Executive Summary

Wagoner Cherokee Irrigation District
Level II Phase 1 and Phase 2 Study

A Wyoming Water Development Commission Project

January 2005

PMPC
Saratoga, Wyoming

in association with

States West Water Resources Corporation
Cheyenne, Wyoming

Anderson Consulting Engineers, Inc.
Fort Collins, Colorado
INTRODUCTION
The Wagoner Cherokee Irrigation District (District) is located in southern Carbon County near the Towns of Encampment and Riverside. On September 2, 2003, PMPC in association with States West Water Resources Corporation entered into a Consultant Contract for Services No. 05SC0292275 with the Wyoming Water Development Commission (WWDC) for the Wagoner Cherokee Irrigation District Level II Study (referred to as Phase 1). On June 21, 2004, PMPC in association with States West Water Resources Corporation and Anderson Consulting Engineers, Inc. entered into a second Consultant Contract for Services No. 055C0292434 with the WWDC for the Wagoner Cherokee Irrigation District Level II Phase 2 Study (referred to as Phase 2).

PROJECT HISTORY
The WWDC Wagoner Cherokee Irrigation District Level I Master Plan (Level I) was completed in November 2002 by PMPC, States West Water Resources and Water Right Services, LLC. The recommendations of the Level I report were for the Wagoner Cherokee Irrigation District to complete District formation and request the WWDC to proceed with a Level II study. District formation is a requirement to proceed with a WWDC Level II study. The Wagoner Cherokee Irrigation District was officially formed June 17, 2003 and can be seen in Figure 1.

The point of diversion for the Wagoner Ditch is approximately 800 feet downstream of the Cherokee Ditch. The two ditches run parallel to each other for approximately 1.5 miles from the diversions to Highway 230. Water from the Encampment River is diverted into the Wagoner and Cherokee Ditches to irrigate the Project area. The Wagoner Ditch has an appropriation of 15.41 cfs and the Cherokee Ditch has an appropriation of 23.6 cfs plus 7.21 cfs of supplemental supply. A total of 3,243 acres, including the supplemental supply, can be irrigated through these ditches. During low flows in the Encampment River, numerous downstream ditches are supplied through the Cherokee Ditch without properly changing the point of diversion on record with the State Board of Control.

PROJECT SCOPE – PHASE 1 AND PHASE 2
The Level II, Phase 1, study further investigates seepage loss and provides cost estimates based on the Level I selected alternative. The Level I selected alternative is a combined diversion structure at the location of the existing Cherokee Ditch diversion and approximately 960 feet of a combined ditch carrying both Wagoner and Cherokee Ditch flows to a location where the Wagoner Ditch flows are diverted from the combined ditch into the existing Wagoner Ditch. The scope includes an attempt to identify areas of higher seepage with the option of treating isolated areas.

The Wagoner Cherokee Irrigation District discussed the possibility of adding a geomorphology study of the Encampment River and design of a rock weir diversion to the Level II report. After discussions between the District and the WWDC it was decided that the additional scope could not be added to the original Level II scope. The WWDC distributed a request for proposals for the additional work. PMPC submitted a statement of interest and was awarded the work. Phase 1, the original Level II contract, and Phase 2, the geomorphology study, results are incorporated into one report.
The Phase 2 scope includes performing a geomorphic characterization of the Encampment River, designing rock weir/vane type diversion structure(s) and developing cost estimates. The same criteria developed for the Level I study to design the Obermeyer diversion structure will be used for the rock weir/vane type diversion. Constructing one combined diversion or two separate diversions, the same two scenarios developed in the Level I, will be analyzed.

Figure 1 – Irrigation District Location Map
FIELD INVESTIGATION
PMPC conducted field investigations to examine the condition of the ditches by a visual inspection, gage ditch flows from the Encampment River diversions to Highway 230 attempting to identify areas of higher seepage. Surveys included cross sections in the Encampment River both upstream and downstream of the proposed structure, gaging locations and the property line between land owners. A geotechnical investigation was completed at the site of the existing Cherokee Ditch diversion.

The visual inspections concluded that the material in the ditches was uniform and consistent and no soil changes were noted. The rock outcrop, Station 105+00 to Station 109+00, was the only physical feature that might have an effect on the seepage loss.

Seepage Analysis
The Level I seepage analysis concluded that the Cherokee Ditch has a 21.5% seepage loss and the Wagoner Ditch has a 15.6% seepage loss. The Level II stream gaging was an attempt to isolate areas of higher seepage and determine the amount of seepage that migrates from the Cherokee Ditch into the Wagoner Ditch.

Prior to the Cherokee Ditch being turned on, the Wagoner Ditch had a seepage loss of 10% with 40 cfs measured at the diversion. After the Cherokee Ditch was turned on, the Wagoner Ditch seepage decreased, indicating seepage from the Cherokee Ditch flows into the Wagoner Ditch. The Cherokee Ditch had a significantly lower seepage loss compared to the Level I analysis. The Cherokee Ditch was measured twice for verification of the much lower results. The first overall seepage loss was 7% (44 cfs measured at the diversion) and the second measurement resulted in a 4% seepage loss (45 cfs was measured at the diversion).

Encampment River Geotechnical Investigation
A geotechnical investigation was conducted at the site of the existing Cherokee diversion structure. The geotechnical investigation concluded that there is a five-foot drop in bedrock elevation above and below the existing Cherokee Ditch diversion.

Geomorphology Study
A qualitative geomorphic evaluation of the Encampment River was conducted in the vicinity of the proposed project. Upstream of the Grand Valley Ditch diversion, the river was classified as a Type-B3c channel using the Rosgen classification system indicating a transitional zone between a steeper confined mountain stream and a lower gradient, meandering downstream system. Downstream of the diversion, the channel was classified as a Type-C3 meandering channel. Here the channel slope decreases, sediment transport capacity is reduced accordingly, and frequency of alternative and mid-channel bars increases.

Based upon the geomorphic classification, several conclusions can be made:
• Incipient motion analyses indicate that degradation or erosion of the channel bed within the study reach is limited and indicates that the channel bed is relatively stable.
• Laterally, the channel appears to be relatively stable throughout the study reaches.
• Agricultural diversions may disrupt the equilibrium between sediment supply and sediment transport capacity resulting in increased deposition of coarse and fine-grained materials downstream.

• Proposed improvements to the diversion structures for the Wagoner and Cherokee Ditches will have minimal impacts given the limited magnitude of these improvements on the river and incorporation of recommended design considerations.

• The coarse-grained nature of existing bed materials will continue to limit the channel degradation given the potential to armor the channel bed.

CONCEPTUAL DESIGN
The purpose of the conceptual design was to identify potential improvements to the existing irrigation facilities. More specifically, evaluate improvements that would increase system efficiency by designing new Wagoner and Cherokee diversion(s) and reducing seepage.

There were two main considerations relating to the diversion structures. The first consideration is constructing two separate diversion structures in the Encampment River or one combined diversion structure. The other main consideration is the type of diversion structure, an Obermeyer diversion structure or a rock weir structure. A combined diversion structure is more economical.

By combining the diversions, the Cherokee Ditch needs to be enlarged to carry both appropriations until the Wagoner Ditch flows are diverted into the Wagoner Ditch. Seepage is also a concern.

The conceptual design criteria for the diversion structures are as follows:
• Minimize increase in high water and promote passage of kayaks and rafts during periods of high water. The structure should pass high water flows with minimal overbank flow.
• Bypass sediment and debris during high flows.
• Hydraulically efficient to divert water into the headgate structure during periods of low flow.
• Facilitate the passage of fish.
• Blend in with the natural environment.
• Exclude fish from entering the irrigation ditch.

Encampment River Obermeyer Diversion Structure Conceptual Design
The Obermeyer diversion structure would be located slightly downstream of the existing Cherokee diversion structure. The proposed diversion structure including the headgate structure would be approximately 160 feet long, see Figure 2. The central portion of the structure would incorporate 4.5-foot tall hardened-steel Obermeyer gates that would be 60 feet wide and the riprap overflow sections which are 55 feet long. Riprap will be used both upstream and downstream of diversion for erosion protection.

The headgate structure would be 13-feet tall and constructed of reinforced concrete. The structure would incorporate three manually operated 54-inch square slide gates. The headgate structure would be designed to pass up to 190 cubic feet per second. A 10-foot Parshall flume constructed of reinforced concrete would be installed and would be able to measure flows from six to 200 cubic feet per second.
The Obermeyer diversion structure meets all of the District's criteria.

Encampment River Rock Weir Diversion Structure Conceptual Design
Footer rocks and header rocks will be used to construct the rock weir structure. The footer rocks will have a diameter between 48 and 72 inches and the header rocks will have a diameter between 24 and 36 inches, see Figure 3. These rocks are handpicked to be the correct size and shape. The rocks are organized into a "V" configuration with the point of the "V" facing upstream. When complete, the upstream point of the "V" must be the lowest point in the rock weir structure.

Placing individual structures at both the Cherokee and the Wagoner sites was evaluated; however, this option quickly became cost prohibitive and was not investigated any further. The structure that was investigated uses a combined structure at the Cherokee site.

The rock weir structure needs to be placed at least 1,200 feet upstream of the existing Cherokee diversion structure, see Figure 4. The canal that delivers water to the irrigation ditch will be
constructed of grouted riprap. The canal will follow the cliff that is located along the eastern bank and will be trapezoidal shaped with a bottom width of 10 feet and one-to-one side slopes. The west bank of the canal will be 5.75 feet high. The design of the canal allows it to carry 190 cfs without allowing the water to overflow the canal’s banks; however, any water quantity more than 190 cfs will flow over the west bank and back into the river.

Other components include the intake structure, headgate structure, reinforced concrete retaining walls, and a Parshall flume.

The rock weir structure does not meet all of the District’s criteria. The structure would increase the overbank flow during high water and would not blend in with the natural environment very well. Most importantly, the structure would not be hydraulically efficient to divert water into the headgate during periods of low flow. Other disadvantages include the rock weir structure would not be as reliable as the Obermeyer diversion structure, securing the necessary construction permits might be difficult, a U.S. Army Corps of Engineers 404 permit would be required, many trees would have to be removed to allow access for the construction equipment and wetlands and riparian areas will be adversely affected.

Figure 3 – Rock Weir Structure – Vane Structure Details
Figure 4 – Rock Weir Structure – Site Plan View
Combined Ditch Conceptual Design
The conceptual design includes combining the ditches from the proposed diversion to the Wagoner Ditch spillway. The proposed enlarged ditch was designed for 190 cfs.

The ditch design consists of a typical ditch section except through the rock outcrop area. For the remaining portion, the ditch was modeled as a trapezoidal channel with a bottom width of 15 feet, a depth of 4 feet with 1 foot of freeboard. Three-to-one side slopes will be used except through the rock outcrop, from Station 105+00 to Station 109+00.

Wagoner Ditch Diversion and Drop Structure Conceptual Design
For one diversion structure located at the Cherokee diversion site, the water for both ditches will be carried in the enlarged Cherokee Ditch. The Wagoner Ditch flows will be diverted at the transition ditch diversion and drop structure. The diversion structure was designed to divert half of the design capacity, 95 cfs, back into the Wagoner Ditch while maintaining the other half in the Cherokee Ditch. The separation of the flows will be performed by adjusting the slide gates. The diversion structure will be constructed of reinforced concrete with slide gates.

Seepage Treatment Options
Seepage treatment alternatives evaluated include concrete lining, geosynthetic clay lining, polypropylene lining, bentonite treatment, shotcrete lining, a polyacrylamide treatment and a liquid polymer treatment. All of these options with the exception of the shotcrete lining, the polyacrylamide treatment and the liquid polymer treatment were evaluated in the Level I study. Shotcrete was evaluated for the rock outcrop area only.

Polyacrylamide (PAM) is an environmentally friendly flocculent added directly to the water. PAM causes the suspended particles in the water to settle and seal the ditch to reduce seepage. PAM is applied once or twice each year and is not a permanent solution but is economical. The District can oversee and implement the PAM. PAM is a new technology and is still being studied. The reduction in seepage is still unknown; the results vary from 25% to 90% seepage reduction. For the analysis in this study a 50% seepage reduction was used.

PERMITS FOR CONSTRUCTION
For construction of the proposed improvements, the District may need to obtain permits or authorization from the following agencies: Corps of Engineer’s (COE), United States Fish and Wildlife, Wyoming Game and Fish Department, Wyoming Department of Environmental Quality (DEQ) – Water Quality Divisions, State Historic Preservation Office, State Engineer’s Office (SEO) and Land Owners. This list may not be inclusive. There has been correspondence with the COE and this project will be exempt for a Corps of Engineers permit (with the Obermeyer diversion structure only).

PROJECT PHASING
The opportunity for project phasing is minimal. The District could construct the diversion structure, combined ditch, and transition ditch diversion and drop structure. The seepage treatment could be installed at a later time.
ECONOMIC ANALYSIS
A cost/benefit analysis is essential for the District to determine whether or not to continue with the improvements and proceed to Level III construction. Advantages of the proposed improvements include the following.

- By constructing a combined diversion structure, the District will have the ability to divert the water they are entitled to during low flows, which they have historically not been able to do. Therefore, depending on the year, the District can divert more water during the irrigation season and for a longer period of time.
- The proposed diversion structure will provide ease of operation and maintenance resulting in a reduction of annual operation and maintenance costs.
- The District will gain additional water with a seepage treatment and Dwight and Candace France would be able to harvest 15 acres they are currently not able to.

An economic analysis was performed to evaluate the seepage treatment options. The District will need to determine if the additional water is worth the cost per acre-ft. The PAM treatment costs $12/acre-foot, from there the seepage treatments increase to $1,100/acre-foot. The PAM treatment is the only economically feasible seepage treatment option.

CONCEPTUAL COST ESTIMATES AND REPAYMENT PLAN
Cost estimates have been prepared for the conceptual designs. The cost estimates include costs for construction components, construction engineering, preparation of final design plans and specifications, permitting and mitigation, legal fees and acquisition of access and rights of way.

The rock weir structure was investigated to determine if it was more economical than the Obermeyer diversion structure. The required length of the canal extension makes this alternative much more expensive than the Obermeyer diversion structure. The Encampment River Obermeyer diversion structure cost estimate is $489,860 and the rock weir diversion structure cost estimate is $1,299,518. The Transition Ditch diversion and drop structure cost estimate is $60,000.

The cost for a combined enlarged Wagoner Ditch is $26 per lineal foot; this does not include any seepage treatment option. Based on the economics, the PAM treatment is the only feasible option. Based on materials only, the PAM treatment is $0.34 per foot of ditch which equates to $4,900 per year for an annual treatment. The other seepage treatments varied from $28 to $259 per foot of ditch (one time costs).

Table 1 summarizes the total project costs and details a repayment plan. Figures include an assessment with and without the United States Fish and Wildlife (USFW) Section 7 depletion payment for both a 20 and 30-year repayment period. The total projected cost is $564,445. The funding for the Project was assumed to be 50% WWDC grant and 50% WWDC loan. The figures in Table 1 are based on the assumption that there are 3,181.4 benefited acres. The costs of the improvements will be assessed to the benefited acres in the District.
Table 1 – Project Cost Estimate and Repayment Plan

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<th>Conceptual Design</th>
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<tr>
<td>Combined Grouted Riprap Diversion Structure</td>
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<td>Combined Ditch (no seepage treatment)</td>
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<td>Transition Ditch Diversion and Drop Structure</td>
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CONCLUSIONS
The Level II study included the Phase 1 and the Phase 2 portion of the project. The scope included investigation of combining the Wagoner Ditch and Cherokee Ditch diversion structures with one new Obermeyer diversion structure or rock weir diversion structure(s) which required a geomorphology study. Seepage and seepage treatment options were also further investigated. Cost estimates were provided for the evaluated alternatives and a repayment plan for the most economical solution.

The District indicated that their main priority is a diversion structure. A combined structure is more economical than two separate structures, and an Obermeyer diversion structure is more economical than the rock weir structure.

Advantages of the improvements include the ability to divert water the District is entitled to during low flows, provide ease of operation and maintenance and gain additional water with a seepage treatment.

It is obvious there is seepage in both ditches. Flow measuring was done to determine the extent of the seepage in isolated areas but the results were inconclusive. Therefore, areas of higher seepage cannot be treated individually. The seepage analysis indicated that the seepage from the Cherokee Ditch seeps into the Wagoner Ditch. A recommendation is for the District to internally implement the PAM seepage treatment, monitor and evaluate the results.

A ditch maintenance agreement was not adopted during the Level II Study. Further consideration should be give to a formal agreement for operation and maintenance of the ditches including a dedicated means of access.