Project Report for the Shell Valley Storage Level II Study

Prepared for Wyoming Water Development Commission

Prepared by States West Water Resources Corporation, Cheyenne WY


February 2013
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for the
Shell Valley Storage
Level II Study

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In association with
RJH Consultants, Inc., Englewood CO
Leonard Rice Engineers, Inc., Denver CO
Western EcoSystems Technology, Inc., Cheyenne WY
Office of the Wyoming State Archaeologist, Laramie WY
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Chapter I. Introduction

In June, 2010, the Wyoming Water Development Commission contracted with the team led by States West Water Resources to perform the Shell Valley Storage Project, Level II Study. This study was performed on behalf of the Shell Valley Watershed Improvement District. Team members included RJH Consultants, Inc., Leonard Rice Engineers, Inc., Western EcoSystems Technology, Inc., Watts and Associates, Inc., and the Office of the Wyoming State Archaeologist. This report presents the findings of the Level II Study.

As shown in Figure I-1, the general project area consists of the Shell Creek watershed. The highest reaches of the basin are in the Big Horn mountains. Major tributaries include Beaver Creek, Horse Creek, Trapper Creek, White Creek, Willett Creek, Cedar Creek, and Adelaide Creek. The basin terminates at the confluence of Shell Creek and the Greybull River near the town of Greybull.

A Level I Watershed Study was completed between 2006 and 2010 to identify potential late season water shortages as well as a list of preliminary storage alternatives. In addition, the Level I Study incorporated a vast amount of technical information describing conditions and assessments of the watershed, and developed a management and rehabilitation plan outlining site specific projects that may remediate existing issues and address opportunities beneficial to the health and functionality of the watershed. The Level I Study report is available online at http://library.wrds.uwyo.edu/wwdcrept/wwdcrept.html.

The overall purpose of this Level II study is to find and evaluate new and existing potential water storage alternatives, refine the hydrologic data to determine how much water can be stored and how much shortage relief would be attained, determine purpose and need, determine permitting mitigation requirements, conduct an ability to pay analysis, and complete conceptual design and cost estimates for the preferred alternatives.

This study took an in-depth look at the watershed for potential multiuse water storage facilities to supply supplemental water for irrigation and provide benefits including recreation, environmental, and fish and wildlife benefits to the watershed.

The project required the review of previous studies and information and the development of a hydrologic model. Conceptual reservoir designs and cost estimates for the sites that indicated reasonable potential for construction were to be developed. The conceptual designs included embankment configuration and design parameters based on surface reconnaissance and geological mapping review. Environmental impacts of the sites were determined and permitting issues were evaluated. An economic analysis of the preferred site, including ability-to-pay and benefit cost analysis, was completed.
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Chapter II. Basin Hydrology

Introduction

Leonard Rice Engineers, Inc. (LRE) has developed a historic consumptive use (CU) analysis for the Shell Creek Basin (i.e. Shell Valley Watershed). This consumptive use analysis is based on actual ditch diversions from 2003 through 2009. The analysis estimates crop demands from 1951 through 2009 and provides estimates of crop shortages in different areas of the basin for the study period. In addition to the CU analysis, LRE also conducted a hydrologic analysis to estimate available flows above potential storage project locations.

As part of this effort, LRE utilized available information including:

- Shell Valley Watershed Level I Storage Study Report;
- Wind Bighorn Basin Plan;
- Wyoming State Engineer’s Office (WY SEO) Water Rights Database;
- Western Regional Climate Center (WRCC) precipitation and temperature data;
- United States Geological Survey (USGS) stream flow measurements;
- National Agricultural Imagery Program (NAIP) 2006 color aerial photography;
- Wyoming Water and Climate Map Server GIS coverages;
- Ditch Maps stored at the WY SEO; and
- Other information provided by WY SEO through direct communication with SEO personnel.

This chapter summarizes the approach, methodology and results for this study.

Literature Review and Data Collection

A goal going into this study was to represent as long a period of record as was reasonable based on the climatic and hydrologic record, in order to represent a wide variety of hydrologic conditions in the analysis. Climate and Hydrologic data collected as part of the Level I study was reviewed and it was determined that a 1951 through 2009 period of record could be achieved with the available data, with some regression based filling of missing data. Data for this period was collected for precipitation and temperature (from the WRCC), and stream flow (from the USGS).

Diversion data was provided by the District Commissioner for more than half of the active structures in the basin for 2003 through 2009. The irrigated land GIS coverage developed as part of the Wind Bighorn basin plan was used as a starting point for an irrigated acreage assessment. This GIS layer was updated using current permit records ditch maps on file at the SEO and 2006 color aerial photography (NAIP).

Climate Data

Monthly precipitation and temperature data sets were developed for the study period 1951-2009 for both of the climate stations identified within the basin in the Level I Study (GREYBULL and SHELL). Neither of these stations had complete data for the full study period. Two additional stations in close proximity (BASIN and BURGESS
JUNCTION) were identified which had more complete data records and were used to support filling the data for the two stations within the basin (see Figure II-1).

Electronic monthly temperature and precipitation data were obtained from WRCC for the full periods available at each of the four stations. Data at BASIN, 8 miles south of GREYBULL similar in elevation, is fairly complete over the 1951 to 2009 study period with just a handful of missing monthly values. BURGESS is in an adjacent basin at a much higher elevation than both GREYBULL and SHELL, but also has data mostly complete after 1960. GREYBULL has a mostly complete precipitation record and SHELL has fairly complete precipitation data after 1959, but GREYBULL and SHELL have temperature data only from the mid-1980s on.

Data at both SHELL and GREYBULL were found to correlate very well with the other two stations, both for temperature and precipitation, during their periods in common. Only data from the filled GREYBULL and SHELL stations were used in the consumptive use analysis. The climate data for these two stations were filled using the process described below.
Temperature

BASIN is missing four monthly values between 1951 and 2009. These missing values were filled with monthly averages. Missing values in the GREYBULL data set (pre-1988, post-2004, and other scattered months from 1988 through 2004), were filled using a monthly linear regression with BASIN for overlapping periods. Likewise, missing values at SHELL (pre-1981 and scattered months from 1981 through 2004) were filled using a monthly regression with BASIN for overlapping periods.

Precipitation

BASIN is missing six monthly values between 1951 and 2009. These values were filled using the same method described above for temperature. GREYBULL is missing monthly precipitation values primarily in the early 1970s and 2004 through 2009. The BASIN and GREYBULL precipitation data were compared for their common periods of record and a well correlated annual linear regression was determined ($R^2 = 0.85$) (see Figure II-2). This regression was used to fill the missing monthly values at GREYBULL.

Figure II-2 – Climate Station Precipitation Linear Regressions

SHELL precipitation data needed to be filled prior to 1959, in the 1970s, in 2005-2006, as well as a few scattered missing months in other years. Precipitation at SHELL was determined to correlate equally well with both the GREYBULL and BURGESS.
stations ($R^2 = 0.78$ for SHELL v. BURGESS, $R^2 = 0.80$ for SHELL v. GREYBULL) (see Figure II-2). It was also observed that by averaging the BURGESS and GREYBULL when good data was available for both, a regression against the resulting data set, while having a slightly lower $R^2$ value of 0.73, better represented the precipitation patterns seen at SHELL. The averaged stations capture the high BURGESS station events but the drier GREYBULL data effectively tempers them more like what would be expected at SHELL. After 1961 (when BURGESS data is available), SHELL was filled based on an average of the values derived from both annual linear regressions. Prior to 1961, SHELL was filled based on the regression against just GREYBULL.

**Stream Flow Data**

USGS stream flow data was collected for two gages on Shell Creek, 06278500 - Shell Creek near Shell, WY and 06278300 - Shell Creek above Shell Reservoir, WY (see Figure II-3). The gauge above Shell Reservoir is complete from October of 1956 to present. The gauge near Shell is complete from before 1951 through October of 1971 and then has complete summer records (March-September) through present. The 1972-2009 winter data for the gauge near Shell was filled using a power regression against the gauge above the Reservoir for October through March ($R^2=0.52$). The gauge above Shell Reservoir was also filled from 1951 – 1955 using an annual power regression against the gauge near Shell ($R^2=0.92$) (See Figure II-3).

*Figure II-3 - Linear Regression for Filling Monthly Flows at USGS Gages 06278500 and 06278300*

Linear regressions were considered however the wide range of flows from extremely low in the winter to high spring runoffs did not fit a linear regression well. Monthly regressions were also considered for both gages, but the lack of winter records at Shell nr Shell after 1972 made the monthly regressions inferior.

Temporary gauging stations were also monitored on Beaver Creek by States West during the summer of 2010. The upper station data was used as part of this study to verify estimated flows on Beaver Creek (see the Available Flows Analysis section of this report).
Structures and Diversion Records

The SEO Water Rights Database was queried for all permits in the Shell Valley basin. The records include a field indicating the ditch associated with the permit and the active status of the permit. These fields were used to develop a current and complete list of active diversion structures. Forty-nine active structures were identified and are listed in Table II-1.

Historical daily diversions are available electronically from 2003 to 2009 for 30 of the 49 active structures in the basin. The Diversion records were provided by the Division Superintendent for Division III and diversion data was filled for the 1951 through 2009 study period (thirty-three diversions are actually represented in the data provided by the Division Superintendent, however some were combined for this analysis due to shared headgates or common irrigated lands).

The daily diversions were mostly complete for 2003-2009. Missing daily data were filled using linear interpolation between readings. The daily data was aggregated into monthly data and missing months between 2003 and 2009 were then filled based on the period of record average for that month.

The 1951-2002 diversions were filled using StateCU, based on climate driven shortages derived from the years of existing data. This is described in more detail in the Shortages section of this report. Diversions in the winter (November-March) were set to zero.
## Table II-1 – Active Diversion Structures in Shell Valley

<table>
<thead>
<tr>
<th>Stream Source</th>
<th>Structure Name</th>
<th>Irrigated Acres</th>
<th>Diversion Records Available</th>
<th>District Group</th>
<th>Climate Station</th>
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<td>Loveland Ditch</td>
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<td>Reeves Draw</td>
<td>Flitner Ranch Pipeline</td>
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<td><strong>Basin-wide Irrigated Acreage</strong></td>
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</table>
Irrigation and Water Use

An irrigated acreage assessment was completed for Shell Valley using the irrigated lands developed during the Level I Study, 2006 Color Aerial Photography, database records from the WY SEO water rights database, and Ditch Maps collected for the active diversions in the basin. The ditch maps were georeferenced and used to associate and subdivide the Level I Study irrigated land polygons to associate distinct parcels with water right permits and ditches. The irrigated land polygons were modified where necessary to better represent irrigated lands visible in the 2006 photography. Approximately 15,240 acres of irrigated lands were associated with the 49 active diversions.

See Table II-1 for estimated irrigated acreage by structure (these are not permitted acres, rather they represent lands that can be seen as irrigated in the aerial photography). Appendix D includes detailed maps showing diversion locations by name, ditch traces, and irrigated lands throughout the basin.

Consumptive Use and Shortages Analysis

Irrigation shortages in the Shell Valley watershed were estimated using StateCU, a consumptive use analysis tool developed by the State of Colorado. A historical consumptive use (CU) analysis determines irrigation water requirement (what the crops want for a full supply) and water supply-limited use (what the crops actually used) for each structure. The difference defines a monthly time series of estimated shortages for irrigating structures in the model.

Potential Consumptive Use (CU) and Crop Irrigation Water Requirements (CIR)

Crop demands, or potential CU, were estimated using the Soil Conservation Service (SCS) Modified Blaney-Criddle method and “TR-21” crop coefficients defined in Irrigation Water Requirements Technical Release 21 (1970) with the standard elevation adjustment. This method varies crop coefficients by structure according to crop type (and optionally by elevation) and by month according to mean monthly temperature.

Crop Types

Crop types in the Wind Big Horn Basin Plan were reported on a scale larger than the Shell Valley basin. The plan reported that the state-wide Irrigation System Survey Report for 2010 conducted by the WWDC indicated that grass pasture is the dominant crop type (about 60 percent), with alfalfa comprising the second most dominant type (22 percent) and sugar beets, corn and other vegetable or row crops comprising the rest. An assessment has not been completed of crop distribution in Shell Valley, however the sponsor has indicated that this survey is fairly representative of the basin, with Shell Valley lands being more frequently cultivated for just grass pasture and alfalfa in the higher elevations and rowcrops becoming more prevalent in the lower elevations along Shell Creek.

For this study, lands were divided into three different categories for the purpose of assuming crop distributions. The categories were based on input from the sponsor and are an attempt to capture a very general but realistic distribution of crops in the basin.
1. Lands in the upper portions of Beaver and Trapper Creeks were modeled as 60% pasture and 40% Alfalfa.
2. Most land irrigated from Beaver, Horse, and Trapper Creeks were modeled with a crop distribution of 40% pasture, 40% alfalfa and 20% rowcrops.
3. Lands in the lower elevations of the Valley along Shell Creek were assigned crop distributions of 20% pasture, 40% alfalfa, and 40% rowcrops.

The Wind Big Horn basin plan identified a seasonal average crop irrigation water requirement (CIR) of 2.14 AF/acre in the Lower Big Horn basin, which is comprised of primarily Shell Valley, with the addition of three smaller basins tributary to the Big Horn River below Shell Creek. Using the above described crop distributions, the basin-wide seasonal average CIR calculated by StateCU for this study is 2.03 AF/acre. This slightly lower number is reasonable as Shell Valley includes more higher elevation pasture lands than the other Wind Big Horn sub-basins. Despite this basin-wide validation however, refinement of the crop distributions during the surface water modeling and reservoir sizing phase is recommended to more carefully estimate site specific shortages.

Climate Station Assignments and Growing Season

Mean monthly temperature was used to determine growing season start and end dates by structure per TR-21, for each analysis year. Structures were associated with either the GREYBULL or SHELL climate station based on proximity. See Table II-1 for climate station assignments by structure.

Elevation Adjustments

Per recommendation by the ASCE Manuals and Reports on Engineering Practice No. 70, Evapotranspiration and Irrigation Water Requirements (1990), for each structure, elevation adjustments were made to the TR-21 crop coefficients based on the average elevation of lands served by that structure. The standard crop coefficients are adjusted upward 10% for every 1000 meters above sea level, to 2000 meters (6500 ft).

Effective Precipitation and CIR

CIR was determined as potential consumptive use less precipitation ‘effective’ in meeting crop demands from 1951 through 2009. Effective precipitation in the CU analysis was estimated based on the SCS TR-21 monthly method. Monthly precipitation for each structure was based on the associated climate station data (climate station to structure assignments are shown in Table II-1). Minimum, maximum, and average CIR over the study period is summarized in Table II-2. Figure II-4 graphs the modeled annual CIR by tributary for the study period.
Table II-2 - Crop Irrigation Water Requirement Summary by Tributary

<table>
<thead>
<tr>
<th>Tributary</th>
<th>Min</th>
<th>Max</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Creek below Horse Creek</td>
<td>1.52</td>
<td>2.40</td>
<td>2.00</td>
</tr>
<tr>
<td>Shell Creek above Horse Creek</td>
<td>1.65</td>
<td>2.49</td>
<td>2.08</td>
</tr>
<tr>
<td>Horse Creek</td>
<td>1.40</td>
<td>2.39</td>
<td>1.93</td>
</tr>
<tr>
<td>Trapper Creek</td>
<td>1.38</td>
<td>2.37</td>
<td>1.92</td>
</tr>
<tr>
<td>Beaver Creek</td>
<td>1.45</td>
<td>2.45</td>
<td>1.99</td>
</tr>
<tr>
<td>North and South Beaver Creeks</td>
<td>1.51</td>
<td>2.53</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Figure II-2 - Annual CIR by Tributary

**Estimating Shortages**

To estimate shortages for diversions with diversion records, StateCU compares actual diversions for a structure to the monthly CIR calculated for that same structure, taking into account delivery losses and application efficiencies as specified in the model input files.

**Irrigation Efficiency and Delivery Losses**

All lands were modeled as flood irrigated, with an application efficiency of 60%. Most structures were modeled with a 10% delivery loss. Two structures (Shell Canal (including MacDonald Diversion) and Whaley Ditch) were identified in the Level I study, on pages 68 – 74, as suffering from significant delivery losses. Flows at different locations along the ditch were taken in an effort to quantify losses. The data indicated that while the ditch did not seep at a greater rate than expected, because of its great length, the losses over the total length of the ditch were substantial. Total losses were not quantified in the Level I study.

A standard starting point for estimating ditch losses using StateCU is to assume a total loss of 10% on all ditches. For Shell canal, this 10% total loss assumption resulted in no modeled shortages for those structures. The project sponsor has indicated that lands under these structures do suffer shortages, so additional model
runs were performed to determine a more reasonable total delivery loss for these structures.

Two additional structures several miles in length in the same vicinity with diversion records were tested (Porter Canal and High Line Ditch) as well. Annual shortages were estimated directly for smaller ditch systems in the same vicinity as the long ditches by comparing the irrigation requirement of the lands under the ditch to reported deliveries. The StateCU delivery loss factors were then calibrated for each of the longer ditches to duplicate the estimated shortages to the nearby lands. The resulting total delivery losses (and percent loss per mile) are shown in Table II-3.

Table II-3 - Delivery Loss Factors for Long Ditches

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>LENGTH</th>
<th>DELIVERY LOSS FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Canal / MacDonald Diversion</td>
<td>23 mi.</td>
<td>60% (2%/mile)</td>
</tr>
<tr>
<td>Whaley Ditch</td>
<td>8 mi.</td>
<td>55% (6.8%/mile)</td>
</tr>
<tr>
<td>Porter Canal</td>
<td>6 mi.</td>
<td>35% (5.8%/mile)</td>
</tr>
<tr>
<td>High Line Ditch</td>
<td>5 mi.</td>
<td>45% (9%/mile)</td>
</tr>
</tbody>
</table>

For Shell Canal, the per-mile value is appropriately low because lower portions of the ditch probably pick up return flows from lands served higher up. The per mile losses for High Line Ditch seem high and more investigation is needed to better quantify actual ditch losses as part of the StateMod modeling phase of this Level II study.

Filling Diversions and Calculating Shortages for All Structures

Shortages were calculated for each of the 30 structures with diversion data from 2003 to 2009. Table II-4a and Table II-4b show annual shortages modeled by structure for this period. These shortages were used to fill the same 30 structures’ diversion data from 1951 to 2002. Using the CIR already calculated by structure for the full study period, StateCU was used to extrapolate the relationship between shortages and CIR during the known period (2003 to 2009) over the unknown period (1951 to 2002).

Finally, with a complete record of diversions and shortages for the 30 structures with diversion data, and with CIR calculated for all 49 structures as described previously, StateCU was used to estimate shortages for the remaining structures. Structures were grouped together spatially according to characteristics that would likely cause them to experience similar influences on water availability (such as elevation and crop types of lands served and headgate locations relative to major tributaries). Structures that served overlapping lands (as a supplemental source) were grouped together as well.

Each of the 49 structures were assigned to a group, such that each group included structures with and without diversion data. Table II-1 includes a column that shows the groupings. Within each group, the shortages calculated for structures with data were scaled and applied to structures without data based on the relative acreage of irrigated lands at each structure.

To support sizing of reservoirs, the StateMod modeling phase of this Level II study will estimate shortages over the full study period, characterize shortages during wet, average, and dry years, and examine proposed storage facilities to determine
volumes that would be required to meet shortages under different demand and hydrologic scenarios.

Table II-4a - Calculated Shortages for Structures and Years with Diversion Data – BEAVER CREEK

<table>
<thead>
<tr>
<th>North and South Beaver Creeks</th>
<th>31</th>
<th>112</th>
<th>86</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>44</td>
<td>0</td>
<td>140</td>
</tr>
<tr>
<td>2004</td>
<td>29</td>
<td>0</td>
<td>116</td>
</tr>
<tr>
<td>2005</td>
<td>47</td>
<td>0</td>
<td>79</td>
</tr>
<tr>
<td>2006</td>
<td>32</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>2007</td>
<td>42</td>
<td>0</td>
<td>149</td>
</tr>
<tr>
<td>2008</td>
<td>36</td>
<td>0</td>
<td>127</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>AVG</td>
<td>34 af</td>
<td>0 af</td>
<td>117 af</td>
</tr>
<tr>
<td>Acreage Weighted Averages for Diversion Group</td>
<td>51%</td>
<td>0%</td>
<td>61%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beaver Creek below Red Gulch</th>
<th>77</th>
<th>248</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>78</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2004</td>
<td>46</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2005</td>
<td>52</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>2006</td>
<td>117</td>
<td>0</td>
<td>149</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>2008</td>
<td>35</td>
<td>0</td>
<td>74</td>
</tr>
<tr>
<td>2009</td>
<td>55</td>
<td>0</td>
<td>106</td>
</tr>
<tr>
<td>AVG</td>
<td>55 af</td>
<td>0 af</td>
<td>6 af</td>
</tr>
<tr>
<td>Acreage Weighted Averages for Diversion Group</td>
<td>34%</td>
<td>0%</td>
<td>34%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beaver Cr above Red Gulch</th>
<th>205</th>
<th>321</th>
<th>391</th>
<th>200</th>
<th>98</th>
<th>198</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>35</td>
<td>0</td>
<td>251</td>
<td>142</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>45</td>
<td>0</td>
<td>86</td>
<td>98</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>52</td>
<td>0</td>
<td>25</td>
<td>42</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2006</td>
<td>117</td>
<td>0</td>
<td>136</td>
<td>161</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td>144</td>
<td>95</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>35</td>
<td>0</td>
<td>105</td>
<td>66</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>55</td>
<td>0</td>
<td>19</td>
<td>34</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>AVG</td>
<td>69 af</td>
<td>0 af</td>
<td>367 af</td>
<td>0 af</td>
<td>107 af</td>
<td>89 af</td>
</tr>
<tr>
<td>Acreage Weighted Averages for Diversion Group</td>
<td>31%</td>
<td>0%</td>
<td>54%</td>
<td>0%</td>
<td>24%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Chapter II. Basin Hydrology Page 11 of 17
**Available Flows Analysis**

Available flows for potential storage locations were determined for two locations in the basin (see Figure II-5). Shell Creek Basin drainage above the Forest Service Boundary is approximately 90,000 acres with an average elevation of just over 7,200 feet. USGS stream gauge SHELL CREEK NR SHELL, WY (06278500) is located less than a mile below the bottom of this drainage and has a fairly complete record for the 1951-2009 study period (see Stream Flow Data under the Literature Review and Data Collection section of this chapter). Beaver Creek Basin drainage above the North and South Beaver Creek confluence is approximately 17,030 acres with an average elevation of just over 7,500 feet. There is no permanent gauging on Beaver Creek at this time. Some spot-measurements have been taken in the past at various locations along Beaver Creek (Level I Study) and a temporary stream gauge was monitored in 2010 from May to October year the North/South Beaver Creek confluence.

High up on Shell Creek is another stream gauge, SHELL CREEK AB SHELL RESERVOIR, WY (06278300). This gauge falls right above the existing Shell Creek Reservoir, has a complete record from 1956 – 2009 (see Stream Flow Data under the Literature Review and Data Collection section of this chapter). The drainage above this point is approximately 14,670 acres with an average elevation of just over 10,000 feet.
Annual Flows on Shell Creek above the Forest Service Boundary

Available flows above the Forest Service Boundary on Shell Creek were determined using the winter flows (both November to March and October to April totals; see below) evidenced at the Shell Creek near Shell, WY (Shell nr Shell) USGS gauge, after the gauge data was filled (see Stream Flow Data under the Literature Review and Data Collection section of this chapter). It should be noted that some of these flows may not actually be available for storage because of the 1983 in-stream flow rights present on Shell Creek. The in-stream flow rights will be incorporated into the StateMod phase of this Level II study. In addition, when looking at winter flows as a total of flows measured from October to April, some of the flows at Shell nr Shell may be releases from Shell Reservoir for irrigation and not available for storage under a new right.

Examination of the diversion records throughout the basin indicated that irrigation starts as early as April in some years and can extend through October. A most conservative estimation then of the flows that would be available for diversion under a new storage right includes the flows from November – March only. Because irrigation often does not start, however, until later in April or May and sometimes ends in September or early October, potentially available flows were also calculated by totaling October to April stream flows. The actual available flows are likely to fall in between these estimates. The annual 1951 – 2009 potentially available flows are illustrated in Figure II-6.
Annual Flows on Beaver Creek above the North/South Beaver Creek Confluence

The drainage area above the North/South Beaver Creek Confluence is approximately 18% of the size of the drainage above Shell nr Shell and about 116% of the size of the drainage above Shell ab Res. While the Beaver Creek basin is more similar to the drainage above Shell Reservoir in size, the much higher altitude of the Shell ab Res basin results in a pattern of winter flows that are not likely to be representative of the flows available from the Beaver Creek drainage. Beaver Creek above the Confluence and the Basin above Shell nr Shell on the other hand have very similar elevation distributions. To estimate available flows on Beaver Creek above the Confluence, monthly flows in the gauge record at Shell nr Shell (including Shell ab Res) were scaled by 18% (see below in the Temporary Stream Gauge Comparison section for how these estimates compared to the 2010 temporary stream gauge measurements). Please note that these estimates do not take into account effects of
groundwater on streamflows. More measured data on these tributaries would significantly improve these estimates.

Examination of the diversion records throughout the basin indicated that irrigation starts as early as April in some years and can extend through October. A most conservative estimation then of the flows that would be available for diversion under a new storage right includes the flows from November – March only. On Beaver Creek especially, however, irrigation often does not start, until later in April or May and sometimes ends in September or early October, so potentially available flows were calculated also by totaling October to April stream flows. The actual available flows are likely to fall in between these estimates. The annual time series of potentially available flows from 1951 – 2009, for both a November – March and an October – April winter period, are shown in Figure II-7.

*Figure II-7 – Annual Potentially Available Flows on Beaver Creek above the North/South Beaver Creek Confluence*

---

**Average, Wet, and Dry Year Available Flow Estimates**

A useful approximation of potentially available flows for planning purposes may be an estimate based on an average, wet, or dry year. “Wet” and “dry” years are often defined as years in which an annual total flow falls above or below a specified percentile. Depending on the purpose of the analysis, percentiles ranging from 30% down to 10% are common for defining dry years, and ranging from 70% up to 90% for defining wet years.

To estimate available flows for the purpose of reservoir sizing, this analysis has used winter flow totals to categorize wet and dry years (as explained in the previous section). Each year from 1951 – 2009 was categorized as AVERAGE, WET, VERY WET, DRY, or VERY DRY based on the November – March flows at Shell nr Shell. The VERY WET and VERY DRY categories were broken out to represent the potential extremes that may be considered in reservoir sizing. These categories are defined as those years with winter flows at Shell nr Shell above the 90th percentile (~13,100 AF) or below the 10th percentile (~10,800 AF), respectively, over the 1951-2009 study period.
A more conservative categorization has also been included for WET and DRY years with total winter flows above the 70th percentile or below the 30th percentile, respectively. Years with winter totals falling above the 70th percentile for the period of record were categorized as WET. Years with winter totals falling below the 30th percentile for the period of record were categorized as DRY. Years falling between the 30th and 70th percentiles were categorized as AVERAGE.

Monthly available flows and annual totals (for both Nov – Mar and Oct – Apr) summarized by average, wet, and dry year for each of the two storage sites can be found in Table II-5 below and illustrated in Figure II-8.

**Table II-5 – Monthly and Annual Potentially Available Flows Summarized by Average, Wet, and Dry Years**

<table>
<thead>
<tr>
<th>SHELL CREEK AB FS BOUNDARY</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>AVAILABLE (Nov-Mar) FLOWS</th>
<th>AVAILABLE (Oct-April) FLOWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE Winter</td>
<td>2,240</td>
<td>2,084</td>
<td>2,155</td>
<td>2,840</td>
<td>3,312</td>
<td>2,760</td>
<td>2,478</td>
<td>11,717</td>
<td>17,869</td>
</tr>
<tr>
<td>WET Winter (70th Percentile)</td>
<td>2,384</td>
<td>2,173</td>
<td>2,290</td>
<td>2,806</td>
<td>3,738</td>
<td>3,054</td>
<td>2,662</td>
<td>12,562</td>
<td>19,107</td>
</tr>
<tr>
<td>VERY WET Winter (90th Percentile)</td>
<td>2,523</td>
<td>2,303</td>
<td>2,371</td>
<td>3,294</td>
<td>4,286</td>
<td>3,515</td>
<td>2,964</td>
<td>13,674</td>
<td>21,254</td>
</tr>
<tr>
<td>DRY Winter (30th Percentile)</td>
<td>2,202</td>
<td>2,024</td>
<td>2,093</td>
<td>2,868</td>
<td>2,871</td>
<td>2,478</td>
<td>2,273</td>
<td>11,069</td>
<td>16,808</td>
</tr>
<tr>
<td>VERY DRY Winter (10th Percentile)</td>
<td>1,987</td>
<td>1,751</td>
<td>1,895</td>
<td>2,203</td>
<td>2,867</td>
<td>2,367</td>
<td>2,270</td>
<td>10,270</td>
<td>15,340</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BEAVER CREEK AB NORTH/SOUTH BEAVER CR CONFL. (18% of SHELL nr SHELL)</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>AVAILABLE (Nov-Mar) FLOWS</th>
<th>AVAILABLE (Oct-April) FLOWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE Winter</td>
<td>414</td>
<td>385</td>
<td>399</td>
<td>525</td>
<td>613</td>
<td>511</td>
<td>458</td>
<td>2,168</td>
<td>3,306</td>
</tr>
<tr>
<td>WET Winter (70th Percentile)</td>
<td>441</td>
<td>402</td>
<td>424</td>
<td>519</td>
<td>692</td>
<td>565</td>
<td>493</td>
<td>2,324</td>
<td>3,535</td>
</tr>
<tr>
<td>VERY WET Winter (90th Percentile)</td>
<td>466</td>
<td>426</td>
<td>439</td>
<td>609</td>
<td>793</td>
<td>650</td>
<td>548</td>
<td>2,530</td>
<td>3,932</td>
</tr>
<tr>
<td>DRY Winter (30th Percentile)</td>
<td>407</td>
<td>374</td>
<td>387</td>
<td>531</td>
<td>531</td>
<td>458</td>
<td>420</td>
<td>2,048</td>
<td>3,110</td>
</tr>
<tr>
<td>VERY DRY Winter (10th Percentile)</td>
<td>368</td>
<td>324</td>
<td>351</td>
<td>408</td>
<td>530</td>
<td>438</td>
<td>420</td>
<td>1,900</td>
<td>2,838</td>
</tr>
</tbody>
</table>

**Figure II-8 - Annual Potentially Available Flows by Wet, Dry, and Average Year**
Temporary Stream Gauge Comparisons

Temporary flow totalizers were installed at two locations on Beaver Creek in the summer of 2010. Monthly flows on Beaver Creek above the N/S confluence estimated by scaling Shell nr Shell flows by 18% (as described previously) were compared to the temporary gauge data at the upper location. The gauge records were totaled by month and compared to the average, wet, and dry year estimates. Unfortunately, gauge records after July were not reliable due to damming of the stream by beavers and the data in July is questionable as well.

The comparison is summarized in below in Table II-6. The gauged monthly totals were moderately higher than the estimated period of record average in May and June. This is consistent with the relationship between May and June 2010 flows at other locations in the basin. At the two USGS stream flow gages, when compared to their respective 1951-2009 periods of record, totaled May and June flows for 2010 fall at about the 68th-69th percentile of May/June totals from 1951-2009. By comparison, the May/June total flows measured at the temporary stream gauge fall at the 66th percentile when compared to the 1951 – 2009 May/June totals in the estimated data set.

Table II-6 – Upper Beaver Creek Temporary Stream Gauge Comparisons

<table>
<thead>
<tr>
<th>Upper Beaver Creek Summer Flows</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on 18% of SHELL nr SHELL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period of Record Min</td>
<td>574</td>
<td>737</td>
<td>654</td>
<td>580</td>
<td>365</td>
<td>353</td>
</tr>
<tr>
<td>Period of Record Max</td>
<td>4,265</td>
<td>7,012</td>
<td>3,245</td>
<td>1,563</td>
<td>1,177</td>
<td>883</td>
</tr>
<tr>
<td>Period of Record Avg</td>
<td>1,893</td>
<td>3,187</td>
<td>1,363</td>
<td>1,010</td>
<td>748</td>
<td>530</td>
</tr>
<tr>
<td>Average of AVERAGE Years</td>
<td>2,069</td>
<td>3,115</td>
<td>1,371</td>
<td>1,045</td>
<td>786</td>
<td>528</td>
</tr>
<tr>
<td>Average of WET Years</td>
<td>1,791</td>
<td>3,684</td>
<td>1,491</td>
<td>1,062</td>
<td>835</td>
<td>604</td>
</tr>
<tr>
<td>Average of DRY Years</td>
<td>1,771</td>
<td>2,784</td>
<td>1,225</td>
<td>912</td>
<td>614</td>
<td>460</td>
</tr>
<tr>
<td>Temporary Stream Gage Monthly Totals:</td>
<td>2,244</td>
<td>3,910</td>
<td>874</td>
<td>2,957</td>
<td>4,087</td>
<td>4,423</td>
</tr>
</tbody>
</table>

2010 MAY - JUNE Totals as a Percentile of 1951 - 2009 MAY - JUNE Totals

- Temporary Gage 66% (compared to 1951 - 2009 estimates)
- Shell nr Shell 68%
- Shell ab Res 69%

Notes:
- All Values in Acre-feet
- Temporary stream gage values in August, September and October not valid due to beaver damming

While this is just one point of comparison, it does at least verify that the method of estimating flows at the Beaver Creek site is reasonable. It is recommended that monitoring of flows on Beaver Creek just below the North/South confluence continue. This data may be used to improve the historical time series of estimated flows in the next phase of the Level II study and to better understand the impacts of groundwater on the streamflow estimates.
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Highline Reservoir ......................................................... 49
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Chapter III. Site Identification and Screening

Site Identification

The identification of reservoir sites to be analyzed in this study was compiled from previous studies, input from the Project Sponsor, and map and field reconnaissance. The potential storage sites analyzed for this study are shown in Figure III-1. Each of the potential storage sites is discussed in detail in the following sections.

Screening

The screening of potential storage sites was facilitated by the use of a matrix that incorporated the important factors for reservoir feasibility. These factors are weighted to reflect the relative importance of the factors. Each reservoir site is then relatively rated for each factor on a scale from zero to ten. This screening also identified any “fatal flaws” that would make the site either impractical or impossible. Sites with a fatal flaw in one of the factors received a zero score for that factor. The totaling of the ratings and weights results in a total score that allows for comparison of the overall suitability of the potential reservoir sites. A table showing the scoring for each site is included at the end of this chapter.

The factors considered and the weights for screening are as follows:

Ability to Meet Needs

This factor considers the irrigation shortages downstream of the potential reservoir and ability of the reservoir to meet those needs. These considerations are based on the hydrologic model developed for this project. A weight of 30 was assigned to this factor.

Access

This factor considers the physical requirements for providing construction and permanent access to the potential dam and appurtenances as well as potential reservoir impacts to existing access ways. A weight of 10 was assigned to this factor.

Multiple Use Potential

This factor considers the potential for the potential reservoir site to be used for purposes other than irrigation water storage. This consideration includes secondary uses such as recreation, fish habitat, environmental enhancement, and hydropower production. A qualitative assessment of flood control potential is also included in this factor. A weight of 20 was assigned to this factor.

Geotechnical Feasibility

This factor considers the geological and geotechnical aspects of the dam and reservoir site. The initial investigation sought to find any potential “fatal flaws” that could effectively prohibit the construction of a dam and reservoir. A weight of 10 was assigned to this factor.
NORTH BEAVER CREEK CONFLUENCE

LEAVITT RESERVOIR

COYOTE DRAW

BEAVER CREEK CONFLUENCE

SAGE GROUSE CORE POPULATION AREA

0.5 MILE LEX BUFFER (TYP)

BOTSKY DRAW

SAGE GROUSE CORE POPULATION AREA

WETLANDS (TYP)

TRAPPER CREEK

DOUGLAS DRAW

TRAPPER CHIMNEY ROCK

TRAPPER OFF CHANNEL

HEALDON/POTATO

SHELTON/TUNNEL

SHELL RESERVOIR

SHELL VALLEY STORAGE LEVEL 1 STUDY

FIGURE III–1 POTENTIAL RESERVOIR SITES LOCATION MAP

STATES WEST WATER RESOURCES CORPORATION

900 S. MAIN ST. CLEVELAND, OH 44113

WEB: WWW.STATESWATER.COM

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Chapter III. Site Identification and Screening Page 2 of 91
Land Ownership
This factor considers the potential difficulties of obtaining rights-of-way and acquisition or easements for lands for the dam, reservoir, and access ways. A weight of 10 was assigned to this factor.

Cultural Resources
This factor considers the potential cultural impacts of the dam and reservoir site. A weight of 10 was assigned to this factor.

Environmental Impacts
This factor considers the potential environmental impacts of developing the dam and reservoir site. This consideration includes inundation of wetlands, riparian areas, wildlife habitat, bird nesting sites, endangered species, and other potential impacts. A weight of 20 was assigned to this factor.

Ability to Permit
This factor considers the regulatory potential for permitting the dam and reservoir site. Also included in this factor is consideration of potential negative public comment. A weight of 20 was assigned to this factor.

Cost
This factor considers the costs to design and build the prospective dam, reservoir, and associated facilities. Included in this consideration is the unit cost of the reservoir (cost ÷ storage). A weight of 20 was assigned to this factor.
**North Beaver Creek Reservoir**

As shown in Figure III-2, the North Beaver Creek dam would be located near Little Bald Mountain near Hwy 14 in the upper reaches of North Beaver Creek. Considered capacities ranged up to 7000 AF, with corresponding dam heights of up to 270 ft. This dam would be constructed of roller compacted concrete (RCC).

**Ability to Meet Needs**

While the studied North Beaver Creek site is located above all of the points of need, it is also in the headwaters of the drainage, resulting in a very minimal amount of water supply.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 60.

**Access**

Access to the site would require construction of approximately ⅔ mile of road across US Forest Service lands from Hwy 14. While the reservoir would be very near the highway, this road is not open during certain times of the winter.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

**Multiple Use Potential**

A North Beaver Creek Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creek below the reservoir site presently has good flow, and fishery values are high. During good weather, the recreational uses of this reservoir would be enhanced by the accessibility of the site.

While a North Beaver Creek reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Geotechnical Feasibility**

A geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

The full geological/geotechnical report can be found in Appendix A.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.
Land Ownership
The North Beaver Creek dam and reservoir would be located entirely on Forest Service lands.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

Cultural Resources
This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Environmental Impacts
Based on the NWI mapping, no existing wetlands would be impacted by the North Beaver Creek reservoir.

Impacts to riparian areas would most likely be minimal.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Observations of Grizzly Bear, Water Vole (Bighorn Mountain Population), Canada Lynx, Bighorn Mountain Pika, Brewer’s Sparrow, American Three-toed Woodpecker, and Soft Aster have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

The fishery is of high value and is being investigated for potential instream flow designation. If instream flow rights are granted, they could have a significant negative impact on flows available for storage.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Ability to Permit
The permitting process may be extensive for the North Beaver Creek reservoir due to its location on US Forest Service lands; it’s high fishery values can be expected to cause challenges.

The North Beaver Creek dam and reservoir would be in a very remote area with no facilities downstream that would be affected by a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.
Cost

It is anticipated that the only factor to significantly affect dam cost would be the relative inefficiency (water storage capacity versus dam fill) of the site. All other considerations have been included in the scoring for each individual screening factor.

A score of 3 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 60.

Total Matrix Score

As shown in Table III-18, the North Beaver Creek Reservoir total site score is 540, which is 36.0% of the maximum possible score for a site.
FIGURE III–2 NORTH BEAVER CREEK SITE PLAN

WETLANDS (TYP)

HWL ELEV 8880
3,811 AF

HWL ELEV 8920
6,923 AF

APPROX. DAM TOES

HWL = 8920

HWL = 8900

HWL = 8880

HIGHWAY 14

T55N R91W

1000’ 0 1000’

ALL LANDS OWNED BY USFS

STATES WEST WATER RESOURCES CORPORATION
1904 EAST 15TH STREET
CHEYENNE, WYOMING 82001
(307) 634–7948
FAX: (307) 634–7851

SHELL VALLEY STORAGE LEVEL II STUDY

HWL ELEV 8900
5,220 AF

HWL ELEV 8920
6,923 AF

PROJECT 593

FIGURE III–2 NORTH BEAVER CREEK SITE PLAN
### Table III-1 - North Beaver Creek Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incre. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width (ft)</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
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**Note:** RCC Dam. Comparative Earth Efficiency = RCC Efficiency ÷ 7

Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). RCC Dam: 25ft Wide x 30ft Tall Crest, 0.8:1 DS Slope, 10ft Freeboard. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.

![Graph showing storage and efficiency vs elevation](image-url)
**Beaver Creek Confluence Reservoir**

As shown in Figure III-3, the Beaver Creek Confluence dam would be located at the confluence of North Beaver Creek and South Beaver Creek. Considered capacities ranged up to 17,000 AF, with corresponding dam heights of up to 210 ft.

**Ability to Meet Needs**

The Beaver Creek Confluence site would be located above many of the points of need and would have significant flow available from both the North Fork and South Fork of Beaver Creek.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 240.

**Access**

Access to the site would be from Beaver Creek Road. This unpaved county road is generally in good condition and leads directly to the site. Construction of a 17,000 AF reservoir would require relocation of approximately one mile of Beaver Creek Road along with another mile of a less-improved road. Reducing the reservoir size to 4,000 AF would reduce the road loss by approximately one-third.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

**Multiple Use Potential**

A Beaver Creek Confluence Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creeks above the reservoir site have good flow presently and fishery values are high above the reservoir. A reservoir could offer the potential for improvement of the fishery below the dam. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While a Beaver Creek Confluence reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Geotechnical Feasibility**

A geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.
Land Ownership

The Beaver Creek Confluence dam and reservoir would be located nearly entirely on private lands with a nearly inconsequential amount of the dam being on BLM land. A significant portion of the private land is currently being irrigated and acquisition of land ownership or right-of-way could be problematic.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

Cultural Resources

This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Environmental Impacts

Based on the NWI mapping, nearly 2 acres of freshwater emergent wetlands would be impacted by the Beaver Creek Confluence reservoir.

Impacts to riparian areas would most likely be minimal.

This reservoir would be in the Sage Grouse Core Population Area. It would also be within 4 miles of a known lek. Further study would be required to ensure that disturbance created by this reservoir would not exceed allowable limits.

This site is located within the crucial winter mule deer habitat. Mitigation of impacts to this habitat would likely be required.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Water Vole (Bighorn Mountain Population), Brewer’s Sparrow, and American Three-toed Woodpecker have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

Ability to Permit

It is anticipated that the factors that would significantly affect the permitting of the Beaver Creek Confluence reservoir would be fishery losses, wetland and wildlife habitat mitigation, and potential sage grouse habitat losses. While these factors would not be as significant for this site as for others, they could be significant.

The Beaver Creek Confluence reservoir would discharge into Beaver Creek. While a full dam break flood routing would need to be completed for a final
determination, it is possible that a dam break would significantly damage Beaver Creek Road. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class II dam.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

**Cost**

The efficiency (volume of storage versus volume of dam fill) for the Beaver Creek Confluence dam and reservoir would be fair and, therefore, not a significant positive or negative factor. Mitigation of the wetland and wildlife habitat impacts may cause some additional costs. All other considerations have been included in scoring of each individual screening factor.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

**Total Matrix Score**

As shown in Table III-18, the Beaver Creek Confluence reservoir total site score is 910, which is 60.7% of the maximum possible score for a site.
FIGURE III-3 BEAVER CREEK CONFLUENCE RESERVOIR SITE PLAN

ENTIRE SITE INSIDE SAGE GROUSE CORE POPULATION AREA

APPROX. DAM TOES

- HWL = 5400
- HWL = 5360
- HWL = 5320
- HWL = 5280

WETLANDS (TYP)

States West Water Resources Corporation

1904 East 15th Street
Cheyenne, Wyoming 82001
(307) 634-7848
FAX: (307) 634-7651
Table III-2 - Beaver Creek Confluence Elevation-Area-Capacity Information

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<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
Leavitt Reservoir Enlargement

As shown in Figure III-4, the Leavitt enlargement dam would be located on the downstream side of the existing Leavitt Reservoir dam. Considered capacities ranged up to 7,000 AF, with corresponding dam heights of up to 100 ft. This reservoir would require diversion from Beaver Creek.

Ability to Meet Needs

The Leavitt enlargement would be located above the points of need and would have significant flow from Beaver Creek.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 240.

Access

Access to the site would be from Bear Creek Ranch Road. This unpaved county road, which branches off of Beaver Creek Road just to the south of the reservoir site, is generally in good condition and leads directly to the site. Enlarging the existing dam would require raising nearly one mile of Bear Creek Ranch Rd. Nearly all of this raise could be accomplished by placing the road on the proposed dam crest. Recently, a stone and timber ranch gate was constructed on the private road leading to the Leavitt ranch. Raising Bear Creek Ranch Road would necessitate removal and relocation of this gate. Additionally, a reservoir larger than approximately 3,000 AF would inundate approximately ½ mile of an unimproved access trail that would need to be relocated.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 80.

Multiple Use Potential

An enlarged Leavitt Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. Evidence of picnicking and other lakeside activities was evident during the field visit to this site. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While an enlarged Leavitt Reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 180.

Geotechnical Feasibility

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is the Cloverly Formation. This Formation commonly has gypsum and calcite-filled fractures and slickensided joints in mudstone. The portion of the Cloverly Formation observed in the field was the Sykes Mountain member, consisting of siltstone and sandstone interbedded with some shale layers. Alluvium consisting of unconsolidated deposits of sand, gravel, and loam was located in
the valley floor downstream of the existing dam. Depth to competent bedrock is not known and could be in the tens of feet.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

The existing dam would need to be removed for construction of an enlarged dam at this site. Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksideden surfaces at joints causing a weak foundation.

The full geological/geotechnical report can be found in Appendix A.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Land Ownership**

The Leavitt Reservoir dam enlargement would be located on nearly equal amounts of private and BLM lands while the reservoir would be located primarily on BLM lands.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

**Cultural Resources**

The Leavitt Reservoir area was included in a Class I cultural resource survey. Nine cultural sites have been located in the Leavitt Reservoir area.

It is also likely that additional cultural resources would be identified within the proposed reservoir.

A score of 4 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 40.

**Environmental Impacts**

Based on the NWI mapping, approximately 1.75 acres of freshwater emergent and freshwater forested/shrub wetlands would be impacted by the enlarged Leavitt reservoir. However, observations during the field visit indicate the actual acreage of wetlands could be as high as 10 acres.

The potential to create considerable wetland areas at the upstream fringes of the reservoir would exist. These wetlands could be supplied by the reservoir supply pipeline and could serve to mitigate wetland loss as well as to improve the water quality of the water entering the reservoir. These wetlands were not designed at this stage as more precise survey is needed.

Enlarging this dam would entail removal of a small number of cottonwood and Russian olive trees.

A portion of this site is located within the crucial winter/yearlong mule deer habitat. Mitigation of impacts to this habitat would likely be required.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear,
Water Vole (Bighorn Mountain Population), Brewer’s Sparrow, and Large Yellow Lady’s Slipper have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

The fishery values of Beaver Creek below where the diversion for the Leavitt Reservoir would be are low; therefore fishery impacts of this site would be minimal.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of an enlarged Leavitt reservoir would be wetland and wildlife habitat mitigation and potential cultural resource site mitigation.

The Leavitt Reservoir enlargement would discharge into an unnamed tributary Beaver Creek. While a full dam break flood routing would need to be completed for a final determination, it is possible that a dam break would significantly damage Beaver Creek Road. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class II dam.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 180.

**Cost**

Due to the need to remove the existing dam, the efficiency (volume of storage versus volume of dam fill) for the enlarged Leavitt dam and reservoir would be only fair and, therefore, not a significant positive or negative factor. Mitigation of the wetland and wildlife habitat and cultural resource impacts may cause some additional costs. This reservoir would also require a diversion from Beaver Creek. All other considerations have been included in scoring of each individual screening factor.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Total Matrix Score**

As shown in Table III-18, the enlarged Leavitt reservoir total site score is 1110, which is 74.0% of the maximum possible score for a site.
Table III-3 - Leavitt Enlargement Elevation-Area-Capacity Information

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<th>Water Elevation</th>
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<th>Water Area (Ac)</th>
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Volume Shown is Volume of Enlargement, not entire Storage. Dam Fill Quantities May be Inaccurate (Greater Than Actual) due to Imprecision of Quad Map in Showing Existing Dam

Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
**Upper Leavitt Reservoir**

As shown in Figure III-5, the Upper Leavitt dam would be located upstream of the existing Leavitt Reservoir dam through the existing reservoir. Considered capacities ranged up to 6,000 AF, with corresponding dam heights of up to 90 ft. This reservoir would require diversion from Beaver Creek.

This site is being considered as an alternative to the enlarged Leavitt reservoir as a means to avoid the conflicts that would arise from raising Bear Creek Ranch Road.

**Ability to Meet Needs**

The Upper Leavitt Reservoir would be located above the points of need and would have significant flow from Beaver Creek.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 240.

**Access**

Access to the site would be from Bear Creek Ranch Road. This unpaved county road, which branches off of Beaver Creek Road just to the south of the reservoir site, is generally in good condition and leads directly to the site. This reservoir would inundate approximately ¾ mile of an unimproved trail that would need to be relocated.

A score of 10 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 100.

**Multiple Use Potential**

An Upper Leavitt Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. Evidence of picnicking and other lakeside activities was evident during the field visit to the existing Leavitt Reservoir. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While an Upper Leavitt would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 180.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is the Cloverly Formation. This Formation commonly has gypsum and calcite-filled fractures and slickensided joints in mudstone. The portion of the Cloverly Formation observed in the field was the Sykes Mountain member, consisting of siltstone and sandstone interbedded with some shale layers. Alluvium consisting of unconsolidated deposits of sand, gravel, and loam was located in the valley floor downstream of the existing dam. Depth to competent bedrock is not known and could be in the tens of feet.
The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

The existing dam would need to be removed to prevent water from the existing reservoir from saturating the toe of any new dam at this site. Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksided surfaces at joints causing a weak foundation.

The full geological/geotechnical report can be found in Appendix A.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

Land Ownership

The Upper Leavitt Reservoir dam would be located on nearly equal amounts of private and BLM lands while the reservoir would be located primarily on BLM lands.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

Cultural Resources

The Leavitt Reservoir area was included in a Class I cultural resource survey. Nine cultural sites have been located in the Leavitt Reservoir area.

It is also likely that additional cultural resources would be identified within the proposed reservoir.

A score of 4 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 40.

Environmental Impacts

Based on the NWI mapping, approximately 1.75 acres of freshwater emergent and freshwater forested/shrub wetlands would be impacted by the enlarged Leavitt reservoir. However, observations during the field visit indicate the actual acreage of wetlands could be as high as 7.5 acres.

A mitigation wetland of approximately 5.2 acres could be constructed in the area currently inundated by the existing reservoir. Additionally, the potential to create considerable wetland areas at the upstream fringes of the reservoir would exist. These wetlands could be supplied by the reservoir supply pipeline and could serve to mitigate wetland loss as well as to improve the water quality of the water entering the reservoir. These wetlands were not designed at this stage as more precise survey is needed.

A nearly insignificant portion of this site is located within the crucial winter/yearlong mule deer habitat.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Water Vole (Bighorn Mountain Population), Brewer’s Sparrow, and Large Yellow Lady’s Slipper have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would
likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

The fishery values of Beaver Creek below where the diversion for the Upper Leavitt Reservoir would be are low; therefore fishery impacts of this site would be minimal. The stream segments upstream of the confluence of North and South Beaver Creeks are rated as a game fishery. In 1998, the Wyoming Game and Fish Department conducted an electro fishing survey on Beaver Creek very near the proposed diversion structure. The results are included as Appendix E. The survey found a relatively small number of Yellowstone Cutthroat in the reach. The predominate fish species were Longnose Dace and Mountain Sucker. The relative low numbers of cutthroat are probably due to dewatering of the creek by irrigation diversions. There are multiple diversions above the proposed diversion for the potential Upper Leavitt Reservoir.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.

**Ability to Permit**

It is anticipated that the factors that would significantly affect the permitting of Upper Leavitt reservoir would be wetland mitigation and potential cultural resource site mitigation. These factors could be significant.

The Upper Leavitt Reservoir would discharge into an unnamed tributary Beaver Creek. While a full dam break flood routing would need to be completed for a final determination, it is possible that a dam break would significantly damage Beaver Creek Road. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class II dam.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 180.

**Cost**

The efficiency (volume of storage versus volume of dam fill) for the Upper Leavitt dam and reservoir would be fair and, therefore, not a significant positive or negative factor. Mitigation of the wetland and cultural resource impacts may cause some additional costs. This reservoir would also require a diversion from Beaver Creek. All other considerations have been included in scoring of each individual screening factor.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Total Matrix Score**

As shown in Table III-18, the Upper Leavitt reservoir total site score is 1170, which is 78.0% of the maximum possible score for a site.
ROCK CHUTE AT
DISCHARGE OF
SUPPLY PIPELINE

HWL ELEV 4845
6,236 AF

PROPOSED WETLAND

APPROX. DAM TOES
HWL = 4845

FIGURE III-5 UPPER LEAVITT RESERVOIR
SITE PLAN
### Table III-4 - Upper Leavitt Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation (sq.ft.)</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width (CY)</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
</tr>
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</tbody>
</table>

Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. **Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.**

![Graph showing storage (AF) vs. water elevation](image-url)

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Coyote Draw Reservoir

As shown in Figure III-6, the Coyote Draw dam would be located in a valley between Canyon Creek and Beaver Creek approximately 1.5 miles south-southeast of Leavitt Reservoir. Considered capacities ranged up to 7,000 AF, with corresponding dam heights of up to 110 ft. At reservoir capacities above approximately 3,500 AF, a side "saddle" dam would be required in a lower area to the east of the main dam. This reservoir would require diversion from Beaver Creek.

Ability to Meet Needs

The Coyote Draw Reservoir would be located above most of the points of need and would have significant flow from Beaver Creek.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 210.

Access

Access to the site would require significant improvements to existing roads/trails and construction of new access roads. In order to utilize existing roads as much as possible, approximately 1.5 miles of road to the main dam and 1 mile of road to the saddle dam would need to be improved. Additionally, a minimum of 0.5 mile of new road would need to be constructed.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Multiple Use Potential

A Coyote Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Geotechnical Feasibility

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is the Cloverly Formation. This Formation commonly has gypsum and calcite-filled fractures and slickensided joints in mudstone. Two members of the Cloverly Formation were observed in the field: the upper member being the Sykes Mountain member, consisting of yellow or brown siltstone and sandstone and gray shale; and an unnamed lower member of variegated mudstone, shale, sandstone, and lenticular cross-bedded sandstone. Alluvium consisting of unconsolidated deposits of sand, gravel, and loam was located in the valley floor downstream of the existing dam. Depth to competent bedrock is not known and could be in the tens of feet.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.
Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksided surfaces at joints causing a weak foundation.

The full geological/geotechnical report can be found in Appendix A.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Land Ownership

The Coyote Reservoir dam would be located entirely on BLM lands and the reservoir would be located nearly entirely on BLM lands with less than 10 acres on private lands.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

Cultural Resources

The Coyote Reservoir area was included in a Class I cultural resource survey. Seven cultural sites have been located in the Coyote Reservoir area.

The number of cultural resources found in the general area suggests that additional sites might be found within the reservoir area. However, these sites would likely be ineligible prehistoric lithic scatters.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 80.

Environmental Impacts

Based on the NWI mapping, no wetlands would be impacted by the Coyote Reservoir. However, observations during the field visit indicate that wetland fringes occur in the bottom of the existing drainage. Between 0.5 to 0.75 acres of wetlands could be impacted by construction of this reservoir.

This site is located within the crucial winter elk and mule deer habitat. Mitigation of impacts to this habitat would likely be required.

This reservoir would be in the Sage Grouse Core Population Area. It would also be within 4 miles of a known lek. Further study would be required to ensure that disturbance created by this reservoir would not exceed allowable limits.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Water Vole (Bighorn Mountain Population), Brewer’s Sparrow, and Large Yellow Lady’s Slipper have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.
The fishery values of Beaver Creek below where the diversion for the Coyote Draw Reservoir would be are low; therefore fishery impacts of this site would be minimal.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of Coyote reservoir would be wetland and wildlife habitat mitigation. The reservoir would be located within the Sage Grouse Core Population Area and additional study would need to be completed.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Cost**

The efficiency (volume of storage versus volume of dam fill) for the Coyote dam and reservoir would be fair and, therefore, not a significant positive or negative factor. Mitigation of the wetland and wildlife habitat impacts may cause some additional costs. Additionally, Coyote Reservoir would require diversion from Beaver Creek via a canal or pipeline. All other considerations have been included in scoring of each individual screening factor.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Total Matrix Score**

As shown in Table III-18, the Coyote reservoir total site score is 930, which is 62.0% of the maximum possible score for a site.
### Table III-5 - Coyote Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43,560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.

![Graph showing Storage and Efficiency vs. Elevation](image-url)
**Bratsky Draw Reservoir**

As shown in Figure III-7, the Bratsky Draw dam would be located in a valley between Beaver Creek and Horse Creek approximately 1.5 miles upstream from the confluence of Bratsky Draw and Shell Creek. Considered capacities ranged up to 7,600 AF, with corresponding dam heights of up to 115 ft. This reservoir would require diversion from Beaver Creek and/or Shell Creek. A diversion from Shell Creek would be quite lengthy (7 miles).

**Ability to Meet Needs**

While this site would have adequate water supply from Beaver Creek and Shell Creek, it would not practically serve needs on Beaver Creek.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 210.

**Access**

Access to the site would require significant improvements to existing roads/trails and construction of new access roads. In order to utilize existing roads as much as possible, approximately 1.25 miles of road would need considerable improvements. Additionally, a minimum of 0.15 mile of new road would need to be constructed.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Multiple Use Potential**

A Bratsky Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While a Bratsky Reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was completed for this site. As shown in Figure III-8, a 1,000-ft long landslide exists at the left abutment of the proposed dam. This landslide is very large in size and has a strong potential for future movement. An alternate site was investigated about ¼ mile downstream of the proposed site. This site also had a potential landslide. Due to the high risk of continued landslides and excavation required for removal of the existing landslides, Bratsky Draw should be completely eliminated from consideration.

The full geological/geotechnical report can be found in Appendix A.

A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 0.
Land Ownership

Approximately one-half of the Bratsky dam and most of the reservoir would be on BLM land. The balance of the facility would be on private land.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

Cultural Resources

The Bratsky Reservoir area was included in a Class I cultural resource survey. No cultural sites have been located in the Bratsky Reservoir area. The number of cultural resources found in the general area suggests that additional sites might be found within the reservoir area. However, these sites would likely be ineligible prehistoric lithic scatters.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 90.

Environmental Impacts

Based on the NWI mapping and field observations, a little less than 3 acres of palustrine wetlands would be impacted by the Bratsky Reservoir.

This site is located within the crucial winter/yearlong mule deer habitat. Mitigation of impacts to this habitat would likely be required.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Brewer’s Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been
difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of Bratsky reservoir would be wetland and wildlife habitat mitigation.

The Bratsky Draw dam and reservoir would be located less than one mile upstream of Beaver Creek Road. While a full dam break flood routing would need to be completed for a final determination, it is possible that a dam break would significantly damage Beaver Creek Road. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class II dam.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Cost**

The costs caused by the existing and potential future landslides make this reservoir impractical to build. All other factors are insignificant.

A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 0.

**Total Matrix Score**

As shown in Table III-18, the Bratsky reservoir total site score is 820, which is 54.7% of the maximum possible score for a site. However, the site is fatally flawed geotechnically and will not be pursued further.
Figure III-7 Bratsky Draw Site Plan

- HWL ELEV 4340
  - 7,596 AF
- HWL ELEV 4320
  - 4,413 AF
- HWL ELEV 4300
  - 2,128 AF
- Approx. Dam toes
  - HWL = 4340
  - HWL = 4320
  - HWL = 4300
- Landslide location
- Wetlands (Typ)
- Potential alternate dam site

States West Water Resources Corporation

Shell Valley Storage Level II Study

1904 East 15th Street
Cheyenne, Wyoming 82001
(307) 634-7948
Fax: (307) 634-7851

FIGURE III-7 BRATSKY DRAW SITE PLAN
### Table III-6 - Bratsky Elevation-Area-Capacity Information

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<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
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<th>Efficiency (CF/CF)</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) × 43560 (cuft/AF)) / (Dam Fill (CY) × 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5 ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
Sheldon Gulch Reservoir

As shown in Figure III-9, the Sheldon Gulch dam would be located in a valley adjacent to Potato Ridge. Water supply would be from Shell Canal. Considered capacities ranged up to 7,000 AF, with corresponding dam heights of up to 85 ft.

Ability to Meet Needs

Supply of water to this reservoir would be hampered by the capacity of Shell Canal. Additionally, this site would be located below most of the points of need in the project area.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 60.

Access

Access to the site would require construction of approximately $\frac{2}{3}$ mile of new access roads.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Multiple Use Potential

A Sheldon Gulch Reservoir would have fair opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The reservoir would offer the limited potential for improvement of fisheries. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

The relative large surface area of a Sheldon Gulch reservoir compared to direct runoff flood flows would result in significant flood attenuation in Sheldon Gulch without the need for a significant flood pool. However, this attenuation would only affect Sheldon Gulch for approximately 1.3 stream miles, at which point the stream joins Shell Creek. The drainage area for Shell Creek is quite large at this intersection.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Geotechnical Feasibility

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is a mix of Cretaceous Mowry Shale, Thermopolis Shale, and Muddy Sandstone and Cloverly Sykes Mountain. Depth to competent bedrock is not known and could be in the tens of feet.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock.

The full geological/geotechnical report can be found in Appendix A.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.
Land Ownership

Nearly all of the Sheldon Gulch dam and most of the reservoir would be on BLM land. A very small part of the reservoir would be on State land. The balance of the facility would be on private land.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

Cultural Resources

The Sheldon Gulch Reservoir area was included in a Class I cultural resource survey. Nine cultural sites have been located in the Sheldon Gulch Reservoir area. These sites are shown on Figure III-13. The number of cultural resources found in the general area suggests that additional sites might be found within the reservoir area. However, these sites would likely be ineligible prehistoric lithic scatters.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

Environmental Impacts

Based on the NWI mapping 3.82 acres of palustrine wetlands would be impacted by the Sheldon Gulch Reservoir. Field observations indicate that the actual extend of wetlands is considerably larger than the NWI mapping.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Townsend’s Western Big-eared Bat, Black-Footed Ferret, Grizzly Bear, Brewer’s Sparrow, Sage Sparrow, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Ability to Permit

It is anticipated that the only factors that would significantly affect the permitting of Sheldon Gulch reservoir would be wetland mitigation, which could be quite extensive. The Sheldon Gulch dam and reservoir would be located less than one mile upstream of Highway 14. While a full dam break flood routing would need to be completed for a final determination, it is possible that a dam break could flood the highway while someone is driving on it. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class I dam.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.
Cost

The efficiency (volume of storage versus volume of dam fill) for the Sheldon Gulch dam and reservoir would be good and, therefore, a slight positive factor. Mitigation of the wetland impacts may cause some additional costs. All other considerations have been included in scoring of each individual screening factor.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

Total Matrix Score

As shown in Table III-18, the Sheldon Gulch reservoir total site score is 840, which is 52.7% of the maximum possible score for a site.
FIGURE III-9 SHELDON GULCH RESERVOIR SITE PLAN
### Table III-7 - Sheldon Gulch Elevation-Area-Capacity Information

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<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.

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![Graph showing Storage and Efficiency vs. Water Elevation](image-url)
Shell Canal Tunnel Reservoir

As shown in Figure III-10, the Shell Canal Tunnel dam would be located along the Shell Canal approximately ¼ mile from the Shell Canal Tunnel. A capacity of 225 AF was considered, with a corresponding dam height of 50 ft. This dam would be limited by topography and the presence of the Shell Canal. This site is primarily proposed as a potential location to utilize materials that might be produced by the Shell Canal Tunnel project if it is decided to open cut the tunnel, essentially turning it from a tunnel into a canal.

Ability to Meet Needs

The drainage area of this reservoir is relatively small and the storage of the reservoir is quite small. Therefore, this site would not be able to significantly address any of the needs of the project area.

A score of 1 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 30.

Access

Access to the site would require minor improvements to a little more than ½ mile of the existing canal access road.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 90.

Multiple Use Potential

A Shell Canal Tunnel Reservoir would have negligible opportunities for a multiple use project.

While a Shell Canal Tunnel would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 3 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 60.

Geotechnical Feasibility

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is the lower member of the Cloverly Formation. This Formation commonly has gypsum and calcite-filled fractures and slickensided joints in mudstone. At this site, the foundation bedrock was observed to primarily be intensely weathered mudstone with minimum rock structure. This portion of the Cloverly Formation could be susceptible to landslides. Depth to competent bedrock is not known and could be in the tens of feet.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins.
in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksidened surfaces at joints causing a weak foundation.

The full geological/geotechnical report can be found in Appendix A.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Land Ownership**

All of the Shell Canal Tunnel dam and reservoir would be on private land.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 90.

**Cultural Resources**

Although this site was not included in the cultural resources study, portions of the Shell Canal are eligible for the National Register of Historic Places. Further cultural investigation would be needed at this site.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Environmental Impacts**

NWI mapping indicates that no wetlands would be impacted by the Shell Canal Tunnel dam and reservoir. Field observations indicate that a very small (<0.1AC) wetland dominated by cattails was present at the site.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Townsend’s Western Big-eared Bat, Black-Footed Ferret, Grizzly Bear, Brewer’s Sparrow, Sage Sparrow, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 180.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of a Shell Canal Tunnel reservoir would be the possibility for the need for cultural mitigation as the Shell Canal is eligible for the National Register of Historic Places.

The Shell Canal Tunnel dam and reservoir would be located approximately one-half mile upstream of Highway 14. However, due to the reservoir’s relatively small size, the flood flow from a dam break would likely be similar to natural flood flows. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.
A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.

Cost

The efficiency (volume of storage versus volume of dam fill) for the Shell Canal Tunnel dam and reservoir would be good and, therefore, a slight positive factor. The main financial advantage to this site would be its proximity to the Shell Canal Tunnel, which may be modified by removing all material above the canal. All other considerations have been included in scoring of each individual screening factor.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.

Total Matrix Score

As shown in Table III-18, the Shell Canal Tunnel reservoir total site score is 860, which is 57.3% of the maximum possible score for a site.
Figure III-10: Canal Tunnel Reservoir Site Plan

- Approx. Dam Toes
- HWL = 4160
- HWL Elev 4160
- 225 AF

Private Land
BLM Land

Wetlands (Typ)

States West Water Resources Corporation
1904 East 15th Street
Cheyenne, Wyoming 82001
(307) 634-7648
Fax: (307) 634-7651

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Table III-8 - Shell Canal Tunnel Elevation-Area-Capacity Information

<table>
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<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
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Quantities Based on USGS Topo Map. 20-ft Contours Were Digitized. Other Contours Were Estimated.

Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1.

Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
**Douglas Draw Reservoir**

As shown in Figure III-11, the Douglas Draw dam would be located along Hwy 14 approximately one mile west of the town of Shell. Considered capacities ranged up to 5,000 AF, with corresponding dam heights of up to 120 ft. A diversion from Shell Creek would be required to supply this reservoir.

**Ability to Meet Needs**

This reservoir would have sufficient supply from Shell Creek. Although this reservoir could discharge to Shell Creek above Shell Canal, it would not serve any needs on Beaver Creek.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the dam site would require construction of less than ½ mile of access road. Access to the supply/discharge pipeline would require rights-of-way from multiple sources.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 80.

**Multiple Use Potential**

A Douglas Reservoir would have fair opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While a Douglas Draw reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was completed for this site. The general bedrock geology at the site is the lower member of the Sykes Mountain Member and the lower member of the Cloverly Formation. Gypsum and calcite-filled fractures and slickensided joints in mudstone were identified at the site. Depth to competent bedrock is not known and could be in the tens of feet.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksided surfaces at joints causing a weak foundation.
The full geological/geotechnical report can be found in Appendix A.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Land Ownership**

Although the Douglas Draw dam and reservoir would be entirely on BLM land, nearly all of the pipeline from Shell Creek that would be required to supply the reservoir would be on private land.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

**Cultural Resources**

The Douglas Draw Reservoir area was included in a Class I cultural resource survey. Four cultural sites have been located in the area. These sites are shown on Figure III-16. The number of cultural resources found in the general area suggests that additional sites might be found within the reservoir area. The Shell Canal has been determined to be eligible for the National Register of Historic Places. As the canal runs less than 200 ft from the toe of the proposed dam, it may be visually affected by a dam. It may be possible to mitigate these effects.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Environmental Impacts**

NWI mapping indicates that 0.16 acres of wetlands would be impacted by the Douglas Draw dam and reservoir. Field observations indicate that this wetland area is actually a breached pond. Therefore, no significant wetland impacts are expected.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Townsend’s Western Big-eared Bat, Black-Footed Ferret, Grizzly Bear, Brewer’s Sparrow, Sage Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

Approximately half of this reservoir would be in the Sage Grouse Core Population Area (SGCPA). Western EcoSystems Technology, Inc, performed an analysis following the required Density and Disturbance Calculation Tool (DDCT). This analysis determined that construction of a Douglas Draw reservoir would meet the statutory limits. Therefore, it’s presence within the SGCPA should not be a challenge.

The full environmental report can be found in Appendix B. The sage grouse DDCT analysis can be found in Appendix C.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.
Ability to Permit

It is anticipated that the only factors that would significantly affect the permitting of a Douglas Draw reservoir would be the possibility for the need for cultural mitigation as the Shell Canal is eligible for the National Register of Historic Places and the presence of a home located less than 1000 ft from the toe of the dam in the valley immediately downstream of the dam.

The Douglas Draw dam and reservoir would be located approximately one-quarter of a mile upstream of a residence within the Douglas Draw valley and Highway 14. Both of these facilities would be considerable damaged by a dam break with little or no warning. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class I dam.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Cost

The efficiency (volume of storage versus volume of dam fill) for the Douglas Draw dam and reservoir would be poor and, therefore, a slight negative factor. The reservoir would also require a rather lengthy (5.8 miles) supply pipeline from Shell Creek. Additionally, there is a home located less than 1000 ft from the toe of the dam in the valley immediately downstream of the dam. All other considerations have been included in scoring of each individual screening factor.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Total Matrix Score

As shown in Table III-18, the Douglas Draw reservoir total site score is 990, which is 66.0% of the maximum possible score for a site.
Figure 11-11: Douglas Draw Reservoir Site Plan

- **Wetlands (Typ)**
- **Supply/Discharge Pipeline**
- **Approx. Dam Toes**
  - HWL = 4280
  - HWL = 4260
  - HWL = 4240
- **Realigned Highway**
- **Existing House (Typ)**
- **Private Land**
- **BLM Land**
- **H威尔 Elev 4240**
  - 1,054 AF
- **H威尔 Elev 4260**
  - 2,595 AF
- **Sage Grouse Core Population Area Boundary**
- **H威尔 Elev 4280**
  - 5,240 AF

**States West Water Resources Corporation**

**Shell Valley Storage Level II Study**

**Figure III-11 Douglas Draw Reservoir Site Plan**
### Table III-9: Douglas Draw Elevation-Area-Capacity Information

<table>
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<tr>
<th>Water Elevation (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
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Quantities Based on USGS Topo Map. 20-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
**Highline Reservoir**

As shown in Figure III-12, the Highline dam would be located along Hwy 14 approximately one mile west of the town of Shell. Considered capacities ranged up to 2,000 AF, with corresponding dam heights of up to 65 ft. A diversion from Shell Creek would be required to supply this reservoir.

**Ability to Meet Needs**

While this reservoir would have sufficient supply from Shell Creek, it's storage is insufficient to significantly meet the needs of the project area.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 60.

**Access**

Access to the site would require construction of less than ½ mile of access road.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 80.

**Multiple Use Potential**

Due to its relative small size, a Highline Reservoir would have limited opportunities for a multiple use project.

While a Highline reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir's location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was not completed for this site but is likely to be similar to the Douglas Draw site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

Potential negative geologic/geotechnical facets of this site could include the need for deep excavation to locate competent bedrock, existence of gypsum and calcite veins in the dam foundation that could dissolve and create seepage pathways and/or foundation settlement, and slicksideden surfaces at joints causing a weak foundation.

The full geological/geotechnical report can be found in Appendix A.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Land Ownership**

Nearly all of the Highline dam and reservoir would be on BLM land, with the remainder of the dam and reservoir and nearly all of the pipeline from Shell Creek that would be required to supply the reservoir on private land.
A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Cultural Resources**

This site was not included in the cultural resources study. The number of cultural sites found in the general area, however, suggests a moderate possibility of sites to be located at this site.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Environmental Impacts**

NWI mapping indicates that no wetlands would be impacted by the Highline dam and reservoir.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Townsend’s Western Big-eared Bat, Black-Footed Ferret, Grizzly Bear, Brewer’s Sparrow, Sage Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

All of this reservoir would be in the Sage Grouse Core Population Area. Further study would be required to ensure that disturbance created by this reservoir would not exceed allowable limits.

The full environmental report can be found in Appendix B.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of a Highline reservoir would be the need for habitat study related to the site being located in the Sage Grouse Core Population Area and the presence of a home located less than 500 ft from the toe of the dam in the valley immediately downstream of the dam.

The Highline dam and reservoir would be located approximately 300 yards upstream of a residence within the reservoir valley and Highway 14. Both of these facilities would be considerable damaged by a dam break with little or no warning. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class I dam.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.
Cost

The efficiency (volume of storage versus volume of dam fill) for the Highline dam and reservoir would be quite poor and, therefore, a significant negative factor. The reservoir would also require a rather lengthy (5 miles) supply pipeline from Shell Creek. Additionally, there is a home located less than 500 ft from the toe of the dam in the valley immediately downstream of the dam. All other considerations have been included in scoring of each individual screening factor.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.

Total Matrix Score

As shown in Table III-18, the Highline reservoir total site score is 690, which is 46.0% of the maximum possible score for a site.
Table III-10 - High Line Elevation-Area-Capacity Information

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<th>Water Elevation (ft)</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
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Quantities Based on USGS Topo Map. 20-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
Trapper Chimney Rock Reservoir

As shown in Figure III-13, the Trapper Chimney Rock dam would be located near the Trapper Lodge Ranch and Chimney Rock approximately 3 miles south-east of the town of Shell. Considered capacities ranged up to 12,000 AF, with corresponding dam heights of up to 205 ft. A diversion from Trapper Creek would be required to supply this reservoir.

Ability to Meet Needs

This reservoir would have a limited supply from Trapper Creek. While it could serve needs from most of Shell Creek, it would not serve needs from Beaver Creek or Horse Creek.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

Access

Access to the dam site would require construction of less than ½ mile of access road from Trapper Creek Road. Additionally, the reservoir would inundate approximately 1¼ mile of BLM access road that would need to be relocated.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

Multiple Use Potential

A Trapper Chimney Rock Reservoir would have average opportunities for a multiple use project. The uses would be somewhat limited due to the availability of water to the site. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While a Trapper Chimney Rock reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

Geotechnical Feasibility

A review of existing published geological and geotechnical literature was completed for this site. Bedrock in the dam foundation and abutments includes the Chugwater and Goose Egg Formations. The Chugwater Formation typically contains layers of gypsum and the Goose Egg Formation contains gypsiferous carbonate, among other materials. These materials are prone to dissolution, would require extensive treatment to the dam and reservoir foundation and therefore safe development of a dam and reservoir may not be possible. The presence of these materials constitutes a fatal flaw and this reservoir should be removed from further consideration.

The full geological/geotechnical report can be found in Appendix A.
A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 0.

**Land Ownership**

Nearly all of the Trapper Chimney Rock dam and reservoir would be on BLM land, with a small portion of the reservoir on private land.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 60.

**Cultural Resources**

This site was not included in the cultural resources study. The number of cultural sites found in the general area, however, suggests a moderate possibility of sites to be located at this site.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Environmental Impacts**

NWI mapping indicates that no wetlands would be impacted by the Trapper Chimney Rock dam and reservoir.

This site is located within the crucial winter/yearlong mule deer habitat. Mitigation of impacts to this habitat would likely be required.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Brewer’s Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of a Trapper Chimney Rock reservoir would be its presence within the crucial winter/yearlong mule deer habitat.

The Trapper Chimney Rock dam and reservoir would be located approximately 500 yards upstream of the Trapper Creek Lodge. This facility would be considerable damaged by a dam break with little or no warning. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class I dam.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.
Cost

The efficiency (volume of storage versus volume of dam fill) for the Trapper Chimney Rock dam and reservoir would be quite poor and, therefore, a significant negative factor. The reservoir would also require a supply pipeline or ditch from Trapper Creek. Additionally, the dam would require extensive foundation treatment and the reservoir should be lined to prevent seepage. These two factors comprise a fatal flaw for the reservoir. All other considerations have been included in scoring of each individual screening factor.

A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 0.

Total Matrix Score

As shown in Table III-18, the Trapper Chimney Rock reservoir total site score is 780, which is 52.0% of the maximum possible score for a site. However, this site has a geotechnical fatal flaw and should be removed from further consideration.
Figure III-13 Trapper Chimney Rock Reservoir Site Plan

H WL ELEV 4640 11,949 AF
H WL ELEV 4600 6,741 AF
H WL ELEV 4560 3,086 AF

Approx. Dam Toes
- HWL = 4640
- HWL = 4600
- HWL = 4560

Sage Grouse Core Population Area Boundary

States West Water Resources Corporation

Shell Valley Storage Level II Study
### Table III-11 - Trapper Chimney Rock Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. **Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.**
**Trapper Creek Reservoir**

As shown in Figure III-14, the Trapper Creek dam would be located near the Trapper Lodge Ranch at the confluence of Trapper Creek and Bush Creek approximately 3 miles south-east of the town of Shell. Considered capacities ranged up to 3,400 AF, with corresponding dam heights of up to 120 ft.

**Ability to Meet Needs**

This reservoir would have a limited supply from Trapper Creek. While it could serve needs from most of Shell Creek, it would not serve needs from Beaver Creek or Horse Creek.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the site would be via the existing Trapper Creek Road. A portion of this road would be inundated by the reservoir and approximately 1 mile of new road would need to be constructed.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

**Multiple Use Potential**

A Trapper Creek Reservoir would have average opportunities for a multiple use project. The uses would be somewhat limited to the availability of water to the site. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

The relative small surface area of a Trapper Creek reservoir compared to direct runoff flood flows would likely result in minimal flood attenuation in Trapper Creek without the inclusion of a flood pool. The 100-yr flood volume has been calculated to be 460 AF. The 500-flood volume is estimated to be 1,400 AF.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

**Geotechnical Feasibility**

A review of existing published geological and geotechnical literature was completed for this site. Bedrock in the dam foundation and abutments includes the Chugwater and Goose Egg Formations. The Chugwater Formation typically contains layers of gypsum and the Goose Egg Formation contains gyspiferous carbonate, among other materials. These materials are prone to dissolution, would require extensive treatment to the dam and reservoir foundation and therefore safe development of a dam and reservoir may not be possible. The presence of these materials constitutes a fatal flaw and this reservoir should be removed from further consideration.

The full geological/geotechnical report can be found in Appendix A.

A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 0.
Land Ownership

About half of the Trapper Creek reservoir and most of the dam would be on private land, with the remainder on BLM land.

Some structures within the dam footprint are visible on aerial photos of the area. The nature or these structures are unknown, but they appear to have metal roofs.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

Cultural Resources

This site was not included in the cultural resources study. The number of cultural sites found in the general area, however, suggests a moderate possibility of sites to be located at this site.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Environmental Impacts

NWRI mapping indicates that 0.80 acres of palustrine emergent wetlands would be impacted by the Trapper Creek dam and reservoir. While these impacts are not extensive, they are significant.

This site is located within the crucial winter/yearlong mule deer habitat. Mitigation of impacts to this habitat would likely be required.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Brewer’s Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The segment of Trapper Creek through the dam site is a high value fishery that would be impaired by construction of the dam and reservoir.

The full environmental report can be found in Appendix B.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

Ability to Permit

It is anticipated that the only factors that would significantly affect the permitting of a Trapper Creek reservoir would be the presence of a high value fishery at the dam, its presence within the crucial winter/yearlong mule deer habitat and the presence of wetlands.

The Trapper Creek dam and reservoir would be located on Trapper Creek. There are numerous buildings and fishing locations along Trapper Creek that could be
occupied during a dam break. Therefore, this dam would likely be classified by the
Wyoming State Engineer’s Office as a Class I dam.

A score of 5 out of a possible 10 has been assigned for this factor. The factor
weight is 20, resulting in a total factor score of 100.

Cost

The efficiency (volume of storage versus volume of dam fill) for the Trapper
Creek dam and reservoir would be poor and, therefore, a significant negative factor.
Mitigation of wetlands would also add to the cost. All other considerations have been
included in scoring of each individual screening factor. Additionally, the dam would
require extensive foundation treatment and the reservoir should be lined to prevent
seepage. These two factors comprise a fatal flaw for the reservoir. All other
considerations have been included in scoring of each individual screening factor.

A score of 0 out of a possible 10 has been assigned for this factor. The factor
weight is 20, resulting in a total factor score of 0.

Total Matrix Score

As shown in Table III-18, the Trapper Creek reservoir total site score is 690,
which is 46.0% of the maximum possible score for a site. However, this site has a
gеotechnical fatal flaw and should be removed from further consideration.
Figure III-14 Trapper Creek On and Off Channel Reservoirs Site Plan
Table III-12 - Trapper Creek Elevation-Area-Capacity Information

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<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
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Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
*Trapper Off Channel Reservoir*

As shown in Figure III-14 (see Trapper Creek section), the Trapper Off Channel dam would be located near the Trapper Lodge Ranch near the confluence of Trapper Creek and Bush Creek approximately 3 miles south-east of the town of Shell. Considered capacities ranged up to 4,400 AF, with corresponding dam heights of up to 125 ft.

**Ability to Meet Needs**

This reservoir would have a limited supply from Trapper Creek. While it could serve needs from most of Shell Creek, it would not serve needs from Beaver Creek or Horse Creek.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the site would be via the existing Trapper Creek Road. Access to the top of the dam would require the construction of approximately ¼ mile of new road.

A score of 9 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 90.

**Multiple Use Potential**

A Trapper Off Channel Reservoir would have average opportunities for a multiple use project. The uses would be somewhat limited to the availability of water to the site. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The recreational uses of this reservoir would be enhanced by the good accessibility of the site.

While a Trapper Off Channel reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

**Geotechnical Feasibility**

A review of existing published geological and geotechnical literature was completed for this site. Bedrock in the dam foundation and abutments includes the Chugwater and Goose Egg Formations. The Chugwater Formation typically contains layers of gypsum and the Goose Egg Formation contains gypsiferous carbonate, among other materials. These materials are prone to dissolution, would require extensive treatment to the dam and reservoir foundation and therefore safe development of a dam and reservoir may not be possible. The presence of these materials constitutes a fatal flaw and this reservoir should be removed from further consideration.

The full geological/geotechnical report can be found in Appendix A.
A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 0.

**Land Ownership**

The majority of the reservoir would be on BLM land; all of the dam and a small portion of the reservoir would be on private land.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 70.

**Cultural Resources**

This site was not included in the cultural resources study. The number of cultural sites found in the general area, however, suggests a moderate possibility of sites to be located at this site.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Environmental Impacts**

NWI mapping indicates that no wetlands would be impacted by the Trapper Off Channel dam and reservoir.

Approximately half of this site is located within the crucial winter/yearlong mule deer habitat. Mitigation of impacts to this habitat would likely be required.

A small portion of the reservoir would be located within the Sage Grouse Core Population Area. Further study would be required to ensure that disturbance created by this reservoir would not exceed allowable limits.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, Brewer’s Sparrow, Sage Thrasher, Large Yellow Lady’s Slipper, and Giant helleborine have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 8 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 160.

**Ability to Permit**

It is anticipated that the only factors that would significantly affect the permitting of a Trapper Off Channel reservoir would be its presence within the crucial winter/yearlong mule deer habitat and Sage Grouse Core Population Area.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.
Cost

The efficiency (volume of storage versus volume of dam fill) for the Trapper Off Channel dam and reservoir would be fair and, therefore, a slight negative factor. Mitigation of big game habitat and the need for a diversion from Trapper Creek would also add to the cost. All other considerations have been included in scoring of each individual screening factor. Additionally, the dam would require extensive foundation treatment and the reservoir should be lined to prevent seepage. These two factors comprise a fatal flaw for the reservoir. All other considerations have been included in scoring of each individual screening factor.

The Trapper Off Channel dam and reservoir would be located in the Trapper Creek valley. There are numerous buildings and fishing locations along Trapper Creek that could be occupied during a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class I dam.

A score of 0 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 0

Total Matrix Score

As shown in Table III-18, the Trapper Off Channel reservoir total site score is 790, which is 52.7% of the maximum possible score for a site. However, this site has a geotechnical fatal flaw and should be removed from further consideration.
### Table III-13 - Trapper Off Channel Elevation-Area-Capacity Information

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<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
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Quantities Based on USGS Topo Map.  40-ft Contours Were Digitized.  Other Contours Were Estimated.  Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)).  Upstream Dam Slope = 4:1.  Downstream Dam Slope = 3:1.  Freeboard = 5ft.  **Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.**
**Shell Reservoir Enlargement**

As shown in Figure III-15, the Shell Reservoir Enlargement dam would be located at the existing Shell Reservoir approximately 18 miles east of the town of Shell. Considered enlargement capacities ranged up to 14,000 AF, with corresponding dam heights of up to 205 ft.

**Ability to Meet Needs**

This reservoir would have adequate supply from Shell Creek. This site could serve all lands receiving water from Shell Creek, but not Beaver, Horse, or Trapper Creeks.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the site would be via the existing Shell Reservoir access trail off of Ranger Creek Road. Several miles of this trail would need significant improvement. Access during the winter would be severely limited.

A score of 4 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 40.

**Multiple Use Potential**

A Shell Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creek below the reservoir site flows continuously presently, and fishery values are high. A reservoir could offer the potential for improvement of the fishery. The recreational uses of this reservoir would be enhanced by the aesthetics of the site.

The relative large surface area of an enlarged Shell reservoir compared to direct runoff flood flows would result in significant flood attenuation in Shell Creek without the need for a significant flood pool. However, this attenuation would only affect Shell Creek for a maximum of approximately 4.5 stream miles (all of which are within the US Forest Service border), at which point Willett Creek joins Shell Creek. The combined drainage area for Shell Creek and its upstream tributaries is quite large at this intersection, rendering the flood attenuation at Shell Reservoir negligible.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.
Land Ownership

This site would be located entirely within the Bighorn National Forest and would be administered by the US Forest Service.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

Cultural Resources

This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Environmental Impacts

NWI mapping indicates that 4.78 acres of palustrine emergent wetlands would be impacted by the enlarged Shell Reservoir dam and reservoir.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Bighorn Mountain Pika, Grizzly Bear, American Three-Toed Woodpecker, Brewer’s Sparrow, Mud Sedge, and Hairy tranquil goldenweed have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 120.

Ability to Permit

The Shell Reservoir is located in the Bighorn National Forest. Additionally, impacts to wetlands would be significant. Therefore, permitting this reservoir would be quite challenging.

The Shell dam and reservoir would be in a very remote area with no facilities downstream that would be affected by a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.

A score of 1 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 20.

Cost

The efficiency (volume of storage versus volume of dam fill) for the Shell enlarged dam and reservoir would be fair and, therefore, a slight negative factor. Permitting costs will be quite extensive. All other considerations have been included in scoring of each individual screening factor.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.
Total Matrix Score

As shown in Table III-18, the Shell reservoir enlargement total site score is 660, which is 44.0% of the maximum possible score for a site.
### Table III-14 - Shell Enlargement Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8997</td>
<td>4,117,949</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>314</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9000</td>
<td>5,013,768</td>
<td>115</td>
<td>314</td>
<td>314</td>
<td>5,465</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9040</td>
<td>6,889,313</td>
<td>158</td>
<td>5,780</td>
<td>40</td>
<td>1,769,229</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8,056</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9080</td>
<td>10,657,118</td>
<td>245</td>
<td>13,836</td>
<td>50</td>
<td>4,082,502</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

Volume Shown is Volume of Enlargement, not entire Storage. Dam Fill Quantities May be Inaccurate due to Imprecision of Quad Map in Showing Existing Dam Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
**Lower Willett Reservoir**

As shown in Figure III-16, the Lower Willett Reservoir dam would be located on Willett Creek approximately 16 miles east of the town of Shell and approximately 1.7 miles from the Ranger Creek Campground. Considered capacities ranged up to 8,000 AF, with corresponding dam heights of up to 125 ft.

**Ability to Meet Needs**

This reservoir would have fair supply from Willett Creek. This site could serve all lands receiving water from Shell Creek, but not Beaver, Horse, or Trapper Creeks.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the site would be via an existing jeep trail off of Ranger Creek Road. Several miles of this trail would need significant improvement. Access during the winter would be severely limited.

A score of 4 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 40.

**Multiple Use Potential**

A Lower Willett Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creek below the reservoir site flows continuously presently, and fishery values are high. A reservoir could offer the potential for improvement of the fishery. The recreational uses of this reservoir would be enhanced by the aesthetics of the site.

While a Lower Willett reservoir would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Land Ownership**

This site would be located entirely within the Bighorn National Forest and would be administered by the US Forest Service.
A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

Cultural Resources

This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Environmental Impacts

NWI mapping indicates that 8.35 acres of palustrine emergent wetlands would be impacted by the Lower Willett Reservoir dam and reservoir.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Grizzly Bear, Sage Thrasher, Brewer’s Sparrow, Mud Sedge, Russet cotton-grass, Cary’s beardtongue, Soft aster, and Hairy tranquil goldenweed have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 3 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 60.

Ability to Permit

The Lower Willett Reservoir is located in the Bighorn National Forest. Additionally, impacts to wetlands would be significant. Therefore, permitting this reservoir would be quite challenging.

The Lower Willett dam and reservoir would be in a very remote area with no facilities downstream that would be affected by a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.

A score of 1 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 20.

Cost

The efficiency (volume of storage versus volume of dam fill) for the Lower Willett dam and reservoir would be fair and, therefore, a slight negative factor. Permitting costs will be quite extensive. All other considerations have been included in scoring of each individual screening factor.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.

Total Matrix Score

As shown in Table III-18, the Lower Willett reservoir total site score is 600, which is 40.0% of the maximum possible score for a site.
FIGURE III-16 UPPER AND LOWER WILLETT RESERVOIR SITE PLANS

STATES WEST WATER RESOURCES CORPORATION

SHELF VALLEY STORAGE LEVEL II STUDY

PROJECT: SWE

1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7648
FAX: (307) 634-7651

FIGURE III-16 UPPER AND LOWER WILLETT RESERVOIR SITE PLANS
Table III-15 - Lower Willett Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8579</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8600</td>
<td>1,567,433</td>
<td>36</td>
<td>378</td>
<td>2,597</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8640</td>
<td>4,089,736</td>
<td>94</td>
<td>2,975</td>
<td>26</td>
<td>646,118</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>8680</td>
<td>6,688,913</td>
<td>154</td>
<td>7,924</td>
<td>34</td>
<td>1,844,437</td>
<td>6.9</td>
<td></td>
</tr>
</tbody>
</table>

Quantities based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.
**Upper Willett Reservoir**

As shown in Figure III-16 (see Lower Willett section), the Upper Willett Reservoir dam would be located on Willett Creek approximately 16 miles east of the town of Shell and approximately 2.3 miles from the Ranger Creek Campground. Considered capacities ranged up to 5,000 AF, with corresponding dam heights of up to 205 ft.

**Ability to Meet Needs**

This reservoir would have fair supply from Willett Creek. This site could serve all lands receiving water from Shell Creek, but not Beaver, Horse, or Trapper Creeks.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

**Access**

Access to the site would be via an existing jeep trail off of Ranger Creek Road. Several miles of this trail would need significant improvement. Access during the winter would be severely limited.

A score of 4 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 40.

**Multiple Use Potential**

An Upper Willett Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creek below the reservoir site flows continuously presently, and fishery values are high. A reservoir could offer the potential for improvement of the fishery. The recreational uses of this reservoir would be enhanced by the aesthetics of the site.

While an Upper Willett would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Geotechnical Feasibility**

An on-site geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Land Ownership**

This site would be located entirely within the Bighorn National Forest and would be administered by the US Forest Service.
A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

**Cultural Resources**

This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Environmental Impacts**

NWI mapping indicates that 2.6 acres of palustrine emergent wetlands would be impacted by the Upper Willett Reservoir dam and reservoir.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Grizzly Bear, Sage Thrasher, Brewer’s Sparrow, Mud Sedge, Russet cotton-grass, Cary’s beardtongue, Soft aster, and Hairy tranquil goldenweed have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 100.

**Ability to Permit**

The Upper Willett Reservoir is located in the Bighorn National Forest. Additionally, impacts to wetlands would be significant. Therefore, permitting this reservoir would be quite challenging.

The Upper Willett dam and reservoir would be in a very remote area with no facilities downstream that would be affected by a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.

A score of 1 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 20.

**Cost**

The efficiency (volume of storage versus volume of dam fill) for the Upper Willett dam and reservoir would be poor and, therefore, a significant negative factor. Permitting costs will be quite extensive. All other considerations have been included in scoring of each individual screening factor.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.

**Total Matrix Score**

As shown in Table III-18, the Upper Willett reservoir total site score is 640, which is 42.7% of the maximum possible score for a site.
### Table III-16 - Upper Willett Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8700</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
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<td>357,860</td>
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<td>82</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8760</td>
<td>929,170</td>
<td>21</td>
<td>673</td>
<td>673</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1,450</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8800</td>
<td>2,229,969</td>
<td>51</td>
<td>2,124</td>
<td>2,124</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,032</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8840</td>
<td>4,374,116</td>
<td>100</td>
<td>5,156</td>
<td>5,156</td>
<td>50</td>
<td>2,672,616</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. **Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.**
Willett Lake

As shown in Figure III-17, the Willett Lake dam would be located on Willett Creek at the existing Willett Lake approximately 18 miles east of the town of Shell and approximately 4.6 miles from the Ranger Creek Campground. Considered capacities ranged up to 9,000 AF, with corresponding dam heights of up to 240 ft.

Ability to Meet Needs

This reservoir would have fair supply from Willett Creek. This site could serve all lands receiving water from Shell Creek, but not Beaver, Horse, or Trapper Creeks.

A score of 6 out of a possible 10 has been assigned for this factor. The factor weight is 30, resulting in a total factor score of 180.

Access

Access to the site would be via an existing jeep trail off of Ranger Creek Road. Several miles of this trail would need significant improvement. Access during the winter would be severely limited.

A score of 3 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 30.

Multiple Use Potential

A Willett Lake Reservoir would have good opportunities for a multiple use project. The primary purpose of the reservoir would be for irrigation supplementary supply. In addition, a dedicated recreation pool could offer opportunity for flat water recreation. The creek below the reservoir site flows continuously presently, and fishery values are high. A reservoir could offer the potential for improvement of the fishery. The recreational uses of this reservoir would be enhanced by the aesthetics of the site.

While a Willett Lake would likely be large enough when compared to direct flood flows to attenuate floods at the reservoir, due to the reservoir’s location in the upper reaches of the basin, the effects of such attenuation would be negligible at any significant point of interest when compared to the flood flows from other sources.

A score of 7 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

Geotechnical Feasibility

An on-site geotechnical and geological investigation was not completed for this site.

The dam site appears to have a potential peak ground acceleration of 0.22g with a 5,000-year return interval. These ground motions may impact dam design and freeboard requirements.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

Land Ownership

This site would be located entirely within the Bighorn National Forest and would be administered by the US Forest Service.
A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 20.

**Cultural Resources**

This site was not included in the cultural resources study.

A score of 5 out of a possible 10 has been assigned for this factor. The factor weight is 10, resulting in a total factor score of 50.

**Environmental Impacts**

NWI mapping indicates that 17.41 acres of palustrine emergent wetlands and 4.14 acres of freshwater pond would be impacted by the Willett Lake Reservoir dam and reservoir.

Several species tracked by the Wyoming Natural Diversity Database as species of concern may occur in or near the reservoir. Grizzly Bear, Sage Thrasher, Brewer’s Sparrow, Mud Sedge, Russet cotton-grass, Cary’s beardtongue, Soft aster, and Hairy tranquil goldenweed have occurred within 5 miles of the reservoir site. Prior to constructing a potential reservoir in this area, surveys for sensitive wildlife and plant species would likely be required. If any sensitive species were to be found, mitigation measures would likely be required. No raptor nests were observed during the site visit, but nests may have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as the northern goshawk.

The full environmental report can be found in Appendix B.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 140.

**Ability to Permit**

The Willett Lake Reservoir is located in the Bighorn National Forest. Additionally, impacts to wetlands would be significant. Therefore, permitting this reservoir would be quite challenging.

The Willett Lake dam and reservoir would be in a very remote area with no facilities downstream that would be affected by a dam break. Therefore, this dam would likely be classified by the Wyoming State Engineer’s Office as a Class III dam.

A score of 1 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 20.

**Cost**

The efficiency (volume of storage versus volume of dam fill) for the Willett Lake dam and reservoir would be fair and, therefore, a slight negative factor. Permitting costs will be quite extensive as would wetland mitigation costs. All other considerations have been included in scoring of each individual screening factor.

A score of 2 out of a possible 10 has been assigned for this factor. The factor weight is 20, resulting in a total factor score of 40.
Total Matrix Score

As shown in Table III-18, the Willett Lake reservoir total site score is 570, which is 38.0% of the maximum possible score for a site.
### Table III-17 - Willett Lake Elevation-Area-Capacity Information

<table>
<thead>
<tr>
<th>Water Elevation</th>
<th>Water Area (sq.ft.)</th>
<th>Water Area (Ac)</th>
<th>Incr. Volume (AF)</th>
<th>Total Volume (AF)</th>
<th>Dam Crest Width</th>
<th>Dam Fill (CY)</th>
<th>Efficiency (CF/CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9300</td>
<td>217,189</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9320</td>
<td>1,848,441</td>
<td>42</td>
<td>474</td>
<td>2,305</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9360</td>
<td>3,172,869</td>
<td>73</td>
<td>2,780</td>
<td>40</td>
<td>481,927</td>
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<td></td>
</tr>
<tr>
<td>9400</td>
<td>4,853,947</td>
<td>111</td>
<td>6,465</td>
<td>48</td>
<td>1,034,985</td>
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<td></td>
</tr>
<tr>
<td>9420</td>
<td>5,542,789</td>
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</tr>
<tr>
<td>9440</td>
<td>6,257,183</td>
<td>144</td>
<td>9,174</td>
<td>50</td>
<td>2,031,695</td>
<td>7.3</td>
<td></td>
</tr>
</tbody>
</table>

Quantities Based on USGS Topo Map. 40-ft Contours Were Digitized. Other Contours Were Estimated. Efficiency = (Storage (AF) x 43560 (cuft/AF)) / (Dam Fill (CY) x 27 (cuft/CY)). Upstream Dam Slope = 4:1. Downstream Dam Slope = 3:1. Freeboard = 5ft. Quantities do not account for foundation excavation/preparation or precise site topography and should be used for comparison of sites only.

![Graph showing Storage and Efficiency vs. Water Elevation]

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Conclusions

Table III-18 presents the site scoring matrix. This matrix compiles the individual factor scores for each of the studied storage sites. The matrix shows the relative feasibility of each site in a quantitative manner. The total score for each site is the sum of each factor score multiplied by the factor multiplier.

Table III-24 presents data for each site regarding location, dam characteristics, and efficiency. Quantities shown are based on a theoretical dam cross section and contours digitized from the USGS quadrangle maps. As such, they are estimates to be used for comparison of sites only. Table III-24 also presents a summary of the factors utilized in accessing the environmental impacts factor for each site.

Based upon the initial screening, it was determined that preliminary designs and cost estimates should be developed for the Upper Leavitt, Douglas Draw, and Shell Canal Tunnel sites.
### Table III-18 - Site Scoring Matrix

<table>
<thead>
<tr>
<th>Reservoir Site</th>
<th>Ability to Meet Needs 30</th>
<th>Access 10</th>
<th>Multiple Use Potential 20</th>
<th>Geotechnical Feasibility 10</th>
<th>Land Ownership 10</th>
<th>Cultural Resources 10</th>
<th>Environmental Impacts 20</th>
<th>Ability to Permit 20</th>
<th>Cost 20</th>
<th>Site Score</th>
<th>% of Possible Points</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Beaver Creek</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>540</td>
<td>36.0%</td>
<td>USFS, Class III Fishery</td>
</tr>
<tr>
<td>Beaver Creek Confluence</td>
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<td>7</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>910</td>
<td>60.7%</td>
<td>SGCPA</td>
</tr>
<tr>
<td>Leavitt Enlargement</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>1110</td>
<td>74.0%</td>
<td>Diversion from Beaver</td>
</tr>
<tr>
<td>Upper Leavitt</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>1170</td>
<td>78.0%</td>
<td>Diversion from Beaver</td>
</tr>
<tr>
<td>Coyote Draw</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>930</td>
<td>62.0%</td>
<td>SGCPA, Diversion from Beaver</td>
</tr>
<tr>
<td>Bratsky Draw</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>820</td>
<td>54.7%</td>
<td>Landslides (Fatal Flaw), Diversion from Shell, Supplies Shell Canal</td>
</tr>
<tr>
<td>Sheldon Gulch</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>790</td>
<td>52.7%</td>
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</tr>
<tr>
<td>Shell Canal Tunnel</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>860</td>
<td>57.3%</td>
<td>SGCPA, Diversion from Shell, Supplies Shell Canal</td>
</tr>
<tr>
<td>Douglas Draw</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>990</td>
<td>66.0%</td>
<td>SGCPA, Enlargement of Highline Canal from Trapper</td>
</tr>
<tr>
<td>Highline</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>690</td>
<td>46.0%</td>
<td>SGCPA, Enlargement of Highline Canal from Trapper</td>
</tr>
<tr>
<td>Trapper Chimney Rock</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>780</td>
<td>52.0%</td>
<td>Bedrock and Dam Fill Materials Soluable (Fatal Flaw), Class III Fishery</td>
</tr>
<tr>
<td>Trapper Creek</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>690</td>
<td>46.0%</td>
<td>Bedrock and Dam Fill Materials Soluable (Fatal Flaw), Class III Fishery</td>
</tr>
<tr>
<td>Trapper Off Channel</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>790</td>
<td>52.7%</td>
<td>Bedrock and Dam Fill Materials Soluable (Fatal Flaw), SGCPA, Class III Fishery</td>
</tr>
<tr>
<td>Shell Enlargement</td>
<td>6</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>660</td>
<td>44.0%</td>
<td>USFS</td>
</tr>
<tr>
<td>Lower Willett</td>
<td>6</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>600</td>
<td>40.0%</td>
<td>USFS, Wetlands</td>
</tr>
<tr>
<td>Upper Willett</td>
<td>6</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>640</td>
<td>42.7%</td>
<td>USFS</td>
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<tr>
<td>Willett Lake</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>570</td>
<td>38.0%</td>
<td>USFS, Wetlands</td>
</tr>
</tbody>
</table>

**Maximum Total Possible= 1500**

**Factor Weight as % of Total:** 20.0% 6.7% 13.3% 6.7% 6.7% 6.7% 13.3% 13.3% 13.3%
### Table III-19 - Storage Sites Summary

<table>
<thead>
<tr>
<th>Site Name</th>
<th>North Beaver Creek</th>
<th>Lower Beaver Creek</th>
<th>Leavitt Enlargement</th>
<th>Upper Leavitt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude, Longitude</td>
<td>44.7600, -107.7989</td>
<td>44.6763, -107.8455</td>
<td>44.6397, -107.8679</td>
<td>44.6427, -107.8719</td>
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<tr>
<td>USGS Identifier</td>
<td>SV-01</td>
<td>SV-02</td>
<td>SV-03</td>
<td>SV-04</td>
</tr>
<tr>
<td>Location (Section, Township N, Range W)</td>
<td>10, 55, 91</td>
<td>7, 54, 91</td>
<td>24, 54, 92</td>
<td>24, 54, 92</td>
</tr>
<tr>
<td>Direct Reservoir Supply</td>
<td>North Beaver Creek</td>
<td>North and South Beaver Creek</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Direct Reservoir Supply</td>
<td>N/A</td>
<td>N/A</td>
<td>Beaver Creek (via Pipeline)</td>
<td>Beaver Creek (via Pipeline)</td>
</tr>
<tr>
<td>Reservoir Storage Capacity (AF)</td>
<td>3,811</td>
<td>5,220</td>
<td>6,923</td>
<td>1,251</td>
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<tr>
<td>Reservoir Water Surface Area (Ac)</td>
<td>64</td>
<td>77</td>
<td>93</td>
<td>45</td>
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<tr>
<td>Reservoir Water Surface Elevation</td>
<td>8880</td>
<td>8900</td>
<td>8920</td>
<td>5280</td>
</tr>
<tr>
<td>Reservoir Service Area</td>
<td>Beaver Creek, Shell Creek below Beaver Creek</td>
<td>Lower Beaver Creek, Shell Creek below Beaver Creek</td>
<td>Lower Beaver Creek, Shell Creek below Beaver Creek</td>
<td>Lower Beaver Creek, Shell Creek below Beaver Creek</td>
</tr>
<tr>
<td>Dam Type</td>
<td>RCC</td>
<td>Earth</td>
<td>Earth</td>
<td>Earth</td>
</tr>
<tr>
<td>Borrow Material Availability</td>
<td>Not Evaluated</td>
<td>Not Evaluated</td>
<td>Process onsite bedrock for fine and coarse grained borrow.</td>
<td>Process onsite bedrock for fine and coarse grained borrow.</td>
</tr>
<tr>
<td>Dam Height (ft)</td>
<td>205</td>
<td>235</td>
<td>270</td>
<td>75</td>
</tr>
<tr>
<td>Crest Elevation (ft)</td>
<td>8880</td>
<td>8900</td>
<td>8920</td>
<td>5280</td>
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<tr>
<td>Crest Length (ft)</td>
<td>875</td>
<td>925</td>
<td>1,225</td>
<td>1,100</td>
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<tr>
<td>Embankment Volume (CY)</td>
<td>225,662</td>
<td>302,836</td>
<td>393,832</td>
<td>194,207</td>
</tr>
<tr>
<td>Efficiency (Capacity/Fill) (CY/ft)</td>
<td>27.2</td>
<td>27.8</td>
<td>28.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Direct Drainage Area (sq-mi)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2.60</td>
</tr>
<tr>
<td>Average Precipitation (in)</td>
<td>82.6</td>
<td>17.0</td>
<td>10yr; 30</td>
<td>100yr; 115</td>
</tr>
<tr>
<td>Potential for Flood Control</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Outlet Works</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Upstream Inlet Box w/Slide Gate, 36&quot; Steel Pipe, Downstream Valve House</td>
</tr>
<tr>
<td>Spillways</td>
<td>Integral with RCC Dam</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Open Excavated Channel Near Dam Abutment</td>
</tr>
<tr>
<td>Geology</td>
<td>Not Evaluated</td>
<td>Not Evaluated</td>
<td>Cloverly Fm: residual strength, contains gypsum and calcite veins. Existing embankment and reservoir sediment must be removed in emankment foot print. Depth to competent bedrock is unknown.</td>
<td>Cloverly Fm: residual strength, contains gypsum and calcite veins. Existing embankment and reservoir sediment must be removed in emankment foot print. Depth to competent bedrock is unknown.</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>USFS</td>
<td>Private, BLM</td>
<td>Private, BLM</td>
<td>Private, BLM</td>
</tr>
<tr>
<td>Irrigated Acreage inundated (acre)</td>
<td>41</td>
<td>65</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Stream Access (Roads - seasonal)</td>
<td>None</td>
<td>Beaver Creek Road (1 mile); Unimproved Road (1 mile)</td>
<td>Bear Creek Ranch Road (1 mile); Unimproved Access Trail (0.5 mile)</td>
<td>Bear Creek Ranch Road (0.2 mile); Unimproved Access Trail (0.7 mile)</td>
</tr>
<tr>
<td>Cultural/Archaeological impacts</td>
<td>Unknown (unlikely)</td>
<td>Unknown</td>
<td>Multiple sites within dam &amp; reservoir limits - Mitigation requirements likely</td>
<td>Multiple sites within dam &amp; reservoir limits - Mitigation requirements likely</td>
</tr>
<tr>
<td>NWI Wetlands impacts (ac)</td>
<td>0</td>
<td>193</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td>Riparian impacts</td>
<td>Unknown (likely minimal)</td>
<td>Unknown (likely minimal)</td>
<td>Small # Cottonwoods, &gt;0.39Ac Scrub/Shrub</td>
<td>Negligible</td>
</tr>
<tr>
<td>Portion of Project within Sage Grouse Core Population Area</td>
<td>None</td>
<td>Entirety</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Species of concern</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
</tr>
<tr>
<td>Big Game impacts - crucial winter</td>
<td>None</td>
<td>Mule Deer</td>
<td>Mule Deer</td>
<td>Mule Deer</td>
</tr>
<tr>
<td>MGFD Stream Class</td>
<td>Yellow</td>
<td>Yellow (South Fork)</td>
<td>Green (North Fork)</td>
<td>(Beaver Creek = Yellow)</td>
</tr>
<tr>
<td>Access</td>
<td>Highway 14 + new access roads (seasonal)</td>
<td>Beaver Creek Road</td>
<td>Bear Creek Ranch Road</td>
<td>Bear Creek Ranch Road</td>
</tr>
</tbody>
</table>

The table contains various data points related to storage sites, including latitude, longitude, GIS identifier, location, reservoir storage capacity, reservoir water surface area, reservoir water surface elevation, reservoir service area, reservoir permitted uses, dam type, borrow material availability, dam height, crest elevation, crest length, embankment volume, efficiency, direct drainage area, average precipitation, potential for flood control, outlet works, spillways, geology, land ownership, irrigated acreage inundated, stream access, cultural/archaeological impacts, NWI wetlands impacts, riparian impacts, and cultural significance of Big Game species. Each site is identified with a unique identifier and has specific data regarding its characteristics and environs.
### Table III-19 - Storage Sites Summary

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Coyote Draw</th>
<th>Bratsky Draw (Beaver Creek Diversion)</th>
<th>Bratsky Draw (Shell Creek Diversion)</th>
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</thead>
<tbody>
<tr>
<td>Latitude, Longitude</td>
<td>44.6239, -107.8439</td>
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<td>44.5561, -107.7993</td>
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<td>Type</td>
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<tr>
<td>Location</td>
<td>30, 54, 91</td>
<td>V049</td>
<td>V049</td>
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<tr>
<td>Direct Reservoir Supply</td>
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<tr>
<td>Indirect Reservoir Supply</td>
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<tr>
<td>Reservoir Water Area (Ac)</td>
<td>75</td>
<td>122</td>
<td>199</td>
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<tr>
<td>Reservoir Water Surface Area (Ac)</td>
<td>4660</td>
<td>4620</td>
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</tr>
<tr>
<td>Site Name</td>
<td>Reservoir Service Area</td>
<td>Other Benefits</td>
<td>Dam Type</td>
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</tr>
<tr>
<td>Shell Canal Tunnel</td>
<td>Lower Shell Creek</td>
<td>Recreation, Fishery</td>
<td>Earth</td>
</tr>
<tr>
<td>Douglas Draw</td>
<td>Shell Creek</td>
<td>Irrigation</td>
<td>Earth</td>
</tr>
</tbody>
</table>

### Table III-19 - Storage Sites Summary

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Latitude, Longitude</th>
<th>Location (Section, Township N, Range W)</th>
<th>Direct Reservoir Supply</th>
<th>Reservoir Storage Capacity (AF)</th>
<th>Reservoir Water Surface Area (Ac)</th>
<th>Reservoir Water Surface Elevation</th>
<th>Reservoir Service Area</th>
<th>Reservoir Permitted Uses</th>
<th>Dam Type</th>
<th>Borrow Material Availability</th>
<th>Potential for Flood Control</th>
<th>Outlet Works</th>
<th>Spillway Work</th>
<th>Geology</th>
<th>Land Ownership</th>
<th>Irrigated Acreage Inundated (acre)</th>
<th>Cultural/Archaeological Impacts</th>
<th>Riparian Impacts</th>
<th>Species of concern</th>
<th>Big Game Impacts - Crucial Winter</th>
<th>WGF Stream Class</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Canal Tunnel</td>
<td>44.5111, -107.9445</td>
<td>6, 52, 92</td>
<td>Sheldon Gulch, Potato Draw</td>
<td>2,021</td>
<td>123</td>
<td>3980</td>
<td>Lower Shell Creek</td>
<td>Irrigation</td>
<td>Earth</td>
<td>Process onsite bedrock for fine grained borrow. Process alluvium and terrace deposits from outside of reservoir for sand and gravel.</td>
<td>Upstream Inlet Box w/Side Gate, 18&quot; Outlet Pipe to Spillway Riser</td>
<td>Upstream Inlet Box w/Side Gate, 48&quot; Steel Pipe, Downstream Valve House</td>
<td>None</td>
<td>None</td>
<td>24</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Douglas Draw</td>
<td>44.5139, -107.8885</td>
<td>3, 52, 92</td>
<td>Unnamed Stream</td>
<td>N/A</td>
<td>18</td>
<td>4160</td>
<td>N/A</td>
<td>Irrigation</td>
<td>Earth</td>
<td>Process onsite bedrock for fine grained borrow. Process alluvium and terrace deposits from outside of reservoir for sand and gravel.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0</td>
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<tr>
<td>Douglas Draw</td>
<td>44.5252, -107.8053</td>
<td>33, 53, 91</td>
<td>Douglas Draw</td>
<td>N/A</td>
<td>54</td>
<td>4240</td>
<td>N/A</td>
<td>Irrigation</td>
<td>Earth</td>
<td>None</td>
<td>Negligible</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
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</table>

**Potential for Flood Control:**
- Likely Significant for Sheldon Gulch: Sheldon Gulch
- Negligible for Shell Creek
- Negligible
- Negligible
- Upstream Inlet Box w/Side Gate, 18" Outlet Pipe to Spillway Riser
- Upstream Inlet Box w/Side Gate, 48" Steel Pipe, Downstream Valve House
- Riser Pipe and 30" Combined Spillway/Outlet Pipe
- Open Excavated Channel Near Dam Abutment

**Outlet Works:**
- Not Designed
- Designed
- Not Designed
- Designed

**Spillway Work:**
- Not Designed
- Designed
- Not Designed
- Designed

**Geology:**
- Mowry Shale, Thermopolis Shale, and Cloverly Formation: predominantly shales with some sandstone, bentonite beds and gypsum filled fractures were identified
- Coverly Fm: residual strength, contains gypsum and calcite veins. Landslide identified in same geologic unit approx. 0.5 miles away. Depth to competent bedrock is unknown.
- Coverly Fm: residual strength, contains gypsum and calcite veins. Depth to competent bedrock is unknown.

**Land Ownership:**
- BLM, Private, State
- BLM
- BLM

**Irrigated Acreage Inundated (acre):**
- 24
- 0

**Cultural/Archaeological Impacts:**
- Shell Canal; Others Possible
- Shell Canal
- Shell Canal
- >3.82
- <0.1
- 0.16 (breached stock pond)
- None

**Riparian Impacts:**
- None
- None
- None
- Approx. Half of Inundation Area; DDCT analysis determined statutory limits met

**Species of Concern:**
- Grizzly (Historical - may not be current)
- Grizzly (Historical - may not be current)
- Grizzly (Historical - may not be current)

**Big Game Impacts - Crucial Winter:**
- None
- None
- None

**WGF Stream Class:**
- Clear
- Clear
- Clear

**Access:**
- Hwy 14 + New Road (0.7 mile)
- Hwy 14 + Existing Canal Road
- Hwy 14 + 1/2mile New Road

**Favorable Characteristic:**
- Unfavorable Characteristic
- Neither Favorable Nor Unfavorable

**Probable Fatal Flaw or Very Unfavorable Characteristic:**
- None

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**Chapter III. Site Identification and Screening Page 89 of 91**
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Douglas Draw - Pump Station Option</th>
<th>Highline</th>
<th>Trapper Chimney Rock</th>
<th>Trapper Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude, Longitude</td>
<td>44.5252, -107.8053</td>
<td>44.5280, -107.7897</td>
<td>44.5152, -107.7288</td>
<td>44.4997, -107.7150</td>
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<tr>
<td>USGS Identifier</td>
<td>SV-11</td>
<td>9T12</td>
<td>9T11</td>
<td>6T19</td>
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<tr>
<td>Location (Section, Township N, Range W)</td>
<td>33, 53, 91</td>
<td>34, 53, 91</td>
<td>1, 52, 91</td>
<td>7, 52, 90</td>
</tr>
<tr>
<td>Direct Reservoir Supply</td>
<td>Douglas Draw</td>
<td>Negligible</td>
<td>Unnamed Stream</td>
<td>Trapper Creek</td>
</tr>
<tr>
<td>Indirect Reservoir Supply</td>
<td>Shell Creek (via Pipeline)</td>
<td>Shell Creek (via Ditch)</td>
<td>Trapper Creek (via Pipeline)</td>
<td>N/A</td>
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<tr>
<td>Reservoir Water Surface Area (AF)</td>
<td>570</td>
<td>2,009</td>
<td>3,096</td>
<td>3,435</td>
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<td>Reservoir Water Surface Area (Ac)</td>
<td>57</td>
<td>87</td>
<td>71</td>
<td>112</td>
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<td>Reservoir Water Elevation</td>
<td>4280</td>
<td>4280</td>
<td>4660</td>
<td>4640</td>
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<tr>
<td>Reservoir Service Area</td>
<td>Shell Creek below Town of Shell</td>
<td>Shell Creek below reservoir</td>
<td>Trapper Creek, Highline Ditch, Shell Creek, Shell Canal</td>
<td>Trapper Creek, Highline Ditch, Shell Creek, Shell Canal</td>
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<tr>
<td>Dam Type</td>
<td>Earth</td>
<td>Earth</td>
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<tr>
<td>Other Benefits</td>
<td>Recreation</td>
<td>Negligible</td>
<td>Recreation</td>
<td>Recreation</td>
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<tr>
<td>Borrow Material Availability</td>
<td>Process onsite bedrock for fine grained borrow. Process alluvium and terrace deposits from outside of reservoir for sand and gravel.</td>
<td>Not Evaluated</td>
<td>Not Evaluated</td>
<td>Not Evaluated</td>
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<td>Dam Height (ft)</td>
<td>70</td>
<td>95</td>
<td>120</td>
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<td>Crest Elevation (ft)</td>
<td>4240</td>
<td>4285</td>
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<td>Crest Length (ft)</td>
<td>1,350</td>
<td>1,520</td>
<td>1,600</td>
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<td>Crest Width (ft)</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>20</td>
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<td>Embankment Volume (CY)</td>
<td>283,797</td>
<td>630,937</td>
<td>1,154,830</td>
<td>1,320,629</td>
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<td>Efficiency (Capacity/Fill) (CY/LY)</td>
<td>5.8</td>
<td>6.6</td>
<td>7.3</td>
<td>2.9</td>
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<td>Efficiency (Fill/Capacity) (CY/LY)</td>
<td>278.7</td>
<td>243.1</td>
<td>220.4</td>
<td>29.5</td>
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<td>Direct Drainage Area (sq-mi)</td>
<td>1,27</td>
<td>0.33</td>
<td>0.89</td>
<td>59.68</td>
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<td>Indirect Drainage Area (sq-mi)</td>
<td>297.30</td>
<td>0.33</td>
<td>0.99</td>
<td>N/A</td>
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<td>Average Precipitation (in)</td>
<td>4.5</td>
<td>9.5</td>
<td>12.9</td>
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<td>Design Flood &amp; Size (AF)</td>
<td>100yr: 13</td>
<td>100yr: 9</td>
<td>100yr: 460</td>
<td>N/A</td>
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<tr>
<td>Potential for Flood Control</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
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<tr>
<td>Outlet Works</td>
<td>Upstream Inlet Box w/Slide Gate, 48&quot; Steel Pipe, Downstream Valve House</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Not Designed</td>
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<tr>
<td>Spillways</td>
<td>Open Excavated Channel Near Dam Abutment</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Not Designed</td>
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<tr>
<td>Geology</td>
<td>Coverly Fm: residual strength, contains gypsum and calcite veins. Depth to competent bedrock is unknown.</td>
<td>Not Evaluated</td>
<td>Chugwater and Goose Egg Fms: consist of gypsiferous and calcareous shales and carbonates, prone to dissolution</td>
<td>Not Evaluated</td>
</tr>
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<td>Land Ownership</td>
<td>BLM</td>
<td>BLM Private</td>
<td>BLM Private</td>
<td>Private, BLM</td>
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<tr>
<td>Irrigated Acreage Inundated (acre)</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Inundated Infrastructure</td>
<td>None</td>
<td>None</td>
<td>1.25 mile BLM access road</td>
<td>Two Small Buildings (Type Unknown): 1 mile Trapper Creek Road</td>
</tr>
<tr>
<td>Cultural/Archaeological impacts</td>
<td>Shell Canal</td>
<td>Unknown (likely)</td>
<td>Unknown (possible)</td>
<td>Unknown (possible)</td>
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<td>NWI Wetlands impacts (ac)</td>
<td>0.16 (breached stock pond)</td>
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<td>Riparian impacts</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Portion of Project within Sage Grouse Core Population Area</td>
<td>Approx. Half of Inundated Area, DDCT analysis determined statutory limits met</td>
<td>Entirely</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Species of concern</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
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<tr>
<td>Big Game impacts - crucial winter</td>
<td>None</td>
<td>Mule Deer</td>
<td>Mule Deer</td>
<td>Trapper Creek</td>
</tr>
<tr>
<td>WGSF Stream Class</td>
<td>(Shell Creek = Red)</td>
<td>(Shell Creek = Red)</td>
<td>(Trapper Creek = Red)</td>
<td>Yellow (Trapper Clear (Dry Bush)</td>
</tr>
<tr>
<td>Access</td>
<td>Hwy 14 + 1/2mile New Road</td>
<td>Hwy 14 + 1/2mile New Road</td>
<td>Trapper Creek Road + 1/2mile New Road</td>
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<table>
<thead>
<tr>
<th>Site Name</th>
<th>Trapper Off Channel</th>
<th>Shell Enlargement</th>
<th>Lower Willett</th>
<th>Upper Willett</th>
<th>Willett Lake</th>
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<td>Latitude, Longitude</td>
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<td>SV-17</td>
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<td>SV-18</td>
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<td>Location (Section, Township, Range W)</td>
<td>12, 52, 91</td>
<td>35, 53, 88</td>
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<td>16, 53, 88</td>
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<td>Direct Reservoir Supply</td>
<td>Negligible</td>
<td>Shell Creek</td>
<td>Willett Creek</td>
<td>Willett Creek</td>
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<tr>
<td>Indirect Reservoir Supply</td>
<td>Trapper Creek (via Pipeline)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Reservoir Storage Capacity (AF)</td>
<td>4,422</td>
<td>5,780</td>
<td>13,836</td>
<td>2,975</td>
<td>9,724</td>
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<tr>
<td>Reservoir Water Surface Area (Ac)</td>
<td>84</td>
<td>158</td>
<td>245</td>
<td>94</td>
<td>154</td>
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<td>Reservoir Water Surface Elevation</td>
<td>9304</td>
<td>9040</td>
<td>9080</td>
<td>8640</td>
<td>8680</td>
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<tr>
<td>Reservoir Service Area</td>
<td>Trapper Creek, Highline Ditch, Shell Creek, Shell Canal</td>
<td>Shell Creek, Shell Canal</td>
<td>Shell Creek, Shell Canal</td>
<td>Shell Creek, Shell Canal</td>
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<td>Reservoir Permitted Uses</td>
<td>Irrigation</td>
<td>Recreation</td>
<td>Recreation</td>
<td>Recreation</td>
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<td>Dam Type</td>
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<td>Earth</td>
<td>Earth</td>
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<td>Not Evaluated</td>
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<td>206</td>
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<tr>
<td>Crest Elevation (ft)</td>
<td>4650</td>
<td>9045</td>
<td>9080</td>
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<tr>
<td>Crest Length (ft)</td>
<td>625</td>
<td>2,950</td>
<td>3,500</td>
<td>1,450</td>
<td>625</td>
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<tr>
<td>Crest Width (ft)</td>
<td>36</td>
<td>40</td>
<td>50</td>
<td>26</td>
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<td>Embankment Volume (CY)</td>
<td>1,971,715</td>
<td>1,789,229</td>
<td>4,082,502</td>
<td>646,118</td>
<td>1,844,437</td>
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<td>Efficiency (Capacity/Fill) (CY/LY)</td>
<td>3.6</td>
<td>5.3</td>
<td>5.5</td>
<td>7.4</td>
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<td>306.1</td>
<td>295.1</td>
<td>217.2</td>
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<td>23.10</td>
<td>12.25</td>
<td>9.03</td>
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<td>Indirect Drainage Area (sq-mi)</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Average Precipitation (in)</td>
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<td>29.2</td>
<td>28.5</td>
<td>28.5</td>
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<td>Design Flood &amp; Size (AF)</td>
<td>100yr: 8</td>
<td>100yr: 114</td>
<td>100yr: 96</td>
<td>100yr: 114</td>
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<td>Potential for Flood Control</td>
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<td>Likely Significant for Shell Creek to Willett Creek (max)</td>
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<td>Negligible</td>
<td>Negligible</td>
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<tr>
<td>Outlet Works</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Not Designed</td>
<td>Not Designed</td>
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<td>Spillways</td>
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<td>Not Designed</td>
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<td>Land Ownership</td>
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<td>US$5</td>
<td>US$5</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inundated Infrastructure</td>
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<td>None</td>
<td>None</td>
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<td>None</td>
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<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>NWI Wetlands impacts (ac)</td>
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<td>4.76</td>
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<td>4.95</td>
<td>17.41</td>
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<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<td>Portion of Project within Sage Grouse Core Population Area</td>
<td>Very Small Portion of Dam and Reservoir</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Species of concern</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td>Grizzly (Historical - may not be current)</td>
<td></td>
</tr>
<tr>
<td>Big Game impacts - crucial winter</td>
<td>Mule Deer</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>WGFSD Stream Class</td>
<td>(Trapper Creek = Yellow)</td>
<td>Red</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Access</td>
<td>Trapper Creek Road + 1/4mile New Road</td>
<td>Ranger Creek Road and existing Access Trail (seasonal)</td>
<td>Ranger Creek Road and existing Access Trail (seasonal)</td>
<td>Ranger Creek Road and existing Access Trail (seasonal)</td>
<td></td>
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</tbody>
</table>

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Chapter IV. Preliminary Design and Cost Estimates

Preliminary designs and cost estimates were prepared for the Upper Leavitt site, the Shell Canal Tunnel site, and the Douglas Draw site. These designs were based on the recommendations presented in the geological/geotechnical report found in Appendix A. These designs are preliminary and site-specific investigation would be required for final designs.

**Upper Leavitt Reservoir Enlargement**

**General**

As shown in Figures IV-1 through IV-20 and Tables IV-1 through IV-2, a preliminary design and cost estimate were developed for a total reservoir capacity of 5,915 AF. The capacity of the existing Leavitt Reservoir is 643 AF, resulting in an enlargement of 5,272 AF. The top of dam elevation would be 4850 and the normal high water level would be at elevation 4845. A recreation pool of approximately 1,000 AF (elevation 4810) would be recommended.

The reservoir high water level would require that the existing county road be raised in two locations. As shown in Figures IV-2 and IV-3, most of the reservoir enlargement and dam embankment would be on BLM lands. The enlargement would inundate approximately 200 acres of BLM lands and 21 acres of private land.

**Dam Embankment**

The details of the proposed embankment are shown in Figures IV-4 to IV-6. The embankment is approximately 1600 ft. long with a maximum height of 85 ft. The crest width would be 22 ft.

The proposed dam section would incorporate 3.5 (horizontal) to 1 (vertical) side slopes on both the upstream and downstream faces, with the upstream face being protected from erosion by riprap and riprap bedding. The dam embankment would be zoned with a compacted clay core and a compacted shell composed of a sandier material. A chimney and blanket drain would be incorporated to inhibit internal dam erosion. The total dam embankment is estimated to require approximately 1.1 million cubic yards of fill.

The entire dam footprint would be stripped to bedrock and a cutoff trench excavated into the bedrock. Foundation grouting to prevent seepage is anticipated to be required.

Earthen material for the dam embankment would primarily be excavated from the reservoir area and from the existing dam. Riprap and drain material would probably be obtained off-site.

Road base would be placed on the dam crest to provide a solid driving surface for crossing the dam.

**Outlet Works**

The details of the outlet works are shown in Figures IV-7 to IV-14. The primary components of the outlet works would be a gated inlet structure, a 36-inch pipe, a control building with valves to regulate the outflow of water, and a stilling pool for discharge to Davis Draw below the existing dam. Davis Draw flows into Beaver Creek
less than one mile below the existing dam. The capacity of the outlet works would be approximately 280 cfs when the reservoir is at its normal high water level of 4845 and 215 cfs at its normal minimum pool level of 4810.

The inlet structure would consist of a concrete box with a sloped top. Flow into the inlet would be controlled by a slide gate with a hydraulic cylinder operator. An emergency pull cable would also be used to open the gate in the event of failure of the cylinder.

A 36-inch welded steel outlet pipe would exit this inlet. Upstream of the dam core, the pipe would be encased in reinforced concrete. Through the core and downstream of the core, the pipe would be located inside of the outlet works access tunnel. At the upstream end of this tunnel, the outlet works pipe would be controlled by a butterfly valve. The outlet tunnel would terminate near the downstream dam toe at the control building.

Inside the control building, the 36-inch pipe would tee into an 18-inch branch for managing smaller discharges. Flows through the 36-inch line and the 18-inch line would be managed by sleeve valves. Meters would also be used to monitor the flows. A 6-inch line would also tee into the outlet pipe to provide water for the proposed downstream wetland.

Downstream of the control building, the outlet pipe would carry flows below the proposed wetland and discharge to a stilling pool.

**Spillway**

The details of the spillway are shown on Figure IV-16. At 1.6 square miles, the drainage area for the Upper Leavitt Reservoir would be relatively small. While a full flood routing was not within the scope of work for this project, the volume of the 100-year flood was calculated to be 27 AF and the PMF was calculated to be 768 AF. Because the water area at the normal high water level is 210 Ac, the 100-yr flood could be contained with a very marginal raise in water level and the PMF could be contained with less than a 4-ft rise in water. Actual water level rises will be less due to reservoir attenuation and spillway discharge. Additionally, the operational high water level, which is defined as the reservoir level at which diversions into the reservoir will cease, can be set to provide storage for run-off events. This level has been preliminarily set at elevation 4844, 1 ft. below the spillway crest, which will provide for approximately 200 AF of storage. Therefore, a nominal spillway was designed. While the reservoir would receive most of its water from a supply pipeline from Beaver Creek and a malfunction in the control could cause the pipeline to deliver water after the normal high water level is achieved, the spillway designed would be able to pass this flow with only about a one-foot raise in water level.

The spillway would be a simple open channel excavated in a saddle located to the west of the proposed dam. It is highly likely that the material at this level would be bedrock. The specific site subsurface characteristics are not known and erosion protection and seepage control measures would need to be considered during final design. Due to the small size of the spillway, the impact of these measures on the project costs would be relatively minor. The overflow elevation would be set by the crest of the spillway and would be 5 ft. below the top of dam elevation.
Supply System

As shown in Figures IV-16 and IV-17, the Upper Leavitt Reservoir would be supplied by a 1.25 mile-long pipeline fed by a diversion on Beaver Creek. This pipeline would be completely located on private lands. The design of the diversion structure, headgate, and meter was not completed during this report phase as more information is needed on topography and required flows. The supply pipeline would be a low-pressure gravity line. Figure IV-17 indicates three different potential pipe sizes and flowrates. A 36-inch pipeline with a capacity of 53 cfs was used for cost estimate purposes. The pipeline would discharge to a riprapped channel for erosion protection. Final design and operation of this pipeline was not completed as a part of this report.

Transfer Pipeline

In order to serve more irrigated lands, a transfer pipeline from Beaver Creek could be incorporated into the Upper Leavitt Reservoir project, as shown in Figures IV-18 to IV-19. This pipeline could discharge reservoir flows to one or more points on Shell Creek, Whaley Ditch, and/or Shell Canal. This pipeline would be a pressure line.

The pipeline would be approximately 3.3 miles long and would parallel Beaver Creek Road for approximately 2.3 miles. A 36-inch pipeline carrying 49 cfs was preliminarily used for cost estimate purposes.

Wetlands

As shown on Figure IV-20, the preliminary design of the Upper Leavitt Reservoir project includes construction of approximately 5.2 Ac of wetlands downstream of the proposed dam. The proposed Upper Leavitt reservoir would inundate roughly 20 acres of existing wetlands along the fringe of the existing reservoir. The proposed wetlands could help to mitigate this effect. These wetlands would have water supply from the reservoir.

Additional wetlands could be constructed at the upper reaches of the reservoir. If reservoir supply pipeline were to supply these wetlands, they could serve to remove sediment from the inflow, thereby resulting in “cleaner” water in the reservoir pool and discharge.

Cost Estimate

As shown in Tables IV-1 and IV-2, cost estimates for the proposed Upper Leavitt reservoir have been developed. These estimates are based on quantities formulated from the preliminary design, past project experience, and estimates from others.
NOTE: NORMAL HIGH WATER LINE SHOWN IS ELEVATION OF SPILLWAY CRESCENT. EXPECTED OPERATION HIGH WATER LINE (LEVEL AT WHICH WATER IS NO LONGER DIVERTED TO RESERVOIR) IS ELEV 4844 (NOT SHOWN).

MAXIMUM WATER LEVEL = TOP OF DAM ELEV 4850

NORMAL HIGH WATER LINE
ELEV 4845
6,236 AF CAPACITY

MINIMUM WATER LEVEL
ELEV 4810

6,236 AF CAPACITY

EXISTING TRAIL TO BE RELOCATED

PROPOSED SPILLWAY

GROUTED RIPRAP CHANNEL

PROPOSED DAM TOE

PROPOSED WETLAND

PROPOSED ROADWAY BERM

PROPOSED SUPPLY PIPELINE

PRIVATE LAND

BLM LAND

POTENTIAL WETLANDS

PROPOSED VALVE VAULT WITH SUPPLY LINES TO WETLANDS

EXISTING TRAIL TO BE RELOCATED

PROPOSED ROADWAY BERM

PROPOSED OUTLET CONTROL BUILDING

SHELL VALLEY STORAGE LEVEL II STUDY

UPPER LEAVITT PRELIMINARY SITE LAYOUT (USGS QUAD VIEW)

FIGURE IV-2

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NOTE: NORMAL HIGH WATER LINE SHOWN IS ELEVATION OF SPILLWAY CREST. EXPECTED OPERATION HIGH WATER LINE (LEVEL AT WHICH WATER IS NO LONGER DIVERTED TO RESERVOIR) IS ELEV 4844 (NOT SHOWN).

NORMAL HIGH WATER LINE ELEV 4845
6,236AF CAPACITY

MAXIMUM WATER LEVEL = TOP OF DAM ELEV 4850

MINIMUM WATER LEVEL ELEV 4810

6,236AF CAPACITY

GROUTED RIPRAP CHANNEL

EXISTING TRAIL TO BE RELOCATED

PROPOSED VALVE VAULT WITH SUPPLY LINES TO WETLANDS

PROPOSED OUTLET CONTROL BUILDING

PROPOSED ROADWAY BERM

PROPOSED WETLAND

PROPOSED DAM TOE

PROPOSED SPILLWAY

POTENTIAL WETLANDS

EXISTING TRAIL TO BE RELOCATED

SHELL VALLEY STORAGE LEVEL II STUDY

FIGURE IV-3
UPPER LEAVITT PRELIMINARY SITE LAYOUT (AERIAL PHOTO VIEW)
FIGURE IV-5

NOTE: GROUT CURTAIN NOT SHOWN. SEE GEOTECHNICAL/GEOLOGICAL REPORT IN APPENDICES FOR DETAILS.
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SEE FIGURE IV-13 FOR OUTLET PIPE IN OUTLET TUNNEL TYPICAL SECTION.
SEE FIGURE IV-9 FOR OUTLET PIPE IN OUTLET TUNNEL THROUGH CUT-OFF TRENCH TYPICAL SECTION.

HYDRAULIC LINE TO SLIDE GATE

CONCRETE ENCASMENT

36" STEEL PIPE

VARIES (1 FT MIN)

BEDROCK

GRADE AREA BETWEEN OUTLET BUILDING
AND WETLAND TO DRAIN TOWARDS WETLAND
MAX ELEVATION = 4765

NORMAL HIGH WATER LEVEL ELEV 4845

DAM CREST

WETLAND SUPPLY PIPELINE

APP. DAM TOE

VALVE CHAMBER

OUTLET PIPE IN TUNNEL

OUTLET PIPE ENCASED IN CONCRETE

APP. DAM TOE

CONTROL BUILDING

CONCRETE ENCASMENT

DAM EMBANKMENT

STATES WEST WATER RESOURCES CORPORATION

SHELL VALLEY STORAGE LEVEL II STUDY

FIGURE IV-7
UPPER LEAVITT PRELIMINARY OUTLET PLAN STN 0+00
TO 7+00
Chapter IV. Preliminary Design and Cost Estimates

FIGURE IV-11

OUTLET CONTROL BUILDING FLOOR PLAN

NOTE: HOISTS, AIR-VACs, VENTS, AND OTHER APPURTENANT ITEMS NOT SHOWN.
Chapter IV. Preliminary Design and Cost Estimates

**INLET STRUCTURE PLAN**

- 4'x4' Slide Gate
- Hydraulic Operator
- Concrete-Encased 36" Steel Outlet Pipe
- Emergency Pull Cable (Extends to Dam Crest)

**VALVE CHAMBER PLAN**

- Butterfly Valve
- Outlet Tunnel
- Dam Embankment
- Air Vent Duct
- Hydraulic Lines to Slide Gate and Butterfly Valve
- 36" Steel Pipe

**OUTLET TUNNEL TYPICAL SECTION**

- Dam Blanket Drain
- Varies (1 ft min)
- Bedrock

**INLET STRUCTURE PROFILE**

- 4'x4' Slide Gate w/ Trashrack (Not Shown)
- Hydraulic Operator
- Emergency Pull Cable (Extends to Dam Crest)
- Dam Embankment
- Outlet Pipe
- Bedrock

SEE FIGURE IV-6 FOR CONCRETE-ENCASED OUTLET PIPE TYPICAL SECTION.
SEE FIGURE IV-9 FOR OUTLET PIPE IN OUTLET TUNNEL THROUGH CUTOFF TRENCH TYPICAL SECTION.

Figure IV-14
Upper Leavitt Preliminary Inlet Structure and Valve Chamber Details
Chapter IV. Preliminary Design and Cost Estimates

NOTE: NORMAL HIGH WATER LINE SHOWN IS ELEVATION OF SPILLWAY CREST. EXPECTED OPERATION HIGH WATER LINE (LEVEL AT WHICH WATER IS NO LONGER DIVERTED TO RESERVOIR) IS ELEV 4844 (NOT SHOWN).
NOTE: NORMAL HIGH WATER LINE SHOWN IS ELEVATION OF SPILLWAY CREST. EXPECTED OPERATION HIGH WATER LINE (LEVEL AT WHICH WATER IS NO LONGER DIVERTED TO RESERVOIR) IS ELEV 4844 (NOT SHOWN).

PROPOSED VALVE VAULT WITH CROSS FOR WETLAND SUPPLY LINES

PROPOSED 36" SUPPLY PIPELINE

PROPOSED DIVERSION DAM, HEADGATE, AND METER (NOT SHOWN)

GROUTED RIPRAP CHANNEL

MINIMUM WATER LEVEL ELEV 4810

MAXIMUM WATER LEVEL - TOP OF DAM ELEV 4850

PRIVATE LAND

500' 0 500'

SHELL VALLEY STORAGE LEVEL II STUDY

UPPER LEAVITT PRELIMINARY SUPPLY PIPELINE PLAN

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FIGURE IV-18
UPPER LEAVITT PRELIMINARY BEAVER CREEK TO SHELL CANAL PIPELINE PLAN
<table>
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<td>LS</td>
<td>---</td>
<td>$350,000.00</td>
<td>$350,000.00</td>
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<tr>
<td>Control of Water</td>
<td>LS</td>
<td>---</td>
<td>$500,000.00</td>
<td>$500,000.00</td>
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<tr>
<td>Clearing and Grubbing</td>
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<tr>
<td>Soils Excavitation</td>
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<td>540,200</td>
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<td>Grout Curtain Holes</td>
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<td>25,700</td>
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<tr>
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<td>CY</td>
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<td>$555,000.00</td>
</tr>
<tr>
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Sub-Total $16,394,565.00
15% Contingencies $2,459,185.00
Total Estimated Construction Cost $18,853,750.00
Preparation of Final Designs and Specifications $650,000.00
Permitting $250,000.00
Legal Fees $10,000.00
Acquisition of Access and Rights of Way $100,000.00
Total Project Cost $19,863,750.00

Use $19.9 M
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Estimated Construction Cost $18,868,650.00
10% Engineering $1,886,865.00
Sub-Total $20,755,515.00
15% Contingencies $3,113,327.00
Total Estimated Construction Cost $23,868,842.00
Preparation of Final Designs and Specifications $650,000.00
Permitting $250,000.00
Legal Fees $10,000.00
Acquisition of Access and Rights of Way $100,000.00
Total Project Cost $24,878,842.00

Use $24.9 M
**Shell Canal Tunnel**

**General**

As shown in Figures IV-21 to IV-25 and Table IV-3, a preliminary design and cost estimate were developed for a total reservoir capacity of 225 AF. As shown in Figure IV-22, the top of dam and high water elevations of 4165 and 4160, respectively, would be limited by topography and the presence of the Shell Canal. The entire dam and reservoir would be located on BLM lands.

This site would not be expected to help alleviate any significant water shortages. It was developed as a way to utilize material that would be created should the Shell Canal Tunnel be excavated to be an open channel and to replace the existing aging canal drop structure crossing the drainage.

**Dam Embankment**

The details of the dam embankment are shown in Figures IV-22 to IV-24. The embankment would be approximately 325 ft. long with a maximum height of approximately 50 ft. The dam crest would be a total of 42 ft. wide and would incorporate a concrete-lined open channel for the Shell Canal. The geometry and slope of this channel would be designed so that no inlet or outlet structures would be needed for the canal itself. A stop-log structure would be provided to allow for water from the canal to enter the reservoir when desired.

The proposed dam section would incorporate a 5 (horizontal) to 1 (vertical) side slope on the upstream faces and a 4 (horizontal) to 1 (vertical) side slope on the downstream face. The dam embankment would be of homogeneous material. A sand chimney and blanket drain would be incorporated to inhibit internal dam erosion.

The entire dam footprint would be stripped of topsoil and a cutoff trench excavated into the bedrock. Foundation grouting to prevent seepage is anticipated to be required.

Earthen material for the dam embankment would primarily be excavated from the Shell Canal Tunnel. Drain material would probably be obtained off-site.

Road base would be placed on the dam crest to provide a solid driving surface for crossing the dam. It is recommended that the canal portion of the dam crest be concrete lined to prevent erosion.

**Outlet Works and Spillway**

The details of the outlet works and spillway are shown on Figure IV-25. Due to the presence of the Shell Canal and topography, design of a typical open channel spillway would not be practical. Additionally, with a drainage area of only 0.59 sq.mi. (resulting in a 100-year flood volume of 18 AF), only a minimal spillway would be needed. Therefore, the preliminary design utilizes a combined outlet works and spillway.

As shown on Figure IV-25, the main components of outlet works and spillway would be a gated inlet structure for the outlet, an 18-inch outlet pipe, an uncontrolled spillway inlet tower, and a 36-inch combined outlet/spillway pipe. Because this reservoir would not be operated to supply irrigation water, other than the upstream outlet slide gate, no additional controls would be needed.
Cost Estimate

As shown in Table IV-3, a cost estimate for the proposed Shell Canal Tunnel reservoir has been developed. This estimate is based on quantities formulated from the preliminary design, past project experience, and estimates from others.
### Table IV-3 - Shell Canal Tunnel Reservoir Cost Estimate

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Estimated Construction Cost: $869,787.50
10% Engineering: $86,979.00
Sub-Total: $956,766.50
15% Contingencies: $143,515.00
Total Estimated Construction Cost: $1,100,281.50
Preparation of Final Designs and Specifications: $400,000.00
Permitting: $20,000.00
Legal Fees: $10,000.00
Acquisition of Access and Rights of Way: $10,000.00
Total Project Cost: $1,540,281.50

Use: $1.6 M
**Douglas Draw Reservoir**

**General**

As shown in Figures IV-26 through IV-41 and Tables IV-3 and IV-4, a preliminary design and cost estimate were developed for a total reservoir capacity of 5,240 AF. The top of dam elevation would be 4285 and the normal high water level would be at elevation 4280. A recreation pool of approximately 1,050 AF (elevation 4240) would be recommended.

As shown in Figures IV-26 and IV-27, the reservoir and dam embankment would be on BLM lands. The reservoir would inundate approximately 165Ac.

**Dam Embankment**

The details of the proposed embankment are shown in Figures IV-28 through IV-31. The main embankment would be approximately 1575 ft. long with a maximum height of 100 ft. The crest width would be 26 ft. A smaller embankment 275 ft. long with a maximum height of 45 ft. would be constructed in a saddle to the east of the main embankment. This embankment would have a crest width of 14 ft. The total dam embankments are estimated to require approximately 1.4 million cubic yards of fill.

The proposed dam sections would incorporate 3.5 (horizontal) to 1 (vertical) side slopes on both the upstream and downstream faces, with the upstream face being protected from erosion by riprap and riprap bedding. The dam embankment would be homogeneous compacted earth. A chimney and blanket drain would be incorporated to inhibit internal dam erosion.

The entire dam footprint would be stripped of topsoil and a cutoff trench excavated into the bedrock. Foundation grouting to prevent seepage is anticipated to be required.

Earthen material for the dam embankment would primarily be excavated from the reservoir area. Riprap and drain material would probably be obtained off-site.

Road base would be placed on the dam crest to provide a solid driving surface for crossing the dam.

**Outlet Works**

The details of the outlet works are shown in Figures IV-32 to IV-36. The primary components of the outlet works would be a gated inlet structure, a 48-inch pipe, a control building with valves to regulate the outflow of water, and a discharge pipeline to Shell Creek or Shell Canal.

The inlet structure would consist of a concrete box with a sloped top. Flow into the inlet would be controlled by a slide gate with a hydraulic cylinder operator. An emergency pull cable would also be used to open the gate in the event of failure of the cylinder.

A 48-inch welded steel outlet pipe would exit this inlet. Upstream of the cut-off trench, the pipe would be encased in reinforced concrete. Through and downstream of the cut-off, the pipe would be located inside of the outlet works access tunnel. At the upstream end of this access tunnel, the outlet would be controlled by a butterfly valve. The outlet tunnel would terminate near the downstream dam toe at the control building.
Inside the control building, the 48-inch pipe would tee into a 12-inch branch to allow discharges to Douglas Draw. Flows through the 36-inch line and the 12-inch line would be managed by butterfly valves. Meters would also be used to monitor the flows. Downstream of the control building, the 48-inch line would connect to the supply/discharge pipeline described later in the section.

The discharge capacity of this pipeline is discussed later in this section.

**Spillway**

The details of the spillway are shown on Figure IV-37. At 1.3 square miles, the drainage area for the Douglas Draw Reservoir would be relatively small. While a full flood routing was not within the scope of work for this project, the volume of the 100-year flood was calculated to be 57 AF and the PMF was calculated to be 607 AF. Because the water area at the normal high water level is 165 Ac, the 100-yr flood could be contained with a very marginal raise in water level and the PMF could be contained with less than a 4-ft rise in water. Actual water level rises will be less due to reservoir attenuation and spillway discharge. Therefore, a nominal spillway was designed. While the reservoir would receive most of its water from a supply pipeline from Shell Creek and a malfunction in the control could cause the pipeline to deliver water after the normal high water level is achieved, the spillway designed would be able to pass this flow with less than a two-foot raise in water level.

The spillway would be a simple open channel excavated in a saddle located to the west of the proposed dam. It is highly likely that the material at this level would be bedrock. The specific site subsurface characteristics are not known and erosion protection and seepage control measures would need to be considered during final design. Due to the small size of the spillway, the impact of these measures on the project costs would be relatively minor. The spillway would discharge into a natural swale that flows into Red Gulch less one-half mile from the spillway. The overflow elevation would be set by the crest of the spillway and would be 5 ft. below the top of dam elevation.

**Supply System**

As shown in Figures IV-38 to IV-41, two options for supplying the Douglas Draw Reservoir were investigated. Both options include diversions from Shell Creek and a two-way pipeline to discharge to either Shell Creek or Shell Canal. Both pipeline options would also connect to the reservoir's outlet works. Both pipeline options would also be entirely on private lands with the exception of the 100 yards closest to the reservoir. The design of the diversion structures, headgates, and meters was not completed during this report phase as more information is needed on topography and required flows.

The first option would be a diversion from Shell Creek just downstream of the existing USGS gaging station. This diversion would divert water into a 5¾-mile long 48” PVC or HDPE pipeline. A portion of the supply pipeline would also serve as the discharge pipeline to discharge reservoir water to Shell Creek just above Shell Canal. While this option would require less with respect to future power expenditures, the initial construction cost would be much higher.
The capacity of this pipeline to supply water to the reservoir would be approximately 99 cfs when the reservoir is at its normal high water level of 4280 and 124 cfs at its normal minimum pool level of 4240. The capacity of this pipeline to discharge water from the reservoir would be approximately 138 cfs when the reservoir is at its normal high water level of 4280 and 82 cfs at its normal minimum pool level of 4240.

The second option would be a diversion from Shell Creek approximately one-half mile west of the Shell cemetery. This option would require a 3000HP pump station and would divert water into a one-mile long 48” PVC or HDPE pipeline. The entire supply pipeline would also serve as the discharge pipeline to return reservoir water to Shell Creek at the diversion point. While this option would require significant power expenditures in the future, the initial construction cost would be considerably lower.

The capacity of this pipeline to supply water to the reservoir, assuming that the shut-off head of the pump station is equal to the reservoir high water level, would be approximately 160 cfs when the reservoir is at its normal minimum pool level of 4240. The capacity of this pipeline to discharge water from the reservoir would be approximately 280 cfs when the reservoir is at its normal high water level of 4280 and 235 cfs at its normal minimum pool level of 4240.

**Cost Estimate**

As shown in Tables IV-4 and IV-5, cost estimates for the proposed Douglas Draw reservoir have been developed. These estimates are based on quantities formulated from the preliminary design, past project experience, and estimates from others.
Chapter IV. Preliminary Design and Cost Estimates

Figure IV-31
DOUGLAS DRAW PRELIMINARY SADDLE DAM PLAN, PROFILE, AND TYPICAL SECTION
CONCRETE ENCASED OUTLET PIPE TYPICAL SECTION

OUTLET TUNNEL TYPICAL SECTION

OUTLET TUNNEL THROUGH CUTOFF TRENCH TYPICAL SECTION
NOTE: HOISTS, AIR-VACS, VENTS, AND OTHER APPURTENANT ITEMS NOT SHOWN.
FIGURE IV-39
DOUGLAS DRAW PRELIMINARY SUPPLY/DISCHARGE PIPELINE PLAN (AERIAL PHOTO VIEW)
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Estimated Construction Cost: $25,697,400.00
10% Engineering: $2,569,740.00
Sub-Total: $28,267,140.00
15% Contingencies: $4,240,071.00
Total Estimated Construction Cost: $32,507,211.00
Preparation of Final Designs and Specifications: $650,000.00
Permitting: $20,000.00
Legal Fees: $10,000.00
Acquisition of Access and Rights of Way: $20,000.00
Total Project Cost: $33,207,211.00

Use: $33.3 M
### Table IV-5 - Douglas Draw Reservoir Cost Estimate - Pump Station Option

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<td>$300,000.00</td>
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Estimated Construction Cost: $19,462,400.00
- 10% Engineering: $1,946,240.00
  - Sub-Total: $21,408,640.00
- 15% Contingencies: $3,211,296.00

Total Estimated Construction Cost: $24,619,936.00

Preparation of Final Designs and Specifications: $650,000.00
Permitting: $20,000.00
Legal Fees: $10,000.00

Acquisition of Access and Rights of Way: $20,000.00

Total Project Cost: $25,319,936.00

Use: $25.4 M
Chapter V. Economic Analysis

Project Benefits

Introduction

This section describes the direct and indirect economic benefits that would accrue to area residents, the regional economy, and the State of Wyoming from additional storage in the project study area. The analysis in this section was performed by Watts and Associates and concentrates on two sites, the Upper Leavitt Reservoir site and the Douglas Draw site, as representing the best alternatives for multipurpose projects that would provide irrigation and recreation benefits. A reservoir at the Upper Leavitt site would provide up to 2,700 acre-feet of additional irrigation diversions for Shell Valley irrigators and the Douglas Draw site would provide up to 3,500 acre-feet of additional diversions. Both projects would also provide flat-water recreation opportunities in an area that currently does not have many local options. The economic benefits attributable to the reservoirs are analyzed below. The Upper Leavitt analysis considers the reservoir (with required diversion supply pipeline) alone as well as a scenario with the reservoir and a pipeline to transfer water from Beaver Creek to one or more potential outlets at Shell Creek, Whaley Ditch, and/or Shell Canal. The Douglas Draw analysis considers two supply scenarios: a gravity-fed pipeline from Shell Creek with a discharge back into Shell Creek upstream of the diversion for Shell Canal; and a two-way pipeline from a pump station/discharge structure on Shell Creek downstream of the Town of Shell.

Direct Irrigation Benefits

Direct irrigation benefits would accrue to local irrigators because the reservoir would supply additional water to supplement current supplies on existing irrigated acreage. The Upper Leavitt reservoir would have an average annual yield of about 3,000 acre-feet. Conveyance losses from the reservoir to diversion points could be high, in particular in Beaver Creek and would be expected to average about 10 percent, meaning that 2,700 acre-feet of additional water would be available for diversion. The Douglas Draw site would utilize a pipeline for discharge; therefore conveyance losses would be negligible, meaning that 3,500 acre-feet of additional water would be available for diversion. Alfalfa, corn, and dry beans are the predominant crops in the area. A cropping pattern map for the Shell Valley produced by the National Agricultural Statistics Service indicates that in 2010, approximately 55 percent of irrigated acreage in the valley was devoted to alfalfa production. Dry beans accounted for about 25 percent of irrigated acreage, while the remaining 20 percent was planted in corn.\(^1\)

If additional irrigation water is made available, it would probably be at a relatively high cost and thus be more likely used on higher valued crops such as beans and corn. Irrigators currently limit their production of these crops based upon water availability. In most years, water is needed to supplement existing supplies on currently irrigated acreage, and a new reservoir would probably not result in any significant increase in total irrigated acreage. With additional water available, however, some irrigators may

\(^1\) Source: John Niziolek, Field Enumerator, National Agricultural Statistics Service, Cheyenne, Wyoming.
choose to increase their acreage of higher valued crops (such as corn or beans) and decrease their hay production.

The magnitude of supplemental irrigation water benefits depend upon whether water would be used to finish crops that are routinely planted, thereby increasing production yields, or, instead, used to convert existing hay fields to higher valued crops such as corn or beans. Finishing water typically has a higher value because fixed costs such as plowing and planting the crop exist regardless of the reservoir and thus do not reduce the benefits of additional water. If fields are replanted because of the reservoir, however, the fixed costs of the crop do reduce benefits because they would otherwise not be incurred. For this analysis it is assumed that one-half of the additional diversions would be used as finishing water and one-half would be used to convert hay fields to corn and beans.

**Finishing Water Benefits**

The direct benefit of finishing water consists of the marginal income increase from increased production per acre that would accrue to irrigators using the water. The first step in estimating that increase is to estimate how crop yields would change in response to additional irrigation water. Such yield changes are best estimated using crop-water production functions relating crop water use (in the form of evapotranspiration, or ET) and yield. Crop water production functions are typically developed using the results of carefully monitored field experiments, and then modified to reflect differences in elevation, climate, and other variables.

Crop-water production functions for corn, dry beans, and alfalfa from other areas of Wyoming were analyzed and adapted to the project area to produce the benefit estimates in this report. The production functions were developed for the North Platte River Basin in eastern Wyoming near Torrington, and the results were adjusted to reflect the fact that the project area has a slightly shorter growing season than the area around Torrington. The results are given below:

- Dry Bean Yield / Acre-foot ET = 17.11 cwt.
- Corn Yield / Acre-foot ET = 102.10 bu.
- Alfalfa Yield / Acre-foot ET = 2.33 tons

These estimates indicate that for every additional acre-foot of water consumptively used, the resulting yield increase would average 17.11 cwt. for bean crops, 102.10 bu. for corn, and 2.33 tons for alfalfa.

To estimate the amount of additional ET water use that would result from the operation of Leavitt Reservoir, conveyance loss and field irrigation efficiency estimates are necessary. Conveyance losses were discussed above. Approximately half of the diversions (2,700/2 AF = 1,350 AF for Upper Leavitt and 3,500/2 AF = 1,750 AF for Douglas Draw) would be expected to be used for finishing water. The majority of Shell Valley acreage is irrigated using gated pipe, which averages about 60 percent field

\[\text{footnote}\]

\[\text{footnote continued}\]

\[\text{footnote concluded}\]
efficiency. Assuming a 60 percent field efficiency results in initial water deliveries of 810 acre-feet of additional crop ET for Upper Leavitt and 1,050 acre-feet of additional crop ET for Douglas Draw.

The remaining diverted water would be initially unused. Because of the layout of irrigation systems in the area, however, a substantial portion of this water would be expected to return to the drainage for reuse through field runoff and seepage. Estimating exact return flow rates is beyond the scope of this analysis, but as a first approximation we assume that about two-thirds of the initially unused water will return to the system for reuse and the rest would be lost to evaporation and deep percolation. Again 10 percent conveyance losses and 60 percent field efficiency can be assumed. Upper Leavitt would provide 195 acre-feet and Douglas Draw would provide 252 acre-feet of additional consumptive use through reuse downstream of the initial diversions. Adding these figures to the initial 810 acre-feet and 1,050 acre-feet of ET results in total annual ET increases of 1,005 acre-feet for Upper Leavitt and 1,302 acre-feet for Douglas Draw.

The finishing water would probably be used mostly on higher valued corn and bean crops rather than alfalfa. For this analysis, it was assumed that it would be apportioned approximately 45 percent to dry beans, 45 percent to corn, and 10 percent to alfalfa. Using the crop-water production functions derived above results in the following total production increase estimates attributable to the project:

**Upper Leavitt:**
- Dry beans = \(1,005 \text{ AF} \times 0.45 \times 17.11 \text{ cwt./AF} = 7,740 \text{ cwt.}\)
- Corn = \(1,005 \text{ AF} \times 0.45 \times 102.10 \text{ bu} = 46,170 \text{ bu.}\)
- Alfalfa = \(1,005 \text{ AF} \times 0.10 \times 2.33 \text{ tons} = 230 \text{ tons}\)

**Douglas Draw:**
- Dry beans = \(1,302 \text{ AF} \times 0.45 \times 17.11 \text{ cwt./AF} = 10,025 \text{ cwt.}\)
- Corn = \(1,302 \text{ AF} \times 0.45 \times 102.10 \text{ bu} = 59,820 \text{ bu.}\)
- Alfalfa = \(1,302 \text{ AF} \times 0.10 \times 2.33 \text{ tons} = 303 \text{ tons}\)

The annual value of these production increases was estimated using average crop prices in Wyoming over the last three years as reported in Wyoming Agricultural Statistics. These prices are $32.10 per cwt. for dry beans, $4.44 per bu. for corn, and $101.33 per ton for alfalfa. Applying those prices to the production estimates derived above results in the following total value of production estimate attributable to the project on an annual basis:

**Upper Leavitt:**
- Dry Beans = \(7,740 \text{ cwt} \times \$32.10/\text{cwt} = \$248,454\)
- Corn = \(46,170 \text{ bu} \times \$4.44/\text{bu} = \$204,995\)
- Alfalfa = \(230 \text{ tons} \times \$101.33/\text{ton} = \$23,306\)
- Total = \$476,755

**Douglas Draw:**
- Dry Beans = \(10,025 \text{ cwt} \times \$32.10/\text{cwt} = \$320,803\)
- Corn = \(59,820 \text{ bu} \times \$4.44/\text{bu} = \$265,601\)
- Alfalfa = \(303 \text{ tons} \times \$101.33/\text{ton} = \$30,703\)
- Total = \$617,107

---

These figures are an estimate of the annual value of increased production attributable to finishing water. To estimate direct irrigation benefits, the marginal increase in production costs incurred to irrigate and harvest the additional crops must be subtracted from this figure. Marginal unit production cost estimates for dry beans, corn, and alfalfa were developed as part of the Torrington study cited earlier in this section. Those unit production cost estimates were updated to current (2010) dollars using a farm production cost index published in the current issue of Wyoming Agricultural Statistics. Those costs are $1.20 per cwt. for dry beans, $0.40 per bu. for corn, and $23.44 per ton for alfalfa. The total marginal cost increase associated with the project is calculated by multiplying the unit marginal production cost estimates by the amount of increased production as given below:

**Upper Leavitt:**
- Dry Beans = 7,740 cwt x $1.20/cwt = $9,288
- Corn = 46,170 bu x $0.40/bu = $18,468
- Alfalfa = 230 tons x $23.44/ton = $5,391
- Total = $33,147

**Douglas Draw:**
- Dry Beans = 10,025 cwt x $1.20/cwt = $12,030
- Corn = 59,820 bu x $0.40/bu = $23,928
- Alfalfa = 303 tons x $23.44/ton = $7,102
- Total = $43,060

Subtracting the production costs from the production value increases yields an annual net benefit estimate of $443,600 for Upper Leavitt Reservoir and $574,047 for Douglas Draw. These figures are an estimate of the annual direct irrigation benefits associated with finishing water from the sites. The present values of the annual benefits would be $9.6 million for Upper Leavitt and $12.5 million for Douglas Draw, assuming a 50-year project life and a four percent discount rate.

**Replanting**

This section analyzes benefits associated with replanting existing hay fields with corn and beans because of increased water availability. The first step in the analysis is to estimate how many acres could be replanted to higher valued crops. This analysis assumes that half of additional diverted water (1,350 AF for Upper Leavitt and 1,750 AF) is available for that purpose, that land in alfalfa now has early season water sufficient to take one full cutting of hay, and that the land currently lacks sufficient water from mid-July through the end of the growing season to raise corn or bean crops, but with the reservoir would support a 50-50 percent mix of corn and dry beans.

A corn and bean crop mix requires, on the average, about 13.6 inches (1.13 ft.) of consumptive water use from mid-July through harvest. In the previous section it was estimated that 1,350 acre-feet of additional diversions from Upper Leavitt and 1,750

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acre-feet of additional diversions from Douglas Draw would result in about 1,005 acre-
feet of additional consumptive use for Upper Leavitt and 1,302 acre-feet of additional 
consumptive use for Douglas draw. Thus, the Upper Leavitt site would support about 
890 additional acres (1,005 AF ÷ 1.13 ft.) of corn and bean production on land 
previously used for hay production and the Douglas Draw site would support about 
1,150 additional acres (1,302 AF ÷ 1.13 ft.) of corn and bean production on land 
previously used for hay production. Assuming a 50-50 mix of corn and dry beans 
results in 445 acres of land being converted to corn and 445 acres of land being 
converted to beans for the Upper Leavitt site and 575 acres of each for the Douglas 
Draw site.

According to local sources, corn crops in the area average 150 to 160 bu. per 
acre, while dry bean crops average 23-24 cwt. per acre\(^7\). Assuming the higher figure in 
each case will allow for future productivity increases. Using the values for production 
presented in the previous section, the total value of the converted acres should be:

### Upper Leavitt

- **Dry Beans**: 
  \[
  445 \text{ Ac} \times 24 \text{ cwt/Ac} \times \$32.10/\text{cwt} = \$342,848
  \]
- **Corn**: 
  \[
  445 \text{ Ac} \times 160 \text{ bu/Ac} \times \$4.44/\text{bu} = \$316,128
  \]
  \[
  \text{Total} = \$658,976
  \]

### Douglas Draw

- **Dry Beans**: 
  \[
  575 \text{ Ac} \times 24 \text{ cwt/Ac} \times \$32.10/\text{cwt} = \$442,980
  \]
- **Corn**: 
  \[
  575 \text{ Ac} \times 160 \text{ bu/Ac} \times \$4.44/\text{bu} = \$408,480
  \]
  \[
  \text{Total} = \$851,460
  \]

To arrive at benefit estimates, these figures must be reduced by the production 
costs associated with the new crops. A dry bean production cost estimate was 
developed from a previous study in the area for Greybull Valley Dam and Reservoir 
project.\(^8\) The estimate was updated to current dollars using production cost indices 
published in *Wyoming Agricultural Statistics*. The resulting cost estimate is $611 per 
acre. A corn production cost estimate was developed from a recent study in the area 
for the proposed Westside Project near Worland.\(^9\) That cost estimate is $557 per acre. 
Total production costs associated with the replanted acreage would thus be:

### Upper Leavitt

- **Dry Beans**:
  \[
  445 \text{ Ac} \times \$611/\text{Ac} = \$271,895
  \]
- **Corn**:
  \[
  445 \text{ Ac} \times \$557/\text{Ac} = \$247,865
  \]
  \[
  \text{Total} = \$519,760
  \]

### Douglas Draw

- **Dry Beans**:
  \[
  575 \text{ Ac} \times \$611/\text{Ac} = \$351,325
  \]
- **Corn**:
  \[
  575 \text{ Ac} \times \$557/\text{Ac} = \$320,275
  \]
  \[
  \text{Total} = \$671,600
  \]

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Statement*. Worland Field Office.
The annual direct irrigation benefits associated with replanting existing irrigated acreage to higher valued crops would be thus $139,200 ($659,000 - $519,800) for Upper Leavitt and $179,860 ($851,460 – $671,600) for Douglas Draw.

**Total Irrigation Benefits**

As discussed above, water used for finishing would provide annual benefits of $443,600 for Upper Leavitt and $574,047 for Douglas Draw. Water used for converting lands now used for alfalfa into lands used for corn and beans would provide annual benefits of $139,200 for Upper Leavitt and $179,860 for Douglas Draw. Therefore, the total direct benefits from irrigation would be $583,000 per year for Upper Leavitt and $753,907 for Douglas Draw. The present values for annual benefits would be $12.6 million for Upper Leavitt and $16.4 million for Douglas Draw, assuming a 50-year project life and a four percent discount rate.

**Indirect Irrigation Benefits**

Indirect benefits, often referred to as secondary benefits, stem from the multiplier effect of new sources of income in a regional economy. In the present case, the availability of additional irrigation water would allow irrigators to increase crop production, thus increasing their income. Much of that increased income would be spent in the region, causing income to grow in other sectors of the local economy. This indirect income growth would be also a benefit attributable to the project.10

The Bureau of Economic Analysis of the U.S. Department of Commerce periodically produces estimates of indirect income multipliers for Wyoming’s agricultural sector. These multipliers estimate the total income increase in Wyoming from a one-dollar increase in farm income. Their latest estimate of this multiplier is 2.63; meaning that for each dollar of additional farm income, total income in Wyoming increases by $2.63.11 The $2.63 increase consists of a one-dollar increase in farm income plus a $1.63 increase in indirect income in other economic sectors.

If we multiply the annual direct irrigation benefit of $583,000 for Upper Leavitt and $753,907 for Douglas Draw by 2.63, the result would be a total irrigation benefit estimate of $1.53 million annually for Upper Leavitt and $1.98 million. The present value of that benefit would be $33.3 million for Upper Leavitt and $43.1 million for Douglas Draw when discounted over a 50 year time frame using a four percent discount rate.

**Reservoir Recreation Benefits**

A dam at the Upper Leavitt site would result in a reservoir with an average water surface area of 175 acres and depths ranging from 30 ft. to 75 ft. A dam at the Douglas Draw site would result in a reservoir with an average water surface area of 140 acres and depths ranging from 50 ft. to 90 ft. Although detailed studies have not been

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10 Although some economists disagree, the inclusion of indirect benefits in project evaluations is appropriate when considering state funded projects using severance taxes on minerals exported from the state. In fact, one intent of enabling legislation for the WWDC was to create indirect jobs to replace those that will inevitably be lost as production of the state’s non-renewable resources eventually declines.

conducted, the reservoirs have the potential to provide flat-water recreational opportunities in the summer and ice fishing in the winter.

Like most small reservoirs in rural areas of Wyoming, these reservoirs would probably be utilized mainly by Wyoming residents. As a result, recreational activity at the reservoirs would not pump a significant amount of new money into the state economy, but would increase the well-being of its recreational users. In economic jargon, this increase in well-being is called consumer surplus because consumers are not required to pay for it directly. Projecting recreational usage and multiplying by an average value of consumer surplus associated with each visit can provide a ballpark estimate of recreation benefits.

Projecting recreational usage is difficult because it depends on numerous variables that are not well known prior to project development, including the quality of the fishery that may develop, the level of recreational facilities to be included in the final development plan, and the uniqueness of the site relative to other sites available in the area. Also, state and federal agencies dealing with recreation seldom collect recreational activity data for smaller reservoirs in rural areas.

In spite of these difficulties, previous studies and actual visitation data from other sites in Wyoming suggest that smaller reservoirs such as Upper Leavitt Reservoir and Douglas Draw may generate in the range of 20 to 25 visitor days of usage annually per surface acre. This study uses a lower bound estimate of 20 activity days per surface-acre for purposes of benefit estimation. Assuming the reservoir averages 175 surface acres for Upper Leavitt and 140 surface acres for Douglas Draw during the recreation season implies an annual usage rate of 3,500 visitor days for Upper Leavitt and 2,800 visitor days for Douglas Draw.

The value of these visitor days can be estimated from numerous studies of that topic at other recreational facilities. A study by Loomis (2005) provides average consumer surplus estimates for numerous site specific studies conducted in the intermountain region from 1967 to 2003, expressed in 2004 dollars. The mean value for fishing from these studies is $49.57, while boating and water skiing are valued at $62.33 per activity day. Assuming two fishing days for each boating/water skiing day implies an average activity day value of $53.78 in 2004 dollars. Updating that value to 2010 dollars gives a current estimate of $70.69 per activity day. If we multiply 3,500 visitor days for Upper Leavitt and 2,800 visitor days for Douglas Draw annually by $70.69 we get an annual recreational benefit estimate of $247,415 for Upper Leavitt and $197,932 for Douglas Draw. The present values of that annual stream of benefits would be $5.4 million for Upper Leavitt and $4.3 million for Douglas Draw using a four percent discount rate and a 50- year project life.

The estimates are, of course, dependent upon the reservoir’s ability to support a viable fishery and the development of a boat ramp and associated recreational facilities at the site, among other things.

12 See, for example, Gannett Fleming. 2003. Little Snake River Dams Level II Study. Report to the WWDC. July.
13 The Intermountain Region includes Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Utah, and Wyoming.
Total Benefits

The total benefits of the Upper Leavitt Reservoir can be summarized as follows:

<table>
<thead>
<tr>
<th>Benefit Type</th>
<th>Annual Benefit</th>
<th>Present Value of Benefit</th>
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</thead>
<tbody>
<tr>
<td>Direct Irrigation</td>
<td>$583,000</td>
<td>$12.6M</td>
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<tr>
<td>Indirect Irrigation</td>
<td>$1,533,000</td>
<td>$33.3M</td>
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<tr>
<td>Recreation</td>
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<td>$5.4M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,363,000</strong></td>
<td><strong>$51.3M</strong></td>
</tr>
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The total benefits of the Douglas Draw Reservoir can be summarized as follows:

<table>
<thead>
<tr>
<th>Benefit Type</th>
<th>Annual Benefit</th>
<th>Present Value of Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Irrigation</td>
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<td>$16.4M</td>
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<tr>
<td>Indirect Irrigation</td>
<td>$1,980,000</td>
<td>$43.1M</td>
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<tr>
<td>Recreation</td>
<td>$198,000</td>
<td>$4.3M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,932,000</strong></td>
<td><strong>$63.8M</strong></td>
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</table>

**Costs – Upper Leavitt**

The estimated construction costs for the reservoir and associated supply pipeline would be $19.9 million. A transfer pipeline from Beaver Creek to Shell Creek, Whaley Ditch, and/or Shell Canal would add an additional $5 million for a total of $24.9 million.

Operation of the project would likely require half-time staffing (approximately 100 hours per month) for 6 months of each year and minimal staffing (approximately 20 hours per month) for the remaining 6 months of the year. Routine maintenance could be expected to require two weeks of labor from a 3-person crew and related equipment. In total, using 2010 dollars, operation and maintenance can be expected to cost $25,000 per year.

**Costs – Douglas Draw**

The estimated construction costs for the reservoir and associated gravity supply pipeline diverting water from Shell Creek near the USGS gage would be $33.3 million. The estimated construction costs for the reservoir and associated supply pipeline with a pump station diverting water from Shell Creek near the Shell cemetery would be $25.4 million.

Operation of the project would likely require half-time staffing (approximately 100 hours per month) for 6 months of each year and minimal staffing (approximately 20 hours per month) for the remaining 6 months of the year. Routine maintenance could be expected to require two weeks of labor from a 3-person crew and related equipment. In total, using 2010 dollars, operation and maintenance can be expected to cost $25,000 per year for both supply/discharge options.

Power costs for the gravity supply pipeline will be very minimal and, therefore, not included in this analysis. Power costs for the pump station option will be significant. The duration and flow rate of pumping will vary; this analysis estimates pumping for an average of 23 days each year. At an average rate of 75 cfs and a head of 150 ft., the horsepower utilized would be 1500 hp (75 X 150 / 7.5). Using a conservative cost of $0.06/kWHR, the average pumping costs will be $37,050 per year (1500hp /
1.341hp/kW X 23 days X 24hrs/day X $0.06/kWhr). While power costs will not be included in the Benefit-Cost ratio, they will be included in the annual cost analysis.

**Benefit-Cost Ratio**

The estimated present value of direct and indirect irrigation benefits and flat-water recreation benefits would be $51.3 million for the Upper Leavitt site. When compared to an estimated construction cost of $19.9 million for the reservoir alone and $24.9 million for the reservoir plus transfer pipeline, the benefit-cost ratio for the project would be 2.56 and 2.06, respectively.

The estimated present value of direct and indirect irrigation benefits and flat-water recreation benefits would be $63.8 million for the Douglas Draw site. When compared to an estimated construction cost of $33.3 million for the gravity supply line option and $25.4 million for the pump station option, the benefit-cost ratio for the project would be 1.91 and 2.51, respectively.

**Ability to Pay – Upper Leavitt**

The Wyoming Water Development Commission offers several grant-loan funding ratios. A common ratio is 67% grant with the remaining 33% costs being funded by a 50-year loan at 4% interest. Assuming a net of 2,700 AF of diversions, the costs at the various funding ratios are listed in the tables below.

<table>
<thead>
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<th>Percent Grant</th>
<th>Annual Payment (50yrs @ 4% interest)</th>
<th>2011 O&amp;M Costs</th>
<th>Total Annual Costs</th>
<th>Annual Cost/AF (2700AF Total)</th>
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<tr>
<td>67</td>
<td>$305,695</td>
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<td>75</td>
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<td>$77.88</td>
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<td>$9.26</td>
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<table>
<thead>
<tr>
<th>Percent Grant</th>
<th>Annual Payment (50yrs @ 4% interest)</th>
<th>2011 O&amp;M Costs</th>
<th>Total Annual Costs</th>
<th>Annual Cost/AF (2700AF Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
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<td>$150.93</td>
</tr>
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<td>Percent Grant</td>
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<td>2011 O&amp;M Costs</td>
<td>Total Annual Costs</td>
<td>Annual Cost/AF (2700AF Total)</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>------------------------------</td>
</tr>
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<td>$25,000</td>
<td>$25,000</td>
<td>$9.26</td>
</tr>
</tbody>
</table>

### Ability to Pay – Douglas Draw

The Wyoming Water Development Commission offers several grant-loan funding ratios. A common ratio is 67% grant with the remaining 33% costs being funded by a 50-year loan at 4% interest. Assuming a net of 3,500 AF of diversions, the costs at the various funding ratios are listed in the tables below.

**Table V-3 – Annual Costs for Douglas Draw Reservoir (Gravity Supply Option)**

<table>
<thead>
<tr>
<th>Percent Grant</th>
<th>Annual Payment (50yrs @ 4% interest)</th>
<th>2011 O&amp;M Costs</th>
<th>Total Annual Costs</th>
<th>Annual Power Costs</th>
<th>Annual Cost/AF (3500AF Total)</th>
</tr>
</thead>
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</tr>
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</tr>
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<tr>
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<td>$25,000</td>
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</tbody>
</table>

**Table V-4 – Annual Costs for Douglas Draw Reservoir (Pump Station Option)**

<table>
<thead>
<tr>
<th>Percent Grant</th>
<th>Annual Payment (50yrs @ 4% interest)</th>
<th>2011 O&amp;M Costs</th>
<th>Annual Power Costs</th>
<th>Total Annual Costs</th>
<th>Annual Cost/AF (3500AF Total)</th>
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<td>$37,050</td>
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</tr>
<tr>
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<td>$17.73</td>
</tr>
</tbody>
</table>

### Ability to Pay – General

Irrigators' ability to make such payments depends upon several factors, some of which are not known at this time. For example, if irrigators would be required to make annual project loan payments, their ability to do so would be partially dependent upon...
the variability (or lack thereof) in the project's water yield. At this level of study, however, the hydrologic reservoir modeling needed to assess this variability has not been performed.

Another issue regarding ability to pay would be how irrigators would allocate the additional water. The irrigation benefit analysis described above indicates that project water would generate more income for irrigators when used as finishing water on existing crops than if used to expand corn and bean production at the expense of hay production. This analysis assumes that one-half of the project’s yield would be used for each purpose. Additional hydrologic analyses are needed, however, to estimate the actual demand for finishing water and the variability in that demand over time.

Conclusions

These projects as currently envisioned would have relatively high benefit-cost ratios of 2.56 (Upper Leavitt reservoir alone), 2.06 (Upper Leavitt reservoir with transfer pipeline), 1.91 (Douglas Draw gravity supply pipeline), and 2.51 (Douglas Draw pump station option). The main reason for these high ratios is that project water could be used to finish relatively high valued crop in times of shortage, thereby increasing production. Secondary reasons include the potential to generate a substantial amount of indirect irrigation benefits in the area and a potential for recreation benefits. Additional hydrologic studies are needed, however, to develop better estimates of irrigation water needs and frequency with which water could be made available to meet those needs. This information would produce a refined benefit cost estimate and could be used to more realistically assess irrigators’ ability to pay for the additional water.
Chapter VI. Permitting

In the current regulation environment, permitting can become a complex and expensive process. Following is a discussion of the permitting that would likely be required of any of the storage sites studied.

Federal Permitting Requirements

U.S. Army Corps of Engineers Section 404 Permitting

For any new reservoir regardless of land ownership, the Applicant must submit a Section 404 permit application to the U.S. Army Corps of Engineers office. Prior to submitting the application the Applicant should address the proposed project’s Purpose and Need and any other alternatives considered and the reasons for their elimination. This study analyzed the Purpose and Needs of the watershed and considered alternatives.

Due to the requirements of the National Environmental Policy Act (NEPA), the Corps of Engineers will require an Environmental Assessment (EA) for those projects that have minimal impacts identified. Most EA’s can be completed within one to two years from the date of application. Those projects that have identified impacts to aquatic resources greater than 0.5 acres or have impacts to threatened or endangered species will likely require that an Environmental Impact Statement (EIS) be prepared. The time requirements for completing an EIS can range from two to five years and be quite expensive. For this reason, it becomes imperative that the Applicant investigate thoroughly those projects with the least damaging impacts to area wildlife, fisheries, and aquatic resources.

Once the Application package has been accepted, the Corps of Engineers will prepare a Public Notice of the pending Application and announce Public Scoping meetings to be held in the area of interest. Public notices will be sent to most local, State, and Federal agencies along with all surrounding land owners. Upon the completion of Public Scoping meetings, a Scoping Document will be prepared summarizing all comments received regarding the proposed project. The Corp of Engineers will then finalize the Scope of Work for conducting the environmental analysis. Unlike most Federal land management agencies, the COE does not require reimbursement of their NEPA/404 participation costs.

Purpose and Need

As with most water projects, the most critical authorization that would be required for a proposed storage project within the Shell Valley basin would likely be the U.S. Army Corps of Engineers Section 404 permit. Prior to acquiring a Section 404 permit, the applicant must submit a Section 404 permit application. Perhaps the most critical component of the Section 404 application would be the preparation of a purpose and need statement. This statement will set the stage for the preparation of environmental documentation.

The Corps of Engineers must comply with the National Environmental Policy Act (NEPA) and the Section 404(b)(1) guidelines when defining project purpose. The project purpose is commonly referred to as the purpose and need statement. The Corps will determine after the issuance of a Public Notice whether an Environmental
Assessment (EA) or an Environmental Impact Statement (EIS) will be required. Several factors will assist the Corps in making their final determination. Typical factors include potential impacts to threatened or endangered species, impacts to wetlands (aquatic resources) and Public Interest. During the Public Notice issued by the Corps, the NEPA process gives the public the opportunity to provide comments on potential impacts and alternatives to be analyzed during the development of the EA/EIS. The Corps reviews and considers all public comments when developing the purpose and need statement. The Corps then uses that statement to evaluate alternatives and independently verifies the project’s need. If the Applicant disagrees with the Corps purpose and need statement, they are allowed to submit their own. Critical questions, such as how much water is available and who will use the water, impact to T&E species, and wetland impacts will assist the Corps in selecting the “least damaging alternative”.

The work performed in this study has preliminarily evaluated the purpose and need for water storage in the Shell Creek drainage. The primary purpose of the storage project would be supplemental irrigation water. The hydrological work and temporary stream gaging has established that adequate water would be available from Beaver Creek and Shell Creek to supply the proposed reservoirs. The investigation has also indicated that significant irrigation shortages occur on Beaver Creek and Shell Creek. A more sophisticated hydrological modeling effort as well as on-going stream gaging will be conducted in the next phase of work.

Other secondary benefits could be created by the reservoir project. These benefits would include substantial recreation values with the incorporation of a substantial reservoir minimum pool, stream fishery improvements, water quality improvement, and wildlife enhancements.

**United States Fish and Wildlife Service (USFWS)**

On many projects the Applicant is required to consult with the USFWS under Section 7 of the Endangered Species Act to make certain that the project is in compliance.

**U.S. Department of Interior – Advisory Council on Historic Preservation (Section 106)**

Section 106 of the National Historic Preservation Act of 1966 (NHPA) requires Federal agencies to take into account the effects of their undertakings on historic properties, and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment.

Section 106 is meant to protect cultural and historic resources. Section 106 functions are coordinated within Wyoming by the Wyoming State Historic Preservation Officer.

**State Of Wyoming Permitting**

In addition to the Federal permits outlined above, there are a host of additional permits/approvals required for any new dam construction. Outlined below are the State of Wyoming permits required for new dam construction.
Wyoming State Engineer’s Office (WSEO) Surface Water Storage Permits

The Applicant must obtain the necessary water rights storage permits from the WSEO for the diversion and storage of the State’s surface water. The sites studied would require Form S.W. 3 reservoir permit.

The Applicant must also provide draft plans and specifications to the WSEO for a Permit to Construct through the Dam Safety office.

Wyoming State Department of Environmental Quality (WDEQ) Permitting

National Pollution Discharge Elimination System (NPDES) permit and corresponding Section 401 Certification. The NPDES permit controls the discharge of stormwater pollutants associated with construction activities. The Section 401 Certification is the State’s approval to insure that the activities authorized under Section 404 (COE) meet State water quality standards and do not degrade water quality.

Wyoming Historic Preservation Office (SHPO) Archaeological Clearance

Clearance is meant to determine the significance of cultural resources potentially affected by ground disturbing activities.
Chapter VII. Summary and Recommendations

Summary of Results

This report presents the results of the Shell Valley Storage Level II Study. The primary tasks of this study were the hydrologic analysis, site screening, preliminary designs and cost estimates of the most viable sites, an economic analysis of the preferred site, and initial formulation of the Purpose and Need statement.

The hydrologic analysis indicates significant shortages during an “average” year. Communications with irrigators in the basin suggest that shortages during drier years are more considerable. The hydrologic analysis also indicates that water available for storage does exist in multiple locations in the basin.

The site screening evaluated seventeen potential storage sites for the following factors:

- Ability to Meet Needs;
- Access;
- Multiple Use Potential;
- Geotechnical Feasibility;
- Land Ownership;
- Cultural Resources;
- Environmental Impacts;
- Ability to Permit;
- Cost

Each of the factors was scored and a total weighted score was computed for each site. The scores and information gained during this evaluation, along with direction from the Wyoming Water Development Office and the Shell Valley Watershed Improvement District, were used in the determination to prepare preliminary designs and cost estimates for the site at Upper Leavitt, Douglas Draw, and Shell Canal Tunnel.

The preliminary designs were based on the recommendations of the geotechnical/geological report. This report uses reconnaissance-level information and is, therefore, a little limited in site-specific details. These estimates are based on quantities formulated from the preliminary design, past project experience, and estimates from others. More extensive study would be required for more precise designs and estimates.

The preferred site was determined to be Upper Leavitt. An economic analysis that included calculation of potential benefits, both direct and indirect, and costs was completed for this site. The analysis indicated a favorable benefit to cost ratio.

Finally, the purpose and need for a project in the Shell Creek drainage was preliminarily evaluated. While many secondary benefits could be achieved by a reservoir project in the area, the primary purpose would be for storage of irrigation water. The hydrologic analysis indicates a need for such a project.
Recommendations

It is the recommendation of the States West team to further study the Upper Leavitt site. Specifically, the following items are recommended:

- Creation of a complete StateMod model in conjunction with stream gaging to establish firm numbers regarding shortages and the effectiveness of an Upper Leavitt reservoir as well as to determine the optimum reservoir size;
- Completion of a full wetlands delineation at the site to determine the extent of potential wetland mitigation requirements;
- Implementation of a subsurface geotechnical program at the site to reveal conditions affecting design of a dam and reservoir;
- Completion of a full topographic and property ownership survey to assist in design of a dam and reservoir; and
- Creation of more accurate preliminary design and cost estimates for the site based upon the geotechnical program and topographic survey.