HORSESHOE CREEK
INTERFERENCE INVESTIGATION REPORT
EXECUTIVE SUMMARY

Prepared for:

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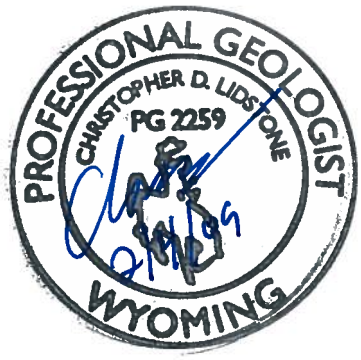

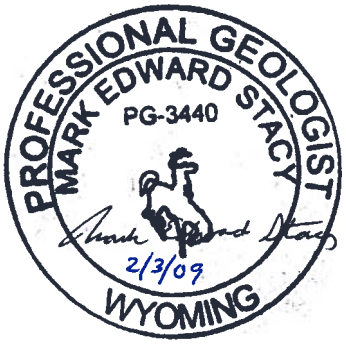

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ACKNOWLEDGMENTS

On behalf of the Wyoming State Engineer's Office (SEO), the Horseshoe Creek Interference Investigation in Platte County, Wyoming, was completed by Lidstone and Associates, Inc. (LA), in association with JR Engineering LLC. LA is grateful for the opportunity to complete this study, and wishes to thank all the SEO and U.S. Geological Survey (USGS) personnel who have worked on this investigation since the 1960s. The success of this investigation rests upon the immense amount of time individuals from these agencies spent evaluating the local geologic and hydrogeologic conditions, gathering Horseshoe Creek streamflow data, constructing monitoring wells, drilling auger test holes, obtaining ground water levels, and inspecting local high capacity wells.

All of the information contained herein was derived directly from SEO records and USGS publications. We thank all of those who were involved in the collection and synthesis of these data, and preparation of these documents.

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1.0 INTRODUCTION

The Wyoming State Engineer's Office (SEO) contracted Lidstone and Associates, Inc. (LA) to complete the Horseshoe Creek Interference Investigation. The SEO initiated the interference investigation based on a March 3, 1988, letter from Mrs. Sommers of Horseshoe Valley Ranch Company. In that letter, Mrs. Sommers alleged that alluvial irrigation wells in the area, particularly those at Lancaster Ranch, were connected to Horseshoe Creek and its associated surface water rights. There was concern that these wells were interfering with their ability to obtain water at their Walker No. 3 and Hoffman No. 1 head gates. The investigation area is located within the Horseshoe Creek Valley of Platte County near Glendo between the intersection of Horseshoe Creek and Horseshoe Creek Road on the west, and the confluence of Horseshoe Creek and the North Platte River on the east within T29N, R68-69W.

Horseshoe Creek is a perennial stream. Numerous agricultural users along the creek have developed water from it for irrigation purposes both within the investigation area, and upstream. Surface water from the creek has been the principal source of irrigation water in the area since 1879, and has generally been used to water alfalfa hay. Ground water has been used as a source of irrigation water since 1921. The SEO and U.S. Geological Survey (USGS) have collected data in the area since the 1960s.

2.0 HISTORY AND PROJECT BACKGROUND

Interference complaints between senior surface water appropriators and junior ground water users date back to at least 1959 in Horseshoe Creek Valley based on records and correspondence provided by the SEO. The SEO issued the first alluvial ground water right in the area in 1954. In August 1959, the District No. 3 Water Commission contacted the SEO regarding Mr. Alfred Waters' (then owner of Walker No. 2 and No. 3) contention that pumping from upstream junior wells owned by Mr. Lancaster and Mr. Dilts was depriving him of his rightful appropriation for his ditches. While no formal action was recorded, the USGS completed an investigation of the area and published a report on the potential interaction of surface and ground water within the Horseshoe Creek Valley after surface flow ceased in a section of the creek during the summer of 1960.

Contention over potential interference between water sources in the Horseshoe Creek Valley persisted into the 1970s as more wells were drilled. The original formal interference complaint was submitted to the SEO on September 15, 1978. This complaint from Mr. John Bishop to the District No. 3 Water Commissioner claimed that Lancaster Ranches' alluvial irrigation wells were capturing surface water flows of Horseshoe Creek, and returning less than 5% of this water to the creek. The lands affected included those owned by Mr. David Sommers/Horseshoe Valley Ranch Company, and irrigated through the Walker No. 1, Hoffman No. 1, and Walker No. 3 ditches. The principal well at issue in this interference claim was Lancaster No. 3 which was completed in 1974. This interference claim became invalid in August 1979 when Mr. Bishop failed to resubmit the $100 fee required by the SEO per correspondence from August 28, 1979.

Despite the procedural invalidity, the SEO continued to pursue the interference investigation, and completed an internal report on the investigation in late 1980. In a December 30, 1980 letter the SEO indicated, "The report is not completed because data collected during the Summers of 1979 and 1980 along with the complexity of water right appropriation in the area is producing a confusing array of problems and questions for which it is difficult to find solutions and answers." During portions of the irrigation seasons in the following two years (1981-1982), the SEO collected instantaneous flow measurements for various points along Horseshoe Creek and from ditches.

Following Mr. Lancaster's completion of a new well in 1987, Mrs. Sommers of Horseshoe Valley Ranch Company filed a second formal interference complaint with the SEO on March 3, 1988. The complaint alleged that alluvial irrigation wells in the area, particularly those at Lancaster Ranch, were connected to Horseshoe Creek and its associated surface water rights. While the well at issue, Lancaster #6, was completed into an aquifer below the alluvium, Mr. Lancaster connected the JR Lancaster #1 well and the Lancaster #6 in order to run a large center pivot and irrigate the same lands with presumably either or both wells. Mrs. Sommers was concerned primarily about their ability to obtain water at their Walker No. 3 and Hoffman No. 1 head gates. The SEO advised Mrs. Sommers that an investigation into the allegations would soon be initiated. In response, Mr. Thomas Cahill, Attorney for Lancaster Ranches, submitted a letter to the SEO requesting answers to eight specific questions regarding the scope, field investigations, and duration of the interference investigation. The SEO's response to these questions was completed in April, 1988.

The SEO installed a series of monitoring wells and drilled numerous auger test holes in 1988-1989 to evaluate the potential connection between water in the alluvial aquifer and Horseshoe Creek. Water levels in these wells were measured intermittently since 1988 and 1996. Annual records of the irrigation diversions have also been maintained by the district Water Commissioner. Flow in Horseshoe Creek has been measured intermittently at two gages: the upstream Cassa gage, and a second gage, Glendo, located downstream where Horseshoe Creek flows into the North Platte River.

2.1 Surface Water Rights Summary

Within the investigation area, there are 10 surface water diversions which appropriate water from Horseshoe Creek. Local diversions from Horseshoe Creek include more than 39 cubic feet per second (cfs) of surface water, with more than 15 cfs for the Walker No. 1 ditch alone. While all surface water rights in the Horseshoe Creek investigation area are senior to ground water rights, the ownership interests in these ditches are significant in correlating the surface and ground water users. Mrs. Sommers and Mr. Christensen hold ownership interests in the oldest ditches on the stream. Walker No. 1 and Walker No. 3 have two of the oldest dates of priority on the stream from 1879 and 1882, respectively. Walker No. 2 is second in priority at 1880, and is solely owned by Mr. Christensen. Hoffman No. 1 and Laughlin No. 1 are both solely owned by

Mrs. Sommers and have priority dates of 1893 and 1898, respectively. In contrast, Mr. Lancaster, Mr. Dilts, Mr. Lockhart, and Mr. Wilson hold ownership interests in ditches that are all junior in priority to Mrs. Sommers and Mr. Christensen, with the exception of the Hoffman No. 1 and Laughlin No. 1 ditches.

2.2 Ground Water Rights Summary

Ground water in the Horseshoe Creek investigation area has been developed since at least 1921. Of the 19 wells that have been completed, 17 are currently permitted for irrigation, domestic, and/or stock use; one is permitted for municipal use by the Town of Glendo; and one is permitted for miscellaneous use to irrigate the Horseshoe Creek Cemetery. Seven of the 19 wells are completed in the Hartville Formation, while 12 are completed in the alluvium of Horseshoe Creek.

Since ground water development in the area began in 1921, the principal source has been the saturated Horseshoe Creek Alluvium. Based on inspected instantaneous and permitted well yields, the total volume of alluvial ground water permitted thus far in the Horseshoe Creek investigation area is 6,775 gallons per minute (gpm) or 15.09 cfs. All of these rights are essentially junior to the senior surface water rights in the area. Most ground water appropriators completed their wells during the 1950s, 1970s, and 2000s. Mr. Lancaster owns the two most senior alluvial ground water wells with permit dates in 1954, and also owns two other wells with permit dates in 1974. Based on inspected yields, these four wells combined are capable of producing 2,825 gpm, or 6.29 cfs. Of the remaining alluvial wells, Mr. Christensen's and Mrs. Sommers' Chris #2 well, which was completed in 1978 has an inspected yield of 1,800 gpm or 4.01 cfs. These five wells account for roughly 68% of the total permitted ground water use in the investigation area. The remaining alluvial irrigation wells are owned by Mr. Dilts and Mr. Wilson, who also have senior surface water rights, and by Mr. Milliken and Mr. Daly, who irrigate solely from their ground water supply. All of these wells are located west and upstream of Mrs. Sommers/Horseshoe Valley Ranch Company property.

To a lesser extent, the Hartville Formation has also been developed for ground water supply within the Horseshoe Creek investigation area. The total volume of ground water permitted from the Hartville Formation in the area currently is 1,785 gpm or 3.98 cfs based on inspected and permitted well yields. These rights generally postdate surface water rights in the area and the wells were completed between 1921 and 2005. While Mr. Lancaster owns five of the seven wells, the Town of Glendo's Downey Well #1, Lancaster #6, Lancaster #8, and Mr. Lockhart's Lloyd #2 wells yield the most ground water. The Downey #1 well has historically provided Glendo's principal municipal supply. The Lloyd #2 well accounts for 50% of the local permitted well yield (900 gpm or 2.00 cfs) from the Hartville Formation in the area, while Lancaster #6 and Lancaster #8 account for 29% (525 gpm or 1.17 cfs) of the remainder.

2.3 Purpose and Scope

The purpose of this current investigation is to address the 1988 complaint, and determine whether junior ground water rights have interfered with senior surface water rights, particularly those related to the Walker No. 3 and Hoffman No. 1 head gates, within the Horseshoe Creek investigation area. LA's analysis is primarily based on the data and conditions that existed during the general period of the complaint, which roughly coincided with the period of SEO data collection. To accomplish this purpose, LA identified the major objectives of the project as follows:

- Analyze historic monitoring data from the SEO and other data sources, and evaluate the relationship between ground water withdrawals in the area and surface water flows within Horseshoe Creek.
- Determine whether local irrigation well pumping by junior appropriators adversely affects stream flows within Horseshoe Creek, thereby interfering with senior surface water rights.
- Assess whether additional unappropriated water is available in the Horseshoe Creek system for future use.
- Provide recommendations for stopping, rectifying, or ameliorating the interference and/or damage caused by the interference, if such exists.

3.0 CONCLUSIONS AND UNCERTAINTY

Based on data collected by the SEO and USGS, LA completed its geologic and hydrogeologic assessment of the Horseshoe Creek investigation area. This investigation included a thorough review of the available information, hydrogeologic analysis of the available geologic and hydrogeologic data, and completion of a water balance model to assess overall water availability in Horseshoe Creek taking into account both surface water diversions and irrigation well pumpage.

The conceptual layout of the water balance model is based on the geologic and hydrogeologic assessment. The Horseshoe Creek investigation area is underlain by several hydrogeologic units that have different hydrogeologic properties and which uniquely interact with each other. The principal source of ground water used for irrigation purposes in the area, the Alluvial Aquifer lies in direct hydrologic communication with Horseshoe Creek. This aquifer is underlain primarily by the Goose Egg Formation west of the Lancaster Ranch #3 well and by the High Plains Aquifer east of this well. The Alluvial Aquifer is not in hydraulic communication with the Goose Egg Formation, but is hydraulically connected to the underlying High Plains Aquifer. Because the transmissivity of the Alluvial Aquifer is significantly higher than that of the underlying High Plains Aquifer, flow through the alluvium is greater than flow into the unit from the White River Formation. Nevertheless, the High Plains Aquifer provides a significant portion of the baseflow to Horseshoe Creek during winter months. Despite its development for municipal and irrigation

purposes in the local area, the Converse Aquifer is hydraulically disconnected from both the Alluvial and High Plains Aquifers in this area, and pumping from this aquifer has no bearing on water levels or recharge in the Alluvial Aquifer.

With regard to local surface and ground water development, the water balance model included the following aspects. Wells completed within the Alluvial Aquifer were modeled as being in direct hydraulic communication with both the stream and aquifer. This modeling assumption is directly supported by potentiometric surface and hydrograph data. Wells that produce ground water from the underlying Converse Aquifer and apply that water for irrigation purposes in the area were included to the extent water was returned to the Alluvial Aquifer. Ditches and lands irrigated with surface water were assumed to have relatively high leakage back to the Alluvial Aquifer.

The question of interference between the senior surface water appropriators and junior ground water rights lies at the heart of this investigation, particularly with regard to Walker No. 3 and Hoffman No. 1. For the purposes of this study, interference is defined as an inability of the senior surface water appropriator to take water from the stream that would be available at their head gate were it not for stream depletion caused by pumping from junior alluvial wells.

On the basis of this investigation and definition of interference, LA has developed the following conclusions:

- Horseshoe Creek is a geomorphically unstable, low gradient, high-sinuosity perennial stream that historically has cut into its banks and washed out surface water diversion structures. The loss of surface diversions has impacted irrigators on at least two occasions within the last 20 years (1991 and 2008). Adverse channel changes have significantly impacted surface water diversions and the irrigator's ability to utilize their head gates.
- Horseshoe Creek is an over appropriated stream that is only capable of meeting surface water irrigation demand within the investigation area (more than 39 cfs of surface water rights) on average during April, May, and June.
- Based on 1981 gaging data and high capacity well observations, during low or baseline flow conditions on Horseshoe Creek when Walker No. 1 is diverting the entire flow of the creek, the creek is typically dry from Walker No. 1 to just above Walker No. 3 even though no alluvial irrigation wells are reportedly pumping.
- Horseshoe Creek lies in direct hydraulic communication with the underlying, unconfined Alluvial Aquifer, such that "the stream surface of Horseshoe Creek coincides with the water table in the alluvium."
- The Alluvial Aquifer is limited in its aerial extent, contains about 9,100 acre feet of ground water between the Cassa gage and the North Platte River confluence, is highly

permeable particularly in a downstream direction through Mr. Lancaster's property, and is permitted for 15.09 cfs of junior ground water rights in the investigation area.

- Horseshoe Creek recharges the Alluvial Aquifer such that water levels in the aquifer generally recover to previous years levels. This recovery indicates that storage in the Alluvial Aquifer is relatively uniformly replenished, despite big annual differences in streamflow at the Cassa gage.
- Pumping from wells completed in the Alluvial Aquifer can adversely impact streamflows in Horseshoe Creek and diminish aquifer storage. The magnitude of this impact is contingent upon how much water is flowing in the creek, the duration of pumping from individual wells, the number of irrigation wells that are pumping at any given time, and the amount of water that is diverted through Walker No. 1. Well depletions and return flows have lagged effects on Horseshoe Creek that last up to a few months. The water withdrawn from the Alluvial Aquifer as a percentage of streamflow from the Cassa gage significantly increases from July through October each year. This period corresponds to the time when flow at that gage typically falls below the amount of water needed in the stream to satisfy the Walker No. 1 appropriation.
- When Walker No. 1 does not receive its full appropriation, there is generally insufficient water in Horseshoe Creek at other surface water head gates to satisfy their appropriations even if they could legally obtain the water. When Walker No. 1 receives its full appropriation, there is generally sufficient water in the stream such that other junior surface water users can appropriate their share. The Hoffman No. 1 ditch has sufficient water available in the stream for diversion, but only diverted water in 1991. The model could not be calibrated at either the Walker No. 3 or Hoffman No. 1 head gates because there were no SEO streamflow measurements taken during the model period.
- Pumping of the junior alluvial ground water wells does not adversely interfere with the downstream senior appropriator's ability to obtain water at Walker No. 3 and Hoffman No. 1. The inability of these appropriators to obtain their water rights at their head gates is a function of insufficient water coming down Horseshoe Creek at the Cassa gage, geomorphic changes to Horseshoe Creek, regulation of Horseshoe Creek for the most senior surface water rights, and/or inadequate diversion maintenance of their head gates.
- The underlying High Plains Aquifer is hydrologically connected to the Alluvial Aquifer. The High Plains Aquifer acts as an aquitard within the investigation area due to its relatively low transmissivity, and provides a portion of the baseflow of Horseshoe Creek.
- The Alluvial and High Plains Aquifers are hydraulically disconnected from the Converse Aquifer in the investigation area by the Goose Egg Formation, which acts as a confining layer above the Converse Aquifer. Pumping from wells completed in this aquifer has no impact on water levels in the Alluvial Aquifer or streamflow in Horseshoe Creek. Return

flows from fields irrigated by Converse Aquifer wells serve to recharge the Alluvial Aquifer.

While these conclusions are in general agreement with work previously completed by both the SEO and USGS, there is some uncertainty regarding these conclusions due to some data gaps, particularly within the water balance model. The biggest limitation and source of most uncertainty in the water balance model approach is the lack of stream stage/elevation data relative to each of the surface water diversion head gates. The results of the model assume that water is in the stream and that it is appropriable. The 1989 to 1991 dataset lacks any streamflow measurements of Horseshoe Creek between the Cassa and Glendo gages that could be used as calibration points in the model. The 1981 dataset included streamflow measurements as well as ditch diversion flows, but did not include detailed irrigation well pumping records. A second source of uncertainty is the actual volumetric amounts of water that were diverted through the ditches. A number of simplifying assumptions were made; therefore the total volumes included in the model may be more or less than were actually diverted.

Another source of uncertainty involves some incomplete or nonexistent datasets. Surface water diversion data for 1988 do not exist. 1988 was an average flow year, so there were likely some return flows from the ditch diversions that are missing from the water budget model in 1989. The 1991 irrigation well pumping records were incomplete. Flooding occurred in the investigation area during this time period, and therefore, the modeling results for this year were not relied upon to draw conclusions. The modeling results for 1991 do not accurately reflect the Horseshoe Creek hydrologic system as indicated by large differences in the balance term relative to previous years.

The balance term used in the model accounts for the inconsistencies with the data sets and uncertainty associated with the hydrologic system. The amount of modeled water at the Glendo gage was more or less than what the USGS had physically recorded. The balance term compensates for unaccounted sources or sinks along the creek due to uncertainty associated with a variety of parameters, including precipitation, ditch conveyance losses, evapotranspiration, and seepage from the High Plains Aquifer. The balance term accounts for the fact that the Horseshoe Creek hydrologic system is narrow and highly dynamic with large responses to large precipitation events. Therefore, fluctuations in the balance term of up to 20% during large precipitation events (such as in 1991) are not unreasonable, considering all of the sources and sinks that are affected.

Despite these uncertainties, the results of the modeling effort appear to agree well with the observed data, particularly for 1989 and 1990. Comparison of the water balance model results and Horseshoe Creek streamflow at the Cassa gage relative to the Walker No. 1 water right indicates that the model represents the hydrologic system reasonably well. In 1990, the streamflow of Horseshoe Creek at the Cassa gage fell below the quantity required to satisfy the Walker No. 1 diversion on about June 30, while the model indicated the volume of water in the

creek was sufficient to satisfy the right through June and deficient in July. In 1989, the model indicated that Horseshoe Creek never fully satisfied the Walker No. 1 ditch, which roughly correlates with the streamflow data for the Cassa gage. Due to these good correlations, the 1989 and 1990 modeling results were considered reliable for drawing conclusions about the Horseshoe Creek hydrologic system.

4.0 RECOMMENDATIONS

Based on the results of the Horseshoe Creek Investigation, LA concludes that the alleged interference on Horseshoe Creek does not exist. Horseshoe Creek and the Alluvial Aquifer form a single source of supply in the investigation area. Pumping from the junior alluvial wells does impact streamflow and aquifer storage, but does not do so injuriously to Walker No. 3 and Hoffman No. 1. As a result of these conclusions, the SEO has options for managing the Horseshoe Creek investigation area. These options are as follows:

- Maintain the existing surface and ground water appropriations and priorities. This interference investigation required by §41-3-911 has resolved that there is no unreasonable interference between the surface water (Walker No. 3 and Hoffman No. 1) and ground water appropriators (Lancaster Ranch).
- Correlate the priorities of all surface and ground water rights that obtain their water from Horseshoe Creek and the Alluvial Aquifer. Results of this investigation indicate the surface water in the stream and ground water in the alluvium are interconnected to the point that they form a single source of supply. In this instance, the SEO per §41-3-916 can develop a single schedule of priorities that relates to the whole common water supply, and implement corrective controls per §41-3-915 as necessary. The owners of the alluvial ground water wells also hold surface water rights in Horseshoe Creek Valley. Correlating these rights with a transfer of the surface water priority dates to the alluvial wells in this instance would maintain the senior priority/ownership structure, and essentially amount to a change in point of diversion for the surface water rights. Decisions regarding the volumetric quantities and irrigated lands tied to each well would then have to be made.

LA has developed the following recommendations that apply to the Horseshoe Creek area:

- Refrain from granting further surface water appropriations in Horseshoe Creek Valley.
- Direct senior surface water appropriators to install and maintain adequate diversion structures to ensure they can take water from the stream when it is available and legally appropriable.
- Encourage water users in the valley to collaborate in order to address water availability and geomorphic instability of the stream. The lack of reservoirs on this stream contributes both to the limited duration of time that water is available in the stream to

supply the surface water rights, and erosive runoff conditions associated with storm events within the drainage area. A complete and detailed watershed study is appropriate. River restoration and enhancement are necessary to ensure the stability of the respective surface water diversions.

- Reestablish both the Cassa and Glendo stream gages to monitor flows entering and leaving this reach of Horseshoe Creek. These gages provide a good baseline for regulation on the creek, and determining which surface water diversions can be met through the irrigation season.
- Direct junior alluvial appropriators to pump the majority of their ground water when streamflow in Horseshoe Creek is less than or only sufficient to satisfy the Walker No. 1 diversion. When other senior surface water rights cannot be met with available water in the stream, pumping water from the alluvial aquifer does not result in adverse impacts to those rights.
- Provided water in the Horseshoe Creek system is regulated as one source, allow the senior surface water right holders the opportunity to construct their own alluvial wells and change their points of diversion for the associated surface water rights.
- If the existing priorities and rights are maintained, the SEO should limit the number of additional alluvial wells within this reach, set well spacing requirements, and determine the permissible total withdrawal of ground water. Any additional wells completed in the Alluvial Aquifer in this area will further deplete streamflow and aquifer storage. Such pumping could adversely impact existing surface water diversions if the wells are located in close proximity to a senior surface water diversion head gate. The construction of additional wells within the area is already partially restricted by the terms of the Modified North Platte Decree.