**PURPOSE**

Wyoming Water Development Commission contracted with Engineering Associates in 2007 to complete a study of Willwood Irrigation District’s dam and system structures. The scope of this study included an in-depth evaluation of Willwood Dam, map grade surveying of system structures including the known locations of their underground drain system, possible locations of passive weed screens, creating a GIS with a search tool and map books.

**WILLWOOD DAM**

Willwood Diversion Dam was constructed in 1924 for the purpose of diverting water into the Willwood Canal. The Willwood Dam is not used for storage of water. Willwood Dam is located on a sharp bend in the Shoshone River and a massive fluvial point bar has developed and is narrowing the river channel from the left bank. Over the last 85 years, two of the three dam sluice gates have been buried in 40 feet of silt and are not operational. The only operational sluice gate is the north gate. The furthest most south gate has a bent stem. The spillway apron was not directly observed during this study. However, due to the age of the dam and the repairs undertaken in 1990, it is anticipated there is severe erosion. The canal gates have been replaced but may require some maintenance and the addition of electric gate operators. The concrete surrounding the canal gates was not evaluated since they are submerged year around. There is erosion of the sandstone rock face at the right abutment both upstream and downstream of the dam. This downstream erosion is caused by continual runoff from the county road that crosses the dam. In 2007, Park County completed major repairs to the road and installed curbing to direct the runoff away from the abutment. The upstream erosion is caused by the river. Construction joints on the downstream face of the dam are leaking. The leaking was noted during a 1989 study. In 2007, leaking was still evident. In 2009, there was a noticeable increase in the amount of flow leaking at these construction joints. The seepage has also degraded the concrete on the face of the dam surrounding and below the leaks. There is water seeping on each side of the dam. The seepage and freeze/thaw cycle is deteriorating the concrete and the sandstone where the two items touch each other. Dam base and abutment stabilization are needed. Both items have suffered degradation over time from the silt loading over time. The only operating sluice gate and the canal gates have a geared operator and motor which control their operation. The gear housing is manually switched from the sluice gate to the canal gates or vice versa. Both gates cannot be operated at the same time. The sluice gate is closed and the canal gates are connected to the motor during the irrigation season. WID adjust the canal gates manually depending on the amount of water being called for by irrigators. In the off-season, WID closes the canal gates and switches the motor to the sluice gate to open it. During the mid-winter, WID is required by the BOR to sluice all river water through the gate so water does not overtop the dam. Per DEQ requirements, WID is not
allowed to exceed 10 NTU's in the river downstream of the dam. WID struggles every off-season to stay within the DEQ requirement and satisfy the BOR dam operating criteria, usually with minimum success.

**HYDROPOWER**
In 2003, a hydropower evaluation was completed on three sites - Deer Creek Drop, Willwood Chute, and Peerless Chute. At that time, these sites were found not feasible. In 2005, Pacific Power increased their avoided power rates over 200%. Therefore, these three sites were re-evaluated during this study with the newer avoided rates.

**MAPPING AND GIS**
WID is in need of a Geographical Information System (GIS) for use in managing their district. Survey information and photographs were collected and inserted into the GIS along with land class maps, farm unit maps, aerial photos, USGS topographic maps, commission districts, grazing leases, and Park County roads and land ownerships. A search tool has been created to help WID easily update and utilize their GIS.

**PASSIVE WEED SCREENS**
In some warmer years, the east end of WID and Lateral 113 and 153 experience an increase in moss growth. The moss accumulates and becomes a bit more troublesome around Roan Wash in the main canal. To provide cleaner water for the east end irrigators, three weeds screen locations have been identified. All three Ogee-crest weed screens would be placed in the main canal. The first weed screen near Roan Wash would deposit the clean water back into the main canal. The second and third weed screens would be constructed in the main canal just before Lateral 113 and Lateral 153, respectively. The clean water would be diverted down Lateral 113 and Lateral 153 and the water with the trash would continue down the main canal.

**TELEMETRY**
Currently, WID does not have water measurement devices along their canal from their first head gate to the end of their canal. WID would like to replace their existing, old radial gates at each siphon with an overshot gate and telemetry. The overshot gate would be used for regulating flow and water measurement.
FINDINGS

WILLWOOD DAM
Martin/Martin evaluated Willwood Dam. The findings are:

- Geotechnical borings identified a depth of sediment to historic streambed and bedrock of approximately 40 to 45 feet.

- Although the condition of the spillway apron was not directly observed, it is believed that significant repairs may be needed based upon the age of the dam, sluicing operations and the sediment which has overtopped the dam in the past.

- It is understood that the canal gates have been replaced as part of previous rehabilitation work. These gates are also understood to be operational and would only require maintenance and the addition of electric gate operators to allow for automation of the system. The gates are submerged. To fully evaluate the gates, the river would need to be diverted away from the gates for de-watering.

- The three existing sluice gates are over 80 years old, and two of the three gates are buried by siltation and have been non-operable for some time.

- Weathering of the right bank is also occurring on the upstream side of the abutment. Erosion has progressed approximately 3’ to 4’ above the water line.

- A previous report (Chen-Northern, Engineering Associates, 1989) noted construction joints in the downstream face of the dam which were seeping water. Seepage was also observed during the March, 2007 preliminary site visit and the February, 2009 detailed site investigation. The water is leaking through construction joints at the north and south ends of the dam. The leak at the south end is approximately 7’ from the south cheek wall and appears to be related to water seeping over and through the south cheek wall. The leak at the north end starts at the north end of the dam near the erosion of the right abutment and extends to the opening for the future power plant penstock. There is also seepage through the north cheek wall in the same area.

- Water appears to be seeping through both abutments behind the cheek walls. This has accelerated the erosion of the abutments downstream from the dam.
• Water is seeping over and through the south cheek wall. Much of the concrete in the cheek wall has been damaged due to water seepage and the action of freeze/thaw cycles. The wall has also been patched at one point.

• Water is seeping over and through the north cheek wall. Seepage was observed in several locations along the length of the wall.

• Concerns with the stability of the dam due to the sediment loading on the upstream face of the dam suggest that some abutment and dam base stabilization, possibly grouting, is needed.

• The ability of the dam to continue supporting the existing roadway is directly related to the condition of the concrete bridge piers, columns, slab, and abutment walls. The concrete elements are in generally good condition, with some erosion noted at the bridge piers, columns and abutments. The underside of the concrete roadway slab appeared to be in good condition.

• A remote control system would allow WID to receive field conditions from gauge stations and sluice gates, as well as wirelessly operate the gates to release flows.

• According to the dam operating criteria and Wyoming Surface Water Quality Standards, water turbidity has to be sampled at upstream and downstream of the Willwood Dam.

• Repair of the upstream face of the dam was not listed as an item of specific concern of the District. However, based on our previous dam experience, it is likely that some scour damage and concrete deterioration to the upstream face of dams can occur. The damage is generally minimal because of low water velocities, except around the sluice gates. Because only the north sluice gate has been in service for much of the recent past, it should be expected that most of the scour damage will be concentrated around this area.

• Replacement of the plug in the penstock for the future power plant was not listed as an item of specific concern to the District. The integrity of this plug may be of concern if the operation of the dam after the silting is removed results in a water level below the elevation of the plug. The opening appears to be blocked with wood dunnage. Water is leaking through and around the dunnage. The upstream face could not be observed due to impounded water behind the dam. The impounded water keeps the dunnage wet and may hold it in place.

• Repair of the construction joints on the spillway was not listed as an item of specific concern of the District. However, based on our previous dam experience, the damage and concrete deterioration that has been occurring should be repaired. The
damage is generally above the waterline of the spillway apron but damage may extend below the waterline.

- Repair of the crest of the spillway was not listed as an item of specific concern of the District. However, based on our February 2009 detailed investigation, the delaminations and concrete deterioration that have been occurring should be repaired.

- Repair of the face of the spillway was not listed as an item of specific concern of the District. However, based on our previous dam experience, the damage and concrete deterioration that has been occurring should be repaired at some time. The damage is generally spalling and erosion of the concrete surface to depths up to 3”.

- Repair of the face of the dam at the future power plant was not listed as an item of specific concern of the District. However, based on our previous dam experience, the damage and concrete deterioration that has been occurring should be repaired at some time. The damage is generally spalling and weathering of the concrete surface to depths up to 3”.

**HYDROPOWER**

States West investigated potential sites for a hydropower system within the Willwood Irrigation District and concluded that Deer Creek Pipe Drop would be the most feasible location. Several power utilities within the district would be available to purchase power generated from the system.

**MAPPING AND GIS**

The following items were included in the GIS:

- Locations of canals, laterals, sublaterals, and irrigation structures, from field surveying.

- Scanning and geo-referencing land class maps and soil class maps provided by WID.

- Include land ownership data received from Park County.

- Include aerial orthophotos showing irrigated and non-irrigated lands.

- Include Public Land Survey System maps showing township/range, section, quarter section or lot or tract, and public and private land ownership.

- Include grazing leases.
Willwood Rehabilitation and GIS Level II Study

Executive Summary

- Include commissioner districts.
- Include underground drains and manholes.
- Hyperlink photos to respective GIS feature.
- Create geo-database showing structure condition and other data.
- Provide training to WID personnel in the use and maintenance of the GIS map.

IRRIGATION GEODATABASE SEARCH TOOL

Anderson Consulting Engineers developed a search tool for this project. This tool will allow WID to easily edit and update the GIS. Anderson initially developed this tool for the Worland Area Irrigation Lands GIS in 2007. Anderson modified and updated this tool to serve WID in their irrigation needs. The tool has various parts:

- IGT (Irrigation Geodatabase Tool) Navigation Tool enables the GIS user to navigate spatially throughout the GIS map.
- IGT Query Tool allows the user to query data contained within the Geodatabase and view information such as structure condition, prior upgrades, rehabilitation needs, priority of rehabilitation, etc.
- IGT Data Review Table can be considered the “workhorse” of the customized tools. A primary function of the DRT is to present the feature attributes and associated data in a clear and easy to read format. The DRT bypasses ArcView’s data table structure, which is inherently cumbersome for the novice user.
- IGT Map Tool allows the user to generate formatted maps of any GIS view. By clicking on Make Map, the GIS automatically switches to ArcView’s layout mode and initiates the generation of a map. The user is asked for information such as a title prior to finalization of the map. The tool automatically scales the map, adds a legend and a north arrow.
- As structures are replaced or new structures added to any of the irrigation systems, the user could add them to the Geodatabase using this feature.

TELEMETRY

Replace existing radial gates with overshot gates and flow measurement at 3 siphons and provide for future automation.
PASSIVE WEED SCREENS

We found the Coanda Effect Screen to be the best option. The benefit to the Coanda Effect Screen is the Bureau of Reclamation setup a full-scale model in their water lab to analyze the screen in various situations. Coanda Effect Screens are manufactured by two companies Norris Screens and Hydroscreen, LLC. The Coanda Effect Screen utilizes the energy of the water to remove debris over an inclined screen. The Coanda Effect Screen is composed of long wire wedges that allow the clean water to flow through the openings and the trash to pass over the inclined screen. Depending on the size of material to be removed, the wedges can be spaced as needed for design purposes.
# Recommendations

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<th>Application Year</th>
<th>Project Name</th>
<th>Type of Rehabilitation</th>
<th>Total Construction Cost</th>
<th>67% WWDC Grant or 100% Materials Grant</th>
<th>WID Matching Funds = WID Engineering, Labor and Equipment Costs</th>
<th>WID Annual Cost/Acre for Contractor-Bid Projects for 20 year loan</th>
<th>Construction Year</th>
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## Executive Summary

### WILLWOOD DAM REHABILITATION COST OPINION SUMMARY

**APRIL 2020**

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<th>Legal Fees</th>
<th>Land Acquisition %</th>
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<th>Total Loan %</th>
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### Notes
1. Annual Loan Payment based on an assumed 25-Year loan term at 4% interest.
2. Per acre costs based on Willwood Irrigation District’s 11,500 acres.

Prepared by Mark Marks, Inc. #333068

---

**APPENDIX A**
## Executive Summary

### Willwood Rehabilitation and GIS Level II Study

<table>
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<tr>
<th>Site</th>
<th>Description</th>
<th>Construction Cost</th>
<th>Construction Engineering %</th>
<th>Construction Utilization %</th>
<th>Contingency %</th>
<th>Construction Total</th>
<th>Total Engineering</th>
<th>Combined Percentage</th>
<th>Combined Utilization</th>
<th>Total Project</th>
<th>Interest (6%)</th>
<th>Total Loan</th>
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<td>6%</td>
<td>$306,909.00</td>
<td>$306,909.00</td>
<td>$306,909.00</td>
<td>10%</td>
</tr>
<tr>
<td>4A</td>
<td>Rec Update - Phase 2</td>
<td>$289,795.00</td>
<td>10%</td>
<td>32%</td>
<td>0%</td>
<td>$289,795.00</td>
<td>$289,795.00</td>
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<td>6%</td>
<td>$289,795.00</td>
<td>$289,795.00</td>
<td>$289,795.00</td>
<td>10%</td>
</tr>
<tr>
<td>4B</td>
<td>Rec Update - Phase 3</td>
<td>$272,636.00</td>
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<td>10%</td>
</tr>
<tr>
<td>4C</td>
<td>Rec Update - Phase 4</td>
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<td>$256,483.00</td>
<td>$256,483.00</td>
<td>$256,483.00</td>
<td>10%</td>
</tr>
</tbody>
</table>

### Key Points
- **Total Construction Cost:** $1,047,853,000
- **Total Engineering Costs:** $104,785,300
- **Total Project Costs:** $1,152,638,300
- **Total Loan Amount:** $767,795,000
- **Total Cost Per Acre:** $115,263.83
- **Interest Rate:** 6%
- **Timing:** 2004-2023

### Notes
1. **Annual Loan Payment Based on 10-Year Amortization at 5% Interest**
   - **Costs Calculated Based on Willwood Irrigation District 11,352 Acres**