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LARAMIE WATER MANAGEMENT STUDY, LEVEL II, PHASE II

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Prepared For:

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I, Theresa Jehn-Dellaport, a Wyoming registered Professional Geologist, certify that this Laramie Water Management Study, Level II, Phase II report was prepared by me or under my direct supervision.

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I, John H. Faulkner, a Wyoming registered Professional Engineer, certify that this Laramie Water Management Study, Level II, Phase II report was prepared by me or under my direct supervision.

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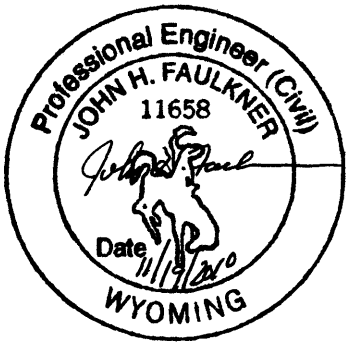

EXECUTIVE SUMMARY

Introduction

The Laramie Water Management Study, Level II, Phase II project (Project) funded by the Wyoming Water Development Commission (WWDC) has been completed. The Level II, Phase II project included a hydraulic computer model of the City's water distribution system, a looped water transmission line for the South of Laramie Water and Sewer District was evaluated, and Aquifer Storage and Recovery (ASR) Testing was completed at the Spur well field. ASR Testing is the subject of this Executive Summary and the following Report. The additional tasks that were approved as part of the Project are summarized in the Tetra Tech Report dated May 26, 2010 (Tetra Tech, 2010).

ASR was identified as a potential strategy for maximizing the efficiency of the City of Laramie's (Laramie) water supply system in the Laramie Water Management Plan, Level II, Phase I study (WWC, 2006). The primary objective of Laramie's ASR activities would be to store water in the Casper aquifer at times when there is surplus water is available, and recover the stored water in times of peak demand. The secondary objective was to potentially increase water levels in the Casper aquifer in the area of the Spur Wellfield that have reportedly been declining (WWC, 2006).

The City of Laramie selected the Spur Wellfield as the preferred location for the pilot ASR testing. ASR at the Spur Wellfield would potentially provide for the storage of water that would otherwise not be used during winter months, reduce reported head decline rates in the Casper aquifer, and allow for the use of the Spur Wellfield as a peaking supply for Laramie (WWC, 2006).

ASR at the Spur Wellfield was viewed as a feasible project because: 1) the source water and piping for the injection testing is nearby; 2) there is an existing monitoring well network; 3) the original exploratory test well (TW-1) could be used as a dedicated injection well; and 4) one of the two production wells could be used to recover water at a later date.

The Project was approved by WWDC in 2007, and the Class V Underground Injection Control permit application was submitted to the Wyoming Department of Environmental Quality (WDEQ) in September 2008. The report for the WDEQ application included the creation of a finite

computer model for the purposes of predicting the effects of the proposed ASR testing on surrounding water levels and on neighboring wells (JWC, 2008). Additional information and analyses were subsequently compiled and submitted to WDEQ, and the Class V permit was issued, by rule, in May 2010. A temporary water use agreement was also obtained from the Wyoming State Engineer's Office prior to the injection testing.

Project Design

The ASR testing at the Spur Wellfield entailed a step test followed by a 5-day injection test. The source water for the injection testing was a blend of treated surface and ground water from Laramie's distribution system. The piping that normally conveys water from the Spur Wellfield to Laramie's distribution system was used to supply water from the distribution system to the injection well. An end-suction centrifugal pump was installed in between the distribution supply piping and the injection well to boost injection rates up to 1,500 gallons per minute (gpm).

Water quality and water level data were collected for both in-field parameter testing and analytical laboratory testing from the existing network of monitoring wells near the Spur Wellfield. Water quality data were collected before, during, and after the injection testing. Water quality monitoring included real-time data collection from in-situ probes installed in the monitoring wells, laboratory analyses, and field test kit analyses.

Findings

The step injection test was conducted with 4 steps at 1,001, 1,240, 1,457, and 1,504 gpm on August 2, 2010. At the termination of the step testing after 7.5 hours, the water level in Spur Well No. 1, which is located approximately 30 feet east of the injection well, had increased by 1.2 feet. The step testing did not cause any adverse changes in water quality. The results of the step testing were summarized in a Technical Memorandum that was submitted to WWDC and WDEQ on August 6, 2010 (JWC, 2010).

The 5-day injection test commenced on August 9, 2010 at 1 PM. Over the first 32 hours of the 5-day ASR test, the average injection rate was 1,516 gpm. From an elapsed time of 34 hours until the end of the test, the average injection rate was 1,053 gpm. At the end of the 5-day test the water level in Spur Well No. 1 had increased by 2.3 feet. Eight days after the end of the

injection testing, the water level in Spur No. 1 remained 0.79 feet, or 34.8%, higher than the static water level prior to the test. Increases in the piezometric head of the Casper aquifer were documented over 2,000 feet away from the injection well. The analysis of the injection test data yielded an average transmissivity of 454,256 gallons per day per foot (gpd/ft), which is comparable to the value determined at the time the Spur Wellfield was completed.

The injection testing did not cause any significant changes in the water quality of the parameters being monitored with in-situ probes, including temperature, pH, conductivity, oxidation-reduction potential, and dissolved oxygen. Both the field and analytical laboratory testing did not show any adverse changes in water quality as a result of the ASR testing. The baseline and post-injection water qualities complied with both State and Federal Drinking Water Standards.

The data from the injection testing were compared to the effects of injection that were predicted with the MODFLOW model for the permit application. The model testing indicated that the predicted modeled results closely matched the actual results in the immediate vicinity of the injection well, but underpredicted the amount of water level rise outside of the injection site area. The calibration of aquifer parameters alone was unable to match the water level rise at distance from the injection well. Complications with the modeling of the Casper aquifer at the Spur Wellfield include: the complexity and variable conditions within the Casper aquifer in the vicinity of the injection well site and the lack of available data detailing that complexity; the injection well itself is partially penetrating the full thickness of the Casper aquifer; and each monitoring well is completed into different limited zones of the Casper aquifer than the injection well. Limited sensitivity analyses completed during calibration attempts suggest that the model results are most sensitive to storage and hydraulic conductivity values.

Recommendations

General

- Drill production wells that fully penetrate all five members of the Casper aquifer.
- The City of Laramie should develop goals for future injection testing. These goals may include:

- Maximizing the use of Laramie's existing water rights. This may include the storage of excess water when available, for future withdrawal at a later date, and potentially during periods of high demand.

- Reducing the rate of water level decline in the Casper aquifer at the Spur Wellfield.

Modeling

It is believed that the base model completed for this injection project is an adequate starting point for predicting water level reactions to injection tests in the immediate vicinity to the injection well at the Spur Wellfield. Due to the geologic complexities of the Casper aquifer, additional data would need to be collected around the area of the injection well to allow for further calibration of the model. If the model were to be used in the future as a predictive tool for future injection projects, the following recommendations would need to be completed to improve the base model.

- A more efficient, fully penetrating injection well would need to be completed. Within the completion process, data would be collected to characterize the Casper aquifer in more detail.

- Monitoring wells would be completed around the new injection well to the same depth and screened across the same aquifer zones as the new injection well.

- The base model would be reduced in size to the vicinity of the injection site to reduce ambiguous noise in the model and make it more manageable.

- Additional injection well testing would be completed on the new injection well in order to collect new data for model calibration.