WHITE RIVER
STORAGE FEASIBILITY STUDY

DRAFT REPORT

Prepared for the
Rio Blanco Water Conservancy District

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EXECUTIVE SUMMARY

The objective of the White River Storage Feasibility Study is to begin the planning process for a new water storage reservoir within the Rio Blanco Water Conservancy District (RBWCD). The Yellow Jacket Water Conservancy District (YJWCD) commissioned a 2013 storage feasibility study in the upper White River and the report provided valuable background information for this study. This study is a separate study for the RBWCD, which is a separate organization focused on water supply issues in the lower White River. The RBWCD encompasses the lower White River basin in western Rio Blanco County, in northwestern, Colorado. The RBWCD owns and operates the Taylor Draw Hydroelectric Project, a run-of-the-river project that provides 2MW of hydropower and flat water recreation on Kenney Reservoir. The RBWCD is facing a serious water crisis because Kenney Reservoir, which originally provided 13,800 acre-feet of storage, is silting in at an average rate of more than 300 acre-feet per year. The loss of this storage reduces recreation use in the reservoir and the ability to provide long term municipal and industrial (M&I) water storage for the Town of Rangely.

This report was prepared by W. W. Wheeler and Associates, Inc. (Wheeler) for the RBWCD. The study and the initial stakeholder involvement process were managed by EIS Solutions. The feasibility study was scoped to be consistent with the alternatives analysis process that is required by the National Environmental Policy Act (NEPA) because any new water storage reservoir will likely require approvals from the U.S. Department of Interior, Bureau of Land Management (BLM). The vast majority of the land in Rio Blanco County is owned by the BLM and approval of a new reservoir will likely require extensive NEPA documentation.

The project included the development of an initial project purpose and need statement; a map study which identified 25 potential reservoir storage alternatives; evaluated and projected the need for future water storage in western Rio Blanco County in the range of 20,000 to 90,000 acre-feet of storage needed by 2065; and a screening evaluation to identify primary reservoir sites for initial engineering feasibility design.

Wheeler developed feasibility-level designs and opinions of probable cost for a 20,000 acre-foot and 90,000 acre-foot reservoir at the Wolf Creek, Spring Creek, and Gilliam Draw sites. Further constraint evaluations were performed at each of the primary sites which included an on-site geological assessment, a Cultural Resources Inventory Assessment, and an on-site biological habitat and wetland assessment. The off-channel Wolf Creek site was selected as the preferred alternative because it has no identified significant environmental, cultural resources, or geologic hazards and has the most favorable capital and operation and maintenance costs. The project has the potential to provide significant flow enhancements for endangered fish, generate between $9.4 million and $12.1 million in annual visitor spending from new lake recreation, and produce $1.1 to $1.4 million annually in sales tax revenue for Rio Blanco and Moffat Counties, Rangely, Meeker, Craig, and the State of Colorado.

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1.0 INTRODUCTION

1.1 Objective

The objective of the White River Storage Feasibility Study is to begin the planning process for a new water storage reservoir within the Rio Blanco Water Conservancy District (RBWCD). The White River Storage Feasibility Study builds upon a previous storage feasibility study in the upper White River basin commissioned by the Yellow Jacket Water Conservancy District (Applegate, 2013).

In the early 1980s, the RBWCD designed, permitted, constructed, and funded the Taylor Draw Dam Hydroelectric Project. The reservoir impounded by Taylor Draw Dam is known as Kenney Reservoir. The dam and reservoir provides hydropower and recreation, and was permitted to provide water supply and mitigate floods and ice dams for the Town of Rangely. Kenney Reservoir, which is located on the main stem of the White River approximately six miles upstream of Rangely, is silting in at an average rate of more than 300 acre-feet per year (GEI, 1999). The original two-mile-long reservoir is now reduced to about one mile of open water and another mile of very diverse wetlands in the original upstream reservoir pool. The loss of reservoir storage has significantly reduced recreation use at Kenny Reservoir and the ability of the reservoir to provide any future water supply to the Town of Rangely. Therefore, the RBWCD has a serious water issue that must be addressed within its District. Most of the land within the RBWCD boundaries is owned by the U. S. Department of Interior, Bureau of Land Management (BLM), so any new reservoir construction will likely require a Special Use Permit from the BLM, which will require extensive permitting and documentation required by National Environmental Policy Act (NEPA).

The planning, permitting, financing, design, and construction of a new water supply reservoir can take many years and the RBWCD realizes that it must begin an aggressive planning process that will be consistent with the NEPA documentation that will be required for the project.

1.2 Authorization

This feasibility report was commissioned by the RBWCD. The majority of the feasibility report funding was provided by Water Supply Reserve Account (WSRA) grants authorized by the Yampa/White/Green Basin Water Roundtable and the Colorado Water Conservation Board (CWCB). Local funding was provided by the RBWCD and Rio Blanco County. The feasibility report was prepared by W. W. Wheeler and Associates, Inc. (Wheeler) with input from EIS Solutions, Harvey Economics (HE), WestWater Engineering (WestWater), and the Grand River Institute (GRI). The feasibility work was managed by EIS Solutions and the scope of work included an initial Phase 1 coarse screening and a second Phase 2 fine screening of potential reservoir sites.

1.3 Feasibility Study Approach

EIS Solutions and Wheeler recognize that due to the wide extent of BLM lands located within the RBWCD, it is highly likely that any new storage reservoir would impact BLM lands and require a Special Use Permit from the BLM. Approval of a BLM permit will require documentation under the National Environmental Policy Act (NEPA). Based on a meeting with representatives from the BLM White River Field Office and the RBWCD on April 16, 2014, the NEPA documentation for a new storage reservoir on the White River will likely require extensive documentation as an Environmental Impact Statement (EIS) because, as a minimum, there will likely be impacts to endangered fish in the White River downstream of the reservoir.

Based on the collective experience of EIS Solutions and Wheeler's key staff with the NEPA process, the focus of this study was to perform an initial, cursory evaluation of alternatives and an initial coarse screening process to minimize the potential of spending scarce project planning funds on engineering evaluations for reservoirs that are likely unpermittable. During the initial stakeholder's meeting with the BLM on April 16, 2014, the BLM Field Office Manager indicated that the initial Phase 1 coarse screening work was very helpful and could be used to document the initial scoping work that would be required for an EIS.

Phase 1 of the study included a map study to identify potential storage sites near the White River, development of an initial purpose and need statement, and a coarse screening evaluation to eliminate reservoir sites from primary consideration that were initially considered to be unpermittable. Coupled with the Phase 1 work was an extensive series of initial stakeholder meetings with key potential project stakeholders to begin to identify key issues that could be a challenge to successfully implementing new water storage in the RBWCD. A secondary purpose of the initial stakeholder meetings was to begin to develop broad-based support for the project.

Phase 2 of the study was intended to develop feasibility-level engineering designs for the primary reservoir sites that resulted from Phase 1 of the study. During Phase 2 of the study preliminary field site visits of the primary reservoir sites were conducted to identify potential environmental or other key constraints that may potentially affect the ability to obtain construction permits for the proposed primary reservoirs. Phase 2 also included the preparation of a financing roadmap for the project. Continued stakeholder meetings with existing and newly identified stakeholders were also performed as part of the Phase 2 work.

1.4 Scope of Work

The scope of Work for the two-phased feasibility study is provided in Appendix A. Key work tasks completed in the White River Storage Feasibility Study in Phase 1 and Phase 2 are summarized below:

1. Performed stakeholder/roundtable meetings and communications,
2. Completed an alternatives map study,
3. Facilitated an initial Alternatives Workshop,
4. Refined purpose and need and water demands,
5. Performed coarse screening evaluations,
6. Facilitated a Coarse Screening Workshop,
7. Performed the preliminary engineering and held a public workshop,
8. Performed constraint evaluations,
9. Prepared a financing roadmap,
10. Performed presentations to key agencies,
11. Prepared a draft report of the work, including both Phase 1 and Phase 2 work, and held a public workshop to present the report,
12. Addressed comments and prepared a Final Report for the study.

1.5 Project Personnel

The following personnel contributed to the work documented in this report:

1. Stephen Jamieson, P.E., Project Manager, Wheeler
2. Danielle Tripp Hannes, P.E., Project Engineer, Wheeler
3. Christine Mugele, P.E., Associate Engineer, Wheeler
4. Gary Thompson, P. E., Water Rights Engineer, Wheeler
5. Ed Harvey, Harvey Economics
6. Susan Walker, Harvey Economics
7. Jessica Harvey, Harvey Economics
8. William Bliton, Geologist, Wheeler
9. Amie Wilsey, Environmental Scientist/Biologist, WestWater Engineering
10. Carl E. Conner, Cultural Resources, Grand River Institute

Brad McCloud provided project management and project oversight direction to the feasibility study and coordinated a majority of the stakeholder meetings. Wheeler gratefully acknowledges the valuable input provided by the RBWVD Board of Directors and the District Manager, Dan Eddy. The RBWCD Board of Directors and District Manager also participated in numerous key stakeholder meetings during both Phase 1 and Phase 2 of this study.

2.0 BACKGROUND

2.1 Project Setting

The White River watershed encompasses approximately 3,750 square miles of land in Rio Blanco and Moffat Counties in northwestern Colorado (see Figure No. 1). The White River flows into the Green River south of Vernal, Utah. Approximately 500,000 acre-feet of water flows out of the White River annually into Utah, and the total consumptive use on the White River in Colorado is approximately 30,000 acre-feet (Y/W/G Roundtable, 2014).

The watershed ranges in elevation from 11,000 feet[1] on the east end to Elevation 5000 at the Utah State Line. Major sub-drainages to the White River include Piceance Creek, Douglas Creek, Wolf Creek, Yellow Creek, and Crooked Wash.

2.2 The Rio Blanco Water Conservancy District

The RBWCD was originally formed in 1978 as part of Water Users Association No. 1 under the Colorado River Water Conservation District. In 1992, all assets of the Water Users Association No. 1 were transferred to form the RBWCD. The RBWCD constructed the Taylor Draw Hydroelectric Project in 1983 and 1984. The main project features of this run-of-the-river project include a powerhouse with a generating capacity of two-megawatts and Taylor Draw Dam, which forms Kenney Reservoir. The RBWCD currently operates and maintains the hydropower plant, the dam, and recreational facilities at Kenney Reservoir. One of the main reasons for the construction of Taylor Draw Dam and Kenney Reservoir was to mitigate flooding and ice dams in and near the Town of Rangely.

The RBWCD collects revenues from a District-wide mill levy of approximately $192,000 annually, on average. The RBWCD also generates hydropower, which produces an annual average revenue of approximately $511,000. Between the mill levy and hydropower revenues, the RBWCD has average annual revenue of $703,000.

2.3 Reservoir Siltation

In 1998, an underwater survey was performed of Kenney Reservoir to obtain topographic information for the top of the accumulated sediment in the reservoir since its first filling in 1985 (GEI, 1999). According to this survey, the reservoir volume below the spillway at Taylor Draw Dam has decreased from 13,800 acre-feet in 1985 to 9,400 acre-feet in 1999, resulting in an average annual rate of sediment accumulation of 315 acre-feet per year. The 1985 surface area of Kenney Reservoir was approximately 650 acres and the 2014 surface area, obtained from a 2013 aerial photograph in ArcGIS, is approximately 335 acres that is available for recreation.

[1] Elevations in this report are reported in feet above the 1988 North American Vertical Datum.

2.4 Summary of Previous Evaluations

No specific water supply studies were completed for the RBWCD since the original feasibility studies completed for Taylor Draw Dam. The Statewide Water Supply Initiative (SWSI) provided a generalized evaluation of water shortages in the White River Basin (SWSI, 2010), but this study was not specifically focused on the seriousness of the developing water crisis within the RBWCD.

The Yellow Jacket Water Conservancy District (YJWCD) prepared a Water Storage Feasibility Study in April 2013; however, this study was focused only on the development of reservoir sites located in the upper White River Basin within the YJWCD (Applegate, 2013). The YJWCD evaluated eight potential storage sites for geotechnical/geological suitability, land ownership, geographical location, topography, recreational opportunities, constructability, existing infrastructure, native water supply, environmental impacts, and permitting concerns. In a meeting between representatives of the YJWCD and the RBWCD on March 26, 2014, the YJWCD indicated that the purpose of their 2013 water storage feasibility study was to help maintain due diligence for its existing water rights. The YJWCD representative indicated that its annual revenues are approximately $30,000 and that they do not have the financial ability to develop any of the proposed reservoir sites. However, the information developed in the YJWCD study has been a valuable resource. The YJWCD is considered to be a strong supporter of this White River Storage Feasibility Project implemented by the RBWCD.

2.5 Water Rights

The majority of the larger senior water rights on the White River are located upstream of Meeker. Downstream of Meeker, the White River operates under free river conditions throughout most of the year. As a result, the RBWCD is filing 2014 water rights for the proposed new reservoir.

The RBWCD also has conditional water rights associated with Taylor Draw Dam that could be transferred to the preferred reservoir site with minimal impacts expected to other water users. The RBWCD conditional water rights include:

- 13,800 acre-feet (Adjudication date: 11/21/1966)
- 13,800 acre-feet (Adjudication date: 12/31/1982)
- 620 cfs (Adjudication date: 11/21/1966)

The Colorado River Water Conservation District owns some conditional water rights on the White River that include:

- 75,957 acre-feet (Strawberry Creek Reservoir, Adjudication date: 12/31/1973)
- 29,374 acre-feet (Wray Gulch Reservoir, Adjudication date: 12/31/1973)

In an initial meeting with representatives of the Colorado River Water Conservation District, the representatives indicated that they would consider transferring these water rights to a proposed new reservoir located within the RBWCD, if it appeared that these water rights could be feasibly transferred.

The Yellow Jacket Water Conservancy District also owns water rights on the White River that it may be willing to transfer to the new reservoir in the RBWCD. At the time this report was written, the water rights potentially available from the YJWCD include:

- 10,000 acre-feet (Sawmill Mountain Reservoir)
  Case No. 09CW48 – Original Decree – 9/29/1977
- 12,500 acre-feet (Ripple Creek Reservoir)
  Case No. 09CW50 – Original Decree – 11/21/1966
- 12,500 acre-feet (Lost Park Reservoir)
  Case No. 09CW50 – Original Decree – 11/21/1966
- 25 cfs North Fork Feeder Conduit
  Case No. 09CW48 – Original Decree – 9/29/1977

One of the stipulations of the Ripple Creek and Lost Park Reservoirs is that the YJWCD has agreed to limit storage to no more than 12,500 acre-feet at one or more locations; therefore the total storage amount that YJWCD holds water rights for is 22,500 acre-feet.

The storage rights that are owned by the Colorado River Water Conservation District and the YJWCD are located further upstream on the White River so a change of these water rights to the proposed downstream locations might include terms and conditions to prevent injury to the intervening water users, including potential limitations on the use of the changed storage rights. It is expected that a change case to transfer the Taylor Draw Dam conditional water rights to the new reservoir would include fewer terms and conditions to prevent injury to other water rights in the White River basin.

3.0 PURPOSE AND NEED

Harvey Economics (HE), in cooperation with EIS Solutions (EIS), updated previous state-wide water demand projection information, interviewed potential water users, and updated general water demands to develop a site-specific future water demand estimate for the RBWCD through the year 2065. The focus of HE's economic evaluations were on economic sectors, or general water-user groups, who might have an existing or future need for additional water rights and water storage in the region. HE then estimated and quantified the amount of reservoir storage space that would be required to meet those needs. This information was then provided to Wheeler in order to develop an initial purpose and need statement and for use in the coarse screening analysis. The initial purpose and need statement for the project is provided in Appendix B and the coarse screening is described in Section 5 of this report. As part of the water demand analysis, several key interviews were conducted by HE. The interviews are documented in Section 9 of this report.

3.1 Water Demand Updates

A summary of the updated RBWCD water demands is provided in Table No. 3.1. A brief description of the methodology used to estimate these water demands is provided after Table No. 3.1. The range of water demands was rounded to evaluate reservoir storage sites that could accommodate a 20,000 acre-foot reservoir to meet the low end of the projected water demands and a 90,000 acre-foot reservoir to meet the high end of the water demands. Additional information is provided in Harvey Economics Summary report provided in Appendix D (HE, 2014).

TABLE 3.1 – PROJECTED WATER STORAGE NEEDS IN RIO BLANCO COUNTY

	Near-Term (through 2030) (acre-feet)	Intermediate-Term (through 2045) (acre-feet)	Long-Term (through 2065) (acre-feet)
Municipal and Industrial (M&I)	1,050 - 2,100	1,250 – 2,500	1,600 – 3,150
Oil and Natural Gas	0	500	3,500
Oil Shale	0	3,500 – 17,600	8,500 – 42,300
Recreation	*Recreation Design Criteria (described in Section 3.1.4)*		
Environmental	3,000 – 42,000	3,000 – 42,000	3,000 – 42,000
Other	?	?	?
TOTAL	**4,050 – 44,100**	**8,250 – 62,600**	**16,600 – 90,950**

3.1.1 Water Demand Projection Assumptions

HE developed water and storage demands for each sector for an approximate 50-year planning period through 2065. The focus of the study was mainly on water needs for Rio Blanco County; however, HE also reviewed the needs for the entire White River Basin. The primary focus of the water demand updates were on industries that have the ability to contribute financially to the construction of a new water storage reservoir within the RBWCD.

The conclusions and estimates of the need for water and storage for the sectors are based, in part, on the experience and professional judgment of the economists along with available information at the time the projections were developed. In many instances, definitive data was not available for a more precise analysis and substantial uncertainty exists with key variables that will determine future water needs.

3.1.2 Municipal and Industrial Demands

The Towns of Rangely and Meeker were the focus of the analysis for this sector because they are the only incorporated jurisdictions located within Rio Blanco County. Because Meeker's existing and future source of water is alluvial groundwater, it was assumed that the town would not require new raw water storage; therefore, the focus of the Municipal and Industrial (M&I) need for new water storage was the Town of Rangely.

Estimates of near, intermediate, and long-term water storage needs for the Town of Rangely are based on HE's projections of annual water demands and the assumption that the Town would likely seek water storage space to hold one to two years' worth of annual water demands in order to ensure available water supplies during times of drought or for other unexpected circumstances. Table No. 3.1 provides HE's projections for water storage needs for M&I for the near and long-term.

3.1.3 Energy Development

The current and future operations of the oil, natural gas, and oil shale industries were evaluated for future water and storage needs. Current prices and shut-in volumes are currently temporarily depressing the natural gas development in the area. Exploration in the Williams Fork strata currently requires minimal fresh water beyond what is currently produced as well by-product; however exploration in the Mancos Shale horizon in the future may require additional water, which was included in the demand projections. Oil production has historically comprised only a small portion of energy activity in Rio Blanco County and that trend was assumed to continue.

The oil shale industry in Colorado is in its early stages of development with small independent pilot programs exploring the development possibilities. At the time this report was written, the oil shale industry was considered to be more active internationally and in other areas of the United States. If the technology, price, and permitting issues are favorably resolved in Colorado, and successful production could be demonstrated in the area, energy companies would likely begin to renew their interest in oil shale development in Rio Blanco County. HE projects a long-term ramping up of production through 2065. The water and storage demands for this industry were estimated for a low water use technology scenario and for a high water use technology scenario, as a result of the unknowns with the type of technology that will be used in the oil shale industry in the future. The projected needs for oil shale, oil, and natural gas development are summarized in Table No. 3.1.

3.1.4 Recreation

It is HE's opinion that there is demand for additional reservoir recreational opportunities based on current recreation activity in Rio Blanco County. That conclusion is supported by the following facts: (1) There are currently only three large lakes available for recreation in the Rio Blanco County; however, Kenney Reservoir is becoming increasingly silted in and will likely become unavailable to flat water recreators at some point in the near future; (2) only two of those reservoirs allow motorized sports (one of which is Kenney Reservoir that is silting in and the other is Rio Blanco Lake which has a small surface area); (3) many Rio Blanco County residents currently travel to areas outside the County for better quality fishing and boating experiences; (4) potential reservoir locations are accessible from a number of larger regional cities and towns, including Grand Junction, Glenwood Springs, and eastern Utah communities; the right reservoir characteristics and amenities are likely to attract visitors from a wide geographic area.

The interviews conducted with people familiar with and involved in recreation in the County indicate that a new reservoir should have the following characteristics in order to attract visitors and support a number of recreational opportunities:

- A minimum of 700 to 1,500 acres of surface area;
- An elongated shape;
- Minimum depth of 50 feet in some areas of the lake;
- Variable bottom shelving;
- Interesting and variable lakeside topography;
- Good road access for visitors with boats and other equipment.

3.1.5 Environmental

The White River, below Kenney Reservoir to the Colorado/Utah border, provides habitat for two federally listed threatened and endangered fish species: the Colorado Pikeminnow and the Razorback Sucker. The Upper Colorado River Endangered Fish Recovery Program (Recovery Program), which includes partners such as the U.S. Fish and Wildlife Service, Bureau of Reclamation, the National Park Service, and the States of Colorado, Utah, and Wyoming have undertaken a number of activities to protect these species in several Colorado River Basins, including the Colorado River, Yampa River, and Gunnison River. At the time this report was written, the Recovery Program had recently begun work to develop a Programmatic Biological Opinion (PBO) for the White River Basin, which will include a number of flow recommendations aimed at maintaining peak flows and minimum flows. It is anticipated that once the final flow recommendations are developed for the White River, some level of future water augmentation will be required to meet the target flows that will likely be established at the Watson Stream Gage Station on the White River near the Colorado/Utah border.

Because the PBO development for the White River Basin was in its infancy at the time this report was prepared, a simple, spreadsheet-based environmental storage model was developed by Wheeler to determine the potential storage needs to meet a target streamflow at the Watson USGS streamflow gage. The model used the daily average flow at the USGS gage at Watson and the USGS gage below Meeker from October 1961 to November 2013, with the exception of October 1979 to September 1985, when data was unavailable. Three other streamflow gages are located between Meeker and the Watson gage, however the USGS gage below Meeker was used because it provided the longest record of data available. The model took into account two daily scenarios:

1) Inflow scenario at times when the minimum streamflow demands were met at the Watson Gage: Water was assumed to be diverted into the new reservoir for storage to be used for future release for environmental water demands. The amount of water that was permitted to be diverted into the reservoir was either 1) the maximum diversion rate possible, which was limited based on the fill facility capacity, which was unknown in Phase 1; 2) the amount of water that would produce the maximum amount of storage available in the reservoir for environmental needs; or 3) the measured discharge at the USGS gage below Meeker minus the target discharge needed at the USGS Watson Gage, the assumed transit losses, and the assumed necessary flows for downstream water rights.

2) Outflow scenario at times when the minimum streamflow demands are not met at the Watson Gage: Water was assumed to be released from the new reservoir to meet the streamflow requirements at the Watson Gage. The

amount of water that was released was the target streamflow needed minus the streamflow measured at the Watson Gage, plus the assumed transit losses, and the assumed required river flows for downstream water rights.

The following assumptions were made in the environmental storage model calculations:

1) A transit loss of 0.5-percent per mile for 63 miles was assumed. Because the preferred reservoir site was unknown in Phase 1 of the study, the river length from the Crooked Wash Reservoir site to the Watson Gage was used since this site was located approximately near the middle of the potential reservoir sites.
2) The maximum diversion fill rate for the reservoir was assumed to be 100 cfs. This was further refined in Phase 2.
3) A streamflow buffer of 20 cfs was estimated during all times in the model to be used to satisfy downstream water rights.
4) The environmental storage volume was estimated assuming the minimum streamflow at the Watson gage would be met 95-percent of the time.
5) The minimum streamflow target at the USGS Watson Gage was assumed to range from 200 cfs to 300 cfs. Based on the Colorado River Recovery Program Project for fiscal year 2013, the baseflow dry target at the Watson Gage was 300 cfs (CRRP, 2013).

Based on target streamflows of 200 cfs and 300 cfs at the USGS Watson Gage, it was estimated that 3,000 acre-feet to 42,000 acre-feet, respectively, of storage could be needed to meet the potential endangered fish target streamflows 95-percent of the time. The Phase 1 model was further refined and expanded upon in Phase 2 of this study to develop the "Reservoir Storage Model". The "Reservoir Storage Model" operations are summarized in Figure No. 5 and further described in Section 6.1.5. Future refinements will need to be made to the model, after the final target streamflow requirements in the White River PBO are completed.

3.1.6 Other Potential Needs

Other potential needs for water storage on the White River include agriculture, Colorado River Compact Storage, and Trans-basin Diversions. Additional agricultural demands have been noted as needed in the SWSI studies, however based on HE's opinion, the agriculture sector is not expected to be able to contribute significant financial resources for a new water storage project now or in the foreseeable future.

Providing an emergency supply of water in storage that could be released to help offset a Colorado River Compact call could assist the State of Colorado in providing the required water demands downstream, without curtailing other Colorado water users; however, the feasibility or demand of this potential water storage was not quantifiable at the time this report was prepared. New trans-basin diversions remain a physical possibility in the State of Colorado, but quantifying a transbasin diversion project from the White River was considered to be too speculative to include in this report at the time it was written.

The agricultural, Colorado River Compact Storage, and transbasin diversion storage were not considered as part of the water demands for this study, but could be added at a future data if any of these future demands become more viable.

4.0 MAP STUDY OF RESERVOIR SITES

In order to provide the water storage needs for the sectors documented in Section 3.0, three potential options were analyzed:

1. Construct a new reservoir in a new location;
2. Raise Taylor Draw Dam (Kenney Reservoir) to provide additional water storage;
3. Dredge Kenney Reservoir to provide additional storage.

4.1 Map Study of Potential New Reservoir Sites

The identification of new reservoir storage sites was based on Wheeler's initial study of USGS 7.5 minute quadrangle maps of the White River watershed. Wheeler determined the approximate dam location along each reach to maximize the storage and surface area potential, while identifying sites with favorable topography for dam construction. In the White River Basin, 23 new reservoir sites were identified. Included in this map study was the Wolf Creek (main stem) reservoir site that was identified in the late 1970's by the U.S. Bureau of Reclamation. Kenney Reservoir (Taylor Draw Dam) was constructed instead of the dam at the Wolf Creek site in the early 1980s. The locations of the initially identified reservoir sites are shown on Figure No. 2 and a list with the general reservoir and dam characteristics of these reservoirs are summarized in Table No. 4.1.

TABLE 4.1 – INITIALLY IDENTIFIED POTENTIAL WHITE RIVER STORAGE SITES

Potential Dam Sites	Approx. Maximum Potential Dam Height (Feet)	Approx. Maximum Potential Dam Length (Feet)	Approx. Maximum Potential Surface Area (Acres)	Approx. Maximum Potential Volume (Acre-Feet)	Approx. Drainage Area (Square Miles)
Chase Draw Reservoir	104	1,554	190	6,349	7
Cottonwood Creek Reservoir	617	4,420	10,790	1,881,534	44
Crooked Wash Reservoir	390	7,460	20,335	2,522,069	155
Douglas Creek Reservoir	362	5,420	5,904	717,528	423
Gillam Draw Reservoir	349	5,180	1,692	210,271	12
Hall Draw Reservoir	146	1,340	194	8,434	3
Hammond Draw Reservoir	91	780	103	3,414	10
Hay Gulch Reservoir	446	6,073	1,669	267,307	15
Kellog Gulch Reservoir	100	880	165	7,041	3
Kenney #2 Reservoir	173	780	45	2,669	1
Little Spring Creek Reservoir	158	1,620	137	6,245	16
McAndrews Gulch Reservoir	198	1,270	205	16,389	15
School Gulch Reservoir	163	1,000	196	9,523	2
Scullion Gulch Reservoir	258	2,150	427	28,810	10
Smith Gulch Reservoir	502	2,768	2,677	425,622	19
Spring Creek Reservoir	379	2,340	1,013	126,622	51
Sulphur Creek Reservoir	747	5,689	3,402	952,476	12
Taylor Draw Reservoir	521	3,300	340	49,617	2
Tom Little Gulch Reservoir	119	700	308	10,896	5
Wolf Creek Reservoir (off channel)	268	3,240	18,549	1,496,812	203
Wolf Creek Reservoir (Main stem)	195	2,870	12,493	785,048	2498
Wray Gulch Reservoir	144	790	438	19,362	8
Yellow Creek Reservoir	759	6,750	32,829	5,864,488	260

4.2 Taylor Draw Dam (Kenney Reservoir) Enlargement

Based on comments received during the initial public meetings, enlarging Taylor Draw Dam (Kenney Reservoir) was also assessed as a potential new water supply reservoir. Figure No. 3 shows the approximate surface area available for recreation prior to siltation (1985); the 2014 estimated surface area available for recreation; and the surface area with an additional 20,000 acre-feet and 90,000 acre-feet reservoir enlargement. This alternative was eliminated from further consideration because enlargement would impact several hundred acres of wetlands upstream of the reservoir, which would eliminate the possibility of obtaining a U.S. Army Corps of Engineers 404 permit. In addition, an enlarged Kenney Reservoir would continue to be subject to excessive additional reservoir siltation issues in the future. This alternative also would have significant impacts to Highway 64 and any infrastructure near Highway 64 for the length of the approximately eight-mile-long reservoir that would be created by the 90,000 acre-feet expansion.

TABLE 4.2 – TAYLOR DRAW ENLARGEMENT SUMMARY

	Approx. Dam Height (Feet)	Approx. Dam Length (Feet)	Approx. Surface Area (Acres)	Approx. Max Volume (Acre-Feet)	Approx. Drainage Area (Square Miles)
Taylor Draw Dam (Existing)	81	1,130	335 [1]	13,800 [2]	2,788
Taylor Draw Dam (Enlarged by 20,000 Acre-feet)	104.5	1,470	1,077	33,800	2,788
Taylor Draw Dam (Enlarged by 90,000 Acre-feet)	142.5	2,030	2,323	103,800	2,788

1 The approximate surface area for the existing Kenney Reservoir includes the approximate area that can be used for recreation.

2 The storage in Kenney Reservoir prior to any siltation of the reservoir.

4.3 Dredge Kenney Reservoir

Dredging Kenney Reservoir to create more storage in Kenney Reservoir was also evaluated based on initial public meeting comments. Dredging had been assessed earlier by the RBWCD, since the existing storage and recreation is being severely impacted by the siltation. A 2010 assessment by Dredge Pro concluded that “there is no economical way to do this project” and no identified location for storage of the silt is available after dredging (Dredge Pro, 2010).

Based on the costs of the 2011 dredging of Strontia Springs Reservoir, located southwest of Denver, Colorado, it would cost approximately $77,520 per acre-foot to dredge Kenney Reservoir. In 2011, approximately 387 acre-feet of silt was dredged at Strontia Springs Reservoir for approximately $30 million. Kenney Reservoir is silting at approximately 315 acre-feet per year (GEI, 1999), indicating that since 1985 approximately 9,450 acre-foot of water storage has been lost. Based on this information, dredging Kenney Reservoir to regain the original storage would cost over $700 million dollars. Strontia Springs also had an identified site for disposal of the dredged sediment within approximately six miles from the reservoir. Dredge Pro’s assessment was that Kenney Reservoir does not currently have an identified waste location, which could make the costs significantly higher.

Based on the cost of this option and since siltation would be expected to occur in the future at this site, this was not considered to be a viable alternative.

5.0 COARSE SCREENING

Based on the future water storage needs summarized in Table No. 3.1, a reservoir with storage of 20,000 acre-feet to 90,000 acre-feet was determined to meet the projected 2065 water demands. In the coarse screening process, Wheeler eliminated several alternatives in a “Preliminary Screening”, then assigned additional coarse screening criteria in the “Secondary Screening” to determine the primary reservoir sites for additional evaluations.

5.1 Preliminary Coarse Screening

Preliminary coarse screening was performed which screened out the reservoir sites that did not meet the minimum water storage needs or the minimum surface area needs for recreation. In total, 14 sites were screened out in the preliminary screening, as documented in Table No. 5.1. The two reservoir sites on the main stem of the White River were also eliminated from further consideration based on location criteria. Cottonwood Creek was considered to be too far downstream to supplement endangered fish stream flows. The main stem Wolf Creek site was expected to have significant wetland impacts along the White River that would complicate approval of a U.S. Army Corps of Engineers permit for this site. The reservoir sites that were evaluated further after the preliminary screenings are shown in red for a 90,000 acre-foot reservoir on Figure No. 2.

TABLE 5.1 – SITES ELIMINATED BY PRELIMINARY SCREENING

Potential Dam Sites	Approximate Maximum Potential Surface Area at Site (Acres)	Approximate Maximum Potential Storage at Site (Acre-Feet)	Reason for Screening		
			Storage	Recreation	Location
Chase Draw Reservoir	190	6,349	X	X	
Cottonwood Creek Reservoir	10,790	1,881,534			X[2]
Hall Draw Reservoir	194	8,434	X	X	
Hammond Draw Reservoir	103	3,414	X	X	
Kellog Gulch Reservoir	165	7,041	X	X	
Kenney #2 Reservoir	45	2,669	X	X	
Little Spring Creek Reservoir	137	6,245	X	X	
McAndrews Gulch Reservoir	205	16,389	X	X	
School Gulch Reservoir	196	9,523	X	X	
Scullion Gulch Reservoir	427	28,810		X	
Taylor Draw Reservoir	340	49,617		X	
Tom Little Gulch Reservoir [1]	308	10,896	X	X	
Wolf Creek Reservoir (Main stem)	12,493	785,048			X
Wray Gulch Reservoir [1]	438	19,362	X	X	

1 Reservoir sites from the Yellow Jacket Water Conservancy District Water Storage Feasibility Study.
2 Cottonwood Creek Reservoir was screened out as a potential reservoir because it is considered to be too far downstream to assist with streamflows for endangered fish.

5.2 Secondary Coarse Screening Criteria

Following the preliminary coarse screening, nine reservoirs were analyzed in the secondary coarse screening. The reservoirs were assessed at the 90,000 acre-feet size for evaluation of the maximum potential impacts at each site. The secondary coarse screening quantified environmental impacts, infrastructure impacts, and property impacts at each site. During the March 26, 2014, public coarse screening workshop, there was a consensus that any reservoir not located within the RBWCD boundary should also be screened because it would be difficult to obtain support within the RBWCD with mill levy taxes for a reservoir that would be located outside of the RBWCD. Figures with each of the nine reservoir sites at the 90,000 acre-feet water surface and the potential impacts associated with these reservoirs are provided in Appendix C.

5.2.1 Environmental Impacts

The nine reservoir sites were assessed for environmental impacts that included:

1. Wetlands
2. Potential Endangered Species Habitat (Greater Sage-Grouse)
3. BLM Wilderness Study Areas
4. BLM Areas of Critical Environmental Concern (ACEC)

The wetlands data in the area was obtained from the National Wetland Inventory (NWI) from the U.S. Fish and Wildlife Service (USFWS, 2013). The NWI data represents the extent and approximate location of wetlands, which excludes certain wetland habitats because of the limitations of aerial imagery which was the primary data source that was used to detect the NWI wetlands. The NWI information is considered to be general, and used for a guideline but it is not considered to be an accurate assessment of jurisdictional wetlands.

Critical habitat for the endangered Colorado Pikeminnow and the Razorback Sucker is designated along the White River up to Rio Blanco Reservoir. None of the nine reservoir sites evaluated in the secondary screening would have any direct impacts on this critical habitat because the reservoirs were all off-channel reservoirs. At the time this report was written, the Greater Sage-Grouse has been included as a candidate species for listing under the Endangered Species Act. The Greater Sage-Grouse GIS data set used to identify the impact areas was obtained from the Bureau of Land Management, which identified the Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH) (BLM, 2013). The Wolf Creek and Crooked Wash reservoir sites are the only sites that are within the preliminary Greater Sage-Grouse habitat. At the Wolf Creek off-channel site, a majority of the reservoir lies within the PGH, with small impacts to the PPH in the upper reaches of the reservoir. At the Crooked Wash site, a majority of the reservoir lies within the PPH.

The BLM Wilderness Study Areas and BLM Areas of Critical Environmental Concern (ACEC) were obtained from the BLM (BLM, 2013). One ACEC was located on the left bank of the Yellow Creek Reservoir site, which was identified to have sensitive plants and remnant vegetation associations by the BLM. Both the Black Mountain and Windy Gulch Wilderness Study Areas were found to be impacted by the Smith Gulch Reservoir site. After discussion with the BLM, it will be nearly impossible to permit a reservoir with impacts to the Wilderness Study Areas or the ACEC.

The environmental impacts that each reservoir would have at the 90,000 acre-foot water surface are summarized in Table No. 5.2 and shown on the figures in Appendix C.

TABLE 5.2 – ENVIRONMENTAL IMPACTS

RESERVOIR	Amount of Potential Wetland Impacts [1] (ACRES)	Greater Sage-Grouse Habitat Impacts (ACRES)	BLM Wilderness Study Area Impacts	BLM Areas of Critical Environmental Concern Impacts (ACEC)
Crooked Wash	19.0	2,032	NO	NO
Douglas Creek	0.0	0	NO	NO
Gillam Draw	1.1	0	NO	NO
Hay Gulch	0.1	0	NO	NO
Smith Gulch	0.9	0	YES	NO
Spring Creek	0.0	0	NO	NO
Sulphur Creek	0.0	0	NO	NO
Wolf Creek (Off Channel)	3.7	2,399	NO	NO
Yellow Creek	5.4	0	NO	YES

5.2.2 Infrastructure Impacts

The nine reservoir sites were also assessed for identified impacts to infrastructure, which included:

1. Oil and Gas Wells
2. State Highways and County Roads

The number of oil and gas wells impacted by each of the reservoirs was determined using the wells that are listed in the Colorado Oil and Gas Conservation Commission (COGCC) inventory and available in the GIS shapefile (COGCC, 2013). Douglas Creek Reservoir is located within the Rangely COGCC Field and the Gillam Draw Field.

The impacts to highways and roads were based on the length of the road impacted at the 90,000 acre-feet water surface. Information on the roads was obtained from the Colorado Department of Transportation (CDOT, 2013). The only State Highway that was impacted at any of the sites was Highway 139, which would be inundated by the Douglas Creek reservoir site.

Infrastructure impacts for each reservoir at 90,000 acre-feet of water storage is summarized in Table No. 5.3 and shown on the figures in Appendix C.

TABLE 5.3 – INFRASTRUCTURE IMPACTS

RESERVOIR	# of Oil and Gas Wells (#)	Total Road Length (MILES)	Dirt or Other Road (MILES)	Length of County Roads (MILES)	State Highway (MILES)
Crooked Wash	0	3.4	3.4	0.0	0.0
Douglas Creek	11	6.4	0.8	1.2	4.5
Gillam Draw	1	4.0	1.4	2.6	0.0
Hay Gulch	0	3.8	2.5	1.3	0.0
Smith Gulch	0	4.1	4.1	0.0	0.0
Spring Creek	0	4.1	4.1	0.0	0.0
Sulphur Creek	0	2.8	0.0	2.7	0.0
Wolf Creek (Off Channel)	0	4.6	4.6	0.0	0.0
Yellow Creek	0	7.3	2.2	5.2	0.0

5.2.3 Property Impacts

The nine reservoir sites were also assessed for any impact to properties, which included:

1. Number of private landowners impacted,
2. BLM /Colorado land impacts.

Although none of the reservoir sites were specifically screened based on the number of landowners impacted, it provided an idea of the number of properties that were impacted and the entities or private landowners that would need to be contacted to further develop a reservoir at the site.

The property that each reservoir would impact at the 90,000 acre-foot water surface is summarized in Table No. 5.4 and shown on the figures in Appendix C.

TABLE 5.4 – PROPERTY IMPACTS

RESERVOIR	BLM Land Impacts	Colorado Land Impacts	Private Property Impacts (# of Properties)
Crooked Wash	YES	YES	3
Douglas Creek	YES	NO	4
Gillam Draw	YES	NO	0
Hay Gulch	YES	YES	0
Smith Gulch	YES	NO	1
Spring Creek	YES	NO	0
Sulphur Creek	YES	NO	2
Wolf Creek (Off Channel)	YES	YES	3
Yellow Creek	YES	YES	0

5.2.4 RBWCD Boundary

Screening reservoirs located outside of the RBWCD boundary, per the March 26, 2014, public workshop consensus, resulted in the screening of reservoirs at Crooked Wash, Hay Gulch, Smith Gulch, and Sulphur Creek. The RBWCD district boundary is shown on Figure Nos. 1 and 2.

5.3 Secondary Coarse Screening Results

A summary of the secondary screening results is provided in Table No. 5.5. Based on the secondary screening, the primary reservoir sites that were selected and analyzed in Phase 2 of the feasibility study were Gillam Draw, Spring Creek, and the Wolf Creek off-channel reservoir.

TABLE 5.5 – SECONDARY SCREENING SUMMARY

RESERVOIR	Screened due to:		
	Environmental Impacts	Infrastructure Impacts	Site is not located in RBWCD
Crooked Wash	YES		YES
Douglas Creek		YES	
Gillam Draw			
Hay Gulch			YES
Smith Gulch	YES		YES
Spring Creek			
Sulphur Creek			YES
Wolf Creek (Off Channel)	[1]		
Yellow Creek	YES		

[1] It was assumed that appropriate mitigation can be provided for the loss of the Preliminary General Habitat for the Greater Sage-Grouse at the Wolf Creek (off-channel) site.

6.0 ENGINEERING FEASIBILITY DESIGNS

6.1 Feasibility Design Criteria

Wheeler developed feasibility-level designs and opinions of probable cost for two reservoir sizes at each of the three primary dam sites. The six feasibility designs include a 20,000 acre-foot reservoir and a 90,000 acre-foot reservoir at Gillam Draw, Spring Creek, and the off-channel Wolf Creek dam site. All of the primary dam sites would be filled by pump stations and pipelines from the White River. Feasibility design drawings for the primary dam sites are provided in Appendix E. Key preliminary dam design criteria are summarized as follows:

6.1.1 General Design Criteria

a. All dams were designed as zoned embankment earthfill dams with a large low-level outlet works designed to meet State of Colorado reservoir drawdown requirements.
b. All of the dams were assumed to be high hazard-potential dams designed to safely pass the inflow associated with the Probable Maximum Flood (PMF).
c. Consistent with the State of Colorado dam safety regulations (Colorado DWR, 2007), the dam crest was set at least one-foot above the maximum water surface resulting from routing the PMF through the reservoir and the emergency spillway.
d. The crest of the emergency spillway was set at either the 20,000 acre-foot or 90,000 acre-foot reservoir water storage level. The emergency spillway was located in an area of the reservoir to take advantage of natural topographic features that were conducive for emergency spillway construction.

6.1.2 Dam Design Criteria

a. Dam crests were designed to be 25-foot-wide.
b. Upstream slopes would be constructed to 3H: 1V (horizontal: vertical).
c. The downstream slopes would be constructed to 3.5H: 1V.
d. A stability bench was included at the Spring Creek and Gillam Draw Dam due to the large dam heights and unknown soil conditions in the area to enhance slope stability.
e. Riprap slope protection was assumed to be placed on the upstream face of the embankment, however final design will involve a better assessment of on-site materials. Soil cement upstream slope protection could prove to be a more viable and less costly option.
f. A five-foot-wide vertical chimney drain and ten-foot-thick blanket drain with a dual envelope toe drain would be provided in each dam for seepage control.
g. Foundation grouting of bedrock was assumed to minimize foundation seepage.
h. The general dam characteristics of the six dams are provided in Table 6.1.

Table 6.1 – Dam Characteristics Summary

	Wolf Creek 20k	Wolf Creek 90k	Spring Creek 20k	Spring Creek 90k	Gillam Draw 20k	Gillam Draw 90K
Dam Crest Length (feet)	2,170	3,300	1,620	5,090	2,600	3,700
Dam Crest Elevation	5555.0	5597.0	5623.0	5744.0	5595.0	5706.0
Maximum Dam Height (feet)	80	122	243	360	210	321
Dam Volume [1] (cubic yards)	1,289,800	3,380,700	5,143,600	21,178,000	6,425,300	18,770,500

[1] Includes the Zone 1 Fill, Zone 3 Fill, Filter Sand, Slope Protection, and Basecourse.

6.1.3 Outlet Works Design Criteria

a. The outlet works discharge conduit would be constructed of a 96-inch-diameter steel conduit encased in concrete.
b. The outlet conduits are designed to discharge the top 5 feet of the reservoir within 5 days and to have adequate capacity to satisfy downstream water rights calls under low head conditions.
c. Flow through the outlet works conduit will be controlled by a high pressure guard gate and control gate.
d. A reinforced concrete gate tower would be included in each dam for control gate and outlet conduit access.
e. A 50-foot-long, prefabricated access bridge would be included in each dam to access the gate tower from dam crest, with the exception of Spring Creek 20,000 acre-foot dam. The 20,000 acre-foot Spring Creek Dam includes the gate tower constructed within the on the Roller Compacted Concrete (RCC) spillway section.
f. A single, reinforced concrete terminal structure would be constructed at the downstream end of the outlet works discharge conduits.
g. General outlet works characteristics at each dam site are provided in Table 6.2.

Table 6.2 – Outlet Works Characteristics Summary

	Wolf Creek 20k	Wolf Creek 90k	Spring Creek 20k	Spring Creek 90k	Gillam Draw 20k	Gillam Draw 90K
Outlet Works Diameter (feet)	8	8	8	8	8	8
Outlet Works Length (feet)	590	800	750	2600	1410	2320
Approx. Outlet Works Capacity from the normal high water level (cfs)	1,280	1,470	2,240	1,660	1,640	1,710

6.1.4 Emergency Spillway Design Criteria

a. A reinforced concrete control section would be included in the emergency spillways.

b. Concrete drop structures with riprap were provided from the spillway control section to the downstream channel.
c. The spillway inflow hydrology and reservoir routing results for the reservoirs for the PMF storm event are provided in Table 6.3.

Table 6.3 – Hydrology and Reservoir Routing Summary

	Wolf Creek 20k	Wolf Creek 90k	Spring Creek 20k	Spring Creek 90k	Gillam Draw 20k	Gillam Draw 90K
Drainage Area (square miles)	202	202	51	51	12	12
PMF Volume (acre-feet)	51,100	51,100	15,400	18,800	4,700	6,000
Peak PMF Inflow (cfs)	68,400	68,400	48,400	26,400	31,600	9,200
Peak PMF Outflow (cfs)	55,400	31,200	14,400	16,500	2,400	728
Spillway Crest Elevation (feet)	5540.8	5585.1	5598.3	5733.7	5582.0	5698.4
Spillway Width (feet)	500	400	50	250	25	25
Max. Water Surface El. (feet)	5552.4	5594.3	5620.2	5741.9	5592.6	5703.2
Dam Crest Elevation (feet)	5555.0	5597.0	5623.0	5744.0	5595.0	5706.0
Freeboard (feet)	2.6	2.7	2.8	2.1	2.4	2.8

6.1.5 Pumping Station Design Criteria

The pump station for the 20,000 acre-foot and 90,000 acre-foot reservoirs were sized based on the flow rate that allowed the reservoirs to maintain water storage in the reservoir during most periods. To determine the pumping capability for each reservoir size, a “Reservoir Storage Model” was created and used, which is similar to the model that was used for the projected water storage needs for environmental as explained in Section 3.1.5. In addition to the operations of the model making releases for the environmental streamflows, the model also makes releases for the projected water storage needs for energy, M&I, and accounts for evaporation losses from the reservoir. The releases for M&I and energy were assumed to occur at the projected long-term need at a constant rate throughout the year; therefore, the 90,000 acre-foot reservoir was assumed a release of 48,950 acre-feet each year (68 cfs average flow) and the 20,000 acre-foot reservoir was assumed to release 13,600 acre-feet each year (19 cfs average flow). The model uses the 1961-2013 streamflow data available the USGS gage on the White River near Watson and the USGS gage on the White River below Meeker to mimic simulate reservoir operations Figure No. 5 provides an overview of how the model was constructed. Table 6.4 provides an overview of the storage capacities provided by the "Reservoir Storage Model" under various analyzed pumping rate inflow scenarios.

Table 6.4 – Reservoir Storage Model Summary [1]

	90,000 Acre-Foot Reservoir			20,000 Acre-Foot Reservoir		
Reservoir Fill Rate	200 cfs	400 cfs	600 cfs	25 cfs	50 cfs	100 cfs
Average Annual Reservoir Storage (acre-feet)	23,700	54,000	63,600	7,500	18,000	18,800
Minimum Average Annual Reservoir Storage (acre-feet)	500	10,600	19,900	1,400	5,600	10,800
Percentage of Years Reservoir is Filled to Capacity during any Period	4%	38%	62%	0%	81%	87%

[1] Based on the 1961 – 2013 available flow data used in the Reservoir Storage Model. The White River streamflow characteristics may deviate from these results in future years.

Based on the "Reservoir Storage Model", it was determined that a 400 cfs inflow capacity would be needed for the 90,000 acre-foot reservoir and a 50 cfs inflow capacity would be needed for the 20,000 acre-foot reservoir. The pump rate for the 90,000 acre-foot reservoir was limited to 400 cfs mainly due to the excessive size of the pumps that would be needed to provide higher flows to the reservoirs. Figure No. 6 provides a plot of the reservoir storage volume from 1961 – 2013 as produced by the "Reservoir Storage Model" for the 90,000 acre-foot and 20,000 acre-foot reservoirs, respectively.

Based on the 20,000 acre-foot and 90,000 acre-foot reservoir storage capacity and the White River streamflow data from 1961 – 2013, each reservoir was analyzed for the approximate "firm annual reservoir yield". In this report, the "firm annual reservoir yield" is defined as the minimum annual volume of water that would be available for release from the reservoir over the entire 53-year study period. For the 20,000 acre-foot and 90,000 acre-foot reservoirs the "firm annual reservoir yield" was estimated to be 24,000 acre-feet and 50,400 acre-feet, respectively.

The "firm annual reservoir yield" was also assessed assuming that releases would be made ensuring that the environmental flows are met 100-percent of the time, prior to allowing releases for M&I and Energy. In this case, the "firm annual reservoir yield" for M&I and Energy would be 0 acre-feet and 13,870 acre-feet for the 20,000 acre-foot and 90,000 acre-foot reservoir, respectively.

The “firm annual reservoir yield” and “Reservoir Storage Model” storage values are based on available streamflow data from 1961 – 2013 on the White River. The future streamflow characteristics will vary from these streamflow values and patterns.

The pump station pipeline was designed to be a 96-inch-diameter fill line for the 400 cfs pump station and a 36-inch-diameter fill line for the 50 cfs pump station to maintain a velocity in the pipe of less than 10 feet per second. All of the sites assume pumping from the White River as the best option for the fill scenario. Further information on other fill scenarios that were analyzed for each site are summarized in Sections 6.2 through 6.4. The pump station and fill line characteristics for each site are summarized in Table 6.5.

Table 6.5 – Pump Station Characteristics Summary

	Wolf Creek 20k	Wolf Creek 90k	Spring Creek 20k	Spring Creek 90k	Gillam Draw 20k	Gillam Draw 90K
Fill Line Capacity (cfs)	50	400	50	400	50	400
Fill Line Length (feet)	3,000	3,000	3,140	3,233	13,200	13,200
Fill Line Diameter (feet)	3	8	3	8	3	8
Pumping Head (feet)	200	190	420	450	620	580
Pump Capacity (HP)	1,130	8,700	2,360	20,480	3,490	26,000

6.2 Gillam Draw Reservoir Engineering

6.2.1 Feasibility Design

Gillam Draw Reservoir is located southeast of Rangely as shown on Figure No. 4. The location on Gillam Draw was selected in an area on Gillam Draw that could provide the 90,000 acre-foot storage, with some additional flood storage for flood routing for the approximately 12 square mile drainage basin. The 20,000 acre-foot site was selected to be in approximately the same location so that if the 20,000 acre-foot reservoir is constructed and additional storage is needed in the future, the height of the dam could be increased to gain more reservoir capacity. The dam height for the 20,000 acre-foot reservoir and 90,000 acre-foot reservoir is approximately 210 feet and 321 feet, respectively. As a result of the large height of the dam, an upstream and downstream stability berm was included in the feasibility design to enhance slope stability. The size and location of these stability berms would be revised during final design based on actual geotechnical investigations, lab testing, and analysis.

The dam site has a steep natural channel just downstream of the left abutment that routes discharges to Gillam Draw, downstream of the dam. A 25-foot-wide earth/rock cut spillway was assumed for both the 20,000 acre-foot and 90,000 acre-foot reservoir that connects to this natural channel. Based on the soils data from U.S. Natural Resources Conservation Service (NRCS) in the area of the spillway, the soil in the vicinity of the spillway estimates a weathered bedrock layer at a depth of 16 to 20 inches below the ground surface. The approximate slope of the natural channel is 0.16 foot per foot, therefore spillway erosion protection of a concrete lined spillway chute was assumed for a length of approximately 2,000 feet.

The feasibility drawings for Gillam Draw at 20,000 acre-feet and 90,000 acre-feet are included in Appendices E.1.1 and E.1.2, respectively.

6.2.2 Feasibility Reservoir Operations

Gillam Draw reservoir would be filled via a pump station on the White River, with a 2.5-mile-long pipeline that extends along Gillam Road (County Road 131) and discharges into the reservoir basin, upstream and right of the right abutment. A few inflow pipeline alignments were considered for evaluation and shown in Appendix E.1.3, however the alignment chosen was primarily due to the relatively gradual changes in topography over the length of the pipeline course. Existing power lines were observed to be located between the Gillam Draw Dam and the White River. It was assumed that these power lines would be available to supply electric power to the proposed pumping station. The pump station characteristics are outlined in Section 6.1.5.

6.2.3 Constraint Evaluations

Some preliminary constraint evaluations were performed as part of the "Coarse Screening" described in Section 5.0. A site visit was performed to the Gillam Draw Reservoir site on May 16, 2014, by William Bliton, Steve Jamieson, and Danielle Tripp Hannes. During the site visit, several oil and gas wells that appeared to have been recently active were observed in the vicinity of the dam and spillway footprint that were not identified in the Colorado Oil and Gas Conservation Commission database. A significant geologic fault system was also observed to be near the downstream footprint of the dam extending from the left to right downstream abutments. The general location of these faults are also shown on the geologic map (Appendix F). A few "coal units" and coal zones were mapped in the upstream portion of the reservoir that will require evaluation relative to seepage and potential loss of reservoir waters. Further information on the geologic conditions at the site can be found in Appendix F.

On May 16, 2014, WestWater Engineering also performed a site visit to assess the reservoir and dam area for potential habitat for threatened, endangered, candidate, and proposed species listed under the Endangered Species Act and identify potential jurisdictional wetlands (WestWater, 2014). In the Gillam Draw basin, no wetlands were observed within the proposed reservoir site. Suitable nesting habitat was observed for Raptors and other migratory birds. Further information on the biological habitat and wetland evaluations is provided in Appendix G.

A Class I Cultural Resources Inventory assessment was performed by Grand River Institute and is provided in Appendix H (GRI, 2014). Within the Gillam Draw area of impact, a trail was observed on the south side of the White River that dates to 1883, a "settler" structure, a historic road down Gillam Draw, two ditches, and a fence line. In the approximately 3,320 acres impact area, 22 Cultural Resources Inventories (CRI) intersect the Reservoir basin and include approximately 540 acres within that basin. A total of six sites and five isolates have been previously recorded within the Gillam area of impact (GRI, 2014).

6.3 Spring Creek Reservoir Engineering

6.3.1 Feasibility Design

Spring Creek Reservoir is located approximately six miles east of Rangely and directly east of Kenney Reservoir as shown on Figure No. 4. Some refinements were made to the location of Spring Creek Dam on Spring Creek from Phase 1 of this project resulting in Spring Creek Dam being moved further downstream on Spring Creek, resulting in a dam that wraps at the abutments to provide 90,000 acre-feet of storage. This was done to reduce the elevation difference between Spring Creek Reservoir and the White River to reduce the reservoir fill pumping costs. The 20,000 acre-foot site was selected to be in approximately the same location so that if the 20,000 acre-foot reservoir is constructed and additional storage is needed in the future, the height of the dam could be increased to gain more reservoir capacity. The dam height for the 20,000 acre-foot reservoir and 90,000 acre-foot reservoir is approximately 243 feet and 360 feet, respectively. As a result of the large height of the dam, an upstream and downstream stability berm was included in the feasibility design to enhance slope stability. The size and location of these stability berms would be revised during final design based on actual geotechnical investigations, lab testing, and analysis.

The spillway for the 90,000 acre-foot reservoir utilizes an existing saddle on the right reservoir rim, which is already near the elevation of the normal high water line for the 90,000 acre-foot storage. Based on the soils data from NRCS in the area of the spillway, the soil in the vicinity of the spillway estimates a bedrock layer at a depth of 16 to 20 inches below the ground surface. The saddle would route the spillway discharges into Quinn Draw, located directly east of the Spring Creek Reservoir, and would discharge into the White River approximately 0.5

miles upstream of the Spring Creek confluence. A waiver would need to be granted by the Colorado State Engineer to allow discharges into a different drainage basin with this spillway concept, but it is Wheeler's opinion that it is likely that the Colorado State Engineer would consider granting this waiver. The approximate slope of the natural channel is 0.17 foot per foot, therefore spillway erosion protection of a concrete lined spillway chute was assumed for a length of approximately 800 feet.

The spillway for the 20,000 acre-foot reservoir was assumed a 50-foot-wide, 220-foot-high Roller Compacted Concrete (RCC) gravity spillway section in the center of the dam, with reinforced concrete spillway training walls because a good location for an excavated abutment spillway was not available for a dam at this size. The spillway walls and concrete discharge channel was assumed to extend past the downstream toe of the embankment to protect the embankment from any erosion from spillway flows.

Improvements may need to be made at the crossing of Highway 64, along Spring Creek, and potentially Quinn Draw for the 90,000 acre-foot reservoir site.

The feasibility drawings for Spring Creek at 20,000 acre-feet and 90,000 acre-feet are included in Appendices E.2.1 and E.2.2, respectively.

If this alternative is carried past this feasibility design, it would be recommended that the following design refinements be considered:

- Consider an excavated rock spillway for the 20,000 acre-foot reservoir similar to the design concept for the 90,000 acre-foot reservoir. This would involve significant rock excavation, but the excavated abutment spillway could be less costly then the RCC spillway constructed in the center of the dam.

- Consider moving the reservoir fill pipeline and pump station further downstream in Kenney Reservoir so that the inevitable further siltation of Kenney Reservoir does not impact the pump station.

6.3.2 Feasibility Reservoir Operations

Spring Creek Reservoir would be filled via a pump station at Kenney Reservoir and a 0.6-mile-long pipeline that extends from Kenney Reservoir to the Spring Creek drainage basin. Any fill pipeline from Kenney Reservoir to the Spring Creek Reservoir would cross the Williams Gas Pipeline and Highway 64. In order to reduce pumping heads, it was assumed that the pipeline would be bored through the ridge that separates Kenney Reservoir and Spring Creek Reservoir at an elevation above the dam crest which results in a tunnel section of 800-1000 feet in length.

Existing power lines were observed to be located along Highway 64, adjacent to Kenney Reservoir. It was assumed that these power lines would be available to supply electric power to the Spring Creek pump station. The pump station characteristics are outlined in Section 6.1.5.

6.3.3 Constraint Evaluations

Some preliminary constraint evaluations were performed as part of the “Coarse Screening” described in Section 5.0. A site visit was performed to the Spring Creek Reservoir site on May 16, 2014, by William Bliton, Steve Jamieson, and Danielle Tripp Hannes. Based on the geologic maps and the site visit, a coal unit was observed approximately 1,500 feet upstream of the proposed dam axis, which would need to be further assessed if this site is pursued. Also several landslides were mapped within the proposed reservoir area, along the east slope of the drainage which may become unstable when inundated by reservoir waters (Bliton, 2014). Further information on the geologic conditions at the site can be found in Appendix F.

On May 16, 2014, WestWater Engineering also performed a site visit to assess the reservoir and dam area for potential habitat for threatened, endangered, candidate, and proposed species listed under the Endangered Species Act and identify potential jurisdictional wetlands (WestWater, 2014). WestWater determined that jurisdictional fringe wetlands are likely located along the banks of Spring Creek. Suitable nesting habitat was observed for Raptors and other migratory birds. Further information on the biological habitat and wetland evaluations is provided in Appendix G.

A Class I Cultural Resources Inventory assessment was performed by Grand River Institute and is provided in Appendix H (GRI, 2014). Within the area of impact for Spring Creek is a trail on the south side of the White River that dates to 1883, Spring Creek Wagon Road, and two land patents. In the approximately 3,318 acres impact area, 25 Cultural Resources Inventories (CRI) intersect the area and include approximately 500 acres within that basin. A total of 20 sites and 19 isolates have been previously recorded within the Spring Creek area of impact (GRI, 2014).

6.4 <u>Wolf Creek Reservoir Engineering</u>

6.4.1 Feasibility Design

The off-channel Wolf Creek Reservoir is located approximately 20 miles northeast of Rangely as shown on Figure No. 4. Some refinements were made to the location of Wolf Creek Dam from Phase 1 of this project resulting in Wolf Creek Dam being moved further upstream on Wolf Creek to ensure that the downstream toe of the dam would not be impacted by major floods on the White River. The 20,000 acre-foot site was selected to be in approximately the same location so that if the 20,000 acre-foot reservoir is constructed and additional storage is needed in the future, the height of the dam could be increased to gain more reservoir capacity. The dam height for the 20,000 acre-foot reservoir and 90,000 acre-foot reservoir is approximately 80 feet and 122 feet, respectively. The Wolf Creek Dams were not designed with stability berms on the upstream and downstream slopes because of the lower dam heights.

The spillway for the 90,000 acre-foot reservoir and 20,000 acre-foot reservoir both utilize a flat area near the left abutment of the dam. The spillway location is near the required normal high water line elevation for the 90,000 acre-foot reservoir, however approximately 30 feet of rock and soil would need to be excavated in this location for the 20,000 acre-foot reservoir. Based on the soils data from NRCS in the area of the spillway, the soil in the vicinity of the spillway estimates a bedrock layer at a depth of 12 to 16 inches below the ground surface. The channel would route spillway discharges downstream of the dam and discharge into the Wolf Creek channel. The approximate slope of the natural channel is 0.04 foot per foot. Drop structures were assumed to be installed downstream of the spillway control section of the spillway channel down to the Wolf Creek channel. The drop structures were also assumed to extend downstream along the Wolf Creek channel to the White River.

The feasibility drawings for Wolf Creek at 20,000 acre-feet and 90,000 acre-feet are included in Appendices E.3.1 and E.3.2, respectively.

6.4.2 Feasibility Reservoir Operations

The Wolf Creek Reservoir would be filled via a pump station at the White River and a pipeline that extends from the White River and discharges into the drainage basin near the right abutment of the dam. Several gravity fill options for filling Wolf Creek were also considered as part of this study, but they were determined to be infeasible due to the variability in topography across the basin. To fill the Wolf Creek Reservoir by gravity, the gravity system would need to pass through the Strawberry Creek basin and Crooked Wash basin, which are each separated by larger ridges on either side, with elevation differences of over 2,000 feet. The fill length for this system would be a pipeline of at least 36 miles in length that would impact several properties along the White River.

Wheeler also evaluated a Wolf Creek Reservoir fill pipeline from the Yampa River. The elevation in the Yampa River in the vicinity of the Wolf Creek basin is lower in elevation than the water surface elevation at the Wolf Creek Reservoir, therefore gravity fill from the Yampa River is not possible. It is possible to pump water from the Yampa River into the Wolf Creek drainage basin, however this would involve a fill pipeline length of approximately three miles and a pump station that could overcome a 1,400 foot elevation gain. This may be an alternative that could be further assessed in future years, but was not considered further for this study.

The more practical filling alternative is a pump station on the White River, which includes a fill pipeline length of approximately 0.6 miles and an elevation difference of 170 feet. The pump station characteristics for this alternative are outlined in Section 6.1.5. Existing power lines were observed to be located between Highway 64 and the White River. It was assumed that these power lines would be available to that supply electric power to the proposed pumping station.

6.4.3 Constraint Evaluations

Some preliminary constraint evaluations were performed as part of the "Coarse Screening" described in Section 5.0. A site visit was performed to the Wolf Creek Reservoir site on May 15, 2014, by William Bliton, Steve Jamieson, and Danielle Tripp Hannes. Based on the site visit, significant erosion was observed in the drainage basin for the reservoir which could potentially create reservoir siltation issues that will need to be mitigated in design. Final design engineering for this dam should include check dams or sediment collection features to minimize siltation in the Wolf Creek Reservoir. Based on the geologic maps, a non-active trending fault is located a short distance north of the White River and south of the proposed dam site that extends to within 1,000 feet of the proposed dam axis (Bliton, 2014). Additional information on the geologic conditions at the site can be found in Appendix F.

On May 15, 2014, WestWater Engineering also performed a site visit to assess the reservoir and dam area for potential habitat for threatened, endangered, candidate, and proposed species listed under the Endangered Species Act and identify potential jurisdictional wetlands (WestWater, 2014). WestWater did not observe any potential for jurisdictional wetlands in the potential Wolf Creek Reservoir area. Potential black-footed ferret habitat was observed and it was noted that the reservoir site is situated within the Wolf Creek Management Area for black-footed ferrets. Habitat area was observed for numerous migratory birds. Wolf Creek Reservoir site is also located within the Greater Sage-Grouse preliminary general habitat. Further information on the biological habitat and wetland evaluations is provided in Appendix G.

A Class I Cultural Resources Inventory assessment was performed by Grand River Institute and is provided in Appendix H (GRI, 2014). Within the area of impact for Wolf Creek are several historic linear routes, including the Uintah Trail from 1883 located midway between Coal Ridge and Wolf Creek; Thornburg Road from Vernal, UT to Rawlins, WY; and the Vernal to Meeker Road. In the approximately 7,169 acres impact area, 19 Cultural Resources Inventories (CRI) intersect the area and include approximately 275 acres within that basin. A total of 10 sites and 5 isolates have been previously recorded within the Wolf Creek area of impact (GRI, 2014).

The annual evaporation losses were factored for the Wolf Creek Site based on the “Reservoir Storage Model” and explained in Section 6.1.5 and Figure No. 5. The reservoir surface area was calculated over the 53-year record in the “Reservoir Storage Model” and was used to estimate the evaporation. The annual evaporation rate was estimated using the Annual Free Water Surface Evaporation in NOAA Technical Report NWS 33 (NOAA, 1982). The annual evaporation rate was distributed over the year using recommendations provided in the General Administration Guidelines for Reservoirs from the Colorado Division of Water Resources (Colorado DWR, 2011). The average annual evaporation for the 20,000 acre-foot and 90,000 acre-foot Wolf Creek Reservoir is 2,550 acre-feet and 5,890 acre-feet, respectively. Since the Spring Creek Reservoir and Gillam Draw Reservoir have a surface area of approximately 30-percent and 38-percent, respectively, compared to that of the Wolf Creek Reservoir for the 90,000 acre-foot storage, it was determined that the evaporation amount would be less at Spring Creek and Gillam Draw.

7.0 OPINION OF PROBABLE COSTS

7.1 <u>Capital Cost Budgeting Approach</u>

Wheeler developed feasibility-level opinions of probable project cost for two reservoir sizes at each of the three primary dam sites. Wheeler's opinions of probable cost are considered to be equivalent to a Class 4, feasibility level budget opinion (AACE, 97). Wheeler's cost opinion was developed to be reasonably conservative and is expected to be within 30 percent on the low end of the budget and within 50 percent on the high end of the budget. As project planning progresses significant project requirements, permitting issues, and other refinements can develop, which could significant change the project and the associated project budgets.

Wheeler's approach to developing opinions of probable project costs was to individually develop costs for direct and indirect construction items. Direct construction costs include items directly related to the dam construction such as embankment and spillway construction. Direct construction items were developed in a bid tab format in 2014 construction dollars. The indirect costs include a budget for non-construction items that are required to develop the project such as easement/land purchase costs, engineering, and permitting. A summary of the opinion of probable direct construction and indirect project development costs for each dam site is provided in Table No. 7.1. A summary of the key elements in the direct construction cost is provided in Table No. 7.2. A summary of the key elements in the indirect project costs are provided in Table No. 7.3. Additional details of Wheeler's feasibility-level opinion of probable project costs at each dam site are provided in Appendix I. It is important to note that Wheeler's opinions of probable project costs are based on year 2014 dollars. These cost opinions will increase in subsequent years, and are subject to further refinement and revision as the development, design, and permitting progresses for the project.

Table 7.1 - Summary of Project Development Opinion of Probable Costs

Item Description	Wolf Creek 20k acre-feet	Wolf Creek 90k acre-feet	Spring Creek 20k acre-feet	Spring Creek 90k acre-feet	Gillam Draw 20k acre-feet	Gillam Draw 90k acre-feet
Direct Construction Costs	$46,322,000	$83,867,000	$197,970,000	$248,016,000	$101,711,000	$237,474,000
Indirect Project Costs	$24,825,000	$43,785,000	$99,980,000	$125,240,000	$51,870,000	$120,430,000
Total Project Costs	$71,147,000	$127,652,000	$297,950,000	$373,256,000	$153,581,000	$357,904,000

Key elements of the direct construction cost opinion were:

1. Site Preparation
2. Foundation Preparation
3. Outlet Works Construction
4. Earthwork

5. Spillway Construction
6. Pump Station and Fill Line Construction
7. Miscellaneous Items
8. Unlisted Items
9. Contractor Mobilization, Bonds, and Insurance

Unlisted items were estimated at 15 percent of the total of Item Nos. 1 through 7. Unlisted items are provided in the cost opinion for work items that cannot be defined at this stage of project development that will be added to the design as the project develops. Contractor mobilization, bonds, and insurance was estimated at 10 percent of the total of Item Nos. 1 through 7. A summary of direct construction elements is provided in Section 7.2.

7.2 Direct Construction Opinion of Probable Cost

The direct construction opinions of probable costs are summarized for each site in Table No. 7.2. These are the expected costs for construction of key elements of the dams. Direct construction opinions of probable costs are in 2014 dollars and are expected to increase based on inflation, further investigations, and final design modifications.

Table 7.2 - Direct Construction Opinion of Probable Costs Summary

Item Description	Wolf Creek 20,000 acre-feet	Wolf Creek 90,000 acre-feet	Spring Creek 20,000 acre-feet	Spring Creek 90,000 acre-feet	Gillam Draw 20,000 acre-feet	Gillam Draw 90,000 acre-feet
Site Preparation	$2,897,000	$2,951,000	$918,000	$2,731,000	$1,153,000	$1,987,000
Foundation Preparation	$2,096,000	$3,856,000	$901,000	$2,757,000	$2,607,000	$5,368,000
Outlet Subtotal	$5,196,000	$6,519,000	$8,957,000	$15,069,000	$9,589,000	$13,875,000
Earthwork	$15,454,000	$34,277,000	$37,216,000	$145,989,000	$50,269,000	$126,930,000
Spillway	$5,887,000	$1,182,000	$101,005,000	$3,238,000	$6,588,000	$1,597,000
Pump Station	$5,468,000	$18,213,000	$9,294,000	$28,396,000	$11,051,000	$40,027,000
Miscellaneous	$56,000	$95,000	$83,000	$234,000	$109,000	$193,000
Base Construction Subtotal (BCS)	**$37,054,000**	**$67,093,000**	**$158,374,000**	**$198,414,000**	**$81,366,000**	**$189,977,000**
Unlisted Items[1]	$5,558,000	$10,064,000	$23,756,000	$29,762,000	$12,205,000	$28,497,000
Mobilization, Bonds, Insurance[2]	$3,710,000	$6,710,000	$15,840,000	$19,840,000	$8,140,000	$19,000,000
Direct Construction Subtotal (DCS)	**$46,322,000**	**$83,867,000**	**$197,970,000**	**$248,016,000**	**$101,711,000**	**$237,474,000**

1 Unlisted Items were estimated at 15 percent of the listed items subtotal.
2 Mobilization, Bonds, and Insurance was estimated at 10 percent of the listed items subtotal.

7.3 Indirect Project Opinions of Probable Cost

The total project opinions of probable costs include the investment in non-construction program items that will be required to permit, design, and construct a dam. Indirect project costs were also developed in 2014 dollars and are also expected to increase for future construction based on inflation, further investigations, and final design modifications.

Table 7.3 - Indirect Project Opinion of Probable Costs Summary

Item Description	Wolf Creek 20,000 acre-feet	Wolf Creek 90,000 acre-feet	Spring Creek 20,000 acre-feet	Spring Creek 90,000 acre-feet	Gillam Draw 20,000 acre-feet	Gillam Draw 90,000 acre-feet
Construction Change Order Contingency	$10,190,000	$18,450,000	$43,550,000	$54,560,000	$22,380,000	$52,240,000
Final Design Engineering	$3,710,000	$6,710,000	$15,840,000	$19,840,000	$8,140,000	$19,000,000
Permitting and Mitigation	$4,630,000	$8,390,000	$19,800,000	$24,800,000	$10,170,000	$23,750,000
Public Outreach	$230,000	$420,000	$990,000	$1,240,000	$510,000	$1,190,000
Land Easement/Purchases	$1,425,000	$1,425,000	-	-	$500,000	$500,000
Legal and Administrative Costs	$930,000	$1,680,000	$3,960,000	$4,960,000	$2,030,000	$4,750,000
Construction Administration and Engineering	$3,710,000	$6,710,000	$15,840,000	$19,840,000	$8,140,000	$19,000,000
Indirect Project Costs	$24,825,000	$43,785,000	$99,980,000	$125,240,000	$51,870,000	$120,430,000

A summary of the development of the indirect project cost elements is provided below.

1. ***Construction Change Order Contingency:***
   A change order contingency equivalent to 25 percent of the direct construction opinion of probable cost total. This contingency is included to address changes to construction quantities or changes that normally occur during a large heavy civil construction project. A large part of this contingency is related to unanticipated changes in foundation conditions that cannot be completely identified until the foundation is excavated during construction. The change order contingency is expected to decrease after geotechnical investigations are completed that would identify the depth and condition of bedrock in the foundation at any particular dam site.

2. ***Final Design Engineering:***
   The final design engineering was assumed to be 8 percent of the direct construction opinion of probable cost total. This would include detailed

construction drawings, construction specifications, a reservoir application and filing fee, a detailed design report that documents the hydraulic design of the spillway and outlet works, structural design of the spillway and outlet works, stability analysis, design of seepage and settlement control features, and design of other project features such as access roads and dam instrumentation systems. Detailed design drawings, specifications, and analysis reports will require approval by the Colorado Office of the State Engineer.

3. ***Permitting and Mitigation:***
   The permitting budget was assumed to be 10 percent of the direct construction opinion of probable cost total. This was assumed to account for environmental studies, alternatives evaluations, and other analysis that may be required to acquire a 404b permit from the USACE, approval from the BLM, and other required permits.

4. ***Public Outreach:***
   The public outreach budget was assumed to be 0.5 percent of the direct construction opinion of probable cost total.

5. ***Easement/Land Purchases:***
   Before constructing the project, the RBWCD would need to either own the property or have easements for all of the property that would be impacted by dam and pump station construction and the areas impounded by the reservoir. At the feasibility level, Wheeler assumed that the RBWCD would purchase the land that would be impacted by the reservoir and any flood event stored in the reservoir up to the PMF. Average land purchase costs of $2,500 per acre were assumed. This cost could likely be reduced, if easements were negotiated for the land that was impacted.

6. ***Legal and Administrative Costs:***
   The legal and administrative costs were assumed to be 2 percent of the direct construction cost total. This would include legal fees, payments for RBWCD staff, and other administrative fees required to develop a project.

7. ***Construction Administration and Engineering:***
   The construction administration and engineering costs were assumed to be 8 percent of the direct construction cost total. Based on experience with the Colorado Dam Safety Branch Rules, the following construction administration activities will be required and are included in this cost:

   a) Full-time resident engineer and daily construction activity reports.
   b) Materials testing.
   c) Monthly progress reports with photos and lab test results.
   d) Review and approval of contractor’s monthly payment requests.

e) Construction engineering and administration of change orders.
f) Responses to contractor Requests for Information (RFI).
g) Preparation of a final construction report.
h) Preparation of record drawings for submittal to the SEO after construction is complete.

7.4 Operation and Maintenance Costs

Annual Operation and Maintenance (O&M) included the projected annual cost for the electric power to pump water up to the reservoir, an annual cost for the RBWCD to hire another employee, and an annual cost for an additional vehicle. Recreation management was assumed to be provided by others.

The Wolf Creek site was the only site that O&M costs were factored for the electricity costs for operating the pump station. The Wolf Creek site will have lower pumping costs relative to Spring Creek or Gillam Draw since the horsepower needed to provide the required flow rate is less than half of the horsepower needed at the other two sites (see Table 6.5). The "Reservoir Storage Model" was used to develop an annual cost for pumping based on the inflow rates for each day. For the Wolf Creek site, the necessary horsepower was calculated for various fill rates ranging from 0 cfs to 400 cfs. The horsepower was then converted to kilowatt-hours (KWH). It was assumed that the electric costs would be $0.04/KWH. For the maximum 400 cfs pump rate for the 90,000 acre-foot reservoir, the pumping costs range from $50,000 to $1,000,000 each year, with an average annual cost of $540,000, depending on the amount of water that is needed to fill the reservoir and the availability of water in the White River. For the 20,000 acre-foot reservoir, the pumping costs range from $80,000 to $300,000 each year, with an average annual cost of $160,000. Depending on the price of natural gas, it may also be advantageous to consider using natural gas pumps to fill the reservoir, which could reduce these O&M costs for pumping. Further operations optimization and design refinements could also be considered to reduce pumping head and required horsepower that have the potential to also reduce the pumping costs.

The additional costs for an additional employee and a vehicle is assumed to be approximately $100,000 per year. As a result, the annual average O&M costs to operate the reservoir are approximately $260,000 for the 20,000 acre-foot reservoir and $640,000 for the 90,000 acre-foot reservoir. Additional costs pump and dam maintenance costs were not developed as part of the feasibility-level study.

8.0 ALTERNATIVES EVALUATION

A total of 25 different water storage alternatives were developed and evaluated in this feasibility study. These alternatives were reviewed in several public meetings. Nine alternatives remained after completion of a coarse screening analysis and three primary alternatives remained after completing a fine screening evaluation.

After considering feasibility-level cost opinions and preliminary environmental and geology information collected during site visits to the primary dam and reservoir sites in May of 2014, the off-channel Wolf Creek reservoir is considered to be the preferred alternative for future planning and permitting assessments. The off-channel Wolf Creek Reservoir has the most favorable capital costs and less expensive pumping costs required to operate the reservoir. In addition, no significant environmental or cultural resources impacts were identified at the off-channel Wolf Creek Reservoir site during the preliminary assessment of this reservoir. The reservoir is also favorably located with access for recreation from U.S. Highway 40 in Moffat County and State Highway 64 in Rio Blanco County. This reservoir site also has the added flexibility that it could be easily expanded above the 90,000 acre-foot capacity to meet other potential State of Colorado or regional future water needs and could be filled or provide supplemental water to both the White and Yampa Rivers in Colorado.

During the October 29, 2014, RBWCD Board of Directors meeting, the RBWCD requested that the Wolf Creek dam site located on the main stem of the White River be included as another preferred alternative because it could have lower capital construction costs and significantly lower operations costs because it would not require any pumping to fill the reservoir. The RBWCD realized that it could be challenging to obtain a U.S. Army Corps of Engineers 404 permit for the main stem Wolf Creek because it is expected to have higher wetlands impacts along the White River. However, when considering the cost criteria included in the Practicability Test as documented in Section 404(b) of the Clean Water Act, the main stem site could potentially be the least environmentally damaging, practicable alternative.

The Spring Creek Reservoir site is considered a secondary alternative if either of the Wolf Creek Reservoir sites are found to be unpermittable during future environmental reviews. The Spring Creek Reservoir would be more costly to construct and operate than the off-channel Wolf Creek Reservoir and there appear to be more environmental impacts associated with this site.

Wheeler does not recommend any further consideration of the Gillam Draw Reservoir site primarily due to the fault system located within the dam axis and the additional oil & gas well impacts that were identified during the May 2015 site visit.

9.0 STAKEHOLDER MEETINGS

During the course of the feasibility study EIS Solutions coordinated and facilitated numerous stakeholder meetings with representatives from the RBWCD, Wheeler or Harvey Economics. The purpose of these initial meetings were to explain the project to the key stakeholders and allow stakeholder input to help identify key issues that may impact or enhance the benefits of the project.

9.1 Key Meetings & Public Workshops

Several public workshops were conducted to gather public input and provide the public with information on the progress of the feasibility study. The following workshops were conducted in Rangely:

- January 29, 2014 - Alternatives Workshop
- February 26, 2014 – Purpose & Need Workshop
- March 26, 2014 – Coarse Screening Workshop
- August 27, 2014 – Engineering Workshop
- September 24, 2014 – Finance Workshop
- December 2, 2014 – Draft Report Workshop

The RBWCD also provided a tour of their facilities and gave a presentation on the project to the Colorado Water Conservation Board (CWCB) on July 16, 2014. Key meetings were also held with representatives from the BLM, the U.S. Fish & Wildlife Service, and the U.S. Army Corps of Engineers to keep them informed on the project progress.

9.2 Y/W/G Roundtable Meetings

EIS Solutions and Wheeler also made several presentations to the Yampa/White/Green Basin Water Roundtable as part of the feasibility study on the following dates:

- October 16, 2013
- January 15, 2014
- April 16, 2014
- May 14, 2014

9.3 Other Stakeholder Meetings

The following is a list of some of the key stakeholders that were involved in the Stakeholder outreach process.

1. Alden Vanden Brink, Town of Rangely Utilities Supervisor, RBWCD
2. Dan Eddy, RBWCD
3. T. Wright Dickinson, YWG Basin Roundtable

4. Jeff Comstock, YWG Basin Roundtable
5. Jeff Devere, YWG Basin Roundtable
6. Russell George, CNCC / CWCB
7. Eric Jaquez, Rio Blanco County
8. Katelin Cook, Rio Blanco County Economic Development
9. Stephanie Kobald, Meeker Chamber of Commerce
10. Kristin Steele, Rangely Area Chamber of Commerce
11. Glenn Vawter, National Oil Shale Association (NOSA)
12. Roger Day, American Shale Oil (AMSO)
13. Jeremy Boak, Colorado School of Mines
14. David Ludlum, Colorado Oil and Gas Association, West Slope Region
15. David Cesark, Mesa Energy Partners
16. Jeff Kirtland, WPX Energy
17. Jessica Dooling, XTO Energy
18. Tim Webber, Western Rio Blanco Metropolitan Recreation & Parks District
19. Kyle Battige, Aquatic Biologist, Colorado Parks and Wildlife
20. Jana Mohrman, U.S. Fish and Wildlife Service, UC Recovery Program
21. Tom Pitts, Water Consultant, Upper Colorado Recovery Program
22. Grant Nulle, Colorado State Demographers Office
23. Dan Birch, Colorado River District
24. Ray Tenney, Colorado River District
25. Peter Brixius, Rangely Town Manager
26. John McClow, Counsel, Gunnison Water Conservation District
27. Jacob Bornstein, Colorado Water Conservation District
28. Bonnie Peterson, Club 20
29. Ed Coryell, Yellow Jacket Water Conservancy District
30. Luke Allard and Scott Ritter, Chevron
31. Tracy Boyd, Shell
32. Bob Lange, BLM White River Field Office Hydrologist
33. Kent Walter, BLM White River Field Office Manager
34. Ester McCullough, BLM White River Field Office Assistant Manager
35. Heather Sauls, BLM Planning & Environmental Manager
36. Richard Brooks, BLM GIS Specialist
37. Scott Meszaros, Meeker Town Manager
38. Audrey Danner, Craig/Moffat County Economic Development Partnership
39. Jon Hill, Rio Blanco County Commissioner
40. Ron Vilarde, Western Colorado Director, Colorado Parks and Wildlife
41. Bill Divergie, Northwestern Colorado Area Manager Colorado Parks and Wildlife

10.0 FINANCING PLAN

Harvey Economics (HE), in cooperation with EIS Solutions (EIS) assessed the financial element of the feasibility study which consisted of quantifying the potential financial benefits of the project, assessing the ability and willingness to pay for key stakeholders, and developing a financial roadmap for funding the Wolf Creek Project construction. Additional information is provided in the Harvey Economics Summary report provided in Appendix J (HE, 2014).

10.1 Project Benefits and Beneficiaries

The economic benefits and the beneficiaries from operation of the Wolf Creek Reservoir are summarized indicated in Table 10.1.

Table 10.1 – Potential Benefits and Beneficiaries for Wolf Creek Project

	Benefits			
Beneficiaries	Recreation	Water Supply	Hydroelectric Generation	Environmental
Rangely	X	X		
Meeker	X			
Rio Blanco County	X			
Moffat County	X			
Rio Blanco Water Conservancy District	X	X	X	
Agricultural Water Users		X		
Oil and Gas Industry		X		
Oil Shale Industry		X		
U.S. Fish and Wildlife				X
Colorado River Recovery Program				X

The recreation that the Wolf Creek reservoir will provide would be a major benefit to Rio Blanco County and Moffat County. In comparison to other reservoirs in the region, annual visitor expenditures is expected to be in the range of \$6.1M to \$7.8M for Rio Blanco County and \$1.9M to \$2.4M for Moffat County for the respective, 20,000 acre-foot and 90,000 acre-foot reservoirs. These visitor expenditures will generate sales tax revenues for local jurisdictions and for the State of Colorado. The estimated additional sales tax revenue is summarized below in Table 10.2.

Table 10.2 –Estimated Sales Tax Revenue from the Wolf Creek Project

	Wolf Creek 20KAF			Wolf Creek 90KAF		
	Project Construction (one time) *	Recreational Spending (annual)		Project Construction (one time) *	Recreational Spending (annual)	
		Direct	Total		Direct	Total
Rangely	$286,000	$77,928	$168,970	$509,080	$99,645	$216,060
Meeker	$286,000	$77,928	$168,970	$509,080	$99,645	$216,060
Rio Blanco County	$245,000	$66,795	$144,832	$436,100	$85,410	$185,195
Craig	$75,000	$25,333	$54,930	$133,500	$32,000	$69,386
Moffat County	$37,000	$12,667	$27,465	$65,860	$16,000	$34,693
State of Colorado	$4.4M	$272,600	$591,079	$7.7M	$350,900	$760,856

Another benefit of the Wolf Creek Reservoir would be to provide water supply, which could be vital for the Town of Rangely during drought periods. The need for water to release to maintain streamflows on the White River is also being assessed by the U.S. Fish and Wildlife Service on the White River and the Wolf Creek Reservoir may be a key potential source for the necessary water. The U.S. Fish and Wildlife Service has contributed approximately $2,700 per acre-foot for a similar project at Elkhead Reservoir to enhance downstream flows for endangered fish in the Yampa River basin.

The Rio Blanco Water Conservancy District may have an additional benefit in storing water in Wolf Creek, and releasing the water to generate hydropower at their Kenney Reservoir Hydroelectric Plant during low streamflow periods on the White River. This could increase revenues by more than $187,000 on average each year.

10.2 Ability and Willingness to Pay

Harvey Economics reviewed the financial records of several beneficiaries for the project to determine the ability to financially contribute to the project. HE focused on the northwestern Colorado local government entities, recognizing that the State of Colorado and the U.S. Government would be sought as financial supporters. It was presumed that both the State and federal governments would be capable of contributing. The following entities were assessed on their willingness and ability to pay:

- The **Town of Rangely** has been successful in passing mill levies that are well justified to the voters. It has been observed that Rangely will invest in its future. Rangely recognizes the need for economic growth and diversification and understands that this project might further those goals. Several officials from Rangely have indicated a preliminary interest in the Wolf Creek Project, pending more information and consideration.

- The **Town of Meeker** has no interest in the water supply from the Wolf Creek Project, given ample groundwater supplies. Meeker does have an interest in economic diversification, but has expressed no opinions related to the water project.

- **Rio Blanco County** has been supportive of White River Basin water storage in the past. Unobligated funds might provide a funding opportunity. In addition, a separate mill levy might secure energy industry funding. More information and consideration must occur before a commitment and funding plan is forthcoming.

- **Moffat County** has certain fund accounts that could apply to the Wolf Creek Project from the Capital Project Fund, County's Conservation Trust Fund, and the Moffat County Tourism Association Fund, which would total approximately $2 million. HE was not able to speak to anyone at Moffat County to confirm its interest in participating in this project.

- **Rio Blanco Water Conservancy District** has a mill levy that was set in the 1980's that could potentially be increased or they could allocate additional planned power revenues from storage releases at the Wolf Creek Reservoir. Overall, the RBWCD is supportive of the project. The RBWCD Board has not deliberated about a specific plan for participating, but has expressed interest in pursuing a funding plan.

10.3 Funding Plan Roadmap

The financial assessment for this feasibility study has found the project to be feasible, but the project cannot move forward without a funding plan. Whereas a funding plan was not part of the Phase 2 feasibility study work scope, the roadmap for establishing such a plan is provided.

Financial support for this project will need to be spread among different levels of government if it is to succeed, consistent with the pattern of economic benefits. HE suggests that Federal, State and local authorities shoulder about a third each of the project funding responsibility.

The Federal interest in this project is primarily related to fish recovery and streamflow maintenance in the White River below Taylor Draw Dam. The level of that interest and the willingness to finance will not be known until the White River Programmatic Biological Opinion (PBO) is completed.

The State of Colorado would incur substantive benefits from the Wolf Creek Reservoir. The reservoir would serve several purposes to help northwestern Colorado, including fulfillment of a recreational void in the area, providing economic diversification, and assisting with future water needs that may be used for energy development. Also, the Wolf Creek Project could potentially be used for compact obligations, should they arise.

In discussions with the local northwestern Colorado beneficiaries, the entities indicated their support without giving specific detail on what they would be able or willing to contribute. Individual discussion and deliberations need to be conducted with key local beneficiaries.

The roadmap for the proposed Wolf Creek Project is as follows:

- Secure definitive support from northwestern Colorado beneficiaries,
- Identify other grant and loan services,
- Seek support from State,
- Work with the U.S. Fish and Wildlife Service on funding support,
- Work with CPW on reservoir planning,
- Refine project planning.

11.0 RESULTS AND CONCLUSIONS

Key results and conclusions of the White River Storage Feasibility Study are summarized below:

1. After evaluating 25 different storage alternatives in the White River, the preferred reservoir site is the off-channel Wolf Creek Reservoir site. This reservoir would eliminate a developing water crisis in Rio Blanco County and could provide significant environmental downstream flow enhancements and significant local and State of Colorado economic benefits with the potential for minimal environmental impacts.

2. The 90,000 acre-foot reservoir is preferred by the Rio Blanco Water Conservancy District because it would maximize water-related benefits and best meet future water demands in Rio Blanco County through the year 2065.

3. The Rio Blanco Water Conservancy District is not ready to eliminate a main stem Wolf Creek Reservoir from consideration because it could be the least environmentally damaging, practicable alternative.

4. Wheeler recommends that the Rio Blanco Water Conservancy District file water rights for a Wolf Creek Reservoir by the end of December 2014.

5. It will be important for representatives if the Rio Blanco Water Conservancy District to become involved in the White River Programmatic Biologic Opinion process to the extent possible. The Wolf Creek Reservoir site has the potential to provide significant downstream flow enhancements to endangered fish on the White River.

6. The Rio Blanco Water Conservancy District needs to continue aggressive pursuit of funding partners for the project from local governments, industry, and the State of Colorado, including Colorado Parks and Wildlife.

7. A Class 4 feasibility cost opinion and evaluation of environmental, geologic, and cultural resources should be completed for the main stem Wolf Creek Reservoir to evaluate its viability as a preferred alternative for future permitting and planning.

8. After development of funding agreements with key project partners, the next steps should include the following:

    a. Perform limited subsurface borings, field testing, laboratory testing, and geotechnical evaluations in the dam foundation and develop a Class 3 conceptual design and budgetary cost opinion for the project. A Class 3 budget opinion is expected to be within 20 percent of the low end of the project cost and 30 percent of the high end of the project cost. This work should also include test pits or subsurface investigations to establish suitable local borrow sources for dam construction coupled with an assessment of suitable local commercial quarries.

    b. Complete detailed topographic mapping of the dam, reservoir, fill and drain lines, spillways, and access roads to develop better construction quantity estimates for the Class 3 cost opinion.

    c. After the above-mentioned features are defined and mapped perform an on-site assessment of cultural resources.

    d. Perform on-site jurisdictional wetlands mapping and biological inventory to identify any potential wetlands impacts or important plant or wildlife habitat within the project boundaries. This should include mapping of wetlands in the upstream end of Kenny Reservoir to quantify future wetlands development that is expected to be created by continued siltation at the upstream end of the reservoir.

    e. File permits with the BLM that will trigger the initiation of a formal National Environmental Policy Act review for the project.

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FIGURES

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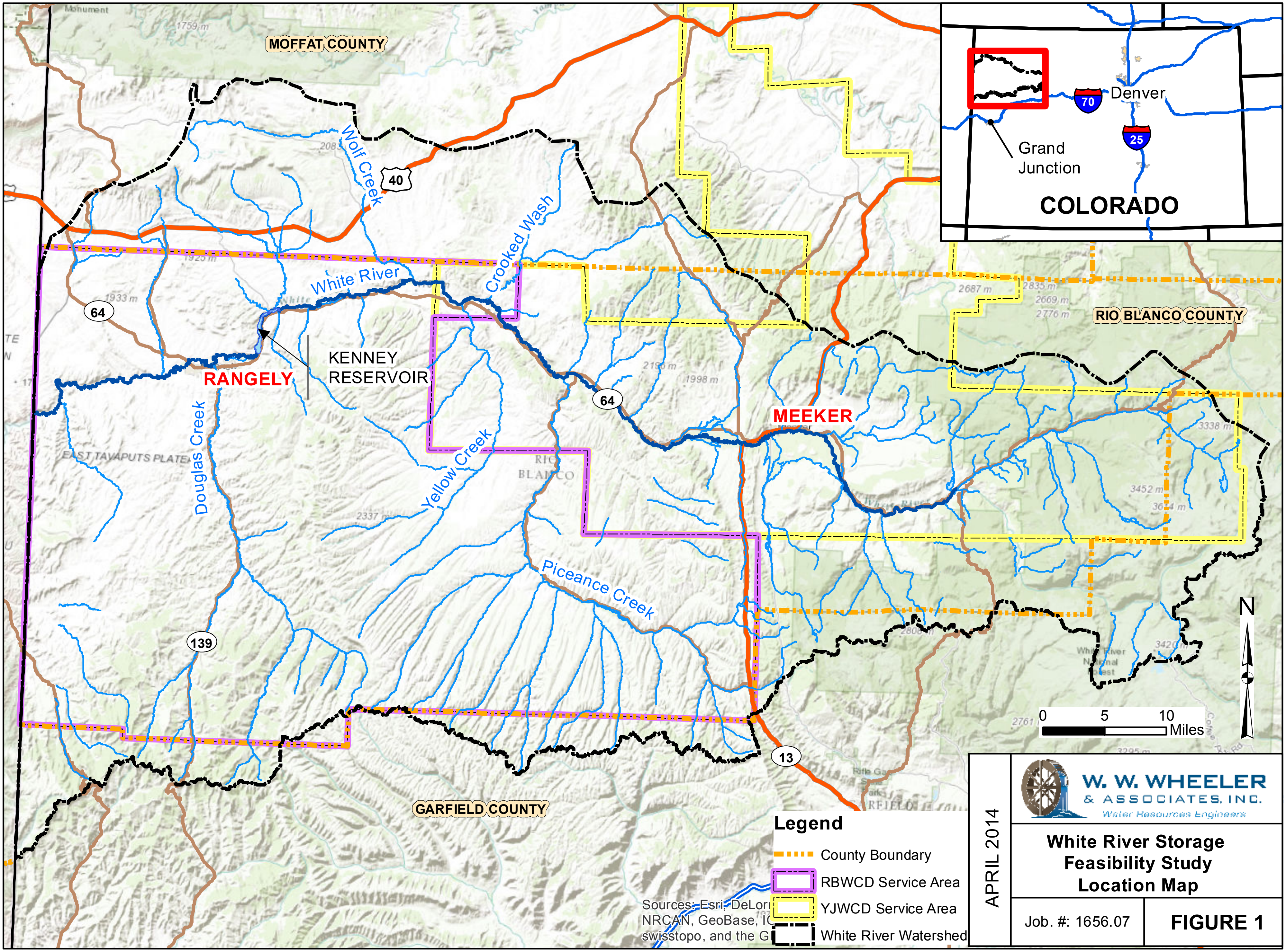

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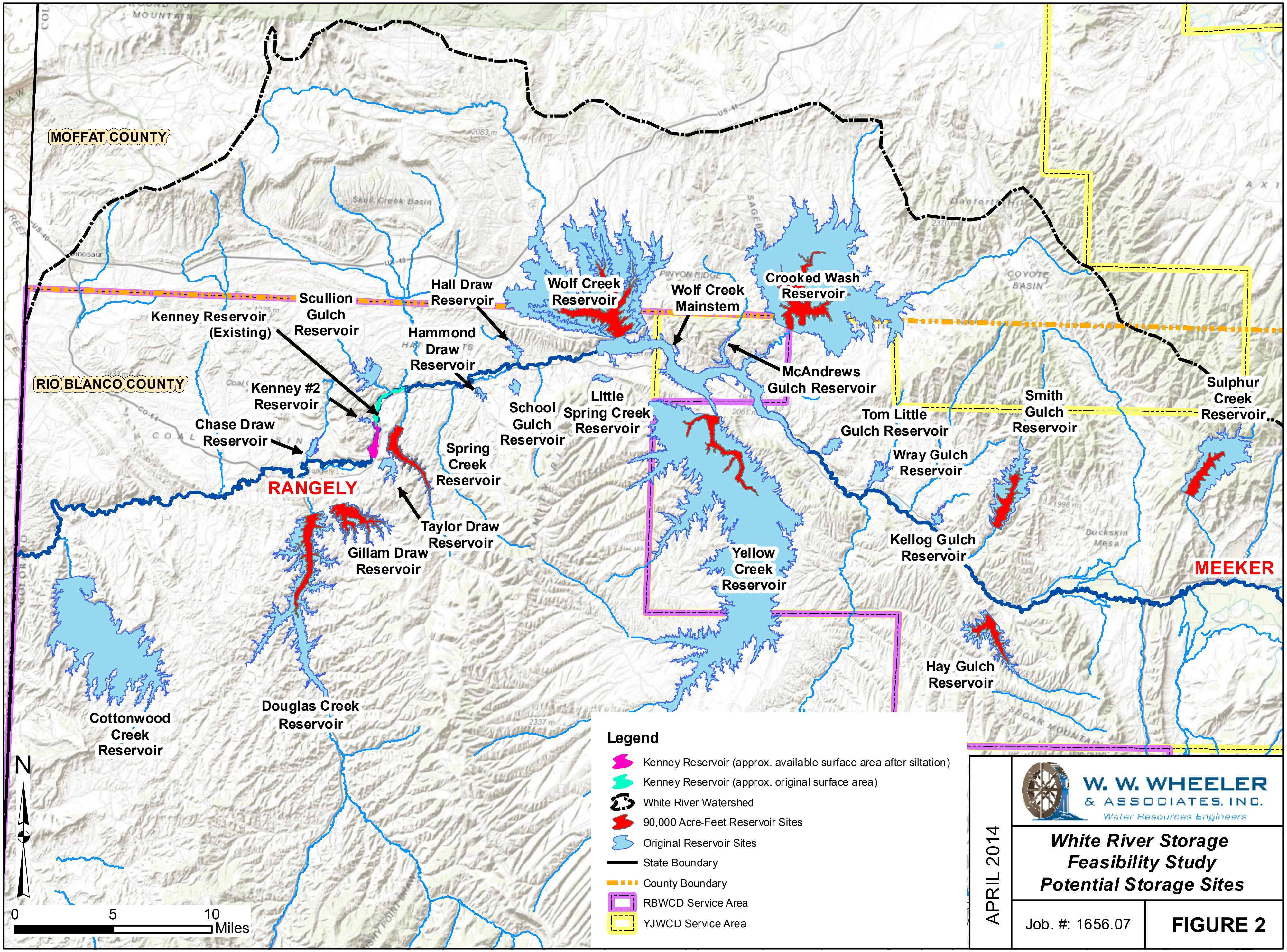

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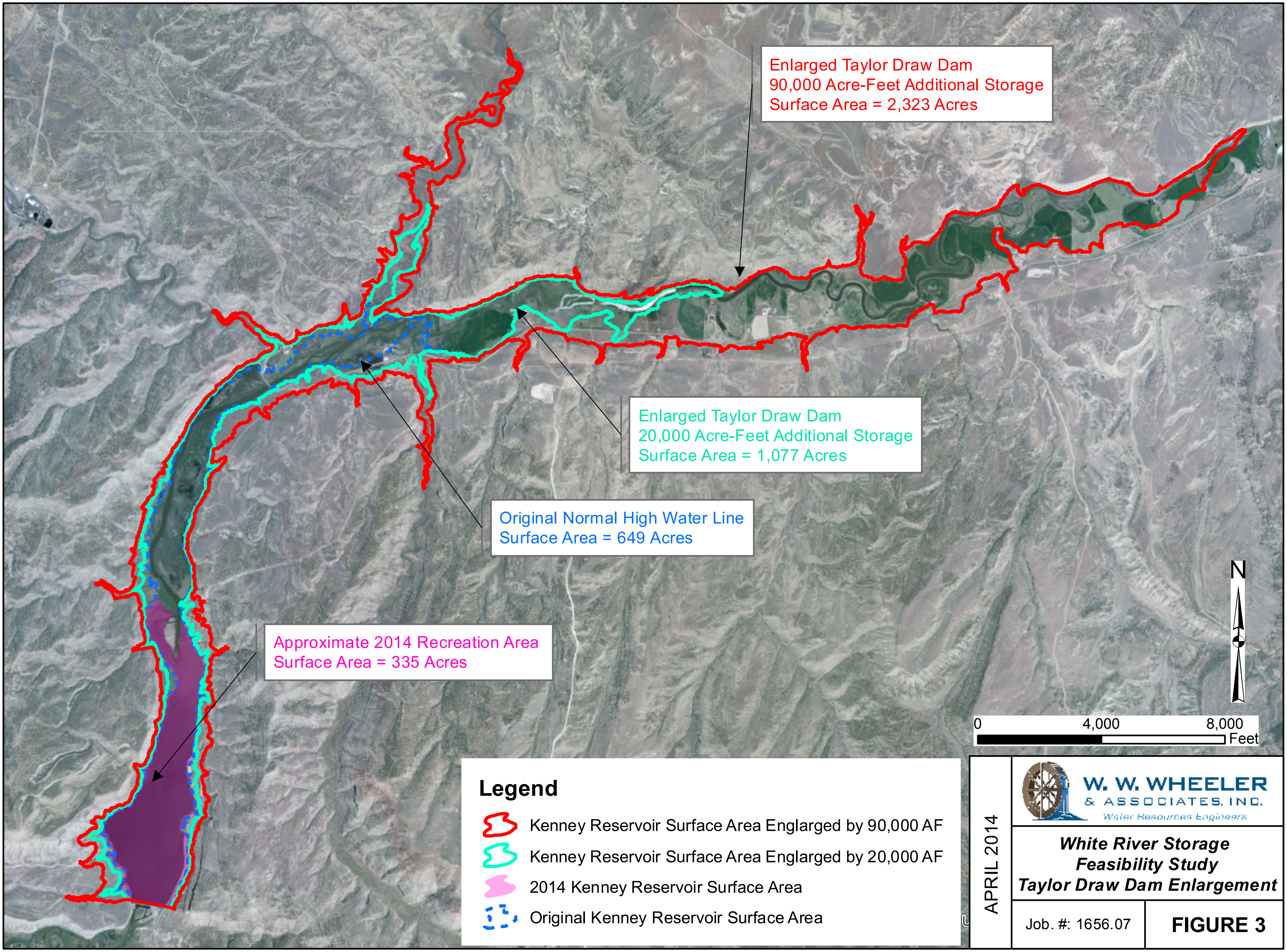

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White River Storage Feasibility Study Taylor Draw Dam Enlargement

Job. #: 1656.07

FIGURE 3

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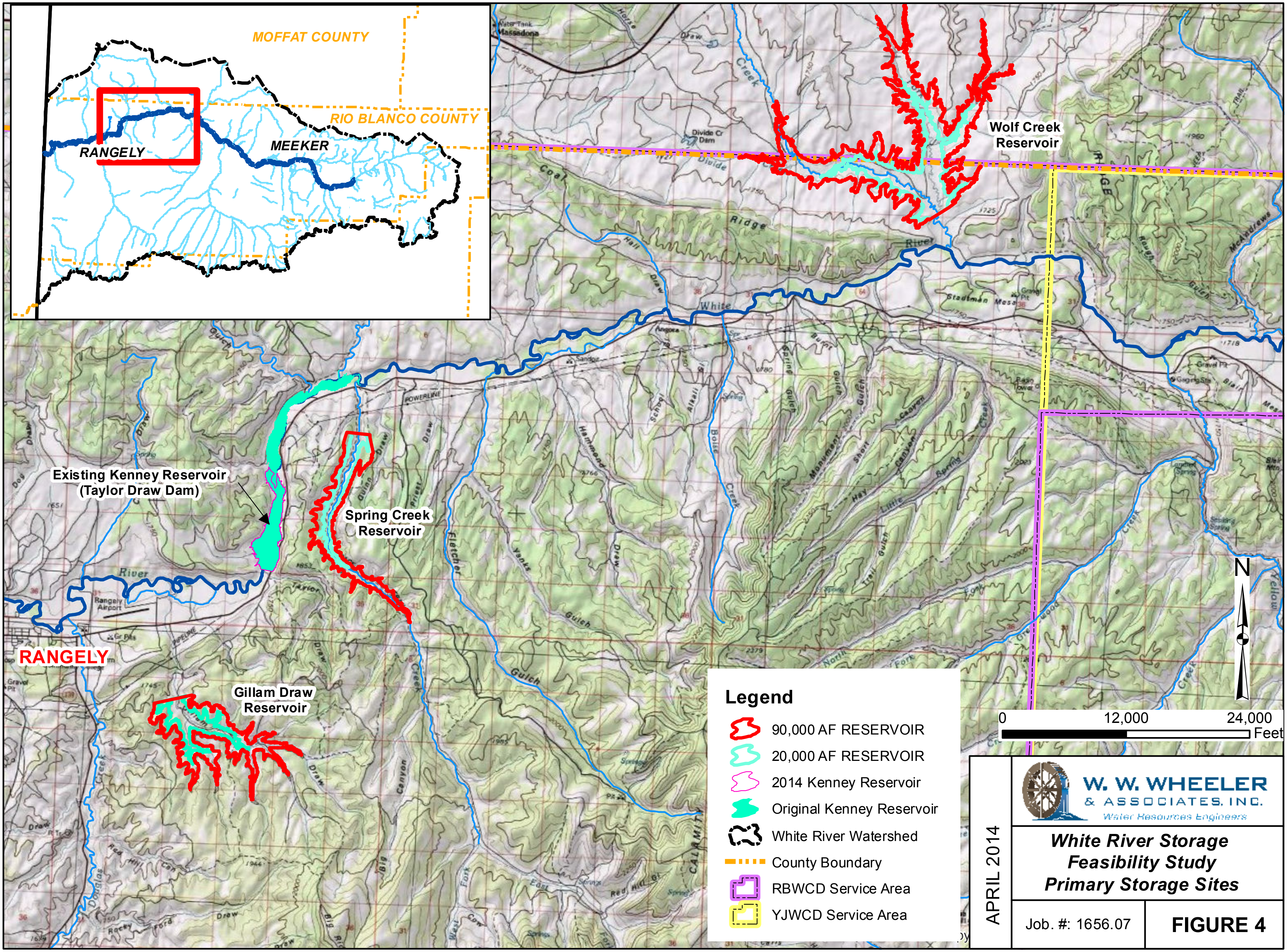
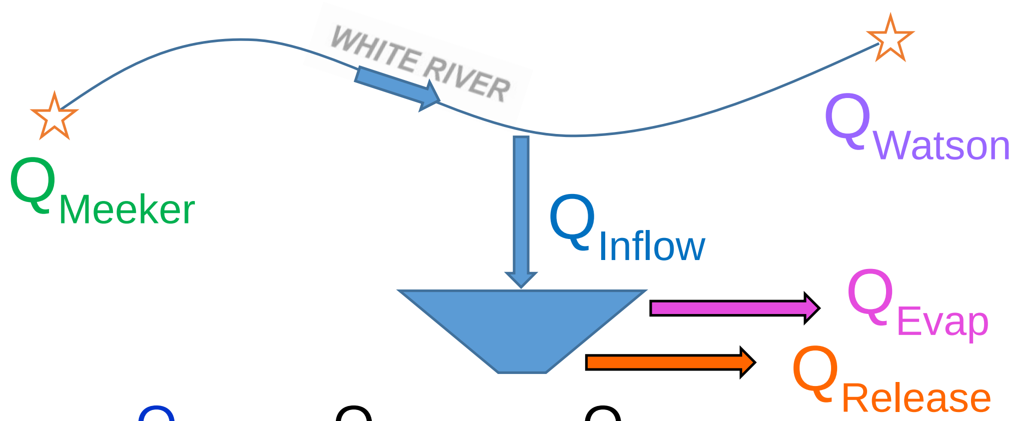


INFLOW SCENARIO:

$Q_{Watson} > Q_{Target}$



LEAST OF:

$Q_{INFLOW} = Q_{Meeker} - Q_{Target} - Q_{TRANSIT} - Q_{DS\_Rights}$

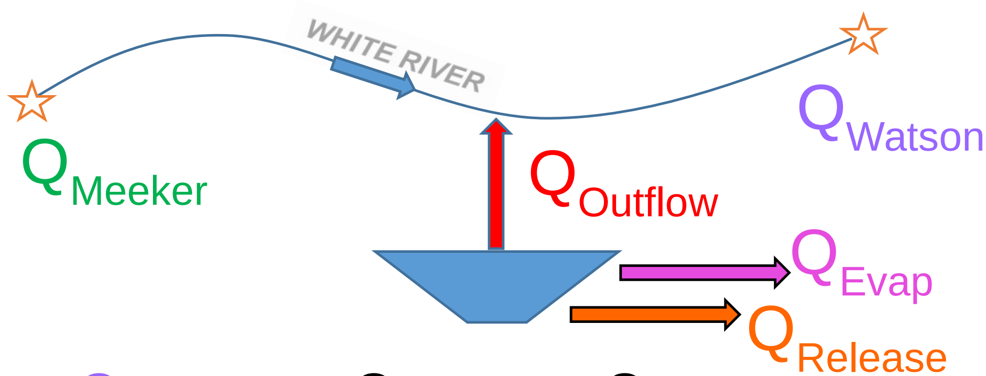
Q_{INFLOW} = Maximum Pump Rate

Q_{INFLOW} = Rate to Fill Reservoir to Capacity

RESERVOIR FLUX = {+ $Q_{INFLOW} - Q_{EVAP} - Q_{RELEASE}$}

OUTFLOW SCENARIO:

$Q_{Watson} < Q_{Target}$



LEAST OF:

$Q_{OUTFLOW} = Q_{TARGET} - Q_{WATSON} + Q_{TRANSIT} + Q_{DS\_Rights}$

$Q_{OUTFLOW}$ = Rate to Drain Reservoir

RESERVOIR FLUX = {– $Q_{OUTFLOW} - Q_{EVAP} - Q_{RELEASE}$}

Legend

Q_{Target} = Target streamflow at Watson, UT for environmental (300 cfs for 90,000 acre-foot reservoir and 200 cfs for 20,000 acre-foot reservoir)
Q_{Watson} = USGS Gage Daily Discharge at Watson, UT
Q_{Meeker} = USGS Gage Daily Discharge below Meeker, CO
$Q_{Transit}$ = Transit losses between the reservoir and Watson, UT
Q_{DS_Rights} = Assumed downstream water right releases (20 cfs)
Q_{Evap} = Evaporation Losses
$Q_{Release}$ = Releases made for Municipal & Industrial and Energy
$Q_{OUTFLOW}$ = Releases made to meet streamflow target at Watson, UT for environmental
Q_{INFLOW} = Inflow to the reservoir
Maximum Pump Rate = 400 cfs for 90,000 AF Reservoir and 50 cfs for 20,000 AF Reservoir

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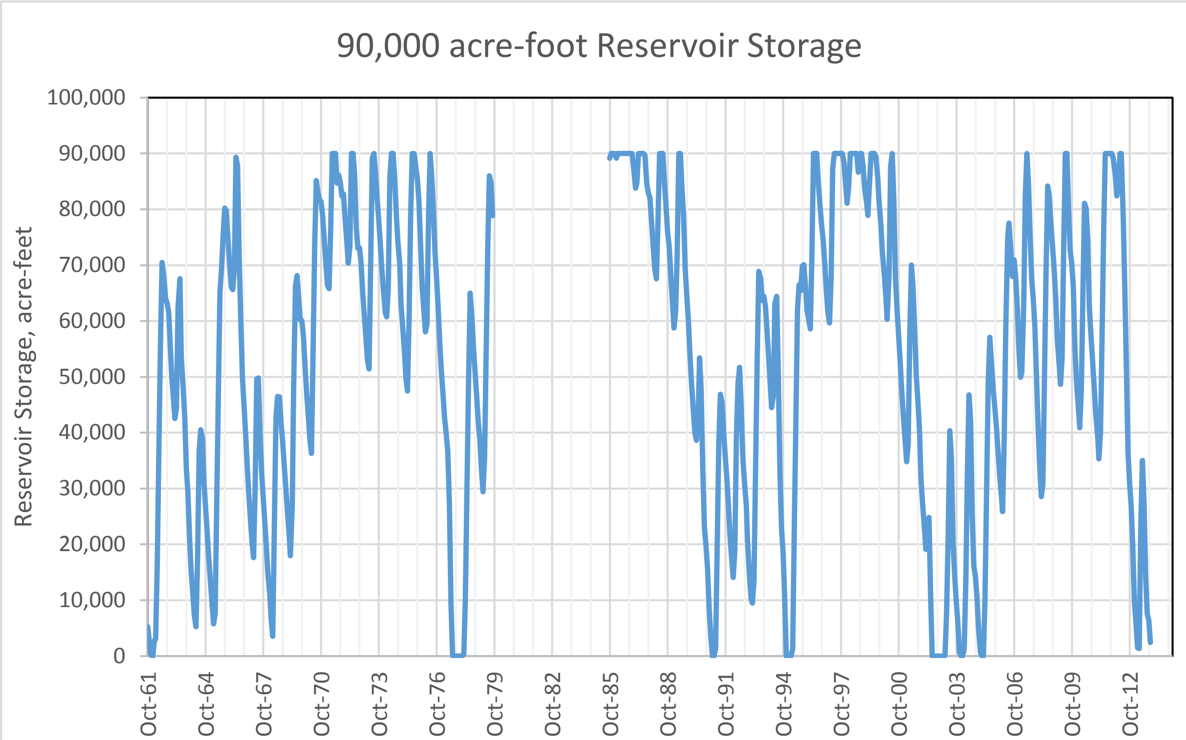
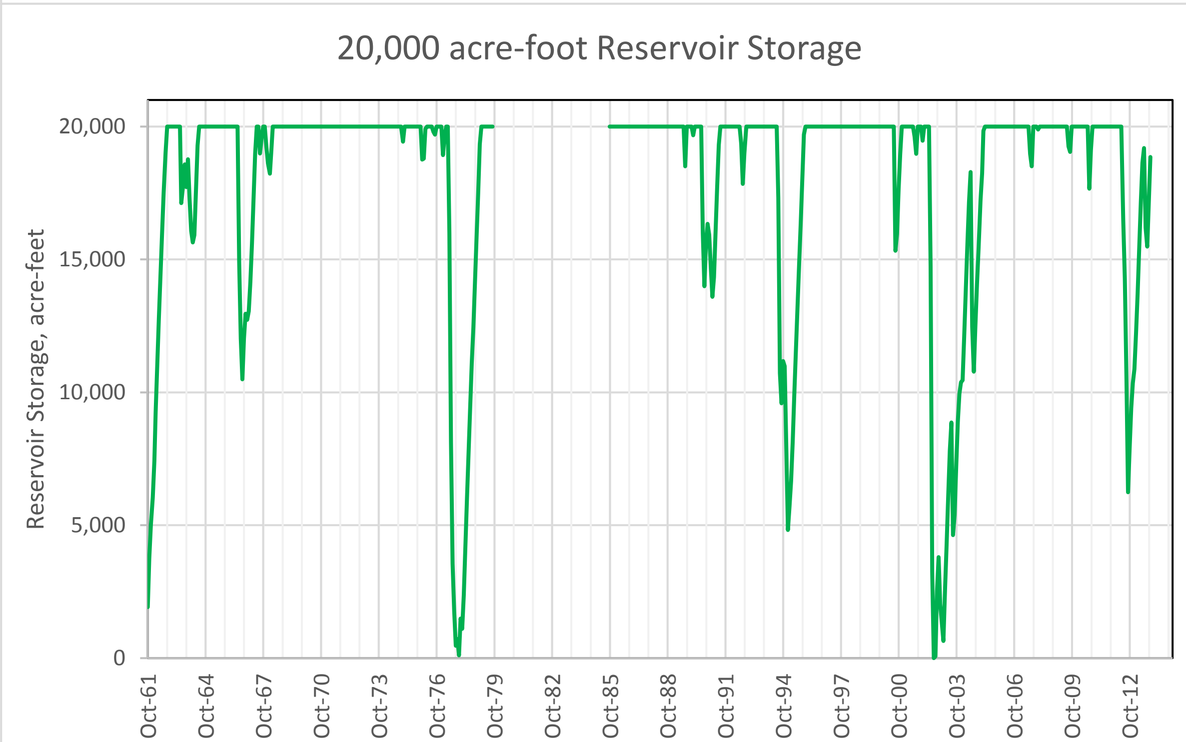
WHITE RIVER STORAGE FEASIBILITY STUDY RESERVOIR STORAGE MODEL

1656.07	**FIGURE 5**





Notes:
1) Monthly reservoir storage estimated using the Reservoir Storage Model shown on Figure 5.
2) The maximum inflow pumping rate for the 90,000 acre-foot reservoir is 50 cfs and for the 20,000 acre-foot reservoir is 400 cfs.

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WHITE RIVER STORAGE FEASIBILITY STUDY RESERVOIR STORAGE MODEL RESULTS

1656.07	FIGURE 6