RAWLINS RAW WATER STORAGE
LEVEL II, PHASE I AND II
REPORT

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Submitted to:

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1.0 EXECUTIVE SUMMARY

1.1 Objective and Background

The Rawlins Raw Water Storage Project, Level II is a Wyoming Water Development Commission study that evaluated the feasibility of constructing a raw water storage reservoir. The purpose of the reservoir is to maintain the reliability of the City of Rawlins’s (the City) municipal water supply system while accommodating increased water demand and or decreased water supply, such as that brought on by drought. The study addressed three issues including 1) water supply system capability, 2) technical siting for reservoirs, and 3) project financing. Figure 1-1 is a project location map and Figure 1-2 is a water system schematic that shows the basic relationship between the various water supplies and water demands of the City.

The following sections summarize the study findings and provide recommendations for the Sponsor’s and WWDC’s consideration.

1.2 Water Supply Evaluation

A water supply evaluation was performed which examined several water supply and water demand scenarios including:
- Modeling the system as it is currently operated,
- Varying degrees of water supply drought,
- Existing and aggressive water demand increases due to population growth,
- With and without the use of the existing Atlantic Rim Reservoir,
- With and without assertive use of the North Platte River water supply.

The evaluation concluded that assertive use of the North Platte River water supply increased the reliability of the entire water supply system and eliminated the need to provide additional storage under most conditions. The evaluation also concluded that a combination of assertive pumping and an additional 500 to 600 ac-ft. of water storage maintained the water supply reliability under all scenarios.
ADDITIONAL RESERVOIR STORAGE EVALUATED UNDER THIS PROJECT

PEAKING NO. 1 RESERVOIR (346.66 AF)

5.25 cfs MAX RESERVOIR SUPPLY (6/7/1966)

GOLF COURSE

NORTH PLATTE RIVER

SINCLAIR SUPPLY

45% SAGE CREEK RESERVOIR (202 AF)

Rawlins Water Rights

FIGURE 1-2
WATER SUPPLY SCHEMATIC
RAWLINS RAW WATER STORAGE, LEVEL II
WYOMING WATER DEVELOPMENT COMMISSION

NOT TO SCALE
1.3 **Reservoir Evaluation**

A two phase (I and II) reservoir evaluation was performed. The Phase I work (Attachment to Appendix B) was a reconnaissance level evaluation of five alternative locations for raw water reservoir storage. The Phase I investigation recommended study of one site in a detailed Phase II field investigation. That site was south of the water treatment plant in an area known as Five-Mile Ridge Reservoir site. However, access for surveys and geotechnical testing was not obtained for that site so the detailed field investigation was performed on the Peaking No.2 site just east of the existing Peaking Reservoir. Figure 1-3 is an exhibit showing the conceptual layout for the Peaking No.2 Reservoir site as prepared in the Phase II evaluation.

In addition to evaluating new reservoirs, the consulting team reviewed the available information related to the existing Atlantic Rim Reservoir. This facility has a history of seepage problems, (as documented in Appendix C), and the team recommends it should not be an element of a long term water supply and storage system. A more detailed analysis of the Atlantic Rim Reservoir is given in chapter 5.

The consulting team also prepared a conceptual design for a pipeline that would replace the existing pipeline between Atlantic Rim Reservoir and the water treatment plant. The existing pipeline may not be large enough, may not have adequate pressure rating, and has experienced some reported line breakage problems. This pipeline is a critical link in the City water supply and may be required as part of a program to replace the Atlantic Rim Reservoir. Additional evaluation of the pipeline without the Atlantic Rim Reservoir should be performed.

1.4 **Project Financing**

WWDC financing was evaluated for constructing a reservoir at the Peaking No.2 site and for replacing the Atlantic Rim Reservoir Pipeline. The total project cost for these two improvements was estimated to be $14,650,000, which
NOTE:
PROPOSED HIGH WATER ELEVATION NEEDS FURTHER STUDY WITH REGARD TO OPERATING NEEDS. THIS MAY REQUIRE CHANGES TO THIS CONCEPTUAL DESIGN.

EXISTING PEAKING RESERVOIR

PROPOSED PEAKING RESERVOIR NO. 2

PROPOSED TOP OF BERM 7160

PROPOSED HWL APPROX. 7155

LEGEND

TEST PIT
CONTROL POINT
WATER VALVE (PROPOSED)
WATER VALVE (EXISTING)
WATER LINE (PROPOSED)
WATER LINE (EXISTING)
CONTOUR
2 TRACK ROAD
FENCE
SEISMIC LINE

FIGURE 1-3
CONCEPTUAL DESIGN
PEAKING RESERVOIR NO. 2

RAWLINS RAW WATER STORAGE, LEVEL II
WYOMING WATER DEVELOPMENT COMMISSION

SCALE

NOT TO SCALE

WATER VALLEY (PROPOSED)
WATER VALLEY (EXISTING)
TO VALVE BAY
3" SAND DRAINAGE LAYER TO 5/8 TIE
3" SAND DRAINAGE LAYER
3" SAND COVER
2" CLAY LINER
2" IMPREGNATED DECOMBINATION BETWEEN TWO SEEPAGE COLLARS
DECOMBINATION SEEPAGE COLLAR
CONCRETE 24" DIA. STEEL
CROSS-SSECTION A-A
CROSS-SSECTION B-B

NOTE:
PROPOSED HIGH WATER ELEVATION NEEDS FURTHER STUDY WITH REGARD TO OPERATING NEEDS. THIS MAY REQUIRE CHANGES TO THIS CONCEPTUAL DESIGN.
included an approximate allowance for the removal and reclamation of the Atlantic Rim Reservoir.

Assuming WWDC participation with a 67% grant and 33% loan and a $15,000 per year operating budget, the annualized cost of constructing and maintaining the projects is about $295,000. This annual cost translates to an approximate user fee increase of $6.28 month/water tap. This annual value is very similar to the annual cost of more assertive North Platte River pumping which is an alternative strategy for maintaining water supply reliability.

1.5 Project Resolution

At a City Council meeting on July 12, 2006 at Rawlins City Hall, the draft report and recommendations for further activity were presented and discussed. The City agreed to ask WWDC for a continuation of the Level II study to explore options for decommissioning Atlantic Rim Reservoir, to explore the Five-Mile Ridge Reservoir site, and to perform a more detailed study of the Atlantic Rim Pipeline. The City also decided that the reservoir and Atlantic Rim Pipeline projects would not be advanced to Level III since the City had identified a higher priority Level III project (steel water storage tank repairs).

1.6 Recommendations

The team recommends that the City apply for an additional WWDC-funded Level II study to perform the following tasks:

- Prepare a conceptual design and cost estimate for decommissioning and reclamation of the Atlantic Rim Reservoir.
- Identify a resolution of the potential water supply issue for the Bureau of Land Management's Rim Lakes which are supplied partly from leakage of the Atlantic Rim Reservoir.
- Obtain access permission from the surface owner of the Five-Mile Ridge Reservoir site and perform a field investigation and other activities to advance the level of evaluation of the Five-Mile Ridge Reservoir site location to an equal level with Peaking No.2 site and to support a conceptual design. The Phase I reservoir evaluation indicated that
reservoir construction at the Five-Mile Ridge Reservoir site location would be about 30% less expensive (more than $3 million) than at the Peaking No.2 site, primarily because the topography is more favorable for efficient dam and reservoir construction. Also, the Phase I matrix evaluation indicated that the Five-Mile Ridge Reservoir site was a better overall project than the Peaking No.2 site project. However, foundation conditions and borrows material availability and quality at the site is unknown at this time.

- Advance the conceptual-level design of the Peaking No.2 site location or Five-Mile Ridge Reservoir site, including optimizing the configuration of the reservoir and its operating pool elevation to best serve the system, and performing additional engineering analyses and value engineering that could potentially identify cost savings for reservoir construction.

- Perform further evaluation on the Atlantic Rim Pipeline project. This project may be needed if the City abandons the use of the Atlantic Rim Reservoir. The configuration of the project depends on the final site selection for a reservoir and how the pipeline is operated.
2.0 INTRODUCTION

2.1 Background

Municipal water supply systems are responsible for providing users a highly reliable supply of good quality water. Since incorporation, the City of Rawlins has been meeting this responsibility by the continual expansion and improvement of its water system infrastructure, including:

- The diversification of resources by development of water wells, springs and North Platte River water. These three primary sources provide a secure set of water supply options that have and will continue to meet the legal (priority) and physical (hydrology) diversification and reliability standards upon which the City has come to rely.
- Construction of raw water supply and re-regulation reservoirs that store seasonal excess supplies for later use during high demand months,
- The replacement and upgrading of water transmission systems from supplies to the treatment facility,
- Water treatment system improvements that keep pace with changing water quality regulations,
- Through the acquisition and lease of water rights needed to ensure legally available supply.

In the past, the City has diligently evaluated their water supply system capability and taken action when infrastructure improvements were shown to be needed. In 1983, the City completed a comprehensive water supply master plan (Montgomery, 1983) that examined the relationship between increasing water demands and the need for system improvements. This work resulted in the expansion of the City’s resources through a new well field and the replacement/enlargement of the critical water transmission pipeline to the Sage Creek Basin. In 1997, the City again examined their supply capability and strengthened it with the reconstruction of their North Platte River water supply pipeline (WWC, 1997).
Since the water infrastructure improvements in the 1980’s and late 1990’s, there have been several system, supply, demand and sociopolitical changes which support the need to examine the City’s current water supply capability. These changes include:

- The construction of the Rochelle municipal golf course in 2004 which is watered with City raw water resources.
- The regionalization of water supplies. In 2003, Rawlins began serving municipal water to the Town of Sinclair. In exchange, Rawlins obtained access to some senior priority North Platte River water rights from the Town of Sinclair.
- The observation that the Miller Hill Well Field is not capable of producing water supplies at the rate conceived when the well field was installed in the 1980’s.
- The City has not obtained the 0.31 cfs Union Pacific Railroad water right in the North Platte River. This water right is still potentially available to the City. Previous planning efforts (Montgomery, 1983, and WWC, 1997) assumed that this water right would be added to the City's portfolio of assets.
- The State of Wyoming has experienced a recent drought cycle that in many areas was the worst on record. Long term climate change is a popular notion in the national press and scientific community.
- Despite a flat or downward trend in population through the 1990’s, the treated water production for Rawlins has increased, due perhaps to an increase in per capita consumption, increasing commercial demands from I-80 travel traffic and other factors.
- The City anticipates and is currently experiencing economic growth in the coming years as oil, gas, and coal resources of southern Wyoming are developed.

2.2 Objectives

This WWDC Level II project evaluated the feasibility of increasing raw water reservoir storage to maintain water system reliability under future changes
in water supply and/or water demand. The objectives of the evaluation included
the following:

1. To estimate the relationships between the City’s water resources
and projected water demands. These relationships define the
hydrologic availability of water resources and the physical and
legal constraints on those resources.

2. To examine technical issues regarding the siting and design of raw
water reservoir storage at various locations, based on geotechnical,
environmental, financial and other factors. This work includes a
matrix evaluation of alternative projects.

3. To develop a conceptual design for a preferred reservoir project,
suitable for Level III funding, if it is needed.

2.3 Project Phasing

This Level II project was completed in two phases. The Phase I project
was directed at objectives No.1 and No. 2. The Phase II work was directed at
preparing a detailed conceptual reservoir design for the preferred project from
Phase I (objective No.3). A Draft Phase I report was issued on December 22,
2005. The consulting team received comments on that Draft report in January
2006 and presented the preliminary findings of that work at a City Council
Workshop in February. The Draft Phase I Report was not finalized. For
completeness, the information from the draft report has been included in this
Phase II report.
3.0 WATER SUPPLY EVALUATION

3.1 Introduction

A water supply reliability and reservoir evaluation was performed. The work quantified the existing reliability of the Rawlins water supply system and estimated the raw water storage requirements needed to maintain the existing reliability when subjected to scenarios of increased demand and or water shortage. The modeling effort accounted for existing senior water rights, future water demands, hydrologic capabilities of the supplies and hydraulic abilities of the system piping. Information regarding the existing water supplies of the City and a complete presentation of the model development and results are presented in Appendix A. A detailed discussion of the City of Rawlins water rights, and Modified North Platte River Decree and the Platte River Recovery Implementation Program and the relationship of these institutional matters and their affect upon the City's municipal water supply are presented in Appendix D.

3.2 Results

Table 3-1 contains the results of the water supply evaluation. The table presents the average number system “failures” for which the water supply system was unable to meet the estimated water demands. A system “failure” was defined as a month in which water supply was less than demand. The evaluations were for a 50 year simulation of the water supply model. A total of sixteen scenarios were evaluated in which there were two “base” scenarios: minimal pumping and assertive pumping from the North Platte River supply.

For each base scenario, seven variables were adjusted to evaluate the reliability of the system and estimate water storage needs. The percentage of months in which demand and operating criteria were satisfied was calculated to provide an estimate of what this study termed “system reliability”. The reliability value is not necessarily a standard that can be compared to other municipal systems; rather it is a standard against which the value of system improvements (such as adding reservoir storage) can be judged.
Table 3.1: Model Scenario Results

<table>
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<th>Scenario:</th>
<th>Mean Number of System Failures in 50 year planning simulation</th>
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<tbody>
<tr>
<td></td>
<td>Scenario No. 1 (minimal pumping)</td>
</tr>
<tr>
<td></td>
<td>A B C D E F G</td>
</tr>
<tr>
<td>Additional Reservoir Storage AC-FT</td>
<td>w/Mild w/Severe w/+20% w/+30% w/o Early Atlantic w/irrig. to Sept. 30</td>
</tr>
<tr>
<td>0</td>
<td>7.2 7.6 31.2 7.9 8.2 11.75 10.1 15.6</td>
</tr>
<tr>
<td>100</td>
<td>6.0 6.4 30.0 6.6 6.9 7.9 6.8 13.8</td>
</tr>
<tr>
<td>200</td>
<td>5.4 5.7 28.9 5.7 5.7 6.1 5.7 12.2</td>
</tr>
<tr>
<td>300</td>
<td>4.8 4.9 28.0 5.2 5.3 5.65 5.1 10.2</td>
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<td>4.0 4.0 26.7 4.3 4.4 4.8 4.3 8.5</td>
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<tr>
<td>500</td>
<td>3.4 3.5 26.1 3.7 3.8 4.3 3.7 6.7</td>
</tr>
<tr>
<td>600</td>
<td>3.0 3.1 25.3 3.2 3.3 3.7 3.3 5.8</td>
</tr>
<tr>
<td>800</td>
<td>2.0 23.3 2.8 2.3 4.6</td>
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<td>Scenario No. 2 (assertive pumping)</td>
</tr>
<tr>
<td></td>
<td>A B C D E F G</td>
</tr>
<tr>
<td>Additional Reservoir Storage AC-FT</td>
<td>w/Mild w/Severe w/+20% w/+30% w/o Early Atlantic w/irrig. to Sept. 30</td>
</tr>
<tr>
<td>0</td>
<td>3.8 3.9 18.5 4.0 4.0 6.2 7.2 7.4</td>
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</tr>
<tr>
<td>800</td>
<td>0.4 1.05 0.75 0.7 1.05</td>
</tr>
</tbody>
</table>

Notes: If Max. Platte is only 2.51 instead of 3.01 - a result of decrease in Sinclair water right after 50 years
- there is a slight increase in failures.
If Platte calls end on May 30 instead of worst-case June 15
- there is a hardly noticeable decrease in failures.
If there is irrigation in Sage Creek until Sept. 30
- the number of failures under all scenarios is roughly double.
If all the above are combined
- the base scenario failures are double
- but there is a slight decrease from double the failures under assertive pumping.

Note: This work was originally presented in a Draft Phase I report.
3.3 **Conclusions**

The water supply and demand evaluation provided the following information about the water system:

- The existing water supply system has a reliability of about 99%. In other words, that in a 50 year planning horizon, there will be about 7 months in 600 in which the system water supplies can not meet the projected demands.

- Assertive use of the North Platte River source eliminates the need to construct additional reservoir storage if demand increases remain as they have been historically (increasing slightly) and if hydrologic conditions are stable. Scenario 2 “Base 2” showed that by filling the Peaking reservoir with North Platte River water, before a projected decline in the supply and before an increase in demand, the system could avoid almost half of the projected shortage events in the planning period.

- Eliminating Atlantic Rim Reservoir will reduce the water system reliability (Scenario F). Decreased reliability could be corrected by constructing an additional 100 ac-ft. of storage at Peaking Reservoir (Scenario 1F). Raw water storage near the existing Peaking Reservoir is more favorable than at Atlantic Rim because the Peaking Reservoir location can take advantage of the entire portfolio of City municipal water supplies, including the supply from the North Platte River. Scenario 2F demonstrates that the assertive pumping regime can counter the effects of eliminating Atlantic Rim and still maintain the current reliability.

- An additional 30% increase in municipal demand over the 50 year planning horizon (Scenario D or E) is the approximate threshold at which additional reservoir storage would be needed to maintain the present day water supply reliability of 99% without increased pumping. Assertive pumping or increased storage would be needed to maintain system reliability under considerably increased water demands.
• Modest drought conditions (five years at 1 standard deviation below mean Sage Creek Spring Yield) evaluated in Scenario A can be tolerated by the water supply system without a reduction in water supply reliability.

• Severe drought conditions (five years at 2 standard deviations below mean Sage Creek Spring yield) evaluated in Scenario B will reduce water supply reliability. System reliability could be maintained at present day levels by providing a combination of assertive North Platte River pumping and additional reservoir storage of between 400 and 500 ac-ft.

• As shown by Scenario 2B, a 500 ac-ft reservoir (active capacity) located in an area that can be supplied by the North Platte River appears to be the maximum size that can be justified from the water supply evaluation. An increase of over 500 acre feet provides smaller incremental benefit to the system. The Phase I report recommended exploration of options to add 500 acre-foot of storage capacity at a location hydraulically equivalent to an expansion of Peaking Reservoir.
4.0 SUMMARY OF PHASE I RESERVOIR EVALUATIONS

4.1 Introduction

As presented in Section 2.3, this project was completed in two phases. During Phase I, a reservoir siting evaluation was performed to identify which one of several sites was the most logical to receive field investigations. The evaluation included a matrix evaluation that considered several reservoir siting factors, including: cost, maximum use of existing water rights, and site and sizing options.

This chapter presents a summary of the Phase I work. More detail related to that effort is presented in Appendix B.

4.2 Site Options

Five 500 ac-ft. reservoir sites were evaluated considering geological/geotechnical conditions. Cost estimates were developed for the options deemed practical. The options are shown on Figure 4-1.

Option 1: Enlarging Peaking Reservoir No. 1 consists of raising the vertical grade of the existing embankment using a mechanically stabilized earth (MSE) wall system. However, from a construction standpoint, this option was not practical. A reinforced 1H:1V side slope configuration was also considered, but required a vertical raise of 35 feet to obtain 500 ac-ft. of storage. Based on these findings, this Option 1 was eliminated from further consideration.

Option 2: Construct Peaking Reservoir No. 2 consists of constructing a new 500 ac-ft. reservoir adjacent to Peaking No. 1 located on City-Owned Property. This option assumes that a two-foot clay liner would be necessary, and riprap erosion protection lining would be utilized for the cost estimate. Option 2 accounts for monitoring instrumentation, modification of outlet works, installation of new supply pipe, and providing an access road.

Option 3: Enlarging Atlantic Rim consists of raising the existing embankment of Atlantic Rim approximately 20 feet. This option
includes a full geomembrane liner, monitoring instrumentation, modification of outlet works, modification of supply pipe, and providing an access road. This site is within BLM lands, and would require expansion of current easement or lease agreements. Technical issues related to seepage and soluble minerals in underlying soils are a factor to consider for this option. Note that during Phase II Study, this option has been dropped from further development as detailed in Chapter 5.

Option 4: Construct Fivemile Ridge Reservoir consists of constructing a new reservoir and dam in the Fivemile drainage area southwest of Peaking Reservoir on property owned by Anadarko Land Resources Company (formerly UPRR). Gannett Fleming (GF) assumed that foundation conditions are similar to Peaking Reservoir No. 1, and a one-foot thick clay liner would be necessary. GF also assumed that the reservoir would be supplied via the existing Atlantic Rim supply pipe which is in close proximity to the Fivemile site. However this pipeline has experienced some reliability issues (noted as early as the 1997 Rawlins Water Supply Project, Level II report--WWC Engineering), particularly related to active operation such as shutdown, and it may need to be replaced, pending further study. Option 4 accounts for monitoring instrumentation, construction of outlet works, and providing an access road.

Option 5: Below Grade Basin initially consisted of the construction of a below-grade basin reservoir to minimize embankment placement costs, and to avoid permitting issues associated with a dam. Due to the depth required to reach the 500 ac-ft. capacity, and the relatively shallow depth to rock, this option was not feasible from a constructability standpoint. Therefore, the option was modified to include a balanced cut and fill configuration. The site is located southwest of the water treatment plant across Highway 71, and spans privately owned and BLM lands. We assumed that a clay
liner and erosion protection similar to Option 2 would be required. Additionally, the supply pipe would be spliced into the existing Atlantic Rim supply pipe, and it would cross Highway 71. Option 5 accounts for monitoring instrumentation, construction of outlet works, installation of supply pipe, and providing an access road.

4.3 **Matrix Evaluation**

Table 4-1 presents the matrix evaluation performed in Phase I on the reservoir options described in the previous section. A complete explanation of the matrix criteria is presented in Appendix B. Table 4-2 presents the Phase I results of the matrix evaluation for two cases, one where criteria weighting factors are used and one where they are not.

Both alternative evaluations demonstrate that assertive pumping from the North Platte River is the preferred solution under all conditions, except for severe drought. While assertive pumping meets the reliability criteria under most scenarios without additional storage (shown in Table 3-1), a combination of events and/or extreme drought conditions, could produce undesirable results related to the reliability and quality of the water supply system. The second highest total scores are associated with the ‘No Action Alternative’, which at a minimum required the lining of the existing Atlantic Rim facility. For reasons explained in the next chapter, this alternative was eventually ruled out as an option.

4.4 **Phase I Summary**

This Phase I reservoir evaluation work demonstrated that additional water supply storage was reasonably feasible from the following three perspectives:

- **Water supply**-The water supply evaluation (presented in Chapter 3.0) has shown that there are conditions of demand and supply that result in the need for water storage and/or operational changes (assertive pumping).
- **Geotechnical**-The geotechnical evaluation work has shown that there are several sites that could be used for reservoir storage. The Peaking
### Table 4-1 Phase I Alternative Storage Screening Matrix

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<td>4 yes</td>
<td>City</td>
<td>no</td>
<td>no</td>
<td>excellent</td>
<td>high</td>
<td>higher</td>
<td>high</td>
<td>high</td>
<td>yes</td>
<td>*lowest cost</td>
<td>low (&lt; 15,000)</td>
<td>low (&lt; $1.00)</td>
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<td>modest</td>
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<td>no</td>
<td>medium (= 15,000)</td>
<td>medium (4.00-6.00)</td>
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<tr>
<td>2 UPRR</td>
<td>possible</td>
<td>yes</td>
<td>fair</td>
<td>low</td>
<td>lower</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>high (&gt; 15,000)</td>
<td>high (&gt; 6.00)</td>
<td></td>
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<tr>
<td>1 BLM</td>
<td>likely</td>
<td>poor</td>
<td>no</td>
<td>*highest cost</td>
<td></td>
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</table>

**Alternative Reservoir Storage Options**

1. No Action (w/ Atlantic Rim Liner)
2. Peaking Reservoir No. 2
3. Enlarge Atlantic Rim Reservoir
4. Five Mile Ridge Reservoir
5. Basin Reservoir
6. Assertive Pumping from North Platte

*lowest to highest refers to the costs associated with the four options reviewed in the geotechnical memorandum (Appendix B).

---

Note: This work was originally presented in a Draft Phase I report. See Appendix B for a discussion of the matrix evaluation.
Table 4-2 - Alternative Evaluation Comparison

<table>
<thead>
<tr>
<th>Sorted by Score</th>
<th>Weighted Total Score</th>
<th>Unweighted Total Score</th>
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<tr>
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<td>157</td>
<td>46</td>
</tr>
<tr>
<td>1. No Action (w/ Atlantic Rim Liner)</td>
<td>153</td>
<td>43</td>
</tr>
<tr>
<td>4. Fivemile Ridge Reservoir</td>
<td>143</td>
<td>41</td>
</tr>
<tr>
<td>3. Enlarge Atlantic Rim Reservoir</td>
<td>141</td>
<td>38</td>
</tr>
<tr>
<td>2. Peaking Reservoir No. 2</td>
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<td>37</td>
</tr>
<tr>
<td>5. Basin Reservoir</td>
<td>123</td>
<td>33</td>
</tr>
</tbody>
</table>

Note: This work was originally presented in a Draft Phase I report. See Appendix B for a discussion of the matrix evaluation.
• Reservoir No.2 and the Five-Mile Ridge Reservoir sites appear to be viable options from the geotechnical standpoint.

• **Financial**-The financial evaluation (Appendix B) showed that the City may have the ability to finance a water reservoir construction project. Although household incomes in the Rawlins are below state average, so are the water rates. Furthermore, the financial evaluation work also showed that the financial impact to water users would be approximately the same if assertive pumping were used (relatively high operating cost) versus the construction of additional reservoir storage (low operating cost but high capital cost).

The Phase I work recommended that a Phase II scope of work, including field investigations, proceed at the Five-Mile Ridge Reservoir site for the following reasons:

• Based on the matrix evaluation, this site was a second runner with a relatively low project cost estimate, although it was not the least expensive.

• The site could provide slightly improved hydraulic benefit to operation of the WTP by reducing the need for influent pumping.

• The reservoir site is adjacent to the existing pipeline corridor.

• The North Platte pumping system can probably be configured to pump to this site without changing pumps, although additional pipe would be needed.

• There is already a reasonable amount of information at the Peaking Reservoir and Atlantic Rim Reservoir Sites. Geotechnical information about the Five-Mile Ridge Reservoir site alternative would bring the level of technical information up to that of Peaking and Atlantic Rim so that a more accurate comparison of alternatives could be performed.

• Due to the problems at Atlantic Rim, it appears that lining and continued monitoring would be required regardless of other options taken for water supply. More discussion of this issue appears in Chapter 5.
5.0 PHASE II RESERVOIR CONCEPTUAL DESIGN

5.1 Introduction

As presented at the end of the last chapter, the Five-Mile Ridge Reservoir site was the preferred option for field investigations under Phase II. Therefore, WWC Engineering approached the surface owners of the Five-Mile Ridge Reservoir site for ingress and egress to perform field investigations. Unfortunately, permission for ingress and egress was not obtained in time to allow for the field work and this reporting to be completed as fast as the City of Rawlins needed the information. The City was very interested in having this draft reporting completed well in advance of the WWDC’s August 15th, 2006 funding application deadline.

In addition to evaluating new reservoirs, the consulting team reviewed the available information related to the existing Atlantic Rim Reservoir. The reservoir has a history of severe seepage problems that include very troubling evidence of internal erosion and piping in the foundation, as indicated by sand boils near the downstream toe of the dam (see Appendix C).

Based on previous studies at the site, the seepage problems are believed to be caused by two possible mechanisms: (1) the presence of soluble minerals in the foundation soils, and (2) the presence of highly weathered and fractured bedrock in the deeper foundation and exposed on the eastern margin of the reservoir. These adverse foundation conditions were first recognized over 20 years ago and the current project team believes it is likely that the shallow (soil) foundation, and possibly the dam embankment itself, may have been further compromised over time under long-term seepage forces. Ongoing dissolution of soluble minerals, and possibly additional internal erosion of fines through piping features or into fractured bedrock, could have opened or widened seepage pathways and softened or weakened the dam and its foundation over time.

Although the conceptual estimated costs as generated in the Phase I evaluation for enlarging Atlantic Rim Reservoir appeared lower than the other options, those estimates assume the foundation of the existing facility is adequate to support continued use and enlargement of the reservoir. However, this is a
very optimistic assumption, and it is likely that costs could be significantly higher for rehabilitating Atlantic Rim to ensure future dam safety.

The team estimates that an appropriately detailed geotechnical evaluation to evaluate the current condition of the embankment and its foundation could cost between $150,000 and $250,000. Even following a rigorous geotechnical evaluation, there would be remaining uncertainties and risk associated with continued use of the facility, especially if it were raised or operated under higher hydraulic heads. Given the high costs for supplemental geotechnical investigations, with no guarantee of a positive outcome, and the likelihood that there would be residual uncertainties and risks at its conclusion, the project team was directed by the Sponsors and the WWDC to concentrate our resources and efforts on other solutions.

The Sponsor, WWDC and consulting team made a decision in May 2006 to investigate the Peaking No.2 site, as it was also one of the preferred locations for a new reservoir. In addition to this decision, the consulting team also recommended that the City consider removing the existing Atlantic Rim Reservoir from service as time allowed, and to replace that reservoir with a new one of equal size near the water treatment plant.

The remainder of this Chapter presents the conceptual design for a reservoir at the Peaking No.2 site location.

5.2 Conceptual Design

5.2.1 Reservoir Size

According to the water supply system model, a reservoir of between 100 and 200 acre-feet at a more optimal location could achieve the same existing reliability as the current Atlantic Rim Reservoir. Currently, Atlantic Rim Reservoir active capacity is limited to approximately the middle third of the total reservoir volume since the reservoir can not be filled due to leakage problems, and the bottom third can only be accessed by siphon since there is a hill at higher elevation on the pipeline between the reservoir and the treatment plant.

The 100 to 200 acre-foot volume should be added to the 500 acre-feet recommended in the Water Supply Evaluation (Chapter 3), which recommended
adding a reservoir of 500 acre-feet to lock in the present level of reliability through drought and growth scenarios. The resulting size is conveniently similar in capacity to the present permitted storage for Atlantic Rim Reservoir at 644 acre-feet. It appears that preserving the present storage right would align with the projected needs of the City.

5.2.2 Reservoir Design

A 644 acre-foot reservoir was designed for the Peaking No.2 site. The preliminary reservoir design layout is shown in Figure 5-1. The design consists of a quasi-rectangular reservoir adjacent to the existing Peaking Reservoir and the City’s water treatment plant. The high point for the reservoir layout is on the southeast side at 7160 feet and gently slopes down to 7115 feet on the northwest side of the layout. Along the northeastern side of the reservoir, the site also slopes downward into a small drainage that empties into the gulch below.

The crest of the embankment is at 7160 feet with a high water level (HWL) of 7155 feet. The upstream slopes will be a 3H:1V with a 20 foot wide crest and a 2H:1V downstream slope. The reservoir will be impounded by a cutslope on the southeast side into a shallow ridge. On the remaining sides, an embankment dam up to 45 feet in height will be constructed. On the southwest side of the embankment, the downstream toe of Peaking No. 2 site will abut the downstream toe of the existing Peaking Reservoir. The bottom floor of the reservoir will be excavated approximately 8 feet deep for two reasons: to gain additional reservoir capacity and provide earthen material for construction of the embankment. Once the reservoir and embankment foundations have been excavated to final grade, the rock surfaces should be cleaned and inspected, and large fractures and joints (larger than about ½-inch wide) should be slush grouted.

The reservoir bottom will then be lined with a geotextile and 2 foot thick clay liner consisting of material from the Atlantic Rim borrow source. The purpose of the geotextile is to span the gaps between bedrock fracturing so that there is not a substantial clay material loss into those fractures. Figures 5-2A and 5-2B display four typical cross-sections through the proposed embankment and cut slopes.
EXISTING WATER TREATMENT PLANT

EXISTING ATLANTIC RIM PIPELINE

EXISTING PEAKING RESERVOIR

FIGURE 5-1
RAWLINS, PEAKING NO.2 RESERVOIR DESIGN LAYOUT

GRAPHIC SCALE

300 0 150 300 600

(IN FEET)
NOTE: SECTION LOCATIONS ARE DESIGNATED ON FIGURE 4.
NOTE: SECTION LOCATIONS ARE DESIGNATED ON FIGURE 4.

HORIZ. AND VERT. SCALE: 1"=40'
Primary construction material will consist of weathered sandstone and siltstone. Material over 6 inches in size will be removed prior to embankment construction. Embankment material should be compacted to at least 95% of the maximum dry density at moisture contents ±2% of optimum, as determined by ASTM D-1557.

5.2.2.1 Upstream Slope Protection Alternative A

Option A for lining the upstream slope consists of a covered geomembrane system. The system is detailed in Figure 5-3. The embankment fill will be covered with a 2 foot thick sand layer which serves as both a drainage layer and a protective bedding for the geomembrane. The sand layer will extend beneath the dam embankment and will drain towards a perforated pipe collector drain at the downstream toe. The geomembrane (45 mil PVC) will be sandwiched between two geotextiles above the sand layer along the slope. The 7-8 oz/yd² geotextile will serve as a cushioning material to protect the membrane from punctures and tears. The next layer will be another 2 foot thick sand cover to keep the membrane in place and protect it from the elements (such as UV rays, burrowing animals, off-road vehicles). This layer will also serve as riprap bedding. The top and final layer will be 2 feet of riprap. Approximately 60 percent of riprap quantity can be salvaged from the existing Atlantic Rim Reservoir. The remaining quantity will need to be imported. The riprap slope cover will protect against scour of the sand from wave and wind action.

5.2.2.2 Upstream Slope Protection Alternative B

Option B for lining the upstream slope consists of an exposed geomembrane system. The system is detailed in Figure 5-4. Similar to option A, the embankment fill will be covered with a 2 foot thick sand layer for bedding and drainage. The upstream sand drain layer will be contiguous with a 3-foot thick sand blanket drain layer that is graded to drain to a collector pipe at the downstream toe. Above the sand layer is a
OPTION A
COVERED GEOMEMBRANE

ZONE 4
ZONE 3
ZONE 2
ZONE 1

NON-WOVEN GEOTEXTILE
PVC GEOMEMBRANE
NON-WOVEN GEOTEXTILE

EXTEND GEOMEMBRANE 10' ONTO RESERVOIR BOTTOM
2' CLAY LINER

GEOMEMBRANE BETWEEN TWO GEOTEXTILES

1' ZONE 2
2' ZONE 4
1' ZONE 3

ZONE 1 - EMBANKMENT (SILT, SAND, GRAVEL AND COBBLES UP TO 6-INCH)
ZONE 2 - DRAINAGE LAYER (CLEAN SAND AND GRAVEL)
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

PREPARED ROCK FORMATION SURFACE

6" GRAVEL SURFACING
20' CREST

NORMAL HIGH WATER LINE
ELEV 7155

ZONE 2 - RIPRAP
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 1 - EMBANKMENT (SILT, SAND, GRAVEL AND COBBLES UP TO 6-INCH)
OPTION B
EXPOSED GEOMEMBRANE

ZONE 1 - EMBANKMENT (SILT, SAND, GRAVEL AND COBBLES UP TO 6-INCH)
ZONE 2 - DRAINAGE LAYER (CLEAN SAND AND GRAVEL)
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

ZONE 1 - EMBANKMENT
1' ZONE 2 - EXPOSED GEOMEMBRANE WITH GEOTEXTILE UNDERNEATH
NORMAL HIGH WATER LINE
ELEV 7155
6" GRAVEL SURFACING
DAM CREST ELEV 7160
20' CRESTM
2' CLAY LINER
NON-WOVEN GEOTEXTILE ONLY
PREPARED ROCK FORMATION SURFACE

ZONE 2 - DRAINAGE LAYER
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

ZONE 1 - EMBANKMENT
ZONE 2 - DRAINAGE LAYER
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

FIGURE 5-4
RAWLINS, PEAKING NO.2 RESERVOIR LINER OPTION B
non-woven geotextile to protect the exposed geomembrane. This design was considered because the exposed geomembrane facing would provide a reliable, robust water barrier, and would eliminate the need for riprap upstream slope protection.

5.2.3 Reservoir Outlet and Inlet Piping

WWC Engineering met with the water treatment plant operators to discuss facilities for filling and draining the proposed reservoir. A conceptual design for those facilities is included on Figure 5-5. Note that the operators preferred the reservoirs be operable in parallel, with interlinked hydraulics based on equal design highwater levels. However, the current design shows different design highwater levels which will be more complex to operate. Design highwater levels should be further evaluated.

The outlet for the new reservoir would be similar in style to the existing Peaking Reservoir, with a free standing tower intake in the reservoir. The intake would have ports at several elevations to allow for selective water withdrawal. The outlet conduit would be buried below the bottom of the reservoir, backfilled with concrete and routed to connect to the existing inlet/outlet pipeline in the valve vault at the west side of the existing Peaking Reservoir. The Atlantic Rim Pipeline connects to this same existing vault just west of the Peaking Reservoir.

Water from the Sage Creek Springs would come through the Atlantic Rim Pipeline, through the described vault, then finally into each reservoir through the outlet/inlet conduits. As long as both outlets to both reservoirs remain open, the reservoir levels would rise and fall together. The new inlet/outlet conduit would be a minimum of 24 inch diameter. Final design calculations would have to demonstrate that the outlet could drain the reservoir sufficiently fast so as to meet dam safety evacuation criteria.

WWC also discussed with water treatment plant operators the option for providing a fine screening arrangement at the intake tower to reduce the inflow of small materials into the plant. However, plant operations and finished water quality would not appear to improve with these intake screens, and so that concept was not evaluated further.
NOTE: PROPOSED HIGH WATER ELEVATION NEEDS FURTHER STUDY WITH REGARD TO OPERATING NEEDS. THIS MAY REQUIRE CHANGES TO THIS CONCEPTUAL DESIGN.
An additional inlet piping system would originate at a tee off the North Platte Pipeline as shown in Figure 5-5. The pipe would be 18-inch diameter, the same size as the North Platte Pipeline. At this connection, gate valves would be installed so that the City could control which of the two reservoirs would receive North Platte River water.

More complex motor operated valves could be installed to direct water to one reservoir or the other, or both, but they are not directly included in the conceptual design cost estimate presented later in this chapter. The inlet end of the inlet piping in the reservoir would be located as far a practically possible from the outlet to reduce the probability of short circuiting. Isolation of one reservoir for repairs is provided in the design.

5.3 Water Right Considerations

The City of Rawlins currently has an adjudicated water right for Atlantic Rim Reservoir, Permit 8016 Res, for 644.5 acre-foot of capacity with a priority date of July 20, 1978. The City also has reservoir supply water rights to fill this reservoir from diversions from Sage Creek and from the City's Sage Creek basin network of springs. This reservoir has been used to temporarily re-regulate the supply of water from these sources and groundwater from the Miller Hill wellfield in combination with Rawlins Peaking Reservoir, to meet the municipal demands for water.

In order to maintain and protect the City's full portfolio of existing water right assets, and for the technical considerations elaborated elsewhere in this report, it is recommended that the City pursue the transfer of the location of the entire storage water right for the Atlantic Rim Reservoir to the proposed new reservoir site. This will require a petition to the State Board of Control, seeking approval for the change in location of the storage reservoir water right. It is anticipated that this requested change will be more beneficial, and procedurally simpler than seeking a new reservoir water right for a new water storage facility.

The benefits of this approach are; first, the City will maintain the historic use and existing priority date for this reservoir facility. Second, it appears from
the water supply reliability analysis indicates that approximately 500 AF of storage would be required; the recommended long-term water rights strategy would be for the City to construct a facility at the full 644.5 AF capacity established for this storage water right at the preferred new location. Third, the City will be continuing the use the reservoir for the same historic beneficial purposes, and to provide both year-to-year carry-over storage and seasonal re-regulation benefits of the existing set of municipal water supplies. As a consequence of the continued increasing nature of enforcement, administration and regulation of water rights in the North Platte River system discussed in Appendix D, it is also recommended that the City continue to fully exercise and protect these existing appropriations of water, rather than to seek new permits for such a facility.

As a part of the recommended water right petitioning process for Atlantic Rim Reservoir, the City should also seek to clarify and describe the re-regulation operations of the City’s North Platte River water supplies since one of the benefits of the preferred alternative reservoir site is that it will allow for the management of the entire portfolio of municipal water supplies, including the North Platte River, along with the Miller Hill wellfield and the Sage Creek and Sage Creek Springs systems.

5.4 Cost Estimate

The total project cost estimate for the Peaking No.2 Reservoir (Slope protection Option A) and its associated inlet/outlet piping is $10,700,000. Appendix E presents the detailed cost estimate. The unit price data was obtained from bid tabulations from recent projects and the Means cost estimating publication.

5.5 Clearances, Easements and Permits

As part of this work, a Class III Cultural Resource Inventory was completed for the Peaking No. 2 reservoir site. The report on this work, included as Appendix G, found no cultural materials and recommended clearance.
Also as part of this work, a Biological Resources Clearance was completed for the reservoir site. The report presents the results of surveys for threatened, endangered, proposed and candidate species, BLM sensitive species and wetlands and other waters of the U.S. The report also provides information on big game winter range. The report on this work, included as Appendix F, recommends further consultation with BLM on surveys for some species, although in general the report does not identify any significant biological issues that would impact project feasibility.

Currently the BLM owns some of the land at the site for Peaking Reservoir No. 2. WWC contacted the Rawlins BLM real estate department to determine options for the City to acquire the land. Per conversation with Chuck Valentine, the following options exist for the City:

1. **Right-of-Way Grant**-The BLM could grant a right-of-way for reservoir construction/operation for a 30 year term, which is renewable. There would be little to no cost for this option. The water utility would also need access and transmission right-of-ways. This process for the BLM is neither automatic nor guaranteed, but can be done in a matter of months. Mr. Valentine indicated that other projects for WWDC (such as High Savery Dam) have been done using this mechanism. For a right-of-way grant, the BLM would require compliance with the NEPA process for environmental impacts, including involvement of the Wyoming SHPO, USACOE, U.S. Fish & Wildlife Service, Wyoming Game and Fish, FEMA, etc.

2. **Purchase Property**-Rawlins could purchase the property outright, but this would be a much longer process than the Option 1 and would require publication, notices, and it would have to be a competitive sale involving the risks of going to public auction.

3. **Long-Term Lease**-A long-term lease does not seem to be a preferred option by the agency (BLM) at this time.
If this location is chosen for the additional reservoir, WWC recommends that the City pursue Option #1 and obtain a right-of-way grant from the BLM for the construction and operation of the Peaking No. 2 site.
6.0 ATLANTIC RIM PIPELINE

6.1 Introduction

In 1997, the Rawlins Water Supply Project, Level II presented a conceptual design for the replacement of the existing Atlantic Rim Pipeline (ARP), between the Atlantic Rim Reservoir and the water treatment plant. At that time, a rational for replacement was that the ARP was not reliable enough during periods when the Peaking reservoir was off line and the Sage Creek Basin water delivery to the treatment plant was directly through the ARP. The plant operators had experienced at least a couple of pipeline failures during this operational mode, although the exact cause of the failure was not identified.

Due to planning decisions made during this current study, there is possibly additional rational for replacement of this pipeline, or restrictions on how it is used. If the Atlantic Rim Reservoir is abandoned and the pipeline extended to the water treatment plant, then the Sage Creek Pipeline system may not have the benefit of an intermediate location at which the “hydraulic grade line” is fixed by the reservoir water level (and standpipe at 33+80). Instead, the hydraulic grade line for a new closed pipeline system will increase operating pressures in the pipeline near the plant, especially when flows from the spring collection systems are throttled at the WTP. As noted in Section 6.4, the benefits and feasibility of operating a pressure pipeline have not been completely addressed by this study. Figure 6-1 presents pipeline hydraulic gradelines for the highflow and lowflow conditions. Unfortunately, the existing ARP asbestos cement pipeline does not have the pressure rating to handle the low flow condition in a closed pressure pipe, valve controlled operational mode.

The remainder of this chapter describes a conceptual design for a new pipeline between Atlantic Rim Reservoir and the water treatment plant.

6.2 Pipeline Design Capacity

Based on discussions with current operators, the Sage Creek Springs area peak discharge has not exceeded 3,600 gpm and the potential contribution from
the Miller Hill Well Field is about 400 gpm. Based on this information, a reasonable pipeline design capacity is 4,000 gpm.

From a water rights viewpoint, the design flow capacity would be slightly more. Current water rights of record for the Sage Creek basin (6.92 cfs = 3,100 gpm) and the Miller Hill Wells (1,350) total 4,450.

Finally, we note that one as-constructed drawing set for the Sage Creek Transmission Pipeline (Montgomery, 1988) indicates that the design flow could be as high as 6,340 gpm (1,340 from Wells and 5,000 from Springs), for a pipeline system with a booster station at the Miller Hill Wellfield junction.

Based on the above information, for the purposes of a conceptual design, we used the largest of the three values for pipeline design.

6.3 Conceptual Design

6.3.1 Alignment

As shown in Figure 6-2, the Atlantic Rim Pipeline (ARP) begins at the existing Atlantic Rim Reservoir and extends to the valve vault just south of the Water Treatment Plant (WTP). The new ARP will connect to the existing 24” steel transmission line from the wellfield and Sage Creek Basin springs at Atlantic Rim Reservoir and follow the alignment of the existing 18” ACP to the WTP. The ARP will end approximately at Station 120+00 with a connection to the existing valve vault which serves as an inlet/outlet from Peaking Reservoir No.1. A sleeve control valve is recommended for controlling line discharge and is included in the conceptual design.

The vertical alignment will follow the alignment of the existing 18” ACP and remain below the hydraulic grade line.

6.3.2 Material

The existing Sage Creek Basin Pipeline is a coated and cathodically protected steel pipeline. Steel pipe is recommended for the proposed ACP. Although steel pipeline requires cathodic protection, the City staff is trained on the maintenance of corrosion control for pipelines. Alternative materials such as
PVC and HDPE generally are very expensive for the pressure rating that would be required in this application.

6.3.3 Existing Utilities

No research was performed into existing utilities that are along the proposed alignment.

6.4 Hydraulic Design

WWC performed a hydraulic evaluation of the Sage Creek pipeline as it is proposed to be modified by this project. An EPANET pressure pipe model was assembled for the existing system based on partial as-constructed information (Montgomery, 1988). An important difference; however, is that the standpipe at 33+80 was not included in the model. The pipeline diameters and hydraulic grade line elevations are shown on Figure 6-1. The results of the evaluation show that a 24-inch pipeline between Atlantic Rim and Peaking will be adequate to convey the design flows presented in a previous section of this chapter. This finding is regardless of whether the line is run as it currently is with the 33+80 standpipe or in a full pressurized mode. This calculation should be confirmed during final design.

We note that it is possible that system hydraulics are controlled by the intake capacity of the spring box collection system, when Rawlins Reservoir is not hydraulically connected to the Sage Creek Pipeline. The hydraulics of the collection system, Rawlins Reservoir and the Sage Creek Pipeline require more study. The use of an open standpipe at 33+80 confirms that the City operates the system by taking all of the water they can collect, as opposed to controlling discharge in a valve controlled pressure pipe system. The feasibility of converting the Sage Creek Pipeline to a pressure system was not addressed in this study. Possible benefits include providing more precise flow control to the plant and providing energy to power plant functions (eliminating booster station).
6.5 **Cost Estimate**

The total project cost estimate for the 24-inch diameter Atlantic Rim Pipeline is $3,950,000. Appendix E presents the detailed cost estimate. The unit price data was obtained from bid tabulations from recent projects and the Means cost estimating publication.

6.6 **Permits and Easements**

The pipeline project will fall under the US Army Corps of Engineer’s jurisdiction. In accordance with Section 404 of the Clean Water Act, a Nationwide Permit will be required for a utility crossing of waters of the United States. A Nationwide Permit No.12 for Utility Line Activities must be acquired for the Atlantic Rim Pipeline.

The easement for the existing pipeline has not been researched. That document should be consulted to ensure that adequate right of way exists and that pipe replacement work is allowed under the easement.

Cultural resources inventories and wildlife clearances should be performed as were done for the reservoir.
7.0 PROJECT FINANCING

This chapter presents an analysis of project financing for the Peaking No.2 site and other projects. From this information, monthly fee increases to the end user were estimated.

The Wyoming Water Development Commission (WWDC) is the only State program available to assist the community with water system improvements projects such as a raw water storage reservoir. WWC assumed that all funding will come from the WWDC or the City.

At the present time, eligible rehabilitation projects receive a 67% grant and 33% loan arrangement. The loan portion of the financing, if needed, does not have to originate from the WWDC. But if it does, the present loan rate is 4% for a 30 year (negotiable) term.

Table 7-1 presents the project cost estimates, project financing and estimated rate increase required to retire project debt and operational costs. Based on the results of 2004 Water Survey Report (WWDC, 2004), the number of taps in the Rawlins area is estimated at 3,907. Currently the average water bill in Rawlins is $17.00, and the average water bill for the state is $25.49, a difference of $8.49. The average billing rate in Rawlins is 33% lower than that of the state, while the average mean income is 17% lower (WWDC, 2004). Assuming that an affordable rate increase for the citizens of Rawlins should be proportional to average incomes, meaning that they can afford to pay 83% of the average state water bill, the citizens could afford the Peaking No.2 Reservoir project. This project has an estimated $6.28/month/tap water rate increase.
### Table 7-1 Project Financing

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<th>GRANTS AND LOANS</th>
<th>Peaking Reservoir No. 2</th>
<th>Peaking Reservoir No. 2</th>
<th>Atlantic Rim Pipeline</th>
<th>Assertive North Plate Pumping</th>
<th>No Action</th>
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<td>option A</td>
<td>option B</td>
<td>without Reservoir</td>
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| B GRANTS | | | |
| 1 Total of WWDC Grant Eligible | $14,650,000.00 | $19,150,000.00 | $3,950,000.00 | $5,200,000.00 | $5,200,000.00 |
| 2 WWDC Total Grant (67% of Cost Est.) | $9,815,500.00 | $12,830,500.00 | $2,646,500.00 | $3,484,000.00 | $3,484,000.00 |

| C LOANS | | | |
| 1 WWDC Loan Amount (B1-B2) | $4,834,500.00 | $6,319,500.00 | $1,303,500.00 | $1,716,000.00 | $1,716,000.00 |

| USER COSTS | | | |
| ANNUAL LOAN PAYMENTS | | | |
| 1 WWDC | | | |
| $279,579.61 | $365,457.31 | $75,381.53 | $99,236.45 | $99,236.45 |

| ANNUAL OPERATIONS AND MAINTENANCE | | | |
| 1 Based on NRCS project data | | | |
| $15,000.00 | $15,000.00 | $15,000.00 | $192,000.00 |

| TOTAL COSTS (A +B) | | | |
| $294,579.61 | $380,457.31 | $90,381.53 | $291,236.45 | $99,236.45 |

| WATER RATES | | | |
| Current Average Monthly Water Bill = | $17.00 | | | | |
| 1 Calculated Rate increase | $6.28 | $8.11 | $1.93 | $6.21 | $2.12 |
REFERENCES


Wyoming Department of Transportation’s (WYDOT) Endangered, Threatened, Candidate & Proposed Species Resource Manual (1999)

MEMORANDUM

To: WWC Engineering File JN 2005-173, Task 3

From: Stan Miller
Murray Schroeder

Date: December 8, 2005, Revised 7/6/2006

RE: Water Supply Reliability and Reservoir Storage Evaluation

1.0 Objective

This study was performed to evaluate the reliability of the existing Rawlins water supply system and to evaluate how much additional raw water supply storage would be needed to maintain this reliability under scenarios of future water demand growth and or water supply shortage. The study assumes compliance with permitted water rights for the City’s three water supply sources, takes into account the physical characteristics of the existing reservoir storage and conveyance systems, and reflects hypothetical demand increase scenarios.

2.0 System Overview

Figure 1 is a schematic showing the relationship of the system elements that the evaluation considered. This water supply system is typically operated as described in the following: Water from Sage Creek Basin is preferred because it flows via gravity (no pumping) and is of good quality (requires little treatment). If the Sage Creek supply can meet the municipal water demand, no additional sources are used. If demand exceeds the water available from Sage Creek, then the Miller Hill wells may be used, though the water does not meet the current EPA MCL for sodium and can not directly be sent to the water plant without first blending in a reservoir. Next, if the demand is a little more than can be supplied from the Sage Creek and Miller Hill, then first Peaking reservoir and then Atlantic Rim reservoir may be tapped to provide water. The North Platte River supply is pumped as a last supply choice, because of the relatively high cost of pumping and additional treatment required to meet turbidity requirements. From the data supplied by Rawlins it appears that the North Platte River has not historically been pumped to fill the reservoirs, so the basic model was set up to reflect this. Any solutions to projected water shortages should reflect the relative costs and quality issues presented in this section.

3.0 General Approach

Together, six approaches were used to evaluate the reliability of the water supply system, including:
3.1 Use of actual system operating data and gaging station records where possible to characterize system variables and provide a basis for forecasting future conditions. An example of this was the use of historical water plant production data to establish a basis for estimating future water demands.

3.2 The synthesis of system data where actual data was not available. As an example, the hydrologically available water supply in the Upper Sage Creek basin is an important consideration. However, there is very little stream gauging data that provides an estimate of virgin flows from the basin. For this reason, an estimate of virgin flows was made using a published relationship using drainage area and elevation.

3.3 Consideration for the variability of data. All of the water supply system variables have some degree of uncertainty and variation. This evaluation considered that variation by characterizing water supplies in terms of statistical distributions wherever possible.

3.4 Simulation. Evaluations included making multiple forecasts (20) of system variables over a 50 year period, aggregating and interpreting these multiple run results. This method is a Monte Carlo simulation approach.

3.5 Perform a mass balance or water accounting of the various water supply inputs and demands. This method included considerations for reservoir geometry, evaporation, pipeline capacity constraints, water rights and other physical considerations.

3.6 The modeling work was done in a spreadsheet.

4.0 Detailed Background, Modelling Methods and Assumptions

The following is a detailed description of the methods and assumptions used in the water system reliability evaluation. In addition, this section presents general background information about the supply system.

4.1 Upper Sage Creek Basin – Sage Creek Springs and Rawlins Reservoir

- The Sage Creek Springs are the primary source of water for Rawlins and are located about 26 miles south of the City in the Sierra Madre Mountains just east of the Continental Divide. Discharge from the springs is either collected by an infiltration collection system and delivered to the City via a pipeline, or the springs discharge water to the area drainages. The area drainages form the headwaters of Sage Creek, in which the Rawlins Reservoir is located. The drainage area contributing to the spring collection system and Rawlins reservoir is herein referred to as the Upper Sage Creek Basin. Figure 2 shows the water supply features of this area.

- The Sage Creek Springs system is the preferred source of water because it is the least expensive and best quality water supply. Thus, the model attempts to satisfy demands with this supply first, before reverting to meeting demands with other direct flow groundwater or stored water supplies. The operating logic and assumptions for this and the other water supplies are graphically presented in Figure 3.

- According to water operators, the Sage Creek Springs pipeline has never been shut down and the pipeline has historically taken all the water that can be collected. Water is passively collected by approximately 26 spring boxes with lateral piping systems, linked to a series of transmission lines that eventually connect to the Sage Creek Springs.
Transmission Line. Because of the passive collection system, un-impeded by operational decisions, the Sage Creek Spring Collection (SCSC) flow is a measure of spring productivity both in magnitude and annual distribution. Figure 4 presents the historical SCSC data, which has averaged 3.138 cfs with a standard deviation of 0.525. The evaluation assumes that the annual average flow has a normal distribution. The model forecasts SCSC by randomly sampling the normal distribution of annual flow. These annual SCSC values are distributed by month using the historical average monthly distribution (as a percentage of the annual total) for the 1988 to 2005 period of record.

• To evaluate the ability of the Upper Sage Creek Basin to meet the senior irrigation water right on Sage Creek and the demands of the City, it was necessary to generate an estimate of the virgin yield on Sage Creek. However, there are not enough stream gauging records in Sage Creek alone to estimate the hydrologically available virgin flows from the Upper Sage Creek Basin (VFUSCB), therefore, WWC used an approach presented in “Floodflow Characteristics of Wyoming Streams” (Druse, Lowham, Cooley, and Wacker – 1988. The method uses stream flow data from 190 gauging stations in the mountainous regions of Wyoming to generate a regression equation to predict surface flows in ungauged streams based on basin size and elevation data. The estimates derived from the published method are then adjusted for the fact that the distribution of actual spring flows is probably different than distribution of VFUSCB, which is a surface water/snowmelt runoff. This entire approach is fully presented in the next few paragraphs.

  o From USGS topographic maps, the Upper Sage Creek Basin has a contributing drainage area of 12.1 square miles and a mean area-weighted elevation of 7,891.6 ft. Using Table 1 from “Floodflow Characteristics of Wyoming Streams”, pg. 27), the average annual VFUSCB is estimated at 7.16 cfs, with a standard deviation of 4.08. A check using the area/precipitation calculations given on Table 2 (pg. 28) of the same publication, this average annual flow equates to an annual precipitation of 16.28 inches. NRCS weather station data at Divide Peak indicates that this flow is a reasonable expectation.

  o The average annual VFUSCB estimated above is an average, with variation expected from year to year. The hydrologic evaluation of this current study accounts for the variability in this basin yield by considering the annual Upper Sage Creek Basin yield to be a normally distributed random variable, with a mean and standard deviation. Figure 5 presents the assumed normal distribution of annual basin yield from the Upper Sage Creek Basin.

  o There is some gauging data for Sage Creek below Adams Reservoir (station #USGS 06628700) which corresponds to a larger drainage area (24.5 sq. mi.) than the area contributing to the Upper Sage Creek Basin. This gauging station was recorded from 10/1/1966 to 9/30/1968 and has an average flow of 4.30 cfs. Since the City was collecting spring discharge at that time, this data is first used as a check on the upper basin yield estimates. Although the period of record is short, it indicates that if the City were taking water through this period that the City was not depleting all of the water resources in the basin and that there is a reason to believe that some level of other use could be supported. Secondly, this data was used as a basis for estimating the monthly distribution of Upper Sage Creek Basin flows. In other words, the monthly distribution of flows from the Upper Sage
Creek Basin was assumed to follow the same monthly distribution of the 06628700 gauge as a percentage of the annual flow. That raw data and the annual distribution of flows are also presented on Figure 5.

- The evaluation removes all the SCSC from the VFUSCB flow to provide an estimate of "spring depleted" surface water flow that is available to meet the senior downstream irrigation right or to be stored in Rawlins reservoir. The model checks to see if the irrigation demand can be met directly, if not it is met via a release from Rawlins Reservoir.

- Several springs tapped by the Rawlins system are in the Beaver Creek basin which does not contribute inflow to Rawlins Reservoir, however, the net effect of the Springs collection on the total basin surface flow is the same. The only discrepancy with the model is that the model may slightly underestimate the amount of water available to be stored in Rawlins Reservoir.

- We note that in the 1983 Water Master Plan (Montgomery, 1983) the hydrology of the Upper Sage Creek Basin was examined. That effort used a hydrologic regionalization method to prepare an estimate of basin yield available to the City. Figure 6 compares those estimates to the estimates of this study.

- Rawlins Reservoir is located below the spring collection area. Although this reservoir can be used to meet City demands, the model was run assuming that it is not used in this manner. As has been a recent City practice, the reservoir has been used to store water for later release to a downstream irrigation right (Permit No. 1192) that is senior to the spring rights held by Rawlins.

- The model assumes that the senior irrigation water (Permit No.1192) demand is a constant 3.29 from March 15 to August 31. Later, a scenario was added to evaluate the effects of extending the irrigation season to September 30.

- The capacity of Rawlins reservoir is assumed 80% of the original design/permit size of 624 acre-feet and it can be drawn down to a 100 acre-foot inactive pool.

- The senior water irrigation deficit for Sage Creek is estimated using the gauging station data from USGS station 06628800 (SAGE CREEK NEAR SARATOGA, WY - data: Figure 7) which was operated from May 1973 to September, 1981. This station is apparently located at or very near the head gates of the irrigation project served by permit 1192. The future projections for Sage Creek surface flow are estimated by linking the variance in projected basin flow to the basic variance in pipeline collection.

- Because the spring water collection system collects water from shallow underground aquifers (undoubtedly related to the snow pack melt), the monthly distribution of collected flows are not in synchronicity with the monthly distribution of surface water runoff.

4.2 Pipelines
• The 24" transmission pipeline from Sage Creek Basin to Atlantic Rim Reservoir has a capacity of 3,000 gpm (6.68 cfs). However, the maximum flow recorded in the pipeline was 7.28 cfs which exceeds the firm water right amount of 6.92 cfs.

• The 18" pipeline from Atlantic Rim to Peaking and the treatment plant has a capacity of about 4,700 gpm (10.5 cfs). This capacity is based on the hydraulic head difference between the two reservoirs and assumed pipeline geometry, and is not based on other pipeline capacity criteria such as allowable velocity.

• The Sage Creek basin pipeline picks up the Miller Hill well field production and is designed to carry 3000 gpm (6.68 cfs), though booster pumps could increase the flow to about 6300 gpm. Based on the highest flow recorded for the period of record, the actual maximum flow is about 3400 gpm (7.28 cfs). Since the pressure differential between the Sage Creek flow and the Miller Hill wells will vary, the percentage contribution of each source may vary somewhat, however, we have used the historical production from each to form the basis of our predictive model. If the flow from Sage Creek and Miller are projected to exceed 7.28 cfs, the predicted production from Miller is reduced to avoid exceeding the pipeline capacity. Since the production from Sage Creek is usually limited to the 6.92 cfs water right, the model will never allow this portion of the flow to exceed the pipeline capacity by itself.

4.3 Reservoirs

• Reservoir evaporation for existing reservoirs is accounted for using the full reservoir water surface area and the average evaporation as reported from the Pathfinder Dam recording station (data from 1949 to 1979 – Wyoming Climate Atlas, Brooks E. Martner, 1986, pg. 178).

• For Atlantic Rim Reservoir there is a significant leakage rate as reported by the City, though this loss factor is has not been reduced to account for decreasing head as the reservoir level is reduced. The model accounts for these losses.

4.4 Miller Hill Well Field

• Water from the Miller Hill well field is the second preferred source, especially from a cost standpoint since the wells are artesian and do not require pumping. They feed into the same Sage Creek pipeline and can supply either the Atlantic Rim or Peaking reservoirs or the Treatment Plant.

• Water from the Miller Hill Well Field exceeds the EPL MCL on sodium, and the model assumes that the Wells will provide at most 50% of the water in any month.

• The future production and monthly distribution of well production is assumed to be the historical average of the well production as reported from 1988 to 2005. Although there is a trend toward taking less water from the wells, the model assumes that the annual production over the planning horizon remains relatively constant, with the wells being used mostly from July to September.
4.5 North Platte River

- This resource is used as a source of last resort since the water requires pumping and more costly treatment (for turbidity) than the other sources. However, this supply has proven to be historically reliable under any scenario, including drought, such as the 2000 to 2005 drought period.

- Rawlins has 3.01 cfs of senior (1901) water rights in the Platte, but at times, these are exchanged for the use of water in the Sage Creek Basin, if available. The model assumes that this is always true from February to May 31, the period historically affected by the North Platte River calls. During this period, the model assumes water in excess of 3.89 cfs taken from Sage Creek will reduce the amount that can be taken from the North Platte by an equivalent amount up to 3.01 cfs. During the rest of the year, the water is available in the North Platte, however, it is only tapped when needed. An additional 1.21 cfs of senior priority water from the North Platte is available under an agreement with Sinclair, but the affect of this right was ignored since the operator expressed a preference for not pumping more than would be absolutely necessary.

- North Platte river water is currently used for watering the golf course (prior to treatment and not requiring re-pumping to the Peaking reservoir), but it can also be pumped into the Peaking reservoir. Historically, the North Platte River water has not usually been used to fill Peaking reservoir because of the cost.

- Generally, the quality of the river water is lower than the Sage Creek water, and becomes sporadically turbid after rain events, especially in the fall season when there is less total water in the river.

4.6 Municipal Demand

- The historical production data for the Rawlins water treatment plant shows there is a slight growth trend in the water usage for the service area, which was recently increased due to water being sold to Sinclair. According to the data in figure 9 water use appears to be increasing at a rate of 0.001028 cfs per month, resulting in a projected growth of about 30% over the 50 year planning horizon.

- The water demand growth rate includes industrial and commercial use as well as an increase in gallons per capita per month over time. The population served by the system is projected to decrease slightly in the near term, but the City has indicated that they project long term growth. It seems prudent at this time to at least use the growth trend based on the historical increase in water treated at the plant. Additional model runs were made with more elevated growth rates to test the system under those conditions.

4.7 Golf Course Demand

- The golf course has a total of 70 acres of turf under irrigation and has been in operation for two years. Based on the acreage and the consumptive irrigation data for Rawlins taken from “Consumptive Use and Consumptive Irrigation Requirements in Wyoming”,

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Page 6

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(Pochop, Teegarden, Kerr, Delaney, and Hasfurther – 1992), the golf course demand is projected to be between 34 and 55 million gallons (MG) per season.

- The actual water metered to the golf course in 2004 was 137 million gallons, but during this time the golf course was being established. In 2005 the water used was around 50 MG.

- The model projects the golf course water demand by use of an inverse normal distribution of the projected SCSC. The logic of this adjustment is that in years of less SCSC there should be higher irrigation demand since the decrease in production is probably caused by a reduction in weather moisture. The method of calculation is the inverse of that used to project the Sage Creek surface runoff. As an example, if SCSC is projected to be 1 standard deviation below normal in a given year, the water demanded by the golf course is projected to be 1 standard deviation above normal in that same year.

5.0 Model Simulation

5.1 General

To provide monthly estimates of Sage Creek Springs Collection (SCSC), normally distributed random values were generated with a random number generation scheme in the spreadsheet. These estimates were generated for the 50 year planning horizon. For each SCSC estimate the corresponding VFUSCB and Rawlins Golf Course demands were generated and a mass balance was performed using the system inflows and outflows and reservoir levels. If there was a net positive balance between available water and the municipal demand, water was added first to the Peaking Reservoir, then to the Atlantic Rim Reservoir unless both were full, in which case the water was “spilled”. The operational logic in Figure 2 was applied.

In some instances, but very few, conditions were such that all model criteria could not be satisfied while meeting the municipal demand. In other words, reservoir levels were exhausted and the combined direct flow of supply was less than monthly demand. These cases were identified as “failures” to meet the demand and these occurrences were counted. Each 50 year simulation was performed 20 times to provide a large number of solutions, from which average values for system “failure” could be abstracted. Next, the percentage of months that demand and criteria were satisfied was calculated (100 - % failure) to provide an estimate of what this study defines as “system reliability”.

Several scenarios were evaluated that considered a range of assumptions regarding the following model variables:

- Sage Creek Spring Collection
- North Platte pumping strategy
- Municipal water demand

5.2 Scenario No. 1 – Baseline
This scenario assumed that the SCSC system would collect spring water at a rate typical of historical levels, that the Platte River system would be pumped only as needed (as is current operation), and that water demands would increase modestly over the planning horizon, which is about 30% from 2005 conditions.

This scenario results in an average system failure rate of 7.2 supply shortage months over the next 50 years, which equates to a system reliability of 98.8%. Attachment A is a partial print out of spreadsheet model input and output. With careful study the reader should be able to understand the general arrangement of the spreadsheet, but is referred to the Project Notebook for a complete printout and model documentation. In addition, approximately 351 acre feet of water would need to be pumped from the North Platte River on average per year.

5.3 Scenarios A and B: Drought Conditions

To evaluate a lengthy drought cycle, we input into the model a string of five consecutive years of annual SCSC values that were at 2 standard deviations lower than the mean of 3.138 cfs. This annual drought flow was 2.09 cfs. The results of this effort are as presented in Table 1. The projected drought scenarios are more severe even than the recent drought in which the annual SCSC values fell to 2.78 cfs in 2003. This value is roughly 1 standard deviation below normal.

The data in Table 1 indicates that if Rawlins wishes to maintain the same level of system reliability during a severe drought period as during average conditions, then additional reservoir storage and more assertive pumping will be needed. Table 1 shows that it will be necessary to rely more fully on the active pumping of the Platte river supply, in conjunction with a storage increase to 400 to 500 acre-feet (to keep the mean number of failures to around 7 or the reliability equal to that from the base, Scenario 1).

Table 1 also presents the results for a "minor" drought cycle evaluation. The minor drought cycle included 5 continuous years of SCSC at 1 standard deviation less than average. The result was that there was no appreciable difference in the reliability of the water supply system when compared to the Scenario 1 conditions.

The 1983 Montgomery report used a "100-year drought condition" on the upper basin that estimated a surface flow of 0.7 cfs during those conditions, while our model used a surface flow of 0 cfs under the drought condition, which is quite conservative and would imply an insignificant snow pack for the year. However, even under these conditions, according to the model, the Sage Creek Springs would continue to generate 2.09 cfs for Rawlins, which is slightly higher than the Montgomery study assumed, yet is based on the 17 years of historical record. A comparison of the current assumptions with the Montgomery study is presented in Figure 6.

5.4 Scenario 2 – Assertive Platte River Pumping

The North Platte River supply utilization rate has a significant effect on the water system reliability. As currently operated, the City does not generally pump more than the amount of water required for the golf course from the North Platte River. Although not exactly the same as current operation, the previous scenario (1) mimicked this
operational strategy by pumping only when demands were not being met by all other combined resources.

Scenario 2 was modeled to evaluate the operational strategy of providing as much water as possible from the North Platte River, either as a direct flow supply or one that could be stored in Peaking Reservoir. This strategy will result in higher pumping (and treatment) costs, especially since the cleaner water from Sage Creek will more often be stored in the Atlantic Rim reservoir while the demand is being met with North Platte River water. The model run operating strategy was applied to the Scenario 1 baseline model assumptions.

Scenario 2 resulted in an average of 3.8 shortage months (0.60%) over the 50 year planning horizon. This equates to a system reliability of 99.4%. To achieve this, the North Platte would require pumping 1020 acre feet of per year on average.

5.5 Scenario C – 20% Demand Growth

This scenario is exactly the same as the base Scenarios Nos.1 and 2, except that the current City demands are increased by 20% during the planning horizon, from 3.03 cfs now to 4.06 cfs at the end of the planning horizon. The results of this scenario are presented in Table 1, but do not indicate appreciable increase in system failures.

5.6 Scenario D – 30% Demand Growth

This scenario is exactly the same as the base Scenarios Nos.1 and 2, except that the current City demands are increased by 30% during the planning horizon. This scenario projects that average demand after 50 years is 4.15 cfs, resulting in a slight increase in system failures as shown in Table 1.

Additional runs with this inflated growth scenario were made to estimate the size of reservoir enlargement that would be required to keep the system reliability the same as for present day conditions (i.e. as in Scenario 1). The required reservoir size is 100 Acre-Feet. From this data, it appears that the ability of the system to meet the water demand is much more sensitive to supply shortages than to demand increases.

5.7 Scenario E – Early Growth

This scenario is the same as the base Scenarios Nos. 1 and 2, except the projected demand growth over the 50 year planning horizon is all applied at the beginning of the planning period. Once the peak demand of 3.89 cfs is reached, the demand is kept constant for the rest of the planning horizon. As presented in Table 1, most of the increase in system failures can be countered with assertive pumping or with the creation of additional storage.

5.8 Scenario F – Failure of Atlantic Rim
This scenario took the base Scenarios Nos. 1 and 2, and assumed that the Atlantic Rim Reservoir was unable to contribute any storage to the model. This would happen if the leakage of the reservoir were to increase to the point that the reservoir was deemed unsafe. There was an increase of system failures from an average of 7.2 to 10.1 that could be resolved with 100 to 200 additional acre-feet of storage at Peaking (thus demonstrating that storage at Peaking is more efficient than storage at Atlantic Rim), or the deficit could be made up with assertive pumping.

An analysis of how sensitive the model was to the 0.66 acre-feet per day leakage at Atlantic Rim could discern no change in the number of expected failures whether or not the leakage from Atlantic Rim was included in the model.

5.9 Scenario G – Extending Sage Creek irrigation to September 30.

If the irrigation period for Sage Creek is extended to September 30, there is an increase of roughly 100% in the system failures. The original model assumed irrigation would cease at the end of August, based on the average growing season for the area shown in the Wyoming Climate Atlas. However, the irrigation rights normally extend to the end of September, regardless of the growing season, so an adjustment to the model was made to supply the senior irrigation rights for Sage Creek until September 30.

6.0 Summary and Recommendations

6.1 Based on the methods and assumptions used in this water supply evaluation, the existing water supply system has a reliability of about 98.8% for the Base Scenario. In other words, the modeling effort estimated that in 50 year planning horizon, there will be on average 7.2 months (in 600 total) in which system criteria are violated. Although we have not identified “reliabilities” in the literature for comparison, this level of reliability seems entirely appropriate. This value is not necessarily a standard that can be compared to other municipal systems, rather it is a standard against which the value of system improvements (such as adding reservoir storage) can be judged.

6.2 Assertive pumping from the North Platte River can obviate the need for constructing additional reservoir storage if demand increases remain as they have been historically (increasing slightly) and if hydrologic conditions are stable. Assertive pumping will cost more than supplies from gravity and those costs have not been quantified for comparison against reservoir storage costs.

6.3 A 30% increase in municipal demand over the planning horizon is the approximate threshold at which additional reservoir storage would be needed to maintain the present day system reliability of 98.8%. As above, assertive pumping would eliminate this need.

6.4 Modest drought conditions (five years at 1 SD below mean Sage Creek Spring Yield) can be tolerated by the water supply system without impact to system reliability.

6.5 Severe drought conditions (five years at 2 SD below mean Sage Creek Spring yield) result in slight impact to the system reliability. System reliability could be maintained at
present day levels by providing a combination of assertive North Platte River pumping and additional reservoir storage of between 400 and 500 ac-ft.

6.6 There are as yet non-quantified operational reasons to consider additional reservoir storage, including

A. Collecting and using higher quality water preferentially over lower quality water, which in turn may reduce treatment cost

B. Minimizing pumping costs

C. Situating additional storage to provide hydraulic benefits (additional head) to the existing Water Treatment Plant.

D. There is a security advantage in being able to supply water without reliance on pumping.

6.7 WWC recommends that the remaining efforts in Phase I of this WWDC program evaluate the feasibility of a 500 ac-ft reservoir (active capacity) in the area between the existing Peaking and Atlantic Rim reservoirs. This appears to be the maximum size that can be justified from a reasonable hydrologic/demand evaluation. The additional Phase I efforts should focus on equally important considerations such as technical feasibility (siting/geotech) and the economic feasibility of funding construction. Then, at the conclusion of Phase I, a recommendation can be made that considers all three of these critical factors.

6.8 The evaluation assumes that the water rights will continue to be applied as they have in the past; however, the agreements for allowing for servicing the irrigation rights on Sage Creek from Rawlins reservoir need to be formalized with the holders of those rights. If the use of Rawlins reservoir is restricted to Municipal use only, the estimated quantity of water available to Rawlins from the upper basin would not change, but the quality would be impacted—the Rawlins reservoir has historically had a taste and odor problem. Similarly, the arrangement whereby water rights on the Platte River are exchanged for an allowance to take water from Sage Creek should to be formalized lest the right to make this substitution is withdrawn. This is also for water quality reasons—a desired substitution of cheap, good quality Sage Creek Spring water for potentially less desirable Platte River water.

6.9 Proactive pumping from the North Platte River is beneficial, and reduces the need for providing reservoir storage. The model showed that by filling the Peaking reservoir with Platte River water before a projected decline in production and before an increase in demand could avoid almost half of the projected shortage events on the planning horizon.
RAWLINS WATER SUPPLY SYSTEM
HISTORICAL SPRINGS PRODUCTION
17 year historical record

CFS - BY MONTH

- cfs av.
- cfs max
- Right
- cfs min

jan feb mar apr may jun jul aug sept oct nov dec

6.94
Sage Creek Springs Collection - Frequency Analysis

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Average: 3.14
Standard Deviation: 0.52539
96% Confidence Interval: 2.88
RAWLINS WATER SUPPLY SYSTEM
ESTIMATED UPPER SAGE CREEK BASIN FLOW
Montgomery Report vs. current estimates

average annual cfs

- Springs Collection
- Upper Basin Surface Flow

Montgomery (M)
SCSC (current)
100 year drought
2 year drought
(current)

NO SCALE
Compiled data from 1973-1980 shows surface flows do not always meet 3.29 cfs irrigation needs at permit 1192.
RAWLINS WATER SUPPLY SYSTEM
SAGE CREEK SPRINGS
Calculated Surface Flows and Springs Collection

Average flow in cfs

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sept  Oct  Nov  Dec

6.94 firm water right

Average Springs Production.

Historical max.
Springs production.

Total estimated virgin stream flow.

Calculated average surface flow.

NO SCALE
RAWLINS WATER SUPPLY SYSTEM
ANNUALIZED WTP PRODUCTION GROWTH

growth factor: 0.1026%/month

---

WWW ENGINEERING

NO SCALE
APPENDIX B

Introduction

As presented in the body of this Phase II report, one objective of the project was to evaluate several potential reservoir sites in the project area, and to identify which one was suitable for more detailed investigation under Phase II of the study. The evaluation of alternative sites was performed during Phase I, and was limited to an evaluation of existing data.

Also as described in the Introduction to this Phase II report, there was a Draft Phase I report that never saw wide distribution and will not be finalized. Instead of finalizing the Phase I reservoir evaluation work in the form of a report, that material is included in this appendix for completeness. The material in the following sections is essentially the same material that was included in the Draft Phase I report:

B.1 Phase I Reservoir Siting Evaluation
B.2 Financial Evaluation
B.3 Alternative Evaluation

B.1 PHASE I RESERVOIR SITING EVALUATION

The Geotechnical Reconnaissance and Preliminary Design Recommendations memorandum at the end of this Appendix B documents the preliminary siting and design evaluation. The investigators compiled and reviewed existing subsurface data from previous investigations for the Peaking Reservoir and the Atlantic Rim Reservoir, and a preliminary site reconnaissance by Gannett Fleming’s senior geotechnical engineer, Debora J. Miller, P.E., Ph.D. on October 27, 2005.

B.1.1 Site Options

Five preliminary 500 ac-ft. reservoir sites were evaluated considering geological/geotechnical conditions. Cost estimates were developed for the options deemed practical. WWC assumed that the options described in the memorandum would
be included in the final alternative evaluation. The options presented in the memorandum are as follows, and are shown on Figure 3, Appendix B.

Option 1: Enlarging Peaking Reservoir No. 1 consists of raising the vertical grade of the existing embankment using a mechanically stabilized earth (MSE) wall system. However, from a construction standpoint, this option was not practical. A reinforced 1H:1V side slope configuration was also considered, but required a vertical raise of 35 feet to obtain 500 ac-ft. of storage. Based on these findings, this Option 1 was eliminated from further consideration.

Option 2: Construct Peaking Reservoir No. 2 consists of constructing a new 500 ac-ft. reservoir adjacent to Peaking No. 1 located on City-Owned Property. This option assumes that a two-foot clay liner would be necessary, and riprap erosion protection lining would be utilized for the cost estimate. Option 2 accounts for monitoring instrumentation, modification of outlet works, installation of new supply pipe, and providing an access road.

Option 3: Enlarging Atlantic Rim consists of raising the existing embankment of Atlantic Rim approximately 20 feet. This option includes a full geomembrane liner, monitoring instrumentation, modification of outlet works, modification of supply pipe, and providing an access road. This site is within BLM lands, and would require expansion of current easement or lease agreements. Technical issues related to seepage and soluble minerals in underlying soils are a factor to consider for this option.

Option 4: Construct Fivemile Ridge Reservoir consists of constructing a new reservoir and dam in the Fivemile drainage area southwest of Peaking Reservoir on Union Pacific Railroad (UPRR) owned property. Gannett Fleming (GF) assumed that foundation conditions are similar to Peaking Reservoir No. 1, and a one-foot thick clay liner would be necessary. GF also assumed that the reservoir would be supplied via the existing Atlantic Rim supply pipe which is in close proximity to the Fivemile site. Option 4 accounts for monitoring instrumentation, construction of outlet works, and providing an access road.

Option 5: Below Grade Basin initially consisted of the construction of a below-grade basin reservoir to minimize embankment placement costs, and to avoid permitting issues associated with a dam. Due to the depth required to reach the 500 ac-ft. capacity,
and the relatively shallow depth to rock, this option was not feasible from a constructability standpoint. Therefore, the option was modified to include a balanced cut and fill configuration. The site is located southwest of the water treatment plant across Highway 71, and spans privately owned and BLM lands. GF assumed that a clay liner and erosion protection similar to Option 2 would be required. Additionally, the supply pipe would be spliced into the existing Atlantic Rim supply pipe, and it would cross Highway 71. Option 5 accounts for monitoring instrumentation, construction of outlet works, installation of supply pipe, and providing an access road.

B.1.2 Environmental Considerations

Environmental resources (socioeconomic, cultural, natural, and physical) should be considered for the siting alternatives. These considerations include land use, cultural/historic resources, threatened and endangered (T & E) species, wildlife, fisheries and habitats, wetlands, and physical impacts that may occur during and after construction. Presently, little is known regarding existing environmental conditions of each reservoir site. For the purposes of the final alternative evaluation, it is possible that each reservoir alternative will have some type of environmental impact, and the exact nature and/or severity of the impact will need to be determined during the Phase 2 process.

According to the mapping resources in Wyoming Department of Transportation's (WYDOT) Endangered, Threatened, Candidate & Proposed Species Resource Manual (1999), the black-footed ferret is the only T & E species as having potential to exist within the project area. However, according to a USFWS letter of February 2, 2004, with attached table, a Block Clearance for black-footed ferret surveys has been issued for all black-tailed prairie dog colonies, and for white-tailed prairie dog colonies not included on that table. The project area is not one of those areas listed on the table, and the likelihood of a wild population of the black-footed ferret to exist at a site is low.

Consultation with Wyoming Game and Fish Department (WGFD) should be initiated to identify possible aquatic and terrestrial concerns. It is possible that construction timing restrictions could be imposed should the project area exist within
crucial winter range for game animals or in the vicinity of sage grouse leks or rearing habitats.

Wetlands are protected under Section 404 of the Clean Water Act (33 CFR 1251 et seq.) and are considered sensitive and valuable resources. During the Pre-Proposal Meeting (April, 2005), WWC observed possible wetlands in the Fivemile drainage area adjacent to the highway. Therefore, WWC assumed that the Fivemile Ridge Reservoir is likely to have environmental impacts. Due to the seepage at Atlantic Rim, WWC assumed that wetlands may exist at this location as well. WWC will conduct further wetland analyses, once conditions allow.

Typically, projects on BLM lands require a more extensive environmental impact evaluation. They may impose additional wildlife, surface disturbance, and visual resources assessments on any given project within their jurisdiction. The BLM will likely recommend a Class III inventory be completed for cultural and historic resources. Additionally, reclamation of slopes, construction zones, and material sources may require a special provision for noxious weed control. Based on these assumptions, and the fact that federal lands require a somewhat more extensive right-of-way engineering effort, alternatives on BLM properties have the potential to complicate matters.

Regardless of ownership, once an alternative is selected, a more thorough environmental resource investigation will be required.

B.1.3 Summary and Conclusions

Based on the preliminary geotechnical review and conceptual design study, Gannett Fleming evaluated the optional storage sites, and provided a screening value for each option considered (Table 7, Appendix B). The screening values ranged from 1 to 4: 1 having the most geotechnical/foundation constraints, and 4 having the least difficulties. Option 2 rated the highest at a 4, followed by Option 4, Option 5, and finally Option 3. Option 1 was eliminated. The least costly alternative is Option 5, raising Atlantic Rim, and the highest cost is Option 2, constructing Peaking Reservoir No. 2. Because there is significant uncertainty and potential safety risk associated with raising Atlantic Rim, Gannett Fleming recommended further action be taken to resolve seepage conditions at Atlantic Rim. Therefore, cost estimates for all alternatives that incorporated Atlantic Rim
as part of the total water supply system include an estimated additional cost for liner installation at Atlantic Rim.

**B.2 FINANCIAL EVALUATION**

Based on the results of the Water Supply (See Appendix A) and the Reservoir Siting Evaluation, WWC chose the following alternatives to be included in the Financial Evaluation.

- No Action
- Peaking Reservoir No. 2
- Enlarge Atlantic Rim
- Fivemile Ridge Reservoir
- Basin Reservoir
- Assertive Pumping

The financial evaluation examined capital construction costs, additional operating and maintenance costs, and funding resources that are associated with each alternative. From this information, an estimated monthly fee to the end user was estimated. WWC used the results of WWDC’s 2004 Water System Survey for the City of Rawlins’s number of taps in and outside of entity, and also for comparison purposes against state averages. Capital cost calculations associated with each reservoir alternative are included in the geotechnical and siting memorandum (Appendix B). Appendix B contains the Financial Evaluation calculations.

**B.2.1 Capital Costs**

Capital costs are based on Gannett Fleming’s cost estimates generated from the preliminary conceptual design analysis. Included in the capital costs are the estimated Construction Cost, Final Design and Specification Cost, Permitting and Mitigation Cost, Land Acquisition and Easement Cost, Engineering Cost, and a 15% of Construction and Engineering Contingency (Tables 3-6, Appendix B). WWC has incorporated the Atlantic Rim liner cost estimate (Table 8, Appendix B) into the initial capital cost estimates to
each alternative except Enlarging Atlantic Rim, where it is included in the construction cost. Table 2 summarized the total capital cost estimates for each alternative.
### Table 1-Adjusted Cost Estimates to Include Atlantic Rim Liner

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>Initial Construction</th>
<th>Peaking Reservoir No.2</th>
<th>Enlarge Atlantic Rim</th>
<th>Fivemile Ridge Reservoir</th>
<th>Basin Reservoir</th>
<th>Assertive Pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Action</td>
<td>$6,525,890</td>
<td>$3,863,602</td>
<td>$3,921,788</td>
<td>$5,400,141</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liner Construction</td>
<td>$872,000</td>
<td>$872,000</td>
<td>$0</td>
<td>$872,000</td>
<td>$872,000</td>
<td>$872,000</td>
</tr>
<tr>
<td>Permitting &amp; Mitigation</td>
<td>$50,000</td>
<td>$100,000</td>
<td>$100,000</td>
<td>$100,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Acquisition &amp; Easements</td>
<td>$80,000</td>
<td>$180,000</td>
<td>$180,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Design &amp; Specs (15% of Const.)</td>
<td>$130,800</td>
<td>$1,109,684</td>
<td>$579,540</td>
<td>$719,068</td>
<td>$940,821</td>
<td>$130,800</td>
</tr>
<tr>
<td>Const. Engineering (10% of Const.)</td>
<td>$87,200</td>
<td>$739,789</td>
<td>$386,360</td>
<td>$479,379</td>
<td>$627,214</td>
<td>$87,200</td>
</tr>
<tr>
<td>Sub Total</td>
<td>$1,090,000</td>
<td>$9,297,363</td>
<td>$5,009,502</td>
<td>$6,272,235</td>
<td>$8,120,176</td>
<td>$1,090,000</td>
</tr>
<tr>
<td>Contingency (15% of Const. &amp; Eng.)</td>
<td>$163,500</td>
<td>$1,394,604</td>
<td>$751,425</td>
<td>$940,835</td>
<td>$1,218,026</td>
<td>$163,500</td>
</tr>
<tr>
<td>Grand Total (Rounded)</td>
<td>$1,250,000</td>
<td>$10,690,000</td>
<td>$5,760,000</td>
<td>$7,210,000</td>
<td>$9,340,000</td>
<td>$1,250,000</td>
</tr>
</tbody>
</table>

Rounded to the nearest $10,000
B.2.2 Operating and Maintenance

Storage reservoir operating and maintenance costs for an earth embankment with 500 ac-ft. of storage capacity are estimated at $15,000 annually. This is based on a similar sized project for NRCS in Texas. Each reservoir alternative will require this amount of O & M costs with the exception of Enlarging Atlantic Rim. WWC assumed that O & M costs for this alternative would be increased by half the cost of a new reservoir’s earth embankment.

The assertive pumping regimen associated with the North Platte River Pumping Alternative primarily consists of additional O & M costs based on the existing equipment and pipelines that are currently in place now. However, Atlantic Rim rehabilitation is included as a capital cost. WWC assumed that no construction or up-front equipment costs are associated with the Assertive Pumping Alternative. These O & M costs account for an additional employee, pump replacement and repairs over a 10-year period of time, and electrical costs. See Appendix C for the North Platte River Pumping Alternative assumptions and equations. This alternative assumes that the water pumped will be stored in Peaking and mixed with higher quality water from Sage Creek. Therefore, the financial analysis does not consider additional treatment costs.

Table 2 summarizes the breakdown of the monthly O & M costs for the North Platte River Pumping Alternative.

Table 2-North Platte River Pumping O & M

<table>
<thead>
<tr>
<th>Item</th>
<th>Monthly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries and wages</td>
<td>$4,000.00</td>
</tr>
<tr>
<td>Parts and repairs</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>Pumping - electrical only</td>
<td>$11,000.00</td>
</tr>
<tr>
<td>Rounded to the nearest $1,000.00</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>$16,000.00</td>
</tr>
</tbody>
</table>
B.2.3 **Financial Resources**

The Wyoming Water Development Commission (WWDC) is the only State funding agency program available to assist the community with water system improvements projects such as a raw water storage reservoir. As a general rule, it takes 1 to 2 years to secure and begin construction using funding from these sources. Under Phase 1, WWC assumed that all funding will come from the WWDC.

At the present time, eligible rehabilitation projects typically receive a 50% grant and 50% loan arrangement. The loan portion of the financing, if needed, does not have to originate from the WWDC. But if it does, the present loan rate is 6% for a 30 year (negotiable) term.

During this year's legislative session, WWDC is asking for an increase in grant monies to a more favorable 67% grant and 33% loan arrangement, and a reduction in interest rates on loans to 4% for a 30 year term. The Financial Evaluation in Appendix B presents both scenarios.

B.2.4 **Monthly Cost to User**

Based on the results of 2004 Water Survey Report (WWDC, 2004), the number of taps in the Rawlins area is estimated at 3,907. Table 3 summarizes the monthly increase to water rates for each alternative under current and "favorable" WWDC financing. Currently the average water bill in Rawlins is $17.00, and the average water bill for the state is $25.49, a difference of $8.49. The average billing rate in Rawlins is 33% lower than that of the state, while the average mean income is 17% lower (WWDC, 2004). Assuming that an affordable rate increase for the citizens of Rawlins should be proportional to average incomes, meaning that they can afford to pay 83% of the average state water bill, the citizens could afford a $4.16 water rate increase.
<table>
<thead>
<tr>
<th>Monthly Water Rate Increase per tap</th>
<th>No Action</th>
<th>Peaking Reservoir No. 2</th>
<th>Enlarge Atlantic Rim</th>
<th>Fivemile Ridge</th>
<th>Basin</th>
<th>Assertive Pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Funding (50 / 50 6%)</td>
<td>$ 0.97</td>
<td>$ 8.60</td>
<td>$ 4.62</td>
<td>$ 5.91</td>
<td>$ 7.55</td>
<td>$ 5.07</td>
</tr>
<tr>
<td>Favorable Funding (67 / 33 4%)</td>
<td>$ 0.51</td>
<td>$ 4.67</td>
<td>$ 2.50</td>
<td>$ 3.25</td>
<td>$ 4.12</td>
<td>$ 4.60</td>
</tr>
</tbody>
</table>
B.3 ALTERNATIVE EVALUATION

WWC preformed a matrix evaluation of alternatives to account for quantitative and qualitative project benefits. The matrix approach is useful at eliminating alternatives from further consideration, or reducing the number of alternatives to those that merit further investigation.

The matrix presented in Table 5 includes the alternatives discussed in the geotechnical memorandum along with a No Action alternative and the Assertive Pumping alternative. The table lists each criterion that was considered in the screening process. Under the criterion, a value, or score, from 4 to 1 (4 being the best choice) is assigned to the specific definition as it relates to each alternative. In addition, the criterion is assigned a separate “importance” weighting factor. The numeric weighting factor (1-6 with 6 the most important) is an approximate indicator of the relative importance of the particular criteria in the selection process. The procedure for assigning weighting factors is not precise and it involves some judgment. One benefit to a weighting factor is the ability to adjust the “importance,” as new information becomes available. The value given is multiplied by the weighting factor, and the total score is the sum of all criteria. The ultimate goal is to choose the alternative with the highest score as the preferred alternative.

B.3.1 Alternatives

For the purposes of the final Alternative Evaluation, WWC assumed that the City of Rawlins desires to maintain the current reliability of 98.8%. Based on this assumption, a 500 ac-ft reservoir was chosen as the basis of the alternative analysis. This capacity was chosen because under severe drought conditions, combined with the assertive pumping regimen, the reliability of the water supply system over the fifty year planning horizon is comparable to current reliability. The 500 ac-ft of storage will not meet severe drought conditions under the minimal pumping regimen, but does increase the reliability for all other scenarios. This gives the City flexibility to initiate assertive pumping under extreme conditions.
The final alternative evaluation examines assertive pumping as an independent alternative. This is because it too increases (or maintains in Scenario F, Water Supply Evaluation) the system reliability under all conditions, but severe drought. Furthermore, the locations and determinations evaluated under the siting and design investigation define the reservoir alternatives in the final Alternative Evaluation. The primary purpose to separate pumping and reservoir storage alternatives is to differentiate between construction and operating costs and distinguish the funding availability between the two types of supply increases. In reality, a combination of the two supply sources proved to be most effective means to assure system reliability.

- **No Action:** This alternative refers to a do nothing scenario as far as increasing reservoir storage or pumping operations. However, Atlantic Rim Reservoir requires rehabilitation, and capital costs for this are considered in this and all other alternatives except enlarging Atlantic Rim. While system reliability may be met under base conditions for a 50-year planning horizon, more system failures will occur as drought and/or demand conditions increase.

- **Construct Peaking Reservoir No. 2:** This reservoir is located adjacent to Peaking Reservoir No. 1. It had the highest capital costs, but receives higher scores for efficiency, reliability, geotechnical, environmental, and land ownership.

- **Enlarge Atlantic Rim Reservoir:** Under this alternative, separate rehabilitation of Atlantic Rim is eliminated. This alternative had the lowest capital costs, but receives lower values for efficiency, geotechnical, environmental, and land ownership.

- **Fivemile Ridge Reservoir:** This alternative is located in the Fivemile drainage area, on UPRR property, and will more than likely include wetland impacts.

- **Basin Reservoir:** This alternative traverses private and BLM properties across Highway 71 from the water treatment plant. While the intention
was to reduce earth embankment and permitting issues, geotechnical constraints limited the success of this alternative.

- **Assertive Pumping from North Platte:** This alternative evaluates an operational strategy that provides as much water as possible from the North Platte River. This equates to an average 1020 ac-ft per year, and results in a 99.4% system reliability rating without additional reservoir storage, under base conditions. The capital costs associated with this project are minimal; however, O & M costs are not funded through WWDC, and are directly passed on the user.

**B.3.2 Alternative Screening Criteria Definitions**

- **Additional Benefits:** This criterion refers to beneficial elements of a particular alternative such as increased hydraulic performance. This criterion is not a major consideration in the overall selection process, and is weighted accordingly, as a 1.

- **Land Ownership:** Values are assigned to specific land ownership. Land ownership has the potential to increase costs and/or slow the construction process down. In the case of multiple owners, it is scored with the highest contributing value. Ownership is considered important in the final selection, and given a weighting factor of 2.

- **Environmental & Cultural Impacts:** This criterion refers to environmental and cultural impacts that occur with a given alternative based on the information readily available. Depending on the type of impacts, this criterion also has the potential to increase costs and slow, or even halt, construction. It is weighted as a 2.

- **Water Rights Issues:** This criterion is included for the alternatives that require a change to existing or additional agreements. While water rights issues are normally an important consideration, the alternatives considered here do not require extensive alterations to the current system. It is assigned a weighting factor of 2.
• **Geotechnical/Foundation Conditions:** This criterion rates the overall assessment of issues related to constructability, suitability of foundation of dam and/or reservoir construction, foundation treatment, etc. The values displayed come directly from the geotechnical memorandum. This plays an important role in the selection process and is given a weighting factor of 3.

• **Water Supply & Delivery Accessibility:** This criterion evaluates the accessibility to existing pipelines for water supply and delivery to and from the alternative location. This is closely related to other siting conditions, and is weighted as a 3.

• **Water Quality/Treatment:** For the purpose of this evaluation, it is assumed that the water quality is directly proportional to amount of treatment required for that source, which in turn increases cost. For that reason it given a weighting value of 3.

• **Operational Efficiency:** The water evaluation model run without Atlantic Rim demonstrated that storage at Peaking Reservoir hydraulic conditions is more efficient than that of Atlantic Rim. The values assigned to this criterion assume that the closer the hydraulic conditions are to Peaking Reservoir, the higher the score. This is assigned a weighting factor of 4.

• **System Reliability:** This criterion refers to the reliability rating from the water supply evaluation. This is assigned a weighting factor of 5.

• **Funding Availability:** This criterion evaluates whether grants or low interest loan funding is available or not. It is an important consideration, and is given a weighting factor of 5.

• **Capital Costs:** For the purposes of this evaluation, the preliminary construction cost estimates on each reservoir alternative are ranked from lowest to highest. The No Action and Assertive Pumping Alternative would be ranked lowest. This is one of the major considerations in the
overall feasibility of reservoir construction. It is given a weighting factor of 5.

- **Additional Annual O & M Costs:** The additional annual operation and maintenance costs are included in the selection process primarily to differentiate the pumping alternative from the reservoir alternatives. It is also given a weighting factor of 5.

- **Monthly Cost to User:** Cost to the user may be the ultimate consideration when evaluating the feasibility of reservoir storage. For this reason, it is assigned a weighting factor of 6.

### B.3.3 Results

In addition to the screening process above, WWC performed an evaluation in which all criteria were considered equally important (unweighted). Table 6 compares the total scores for the alternatives under weighted and unweighted conditions.

<table>
<thead>
<tr>
<th>Sorted by Score</th>
<th>Weighted Total Score</th>
<th>Unweighted Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assertive Pumping from North Platte</td>
<td>157</td>
<td>46</td>
</tr>
<tr>
<td>1. No Action (w/ Atlantic Rim Liner)</td>
<td>153</td>
<td>43</td>
</tr>
<tr>
<td>4. Fivemile Ridge Reservoir</td>
<td>143</td>
<td>41</td>
</tr>
<tr>
<td>3. Enlarge Atlantic Rim Reservoir</td>
<td>141</td>
<td>38</td>
</tr>
<tr>
<td>2. Peaking Reservoir No. 2</td>
<td>140</td>
<td>37</td>
</tr>
<tr>
<td>5. Basin Reservoir</td>
<td>123</td>
<td>33</td>
</tr>
</tbody>
</table>

Both alternative evaluations demonstrate that assertive pumping from the North Platte River is beneficial under all conditions, but severe drought. While assertive pumping meets the reliability criteria under most scenarios without additional storage, a combination of events and/or extreme drought conditions, could produce undesirable
results related to the reliability and quality of the water supply system. The second highest total scores are associated with the No Action alternative, but here again, reliability may suffer significantly.
TECHNICAL MEMORANDUM
GEOTECHNICAL RECONNAISSANCE AND
PRELIMINARY DESIGN RECOMMENDATIONS
RAWLINS RAW WATER SUPPLY, LEVEL II

Submitted to:

WWC Engineering
611 Skyline Road
WWC Engineering
Laramie, Wyoming 82070

Submitted by:

Gannett Fleming
4722 N. 24th Street, Suite 250
Phoenix, AZ 85016

December 16, 2005
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1. INTRODUCTION

Five alternatives are being considered to provide supplemental raw water storage capacity for the City of Rawlins. Increased capacity on the order of 250 to 500 acre-feet is needed. The alternatives for providing increased raw water storage are as follows:

1. Enlarge the existing Peaking Reservoir.
2. Construct a new embankment and reservoir adjacent to the existing Peaking Reservoir (Peaking Reservoir No. 2).
3. Enlarge the existing Atlantic Rim Reservoir.
4. Construct a new embankment and reservoir in the drainage southeast of the water treatment plant (Fivemile Ridge Reservoir).
5. Construct a below-grade basin reservoir southwest of the water treatment plant (Basin Reservoir).

This memorandum documents preliminary geotechnical reconnaissance to support alternatives analyses and the decision process for selecting a preferred alternative. The current investigation included compilation and review of existing subsurface data from previous investigations for the Peaking Reservoir and the Atlantic Rim Reservoir, and a preliminary site reconnaissance by Gannett Fleming's senior geotechnical engineer, Debora J. Miller, P.E., Ph.D. on October 27, 2005.

2. BACKGROUND INFORMATION REVIEW

2.1. Regional and Site Geology

The regional geology of the Rawlins area is dominated by the Rawlins uplift. The uplift is an anticlinal structure composed of a Precambrian core. The uplift is flanked by east-dipping sedimentary units (Figure 1). The dip of the units becomes shallower moving to the east away from the uplift. The bedrock geology in the vicinity of the proposed reservoir sites is within these gently east-dipping sedimentary units. The Upper Cretaceous Steele Shale underlies the Atlantic Rim site, and the Mesaverde Group sandstones underlie the other four sites, north of the Atlantic Rim Reservoir.

The Steele Shale is a Late Cretaceous unit of dark-gray, thinly bedded, locally micaceous and silty mudstone. It also has thin interbeds of gray-green siltstone and fine-grained sandstone. The formation is known as the Steele Shale when the underlying Niobrara Formation cannot be distinguished from the Frontier Formation; otherwise, it is known as the Cody Shale. In the project area (Eight Mile Lake Basin), the Steele Formation is described as soft gray marine shale with numerous thin gray and brown lenticular
sandstone beds (Weitz and Love, 1952; Wyoming Geological Association, 1951). The shale weathers to a residuum of silty to sandy clay. The contact between the Steele Formation and the Mesaverde Formation occurs about one-half mile north of the reservoir.

The Mesaverde Formation overlies the Cody / Steele Shale and is composed of sandstone and silty sandstone interlayered with siltstone in the site area. The bedrock is well-cemented, but highly fractured and jointed.

A published soil survey is not available for the area, however, preliminary soils information was obtained from the NRCS under a clarification statement that the data does not meet national standards for quality and is subject to change without notice. According to these preliminary soils reports, approximately 10 to 30 inches of sandy to gravelly loams overlie the Mesaverde Formation. However, soils are assumed to be much deeper in the drainage area of the Fivemile Ridge site. The soils have a moderate permeability and overlie unweathered bedrock. At the Atlantic Rim site residual silty clay overlies the Steele Shale. Typically, the surface layer is light yellowish brown silty clay about 4 inches thick. The subsoil is light yellowish brown silty clay about 16 inches thick. The substratum is pale brown silty clay loam about 40 inches thick or more. Depth to bedrock is greater than 60 inches. Permeability of the soil is slow, runoff is rapid, and the hazard of water erosion is severe.

2.2 Seismicity

Both probabilistic and deterministic methods are commonly used to evaluate earthquake magnitude and peak horizontal accelerations (PHA’s) for design of slopes. Probabilistic methods are based on statistical analysis of the frequency of occurrence of a range of earthquake magnitudes over time and their related PHA’s. These relationships are a function of the particular seismo-tectonic setting. In an area of low seismicity such as Southeastern Wyoming, probabilistic analysis only provides a rough approximation of earthquake design parameters. This limitation is due to the small amount of data that has been accumulated since the modern network of seismographs was fully in service.

A preliminary review of existing data was performed for this Phase I study. Based on data presented in Machette, Pierce, and McCalpin (2001) relatively few faults have been identified and characterized in the area (see Figure 2, from Machette, et al., 2001), and the majority of these are located more than 30 miles north of the project site. The closest fault activity is approximately 30 miles to the northwest and occurred about 15,000 years ago along the Chicken Springs fault. According to the USGS seismic hazard map of Wyoming, the peak acceleration for the Rawlins area is approximately 0.18g (with 2% probability of exceedance in 50 years). To further characterize the site and determine the MCE and upper limit of the credible PHA it is recommended that a deterministic appraisal coupled with a probabilistic analysis be performed.
3. SUMMARY OF KNOWN GEOTECHNICAL CONDITIONS BASED ON AVAILABLE INFORMATION

3.1. Peaking Reservoir and Peaking Reservoir No. 2 Site

3.1.1. Peaking Reservoir No. 1
The existing Peaking Reservoir No. 1 is an impoundment created by a circular embankment dam located immediately southeast of the water treatment plant. The reservoir is approximately 970 feet in diameter and about 27 feet deep on average and stores approximately 96.9 million gallons (about 300 acre-feet). According to drawings by Robert Jack Smith & Associates dated 1962, the embankment is about 35 feet high at maximum section, and is believed to be a zoned embankment with 3H:1V upstream and 2H:1V downstream slopes. The crest elevation is 7135 feet and the crest width is 15 feet. Normal high water elevation is 7130 feet. The upstream slope is shown as being faced with a 1.5 feet thick rock and soil cover underlain by 1.5 feet of compacted clay lining over the full height of the embankment as well as under the reservoir bottom. There is 4 feet of “Select Material” (Zone 1) shown under the clay lining on the upstream face. The drawings indicate the clay lining was to have been compacted to 100% Modified Density. The remainder of the embankment (Zone 2) is shown on the drawings to have been compacted to 90% Modified Density. The drawings indicate that soils studies and recommendations were prepared by Woodward, Clyde, Sherard and Associates Consulting Civil Engineers of Denver, Colorado, however no records of those studies could be located.

3.1.2. Peaking Reservoir No. 2

3.1.2.1. Peaking Reservoir No. 2 - 1978 Embankment Design
In 1978, plans were developed by Meurer, Serafini and Meurer, Inc. of Denver, Colorado for a proposed Peaking Reservoir No. 2. The planned reservoir was designed to be a circular embankment located immediately northeast of Peaking Reservoir No. 1. The reservoir was laid out to provide 350 million gallons (approximately 1075 acre feet) of additional storage, with the same high water line elevation (7130) as Peaking Reservoir No. 1. The reservoir would be about 1700 feet in diameter, and about 35 feet average depth at the normal high water line elevation of 7130.

The embankment design for Peaking Reservoir No. 2 appeared very similar to the design for No. 1, with 3H:1V upstream slope, 2H:1V downstream slopes, 15-feet wide crest, a 2-feet thick compacted clay liner over the entire upstream slope and reservoir bottom, overlain by 6 inches of soil and rock cover. The clay liner on the upstream embankment slope is shown to be underlain by 5 feet of Zone I “Select Material” compacted to 98% Standard Proctor. The remainder of the embankment (Zone II) was shown as a “Random Zone” with compaction specified as 95% standard Proctor. The upstream slope surfacing (6 inch soil and rock cover over clay liner) on the embankment was to be overlain by 2-feet of riprap and 8-inches of riprap bedding extending from the crest at elevation 7135 partway down the slope to elevation 7120.
The embankment is shown as founded on bedrock, with a shallow (5 feet deep) key trench located under the dam centerline. A 1.5 feet thick horizontal blanket drain of coarse sand is indicated under the downstream zone, extending from the downstream toe to about \( \frac{1}{4} \) of the embankment base width back towards the centerline. A toe drain with an 8-inch perforated drain pipe was to provide drainage around the perimeter of the embankment.

3.1.2.2. Peaking Reservoir No. 2 - Foundation Conditions

CTL Thompson, Inc. of Denver, Colorado performed a geotechnical exploration in 1978 to support the design of Peaking Reservoir No. 2. Several potential borrow areas were explored by 23 test pits to investigate materials sources for construction of the embankment and special zones (drain, riprap, clay lining, etc.). In addition, 11 test borings were drilled on the embankment alignment (borings F-1 through F-11), and 7 borings were drilled in an area called “Borrow Area A”. Boring and test pit logs for these investigations were located in the CTL file archives, but no geotechnical report could be located.

Based on logs for borings F-1 through F-11, and test pits 15, 16 and 17, the foundation for the reservoir site appears to be comprised of a very thin layer (0 to 1.5 feet thick) of silty, fine to medium SAND topsoil containing large fragments and pieces of sandstone, overlying interlayered sandstone and siltstone bedrock. The bedrock was described on the boring logs as hard to very hard and well-cemented. In 2 borings located on the north end of the explored area (F-6 and F-11), the upper 8 to 13 feet of the bedrock was described as weathered. Test pit logs indicate the shallow (upper 2 to 4 feet) of the bedrock is very fractured and rippable, but extremely hard (excavator refusal) below the upper fractured zone. Generally, based on the boring and test pit logs the sandstone and siltstone bedrock appears to be rippable to elevation 7105, roughly the elevation of the bottom of Peaking Reservoir No. 1.

3.2. Atlantic Rim Reservoir Site

3.2.1. History of Atlantic Rim Reservoir

The Atlantic Rim Reservoir is an off-channel reservoir located approximately 2 miles south of the Rawlins Water Treatment Plant in Section 11, Township 20N, Range 87 W, in Carbon County. The reservoir stores approximately 200 million gallons (614 acre-feet) of water, and serves as a supplemental storage reservoir that is operated in tandem with the existing Peaking Reservoir to supply the water treatment plant. The reservoir was constructed between 1979 and 1980, and first filling began in early 1980. The structure has a history of foundation seepage problems starting from first filling. These seepage problems were investigated by various geotechnical firms between 1980 and 1983. The reservoir bottom was partially lined with clay liner in 1980, but continuing seepage has been noted even after the lining was installed. The history of the Atlantic Rim Reservoir, based on available records, is summarized on Table 1.
3.2.2. Description of Embankment

The reservoir is roughly triangular-shaped, impounded by a 2300 feet long earth embankment on the south, west and north sides that ties into a cut slope which forms the east side of the reservoir. The embankment is about 33 feet high at its maximum section along the east side, with a crest elevation of 7227 feet, and crest width of about 15 feet. Available drawings show the dam embankment as a homogeneous section, with 3H:1V upstream and 2.5H:1V downstream slopes. A cutoff trench was excavated approximately 10 feet below the original ground surface, with a 20 feet base width. The downstream edge of the base of the cutoff is aligned with the centerline of the dam crest. The embankment and cutoff trench fill materials (Zone I) are described as having minimum 50 percent of particles passing the #200 sieve, with a minimum plasticity index of 8 percent, and maximum particle size of 3 inches. A drainage layer (Zone II) is indicated under the downstream portion of the dam, comprised of non-plastic, fine-grained materials conforming to filter design gradation requirements (Law Engineering, 1982b). Fill material not conforming to the requirements of Zone I was reportedly placed in the downstream toe of the embankment above the blanket drain. Riprap slope protection is provided on the inside slopes of the embankment and on the 3H:1V cut slope on the western hillside.

3.2.3. Foundation Conditions

Previous geotechnical investigations by Lincoln Devore, CTL Thompson, and Law Engineering were compiled by Law Engineering (1982b), and indicate the site foundation stratigraphy as generally comprising the following units:

- **Colluvium:** Surficial layer, generally between 5.5 to 8 feet thick was encountered in most borings drilled. The material is described as firm to hard, sandy silty calcareous CLAY to silty fine-grained calcareous SAND, with sand-sized weathered limestone fragments, organic materials, and abundant concentrations of sulfate crystals.

- **Residual Soil:** Underlying colluvium up to 13.5-feet thick, low plasticity CLAY derived from in-place weathering of the Steele Formation bedrock. Clay is stiff to hard, calcareous, and contains varying amounts of sand, silt, and sulfate crystals. Sulfate mineralization was absent in moist samples, indicating possibility of leaching of certain zones within the residuum (Law Engineering, 1982b). Gradational transition of residual soil to underlying weathered bedrock.

- **Weathered Bedrock (Steele Formation):** Interbedded, fine to medium-grained silty sandstone, fine sandy siltstone, and shale. Majority of material encountered in borings was silty sandstone. Carbonate is generally disseminated throughout, and calcite and sulfate mineralization was observed along joints and in discrete concentrations. Abundant zones of very close fracturing, severe weathering, and inclined jointing. Poorest rock quality was observed in severely weathered zones, which were typically soft and brittle. Degree of fracturing and weathering generally decreased with depth, with fractured/weathered zone generally extending to a depth of 25 to 30 feet below the residual soil layer.
In-place and laboratory permeability tests were performed by Law Engineering (1982b) in support of the seepage evaluation. The results of those tests are summarized on Table 2.

Based on the permeability estimates and interpretation of the geologic stratification, Law Engineering (1982b) concluded that the seepage problem at Atlantic Rim was attributable to the highly fractured and pervious bedrock that underlies the reservoir, and which is exposed in the cut slope on the east side of the reservoir. Law Engineering estimated that the reservoir was losing about 80 gpm into the fractured rock zone, with the reservoir at about elevation 7210 (about 12 feet below its design water surface elevation of 7222). They estimated that as much as 200 gpm could be lost at maximum pool, with about half of the seepage losses expected to surface in areas downstream from the reservoir.

The soils and weathered rock were also tested for soluble minerals. The amount of soluble minerals present ranged from about 0.23 to 0.95 percent, with an average of 0.54 percent by weight. Over 60 percent of the soluble minerals present are sulfates. Sodium comprises about 7 to 13 percent of the soluble fraction (Law Engineering, 1982b).

Water quality sampled from wells indicated extremely high concentrations of soluble minerals in wells located in areas of concentrated seepage. Areas of highest seepage gradients and poorest water quality are (in order from highest to lowest):

- at the southwest corner of the reservoir, where dissolved solids concentrations ranged from 40,000 to 95,000 mg/l
- along the west and northwest boundaries where the reservoir is contained by embankments, where the total dissolved solids ranged between 10,000 to 20,000 mg/l.
- along the northeast and southeast abutment contacts between the embankment and the cut slope, where the total dissolved solids concentrations were less than 10,000 mg/l.

The overall gradient is generally westward from the reservoir.

Law Engineering (1982b) also tested the dispersion potential of the soil, and found that the materials were slightly susceptible to dispersion.

The key geotechnical conditions summarized by Law Engineering (1982b) were as follows:

1. Seepage quantities may be as high as 200 gpm.
2. Seepage water quality is very poor, with typical total dissolved solids concentrations ranging from 20,000 to 40,000 mg/l.
3. Foundation soils are slightly susceptible to dispersion.
4. The primary seepage conductor is the upper fractured and weathered bedrock zone that underlies the colluvial and residual soils under the reservoir, but is partially exposed in the cut slope that forms the eastern margin of the reservoir. This transmissive zone is estimated to be about 30 feet thick. This zone
transitions to less fractured and more sound bedrock at about elevation 7150 feet, which is about 45 to 50 feet below the bottom of the reservoir.

3.2.4. Remedial Options (Law Engineering, 1982b)
Law Engineering evaluated several concepts to deal with the seepage as follows:

1. Slurry trench cutoff: would need to extend to depths of up to 50 feet to reach intact bedrock, through difficult rock excavation. Estimated cost would be in excess of $1,000,000 (1982 dollars).
2. Leaky reservoir option: Accept some reservoir seepage losses, extend existing soil liner up embankment sides by removing riprap to place liner up side slopes, and thickening and improving liner on bottom of reservoir, providing protection of clay liner during periods of exposure to prevent desiccation/shrinkage cracking, and continue monitoring of seepage to ensure dam safety. Estimated cost for this option was about $500,000 (1982 dollars).
3. “Zero discharge” synthetic liner: Completely line the reservoir with synthetic liner materials to create “zero discharge” reservoir. Estimated cost for this option was about $1,000,000 (1982 dollars).

3.3. Fivemile Ridge Reservoir Site
No previous geotechnical information was available for this site. For purposes of preliminary alternatives screening, bedrock foundation conditions are assumed to be similar to the Peaking Reservoir site area. The soil layer is assumed to be thicker than the Peaking site since this area is within a drainage.

3.4. Basin Reservoir Site
Borrow pits labeled 1 through 4 were excavated as part of the Peaking Reservoir No. 2 borrow site investigation by CTL Thompson in 1978, in the general area proposed for the basin reservoir. The test pit logs indicate variable thickness (6-inches to 8 feet) of SAND to clayey or silty SAND over bedrock. The bedrock is described as sandstone, sandy claystone, and claystone conglomerate.

4. PRELIMINARY DESIGNS AND COST ESTIMATES
The five optional sites discussed above were evaluated with the objective of capturing 500 acre-feet of additional storage volume to be added to the existing Peaking Reservoir. Preliminary layouts were evaluated considering what is currently known about the geologic conditions and comparative cost estimates were developed for the options that are deemed practical. Since limited geologic information regarding the foundation conditions is available for the Peaking No. 2, the Fivemile Ridge, and the below grade basin options, it was assumed that the conditions will be similar to those present at the Peaking No. 1 Reservoir. The Peaking No. 1 Reservoir currently has a clay liner; therefore, it was assumed that these three options will also require the use of a clay liner and the cost of this item was included in each of these options. Figure 3 shows the general locations for the five optional sites relative to the existing Peaking Reservoir.
4.1. Peaking Reservoir – Raise (Option No. 1)
Option No. 1 was evaluated first assuming a centerline raise of the existing embankment. However, under this scenario it is not practical to obtain the additional 500 acre-feet since the existing reservoir volume decreases to accommodate the upstream portion of the 3H:1V side slopes. Due to existing pipeline and roadway constraints, a downstream raise was not feasible. The option was revised assuming a vertical raise could be constructed using a mechanically stabilized earth (MSE) wall system constructed on the crest of the existing embankment. However, from an operations standpoint (vehicle traffic on a 15-feet wide crest with 15 plus feet of vertical wall on either side) this option did not seem practical. Reinforced 1H:1V side slopes were considered but would require a raise of 35 feet to obtain the desired 500 acre-feet of additional storage volume. Based on these findings Option No. 1 was not considered further and costs estimates were not developed.

4.2. Peaking Reservoir No.2 – New Reservoir (Option No. 2)
Option No. 2 is to construct a new reservoir adjacent (north and east) to the existing Peaking Reservoir. The site elevation varies from 7090 at the northern end to a ridge at 7155 on the southern end. Figure 4 shows a plan view of the Peaking Reservoir No. 2 option and a section view through the reservoir showing a typical embankment section to the north and a cut slope to the south. The volume of the reservoir shown in Figure 4 is approximately 500 acre-feet (with 3 feet of freeboard). To obtain the 500 acre-feet of storage while maintaining the crest elevation at 7135, the bottom of the reservoir would need to be at elevation 7105. The crest elevation of 7135 will be the same as the existing Peaking Reservoir to form a merged crest between the two on the western edge.

Assuming 2 feet of compacted clay liner in the bottom of the reservoir, the cut would need to be completed at elevation 7103. Assuming 3H:1V cut slopes and a 30 feet wide roadway at elevation 7135 the volume of cut would be approximately 457,000 cy. In addition to the clay liner, riprap protection would be utilized on all the inside slopes at a depth of 1.5 feet. Based on the configuration shown in Figure 4 the estimated volume for construction of the embankment on the north end of the reservoir is 340,000 cy. It is important to note that a comprehensive geotechnical investigation of the cut area has not been completed. There is uncertainty regarding the rippability of the weathered sandstone and whether that material can be used for the embankment.

The cost estimate for construction of Option No. 2 is shown in Table 3. For the purposes of estimating costs it was assumed that a clay liner would be necessary. It was also assumed that an erosion protection layer will be required on the upstream embankment slopes of the reservoir. Two alternatives for the erosion protection were considered and included an 18-inch thick riprap layer and a 1-foot thick layer of soil cement. Due to the current volatility of the price of cement, the riprap lining alternative was selected for use in the cost estimate since it represents a more stable cost for this item of work. It should be noted that both of these alternatives are technically suitable for the intended use, and the costs should be investigated further during final design to select the most appropriate type of erosion protection.

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The cost estimate also includes costs for providing monitoring instrumentation, modification of the outlet works, the installation of a new supply pipe, and providing an access road. For the purposes of this estimate, it was assumed that the new supply pipe will be spliced into the existing Atlantic Rim supply pipe.

4.3. Atlantic Rim – Raise (Option No. 3)

Option No. 3 is to construct an embankment raise of the existing Atlantic Rim Reservoir. A downstream raise of 20 feet would be required at the existing Atlantic Rim reservoir site to accommodate the additional 500 acre-feet of storage capacity required by the City of Rawlins. However, along the eastern boundary of the existing reservoir, the centerline of Wyoming State Highway 71 is approximately 175 feet away (see Figure 5). Therefore, between the northeastern and southeastern corners of the reservoir the raise would need to transition from a downstream raise to a centerline raise. As shown in Figure 5 the existing 15 feet wide crest would be maintained for the dam raise. Preliminary volume calculations show approximately 527,000 cubic yards of fill material are required to raise the structure approximately 20 feet from the existing crest elevation of 7227 to 7247 feet to achieve the additional 500 acre-feet of capacity. In addition, due to the existing seepage problems, a full geomembrane liner is recommended. A 45 mil polypropylene liner with a design life of 20 years was assumed for the cost estimate. The cost estimate also includes costs for providing monitoring instrumentation, modification of the outlet works, the modification of the existing supply pipe, and providing an access road. The modifications to the existing supply pipe are necessary since the proposed embankment will be placed over the existing pipe alignment.

The estimated cost for Option No. 3 is shown in Table 4. As described above there are a number of technical issues related to the geologic conditions at the Atlantic Rim Reservoir site including excessive seepage from the existing reservoir and likely soluble minerals in the underlying soils.

4.4. Fivemile Ridge – New Reservoir (Option No. 4)

Option No. 4 is to construct a new reservoir and dam at the Fivemile Ridge location (see Figure 3). As mentioned above, a geotechnical investigation has not been completed at this location; and for the purposes of this study it was assumed that the foundation conditions are similar to the conditions at Peaking Reservoir No. 1. A cut into the assumed weathered sandstone is required to obtain 500 acre feet of storage capacity within the Fivemile drainage. It is also assumed that the material generated from the excavation could be used to construct an embankment across the drainage. To achieve the required 500 acre-feet of storage capacity and maintain the best possible balance between excavation for the basin and construction of the dam, the bottom elevation of the reservoir would slope between elevation 7100 feet at the toe of the dam and 7121 feet at the toe of the basin cut. The crest of the dam would be at elevation 7145 feet. Similar to the Peaking No. 2 Reservoir (Option No. 2), it was assumed that a clay liner and erosion protection of the upstream embankment slopes will be required. The cost estimate includes a one-foot thick clay liner. This thickness is less than the other sites since it is assumed that the drainage has a greater amount of existing soil cover. The cost estimate also includes costs for providing monitoring instrumentation, construction of the outlet
works, and providing an access road. For the purposes of this estimate, it was assumed that the reservoir would be supplied via the existing Atlantic Rim supply pipe which is in close proximity to the new reservoir. Therefore, the cost for supply and delivery piping would be minimal and was not included in the estimate. Figure 6 shows a plan view and cross section of a proposed reservoir at this location. The estimated cost for Option No. 4 is shown in Table 5.

4.5. Below-Grade Basin – New Reservoir (Option No. 5)
Option No. 5 initially consisted of the construction of a below-grade basin reservoir southwest of the water treatment plant. The initial goal of this option was to capture the required additional 500 acre feet of storage capacity within a below-grade basin with the intent of minimizing embankment placement costs and avoiding permitting issues associated with a dam. As mentioned above, a geotechnical investigation has not been completed at this location; and for the purposes of this study it was assumed that the foundation conditions are the same as at Peaking Reservoir No. 1. The feasibility of this option at the site was evaluated with respect to the required excavation for the construction of the basin. Due to the significant depth required to achieve the required 500 acre feet of capacity and the relatively shallow depth to rock, it became evident that this option was not feasible from a constructability standpoint. Therefore, this option was modified to include a reservoir with both below-grade and above-grade portions with balanced cut and fill quantities.

Obtaining 500 acre feet of storage capacity would require a cut into the assumed weathered sandstone at the site. It is assumed also that the material generated from the excavation could be used to construct an embankment across the down slope portion of the site. To achieve an approximate balance between excavation for the basin and construction of the dam, the bottom elevation of the reservoir would slope between elevation 7160 feet at the toe of the dam and 7173 feet at the toe of the basin cut. The crest of the dam would be at elevation 7203 feet. Similar to the Peaking No. 2 Reservoir (Option No. 2), it was assumed that a clay liner and erosion protection of the upstream embankment slopes will be required. The cost estimate also includes costs for providing monitoring instrumentation, construction of the outlet works, the installation of a new supply pipe, and providing an access road. For the purposes of this estimate, it was assumed that the new supply pipe will be spliced into the existing Atlantic Rim supply pipe, and would need to cross beneath Highway 71. Figure 7 shows a plan view and cross section of a proposed reservoir at this location. The estimated cost for Option No. 5 is shown in Table 6.

5. SUMMARY AND CONCLUSIONS
Table 7 summarizes the results of our preliminary geotechnical review, conceptual-level dam/reservoir designs, and cost estimates for the five alternatives. Note that Alternative 1 (enlargement of Existing Peaking Reservoir) was dropped from further consideration due to constructability concerns and high costs associated with the design requirement for an additional 500 acre-feet of storage capacity.
Based on this preliminary study, the least costly alternative is to raise Atlantic Rim Reservoir, and the highest cost option is to construct a new Peaking Reservoir No. 2. However, there is significant uncertainty and potential dam safety risk associated with raising Atlantic Rim, based on the historic poor seepage performance of the foundation under this reservoir. Gannett Fleming recommends the following actions be undertaken for all storage options considered by City that retain the Atlantic Rim Reservoir as part of the system:

1. The current foundation conditions under the Atlantic Rim dam and reservoir should be assessed through an appropriate subsurface investigation to evaluate whether the long-term seepage has compromised the structural integrity of either the embankment or its foundation, and;

2. Assuming the foundation is determined to be structurally competent based on updated geotechnical investigations, a geomembrane liner should be installed to mitigate future reservoir seepage, and minimize the risk of internal erosion and piping of the dam and foundation soils. This liner installation is recommended, whether Atlantic Rim is raised or not. (We note that this recommendation was also made by other geotechnical consultants over 20 years ago (Law Engineering, 1992b).)

Based on these recommendations, the cost estimates for all alternatives that incorporate Atlantic Rim as part of the total system should include an estimated additional cost for liner installation at Atlantic Rim. Table 8 provides the cost estimate for liner installation without a raise of Atlantic Rim.
References Cited


<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>Reservoir designed by Meurer, Serafini, and Meurer (MSM) Consultants</td>
</tr>
<tr>
<td>1979</td>
<td>Reservoir constructed: embankment complete except for riprap by Sept.</td>
</tr>
<tr>
<td>1980</td>
<td>Initial filling begun in winter 1979-1980</td>
</tr>
<tr>
<td>June 1980</td>
<td>Excessive seepage noted at toe of dam; seepage so excessive that reservoir could not be filled; CTL Thompson Consultants of Denver, CO, was contacted to initiate investigations and make recommendations</td>
</tr>
<tr>
<td>Summer 1980</td>
<td>CTL seepage evaluation included 9 observation wells on high portion of dam (6 in embankment and 3 at downstream toe); 3 alternatives presented to reduce seepage rates; clay liner in bottom of reservoir selected as preferred alternative</td>
</tr>
<tr>
<td>Sept-Nov 1980</td>
<td>A 3-feet thick clay liner was constructed in the bottom of reservoir; liner was not carried to normal water surface elevation; re-filling of reservoir begun in November</td>
</tr>
<tr>
<td>Nov 1980 – Feb 1981</td>
<td>Reservoir filled to maximum elevation of 7218 feet; when water surface reached elevation 7214, seepage was observed at the downstream toe of the maximum embankment section; at elevation 7215 seepage was also observed where the embankment abuts the natural hillside</td>
</tr>
<tr>
<td>Feb-Apr 1981</td>
<td>CTL monitored existing observation wells; high pore pressures were noted in the foundation; CTL recommended reservoir filling be stopped on April 1, 1981</td>
</tr>
<tr>
<td>May-June 1981</td>
<td>CTL installed 18 additional observation wells and conducted geotechnical investigation of seepage; investigation reported zone of “porous” clay with substantial amounts of soluble minerals (salts) in soils below the cutoff trench above bedrock; interpretation was that the bottom liner was effective, but that transition zones at cut slopes exposed the “porous” clay zone; an estimated 100-125 gpm of seepage was estimated.</td>
</tr>
<tr>
<td>July-Sept 1981</td>
<td>CTL evaluated cutoff alternatives including slurry trench, grouting, cutoff trench to bedrock and geomembrane lining; recommended installation of slurry trench cutoff along upstream toe of the embankment section; and seepage monitoring systems</td>
</tr>
<tr>
<td>Jun 1982</td>
<td>Law Engineering evaluated seepage control measures proposed by CTL; Law Engineering was concerned that the slurry trench cutoff may not be effective due to possibility of high permeability bedrock exposed on the west side cut slope; recommended additional testing of bedrock permeability to evaluate this concern.</td>
</tr>
<tr>
<td>July 1982</td>
<td>Law Engineering conducted additional subsurface investigations of the dam and reservoir foundation. Eight borings and two test pits were excavated, geotechnical samples of soil and rock were collected and tested, and monitoring wells were installed. Tests included field and laboratory permeability tests, soluble minerals contents of soils, total dissolved solids in groundwater, and dispersion potential of soils. Primary interpretation from the study was that seepage was attributed to a 30 feet thick fractured, weathered bedrock zone that underlies soil materials beneath the bottom of the reservoir and is exposed in the cut</td>
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</table>
Table 1. History of Atlantic Rim Reservoir

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>August 1982</td>
<td>Law Engineering in a letter report dated August 3, 1982, recommended temporary remedial actions for dam safety, including: 1. Collector Drain - recommended extension and improvements to ditch collector located about 100 feet downstream from toe of the west and southwest portions of the embankment; 2. Embankment Toe Drain - installation of lateral drains on about 100-feet centers to connect the embankment toe drain to the collector drain; 3. Area Grading - areas adjacent to the embankment graded to direct seepage and runoff to the collection system and prevent ponding at the toe of the dam; 4. Effluent Monitoring - Installation of a weir box to measure seepage flow rate and monitoring for any fines transport; 5. Reservoir Stage Monitoring - to allow comparison of weir measurements with reservoir levels; and 6. Site Monitoring Program - measurement of piezometric levels in installed monitoring wells, reservoir stage, seepage water flowrate, general embankment conditions, seepage water inspection for fines, and general maintenance of all instruments on site. Also recommended installation of weather station and monitoring of evaporation and precipitation data.</td>
</tr>
<tr>
<td>March 1983</td>
<td>Law Engineering engineer (Mr. David Thompson) conducted a site visit to discuss monitoring program and results of initial analyses of groundwater levels and weir discharge measurements. In a letter dated March 22, 1983, Law Engineering recommended the City “...complete the construction of the seepage collection and monitoring system and to continue regular observation and reporting of measurement of site instruments.” Mr. Thompson noted a “boil” near the south edge of the northern lateral ditch, approximately 20 feet from the embankment toe. The letter report stated that “...concentrated seepage may indicate the commencement of piping, which is a type of internal erosion of the dam on its foundation which can lead to dam failure.” Significance of the boil was expressed in a meeting between Mr. Thompson and City engineers on March 11, 1983. Recommended that city pursue existing plans to install an impermeable liner in the reservoir as a positive means of reducing or eliminating the under seepage.</td>
</tr>
<tr>
<td>April 1983</td>
<td>In a letter report from Law Engineering to the City of Rawlins dated April 5, 1983, the engineers noted that monitoring of the boil area indicated increasing movement of fines (on the order of 35 cubic inches per day). Law recommended that the city provide means for drainage of zones of concentrated seepage. Means for draining the reservoir were discussed with the city engineers.</td>
</tr>
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</table>
Table 2. Summary of Permeability Test Results
(compiled from Law Engineering, 1982b)

<table>
<thead>
<tr>
<th>Geologic Unit</th>
<th>Hydraulic Conductivity (ft/min)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Range</td>
</tr>
<tr>
<td>Embankment &amp; Clay Liner</td>
<td>$10^{-5}$ to $10^{-6}$</td>
</tr>
<tr>
<td>Colluvium</td>
<td>$2.7 \times 10^{-8}$</td>
</tr>
<tr>
<td>Residual Clay Soil</td>
<td>$3.8 \times 10^{-5}$ to $4.3 \times 10^{-6}$</td>
</tr>
<tr>
<td>Weathered Bedrock</td>
<td>$2.5 \times 10^{-4}$ to $&lt;6 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
Table 3 - Engineer's Cost Estimate - Option No. 2
New Reservoir Adjacent to Existing Peaking Reservoir (Peaking No. 2)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization and Prep Work</td>
<td>LS</td>
<td>1</td>
<td>$450,000</td>
<td>$450,000</td>
</tr>
<tr>
<td>2</td>
<td>Reservoir Clearing</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>3</td>
<td>Topsoil Excavation and stockpiling</td>
<td>CY</td>
<td>20,000</td>
<td>$2.00</td>
<td>$40,000</td>
</tr>
<tr>
<td>4</td>
<td>Excavate reservoir - weathered sandstone</td>
<td>CY</td>
<td>457,000</td>
<td>$6.93</td>
<td>$3,167,010</td>
</tr>
<tr>
<td>5</td>
<td>Embankment - reservoir cut source</td>
<td>CY</td>
<td>340,000</td>
<td>$2.10</td>
<td>$714,000</td>
</tr>
<tr>
<td>6</td>
<td>Clay liner material (2’ thick)</td>
<td>CY</td>
<td>79,500</td>
<td>$5.50</td>
<td>$437,250</td>
</tr>
<tr>
<td>7</td>
<td>Place 1.5’ of erosion protection material (slopes)</td>
<td>CY</td>
<td>23,348</td>
<td>$65.00</td>
<td>$1,517,630</td>
</tr>
<tr>
<td>8</td>
<td>Instrumentation</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>9</td>
<td>Outlet Works</td>
<td>LS</td>
<td>1</td>
<td>$80,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>10</td>
<td>WTP Supply Pipe</td>
<td>LS</td>
<td>1</td>
<td>$40,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>11</td>
<td>Access Road</td>
<td>LS</td>
<td>1</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
</tbody>
</table>

Cost of Construction $6,525,890
Final Design and Specifications (15% of Construction Cost) $978,883
Permitting and Mitigation $50,000
Engineering (10% of Construction Cost) $652,589

Construction + Engineering $8,207,362
Contingency (15% Construction + Engineering) $1,231,104
Cost of Construction and Engineering w/ Contingency $9,438,467
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>2</td>
<td>Dam and Reservoir Clearing</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>3</td>
<td>Topsoil stripping and replacement in borrow area</td>
<td>CY</td>
<td>20,000</td>
<td>$2.00</td>
<td>$40,000</td>
</tr>
<tr>
<td>4</td>
<td>Embankment</td>
<td>CY</td>
<td>527,000</td>
<td>$4.50</td>
<td>$2,371,500</td>
</tr>
<tr>
<td>5</td>
<td>45 mil Polypropylene Liner, design life of 20 years</td>
<td>SF</td>
<td>1,803,503</td>
<td>$0.60</td>
<td>$1,082,102</td>
</tr>
<tr>
<td>6</td>
<td>Extend/modify inlet and outlet pipes</td>
<td>LS</td>
<td>1</td>
<td>$60,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>7</td>
<td>Instrumentation</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
</tbody>
</table>

Cost of Construction $3,863,602  
Final Design and Specifications (15% of Construction Cost) $579,540  
Permitting and Mitigation $100,000  
Land Purchase and Easements $80,000  
Engineering (10% of Construction Cost) $386,360  

Construction + Engineering $5,009,502  
Contingency (15% Construction + Engineering) $751,425  
Cost of Construction and Engineering w/ Contingency $5,760,927
Table 5 - Engineer's Cost Estimate - Option No. 4
New Embankment and Reservoir (Fivemile Ridge Reservoir)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>2</td>
<td>Topsoil stripping and replacement in borrow area</td>
<td>LS</td>
<td>1</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>3</td>
<td>Reservoir Clearing</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>4</td>
<td>Excavate reservoir, 3000' haul, scrapers</td>
<td>CY</td>
<td>314,676</td>
<td>$6.93</td>
<td>$2,180,704</td>
</tr>
<tr>
<td>5</td>
<td>Embankment - reservoir cut source</td>
<td>CY</td>
<td>168,000</td>
<td>$2.10</td>
<td>$352,800</td>
</tr>
<tr>
<td>6</td>
<td>Place clay liner material (1' thick)</td>
<td>CY</td>
<td>41,349</td>
<td>$5.50</td>
<td>$227,420</td>
</tr>
<tr>
<td>7</td>
<td>Place 1.5' of erosion protection material (slopes)</td>
<td>CY</td>
<td>15,090</td>
<td>$65.00</td>
<td>$980,864</td>
</tr>
<tr>
<td>8</td>
<td>Instrumentation</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>9</td>
<td>Outlet Works</td>
<td>LS</td>
<td>1</td>
<td>$80,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>10</td>
<td>Access Road</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
</tbody>
</table>

Cost of Construction $3,921,788
Final Design and Specifications (15% of Construction Cost) $588,268
Permitting and Mitigation $100,000
Engineering (10% of Construction Cost) $392,179
Land Acquisition $180,000
Construction + Engineering $5,182,234
Contingency (15% Construction + Engineering) $777,335
Cost of Construction and Engineering w/ Contingency $5,959,575
# Table 6 - Engineer's Cost Estimate - Option No. 5

**New Embankment and Reservoir Southwest of WTP (Basin Reservoir)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mobilization and Prep Work</td>
<td>LS</td>
<td>1</td>
<td>$450,000</td>
<td>$450,000</td>
</tr>
<tr>
<td>2</td>
<td>Reservoir Clearing</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>3</td>
<td>Topsoil Excavation and stockpiling</td>
<td>CY</td>
<td>20,000</td>
<td>$2.00</td>
<td>$40,000</td>
</tr>
<tr>
<td>4</td>
<td>Excavate to basin subgrade, 3000' haul</td>
<td>CY</td>
<td>332,041</td>
<td>$6.93</td>
<td>$2,301,046</td>
</tr>
<tr>
<td>5</td>
<td>Embankment - reservoir cut source</td>
<td>CY</td>
<td>346,487</td>
<td>$2.10</td>
<td>$727,623</td>
</tr>
<tr>
<td>6</td>
<td>Place clay liner material (2' thick)</td>
<td>CY</td>
<td>78,700</td>
<td>$5.50</td>
<td>$432,850</td>
</tr>
<tr>
<td>7</td>
<td>Place 1.5' of erosion protection material (slopes)</td>
<td>CY</td>
<td>18,594</td>
<td>$65.00</td>
<td>$1,208,623</td>
</tr>
<tr>
<td>8</td>
<td>Instrumentation</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>9</td>
<td>Outlet Works</td>
<td>LS</td>
<td>1</td>
<td>$80,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>10</td>
<td>WTP Supply Pipe</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>11</td>
<td>Access Road</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
</tbody>
</table>

- **Cost of Construction** $5,400,141
- **Final Design and Specifications (15% of Construction Cost)** $810,021
- **Permitting and Mitigation** $100,000
- **Engineering (10% of Construction Cost)** $540,014
- **Land Acquisition** $180,000
- **Construction + Engineering** $7,030,176
- **Contingency (15% Construction + Engineering)** $1,054,526
- **Cost of Construction and Engineering w/ Contingency** $8,084,702
Table 7. Summary of Estimated Costs and Geotechnical/Foundation Conditions for Storage Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Estimated Cost</th>
<th>Geotechnical/Foundation Constraints</th>
<th>Screening Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enlarge Existing Peaking Reservoir</td>
<td>Alternative eliminated based on technical considerations and high costs to provide 500 acre-feet additional storage capacity</td>
<td>Competent dam foundation (sandstone bedrock at shallow depth), but potentially high costs for rock excavation in reservoir area, and long embankment section required. Assumed clay liner will be required (from borrow source near Atlantic Rim), based on performance of Peaking Reservoir No. 1.</td>
<td>4</td>
</tr>
<tr>
<td>2. Construct New Peaking Reservoir No. 2</td>
<td>$9,440,000</td>
<td>History of foundation seepage problems since first filling; uncertainties regarding structural integrity of existing soil foundation due to long-term, uncontrolled foundation seepage and past evidence of piping (sand boils); continued use of reservoir requires assessment of current foundation conditions in areas where past seepage was evident, and installation of a geomembrane liner to minimize future seepage to the extent possible.</td>
<td>1</td>
</tr>
<tr>
<td>3. Raise Atlantic Rim</td>
<td>$5,760,000</td>
<td>Foundation conditions unknown at present, but bedrock geology is probably similar to conditions at Peaking Reservoir site, possibly with greater thickness of soil cover due to better-defined drainage, potentially reducing clay liner requirement.</td>
<td>3</td>
</tr>
<tr>
<td>4. Construct New Fivemile Ridge Reservoir</td>
<td>$6,290,000</td>
<td>Foundation conditions unknown; assessment based on very limited shallow test pit information from previous studies. Topography not favorable for full basin excavation, requiring construction of embankment section. Assumed clay liner will be required (from borrow source near Atlantic Rim), based on performance of Peaking Reservoir No. 1.</td>
<td>2</td>
</tr>
<tr>
<td>5. Construct New Basin Reservoir</td>
<td>$8,080,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Rounded to nearest $10,000; includes base cost for construction, engineering, permitting and mitigation, land acquisition, and contingencies.
Table 8 - Engineer's Cost Estimate - Atlantic Rim Liner
Estimated Cost for Lining the Existing Atlantic Rim Reservoir

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Riprap Removal</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>2</td>
<td>Stockpiling</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>3</td>
<td>45 mil Polypropylene Liner, design life of 20 years</td>
<td>SF</td>
<td>1,420,000</td>
<td>$0.60</td>
<td>$852,000</td>
</tr>
</tbody>
</table>

Cost of Construction $872,000
Final Design and Specifications (15% of Construction Cost) $130,800
Engineering (10% of Construction Cost) $87,200

Construction + Engineering $1,090,000
Contingency (15% Construction + Engineering) $163,500
Cost of Construction and Engineering w/ Contingency $1,253,500
Figure 1. Cross-section showing Rawlins uplift with Cretaceous units of the site area to the east (The Geological Survey of Wyoming, Public Information Circular No. 27, 1986)
Figure 2. Fault activity in the Rawlins, Wyoming area (data compiled by Michael N. Machette, Kenneth L. Peirce and James P. McCalpin, ILP Task Group 1-2, 2001).
EXISTING ATLANTIC RIM RESERVOIR (OPTION NO.3)

EXISTING PIPELINE FROM SAGE CREEK

PROPOSED FIVEMILE RIDGE RESERVOIR (OPTION NO.4)

EXISTING PEAKING RESERVOIR (OPTION NO.1)

EXISTING PEAKING RESERVOIR (OPTION NO.2)

PROPOSED BASIN RESERVOIR (OPTION NO.5)

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OPTIONS 1 THRU 5 FOR INCREASING STORAGE CAPACITY BY 500 ACRE-FEET
EXISTING WATER TREATMENT PLANT

EXISTING ATLANTIC RIM PIPELINE

PROPOSED PEAKING NO.2 RESERVOIR

EXISTING PEAKING RESERVOIR

EXISTING PEAKING RESERVOIR

SECTION A-A

SCALE: HORIZ 1"=150' VERT 1"=20'

NEW EMBANKMENT

CREST ELEV 7135

HWL ELEV 7132

1.5' RIPRAP SLOPE PROTECTION

2' CLAY LINER

30' BENCH

3:1

1.5' RIPRAP SLOPE PROTECTION

2' CLAY LINER

3:1

EXISTING GROUND

2' CLAY LINER

BOTTOM ELEV 7105

7155

7150

7145

7140

7135

7130

7125

7120

7115

7110

7105

7100

7095

7155

7150

7145

7140

7135

7130

7125

7120

7115

7110

7105

7100

7095

FIGURE 4

PEAKING NO.2 RESERVOIR

PLAN & CROSS SECTION

GRAPHIC SCALE (IN FEET)
SECTION C-C
SCALE: HORIZ 1"=150' VERT 1"=20'

SECTION B-B
SCALE: HORIZ 1"=150' VERT 1"=20'

SECTION A-A
SCALE: HORIZ 1"=150' VERT 1"=20'

FIGURE 7
BASIN RESERVOIR
PLAN & CROSS SECTIONS
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              Extremely Cold and Windy Site in Iran

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   Appendix B  Seismic Refraction Survey
   Appendix C  Test Pit Logs and Photographs
   Appendix D  Laboratory Test Results

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1. INTRODUCTION, BACKGROUND, AND SCOPE OF PHASE II

Key findings of the Phase I evaluations of raw water supply and system reliability are summarized as follows (WWC, 2005):

1. The existing water supply system has a reliability of about 98.8%.
2. Assertive pumping from the North Platte River can obviate the need for constructing additional reservoir storage if demand increases remain as they have been historically (increasing slightly), and if hydrologic conditions are stable.
3. Modest drought conditions can be tolerated by the water supply system without impact to system reliability.
4. Severe drought conditions result in slight impact to the system reliability. System reliability could be maintained at present-day levels by providing a combination of assertive North Platte River pumping and additional reservoir storage of between 400 and 500 acre-feet.
5. WWC recommended that the study evaluate feasibility of constructing a 500 acre-foot reservoir (active capacity) in the area between the existing Peaking and Atlantic Rim reservoirs.

The Phase I geotechnical review and preliminary design study considered five preliminary alternatives to provide supplemental water storage of up to 500 acre-feet. The preliminary alternatives evaluated for providing increased raw water storage were as follows:

1. Enlarge the existing Peaking Reservoir.
2. Construct a new embankment and reservoir adjacent to the existing Peaking Reservoir (Peaking Reservoir No. 2).
3. Enlarge the existing Atlantic Rim Reservoir.
4. Construct a new embankment and reservoir in the drainage southeast of the water treatment plant (Fivemile Ridge Reservoir).
5. Construct a below-grade basin reservoir southwest of the water treatment plant (Basin Reservoir).

Alternative 1 (Enlarge the Existing Peaking Reservoir) was dropped from further consideration due to constructability concerns and high costs.

The geotechnical study included a detailed review of the historic files and records on Atlantic Rim. The project records document chronic, historic seepage problems in the dam foundation. The Phase I technical memorandum highlighted potential dam safety concerns, both for the existing dam, and for a potentially enlarged Atlantic Rim dam and reservoir. The Phase I study recommended that any option which included retaining the

---

1 Refer to “Technical Memorandum, Geotechnical Reconnaissance and Preliminary Design Recommendations”, prepared by Gannett Fleming, Dec., 2005, and attached as Appendix B to WWC (2005)
Atlantic Rim reservoir as part of the system should include: (1) a detailed investigation of the existing foundation to evaluate whether the long-term seepage has compromised the structural integrity of either the embankment or its foundation, and (2) assuming the foundation is determined to be structurally competent based on updated geotechnical investigations, a geomembrane liner should be installed to mitigate future reservoir seepage and minimize the risk of internal erosion and piping of the dam and foundation soils. It was recommended that a full reservoir liner be installed at Atlantic Rim whether or not the reservoir was enlarged.

Based in part on the geotechnical uncertainties and potential dam safety concerns for Atlantic Rim, the WWDC and sponsors opted to advance the Phase II follow-on study to focus on replacing the Atlantic Rim Reservoir with a new reservoir at either the Peaking No. 2 site or the Fivemile Ridge site. Additional studies for the Fivemile Ridge site were delayed by landowner access issues.

This technical memorandum documents supplemental geotechnical investigations, preliminary design, and preliminary engineer's cost opinions for construction of a 645 acre-feet reservoir at the Peaking No. 2 site. A reservoir of this size would replace the existing, permitted Atlantic Rim reservoir storage volume. The Phase II study included evaluation of rock rippability in the reservoir area for the purpose of refining cost estimates for balanced earthwork (cut and fill), lined reservoir construction at the site.

2. GEOTECHNICAL INVESTIGATIONS

2.1. 1978 CTL-Thompson Site Investigation

CTL-Thompson, Inc. of Denver, Colorado, performed a geotechnical site investigation in 1978 to support the design of Peaking Reservoir No. 2. Several potential borrow areas were explored by 23 test pits to investigate materials sources for construction of the embankment and special zones (drain, riprap, clay lining, etc.). In addition, 11 test borings were drilled on the embankment alignment (borings F-1 through F-11), and 7 borings were drilled in an area called “Borrow Area A”. Locations of borings and test pits excavated for the 1978 site investigation are shown on Figure 1. Boring and test pit logs for these investigations were located in the CTL file archives and copies are attached with this report in Appendix A.

Based on logs for borings F-1 through F-11, and test pits 15, 16 and 17, the foundation for the reservoir site appears to be comprised of a very thin layer (0 to 1.5 feet thick) of silty, fine to medium SAND topsoil containing large fragments and pieces of sandstone, overlying interlayered sandstone and siltstone bedrock. The bedrock was described on the boring logs as hard to very hard and well-cemented. In 2 borings located on the north end of the explored area (F-6 and F-11), the upper 8 to 13 feet of the bedrock was described as weathered. Test pit logs indicate the shallow (upper 2 to 4 feet) of the bedrock is very fractured and rippable, but extremely hard (excavator refusal) below the upper fractured zone. Generally, based on the boring and test pit logs the sandstone and siltstone bedrock appeared to be rippable to elevation 7105, roughly the elevation of the bottom of Peaking Reservoir No. 1.
2.2. Supplemental (2006) Geotechnical Site Investigation

The current (May 2006) site investigation was intended primarily to: (1) verify and supplement the previous (1978) site data and (2) investigate the feasibility for on-site balanced cut and fill construction of the Peaking No. 2 dam and reservoir. The main emphasis was therefore on evaluating the rippability and compactability of the weathered bedrock material in the shallow foundation.

The site investigation included:
- Performing a geophysical survey comprising two, 950-feet long seismic refraction lines across the reservoir footprint area.
- Excavating 4 test trenches at the Peaking No. 2 site, two trenches on each seismic line. Excavations were made with a Caterpillar E200B excavator and a Caterpillar D-8 dozer equipped with ripper.
- Excavating 2 test pits and collecting samples from a potential clay borrow source area west of Atlantic Rim reservoir.

2.2.1. Seismic Refraction Survey

A geophysical investigation was conducted by MicroGeophysics Corporation (MOC) at the Peaking No. 2 project site on May 16 and May 17, 2006. MOC completed two p-wave seismic refraction lines which were each 950 feet in length. The seismic line locations are shown in Figure 2. The full report is included as Appendix B.

The two seismic lines were generally interpreted using a three-layer model. The upper surface layer velocities ranged from about 1000 to 2400 feet per second. The upper seismic layer ranged from negligible to approximately 20 feet thick. This layer roughly correlates with the residual soil and/or weathered sandstone with an increased portion of weathered siltstone. The middle layer ranged from about 1750 to 5100 feet per second. This layer represents weathered sandstone and siltstone and varies quite a bit, from 10 feet to 70 feet in thickness. However, along spread 3 of Line 2 (near TP-7), this middle layer was not detected. In this area, the upper layer was approximately 10 to 20 feet thick. It is likely that this is due to a higher concentration of siltstone within the weathered sandstone at these depths. The lower unweathered bedrock layer ranged from approximately 6500 to 9200 feet per second.

Velocities less than 7500 feet per second are generally considered rippable with a D9 dozer or equivalent. According to the seismic refraction results, the site has between 10 to 70 feet of material with seismic velocities less than 5000 feet per second. This material falls within the rippable category for heavy equipment.

2.2.2. Peaking No. 2 Test Trenches with Large Excavator and Dozer/Ripper

Test pitting for the Rawlins, Wyoming, Peaking No. 2 site was conducted on May 24, 2006. The program consisted of four test pits within the current reservoir design location east of the existing Peaking Reservoir (Figure 2, TP #5-8). The four pits were located on the seismic line locations. In addition, two test pits were excavated for the purpose of investigating a clay liner borrow source west of the existing Atlantic Rim Reservoir (TP #3 and #4).
A&D OilField Dozers, Inc. in Rawlins provided both a CAT D8 dozer with ripper blade and a CAT E200B trackhoe for the test pitting. The dozer was utilized to determine the excavatability of the sandstone and whether or not a ripper blade would be required for reservoir construction. The dozer excavated TP #6 and was used to backfill TP # 5, 7, and 8. The excavator was used to dig TP # 3, 4, 5, 7, and 8. Video footage was taken by representatives of WWC Engineering and Gannett Fleming. Test pit logging and photographs were completed by Gannett Fleming’s project geological engineer, Jessica Humble. A CD with the video footage is attached with this report, and test pit logs and photographs are included in Appendix C.

The test pits ranged from 10 to 15 feet in depth. Two of the pits (TP #5 and #7) were located near the bedrock highs as mapped by seismic refraction surveying. Both of these pits were excavated with the backhoe until refusal was reached at 10 and 10.5 feet, respectively. For TP #6, the dozer operator began using the ripper blade at approximately one foot depth. He continued using the blade until a siltstone layer at 8 feet depth was reached at which point the fractured, weathered siltstone was removed with the front bucket only.

Representative bucket samples were taken from each of the test pits for compaction and gradation testing. In addition, Ziploc sample bags for moisture content and Atterberg Limits testing accompanied some of the buckets. Test pit logs are found in Appendix C and laboratory test results can be found in Appendix D.

2.2.3. Clay Liner Borrow Source Investigation

Two test pits were excavated at the Atlantic Rim site for the purpose of determining the suitability of the clay material for potential use as a liner material for a new reservoir. Both pits were excavated to 10 feet in depth and no free water was encountered. The pits consisted of lean clay with sand and sandy silty clay. Both test pits contained thin lenses of evaporitic material throughout. However, the top 2 to 3 feet of clay soil contained a heavy concentration of evaporitic material. From past reports, this material is reported to be sulfates. The test pit logs are found in Appendix C and the laboratory results are located in Appendix D.

2.2.4. Laboratory Testing

Samples from both the Peaking No. 2 and Atlantic Rim Test Pits were sent to Terracon in Cheyenne, Wyoming. The Peaking No. 2 samples were tested for compaction using a 6-inch mold (ASTM D1557), moisture content, and gradation. The Atlantic Rim samples were testing for compaction (ASTM D698), moisture content, Atterberg limits, and gradation (including double hydrometer). A summary of the laboratory test data is included as Table 1.
3. SITE CONDITIONS

3.1. Peaking No. 2

Site conditions at Peaking No. 2 consisted of 6 inches to 1 foot of residual silty sand overlying the Mesaverde Group Formation. The formation consisted of sandstone with some interlayers of siltstone. The sandstone was moderately weathered with joints spaced approximately every 2 inches vertically and every 6 to 12 inches horizontally. The fracture openings were small (1-2 mm) and generally filled with sand-sized particles. The sandstone material was excavated as small slabs (generally 2" by 6-12") with some soil. The siltstone and the sandstone interlayered with siltstone was more intensely fractured and excavated as more of a soil material.

The material was rippable to a depth of at least ten feet in all the test pit locations. Test Pits #5 and #7 were purposefully located near the bedrock highs mapped by seismic refraction testing. Refusal was at 10 and 10.5 feet for each of these pits, which correlates well with the seismic results that show unweathered bedrock at approximately 10-12 feet in depth at these locations.

Laboratory results indicated natural water contents of approximately 3.7% for the sandstone and 12.2% for the siltstone. Results indicated between 32% and 53% gravel for the sandstone and siltstone samples. The compaction testing using a D1557 (6-inch) mold showed a maximum dry density of 133.5 pcf and optimum moisture content of 7.5% for both the TP-7 and TP-6 samples.

3.2. Atlantic Rim – Clay Borrow Source

From review of past reports and the new information gathered from test pitting, there appears to be sufficient clay borrow material for the Peaking No. 2 liner. However, the quantity of sulfates in the clay material is of concern. Previous investigations in 1982 by Law Engineering found that the clay material contains sulfates. It is possible that the sulfates or salts within the clay soil may cause it to be dispersive. Dispersive clays may deflocculate in still water and erode if exposed to low-velocity water. An embankment or liner constructed of these materials may crack and lead to piping. A double hydrometer test was conducted on a lean clay sample from TP-3 to test for dispersivity. The topmost clay contained what appeared to be a heavy concentration of sulfates and that material was utilized for the test. The percent dispersion value was determined to be 25.06% from this sample. Generally, values above 35 are considered dispersive. Although this sample is not above 35% dispersion, it is recommended that the topmost layer of clay (above 2-3 feet) should be well mixed with the deeper clay for construction.

4. PRELIMINARY DESIGN RECOMMENDATIONS – 645 AF PEAKING RESERVOIR NO. 2

A 645 acre-foot reservoir is requested by WWDC for the Rawlins site. The preliminary reservoir design layout is shown in Figure 4. The design consists of a quasi-rectangular reservoir adjacent to the existing Peaking Reservoir. The site area is on a sloping hillside east of Highway 71 several miles southwest of the City of Rawlins. It is approximately ½ mile to the northwest of the Fivemile Ridge with a small drainage separating the two
features. The high point for the reservoir layout is on the southeast side at 7160 feet and gently slopes down to 7115 feet on the northwest side of the layout. Along the northeastern side of the reservoir, the site also slopes downward into a small drainage that empties into the gulch below.

The crest of the embankment is currently designed at 7160 feet with a high water level (HWL) of 7155 feet. The upstream slopes will be a 3:1 with a 20 foot crest width and 2:1 downstream slope. The reservoir will be impounded by a cutslope on the southeast side into a shallow ridge. On the remaining sides, an embankment dam up to 45 feet in height will be constructed. On the southwest side of the embankment, the downstream toe of Peaking No. 2 will abut the downstream toe of the existing Peaking Reservoir. The bottom floor of the reservoir will be excavated approximately 10 feet deep for two primary reasons: to gain additional reservoir capacity and provide cut material for construction of the embankment. Once the reservoir and embankment foundations have been excavated to final grade, the rock surfaces should be cleaned and inspected, and large fractures and joints (larger than about ¼-inch wide) should be slush grouted. The reservoir bottom and cutslope will then be lined with a geotextile and 2 foot thick clay liner consisting of material from the Atlantic Rim borrow source. The purpose of the geotextile is to span the gaps between bedrock fracturing so that there is not a substantial clay material loss into those fractures. Figures 5A and 5B display four typical cross-sections through the proposed embankment and cut slopes.

Primary construction material will consist of weathered sandstone and siltstone. Material over 6 inches in size will be removed prior to embankment construction. Embankment material should be compacted to at least 95% of the maximum dry density at moisture contents ±2% of optimum, as determined by ASTM D-1557.

4.1. Upstream Slope Protection Alternative A – Covered Geomembrane Upstream Liner with Salvaged Riprap Erosion Protection

Option A for lining the upstream slope consists of a covered geomembrane system. The system is detailed in Figure 6A. The embankment fill will be covered with a 1 foot thick sand layer which serves as both a drainage layer and a protective bedding for the geomembrane. The sand layer will extend beneath the dam embankment (2 feet thick) and will drain towards a perforated pipe collector drain at the downstream toe. The geomembrane (45 mil PVC) will be sandwiched between two geotextiles above the sand layer along the slope. The 7-8 oz/yd² geotextile will serve as a cushioning material to protect the membrane from punctures and tears. The next layer will be another 1 foot thick sand cover to keep the membrane in place and protect it from the elements (such as UV rays, burrowing animals, off-road vehicles). This layer will also serve as riprap bedding. The top and final layer will be 2 feet of riprap. Approximately 60 percent of riprap quantity necessary can be salvaged from the existing Atlantic Rim Reservoir. The remaining quantity will need to be imported from a nearby quarry source. The riprap slope cover will protect against scour of the sand from wave and wind action.
4.2. Alternative B – Exposed Geomembrane Upstream Liner

Option B for lining the upstream slope consists of an exposed geomembrane system. The system is detailed in Figure 6B. Similar to the covered option, the embankment fill will be covered with a 1 foot thick sand layer for bedding and drainage. The upstream sand drain layer will be contiguous with a 2-feet thick sand blanket drain layer that is graded to drain to a collector pipe at the downstream toe. Above the sand layer is a non-woven geotextile to protect the exposed geomembrane. This design was considered because the exposed geomembrane facing would provide a reliable, robust water barrier, and would eliminate the need for riprap upstream slope protection. A photo of this type of system that was used in a recent installation on a sand dam in harsh (freezing and windy) climatic conditions at a site in Iran is shown as Figure 7. Preliminary costs for this system were requested from an experienced manufacturer/installer (CARPI http://www.carpitech.com/). Approximate installed cost is $10 per square foot. The geomembrane would be held in place using lean concrete curbs along the edges. Detailed costs for the system are included in Table 3.

5. PRELIMINARY ENGINEER’S COST OPINION

Costs were derived from a variety of sources including Means and local contractor quotes. The sandstone/siltstone cut and fill costs were gathered from A&D OilField Dozers, the local contractor out of Rawlins who provided equipment and personnel for the test pitting program. Unit costs for the liner bedding layers and protection layers are from the Means 2003 Heavy Construction Guide. The covered PVC membrane costs were provided by Watersaver Company in Commerce City, Colorado. The exposed geomembrane costs are from CARPI. Site information was provided to CARPI so that a project specific cost estimate could be obtained. Geotextile prices were gathered from CONTECH’s Cheyenne office.

Unit costs and total costs for each of the two liner options are shown in Tables 2 and 3. The cost for the covered geomembrane system and the exposed geomembrane systems is approximately 7.5 million and 11.4 million dollars, respectively.

6. RECOMMENDATIONS FOR FINAL DESIGN

The site is geologically appropriate for construction of the reservoir. The test pitting and seismic refraction survey confirmed that the overburden and weathered sandstone and siltstone bedrock will be rippable for the recommended 10 foot stripping depth. In addition, this material can be utilized for construction of the embankment once the larger pieces have been removed. Clay liner material for the base of the reservoir is available near the Atlantic Rim site. Due to the sulfate concentration in the upper few feet, it is recommended that the clay material be thoroughly mixed with deeper clay material before use.

Final design analyses are recommended that should include the following components:
  a) slope stability analysis for upstream and downstream mass slope failures to document factors of safety for all required loading conditions,
b) stability analysis for the upstream membrane section that includes interface shear strength parameters determined by laboratory testing of the proposed geomembrane, geotextile, and bedding/cover materials, and
c) grading design of the riprap bedding and filter/drain materials to meet filtering and permeability requirements in accordance with current standards such as NRCS (1994)\textsuperscript{2}.

Future design analysis may also include optimizing the reservoir layout to improve operating heads at the treatment plant if necessary. In addition, details for the outlet conduit penetration through the clay liner need to be developed. Value engineering could also be explored. For example, the riprap quantities may be reduced by limiting the elevations of placement on the dam face to normal operating pool elevations, and/or performing additional analyses to evaluate limiting wave action at shallow depths of the reservoir pool.

Table 1. Summary of Laboratory Test Results

<table>
<thead>
<tr>
<th>Site</th>
<th>Test P. No</th>
<th>Sample No</th>
<th>Depth (ft)</th>
<th>Description</th>
<th>Gravel</th>
<th>Sand</th>
<th>Clay</th>
<th>PL</th>
<th>PI</th>
<th>Natural Water Content (%)</th>
<th>Maximum Proctor Density (pcf)</th>
<th>Optimum Moisture Content (%)</th>
<th>Maximum Proctor Density (pcf)</th>
<th>Optimum Moisture Content (%)</th>
<th>% Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic Rim</td>
<td>TP-3</td>
<td>B-3</td>
<td>1-2</td>
<td>Lean Clay with Sand</td>
<td>0</td>
<td>19.8</td>
<td>56.9</td>
<td>23.3</td>
<td>34</td>
<td>18</td>
<td>10.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atlantic Rim</td>
<td>TP-4</td>
<td>B-4A</td>
<td>4-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atlantic Rim</td>
<td>TP-4</td>
<td>B-4B</td>
<td>6-8</td>
<td>Sandy Silty Clay</td>
<td>1</td>
<td>41.6</td>
<td>24.2</td>
<td>33.2</td>
<td>24</td>
<td>18</td>
<td>6</td>
<td>117.5</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peaking No. 2</td>
<td>TP-5</td>
<td>B-5</td>
<td>8-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Peaking No. 2</td>
<td>TP-6</td>
<td>B-6A</td>
<td>2-3</td>
<td></td>
<td>37</td>
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<td>13.2</td>
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<td></td>
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<td>126.5</td>
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<td>133.5</td>
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<tr>
<td>Peaking No. 2</td>
<td>TP-6</td>
<td>B-6B</td>
<td>8-11</td>
<td></td>
<td>53</td>
<td>5.3</td>
<td>41.7</td>
<td></td>
<td></td>
<td></td>
<td>12.2</td>
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<td></td>
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<tr>
<td>Peaking No. 2</td>
<td>TP-7</td>
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<td></td>
<td>32</td>
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<td>57.1</td>
<td></td>
<td></td>
<td></td>
<td>133.5</td>
<td>7.5</td>
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Table 2. Engineer’s Cost Estimate – Peaking No. 2 Option A, Covered Geomembrane

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cut and Fill</td>
<td>CY</td>
<td>363,500</td>
<td>$5.00</td>
<td>$1,817,500</td>
</tr>
<tr>
<td>2</td>
<td>Cleaning and Slush Grouting of Large Joints/Fractures</td>
<td>SY</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>3</td>
<td>Geotextile under Clay Liner Installed</td>
<td>CY</td>
<td>78,100</td>
<td>$7.00</td>
<td>$546,700</td>
</tr>
<tr>
<td>4</td>
<td>Clay Liner Installed</td>
<td>CY</td>
<td>45,250</td>
<td>$21.00</td>
<td>$950,250</td>
</tr>
<tr>
<td>5</td>
<td>2' Horizontal Sand/Drainage Layer Placement</td>
<td>CY</td>
<td>13,000</td>
<td>$21.00</td>
<td>$273,000</td>
</tr>
<tr>
<td>6</td>
<td>1' Sand/Drainage Layer Placement on Slope</td>
<td>CY</td>
<td>39,000</td>
<td>$1.00</td>
<td>$39,000</td>
</tr>
<tr>
<td>7</td>
<td>Geotextile over Geomembrane Installed</td>
<td>CY</td>
<td>39,000</td>
<td>$0.60</td>
<td>$235,238</td>
</tr>
<tr>
<td>8</td>
<td>45 mil Polypropylene Liner, design life of 20 years</td>
<td>CY</td>
<td>13,000</td>
<td>$7.00</td>
<td>$147,000</td>
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<tr>
<td>9</td>
<td>Riprap Placement (from quarry site)</td>
<td>CY</td>
<td>10,330</td>
<td>$50.00</td>
<td>$516,500</td>
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</table>

Cost of Construction $5,204,188

Final Design and Specifications (15% of Construction Cost) $780,628

Engineering (10% of Construction Cost) $520,419

Construction + Engineering $6,505,236

Contingency (15% Construction + Engineering) $975,785

Cost of Construction and Engineering w/ Contingency $7,481,021
Table 3. Engineer’s Cost Estimate – Peaking No. 2 Option B, Exposed Geomembrane

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cut and Fill</td>
<td>CY</td>
<td>363,500</td>
<td>$5.00</td>
<td>$1,817,500</td>
</tr>
<tr>
<td>2</td>
<td>Cleaning and Slush Grouting of Large Joints/Fracture</td>
<td>Lump Sum</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>3</td>
<td>Geotextile under Clay Liner Installed</td>
<td>SY</td>
<td>117,000</td>
<td>$1.00</td>
<td>$117,000</td>
</tr>
<tr>
<td>4</td>
<td>Clay Liner Installed</td>
<td>CY</td>
<td>78,100</td>
<td>$7.00</td>
<td>$546,700</td>
</tr>
<tr>
<td>5</td>
<td>2’ Horizontal Sand/Drainage Layer Placement</td>
<td>CY</td>
<td>45,250</td>
<td>$21.00</td>
<td>$950,250</td>
</tr>
<tr>
<td>6</td>
<td>1’ Sand/Drainage Layer Placement on Slope</td>
<td>CY</td>
<td>13,000</td>
<td>$21.00</td>
<td>$273,000</td>
</tr>
<tr>
<td>7</td>
<td>Non-Woven Geotextile on Slope Installed</td>
<td>SY</td>
<td>39,000</td>
<td>$1.00</td>
<td>$39,000</td>
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<tr>
<td>8</td>
<td>Exposed CARPI Liner System</td>
<td>SF</td>
<td>392,064</td>
<td>$10.00</td>
<td>$3,920,642</td>
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</table>

Cost of Construction $7,914,092  
Final Design and Specifications (15% of Construction Cost) $1,187,114  
Engineering (10% of Construction Cost) $791,409  

Construction + Engineering $9,892,615  
Contingency (15% Construction + Engineering) $1,483,892  
Cost of Construction and Engineering w/ Contingency $11,376,507
NOTE: SECTION LOCATIONS ARE DESIGNATED ON FIGURE 4.

HORIZ. AND VERT. SCALE: 1"=40'
NOTE: SECTION LOCATIONS ARE DESIGNATED ON FIGURE 4.

HORIZ. AND VERT. SCALE: 1"=40'
OPTION A
COVERED GEOMEMBRANE

ZONE 1 - EMBANKMENT (SILT, SAND, GRAVEL AND COBBLES UP TO 6-INCH)
ZONE 2 - DRAINAGE LAYER (CLEAN SAND AND GRAVEL)
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

NON-WOVEN GEOTEXTILE
PVC GEOMEMBRANE
NON-WOVEN GEOTEXTILE

EXTEND GEOMEMBRANE 10' ONTO RESERVOIR BOTTOM

2' CLAY LINER

PREPARED ROCK FORMATION SURFACE

ZONE 1
ZONE 2
ZONE 3
ZONE 4

2' ZONE 2

GEOMEMBRANE BETWEEN TWO GEOTEXTILES

NORMAL HIGH WATER LINE
ELEV 7155

DAM CREST ELEV 7160

6" GRAVEL SURFACING

20' CREST

FIGURE 6A
RAWLINS, PEAKING NO.2 RESERVOIR LINER OPTION A
OPTION B
EXPOSED GEOMEMBRANE

ZONE 1 - EMBANKMENT (SILT, SAND, GRAVEL AND COBBLES UP TO 6-INCH)
ZONE 2 - DRAINAGE LAYER (CLEAN SAND AND GRAVEL)
ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

CARPI GEOMEMBRANE
NON-WOVEN GEOTEXTILE
EXTEND GEOMEMBRANE 10' ONTO RESERVOIR BOTTOM
2' CLAY LINER
NON-WOVEN GEOTEXTILE ONLY
PREPARED ROCK FORMATION SURFACE

ZONE 2

NORMAL HIGH WATER LINE
ELEV 7155

1' ZONE 2
EXPOSED GEOMEMBRANE
WITH GEOTEXILE UNDERNEATH

6" GRAVEL SURFACING

20' CREST

2' ZONE 2

ZONE 3 - RIPRAP BEDDING/PROTECTIVE COVER
ZONE 4 - RIPRAP

RAWLINS, PEAKING NO.2 RESERVOIR
LINER OPTION B
FIGURE 7
EXPOSED GEOMEMBRANE SYSTEM (CARPI) INSTALLED ON A SAND DAM LOCATED AT AN EXTREMELY COLD AND WINDY SITE IN IRAN
The Appendices for this Phase II Geotechnical Report include the following:

- Appendix A-1978 Site Investigation Boring Logs and Test Pit Logs
- Appendix B-Seismic Refraction Survey
- Appendix C-Test Pit Logs and Photographs
- Appendix D-Lab Test Results

These Appendices can be found in the project notebook and in PDF format in the project files.
Appendix D
D.1 WATER RIGHTS AND INSTITUTIONAL CONSTRAINTS

D.1.1 Municipal Water Rights

As a part of this Level II study, a comprehensive and updated listing of the City of Rawlins water rights was developed. Based upon a review of the City’s records, prior technical studies and a current review of the records of the Wyoming State Engineers Office a table summarizing the municipal water rights was prepared and attached as part of this Appendix. This listing provides the key information about the City’s water rights including; permit number, name, source, priority date, use, amount, legal status, the point of diversion, and the reference to the State Board of Control adjudication certificate numbers and records location, and should be useful reference.

This summary outlines the details of the water rights for: direct flow diversions (for the pipelines from the North Platte River, Sage Creek and the Sage Creek Springs), reservoir storage (carryover, re-regulation and related Sage Creek basin facilities), and groundwater wells (Miller Hill wellfield, and some in city wells) currently held by the City of Rawlins. The table includes some detailed explanatory footnotes for some of the past municipal water right transfers. This listing also includes the senior priority municipal water rights that are leased (for 50 years) from the Town of Sinclair in 2003.

As mentioned in this report, the City of Rawlins has invested wisely in a multiple source supply of municipal water which has a secure physical (hydrology of the Sage Creek springs, and the North Platte River) and legal (priority) water availability foundation upon which to build and grow. However, the City should continue to be vigilant in its protection, monitoring, measuring, and reporting of its diversion, use and return flow of the municipal water system, particularly in the North Platte River basin of Wyoming. In this regard, presented below is a discussion of the existing institutional and legal entities and constraints that exist which the City should continue to follow and monitor with interest.

D.1.2 Court Decrees

In 1945, the U. S. Supreme Court issued a decree apportioning the waters of the North Platte River (and some tributaries) among the States of Wyoming, Colorado, and Nebraska. This Decree was modified by the Court in 1953 to accommodate the
construction of Glendo Reservoir and to address other matters. On October 6, 1986, Nebraska petitioned the Court to reopen the North Platte Decree. Among her several allegations, Nebraska contended that Wyoming was not protecting Nebraska’s interests in the North Platte Project, which includes Pathfinder Reservoir, Guernsey Reservoir, and the Inland Lakes in Nebraska.

Ultimately, the 1986 Nebraska v. Wyoming law suit was settled and the U.S. Supreme Court approved a Final Settlement Stipulation presented by the parties on November 13, 2001. During the settlement process, it was agreed that if it is apparent that the supply for the North Platte Project will be less than its historic demand for irrigation water of 1.1 MAF, the available supply would be “allocated” to the thirteen (13) contractors of storage water to ensure each contractor receives its fair share. Each year, the Bureau of Reclamation (Bureau) completes forecasts estimating the available supply for the upcoming water year. If the forecasted supply is less than 1.1 MAF, the Bureau will advise that an allocation is likely. If the Wyoming State Engineer (WSEO) agrees with the Bureau, the declaration that an allocation year is likely becomes the mechanism within the settlement that triggers several conservation measures and administrative procedures. One of these administrative procedures affects the City of Rawlins.

If the Bureau advises and the WSEO agrees that an allocation is likely, it is deemed that the Bureau has automatically placed a call for water rights administration until May 1 for the benefit of Pathfinder Reservoir, excluding the Pathfinder Modification Project, which is discussed below. Consistent with applicable state law, the Wyoming State Engineer shall determine whether the call is valid and warrants the administration of water rights.

If the WSEO deems the call is valid, water rights above Pathfinder Reservoir will be administered. Use under water rights with priority dates junior to the Bureau’s water right for Pathfinder Reservoir, with a priority date of December 6, 1904, may be curtailed and water rights for irrigation water senior to Pathfinder’s water right may be limited to 1 cubic foot per second per 70 acres. During the recent drought, water rights administration has been implemented in accordance with the settlement. Due to its senior water rights and non-hydrologically connected Nugget wells, the City of Rawlins has not been impacted.
It is important to emphasize that any water rights administration for the benefit of the call described above ceases on May 1, the first day of the irrigation season. During the irrigation season, other provisions of the settlement begin. These provisions entitle Wyoming to irrigate lands and consume water up to specified limits. While the Bureau, like any holder of a Wyoming water right, may call for water right administration for the benefit of Pathfinder Reservoir after May 1, it is very unlikely that the WSEO would find such a call valid given Wyoming’s entitlements to irrigate and consume water during the irrigation season.

The settlement documented the agreement by the parties that the Pathfinder Modification Project should be constructed. The project would increase the existing capacity of Pathfinder Reservoir by 53,493 acre feet to recapture storage space lost to accumulated sediment. This increased capacity would be administered through two accounts, the "Environmental account" and the "Wyoming account."

The recaptured storage space would store water under the existing 1904 storage right for Pathfinder Reservoir and would enjoy the same entitlements as other uses in the reservoir, with the exception that the recaptured storage space could not place regulatory calls on existing water rights upstream of Pathfinder Reservoir, other than the rights pertaining to Seminoe Reservoir.

33,493 acre feet of the proposed 53,493 acre foot enlargement will be allocated to an "Environmental account" and will be operated for the benefit of the endangered species and their habitat in Central Nebraska. The Environmental account is the state’s contribution to the Platte River Recovery Implementation Program (Program) on behalf of its water users as it will serve as the reasonable and prudent alternative under the ESA for the depletions occurring in Wyoming on or before July 1, 1997. Specific to the City of Rawlins, the Environmental Account, as part of the Program, will serve as the reasonable and prudent alternative for its water use and will assist in securing federal clearance in the future.

The State of Wyoming has the exclusive right to contract with the Bureau of Reclamation (USBR) for the use of 20,000 acre feet of the enlargement capacity in a "Wyoming account." The USBR, under contract with Wyoming, will operate the 20,000 acre feet of storage to insure an annual firm yield of 9,600 acre feet. This is the same yield that was anticipated from the proposed Deer Creek Dam and Reservoir. The first
priority of the Wyoming Account is to serve as a supplemental water supply for Wyoming's municipalities during times of water rights regulation. The City of Rawlins could contract with the Wyoming Water Development Commission to secure water from the Wyoming Account.

**D.1.3 Platte River Recovery Implementation Program**

The Endangered Species Act of 1973 (ESA) constrains all federal agencies from taking any action that may jeopardize the continued existence of an endangered species. If a federal agency is considering an action that may jeopardize a listed threatened or endangered species, Section 7 of the ESA requires that agency to consult with the U.S. Fish and Wildlife Service (USFWS). Federal actions that require consultation include, for example, issuing Section 404 Permits under the Clean Water Act, disbursing federal loans and grants, approving federal right-of-ways, leasing or acquisition of federal lands or minerals, contracting for water from U.S. Bureau of Reclamation (USBR) water projects, and many others. Actions requiring such consultations are said to fall under the “federal nexus”.

The “federal nexus” has been affecting water development and management in the Platte River basin in Wyoming and elsewhere since the late 1970’s with the designation of the whooping crane, least tern, and pallid sturgeon as endangered species and the piping plover as a threatened species and the designation of the Central Platte River in Nebraska as critical habitat. Initially, consultations were only required for new water uses and projects. In the late 1980’s, the USFWS began requiring consultations on a wider set of actions and projects that improved or rehabilitated existing water supply facilities or systems. In essence, the USFWS was requiring that all depletions, whether existing or new, resulting from a federal action, be replaced, until such time as it was deemed that there was enough water in the system to recover the endangered species and restore their designated critical habitat in the Central Platte River basin in Nebraska.

In the 1990’s, representatives from the Department of the Interior (representing both USFWS and USBR) and the States of Wyoming, Colorado, and Nebraska began meetings to discuss the feasibility of developing a recovery program that would 1) benefit the listed species and their habitat, and 2) provide ESA compliance for the water users in the three states. On July 1, 1997, the parties executed the North Platte Cooperative
Agreement (NPCA). Under this agreement, the parties agreed to cooperatively develop a Platte River Recovery Implementation Program (PRRIP). The negotiations relating to the PRRIP are nearing completion. The goal is to have the PRRIP operational on October 1, 2006.

During the term of the NPCA, the USFWS was completing interim consultations on water related activities in the three states. The City of Rawlins underwent interim consultations to receive federal approvals and funding for improvements to its diversion structures. The interim consultations completed since July of 1997 allowed projects to obtain the necessary approvals in accordance with federal law and precede with the payment of annual depletion fees by the project proponents. However, the approvals of the federal actions covered by these interim consultations were predicated on the completion of the PRRIP. Once the PRRIP is operational, the projects that obtained approval through these interim procedures will undergo an abbreviated re-consultation that will eliminate the need for the payment of annual depletions fees and will document that the PRRIP is serving as the “reasonable and prudent” alternative under the ESA for the projects. If the PRRIP is not completed and implemented, the project receiving an interim approval will be subjected to an intensive re-consultation which could result in the requirement for the project proponents to pay higher depletion fees and provide an off-setting amount of replacement water for the depletions resulting from the project previously covered by the interim consultations.

One of the overall goals of the PRRIP is to provide an average of 130,000-150,000 acre feet per year to reduce shortages to USFWS target flows along the Platte River in Central Nebraska. As previously noted, the State of Wyoming’s water contribution under the recovery program on behalf of all water users in the basin is the Environmental Account in the Pathfinder Modification Project. Funding to be provided by the parties will be used to acquire additional water, provide and maintain 10,000 acres of habitat in the Central Platte River valley, and implement a scientific adaptive management approach to determine the water and habitat needs of the species. The term of the PRRIP is 13 years. The term may be extended if approved by the parties.

In addition, the three states recognized that it did not make sense to provide water to the PRRIP and, at the same time, increase its water use thereby undermining the water goals of the PRRIP. Therefore, the states agreed to curtail their water use to 1997 levels.
with the understanding that the PRRIP would provide the regulatory certainty for that use under the ESA. Each state developed a depletions plan that quantified its pre-1997 water use and thereby determined the water use to be covered by the PRRIP.

The State of Wyoming developed the “Depletions Plan, Platte River Basin, Wyoming” (Wyoming’s Depletions Plan). The plan establishes three (3) existing water related baselines. Each particular water use has a benchmark under the baseline. The City of Rawlins’s water use is included as a benchmark under existing water related baseline no. 2, which also includes:

a. the irrigation water use in the entire North Platte River Basin (which includes the Laramie River), with the exception of the irrigation uses between the Colorado/Wyoming state line and Guernsey Reservoir and

b. all municipal, industrial, rural domestic, and other uses in the North Platte River Basin.

The information contained in this baseline was developed on the basis that the threshold for pre-1997 water use is the maximum annual water use of each particular use between 1992 and 1996. In the future under the PRRIP, if all of the water use in the basin during a particular year when added together is less than the total water use under existing water related baseline no. 2, the baseline will not be exceeded. This provides flexibility under the baseline. For example, if a particular municipality exceeds its benchmark under the baseline, but the irrigated water use is less than its benchmark by an amount greater than the excess water use of the municipality, the baseline is not exceeded and no mitigation is required. However, if the baseline is exceeded when all the water uses in a particular year are considered, the State of Wyoming will be responsible for mitigating the excess use at the Wyoming/Nebraska state line.

The benchmarks of historic use contained within the baselines for municipalities are based on depletions (diversion less return flow) on surface water and non-hydrologically connected groundwater wells. A hydrologically connected groundwater well is defined for this program; as a well so located and constructed that if water were withdrawn by the well continuously for 40 years, the cumulative stream depletion would be greater than or equal to 28% of the total volume of groundwater withdrawn.
Depletions of water from non-hydrologically connected wells are not considered in the benchmarks and future use of these wells does not count against water use benchmarks.

The City of Rawlins’ benchmark was based on information provided by the City. In the development of the benchmark, it was recognized that the wells in the City’s Nugget Well Field were non-hydrologically connected. Therefore, the accretions (return flows) resulting from the use of the wells were deducted from the surface water depletions. Using this process, it was determined that the city’s maximum depletions between 1992 and 1996 occurred in 1995. The benchmark for the City of Rawlins’ water use under existing water related baseline no. 2 is shown below. The benchmark is broken down into depletions that occurred during the irrigation season and non-irrigation season. This is due to the fact that overruns in the irrigation season have different effects on streamflows at the Wyoming/Nebraska state line than overruns in the non-irrigation season.

<table>
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<tr>
<th>Season</th>
<th>Surface Water Depletions (AF)</th>
<th>Groundwater Acretions (AF)</th>
<th>Total Benchmark (AF)</th>
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<td>Irrigation</td>
<td>1,362</td>
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<td>Non-irrigation</td>
<td>609</td>
<td>147</td>
<td>462</td>
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<tr>
<td>Total annual</td>
<td>1,971</td>
<td>168</td>
<td>1,803</td>
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* Irrigation season-May through September; Non-irrigation season-October through April.

One of the reasons that the Benchmark is based on 1995 water usage is that the use of the Nugget Well Field was somewhat limited. As there were less accretions from the non-hydrologically connected ground water wells, there were more surface water depletions to meet the city’s demands in that particular year, which increased the City’s benchmark.

The non-hydrologically connected groundwater wells benefit the City of Rawlins. The wells can be used to meet increased demands; thereby ensuring those increased demands do not result in the city exceeding its benchmark. In addition, increased use of the wells will result in more accretions, which will help offset increased depletions from the city’s surface water supplies. While this may not be wise from an economic
perspective, water from the wells could be delivered to the North Platte River to offset depletions from increased or new surface water supplies.

The following discussion offers some actions the City may want to consider in the future:

1. Return flow measurements from the wastewater facilities are essential in accurately determining the City’s surface water depletions and groundwater accretions. The City may wish to develop means to more accurately measure return flows. The measurements should be made at the discharge point. It is not necessary to determine how much of that return flow reaches the North Platte River, as the city has no control of the water after it leaves its facilities.

2. As the return flow (effluent) from the non-hydrologically connected groundwater wells can be reused by the City, it could be used to reduce demands on the surface water supplies. The effluent could be used to irrigate parks and golf courses.

3. The City may want to consider converting its wastewater treatment facilities from evaporation ponds to a flow through wastewater treatment plant. This would retrieve the water lost to evaporation by increasing return flow. As the benchmark is based on depletions (diversions less return flow), this would provide additional water under the benchmark for future use. Increasing return flow would also provide the opportunity to retrieve more return flow from the use of the Nugget Well Field to be used for other purposes.

If the City decides to undertake improvements that could improve the opportunity for new uses under the benchmark, the City should contact the State Coordinator of Wyoming’s Depletions Plan in the Interstate Streams Division of the Wyoming State Engineer’s Office. The State Coordinator will evaluate the improvements to determine the amount of additional water usage that could be permitted under a revised benchmark and covered by Wyoming’s Depletions Plan.

If the City of Rawlins exceeds its benchmark with water use through its existing water rights and water supply system, that excess may be offset by under-runs to other benchmarks. If the existing water related baseline no. 2 is exceeded, the State of Wyoming, through the Wyoming Water Development Commission, will provide the mitigation to offset the effects of the excess at the Wyoming/Nebraska state line. However, if the City is proposing to expand its water use and water system and the
effects of that expansion is that the City’s benchmark will be exceeded, the expansion will be considered a new water related activity that cannot be covered by Wyoming’s Depletions Plan. The City will need to contact the State Coordinator of Wyoming’s Depletions Plan. The State Coordinator will assist the City in developing a mitigation plan that will be acceptable to the U.S. Fish and Wildlife Service and will meet Wyoming’s obligations under the PRRIP.
<table>
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<tr>
<th>Permit No.</th>
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<td>Mo-Day-Year</td>
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<td>6245 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.5-b</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.08 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-232</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6246 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.5-c</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.14 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-233</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6247 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.5-d</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.72 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-234</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6248 Enl.</td>
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<td>Spring No.6</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.18 cfs</td>
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<td>26-17-88</td>
<td>69-235</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6249 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.8</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.30 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-237</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6250 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.9-a</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.15 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-238</td>
<td>Supply to 7185 Res.</td>
</tr>
<tr>
<td>6253 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.9-d</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.34 cfs</td>
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<td>69-241</td>
<td>Supply to 7185 Res.</td>
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<td>6256 Enl.</td>
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<td>Spring No.11</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.58 cfs</td>
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<td>69-220</td>
<td>Supply to 7185 Res.</td>
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<td>6257 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.12</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.40 cfs</td>
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<td>26-17-88</td>
<td>69-221</td>
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<tr>
<td>6262 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.15</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Abandoned May 13, 1986</td>
</tr>
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<td>6263 Enl.</td>
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<td>Spring No.7</td>
<td>6/7/1966</td>
<td>Res. Sup.</td>
<td>0.40 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>69-236</td>
<td>Supply to 7185 Res.</td>
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<tr>
<td>6644 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Sage Creek</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>5.25 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>75-342</td>
<td>Supply to 8016 Res. - Atlantic Rim</td>
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<td>6645 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.1</td>
<td>7/20/1978</td>
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<td>0.15 cfs</td>
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<td>26-17-88</td>
<td>74-11</td>
<td>Supply to 8016 Res.</td>
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<td>Res. Sup.</td>
<td>0.20 cfs</td>
<td>adj</td>
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<td>74-7</td>
<td>Supply to 8016 Res.</td>
</tr>
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<td>Spring No.3</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.45 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-8</td>
<td>Supply to 8016 Res.</td>
</tr>
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<td>6648 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.4</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.33 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-9</td>
<td>Supply to 8016 Res.</td>
</tr>
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<td>Spring No.5-a</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.04 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-12</td>
<td>Supply to 8016 Res.</td>
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<td>Enl. Rawlins Pipeline</td>
<td>Spring No.5-b</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.08 cfs</td>
<td>adj</td>
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<td>74-13</td>
<td>Supply to 8016 Res.</td>
</tr>
<tr>
<td>6651 Enl.</td>
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<td>Spring No.5-c</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.14 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-14</td>
<td>Supply to 8016 Res.</td>
</tr>
<tr>
<td>6652 Enl.</td>
<td>Enl. Rawlins Pipeline</td>
<td>Spring No.5-d</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.72 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-15</td>
<td>Supply to 8016 Res.</td>
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<td>Enl. Rawlins Pipeline</td>
<td>Spring No.6</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.18 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-16</td>
<td>Supply to 8016 Res.</td>
</tr>
<tr>
<td>Permit No.</td>
<td>Name</td>
<td>Source</td>
<td>Priority</td>
<td>Use</td>
<td>Amount</td>
<td>Status</td>
<td>POD</td>
<td>Certificate</td>
<td>Remarks</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------</td>
<td>-----------------</td>
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<td>--------</td>
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<td>------------------------------</td>
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<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.40 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-17</td>
<td>Supply to 8016 Res.</td>
<td></td>
</tr>
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<td>6655 Enl.</td>
<td>Enl. Rawlins Pipeline Spring No.8</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.30 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-10</td>
<td>Supply to 8016 Res.</td>
<td></td>
</tr>
<tr>
<td>6657 Enl.</td>
<td>Enl. Rawlins Pipeline Spring No.9-b</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.15 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-19</td>
<td>Supply to 8016 Res.</td>
<td></td>
</tr>
<tr>
<td>6659 Enl.</td>
<td>Enl. Rawlins Pipeline Spring No.9-d</td>
<td>7/20/1978</td>
<td>Res. Sup.</td>
<td>0.34 cfs</td>
<td>adj</td>
<td>26-17-88</td>
<td>74-21</td>
<td>Supply to 8016 Res.</td>
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<tr>
<td>6668 Enl.</td>
<td>Enl. Rawlins Pipeline Spring No.15</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Cancelled July 11, 1986</td>
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</table>

### Reservoirs

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<th>Permit No.</th>
<th>Name</th>
<th>Source</th>
<th>Priority</th>
<th>Use</th>
<th>Amount</th>
<th>Status</th>
<th>POD</th>
<th>Certificate</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>2040 Res.</td>
<td>Sage Creek Reservoir</td>
<td>Sage Creek</td>
<td>12/7/1910</td>
<td>Mun.</td>
<td>273.0 a/f</td>
<td>adj</td>
<td>2-18-86</td>
<td>41-606</td>
<td>See Footnote No.5</td>
</tr>
<tr>
<td>6133 Res.</td>
<td>Rochelle Reservoir</td>
<td>Sage Creek</td>
<td>5/19/1954</td>
<td>Rec.-Fish</td>
<td>255.3 a/f</td>
<td>un-adj</td>
<td>20-17-87</td>
<td>n/a</td>
<td>Formerly called Adams Reservoir</td>
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<td>6271 Res.</td>
<td>Rawlins Reservoir</td>
<td>Sage Creek</td>
<td>1/28/1955</td>
<td>Mun.</td>
<td>624.0 a/f</td>
<td>adj</td>
<td>26-17-88</td>
<td>R2-300</td>
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<tr>
<td>7185 Res.</td>
<td>Rawlins Peaking Res.</td>
<td>Sage Creek &amp; Springs</td>
<td>6/7/1966</td>
<td>Mun.-I-D</td>
<td>346.6 a/f</td>
<td>adj</td>
<td>31-21-87</td>
<td>R5-245</td>
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<td>8016 Res.</td>
<td>Atlantic Rim Reservoir</td>
<td>Sage Creek &amp; Springs</td>
<td>7/20/1978</td>
<td>Mun.</td>
<td>644.5 a/f</td>
<td>adj</td>
<td>14-20-88</td>
<td>R8-744</td>
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</table>

### Wells

<table>
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<th>Permit No.</th>
<th>Name</th>
<th>Source</th>
<th>Priority</th>
<th>Use</th>
<th>Amount</th>
<th>Status</th>
<th>POD</th>
<th>Certificate</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>W.R. 306</td>
<td>Rawlins No.2 Well</td>
<td>Rawlins No.2 Well</td>
<td>8/27/1954</td>
<td>Mun.</td>
<td>120.0 gpm</td>
<td>un-adj</td>
<td>010-18-88</td>
<td>n/a</td>
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<tr>
<td>U.W. 26776</td>
<td>City Well No.1 Well</td>
<td>City Well No.1 Well</td>
<td>1/25/1974</td>
<td>Mun.</td>
<td>2.0 gpm</td>
<td>un-adj</td>
<td>16-21-87</td>
<td>n/a</td>
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<td>U.W. 26777</td>
<td>City Well No.1A Well</td>
<td>City Well No.1A Well</td>
<td>1/25/1974</td>
<td>Mun.</td>
<td>2.0 gpm</td>
<td>un-adj</td>
<td>16-21-87</td>
<td>n/a</td>
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<td>U.W. 37510</td>
<td>Cemetery No.1 Well</td>
<td>Cemetery No.1 Well</td>
<td>2/7/1977</td>
<td>Misc.</td>
<td>250.0 gpm</td>
<td>adj</td>
<td>17-21-87</td>
<td>UW 6-46</td>
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<tr>
<td>U.W. 70332</td>
<td>Nugget No.1 Well</td>
<td>Nugget No.1 Well</td>
<td>5/24/1985</td>
<td>Mun.</td>
<td>350.0 gpm</td>
<td>un-adj</td>
<td>002-18-88</td>
<td>n/a</td>
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<tr>
<td>Well Name</td>
<td>Well Name</td>
<td>Date</td>
<td>Type</td>
<td>GPM</td>
<td>Adj.</td>
<td>Date</td>
<td>Notes</td>
<td></td>
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<tr>
<td>Nugget No.2 Well</td>
<td>Nugget No.2 Well</td>
<td>5/24/1985</td>
<td>Mun.</td>
<td>500.0</td>
<td>un-adj</td>
<td>002-18-88</td>
<td>n/a</td>
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<td>Nugget No.3 Well</td>
<td>Nugget No.3 Well</td>
<td>5/24/1985</td>
<td>Mun.</td>
<td>500.0</td>
<td>un-adj</td>
<td>002-18-88</td>
<td>n/a</td>
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<td>Spring No.1 Well</td>
<td>Spring No.1 Well</td>
<td>9/14/1989</td>
<td>Misc.</td>
<td>5.0</td>
<td>adj</td>
<td>20-21-87</td>
<td>UW 10-21</td>
<td></td>
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<tr>
<td>RBF No.1 Well</td>
<td>RBF No.1 Well</td>
<td>8/10/1995</td>
<td>Misc.</td>
<td>5.0</td>
<td>un-adj</td>
<td>34-22-87</td>
<td>n/a</td>
<td></td>
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</tbody>
</table>

**Footnotes**

1. Water right owned by the Town of Sinclair, with an alternate point of diversion at the Rawlins Pipeline, for diversion, treatment and delivery by City of Rawlins for Sinclair.
2. Water right owned by the Town of Sinclair and leased to the City of Rawlins for a period of 50 years (2052).
3. Irrigation water right detached from 275.0 acres under Sage Creek Ditch P.N. 2947 and changed to municipal use, for diversion from the Sage Creek Diversion System and Rawlins P/L - See O.R. 6, P. 412.
4. Irrigation water right detached from 210.0 acres under Sage Creek Ditch P.N. 11509 and changed to municipal use, for diversion from Sage Creek Diversion System and Rawlins P/L - See O.R. 6, P. 412.
5. A portion of the water stored in Sage Creek Reservoir detached from the irrigation of 210.0 acres under secondary supply P.N. 15403 and changed to municipal use - See O.R. 6, P. 412.
### TABLE E-1 - PEAKING NO. 2 RESERVOIR OPTION A CONCEPTUAL DESIGN PROJECT COST ESTIMATE

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
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</thead>
<tbody>
<tr>
<td>1 Mobilization and Bonds (% of Items)</td>
<td></td>
<td></td>
<td>10%</td>
<td>$690,957</td>
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<tr>
<td>2 Peaking No. 2 Reservoir (Option A)</td>
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<tr>
<td>a. Cut and Fill</td>
<td>CY</td>
<td>363,500</td>
<td>$5</td>
<td>$1,817,500</td>
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<tr>
<td>b. Cleaning and Slush Grouting of Large Joints/Fractures</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>c. Geotextile under Clay Liner Installed</td>
<td>SY</td>
<td>117,000</td>
<td>$1</td>
<td>$117,000</td>
</tr>
<tr>
<td>d. Clay Liner Installed</td>
<td>CY</td>
<td>79,100</td>
<td>$7</td>
<td>$546,700</td>
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<tr>
<td>e. 2' Horizontal Sand/Drainage Layer Placement</td>
<td>CY</td>
<td>45,250</td>
<td>$21</td>
<td>$950,250</td>
</tr>
<tr>
<td>f. 1' Sand/Drainage Layer Placement on Slope</td>
<td>CY</td>
<td>13,000</td>
<td>$21</td>
<td>$273,000</td>
</tr>
<tr>
<td>g. Geotextile under Geomembrane Installed</td>
<td>SY</td>
<td>39,000</td>
<td>$1</td>
<td>$39,000</td>
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<tr>
<td>h. 45 mil Polypropylene Liner, Design Life of 20 years</td>
<td>SF</td>
<td>302,064</td>
<td>$0.60</td>
<td>$181,238</td>
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<tr>
<td>i. Geotextile over Geomembrane Installed</td>
<td>CY</td>
<td>13,000</td>
<td>$21</td>
<td>$273,000</td>
</tr>
<tr>
<td>j. Riprap Placement (from Atlantic Rim)</td>
<td>CY</td>
<td>10,330</td>
<td>$50</td>
<td>$516,500</td>
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<tr>
<td>3 Intake Structure</td>
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<tr>
<td>a. Concrete (Slab and Tower)</td>
<td>CY</td>
<td>115</td>
<td>$1,000</td>
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<tr>
<td>b. Piping (inside structure up to 90° bend under foundation)</td>
<td>LF</td>
<td>10</td>
<td>$164</td>
<td>$1,640</td>
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<tr>
<td>c. 42&quot; x 42&quot; Heavy Duty Sluice Gate</td>
<td>EA</td>
<td>3</td>
<td>$16,000</td>
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<tr>
<td>d. Trash racks</td>
<td>EA</td>
<td>3</td>
<td>$6,700</td>
<td>$20,100</td>
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<td>e. Walkway from Structure to Embankment</td>
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<td>$100,000</td>
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<td>f. Guardrail</td>
<td>LF</td>
<td>40</td>
<td>$75</td>
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<td>4 Piping (Intake Structure to Existing Peaking Res. Outlet)</td>
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<tr>
<td>a. 24&quot; Steel Pipe, 300# Class</td>
<td>LF</td>
<td>1,400</td>
<td>$164</td>
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<tr>
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<td>5 Piping (Platte River Pipeline to Peaking Res No. 2)</td>
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<td>a. 18&quot; PVC C905</td>
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<td>$85</td>
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<tr>
<td>b. Appurtenaces</td>
<td>LS</td>
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<tr>
<td>c. Concrete (Inlet Structure Pad)</td>
<td>CY</td>
<td>4</td>
<td>$350</td>
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<tr>
<td>6 Rehabilitation of Peaking Reservoir Intake</td>
<td>LS</td>
<td>1</td>
<td>$60,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>7 Reclamation of Atlantic Rim Reservoir</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>8 Unlisted Items (% of Items 2-7)</td>
<td>LS</td>
<td>1</td>
<td>10%</td>
<td>$628,143</td>
</tr>
</tbody>
</table>

| A | Construction Cost Subtotal | | $7,600,529 |
| B | Engineering Costs (% of A) | 10% | $760,053 |
| C | Subtotal (A+B) | | $8,360,581 |
| D | Contingency (% of C) | 15% | $1,254,087 |
| E | CONSTRUCTION COST TOTAL (C+D) | | $9,614,668 |
| F | Prepare Final Design and Specs (% of E) | 10% | $961,467 |
| G | Permitting and Mitigation | | $10,000 |
| H | Legal Fees | | $10,000 |
| I | Acquisition of Access and ROW | | $10,000 |
| | PROJECT TOTAL COST | | $10,606,135 |
| | ROUNDED TOTAL COST | | $10,700,000 |

**Notes**

1. Cost is a guess, not based on design
TABLE E-2 - PEAKING NO. 2 RESERVOIR OPTION B CONCEPTUAL DESIGN PROJECT COST ESTIMATE

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobilization and Bonds (% of Items)</td>
<td></td>
<td></td>
<td>10%</td>
<td>$989,046</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peaking No. 2 Reservoir(Option B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Cut and Fill</td>
<td>CY</td>
<td>363,500</td>
<td>$5</td>
<td>$1,817,500</td>
</tr>
<tr>
<td>b. Cleaning and Slush Grouting of Large Joints/Fractures</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>c. Geotextile under Clay Liner Installed</td>
<td>SY</td>
<td>117,000</td>
<td>$1</td>
<td>$117,000</td>
</tr>
<tr>
<td>d. Clay Liner Installed</td>
<td>CY</td>
<td>78,100</td>
<td>$7</td>
<td>$546,700</td>
</tr>
<tr>
<td>e. 2’ Horizontal Sand/Drainage Layer Placement</td>
<td>CY</td>
<td>45,250</td>
<td>$21</td>
<td>$950,250</td>
</tr>
<tr>
<td>f. 1’ Sand/Drainage Layer Placement on Slope</td>
<td>CY</td>
<td>13,000</td>
<td>$21</td>
<td>$273,000</td>
</tr>
<tr>
<td>g. Non-Woven Geotextile on Slope Installed</td>
<td>SY</td>
<td>39,000</td>
<td>$1</td>
<td>$39,000</td>
</tr>
<tr>
<td>h. Exposed CARPI Liner System</td>
<td>SF</td>
<td>392,064</td>
<td>$10</td>
<td>$3,920,640</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Concrete(Slab and Tower)</td>
<td>CY</td>
<td>115</td>
<td>$1,000</td>
<td>$115,000</td>
</tr>
<tr>
<td>b. Piping (Inside structure up to 90° bend under foundation)</td>
<td>LF</td>
<td>10</td>
<td>$164</td>
<td>$1,640</td>
</tr>
<tr>
<td>c. 42” x 42” Heavy Duty Sluice Gate</td>
<td>EA</td>
<td>3</td>
<td>$16,000</td>
<td>$48,000</td>
</tr>
<tr>
<td>d. Trash racks</td>
<td>EA</td>
<td>3</td>
<td>$6,700</td>
<td>$20,100</td>
</tr>
<tr>
<td>e. Walkway from Structure to Embankment</td>
<td>EA</td>
<td>1</td>
<td>$100,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>f. Guardrail</td>
<td>LF</td>
<td>40</td>
<td>$75</td>
<td>$3,000</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping (Intake Structure to Existing Peaking Res. Outlet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. 24” Steel Pipe, 300#</td>
<td>LF</td>
<td>1,400</td>
<td>$164</td>
<td>$229,600</td>
</tr>
<tr>
<td>b. Appurtenances</td>
<td>LS</td>
<td>1</td>
<td>$25,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>c. Concrete Backfill</td>
<td>CY</td>
<td>130</td>
<td>$350</td>
<td>$45,500</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping (Platte River Pipeline to Peaking Res No. 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. 18 PVC C905</td>
<td>LF</td>
<td>1800</td>
<td>$85</td>
<td>$153,000</td>
</tr>
<tr>
<td>b. Appurtenances</td>
<td>LS</td>
<td>1</td>
<td>$25,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>c. Concrete (Inlet Structure Pad)</td>
<td>CY</td>
<td>4</td>
<td>$350</td>
<td>$1,400</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehabilitation of Peaking Reservoir Intake</td>
<td>LS</td>
<td>1</td>
<td>$60,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reclamation of Atlantic Rim Reservoir</td>
<td>LS</td>
<td>1</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unlisted Items (% of Items 2-7)</td>
<td>LS</td>
<td>1</td>
<td>10%</td>
<td>$899,133</td>
</tr>
</tbody>
</table>

A Construction Cost Subtotal | $10,879,509
B Engineering Costs (% of A) | 10% | $1,087,951
C Subtotal (A+B) | $11,967,460
D Contingency (% of C) | 15% | $1,795,119
E CONSTRUCTION COST TOTAL (C+D) | $13,762,579
F Prepare Final Design and Specs (% of E) | 10% | $1,376,258
G Permitting and Mitigation | | $10,000
H Legal Fees | | $10,000
I Acquisition of Access and ROW | | $10,000

PROJECT TOTAL COST | $15,168,837
Rounded TOTAL COST | $15,200,000

Notes
1 Cost is a guess, not based on design

K:\WWDC\2005-173 Rawlins\Final Report\Atlantic Rim Pipeline Cost.xls 10/13/2006
<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mobilization and Bonds (% of Items)</td>
<td></td>
<td></td>
<td>10%</td>
<td>$234,375</td>
</tr>
<tr>
<td>2 Structural Excavation and Backfill</td>
<td>LS</td>
<td>1</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>a. Atlantic Rim Connection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Pipe and Appurtenances</td>
<td>LF</td>
<td>12218</td>
<td>$164</td>
<td>$2,003,752</td>
</tr>
<tr>
<td>a. 24&quot; Steel Pipe, 300# Class</td>
<td>EA</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>b. Connection at Valve Vault and Pressure Control Valve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Road Crossings (Open Cut)</td>
<td>EA</td>
<td>5</td>
<td>$10,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>d. Blowoff &amp; Isolation Installations on Transmission Line (Assume every 1/2 mile)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. AVAR Assemblies (exclude Manholes) on Transmission Line (Assume every 1/2 mile)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Cathodic Protection</td>
<td>LS</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>4 Revegetation</td>
<td>AC</td>
<td>30</td>
<td>$1,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>a. Pipeline Corridor 0+00 to 128+55 (100'wide)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Pre-Cast Concrete Units</td>
<td>EA</td>
<td>5</td>
<td>$5,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>a. Manhole for AVAR Valves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Unlisted Items (% of Items 2-5)</td>
<td>LS</td>
<td>1</td>
<td>10%</td>
<td>$234,375</td>
</tr>
</tbody>
</table>

A Construction Cost Subtotal | $2,812,502 |
B Engineering Costs (% of A) | 10% | $281,250 |
C Subtotal (A+B) |  |  | $3,093,753 |
D Contingency (% of C) | 15% | $464,063 |
E CONSTRUCTION COST TOTAL (C+D) |  |  | $3,557,816 |
F Prepare Final Design and Specs (% of E) | 10% | $355,782 |
G Permitting and Mitigation |  |  | $10,000 |
H Legal Fees |  |  | $10,000 |
I Acquisition of Access and ROW |  |  | $10,000 |

PROJECT TOTAL COST |  |  | $3,943,597 |
Rounded Total Cost |  |  | $3,950,000 |
Appendix F
BIOLOGICAL RESOURCES CLEARANCE OF THE RAWLINS RAW WATER STORAGE LEVEL II STUDY, CARBON COUNTY, WYOMING

Prepared for

Western Water Consultants, Inc.
Laramie, Wyoming

Prepared by

TRC Mariah Associates Inc.
Laramie, Wyoming

June 2006
BIOLOGICAL RESOURCES CLEARANCE OF THE
RAWLINS RAW WATER STORAGE LEVEL II STUDY,
CARBON COUNTY, WYOMING

Prepared for

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Laramie, Wyoming

By

TRC Mariah Associates Inc.
Laramie, Wyoming
MAI Project 52361

June 2006
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  3.3 BLM-SENSITIVE SPECIES ............................................................................................... 8
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1.0 INTRODUCTION

The City of Rawlins, in cooperation with the Wyoming Water Development Commission and Western Water Consultants, Inc., is conducting a Level II study to better define plans, feasibility, and parameters for construction of a second raw water peaking reservoir. The best location would be adjacent to the existing raw water storage reservoir. At this time, the exact location of ground disturbance is not known. TRC Mariah Associates Inc. conducted a biological resource survey on a 65-acre parcel for the eventual construction of the second water reservoir and ancillary facilities. The project area is located in Sections 31 and 32, T21N, R87W (Figure 1.1), on public land managed by the U.S. Bureau of Land Management (BLM).

This report presents the results of surveys for threatened, endangered, proposed, and candidate (TEP&C) species; BLM-sensitive species, including raptors; and wetlands and other waters of the U.S. (WUS). It also provides information regarding big game winter range.
Figure 1.1  Project Location.
2.0 METHODS

A list of TEP&C species was obtained from the U.S. Fish and Wildlife Service (USFWS) website (USFWS 2006a). The *BLM Wyoming Sensitive Species Policy and List* (BLM 2002) was used to identify BLM-sensitive species that may occur in the project area. The Wyoming Natural Diversity Database (WYNDD) was queried for information regarding known locations of TEP&C or other sensitive species that may occur in the project vicinity. U.S. Geological Survey 7.5' topographic maps and *National Wetlands Inventory* maps (USFWS 2006b) were used to identify potential wetlands and other WUS. The Wyoming Game and Fish Department (WGFD) database was queried for locations of greater sage-grouse leks (WGFD 2005a) and big game winter range (WGFD 2005b), and the BLM's raptor nest database (BLM 2005) was queried for known raptor nest locations.

A field investigation was conducted on May 25, 2006, and included surveys for the following resources.

- Potential TEP&C species habitat;
- BLM-sensitive species habitat including raptor nests; and
- wetlands and other WUS.

Potential habitat for TEP&C and BLM-sensitive species was identified based on habitat descriptions provided by the USFWS, BLM, and/or field guides.

Potential raptor nesting habitat in and adjacent to the project area was searched for raptors, raptor nests, and whitewash using binoculars and the naked eye.

Potential wetlands were identified based on vegetative and hydrologic characteristics observed in the field and were delineated in accordance with the U.S. Army Corps of Engineers (Corps) Wetlands Delineation Manual (Environmental Laboratory 1987). WUS were identified based on the current regulatory definition under the *Clean Water Act*.
3.0 RESULTS

3.1 OVERVIEW

The project area is located in south-central Wyoming, approximately 3.0 mi south of Rawlins (see Figure 1.1). The landscape consists of rolling hills with northwest/southeast-trending low ridges. Elevation ranges from 6,600-7,800 ft. Sandstone bedrock from the Mesaverde Formation (Love and Christiansen 1985) is abundant across the site, especially in the western half, with predominately sandstone regolith deposits throughout the survey area. Isolated low aeolian dunes also occur in the western half. Soils are shallow to nonexistent, consisting of light tan sandstone regolith with abundant surface gravels with some deeper deposits around dunes. Some residual sandy deposits are present near the eastern edge adjacent to the ephemeral drainages.

Project area vegetation consists of Wyoming big sagebrush steppe (WYNDD 2006) (Figure 3.1), which is common throughout the region. Vegetation in the project area includes sagebrush, wheatgrass, shadscale, and prickly pear with 60-75% vegetative cover. Cherokee, Coal, and Sugar Creeks are located nearby, and at least 16 small reservoirs and lakes, including Hogback Lake and Eightmile Lake, occur in the surrounding area. Disturbances in the area include erosion, the existing reservoir to the west, and limited blading and pits.

The existing water storage reservoir consists of an earthen tank with steeply sloping banks. Ducks were observed on the water during the survey, and it is likely that a wide variety of bird and small mammal species use the tank. However, it is fenced and thus not used by big game or other large mammals.

3.2 TEP&C SPECIES

Fifteen TEP&C species are listed for Carbon County (Table 3.1).
Figure 3.1  Vegetation, Known Raptor Nests, Big Game Winter Range, and NWI Wetlands.

TRC Mariah Associates Inc.
Table 3.1  TEP&C Species Listed for Carbon County.¹

<table>
<thead>
<tr>
<th>Common Name/ Scientific Name</th>
<th>Federal Status ²</th>
<th>Habitat</th>
<th>Potential to Occur in the Project Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bald eagle ³</td>
<td>T</td>
<td>Nests and roosts in trees and snags near perennial waters; forages widely</td>
<td>May forage in the project area</td>
</tr>
<tr>
<td>Black-footed ferret ³</td>
<td>E</td>
<td>Prairie dog colonies</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Blowout penstemon ³</td>
<td>E</td>
<td>Sparsely vegetated, actively shifting sand dunes and blow-out depressions.</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Bonytail ³, <em>Gila elegans</em></td>
<td>E</td>
<td>Colorado River watershed</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Canada lynx ³, <em>Lynx canadensis</em></td>
<td>T</td>
<td>Montane coniferous forest</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Colorado pikeminnow ⁴</td>
<td>E</td>
<td>Colorado River watershed</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Eskimo curlew ⁵, <em>Numenius borealis</em></td>
<td>E</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
<tr>
<td>Humpback chub ⁴, <em>Gila cypha</em></td>
<td>E</td>
<td>Colorado River watershed</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Interior least tern ⁵</td>
<td>E</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
<tr>
<td>Pallid sturgeon ⁵, <em>Scaphirhynchus albus</em></td>
<td>E</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
<tr>
<td>Piping plover ⁵, <em>Charadrius melodus</em></td>
<td>T</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
<tr>
<td>Razorback sucker ⁴</td>
<td>E</td>
<td>Colorado River watershed</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Ute ladies'-tresses ⁵</td>
<td>T</td>
<td>Moist meadows</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Western prairie fringed orchid ⁵, <em>Platanthera praeclara</em></td>
<td>T</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
<tr>
<td>Whooping crane ⁵, <em>Grus americana</em></td>
<td>E</td>
<td>South Platte River watershed</td>
<td>Occurs downstream from the project area</td>
</tr>
</tbody>
</table>

¹ USFWS 2006a.
² T = threatened, E = endangered.
³ WYND 2006.
⁴ Water depletions in the Colorado River, Yampa River, and Green River may affect the species and/or critical habitat in downstream reaches in other states.
⁵ Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other states.
Bald eagles may occasionally fly over or forage in the project area, but the project area is not potential nesting or roosting habitat. No bald eagle nests are known to occur in or near the project area (see Figure 3.1) (BLM 2005) and no nests or roosts were observed during the field survey. Since bald eagles are highly mobile, direct impacts (i.e., collisions with project vehicles) are unlikely. Indirect impacts will include temporary loss of a small amount of foraging habitat. The project may affect but is not likely to adversely affect bald eagles.

Prairie dogs, potential prey for black-footed ferrets, occur within the project area; however, the project is located in an area that no longer requires black-footed ferret surveys (USFWS 2004). The project will not affect black-footed ferrets.

Stable sand dunes occur in the western portion of the project area; they are not active and no blowouts were observed during the field survey, so no potential habitat for blowout penstemon occurs in the project area. The project will not affect blowout penstemon.

The project area is located in the North Platte River watershed and thus the Colorado River species—bonytail, Colorado pikeminnow, humpback chub, and razorback sucker—will not be affected by the project.

No habitat for Canada lynx occurs in the project area; therefore, the project will not affect Canada lynx.

If the project results in depletions in the South Platte River watershed (including the North Platte River in the project vicinity), the project will adversely affect Eskimo curlew, interior least tern, pallid sturgeon, piping plover, western prairie fringed orchid, and whooping crane. PUT DEPLETION DISCUSSION HERE.

The project is located entirely in uplands, so no potential habitat for Ute ladies'-tresses occurs in the project area, and the project will not affect Ute ladies'-tresses. The adjacent reservoir does not contain Ute ladies'-tresses habitat.
3.3 BLM-SENSITIVE SPECIES

Of the 35 BLM-sensitive species listed for the Rawlins Field Office area, 11 may occur within the project area (Table 3.2).

On February 16, 1999, the USFWS proposed the mountain plover for federal listing as threatened. On September 9, 2003, the USFWS withdrew their proposed rule to list the mountain plover. A key factor to the "not warranted" listing determination is the greater involvement in mountain plover management on the part of federal land management agencies, state and county governments, and the private sector. Therefore, while the mountain plover does not appear on the BLM's sensitive species list, BLM continues to protect mountain plover, and it is treated as a BLM-sensitive species in this report.

BLM-sensitive animal species that may nest, roost, den, burrow, forage, or occur in the project area include: three bat species, white-tailed prairie dog, Wyoming pocket gopher, swift fox, mountain plover, ferruginous hawk, greater sage-grouse, Columbian sharp-tailed grouse, burrowing owl, sage thrasher, loggerhead shrike, Brewer's sparrow, and sage sparrow. Other sensitive bird species may be rare flyovers that would not be impacted by the project and are not discussed further in this report. No BLM-sensitive plant species are likely to occur in the project area.

The bat species may occasionally fly through or forage in the project area and the existing reservoir and other waterbodies may provide foraging habitat that attracts bats to the project vicinity. No trees, caves, or mines occur near the project, so no bat roosts will be impacted. Direct impacts to bats could include mortality due to collisions with vehicles, although this is highly unlikely. Indirect impacts could include temporary displacement due to human activity and noise and permanent loss of foraging habitat at the reservoir site. Potential for impacts is minimal.
<table>
<thead>
<tr>
<th>Common Name/Scientific Name</th>
<th>Habitat</th>
<th>Potential to Occur in the Project Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-eared myotis <em>Myotis evotis</em></td>
<td>Conifer and deciduous forests, caves and mines</td>
<td>Rare flyovers</td>
</tr>
<tr>
<td>Fringed myotis <em>Myotis thysanodes</em></td>
<td>Conifer forests, woodland-chappar, caves, and mines</td>
<td>Rare flyovers</td>
</tr>
<tr>
<td>Townsend’s big-eared bat <em>Corynorhinus townsendii</em></td>
<td>Forests, basin-prairie shrub, caves, and mines</td>
<td>Occasional flyovers</td>
</tr>
<tr>
<td>White-tailed prairie dog <em>Cynomys leucurus</em></td>
<td>Basin-prairie shrub, grasslands</td>
<td>Known to occur within the project area</td>
</tr>
<tr>
<td>Wyoming pocket gopher <em>Thomomys clusius</em></td>
<td>Meadows with loose soil</td>
<td>May occur but not observed during field survey</td>
</tr>
<tr>
<td>Swift fox <em>Vulpes velox</em></td>
<td>Grasslands</td>
<td>May occasionally travel through the project area</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-faced ibis <em>Plegadis chihi</em></td>
<td>Marshes, wet meadows</td>
<td>Occasional flyovers; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Trumpeter swan <em>Cygnus buccinator</em></td>
<td>Lakes, ponds, and rivers</td>
<td>Occasional flyovers</td>
</tr>
<tr>
<td>Northern goshawk <em>Accipiter gentilis</em></td>
<td>Conifer and deciduous forests</td>
<td>Rare flyovers</td>
</tr>
<tr>
<td>Ferruginous hawk <em>Buteo regalis</em></td>
<td>Basin-prairie shrub, grassland, rock outcrops</td>
<td>Likely to occur; potential to nest on or adjacent to the project area, although no nests observed during the field survey; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Peregrine falcon <em>Falco peregrinus</em></td>
<td>Tall cliffs</td>
<td>Occasional flyovers</td>
</tr>
<tr>
<td>Greater sage-grouse <em>Centrocercus urophasianus</em></td>
<td>Basin-prairie shrub, mountain-foothill shrub</td>
<td>May occur; potential to breed and nest on or adjacent to the project area, no leks known to occur nearby; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Columbian sharp-tailed grouse <em>Typanuchus phasianellus columbianus</em></td>
<td>Grasslands</td>
<td>May occur; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Long-billed curlew <em>Numenius americanus</em></td>
<td>Grassland, plains, foothills, wet meadows</td>
<td>Rare flyovers</td>
</tr>
<tr>
<td>Yellow-billed cuckoo <em>Coccyzus americanus</em></td>
<td>Open woodlands, streamside willow and alder groves</td>
<td>Rare flyovers</td>
</tr>
<tr>
<td>Burrowing owl <em>Athene cunicularia</em></td>
<td>Grasslands, basin-prairie shrub, associated with burrows of other animals</td>
<td>May occur; potential to nest in adjacent areas</td>
</tr>
<tr>
<td>Sage thrasher <em>Oreoscoptes montanus</em></td>
<td>Basin-prairie shrub, mountain-foothill shrub</td>
<td>May occur; potential to breed and nest on or adjacent to the project area; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Loggerhead shrike <em>Lanius ludovicianus</em></td>
<td>Basin-prairie shrub, mountain-foothill shrub</td>
<td>May occur; potential to breed and nest on or adjacent to the project area; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Brewer’s sparrow <em>Spizella breweri</em></td>
<td>Basin-prairie shrub</td>
<td>May occur; potential to breed and nest on or adjacent to the project area; has been documented within 1.0 mi²</td>
</tr>
</tbody>
</table>
Table 3.2 (Continued)

<table>
<thead>
<tr>
<th>Common Name/Scientific Name</th>
<th>Habitat</th>
<th>Potential to Occur in the Project Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sage sparrow</td>
<td>Basin-prairie shrub, mountain-foothill shrub</td>
<td>May occur; potential to breed and nest on or adjacent to the project area; has been documented within 1.0 mi²</td>
</tr>
<tr>
<td>Amphispiza belli</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baird’s sparrow</td>
<td>Grasslands, weedy fields</td>
<td>Occasional flyovers</td>
</tr>
<tr>
<td>Ammodramus bairdii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundtail chub</td>
<td>Colorado River watershed, mostly large rivers, also streams and lakes</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Gila robusta</td>
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<td></td>
</tr>
<tr>
<td>Bluehead sucker</td>
<td>Bear, Snake, and Green River watersheds</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Catostomus discobolus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flannelmouth sucker</td>
<td>Colorado River watershed, large rivers, streams, and lakes</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Catostomus latipinnis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado River cutthroat trout</td>
<td>Colorado River watershed, clear mountain streams</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Oncorhynchus clarki pleuriticus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphibians</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern leopard frog</td>
<td>Beaver ponds, permanent water in plains and foothills</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Rana pipiens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Basin spadefoot</td>
<td>Spring seeps, permanent and temporary waters</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Spea intermontana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boreal toad</td>
<td>Pond margins, wet meadows, riparian areas</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Bufo boreas boreas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laramie columbine</td>
<td>Crevices of granite boulders and cliffs, 6,400-8,000 ft in elevation</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Aquilegia laramiensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nelson’s milkvetch</td>
<td>Alkaline clay flats, shale bluffs and gullies, pebbly slopes, and volcanic cinders in sparsely vegetated sagebrush, juniper, and cushion plant communities, 5,200-7,600 ft in elevation</td>
<td>Not likely to occur within the project area</td>
</tr>
<tr>
<td>Astragalus nelsonianus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar Rim thistle</td>
<td>Barren, chalky hills, gravelly slopes, and fine textured, sandy-shale draws, 6,700-7,200 ft elevation</td>
<td>Not likely to occur within the project area</td>
</tr>
<tr>
<td>Cirsium aridum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weber’s scarlet gilia</td>
<td>Openings in coniferous forests and scrub oak woodlands</td>
<td>Does not occur in the project area</td>
</tr>
<tr>
<td>Ipomopsis aggregate weberi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gibben’s beardtongue</td>
<td>Sparsely vegetated shale or sandy-clay slopes, 5,500-7,700 ft in elevation</td>
<td>Not likely to occur within the project area</td>
</tr>
<tr>
<td>Penstemon gibbensus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistent sepal yellowcress</td>
<td>Riverbanks and shorelines, usually on sandy soils near high water mark</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Rorippa calycina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laramie false sagebrush</td>
<td>Cushion plant communities on rocky limestone ridges and gentle slopes, 7,500-8,600 ft in elevation</td>
<td>Does not occur within the project area</td>
</tr>
<tr>
<td>Sphaeromeria simplex</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 BLM 2002.
2 WYNDND 2006.
White-tailed prairie dogs inhabit the project area, especially in the northwestern corner. Direct impacts to white-tailed prairie dogs could include mortality due to collisions with vehicles and excavation. Indirect effects will include permanent habitat loss and temporary displacement due to human activity and noise. BLM should be contacted to determine if mitigation for impacts to white-tailed prairie dogs will be required. None of the other BLM-sensitive species were observed during the field survey.

No Wyoming pocket gophers or their burrows were observed during the field survey. Since rodent colonies are dynamic and Wyoming pocket gophers may occur in the project area in the future, BLM should be contacted prior to construction to determine if additional surveys or mitigation for Wyoming pocket gophers are necessary.

Swift fox may den, hunt, and travel through the project area. No dens were observed during the field survey. Since swift fox are highly mobile, direct impacts (e.g., collisions with vehicles) are unlikely. Indirect impacts could include temporary displacement due to human activity and noise and a small amount of permanent habitat loss. If construction is to occur during the denning season (March through July) (Clark and Stromberg 1987), BLM should be contacted to determine if additional surveys or mitigation regarding swift fox are warranted.

Potential habitat for mountain plover occurs in the prairie dog colony in the northeastern portion of the project area. If construction is to occur between April and July, BLM should be contacted to determine if surveys for mountain plover will be required.

Ferruginous hawks likely forage in the area and may nest nearby, but no potential nesting habitat occurs in the project area. Sage thrasher, loggerhead shrike, Brewer’s sparrow, and sage sparrow are likely to occur and may nest in the project area. Direct impacts could include inadvertent nest destruction during surface disturbance. Indirect effects could include temporary displacement due to human activity and noise and permanent habitat loss. If construction is to occur during the nesting season (February through July), BLM should be contacted to determine if additional surveys or mitigation are necessary.
Burrowing owls may occur in the prairie dog burrows on-site, although burrowing owls were not observed during the field surveys. Direct impacts could include mortality due to collisions with project vehicles or during excavation. Indirect impacts could include habitat loss due to destruction of burrows. If construction is to occur during the nesting season (February through July), BLM should be contacted to determine if surveys for burrowing owls will be necessary prior to construction.

No greater sage-grouse or Columbian sharp-tailed grouse leks are known to occur near the project area (Wyoming Game and Fish Department 2005a; personal communication, June 2006, with Heath Cline, BLM). Direct impacts to the two grouse species could include mortality due to collisions with vehicles; however, this is highly unlikely. Since no leks are known to occur nearby, no impacts to breeding and nesting grouse are anticipated, but if construction is to occur during the breeding and nesting season (March through July), BLM should be consulted to determine if preconstruction nest surveys will be required. Indirect effects will include temporary displacement due to human activity and noise and permanent loss of habitat at the new reservoir site. Since no leks are known to occur in the vicinity, since the project will be of limited extent, and since the city of Rawlins will coordinate with the BLM regarding the need for pre-construction surveys, impacts to greater sage-grouse and Columbian sharp-tailed grouse are expected to be minimal.

No raptor nests are known to occur within 1.0 mi of the project area (BLM 2005) and none were observed during the field survey. The nearest nest (unknown species) is about 1.3 mi northeast of the project area, and 2 golden eagle nests are known to occur about 2 mi northwest of the project (see Figure 3.1). Potential nesting habitat for several raptor species (e.g., ferruginous hawk, red-tailed hawk, Swainson’s hawk, golden eagle, prairie falcon) occurs in the vicinity. If construction is to occur during the raptor nesting season (February through July), BLM should be contacted to determine if surveys for raptor nests are required.
3.4 BIG GAME RANGE

The project is not located within big game crucial winter range or birthing areas, so no additional surveys or mitigation regarding big game range are necessary.

3.5 WETLANDS AND OTHER WUS

No wetlands or other WUS occur within the project area. The existing reservoir to the west consists of open water with steep banks that do not support wetlands; further, the reservoir was constructed entirely on uplands and thus is not a jurisdictional water. No mitigation or consultation with the Corps is required.
4.0 CONCLUSIONS

The project may affect but is not likely to adversely affect bald eagles. The BLM should be contacted to confirm this conclusion.

The project will not affect black-footed ferrets, Canada lynx, blowout penstemon, the Colorado River endangered fish species, or Ute ladies'-tresses.

PUT DEPLETION DISCUSSION HERE.

The BLM should be contacted prior to construction to determine if additional surveys or mitigation for white-tailed prairie dogs and/or Wyoming pocket gophers are necessary.

If construction is to occur during the swift fox denning season (March through July), BLM should be contacted to determine if additional surveys or mitigation regarding swift fox are warranted.

If construction is to occur during the nesting season (February through July) for mountain plover, ferruginous hawk, burrowing owl, other raptors, sage thrasher, loggerhead shrike, Brewer’s sparrow, sage sparrow, greater sage-grouse, or Columbian sharp-tailed grouse, BLM should be contacted to determine if additional surveys or mitigation are necessary.

No mitigation regarding big game range is necessary.

No mitigation or consultation with the Corps regarding direct impacts to wetlands and other WUS is required.
5.0 LITERATURE CITED


Wyoming Game and Fish Department 2005a. Statewide greater sage-grouse lek GIS shapefile information. Wyoming Game and Fish Department, Geographic Information System Sciences and Services, Cheyenne, Wyoming.


_____ . 2005b. Big game herd unit and range GIS shapefile information, Wyoming Game and Fish Department, Geographic Information Sciences and Services, Cheyenne, Wyoming.
Photograph A.1 Overview of Project Area, Eastern Portion. Looking North.

A CLASS III CULTURAL RESOURCE INVENTORY OF THE RAWLINS RAW WATER STORAGE LEVEL II STUDY, CARBON COUNTY, WYOMING

Prepared for

Western Water Consultants, Inc.
Laramie, Wyoming

Prepared by

TRC Mariah Associates Inc.
Laramie, Wyoming

June 2006
AUTHOR(S): Edward Schneider

REPORT TITLE (include client name, undertaking name, survey project type, and report number): A Class III Cultural Resource Inventory of the Rawlins Raw Water Storage Level II Study, Carbon County, Wyoming

DATE OF REPORT (MONTH/YEAR): June 21, 2006

LEAD AGENCY (e.g., BLM ADMINISTRATIVE UNIT): Bureau of Land Management, Rawlins Field Office

SURVEY ORGANIZATION/NAME: TRC Mariah Associates Inc.

FEDERAL PERMIT NO. (e.g., BLM CULTURAL RESOURCE USE PERMIT and EXPIRATION DATE): Bureau of Land Management Cultural Resource Use Permit No. 015-WY-SR04 (expires 9/30/06)

BRIEF DESCRIPTION OF UNDERTAKING: The City of Rawlins, in cooperation with the Wyoming Water Development Commission and Western Water Consultants, Inc., is conducting a Level II study to better define plans, feasibility, and parameters for construction of a second raw water peaking reservoir. The best location would be adjacent to the existing raw water storage reservoir. At this time, the exact location of ground disturbance is not known. TRC Mariah Associates Inc. conducted a 65-acre inventory for the eventual construction of the second water reservoir and other ancillary facilities.

VEE METHODS:

- Standard 30 Meter Transects
- Non-Standard (Describe in body of report)

Survey Width (All Linear Inventory):

- 100 feet (individual road or pipeline corridor)
- 150 feet (parallel road/pipeline corridor)
- Other (indicate width: ___ feet)

COUNTY(IES): Carbon


LAND OWNER: X BLM, BuREC, FS, NPS, PRIVATE, STATE, USFWS, OTHER (Specify)

LEGAL DESCRIPTION (T/R/Sec/up to 4 qtrs and identify template corner): T21N, R87W, Section 31 (ENESE, EWNES, ENESE, NNSESE) and Section 32 (WNWSW, WENWSW, NWSWSW, NWNWSW)

ACREAGE:

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<th>BLOCK</th>
<th>LINEAR</th>
<th>TOTAL</th>
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<td>30.0</td>
</tr>
<tr>
<td>NON-FED SURFACE</td>
<td>35.0</td>
<td>0.0</td>
<td>35.0</td>
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</table>

TOTAL ACREAGE: 65.0

FILE SEARCH DATE(S): May 23, 2006

FIELD WORK DATE(S) (MONTH/YEAR): May 25, 2006

PERSONNEL: Edward Schneider, Mark Nelson, and William Batterman

SURVEY RESULTS: X NO CULTURAL MATERIAL ___ #ISOLATED FIND(S) ___ #SITE(S)

+ attach continuation sheets for additional data * check all that pertain
**SITE SUMMARY TABLE** (Field Agent Use)

| National Register of Historic Places Eligibility: | E (Eligible); NE (Not Eligible); U (Unevaluated) |
| Eligibility Determination: | R-Listed on NRHP Register; K-Eligible by NRHP Keeper; C-Eligible-SHPO concurrence; E-Eligible-Consultant/Agency; U-Eligibility Unknown; N-Not eligible |
| Effect: | NO for sites with no effect; NAE for site with no adverse effects; AE for sites with adverse effect; U for Unknown |
| Proposed Mitigation: | e.g., data recovery, avoidance, fencing, sign, etc. |

*ATTACH CONTINUATION SHEETS AS NEEDED/EXPAND, ADD OR DELETE INDIVIDUAL SITE COLUMNS AS NECESSARY; Please list sites in alphabetical/numeric order first and isolates after the sites. Note: Information about the location, actor, or ownership of historic properties in the report may not be disclosed to the public unless authorized by the appropriate agency and/or the Wyoming State Historic Preservation Office.*

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<thead>
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<th>nthsonian No. or diplomat Find No.</th>
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<td>Previous SHPO Concurrence? (Y/N)</td>
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<td>Current Eligibility</td>
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<td>NRHP Criteria (A, B, C, or D)</td>
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<td>Contributing Portion? (Y/N)</td>
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<td>Current Project Effect?</td>
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<td>Proposed Mitigation or Protection Measures</td>
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*User may add additional optional attributes from this point*
ENVIRONMENTAL SETTING:
The project area is located in southcentral Wyoming, approximately 3.0 mi (4.8 km) south of Rawlins (Figures 1-4). The project is located in rolling hills with northwest/southeast-trending low ridges. Abundant areas of sandstone bedrock are visible, especially in the western half, with predominately sandstone regolith deposits throughout the survey area. Isolated low aeolian dunes were noted in the western half. Soil deposits are shallow to nonexistent, consisting of light tan sandstone regolith with abundant surface gravels with some deeper deposits around dunes. However, some residual sandy deposits are present near the eastern edge adjacent to the ephemeral drainages. Vegetation in the project area includes sagebrush, wheatgrass, shadscale, and prickly pear with 25 to 40% ground visibility. Disturbances in the area include erosion, the existing reservoir to the west, and limited blading and pits.

FILE SEARCH RESULTS:
A file search (No. 17206) was conducted through the Cultural Records Office of the Wyoming State Historic Preservation Office (SHPO) for Sections 31 and 32, T21N, R87W. According to the file search, 10 cultural resource projects have been conducted in the sections between 1977 and 1999. The projects include four gas pipeline inventories, three fiber optic cable inventories, one water pipeline inventory, one seismic inventory, and one cattle grazing pasture inventory.

Two sites are present in these sections. Site 48CR643 is a prehistoric lithic scatter that has been determined not eligible for the National Register of Historic Places (NRHP). Although the file search indicates the site is in the SWSW of Section 32, it is in error; in fact, it is in the NENE of Section 32, approximately 1.0 mi (1.6 km) northeast of the project area.

Site 48CR2181 is the Rawlins wood pipeline that has been determined as eligible for the NRHP under Criteria A and C, and it is located approximately 600 ft (183 m) west of the project area. This site is a 12-inch diameter buried water line that formerly supplied the city of Rawlins with a domestic water supply. The water line is historically significant for supplying water to Rawlins in the early part of the twentieth century and for its attributes of design, workmanship, and materials. The water line is 35 mi (56 km) long, was constructed in 1927, and abandoned in 1986. The unique wooden barrel construction design consists of wooden staves and metal bands that hold the pipeline together. The gravity flow pipeline carried water from 25 fresh water springs located in the Sage Creek Basin south of Rawlins. Currently, the pipeline lies within a corridor with four other water lines marked by blue painted vertical pipes/markers along its centerline. Since this historic pipeline is buried and cannot be seen from the project area, there will be no indirect adverse affects from the proposed project.

Given the paucity of sites recorded in these two sections, few if any cultural resources were expected from the current project. However, prehistoric lithic scatters and historic trash scatters may be present in the area.

SURVEY METHODS:
The Class III cultural resource inventory was conducted on May 25, 2006, by Edward Schneider, Mark Nelson, and William Battnerman. Standard archaeological procedures were followed throughout the project. The inventoried areas were examined for surface artifacts, features, or other evidence of prehistoric or historic activity. The survey was conducted using 100-ft (30-m)
Figure 1    Location of Project Area.
Figure 2  Topographic Map Showing the Location of the Inventoried Area. Taken from the Rawlins (1953, Photorevised 1981), Smith Draw West (1983), Coal Mine Ridge (1983), and Rawlins Peak (1983), Wyoming, USGS 7.5' Series Quadrangles (1:24,000 Scale).
Figure 3  Overview of Project Area at the Eastern Edge of the Inventory Block, Looking North (Taken by Mark Nelson, 5/25/06).

Figure 4  Overview of Project Area at the Central Eastern Area of the Inventory Block, Looking West-northwest (Taken by Mark Nelson, 5/25/06).
transects. The corners of the survey area were staked. Particular attention was given to erosional areas, animal burrows, dunes, or areas of previous disturbance for indications of surface or buried cultural deposits. The field methods were sufficient to locate any cultural sites on the surface of the inventoried area, and the possibility of buried cultural deposits is considered to be low.

The site criteria outlined by the Wyoming SHPO was employed during this project. These guidelines define a site as a discrete area containing 15 or more prehistoric artifacts, one or more cultural features, or 50 or more historic artifacts exceeding 50 years in age within a 100-ft (30-m) diameter area. An isolated find is defined as 14 or fewer prehistoric artifacts or 49 or fewer historic artifacts with no association to any other cultural material.

SURVEY RESULTS AND MANAGEMENT RECOMMENDATIONS:
No cultural resources were noted within the project inventory area. Given the residual nature of the deposits throughout the area, the likelihood of encountering intact buried cultural remains is low. Cultural resource clearance is recommended for the project.