LANDER
LEVEL II WATER SUPPLY PROJECT
EXECUTIVE SUMMARY

AUGUST 2004
SUBMITTED TO
THE WYOMING WATER DEVELOPMENT COMMISSION
AND
THE CITY OF LANDER, WYOMING

WESTON
GROUNDWATER • ENGINEERING
WESTON ENGINEERING, INC.
EXECUTIVE SUMMARY
for:

LANDER LEVEL II
WATER SUPPLY PROJECT

Prepared for:

Wyoming Water Development Commission

Submitted by:

Weston Engineering, Inc

AUGUST 2004
EXECUTIVE SUMMARY

LANDER
LEVEL II WATER SUPPLY PROJECT

INTRODUCTION

The City of Lander is located in west-central Wyoming in the foothills of the eastern slope of the Wind River Mountains at an elevation of approximately 5,350 feet above sea level (Figure 1). The City is situated in the valley of the Middle Popo Agie River in western Fremont County, of which it is the county seat. Located at the junction of U.S. Highway 287 and State Highway 789, Lander is on a major route to Teton and Yellowstone National Parks.

The current population of Lander is 6,867 people, as recorded in the 2000 census. Since 1980 when the population was 8,189, there has been a steady decrease in Lander’s population. According the City of Lander Comprehensive Plan (2002), the decrease in population can be attributed to closure of the U.S. Steel mine in 1985, a growing retirement community, a decrease in family units, and movement of families to rural properties in the Lander area.

The Lander service area currently has 2,706 taps and includes those areas within the corporate City limits, approximately 20 taps in the Tweed Lane Water and Sewer District, approximately 20 taps on properties adjacent to the corporate City limits, and several taps along the present water transmission lines.

PRESENT AND FUTURE WATER NEEDS

Although Lander has historically obtained drinking water from the Middle Popo Agie River, an extended drought cycle has diminished flows in the river in recent years. In addition, the U.S. Environmental Protection Agency (EPA) has determined that the City’s infiltration gallery, which supplies up to 2 million gallons per day (MGD) to the City, is under the direct influence of surface water and must be abandoned or the water must be treated (Nelson, 1999). The City has decided to discontinue use of the infiltration gallery, effective June 15, 2004. Because the City of Lander is concerned about obtaining sufficient quantities of surface water to meet drinking water demands in the future, they have decided to investigate the potential of supplementing their surface water supply with groundwater sources.

SCOPE OF THE LEVEL II STUDY

The Lander Level II Water Supply Study consisted of three phases: Phase I – the Paleozoic Aquifer well siting study; Phase II – exploration well construction; and Phase III – conceptual design and cost estimates. Phase I, the Lander Paleozoic Aquifer Well Siting Study, was conducted during 2002 and submitted to the City of Lander and the WWDC in November 2002 (WESTON, 2002). Several potential Paleozoic Aquifer well sites, one of which was selected as the site of the Lander Exploration Well, were proposed as a result of the well siting study.

Phase II, which consisted of permitting, developing bid documents and selecting a drilling contractor, and drilling, constructing, and testing the Lander Exploration Well, was conducted during late fall and winter of 2003 and 2004. Phase III was not conducted as part of this phase of the study because of the desire of the City of Lander to deepen the Lander Exploration Well to test the hydraulic properties of the Madison Limestone.
WELL SITING STUDY

The major purpose of this Level II Water Supply Project was the drilling, construction, and testing of an exploration well completed in the Tensleep Sandstone. The Phase I Paleozoic Aquifer well siting study identified eight potential well sites within the 400 square mile study area. The Tensleep Aquifer was identified as the target aquifer for the Lander Exploration Well based on water quantity and quality issues, as well as depth to the aquifer. The eight potential well sites were presented to the Lander City Council and after considering several well siting criteria the Council decided to pursue funding for drilling an exploration well in the northern part of the study area. The decision to focus on the northern part of the study area was based primarily on high construction costs associated with long transmission lines from the southern well sites to the existing infrastructure.

As part of Phase II, WESTON revisited areas within the drainages of the Middle Fork of the Popo Agie River, Baldwin Creek, and Squaw Creek for considering potential well sites. WESTON also interviewed Lander City officials and local property owners regarding their interest and concerns regarding potential exploration well sites. Four potential exploration well sites were identified within the three drainages using the same criteria employed in the formal well siting study. With the absence of any favorable geologic structures to enhance secondary permeability in the Tensleep Sandstone, the site selection was made based upon ease of access and proximity to existing infrastructure. The selected site offered a distinct advantage of having a short pipeline length required to tie the exploration well into the existing water system. Furthermore, an access agreement was readily reached with the landowner.

GROUNDWATER EXPLORATION PROGRAM

The Lander Exploration Well was drilled to a total depth of 2,545 feet during the fall and winter of 2003. As shown in Figure 2, an as-built diagram of the Lander Exploration Well, the top of the Tensleep Sandstone was penetrated at a depth of 1,920 feet and 9 5/8-inch O.D. casing was set and cemented to a depth of 1,922 feet. Groundwater flow from the well is contained by a 10-inch gate valve attached to the top of 9 5/8-inch casing. The base of the Tensleep Sandstone was encountered at a depth of 2,310 feet. After reaching this depth a short flow test was conducted to determine the production capacity of the well under flowing conditions. The test was conducted to assess the capacity of the well before resuming drilling to the Madison Limestone. The well was tested for a period of 24 hours at a rate of 90 gallons per minute (gpm). After approximately 200 minutes of testing the drawdown leveled off and became constant at 207 feet. The well recovered to the pre-test shut-in pressure 23 minutes after closing the gate valve.

After allowing the well to recover, the drilling contractor rigged up to continue drilling with the ultimate goal of testing the Madison Limestone. The driller used clear water as the drilling medium to allow any changes in flow rate to be observed and drilling was advanced to a depth of 2,545 into the Amsden Formation. The lithology of the Amsden Formation was composed of limestone and tight sandstone and no increase in water production was observed across that interval. At a depth of 2,470 feet red shale became the dominant lithology and drilling could not advance beyond that depth because the drilling contractor could not make a connection. Frac sand, graded to 20 x 40, was used to plug the Amsden Formation.

The well was pump tested at a rate of 325 gpm for a period of seven days. The drawdown at the end of the pump test was 1,015 feet, which corresponds to a pumping water level of 657 feet below ground level. The effective transmissivity of the aquifer in the vicinity of the well ranged from approximately 1,225 gpd/ft for the early-time data to 610 gpd/ft for the late-time data. A first-order analysis of the constant-rate pump test data indicates that the Lander Exploration Well could
155 PSI SHUT-IN PRESSURE (358 FEET ABOVE GROUND LEVEL) ON JANUARY 7, 2004

T.D. = 2,545 FEET NOT TO SCALE

DESIGN DETAILS

10-INCH GATE VALVE

PRESSURE GAUGE

0 - 120 FEET: 13 3/8-INCH O.D. STEEL CASING

0 - 1,622 FEET: LIGHT CEMENT GROUT

+1.5 - 1,922 FEET: 9 5/8-INCH O.D. STEEL CASING

120 - 1,938 FEET: 12 1/4-INCH DIAMETER BOREHOLE

1,622 - 1,922 FEET: TYPE G CEMENT

1,922 FEET: GUIDE SHOE

1,938 - 2,545 FEET: 8 3/4-INCH BOREHOLE

2,430 - 2,545 FEET: CEMENT AND COLORADO 20 X 40 FRAC SAND

CASING TO FORMATION CENTRALIZERS (FEET)

<table>
<thead>
<tr>
<th>Depth</th>
<th>Centralizer</th>
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<tbody>
<tr>
<td>45</td>
<td>1,122</td>
</tr>
<tr>
<td>225</td>
<td>1,347</td>
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<tr>
<td>449</td>
<td>1,571</td>
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<td>673</td>
<td>1,795</td>
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<td>898</td>
<td>1,884</td>
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LANDER TENSLEEP WELL
AS-BUILT DIAGRAM
FIGURE 2
sustain a constant production rate of 285 gpm for a period of one year. The predicted drawdown at the end of one year of continuous pumping is 750 feet below ground level.

Potential interference between the Lander Exploration Well and existing neighboring wells completed in the Tensleep Sandstone indicates that the predicted average drawdown at the end of one, five, and ten years of pumping would be approximately 115, 202, and 240 feet, respectively.

The quality of the water developed by the well is excellent, with a TDS concentration of 190 mg/L, which is well below the EPA-recommended concentration of 500 mg/L. None of the analyzed constituents exceed either primary or secondary standards set by EPA.

CONCLUSIONS AND RECOMMENDATIONS

As stated in the Level II Well Siting Study, the goal for the Lander Exploration Well was to develop a well or wellfield capable of replacing the 2 million gallon per day infiltration gallery. Thus, in order to replace the infiltration gallery, such a well or wellfield would have to yield approximately 1,400 gpm.

Although the Lander Level II Water Supply Project successfully sited, drilled, and constructed an exploration well completed in the Tensleep Sandstone, the well is not capable of yielding large enough quantities of water to meet the goal stated above. In addition, aquifer analysis indicates that a wellfield capable of yielding 1,400 gpm from the Tensleep Aquifer would severely impact other area Tensleep wells.

Possible paths forward for this project given the project goals and available data include, but are not limited to:

- Not accepting the Lander Exploration Well and attempting to drill another exploration well at a different site;
- Purchasing the Lander Exploration Well from the WWDC, completing the well without pumping equipment, and allowing the well to flow into the Lander water supply system; or
- Setting a liner assembly in the Lander Exploration Well and drilling through the Madison Limestone to ascertain the productivity of that formation.
- If productivity of the Madison Limestone does not meet expectations, conduct an acid fracturing program designed to enhance the local permeability of the Madison Limestone.

Conversations with the WWDC project manager and the City of Lander indicate that the preferred alternative at this time is to set a liner assembly in the well and drill through the Madison Limestone. Completion of this alternative would include mobilization of the drilling rig, re-entering the well and stemming flow with bentonite-based drilling mud, circulating out the frac sand plug in the Amsden Formation, drilling approximately 160 feet to the top of the Madison Limestone, and setting and cementing a liner assembly from approximately 1,850 feet to 2,670 feet. After allowing the cement behind the liner to cure, drilling will advance through the Madison Limestone. Additional tasks would include well development, testing, and site reclamation. Figure 3 is a proposed well design for the Madison well.

Table 1 summarizes the tasks and estimated costs for providing drilling and engineering services for deepening the Lander Exploration Well to the Madison Limestone and completing the Level II Study. Also included in Table 1 is an option for conducting an acid fracture enhancement...
DESIGN DETAILS

12-INCH GATE VALVE

PRESSURE GAUGE

0 - 140 FEET: 13 3/8-INCH O.D. STEEL CASING CEMENTED IN PLACE

CEMENT GROUT

+1.0 - 1,922 FEET: 9 5/8-INCH O.D. STEEL CASING

137 TO 2,434 FEET: 12 1/4-INCH DIAMETER BOREHOLE

1,850 FEET: LINEAR-HANGER ASSEMBLY

GUIDE SHOE

1,922 - 2,545 FEET: CURRENT 8 3/4-INCH OPEN HOLE COMPLETION

1,850 - 2,656 FEET: 7-INCH STEEL CASING

2,430 - 2,545 FEET: CURRENT PLUGGED SECTION

2,545 - 3,200 FEET: TARGET ZONE FOR WELL DEEPENING

T.D. = 3,200 FEET

NOT TO SCALE

LANDER LEVEL II WATER SUPPLY STUDY
MADISON PRELIMINARY DESIGN DIAGRAM
FIGURE 3

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program, if deemed necessary. The costs provided in Table 1 are based on the typical WWDC requirements for exploration well drilling projects.

**TABLE 1**

**COST ESTIMATE SUMMARY FOR ENGINEERING AND CONSTRUCTION SERVICES FOR DEEPENING AND TESTING THE LANDER EXPLORATION WELL**

**PHASE I. WELL CONSTRUCTION**

<table>
<thead>
<tr>
<th>Task</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Task 1. Scoping Meeting and Project Meetings (1)</td>
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<td>Task 2. Permits, Access, Testing Program Development</td>
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<tr>
<td>Task 3. Contract Negotiations</td>
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<td>Task 4. Consultant Services During Well Construction and Aquifer Testing</td>
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<td>Task 5. Water Quality, Reclamation</td>
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<td>Task 6. Well Construction Contracts</td>
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<td>Task 7. Project Reports</td>
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<td>Option 1. Acid Fracture Enhancement Program</td>
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**PROJECT TOTAL COST (Without Option 1)**

$231,156

**PROJECT TOTAL COST (With Option 1)**

$406,616