.00	\$1,140,000.00
	4	Sheet pile wall connection to existing concrete wall Wall will be anchored by special section anchored by divers (underwater work)	8312	1	LS	\$38,000.00	\$38,000.00
	5	Sandbag wall to start of sheet pile wall Use 170 ft <sup>3</sup> of sand bags	8312	1	LS	\$2,400.00	\$2,400.00
		<b>This Sheet =&gt;</b>					<b>\$1,572,400.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY R. Davis	CHECKED Roger Torres	BY <i>TH</i> T. Hanke	CHECKED <i>TH</i>
DATE PREPARED 01/08/08	PEER REVIEW R. H. Davis	DATE PREPARED 02/04/08	PEER REVIEW <i>TH</i>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept  (Cofferdam & Water Control)  <b>86-68312</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;"><b>REGION:</b> GP</td> <td style="width:30%;"><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal				
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07				

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>Second half of cofferdam</b>					
	6	Pull sheets (leaving center wall) Extract 11 piles @ 23ft long 10ft deep Extract 34 piles @ 43ft long 20ft deep	8312	1	LS	\$59,000.00	\$59,000.00
	7	Reinstall 34 piles driven 20 ft deep	8312	1	LS	\$71,000.00	\$71,000.00
	8	Furnish and install 7 piles @ 43 ft long @ 20ft deep 20,500 lbs of sheet pile	8312	1	LS	\$40,000.00	\$40,000.00
	9	Use W14X90 for whalers and brace struts 100 ft whaler = 9,450 lbs 9 struts @ 30 ft ≈ 24,300 lbs Assuming includes removal of first half whalers/struts	8312	1	LS	\$70,000.00	\$70,000.00
	10	Dewatering/Unwatering Assume 1 month use (before base slab placement) 10 wellpoints (induction wells 10 ft deep) 2 - 20 hp - 3-inch line sump pumps to unwater construction area  Pump operation assumed @ 4 months (24/7)	8312	1	LS	\$910,000.00	\$910,000.00
	11	Sheet pile wall connection to existing concrete wall Wall will be anchored by special section anchored by divers (underwater work)	8312	1	LS	\$38,000.00	\$38,000.00
	12	Remove cofferdam Extract 41 piles @ 43ft @ 20ft deep Cut and extract 7 piles @ 15 ft long Piles will be cut underwater	8312	1	LS	\$70,000.00	\$70,000.00
		<b>This Sheet =&gt;</b>					<b>\$1,258,000.00</b>
		<b>Sheet 1 of 2 subtotal =&gt;</b>					<b>\$1,572,400.00</b>
					<b>Total 86-68312 =&gt;</b>		<b>\$2,830,400.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY R. H. Davis	CHECKED Roger Torres	BY <i>TH</i> T. Hanke	CHECKED <i>TH</i>
DATE PREPARED 01/08/08	PEER REVIEW R. H. Davis	DATE PREPARED 02/04/08	PEER REVIEW <i>ded</i>

# ESTIMATE WORKSHEET

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Foundation Piles)  <b>86-68312</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;"><b>REGION:</b> GP</td> <td style="width: 25%;"><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal				
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07				

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Assume foundation piles driven in the wet Piles driven from barge Piles driven 25 ft deep Piles spaced at 4-foot center					
	1	Foundation Piles: 26 rows of 3 pile ea row = 78 piles Use HP12x74 at 30 ft length Total wt = 144,300 lbs	8312	1	LS	\$240,000.00	\$240,000.00
<b>This Sheet and 86-68312 (Foundation Piles) Total =&gt;</b>							<b>\$240,000.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY R. Davis	CHECKED Roger Torres	BY <i>TH</i> T. Hanke	CHECKED <i>DC</i>
DATE PREPARED 01/08/08	PEER REVIEW R. H. Davis	DATE PREPARED 02/04/08	PEER REVIEW <i>DCD</i>

# ESTIMATE WORKSHEET

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Mechanical)  <b>86-68410</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;"><b>REGION:</b></td> <td style="width: 25%;">GP</td> <td style="width: 25%;"><b>ESTIMATE LEVEL:</b></td> <td style="width: 25%;">Appraisal</td> </tr> <tr> <td><b>WOID:</b></td> <td>6B921</td> <td><b>PRICE LEVEL:</b></td> <td>Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal	<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07
<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal						
<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07						

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Furnish and install trashrack embedded guides Structural steel (10 bays, 2 sets of guides/bay), coated	86-68410	68,600	LBS	\$8.00	\$548,800.00
	2	Stackable trashrack panels for 10 bays Structural steel, coated	86-68410	140,400	LBS	\$5.00	\$702,000.00
	3	Trashrack lifting beam, steel, coated	86-68410	800	LBS	\$4.00	\$3,200.00
	4	Monorail hoist, 2-ton, 62 ft of lift capacity, 4 Hp motor (motorized lift and trolley)	86-68410	1	L.S.	\$19,000.00	\$19,000.00
	5	Trash rake (assume Atlas Polar Hydrorake DT8300) 7.5 Hp, double boom rake, chasis and control panel Rake travel rail and supports, structural steel, coated	86-68410	1	L.S.	\$650,000.00	\$650,000.00
				6,000	LBS	Inc above	
				20,000	LBS	Inc above	
	6	Drag chain type conveyor, 10 Hp drive, 110 ft Steel, coated	86-68410	11,000	LBS	\$27.00	\$297,000.00
<b>This Sheet and 86-68410 Total =&gt;</b>							<b>\$2,220,000.00</b>

QUANTITIES		PRICES	
BY R. Christensen	CHECKED R. Stephen	BY <i>TH</i> T. Hanke	CHECKED <i>TSV</i>
DATE PREPARED 01/17/08	PEER REVIEW J. Grass	DATE PREPARED 02/04/08	PEER REVIEW <i>Doc</i>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Motor Operators)  <b>86-68420</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;"><b>REGION:</b> GP</td> <td><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> </table> <b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal				
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07				

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>60" Slide Gates Motor-Operators</b>	86-68420	1	LS	\$390,000.00	\$390,000.00
	1	Motor Operators - Eleven Required		3,850	Pounds	Inc above	
	2	Stainless Steel Motor Mounting Brackets - Eleven Required		1,100	Pounds	Inc above	
	3	Gate Stems - Stainless Steel - Eleven Required		3,700	Pounds	Inc above	
	4	Misc. Parts		550	Pounds	Inc above	
		<u>Total</u>		9,200	Pounds		
<b>This Sheet and 86-68420 Total =&gt;</b>							<b>\$390,000.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY G.W Rood	CHECKED N. Nakamoto	BY <i>TH</i> T. Hanke	CHECKED <i>BO</i>
DATE PREPARED 01/16/08	PEER REVIEW D. Read	DATE PREPARED 02/04/08	PEER REVIEW <i>Doc</i>

**ESTIMATE WORKSHEET**

<p><b>FEATURE:</b></p> <p style="text-align: center;">Lower Yellowstone Diversion Dam</p> <p style="text-align: center;">Intake Diversion Headworks Trashrack Concept (Electrical)</p> <p><b>86-68430</b></p>	<p><b>PROJECT:</b></p> <p style="text-align: center;">Lower Yellowstone Project</p> <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;"><b>REGION:</b></td> <td style="width:20%;">GP</td> <td style="width:30%;"><b>ESTIMATE LEVEL:</b></td> <td style="width:20%;">Appraisal</td> </tr> <tr> <td><b>WOID:</b></td> <td>6B921</td> <td><b>PRICE LEVEL:</b></td> <td>Oct - 07</td> </tr> </table> <p><b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary</p>	<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal	<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07
<b>REGION:</b>	GP	<b>ESTIMATE LEVEL:</b>	Appraisal						
<b>WOID:</b>	6B921	<b>PRICE LEVEL:</b>	Oct - 07						

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	F&I 200 A, 480 V, 3 Phase meter socket	86-68430	1	Each	\$700.00	\$700.00
	2	F&I 200 A, 600 V, 3 Phase fused disconnect switch in NEMA 3 R enclosure	86-68430	1	Each	\$4,500.00	\$4,500.00
	3	F&I 480 V, Distribution Panelboard, 225 A bus: a. NEMA 3R enclosure (21"H X 20"L X 6"D) b. 1-110 A trip with 225 A frame, Main breaker c. 11-15 A trip with 100 A frame d. 1-20 A trip with 100 A frame e. 1-30 A trip with 100 A frame f. 1-35 A trip with 100 A frame	86-68430	1	Each	\$8,300.00	\$8,300.00
	4	F& I Load Center, 5KVA, 1 phase, 480-240/120V: a. NEMA 3R enclosure (33"H X 12"L X 12"D) b. 1-20 A trip with 100 A frame (2 P), Primary c. 1-30 A trip with 100 A frame (2 P), Secondary d. 2-20 A trip with 100 A frame (1 P) e. 4-15 A trip with 100 A frame (1 P)	86-68430	1	Each	\$18,000.00	\$18,000.00
	5	F&I Grounding System: a. 4 AWG bare copper b. 3/4" dia. 10 foot ground rod	86-68430	250	Feet	\$4.00	\$1,000.00
				4	Each	\$350.00	\$1,400.00
	6	F&I PVC coated Rigid Steel Conduit: a. 2 Inch	86-68430	100	Feet	\$70.00	\$7,000.00
	7	F&I Rigid Metal Conduit: a. 3/4 Inch	86-68430	1,000	Feet	\$20.00	\$20,000.00
	8	F&I 600 V,Copper, Single Conductor Type THHN/THWN: a. 1 AWG	86-68430	300	Feet	\$8.00	\$2,400.00
	9	F&I Multi-Conductor, 600 V, Copper: a. 1-4/c 12 AWG	86-68430	1,000	Feet	\$4.00	\$4,000.00
<b>This Sheet =&gt;</b>							<b>\$67,300.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY Richard Noi	CHECKED L. Rossi	BY <i>TH</i> T. Hanke	CHECKED <i>TH</i>
DATE PREPARED 01/09/08	PEER REVIEW G. Girgis	DATE PREPARED 02/04/08	PEER REVIEW <i>TH</i>

**ESTIMATE WORKSHEET**

<b>FEATURE:</b> Lower Yellowstone Diversion Dam  Intake Diversion Headworks Trashrack Concept (Electrical)  <b>86-68430</b>	<b>PROJECT:</b> Lower Yellowstone Project  <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;"><b>REGION:</b> GP</td> <td><b>ESTIMATE LEVEL:</b> Appraisal</td> </tr> <tr> <td><b>WOID:</b> 6B921</td> <td><b>PRICE LEVEL:</b> Oct - 07</td> </tr> <tr> <td colspan="2"><b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary</td> </tr> </table>	<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal	<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07	<b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary	
<b>REGION:</b> GP	<b>ESTIMATE LEVEL:</b> Appraisal						
<b>WOID:</b> 6B921	<b>PRICE LEVEL:</b> Oct - 07						
<b>FILE:</b> J:\0001 ESTIMATES\Lwr Yellowstone Div Intake Trashrack\Lwr Yellowstone Rvr Intake Div Dam Trash Racks_Appraisal 02_2007.xls Summary							

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	10	F&I 1 inch liquidtight flexible metal conduit	86-68430	50	Feet	\$30.00	\$1,500.00
		<b>This Sheet =&gt;</b>					<b>\$1,500.00</b>
		<b>Sheet 1 of 2 subtotal =&gt;</b>					<b>\$67,300.00</b>
				<b>Total 86-68430 =&gt;</b>			<b>\$68,800.00</b>

<b>QUANTITIES</b>		<b>PRICES</b>	
BY Richard Noi	CHECKED L. Rossi	BY <i>TH</i> T. Hanke	CHECKED <i>TH</i>
DATE PREPARED 01/09/08	PEER REVIEW G. Gorgis	DATE PREPARED 02/04/08	PEER REVIEW <i>AGD</i>