Executive Summary

Introduction

There has long been a need for water development in the Uinta Basin. The Central Utah Project (CUP) was envisioned to develop water throughout the central part of Utah including the Uinta Basin. The Uinta Unit of the CUP had the potential to develop enough water to alleviate much of the estimated shortage. The ultimate phase of the CUP was intended to provide approximately 450,000 acre feet of water for Uintah and Duchesne Counties, but it was never built. The Flaming Gorge water rights intended for use by the ultimate phase of the CUP were transferred to the Utah Division of Water Resources (UDWR) by the Bureau of Reclamation. The UDWR has allocated this water right to water users throughout the state of Utah. Uintah WCD and Duchesne County WCD have been allocated approximately 22 percent of the water originally appropriated for the ultimate phase of the CUP. While the portion of Flaming Gorge water rights allocated to Uintah and Duchesne Counties has decreased, the actual demand for water in this area has increased. Agricultural, municipal, and energy sectors in Uintah and Duchesne Counties are expected to significantly increase their demand for water in the near future. Currently, many areas throughout the Uinta Basin are in short supply of water for municipal and industrial (M&I) and agricultural uses. There is a need for water to supplement existing agricultural supplies, as well as to provide a full supply to land that is suitable for irrigation but is not currently irrigated. The growing energy industry in the Basin also has a need for water. The development of agricultural, M&I, and energy industry water will strengthen the economy of the Uinta Basin.

The Central Utah Water Conservancy District (WCD), Duchesne County WCD, and Uintah WCD collaborated their time and resources to commission this study, which identifies and evaluates alternatives to use water rights on the Uinta and Green Rivers to meet increasing demands.

Purpose

The purpose of this project is to justify the transfer of Green River water rights to Uinta WCD and Duchesne County WCD. In addition to justifying this transfer, this study identifies and evaluates scenarios to use the water rights on the Uinta and Green Rivers (held by the Duchesne County WCD and Uintah WCD) to meet municipal, agricultural, and energy (oil and gas) demands. The Green River water represents a “new” puzzle piece to efficiently develop a water supply for the Uinta River Basin. Supplies can be increased by allowing water right exchanges using Green River water and unused Uinta River water to maximize the deliveries while addressing the highly variable seasonal supplies of the Uinta River.

Previous Work Completed

Over the years, the Duchesne County WCD and the Uintah WCD have investigated the feasibility of projects that could increase their water supplies. Projects to use Green River water, improve water delivery efficiency, and identify potential reservoir sites have all been explored. Based on the previous studies, issues and concepts that are relevant to the current plan for Uinta and Green River water development were identified. These issues, as well as a summary of previously completed work, are provided in Technical Memorandum 1.

Existing and Future Demands

The three most significant demand categories in the Uinta Basin are agricultural, municipal, and energy demands. This section summarizes the existing and future water demands in the Uinta Basin. Future demands are split into two categories—near future and likely future. Near future demands refer to applications for a portion of the Green River Allocation that have been approved by the Uintah WCD and Duchesne County WCD and imminent water needs. Likely future water demands are demands that are expected to be realized in the future because of projected growth based on previous studies and actual discussions with land owners, municipalities, and energy industry developers.

Agricultural Demands

The agricultural demands are based on water righted acreage. The 1923 Federal Court Decree specifies that lands served from the Uinta River drainage can receive no more than 3 acre-feet per acre. Therefore, the total demand is the water right acreage multiplied by 3 acre-feet per acre. The agricultural acreage and demand amounts used in this study are summarized in Table ES-1.

TABLE ES-1
Agricultural Demand Summary

Area	Existing Acreage	Existing Demands (AF/yr) [a]	Near Future Demands (AF/yr) [a]	Likely Future Demands (AF/yr) [a]
Total Indian Compact	33,761	101,283	101,283	101,283
Total Stock Water	-	6,897	6,897	6,897
Total Secondary Users	45,924	137,772	146,230[b]	170,403
Green River Water Rights Segregated for New Lands [c]	-	7,472	7,472	7,472
Total	**79,685**	**253,424**	**261,882**	**286,055**

NOTES:
[a] Demands increase cumulatively from “Existing” to “Near Future” to “Likely Future.”

[b] The increase in secondary demands in the near future represent applications approved by the UWCD Board for demands on new agricultural lands but not yet segregated.

[c] Green River Water Rights Segregated for New Lands includes 280 AF of New Ouray Park agricultural land, 7,040 AF for lands adjacent to the Green River, and 152 AF for wells developed for other new lands. Segregated water rights means that the state engineer has put a portion of the Green River water right in the name of the applicant.

Municipal Demands

In 2006, CH2M HILL completed a Culinary Water Master Plan for Duchesne and West Uintah Counties. This master plan identified existing demands and projected demands to 2050 based on projected population growth. The population growth projections were made prior to the current energy boom in the area and likely underestimate the population growth. Many of the municipal water systems in the Basin were having difficulty meeting demands in 2004 before the energy boom hit the area. To meet current demands, it is now estimated that at least 4,228 acre-feet of water supply is needed. To meet projected demands for the near future, it is estimated that an additional 10,554 acre-feet (for a total demand in 2050 of 14,782 acre-feet) of water supply needs to be obtained. An area located just south of Pelican Lake in the Ouray Park area, referred to as the Four Star Ranch, is projected to grow rapidly to support the ongoing energy industry boom. Property owners in this area foresee significant population growth that would require an estimated near future demand of 6,000 acre-feet per year.

Table ES-2 is a summary of existing and future municipal demands for the Basin.

TABLE ES-2
Summary of Municipal Demands

Municipal Demand Type	Existing Demands (AF/yr)[c]	Near Future Demands (AF/yr)[c]
Existing Municipal Demands	4,228	4,228
New Municipal Demands [b]	-	4,054
New Municipal Demands in Whiterocks	-	500[a]
New Ouray Park Area (Four Star Ranch)	-	6,000[a]
Total	**4,228**	**14,782**

NOTES:

[a] Applications for this water have been approved by the UWCD Board for new agricultural land, municipal, and industrial demands.

[b] This demand is the increased demand identified in the Culinary Water Master Plan for the Duchesne and West Uintah Counties.

[c] Demands increase cumulatively from “Existing” to “Near Future.”

It is anticipated that municipal demands will take first priority on new storage water developed. Municipal demands are documented in more detail in Technical Memorandum 2.

Energy Industry Demands

Energy industry water demands will likely increase dramatically as energy resources in the Uinta Basin are further developed. Oil shale and tar sand deposits in Utah and Colorado have been estimated to have more oil than all of the OPEC nations combined. Technological advances and higher crude oil prices are combining to make large-scale development of oil shale and tar sands resources likely, thus increasing future water demands.

Given that the crude oil price recently exceeded $90 per barrel and that the cost to produce a barrel of oil from oil shale and tar sands is estimated to be $40 to $50 per barrel, it is reasonable to assume that oil production in the Basin will increase dramatically in the near future. Since water is needed to develop oil, it is also reasonable to assume that water demands for oil shale and tar sands production will also increase dramatically. In the near future, oil production from both oil shale and tar sands may exceed 1,000,000 barrels per day (estimated combined production from 500,000 barrels per day for oil shale and 500,000 barrels per day for tar sands). This production rate would correspond to a water demand of over 100,000 acre-feet for both oil shale and tar sands in the near future.

Over and above this near future demand to support oil production, it is likely that future water demands could increase by an additional 108,000 acre-feet. Table ES-3 is a summary of the estimated existing and future energy industry demands in the Basin.

TABLE ES-3
Summary of Energy Industry Demands

Demand Type	Existing Demands (AF/yr)[b]	Near Future Demands (AF/yr)[b]	Likely Future Demands (AF/yr)[b]
Water for Traditional Oil Production	1,330	3,450	8,450
Water Segregated for Oil (DCWCD)	2,900	2,900	2,900
Water for Oil Shale	-	54,000	108,000
Water for Oil Shale with Approved UWCD Application	-	1,360[a]	1,360[a]
Water for Tar Sands	-	50,000	104,000
Water for Tar Sands with Approved UWCD Application	-	5,000[a]	5,000[a]
Water for Power Plants	-	-	12,000
Total	**4,230**	**116,710**	**241,710**

NOTES:

[a] Applications for this water have been approved by the UWCD Board for new industrial demands.
[b] Demands increase cumulatively from “Existing” to “Near Future” to “Likely Future.”

Data from Tables ES-1 through ES-3 are summarized in Table ES-4 to provide an overall summary of existing and future demands in the Uinta Basin.

TABLE ES-4
Summary of Overall Existing and Future Demands

Demand Type	Total Existing Demand [a]	Total Near Future Demand [a]	Total Likely Future [a]
Agricultural	253,424	261,882	286,055
Municipal	4,228	14,782	14,782
Energy Industry	4,230	116,710	241,710
Total	**261,882**	**393,374**	**542,547**

NOTE:
[a] Demands listed are in acre-feet per year and increase cumulatively from “Existing” to “Near Future” to “Likely Future.”

For more information about existing and projected water demands in the Basin, refer to Technical Memorandum 2.

Water Supply

Green River Supplies Available

Additional water is available and obtainable from water rights in the Green River that were allocated to both the Uintah WCD and the Duchesne County WCD by the UDWR in the spring of 1999. Duchesne County WCD was allocated 47,600 acre-feet and Uintah WCD was allocated 51,800 acre-feet of diversions. Of the diversion amounts allocated, Duchesne County WCD and Uintah WCD can deplete 31,160 acre-feet and 24,745 acre-feet from the Green River, respectively.

Both Districts have been pursuing the beneficial use of this water. A portion has been segregated (divided off and put to use) by the Districts. Duchesne County WCD has segregated 2,900 acre-feet for industrial use. This 2,900 acre-feet will have a 100 percent depletion from the Green River. Uintah WCD has segregated 8,172 acre-feet for agricultural use (65 percent depletion) and has committed 6,360 acre-feet for industrial use (100 percent depletion).

The Utah Board of Water Resources held hearings in December 2006 concerning the beneficial use of the water they allocated to various users in 2000. At the Board of Water Resources meeting on December 8, 2006, both Districts received an extension until December 2007 to submit their plans to put the water to beneficial use. More detail on the availability of Green River water is documented in Technical Memorandum 2.

Uinta Supplies Available

The Uinta River Basin is comprised of two main river systems, which include the Uinta River, Whiterocks River, and multiple tributaries. Tributaries to the main rivers include Deep Creek, Pole Creek, Farm Creek, and Dry Gulch Creek. These tributaries also contribute to the Basin. Additionally, water from the Yellowstone Feeder Canal contributes to the total inflow to the Uinta River Basin. Table ES-5 shows the average annual inflow to the Uinta River Basin.

TABLE ES-5
Average Annual Inflow Summary (average of years 1950–2006)

Tributary	Average Annual Inflow[a]	
Uinta River	125,974	
Whiterocks River	82,692	
Farm Creek	4,100	
Pole Creek	7,983	
Deep Creek	2,185	
Dry Gulch Creek	2,706	
Total Streamflow into the Uinta Watershed		***225,640***
Yellowstone Feeder Canal	14,704	
Total Inflow to the Uinta Watershed		***240,344***

NOTE:
[a] acre-feet per year

Streamflow in this watershed is highly variable, especially during the spring snowmelt and runoff periods. This variability makes it difficult for water users to divert all the available water into the existing canals, and therefore, some water continues downstream without being used. The water that flows out of the Basin is considered available, but it is not always necessarily obtainable. The total available and obtainable water supply from the Uinta watershed is summarized in Table ES-6.

TABLE ES-6
Water Supply Available and Obtainable for Storage or Exchange in the Uinta Watershed (1950–2006 average)

Description	Average Annual Volume[a]
Total Inflow	240,300
Used Water (amount diverted)	198,800
Unused and Available Water (outflow from watershed)	41,500
Unused and Obtainable Water	16,000
Unused and Unobtainable Water	25,500

NOTE:
[a] acre-feet per year

The obtainable water in the Uinta Basin was estimated using the URWR model (refer to Technical Memorandum 5 for a description of this model). From all the scenarios evaluated in this model, the greatest amount of water obtained from available water in the Uinta watershed was found to be 16,000 acre-feet per year on average.

Table ES-7 is a summary of total supplies available from the Green River and the Uinta watershed.

TABLE ES-7
Total Available Water Supplies

Description of Supply	Average Annual Volume[a]
Duchesne County WCD Allocation from Green River	47,600
Uintah WCD Allocation from Green River	51,800
Current Uinta River Basin Diversions	198,800
Obtainable Water from the Uinta River Basin	16,000[b]
Total Water Supply	314,200

NOTES:
[a] acre-feet per year
[b] part of this supply will be used to supply municipal demands

Summary of Scenarios

Task 6 of this study involved identifying and developing scenarios for evaluation. This process is documented in Technical Memorandum 4. Ten scenarios were identified and developed for this study. Each scenario is made up of different combinations of proposed project features. These project features include the following:

- Four proposed reservoir sites
- Two proposed enlarged reservoirs
- An extension of the Yellowstone feeder canal
- Pumping from the Green River
- Multiple water right exchanges

The four potential new reservoirs identified in the project area include Upper Uinta Reservoir, Neola Reservoir, Bennett Reservoir, and East Cottonwood Reservoir. The proposed reservoir enlargements include Montes Creek Reservoir and Brown's Draw Reservoir. Green River pumping options evaluated in this task include pumping from Green River to Pelican Lake, pumping from Green River to the Cottonwood Service Area, pumping from Pelican Lake to the Cottonwood Service area, and combinations of these three options.

Scenario 1 is the baseline scenario, so it has no proposed project features. A summary of the project features included in each scenario is summarized in Table ES-8.

TABLE ES-8
Summary of Scenarios

	Scenarios									
Project Features	**1**[a]	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stabilization of Uinta High Mountain Lakes (transfer storage to downstream storage)		✓	✓	✓	✓	✓	✓			
Upper Uinta Reservoir (28,000 acre-feet of storage)		✓	✓			✓	✓			
Brown’s Draw Enlargement (1,900 acre-feet increase in storage)				✓	✓	✓	✓			
Montes Creek Enlargement (950 acre-feet increase in storage)				✓	✓	✓	✓			
Bennett Reservoir (5,000 acre-feet of storage)				✓	✓	✓	✓			
Neola Reservoir (5,000 acre-feet of storage)				✓	✓	✓	✓			
East Cottonwood Reservoir (5,200 acre-feet of storage)				✓	✓	✓	✓			
Renn Smith Reservoir [b]		✓	✓	✓	✓	✓	✓	✓	✓	✓
Cliff and Whiterocks High Mountain Lakes transfer to M&I demand		✓								
Fill Cottonwood Reservoir with Exchange								✓	✓	✓
Yellowstone Feeder Canal Extension to Area 16 (capacity = 19 cfs)				✓	✓	✓	✓			
Pump from Green River to Pelican Lake		✓		✓		✓		✓	✓	✓
Pump from Green River to Ouray Park, Cottonwood Service Area		✓		✓		✓		✓		
Pump from Pelican Lake to Cottonwood Area (3,500 acres in the Cottonwood Service Area)										✓

NOTES:
[a] Baseline Scenario
[b] Although Renn Smith Reservoir is not included in Scenario 1, funding has been provided by the federal government and Utah Division of Water Resources to construct this reservoir. The Renn Smith Reservoir project is already underway.
M&I = municipal and industrial
cfs = cubic feet per second

Evaluation Results

After the project scenarios were identified and developed, they were evaluated based on increased water yield, cost, and other ranking criteria. This section summarizes the results of these evaluations.

Project Yields

A computer model was used to estimate increased water yield for each scenario. Originally, a water rights simulation model was created by the UDWR to gain a better understanding of diversions in the Uinta Basin. The model, called the Uinta River Simulation (GRES) Model, simulates diversions along the Uinta and Whiterocks River system using hydrologic data from 1949–2006, on a daily time step. The model also simulates the operation of the existing reservoirs in the system.

A new model called the Uinta-Green River Water Resources (URWR) model was developed to support this study. The objective of this model was to create a user-friendly, visually enhanced tool that could efficiently assist in screening water development project scenarios. The main steps in developing this tool were to replicate the logic of the GRES model, validate the model by comparing results with those of the GRES model, and then simulate future scenarios. The updated URWR model was built using the GoldSim dynamic simulation software platform. GoldSim is a user-friendly program designed to run dynamic simulations in various scientific, engineering, and management fields.

The amounts of average annual increases in water supply to the Basin were determined using this model. These increases in supply are referred to as project yields and are summarized in Table ES-9. Also shown in Table ES-9 are weighted average unit deliveries as compared to the baseline scenario. Unit delivery is the total water delivery divided by the agricultural acreage being served by the water supply.

TABLE ES-9
Scenario Yields

Scenario	Total Water Developed or Project Yield (acre-feet)	Municipal Water Supply (acre-feet)[a]	Weighted Average Unit Delivery to Secondary Water Users (ac-ft/ac)
1	0	0	2.2
2	22,300	2,047	2.6
3	12,600	1,850	2.5
4	17,900	2,633	2.5
5	8,900	2,018	2.3
6	26,200	2,978	2.7
7	16,200	2,468	2.5
8	9,800	1,268	2.4
9	4,200	1,235	2.3
10	8,400	1,275	2.3

NOTE:
[a] Municipal Water Supply is part of the Total Water Developed or Project Yield

Project Costs

A conceptual level cost estimate was prepared for each scenario. Cost estimates are broken down into the following major project features:

- Stabilization of High Mountain Lakes
- Reservoirs
- Pipelines
- Pump Stations
- 30-Percent Contingency
- Right-of-Way and Easements
- Variable Other Costs (engineering, administration, legal, etc.)
- Operation and Maintenance and Power Costs

Detailed cost estimates and a discussion of cost estimate approaches are provided in Technical Memorandum 4. A cost estimate summary for each scenario is shown in Table ES-10.

TABLE ES-10
Project Costs

	Scenario								
Project Feature	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stabilize High Mtn Lakes ($)	5 M	5 M	5 M	5 M	5 M	5 M	0	0	0
Reservoir Cost ($)	63.3 M	63.3 M	112.7 M	112.7 M	176.0 M	175.9 M	0	0	0
Pipeline Cost ($)	4.2 M	0	25.2 M	20.8 M	25.2 M	20.8 M	4.2 M	2.7 M	7.1 M
Pump Station Cost ($)	5.1 M	0	6.6 M	1.4 M	6.6 M	1.4 M	5.3 M	3.1 M	8.9 M
Contingency ($)	23.3 M	20.5 M	44.8 M	42.0 M	63.8 M	61.0 M	2.3 M	1.7 M	4.8 M
ROW and Easements ($)	2.2 M	2.2 M	3.9 M	3.8 M	6.1 M	6.1 M	0.01 M	0.01 M	0.02 M
Variable Other Costs ($)	20.2 M	17.8 M	38.8 M	36.4 M	55.3 M	52.8 M	1.8 M	1.5 M	4.2 M
Total Capital Cost ($)[a]	***123.3 M***	***108.8 M***	***237.0 M***	***222.1 M***	***338.0 M***	***323.0 M***	***13.6 M***	***9.0 M***	***25.0 M***
Annual O&M ($)	144 k	63 k	237 k	155 k	300 k	218 k	83 k	49 k	141 k
Annual Power ($)	756 k	0	705 k	10 k	814 k	11 k	650 k	338 k	555 k
Total Present Value ($)[a]	***137.5 M***	***109.7 M***	***251.9 M***	***224.8 M***	***355.5 M***	***326.7 M***	***25.1 M***	***15.1 M***	***36.0 M***

NOTES:
[a] Based on costs escalated to 2010
ROW = Right-of-Way
O&M = Operation and Maintenance
M = Million
k = Thousand

Ranking Criteria

In order to provide an organized and systematic approach to evaluating alternatives, a set of criteria has been developed. These criteria fall under four categories used to test if an alternative is viable. It is assumed that an alternative must be complete, effective, efficient, and acceptable in order to be viable. Technical Memorandum 4 provides definitions for each test of viability and explanations for each criterion, with more detailed results of the ranking analysis. The overall results of this analysis are summarized in Table ES-11.

TABLE ES-11
Scenario Ranking Scores

Scenario	Scenario Description	Total Score
2	Main stem with pumping	593
3	Main stem without pumping	486
4	Off-stream storage with pumping	525
5	Off-stream storage without pumping	384
6	Main stem plus off-stream storage with pumping	565
7	Main stem plus off-stream storage without pumping	439
8	Pump to Pelican Lake and Cottonwood service area	464
9	Pump to Pelican Lake only	419
10	Pump to Pelican Lake and from Pelican Lake to Cottonwood Service Area	427

Environmental issues were not addressed in this study, nor was any environmental study performed.

Stakeholder Participation

On Thursday, September 27, 2007, a public meeting was held with water companies and other entities benefiting from the project, Uintah WCD, Duchesne County WCD, Central Utah WCD, U.S. Forest Service, Bureau of Indian Affairs, UDWR, Franson Civil Engineers, and CH2M HILL to discuss preliminary results of the project yield analysis and screen out scenarios that were determined to be less viable. By the end of this meeting, a motion was made by those present that Scenarios 2, 4, 6, 8, and 10 should remain as viable scenarios to consider. These scenarios ended up with either the highest ranking scores or lowest total cost, so the evaluations conducted as part of this study concur with the motion made at the September meeting. Table ES-12 is a summary of the selected scenarios with results for project yield, cost, and ranking scores included.

TABLE ES-12
Summary and Overall Score for Each Scenario

Scenario	Water Developed (acre-feet)	Weighted Average Unit Delivery to Secondary Water Users [a]	Total Present Value [b]	Present Value per acre-foot of Developed Water	Score
2	22,300	2.6	$137,468,000	$6,200	593
4	17,900	2.5	$251,865,100	$14,100	525
6	26,200	2.7	$355,523,600	$13,600	565
8	9,800	2.4	$25,133,300	$2,600	464
10	8,400	2.4	$35,978,400	$4,300	427

NOTES:
[a] Acre-feet per acre
[b] Based on costs escalated to 2010

Conclusions

The need for additional water within the Uinta Basin and particularly the Uinta River drainage has been documented in this report. These needs include agricultural, municipal, and energy demands, including oil shale and tar sands. In fact, the need for water far exceeds the available supplies even when including water from the Green River. The ultimate phase of the CUP originally allocated approximately 450,000 acre-feet of water from Flaming Gorge Reservoir for use in Uintah and Duchesne Counties. After the ultimate phase of the CUP was dissolved, the UDWR was given the Flaming Gorge water rights associated with this phase of the CUP. The UDWR has allocated to Uintah WCD and Duchesne County WCD approximately 22 percent of the original 450,000 acre-feet of water planned for the two counties. This report demonstrates that far more than the 99,400 acre-feet of water allocated to the Uintah WCD and Duchesne County WCD could be used.

Both the Duchesne County WCD and the Uintah WCD are actively pursuing the use of the Green River allocation. To date, 2,900 and 8,172 acre-feet of water have been segregated and put to use by the respective Districts with more in process of being segregated. The Uintah WCD has just selected an engineering firm to design a pumping project (Alternative 10) which will use another 8,500 acre-feet. Of the total 99,400 currently allocated to the two Districts, this 19,572 acre-feet represents approximately 20 percent of the allocation already put to use or actively being developed.

The report identifies several alternatives which would develop additional water supplies. These alternatives were ranked and several were recommended for further study by the local stakeholders along the Uinta River. The estimated cost of these alternatives appear to make them reasonable in today's conditions.

The current price of oil at over $90 per barrel indicates a very high probability of production of crude oil from oil shale and tar sands within the Uinta Basin. The projected demand for water for the production of crude oil from these sources alone far exceeds the available supply from the Green River. Department of Energy planning documents even identify production levels in excess of those identified in this report.

The available water supply within the Uinta River drainage, including the allocated Green River water rights is 314,200 acre-feet. The existing agricultural, municipal, and energy water demand has been identified as 261,900 acre-feet. The additional near future demand for water is estimated to be 131,500 acre-feet. These numbers indicate a shortfall of over 79,000 acre-feet even with the full use of the Green River allocation. Because most of the near future demand is energy industry related, which has a 100 percent depletion rather than the 65 percent depletion for agricultural use, the actual shortfall increases by approximately 30,000 acre-feet to nearly 110,000 acre-feet.

This report provides strong justification for the transfer of the current allocations of Green River water to the Duchesne County WCD and the Uintah WCD. These Districts have a demonstrated need for additional water. In fact, the need far exceeds the available supply. They have shown the ability to put the water to use. They represent all water users within their respective districts and would allow a public board of trustees to make decisions as to the most appropriate use of the water in the future.

Contents

Conceptual Analysis of Uinta and Green River Water Development Projects

Technical Memorandum #1

Summarization of Previous Work Completed and Identification of Existing Project Concepts for Further Evaluation

Prepared by:

FRANSON CIVIL ENGINEERS

&

CH2MHILL

November 2007

TABLE OF CONTENTS

INTRODUCTION

The objective of this technical memorandum is to review and summarize previous work completed to date as well as to preliminarily identify existing project issues, concepts, and alternatives that should be carried forward for further evaluation. The first section of this memorandum will summarize the previous work. The second section will identify the issues and concepts that have been deemed relevant and require further evaluation. The third section will summarize the existing potential alternatives and concepts discussed in the prior two sections. The final section will list the areas in which additional work is needed.

1. SUMMARY OF WORK COMPLETED

The need for additional water development in the Uinta River Basin has been identified for many, many years. The Uintah Unit of the Central Utah Project (CUP) was envisioned to meet that need. Over the years, as plans for the Uintah Unit and subsequent replacement projects were dissolved, the need for water has increased. The Duchesne County Water Conservancy District (DCWCD) and the Uintah Water Conservancy District (UWCD), have recognized the need for both agricultural, and municipal and industrial (M&I) water development. These districts cover parts of the Uinta River Basin. Over the years, both districts have investigated the feasibility of projects that could increase their water supply. When Flaming Gorge water rights became available out of the Green River, both districts applied for an allocation. The following section summarizes the projects that each of the districts have explored over the past several years.

Leota Bench/Ouray Park Pumping Projects from the Green River

Ever since the Flaming Gorge water became available and UWCD was allocated 51,800 ac-ft, landowners in the Leota Bench and Ouray Park areas have been actively pursuing alternatives to pump water from the Green River to Brough Reservoir and Pelican Lake.

Beginning in 1997, UWCD worked with water users to identify how much water was serving the lands on the Leota Bench and around Pelican Lake. It was determined that supplemental water would benefit these lands and an additional 7,770 acres could be irrigated if the water supply was available.

Some specific alternatives were evaluated regarding supplying additional water by pumping water from the Green River. Many scenarios were identified, and included the concepts of pumping supplemental water to lands on the Leota Bench and/or around Pelican Lake, supplying water to new land in either or both of the areas, providing water for environmental enhancement, and providing water to upstream users through exchange. This work was documented in two reports of the same name, “Leota Bench Supplemental Irrigation Project” completed in 1997 and 1998.

Over the next few years, UWCD continued the plan formulation process with the landowners to determine the most feasible and efficient methods of pumping water to Brough Reservoir and to

Pelican Lake. The original concept was to build two separate pumping projects, one to Brough and one to Pelican. As interest in the project grew, a combined system was formulated which included: a pumping plant, a backbone pipeline, and a series of distribution ponds. That project would involve pumping about 35,000 ac-ft of water out of the Green River annually and would supply water to upstream users through an exchange with the existing supply of Ouray Park Irrigation Company. It was summarized in the December 2000 "Funding Prospectus for… Green River Pumping Project…"

Due to financial and social constraints, the large project was put aside and individual landowners returned to the idea of separate smaller projects. Concepts of pumping directly to Pelican Lake and to areas on the Leota Bench were revisited.

In 2004, the "Dry Bench Feasibility Summary" was done for a group of landowners on the Leota Bench to determine the feasibility of pumping Green River water to their five properties. A project was proposed and deemed feasible. Much of the same effort would be required to supply water to these five landowners through this project as to develop a larger project benefiting many more landowners.

The Ouray Park Irrigation Company, in September 2006, had prepared a report entitled "Preliminary Analysis of Pumping Green River Water into Existing Pipe System" for. In 2004, the Ouray Park Irrigation Company was awarded funding from the Colorado River Salinity Control Program, which allowed them to replace a portion of the Ouray Park Canal with approximately 25,000 feet of pipeline. The project identified in this report would incorporate the new pipeline. Instead of pumping water from the Green River to Pelican Lake, a pipeline would be built from the Green River and tie into the end of the new Ouray Park Canal pipeline. Water could be pumped up from the Green River into the existing pipeline. Water could then be diverted from the pipeline to Pelican Lake and directly to irrigated lands. The report concluded that about 2,700 acre-feet of water could be pumped for approximately $70 per acre-foot.

West Side Combined Canal Salinity Project

The West Side Combined Canal Salinity Project (WSCCSP) is a current water project located on the west side of Uintah County approximately where the Uinta River crosses Highway 40. Though it is not directly involved in developing water from the Uinta or Green Rivers, it is a component that may be utilized in conjunction with other potential alternatives to enhance the delivery and usage of the water. It will ultimately eliminate approximately 46.4 miles of seven existing irrigation canals (Ouray Park, Moffat, Harris, Tabby White, Daniels, Military, and Deep Creek-Lateral 7) by replacing them with one pressurized distribution system.

There are five divisions of the WSCCSP, three of which are complete and in operation. Construction of the final two divisions is currently underway. The first division of the project included replacing several diversions out of the Uinta River with one centralized diversion that would deliver water from the river to the combined pipeline. When the project is complete, it will consist of 8.3 miles of 48-inch diameter HDPE pipe, 4.3 miles of other large (24-inch to 36-inch) diameter pipe, and 21 miles of laterals.

The WSCCSP pipeline is used to deliver direct flow water from both the Uinta and Whiterocks Rivers to acreage in the Gusher area, as well as to deliver winter storage water to Cottonwood Reservoir and Pelican Lake. The project has already resulted in a significant savings of water by elimination of seepage from the canals. The on-farm efficiency has also been improved because farmers are now able to use sprinklers due to pressure developed by putting the water in pipe. The lateral pipelines have been sized sufficiently to accommodate any new demands resulting from potential Uinta or Green River water development.

Green River Usage in Duchesne County

In April 2001, the Green River Water Usage Study was prepared for DCWCD. In it, the following eight alternatives and cost estimates were listed:

Instream Fishery Flow Exchange

This alternative assumes that water used as instream flows upstream from the confluence of the Strawberry and Duchesne Rivers, could be used along the Duchesne River by exchange. The water would no longer reach the Green River and, therefore, would need to be replaced using a portion of the Flaming Gorge water right. Water would be diverted from the Duchesne River, thru the Duchesne Feeder Canal, into the Dry Gulch and C Canals. The water those canals currently receive from the Lake Fork River could be exchanged upstream. This alternative would require several pumps and a pipeline to facilitate the diversions. In 2001, the cost was estimated to be approximately $3 million.

Exchange Duchesne River Pumping with Green River Pumping

There is a section of the Duchesne River in Uintah County before the confluence of the Green River, from which many acres of land are irrigated. Water could be pumped from the Green River to those lands. The water they currently use out of the Duchesne River could be kept upstream. Assuming that about 5,000 acres could be served by this alternative, the cost of the necessary pumps and pipeline was estimated to be $7.5 million.

Groundwater Recharge with Winter Water

Unused winter water can be stored in excavated basins located near groundwater formations for the purpose of artificial groundwater recharge. Two possible locations for artificial recharge basins were identified. A 35 acre-foot pond located near the Hayden Well fields has a construction cost of $400,000. A 15 acre-foot pond located near the agricultural area between the Farnsworth and Boneta Canals, approximately 7 miles north of Starvation Reservoir, has a construction cost of $200,000.

Brough Reservoir Exchange

This alternative looked at the option of exchanging Green River water in Brough Reservoir with water from Uinta and Whiterocks Rivers that currently supply it. The river water would then be used on lands in the Neola-Roosevelt area. The viability of this option was questioned due to plans of UWCD to exchange water in Brough to the Whiterocks area.

Direct Pumping from the Green River

Green River water could potentially be pumped directly to Duchesne County for agriculture and M&I use. A 27-mile pipeline could transport 30,000 acre-feet of supplemental irrigation water to the Uinta River at the diversion for the Uintah Canal, which would require a lift of 1,600 feet. The estimated cost is $25,000,000. To use 3,000 acre-feet for M&I use in Roosevelt City, 460-feet of lift through about 21-miles of pipeline would cost approximately $1,500,000.

Oil Well Injection

DCWCD could sell Green River water to local oil companies in exchange for the M&I water currently being used to increase oil yields. The cost to pump water was approximately $5,000,000 for the required facilities including 74,000 linear feet of ductile iron and 25,000 feet of natural gas pipelines, pumps, natural gas engine, and 1-million gallon steel storage tank.

Reservoir Storage

Based on criteria for selecting possible off-stream reservoir sites, four locations were identified south of the Duchesne River between Duchesne City and Myton City. The two best sites for reservoir placement have a reservoir capacity of 90 acre-feet and 350 acre-feet with construction costs of $655,000 and $2,390,000 respectively. The feasibility of constructing these dams are dependant on local geologic conditions.

New Lands

New lands in the South Myton Bench and Pleasant Valley area could be served a full water supply by enlarging the existing Gray Mountain Canal, constructing a pumping plant to lift water to a new canal/pipeline, and constructing a new canal/pipeline and associated laterals to serve the individual farms. The combined cost for this project is $8,720,000.

Other possible alternatives mentioned in the report that do not directly involve Green River water include:

- Duchesne River water management strategies
- Ground water sources
- Watershed management practices
- Canal rehabilitation
- And, other exchange possibilities.

Green River Exchange Project Flow Study

In 2004, DCWCD began working with UWCD and Central Utah Water Conservancy District to determine the feasibility of a basin-wide project that would utilize water from the Green River. The project was termed the Green River Exchange Project (GREP). Concerns over Green River water usage being limited due to flow recommendations proposed by the Upper Colorado River Endangered Fish Recovery Program were evaluated. The operation of Flaming Gorge Dam directly affected the flow in the Green River. The Utah State Engineer has a water rights policy to protect the endangered fish from the dam downstream to the confluence of the Duchesne River. The flow recommendation for the endangered fish in the Green River was to simulate a naturally occurring hydrograph, as if the dam were not there. The report concluded that the Green River Exchange Project could move forward.

DCWCD Culinary Water Master Plan

In January 2006 the Culinary Water Master Plan (CWMP) for Duchesne and West Uinta Counties was completed. The purpose of the master plan is to assist the culinary water agencies in Duchesne and west Uinta Counties to identify adequate, cost-efficient, firm yield water supplies that meet the quantity and quality needs of their communities. This study revealed an imminent need for culinary water in the project area. Water supply firm yields and estimated project water costs were used to prioritize short listed projects in an implementation plan for each regional service area. A total of 43 project options were explored. Of the 43 projects explored, 18 separate projects were recommended. Projects identified in the CWMP that may be related to this study are listed below. Some of the projects identified below were not recommended in the CWMP, but may be feasible in the context of this study.

1. CWMP Project 11, expand Duchesne Valley Water Treatment Plant and South Side Transmission Pipe. This project would allow more of the oil field demand to be provided by the East Duchesne Culinary Water Improvement District and Johnson Water Improvement District as well as allow for increased water agency demands related to growth in the Duchesne, East Duchesne, South Duchesne, Johnson, and Myton areas. Project 11 is relevant to this project because it could reduce oil industry for Green River water.
2. CWMP Project 12.1, Pipe/pump Myton City drains to Newfield Oil. This involves collecting and pumping drains to Newfield Oil's pumps. Project 12.1 is relevant to this project because it could reduce Newfield's demand for Green River water.
3. CWMP Project 22, Water Treatment Plant North of Roosevelt. This involves building a water treatment plant (WTP) north of Roosevelt that would receive water from Brown's Draw Reservoir or the Uintah River. Project 22 is relevant because the proposed source of water is possibly water developed on the Uintah River as a result of this project.
4. CWMP Project 24, 1.5 MGD Water Treatment Plant on Uintah River, Pipe to Neola. Project 24 involves building a WTP to use Uintah River water to supply Cedarview and Neola growth. This project is relevant because the proposed source of water is possibly water developed on the Uintah River as a result of this project.
5. CWMP Project 29.2, 2200 AF in M&R Reservoir, New 4 MGD Water Treatment Plant. This involves building a reservoir to store water from the Ouray–Whiterocks Canal and a new WTP to treat the canal water to drinking water standards. The M&R Reservoir mentioned in this project is the same as the McKee Reservoir or Renn Smith Reservoir discussed later in this memo.
6. CWMP Project 30, Pipe/Pump 4 MGD from Ashley Valley Water Treatment Plant (AVWTP) to Tridell. This project involves pumping water from the AVWTP to fulfill culinary water needs for the Tridell and Lapoint areas. This project would allow the

proposed McKee/Renn Smith Reservoir to be used to store Uintah River water for agricultural use and would eliminate the need to build the WTP mentioned in Project 29.2.

7. CWMP Project 33, Roosevelt to Ouray Pipe. This project would supply water to meet Ouray demands and possibly Randlett demands from a proposed WTP north of Roosevelt. This would provide culinary water for one of the project areas but could also be reversed to provide Green River water to Roosevelt.
8. CWMP Project 34, Highway 88 Pipe (Lapoint to Ouray). This project, in conjunction with Project 30, would provide culinary water to the Ouray area from the AVWTP.

Newfield Oil

Newfield Oil (formerly Inland Oil) contacted DCWCD about obtaining additional oil well injection water from the Green River in 2002. Newfield Oil injects water into poorly producing wells to promote increased oil production in adjacent wells. Newfield Oil is currently receiving injection water from the Johnson Water Improvement District (JWID). JWID receives the majority of its water from the Duchesne Valley Water Treatment Plant. JWID's existing supply pipeline and municipal demands limit the water available to Newfield Oil to approximately 700 gpm (1.01 MGD). Water demands by Newfield Oil have, or soon, will exceed the capacity of the JWID.

A feasibility report for the use of Green River water by Newfield Oil was done in January, 2003. The feasibility report evaluated five scenarios for pumping water from the Green River to Newfield Oils wells. All five scenarios included drilling shallow collector wells adjacent to the Green River assuming that water developed by the wells would primarily come from the Green River. The five scenarios explored various pump and pipe configurations to determine the most feasible option. Ultimately, pumping from the Green River to the Newfield Oil wells was determined to be physically and financially feasible. In January 2003, when the feasibility report was prepared, the projected peak use by Newfield Oil was 3.0 MGD. Since that time the oil wells have been found to accept more water than initially thought and the projected water demands have increased from 3.0 MGD to 4.5 MGD (5,040 acre-feet).

DCWCD has worked directly with Newfield Oil to develop the project. A large diameter collector well has been installed adjacent to the Green River and construction of a 12-inch pipeline is nearly complete. Delivery of up to 2,900 acre-feet of Green River water is expected to begin in May 2007. An additional 1,100 acre-feet of water may be supplied to Newfield Oil from a second collector well in the future with approval by the DCWCD.

Oil Shale and Tar Sands Development

In 1973, the Utah Division of Water Resources prepared what is generally referred to as the White River Report. The White River Report discussed the water needs for oil shale development along the White River and how Utah's allotment of Colorado River water could be used to fill the water demands for oil shale development. At the time of the report Water Resources estimated that 30,000 to 160,000 acre-feet of Utah's Colorado River water allotment could be used for oil shale development. At the time of the report, the Bureau of Land Management (BLM) had set aside two tracks of land in Southeastern Uintah County near the White River for the demonstration of oil shale development technologies. Efforts were made to develop oil shale in this area until the price of oil made development of oil shale economically unfeasible. With increased oil prices, the BLM has received renewed interest in developing oil shale resources in the area. Oil Shale Exploration Company (OSEC) has been selected by BLM to demonstrate their oil shale processing technology and is currently in the process of demonstrating the feasibility of their retort technology at the White River Mine. OSEC's retort technology is expected to require approximately 2.3 barrels of water for every barrel of oil produced. Other technologies for the development of oil shale, that utilize far less water, are being tested in Colorado but OSEC's technology appears to be most effective for the type of high quality oil shale (25 gallons/ton or greater) found in south Uintah County and southeastern Duchesne County. Given an oil shale production of 200,000, 500,000, and 1,000,000 barrels of oil per day, the annual, process only, water needs would be approximately 21,600, 54,000, and 108,000 ac-ft respectively. The actual oil shale production is dependent on many factors, such as the price of oil, many of which cannot be estimated with confidence at this time. However, with crude oil prices currently at over $90/barrel it appears that the pace of oil shale development will be increasing dramatically. Oil shale production may approach 1 million barrels per day in the future.

Tar sands, like oil shale, have to be processed to separate the oil from the sands. Depending on the process used to release the oil, water usage will likely be similar to the water usage needed to process oil shale (i.e. 2.3 barrels of water for each barrel of oil). Approximate Production from tar sands in Uintah and Duchesne counties is expected to be 225,000 barrels/day in the future, which corresponds to an approximate water demand of 24,000 ac-ft.

Potential Reservoir Sites

Uintah Unit

The Uintah Unit Replacement Project Feasibility Study was completed in January 1997. The purpose of this project was to develop flows of the Uinta and Whiterocks Rivers, with minor contributions from other small streams, for supplemental irrigation of Indian and Secondary lands, recreation, and fish and wildlife enhancement.

Project irrigation water was to be made available from storage regulation of surplus flows of the Uinta River, from savings of excessive seepage losses through rehabilitation of existing canals, and retirement of marginal farm land. Storage regulation was to be provided in the Lower Uinta Reservoir located within the Uintah and Ouray Indian Reservation. Irrigation supplies were to be released from the Lower Uintah Reservoir to the stream channel below and distributed through existing canal systems.

Part of the storage in the Lower Uintah Reservoir would have been used to replace the irrigation supply presently stored in five high mountain lakes located in the High Uintas Wilderness. Due to failed contract negotiations with the Ute Tribe, this project never materialized.

Other Sites Previously Researched

As part of the above mentioned project, 41 dam sites were looked at in addition to dam sites investigated by the Bureau of Reclamation. These additional sites are addressed in the Uinta Basin Replacement Project report titled, "Preliminary Geology and Environmental Evaluations of Potential Dam Sites and Reservoirs dated August 1992." Approximately half of the sites identified in this report are outside the project area. This report includes the Upper Uintah Site and discusses the possible enlargement of Brown's Draw and Montes Creek Reservoir but does not include any of the other sites discussed in the Preliminary Dam Site Investigation below.

Preliminary Dam Site Investigation (2006)

The most recent analysis of potential reservoir sites is the "*Green River Exchange Project – Preliminary Dam Site Investigation*" completed in June 2006. In that report, six sites were evaluated. Four of the six sites would be new dams, namely East Cottonwood, McKee, Renn Smith, and Upper Uinta. The other two sites are enlargements of existing reservoirs, Montes Creek and Brown's Draw. Each evaluation summarized the dam location, the water source, the basic facility specifics, land ownership, potential environmental issues, and a preliminary geologic evaluation. See Table 1 below.

TABLE 1
Evaluation of Six Reservoir Sites

Name	Approximate Location	Water Source	Reservoir Capacity	Right-of-Way	Constraints Identified
East Cottonwood	4 miles northeast of Gusher	Off-stream: Uinta or Whiterocks Rivers	5,200 ac-ft	Ouray Park Irrigation Co., Private, and BLM	None
McKee	0.5 miles east of Tridell	Off-stream: Whiterocks River	3,800 ac-ft	Private	Environmental[1] and geologic
Renn Smith	1.5 miles northeast of Tridell	Off-stream: Whiterocks River	3,200 ac-ft	Private	None
Montes Creek Enlargement	4 miles northeast of Roosevelt	Off-stream: Uinta River	950 ac-ft increase to 2,200 ac-ft	Dry Gulch Irrigation Co., and Private	None
Brown's Draw Enlargement	5 miles west of Neola	Off-stream: Uinta River	1,900 ac-ft increase to 7,800 ac-ft	Moon Lake Water Users Assoc., and Private	Geologic
Upper Uinta	Just north of Forest-Reservation Boundary	On-stream: Uinta River	20,000 ac-ft	Ashley National Forest	Environmental and geologic

[1] Environmental concern involves location of a closed landfill.

The summaries were used to add the six sites to the Utah Division of Water Resources' Uinta River Simulation Model (UintaSim). The purpose of the revised model was to provide the districts with the estimated amount of water that can be developed on the Uinta River system through upstream storage. Model results would then assist the Districts in determining which of the six potential reservoirs sites would warrant further investigation.

2. IDENTIFICATION OF RELEVANT ISSUES AND CONCEPTS

Section 1 reviewed specific project components that have been previously investigated. Much of the work that has been done to date is still relevant. It is also too early in the plan formulation process to completely disregard any option for the Uinta and Green Rivers water development. The purpose of this section is to discuss any issues involved with the components described above.

Pumping from the Green River to Brough Reservoir and Pelican Lake

As stated earlier, both the landowners on the Leota Bench and members of the Ouray Park Irrigation Company have begun to pursue individual projects to utilize Green River water. These individual projects show that developing Green River water is feasible and desired. Once water is supplied from the Green River to Brough Reservoir and/or Pelican Lake, exchanges can begin to occur within the Ouray Park Irrigation Company service areas.

Because of the size of the current projects, larger exchanges with other upstream users will require additional facilities, such as upstream storage as well as larger pumps and pipelines from the Green River. However, some of the pipelines designed in the area, such as the WSCCSP and the Ouray Park Canal pipeline, have been designed to enhance any exchanges which may take place.

There are many benefits to pumping Green River water to this area. Environmental benefits include providing a stable water supply to the Ouray National Wildlife Refuge, the Pelican Lake fishery, and the Lower Duchesne River.

Green River Usage in Duchesne County

There are numerous issues that must be addressed for DCWCD to utilize their Green River water allotment. Issues impacting DCWCD's use of their Green River allotment include:

- The possibility of exchanges on the Duchesne River will be impacted by the instream flow requirements for the endangered Colorado River fishes in the Duchesne River.
- Pumping Green River water to Brough Reservoir could provide water for exchange upsteam in the system. Where the water to be exchanged is used will determine whether the UWCD's or DCWCD's allotment is used.

- Although off stream storage in Duchesne County would make exchanges easier, the proposed reservoir sites near the Duchesne River appear to be very expensive relative to the storage volume.
- Direct usage of Green River water in Duchesne County would require large and expensive pump and pipe systems which would also have high operating costs due to lifts of 1,600 feet.
- Industrial usage of culinary water supplies, such as by Newfield Oil, impacts the amount of culinary water available for municipal use as well as impacting the required capacity of delivery and treatment facilities. Increased use of culinary water supplies by industry reduces the amount of culinary water available for further growth and development of the area. Currently, the expected use of culinary water supplies by Newfield and Petroglyph Oil is impacting the size of the projected pipeline needed from the Duchesne Valley Water Treatment Plant to supply the East Duchesne and Johnson Water Improvement District's demands. Industrial water use typically does not require culinary level water quality. Where possible, industry should not be using culinary water supplies.

Green River Water Used For Energy Development

Green River water use by the oil industry to increase well yields is already occurring. Future expansion of oil development in Uintah and Duchesne Counties will continue to increase the water demands by the oil industry.

Future oil shale and tar sands development in Duchesne and Uintah Counties is dependent on oil prices and the ability to economically extract oil from oil shale and tar sands. Successful demonstration of OSEC's process will increase the likelihood of further oil shale development in Duchesne and Uintah Counties. Water for this development will likely be from the Green River directly or on tributaries of the Green River by exchange. The amount of water needed for oil shale development will be a function of oil shale and tar sand production.

Need for storage on the Uinta River

There is a need to manage the water supply of the Uinta River service area to meet the irrigation requirements of the water users. Irrigators along the Uinta River have a need to distribute runoff from the Uinta Mountains on a schedule that better matches the consumptive water use of their crops. Because the Uinta Mountains have an east-west orientation, their extensive south-facing slopes are subject to rapid snowmelt during spring thaw. Water supply is insufficient in April and early-May, overabundant in late May and June, and insufficient again in July, August, and September. There is also a need to attenuate the diurnal fluctuations at the diversion structures to improve regulation of water distributed for irrigation. Energy development in the Uintah Basin will also require a constant supply of water.

Potential Off-stream Reservoir Sites

East Cottonwood

East Cottonwood Reservoir would sit adjacent to the existing Cottonwood Reservoir, and the two dams would share an abutment. The existing spillway of Cottonwood Reservoir would spill into East Cottonwood Reservoir. Therefore, design of East Cottonwood facilities would require special attention to the connection of the two dams and reservoirs and a new spillway that would service both reservoirs. Once the WSCCSP is complete, the outlet from Cottonwood Reservoir will be directly into the pipeline. Water from East Cottonwood Reservoir could also deliver into this pipeline.

East Cottonwood is a key component in exchanging Green River water. Water users in the Ouray Park area have recognized the potential benefit of the reservoir. Plans are underway to investigate the feasibility of building the new reservoir and exchanging water from Pelican Lake in order to meet demands in the Ouray Park service area.

Water could be diverted into East Cottonwood in one of two ways. First, water from the Uinta River could be diverted using the WSCCSP just as it is currently used to fill Cottonwood. Second, water could be diverted from the Whiterocks River using the Whiterocks-Ouray Valley Canal.

Another concept previously researched was to use the WSCCSP to supply water to Brough Reservoir. Water could be diverted out of the Whiterocks-Ouray Valley Canal into East Cottonwood Reservoir and through the combined pipeline into Brough Reservoir. Due to salinity funding issues, the WSCCSP pipeline no longer extends all the way to Brough Reservoir. However, the concept of using the WSCCSP, and therefore, being able to abandon the lower half of the Whiterocks-Ouray Valley Canal, is still viable. It will require additional pipe and possibly a booster pump.

Status of a "Whiterocks" Reservoir

The Whiterocks River is tributary to the Uinta River. In addition to agricultural use, there is a need for culinary water to the Lapoint and Tridell communities. These communities have had a moratorium on any new connections for several years due to the lack of water.

The Tridell-Lapoint Water Improvement District requested 500 acre-feet of water from UWCD's Green River Pumping Project in 1999. However, because the culinary company felt they could not wait for the pumping project, they have been trying to develop their own project. This project, described as Project 29.2 in the Culinary Water Master Plan, would consist of a new reservoir and water treatment plant to supply the culinary water. The project has been vigorously pursued by the Uintah County Commission. They have received an allocation of $5 million from the U.S. Army Corps of Engineers from the 595 program.

Two reservoir sites, McKee and Renn Smith, have been identified and were summarized in the 2006 "Preliminary Dam Site Investigation." Recently, geotechnical studies have determined that the Renn Smith site is more feasible than the McKee site.

The Ouray Park Irrigation Company owns and operates two reservoirs in the high mountain area of the Whiterocks River drainage. These two reservoirs are Cliff Lake and Whiterocks Lake and have a combined capacity of 2,140 acre feet. The water from these two lakes is released during the irrigation season and delivered to either Pelican Lake via Cottonwood Reservoir or to Brough Reservoir via the Whiterocks-Ouray Valley Canal.

Thus, an exchange is possible between the Green River through either Brough Reservoir or Pelican Lake and the high mountain lakes of Cliff and Whiterocks. High quality water could be held in the high mountain lakes and used for culinary purposes in the Tridell-Lapoint area on a year round basis. Based on the quality of water needed for culinary purposes, the Cliff and Whiterocks Lakes could provide at least a two-year supply during the driest of years. The water currently being used in the Brough Reservoir and Pelican Lake areas would be replaced by water from the Green River. This concept, depending on need and hydrologic aspects, may eliminate the need for the storage reservoir near Lapoint or may change the type and quantity of water stored there.

The viability of the above concepts will depend on both paper and wet water. One question is whether or not Green River water rights will be used for the storage in the potential Renn Smith Reservoir. Modeling will be required to show if demands can be met from Cliff and Whiterocks Lakes.

Likelihood of a Montes Creek/Brown's Draw Enlargement

The main question related to enlarging either Montes Creek or Brown's Draw Reservoir is whether or not it is cost effective. Will the amount of water developed by increased storage justify the costs of raising or perhaps rebuilding an existing dam? It is, however, generally accepted that it is easier to modify an existing dam than to build a new one.

Specific issues involved with the Montes Creek site are as follows. The maximum increased capacity is less than 1,000 acre-feet. Since the dam has been given a high hazard rating, rehabilitation of the entire structure would most likely be necessary. The spillway structure and a road on the backside of the reservoir, where the existing inlet culvert is located, would also need to be raised.

The enlargement of Brown's Draw Reservoir is limited by its proximity to the Uintah and Ouray Indian Reservation boundary. This dam has also been given a high hazard rating and would involve extensive rehabilitation. There are some geologic issues on the right abutment where the spillway is located.

One benefit of the high hazard designation is that there is a possibility of funding from the Utah Division of Water Rights Dam Safety office for rehabilitation.

Another question is whether or not these enlargements would be necessary or beneficial if the Upper Uinta site is built. Without the Upper Uinta Reservoir, these enlargements would be necessary to meet the demands on the west side of the project area.

3. IDENTIFICATION OF POTENTIAL ALTERNATIVES

The following list consists of specific project components that should be considered for further evaluation.

- Build Upper Uinta Reservoir and utilize surplus flows on the Uinta River
- Build other upstream storage on off-stream sites to utilize surplus flows, i.e. East Cottonwood
- Enlarge existing reservoirs
- Pump water from Green River to Brough Reservoir, exchange Brough water upstream
  - Exchange up to Renn Smith Reservoir
  - Exchange up to East Cottonwood
  - Exchange up to other site
- Pump water from Green River to Pelican Lake, exchange Pelican Lake water upstream
  - Exchange up to Cottonwood and/or East Cottonwood
  - Exchange Cottonwood up to Cliff and Whiterocks Lakes
  - Exchange up to other sites
- Pump water from Green River to meet supplemental demands in areas adjacent to river, i.e. Leota Bench and Ouray Park
- Pump water from Green River to meet new demands in areas adjacent to river
- Pump water from Green River and build transmission pipeline to meet supplemental or new demands further from the river, i.e. Roosevelt
- Pump water directly out of the Green River to energy industry
- Exchange water on White River for energy industry

4. LIST OF ADDITIONAL WORK NEEDED

As the previous work was reviewed and summarized, many items of necessary additional work were found. The following is a list of only those items which fall under the scope of this study.

- Determine if there are additional dam sites or other project components discussed in the previous work that warrant investigation.
- Compile the list of existing project components into a set of alternatives to evaluate.
- Analyze the defined alternatives using a water supply model. (Part of Task 4)
- Confirm the amount of land (existing and new) that could receive full-service irrigation in the Ouray Park and Leota Bench areas. (Part of Task 4)

- Confirm the availability of the water supply from the Green River and identify water rights that have already been segregated from UWCD and DCWCD's allotment. (Part of Task 4)

Conceptual Analysis of Uinta and Green River Water Development Projects

Technical Memorandum #2

Establish Basic Planning Parameters

Prepared by:

CH2MHILL

&

FRANSON CIVIL ENGINEERS

December 2007

TABLE OF CONTENTS

FIGURES AND TABLES

1. INTRODUCTION

The purpose of the Technical Memorandum #2 (TM#2) is to identify what is known relative to the development of water in the Uinta River Basin. The project area covered in this technical memo can be seen on Figure 1-1. The project area includes lands served by the Uinta River or its tributaries as well as some areas that can be served directly from the Green River. TM #2 discusses: the available water supply, including Duchesne County Water Conservancy District's (DCWCD) and Uinta Water Conservancy District's (UWCD) Green River Water Allocation, existing water delivery systems, the baseline hydrologic model, current and projected water demands, and concepts affecting the development of water resources in the project area.

2. WATER SUPPLY ANALYSIS

2.1 Water Sources

Estimates for the available water supply to the project area were developed primarily from U.S. Geological Survey (USGS) gaging station historical records on the Uinta and Whiterocks Rivers and major tributaries to these rivers. Tributaries contributing to the water supply of the area include Farm Creek, Pole Creek, Dry Gulch Creek, and Deep Creek. The Yellowstone Feeder Canal, which diverts water from the Yellowstone River to the Uinta River, is also included in the water supply for the area. Natural runoff from minor tributaries, such as Montes and Cottonwood Creeks, does not contribute significantly to the water supply, primarily because their watersheds are comparatively low in elevation.

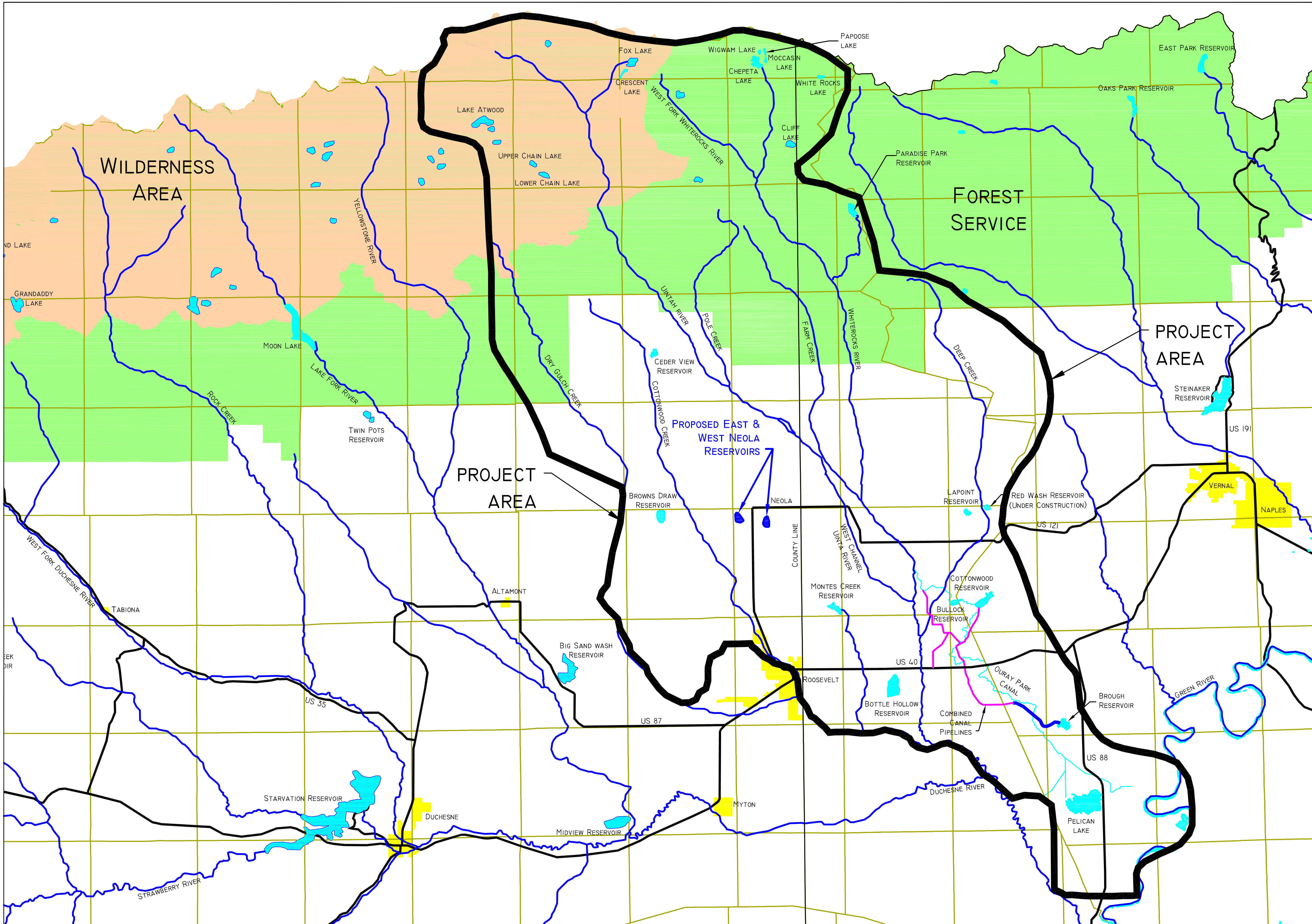
Collectively, the Uinta and Whiterocks Rivers provide most of the incoming surface water to the project area with average annual flows of about 126,000 and 82,700 acre-feet (ac-ft) per year, respectively for the 1950 through 2006 period of record. The total average annual inflow from the major tributaries, including the Yellowstone Feeder Canal, add about 31,700 ac-ft per year for a total project area natural water supply of about 240,400 ac-ft per year.

Data Base

Water supply estimates are based on streamflow records from USGS gaging stations, Lake Fork and Uinta Rivers Water Commissioner annual reports, and records of power plant flows provided by the Moon Lake Electric Company. Table 2-1 lists USGS gaging station number, name, and period of record for each station used in the simulation. The map on Figure 2-1 shows the location of each of the gaging stations.

Period of Analysis

The 57-year period of study from 1950 to 2006 was chosen because it includes a good balance of drought years and high flow years and would provide a good basis for predicting future hydrologic conditions in the area. Any longer period of record was not considered by the team as adding value.



FRANSON CIVIL ENGINEERS

Uinta and Green River Water Development

DATE: May 4, 2007
SCALE: 1" = 8000'
shape map.dwg
H:\CLIENTS\Uintah Basin Area\Uinta-Green River Water Dev\Task 4 Demands\Drawings
LAYOUT: Figure 1-1

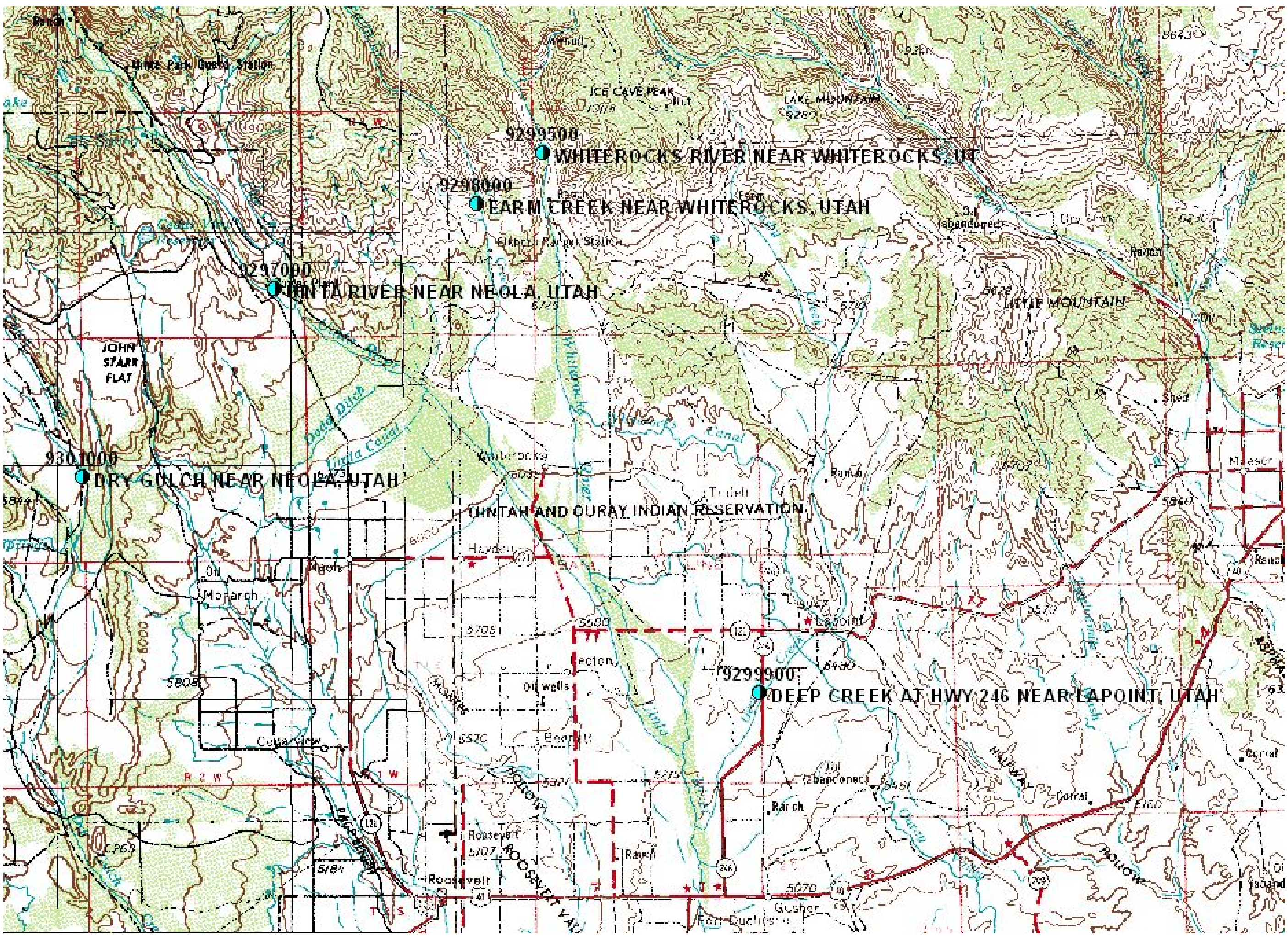
Figure 1-1

Project Area

TABLE 2-1
USGS Gaging Stations Used in Simulation
Units: Acre-feet

Number	Name	Start	End
9297000	Uinta River Near Neola, UT	10/1/1930	9/30/1983
9298000	Farm Creek Near Whiterocks, UT	8/1/1949	10/5/1981
9299500	Whiterocks River Near Whiterocks, UT	10/1/1919	9/30/2006
9299900	Deep Creek At Hwy 246 Near Lapoint, UT	8/25/1976	10/2/1979
9301000	Dry Gulch Near Neola, UT	12/9/1999	9/1/1958
9296800	Uinta River below Power Plant Diversion, Near Neola,UT	10/1/1990	12/31/2006

FIGURE 2-1
Map Showing USGS Gaging Stations



Data Extension and Analysis

In order to provide a continuous record of water supply through the period of analysis, it was necessary to fill in missing data and extend the shorter stream flow records. This was accomplished by correlation analysis using records from the Uinta, Whiterocks, Lake Fork, and Yellowstone Rivers. The only gaging station with a streamflow record for the entire period of study (1930-2006) is the Whiterocks River near Whiterocks, Utah (Station No. 09299500). This station was used as the base station and each of the others were correlated with it to compute a monthly record using the Utah Division of Water Resources (UDWR) CORRA program. This program computes an orthogonal best-fit equation for each month of the year, and then correlates streamflow data from the other stations with it to estimate their streamflow record.

An estimate of daily flow at each station was made using the UDWR DAILYDIS program. This program uses the mean daily hydrograph for each month, and the monthly correlated value, to estimate the daily discharge for the correlated record.

An area altitude study was also made by the UDWR to estimate the ungaged inflow to the high mountain lakes (HML) on the Whiterocks and Uinta Rivers. The smaller of the estimated inflow from this method and the reservoir capacity was used as the mean runoff available at each site. The sum of runoff for each reservoir set was used to compute the fraction of the discharge of the Whiterocks or Uinta gage. The fraction was used in the model to compute the runoff at each site.

Available Water Resource

The Uinta and Whiterocks Rivers are the two major sources of water for the project area. Other water sources include the major tributaries to the Uinta and Whiterocks Rivers; Farm Creek, Pole Creek, Dry Gulch Creek, and Deep Creek. In addition, the Yellowstone Feeder Canal provides additional irrigation water to area lands from the Yellowstone River. Minor tributaries do not contribute significantly to the water supply, primarily because their watersheds are comparatively low in elevation.

The average annual water available to the project area is approximately 240,340 ac-ft per year, as shown in Table 2-2. Figure 2-2 shows, in graphic form, the total annual water supply available to the project area.

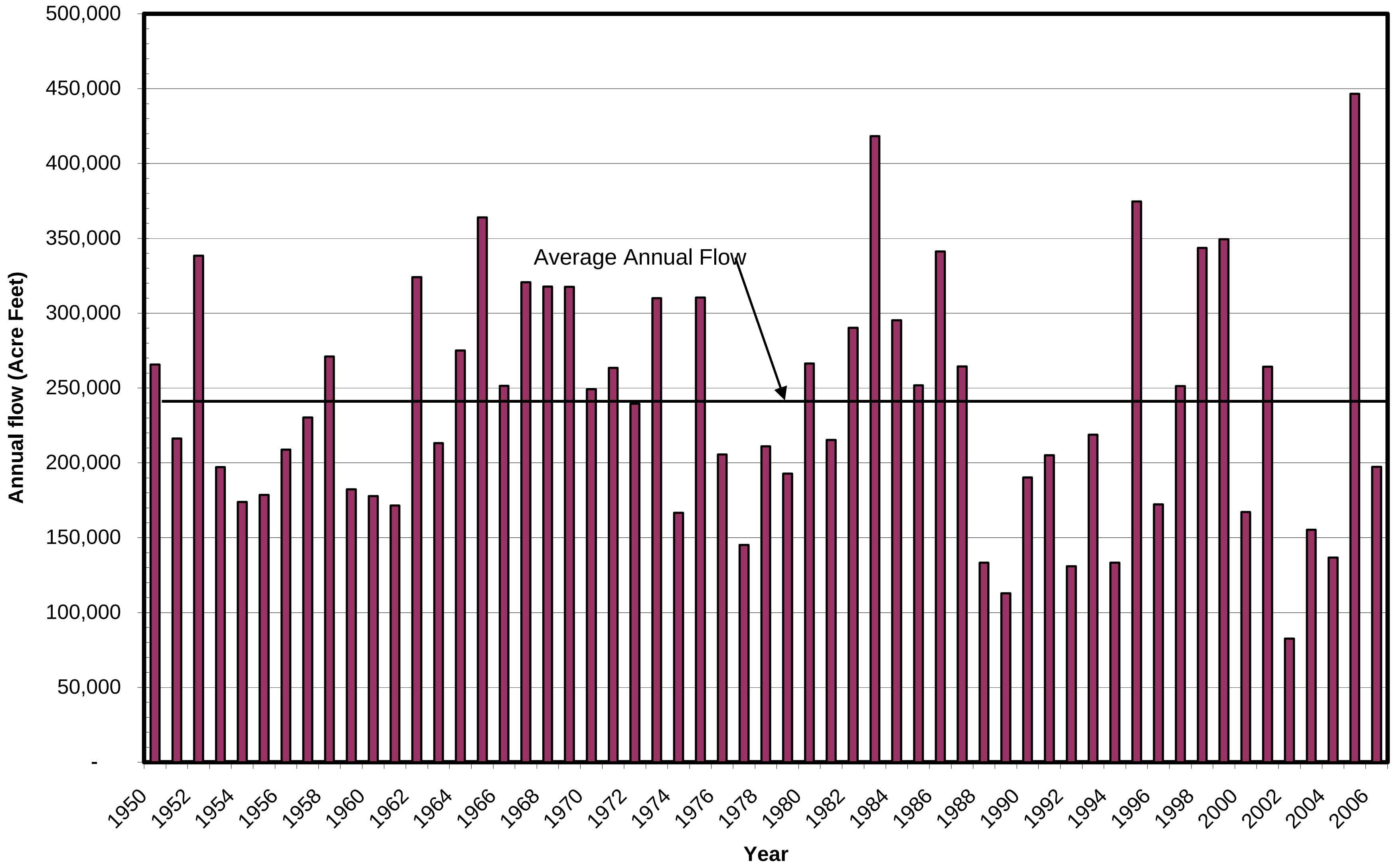
Monthly flow tables for the Uinta River, Whiterocks River, and major tributaries (Pole Creek, Deep Creek, Farm Creek, Dry Gulch Creek, and the Yellowstone Feeder Canal), which, when combined, make up the total available water supply, are shown in Tables A-1 through Table A-7 in Appendix A. For purposes of this study, flows at the Whiterocks River near Whiterocks gage were divided into three river segments; Supply for HML on the Whiterocks River, Reach Gain Whiterocks River below HML, and Inflow to Ouray Park High Mountain Reservoir. These data tables, along with a table showing HML adjustments, are included as Tables A-8 through Table A-11 in Appendix A.

TABLE 2-2
Total Water Available

Year	Uinta River	Whitrocks River	Farm Creek	Pole Creek	Deep Creek	Dry Gulch Creek	Uinta R. Total	Yellowstone Feeder	Total Supply
1950	137,651	93,211	6,579	8,723	2,400	5,006	253,569	12,153	265,722
1951	114,561	72,988	3,919	7,260	1,987	751	201,465	14,832	216,297
1952	183,102	120,389	6,604	11,603	2,956	8,320	332,974	5,320	338,294
1953	105,346	63,384	2,499	6,676	1,789	149	179,843	17,248	197,091
1954	95,131	57,882	2,879	6,029	1,677	376	163,973	9,987	173,960
1955	96,571	60,341	2,656	6,120	1,727	597	168,013	10,506	178,519
1956	111,828	67,172	2,764	7,087	1,867	1,502	192,219	16,616	208,835
1957	124,072	80,204	3,581	7,862	2,134	1,842	219,696	10,709	230,404
1958	140,596	92,303	5,608	8,910	2,382	4,486	254,284	16,800	271,084
1959	100,661	61,230	1,916	6,379	1,746	193	172,125	10,314	182,439
1960	99,876	57,545	2,168	6,329	1,670	1,105	168,693	9,170	177,862
1961	92,743	63,162	1,444	5,877	1,786	337	165,349	6,246	171,594
1962	176,575	110,200	5,446	11,190	2,747	7,737	313,894	10,266	324,160
1963	118,550	65,835	2,579	7,513	1,839	1,170	197,486	15,761	213,247
1964	153,586	87,715	3,305	9,733	2,287	2,406	259,032	16,050	275,082
1965	222,625	115,232	5,452	14,108	2,851	2,871	363,139	879	364,018
1966	133,325	77,962	3,625	8,449	2,088	4,456	229,906	21,508	251,414
1967	174,571	107,760	6,460	11,063	2,698	3,167	305,719	15,061	320,780
1968	175,632	105,203	6,054	11,130	2,645	2,813	303,478	14,318	317,795
1969	170,606	101,754	6,840	10,811	2,575	6,121	298,707	18,955	317,662
1970	129,665	87,624	2,870	8,217	2,286	1,851	232,514	16,676	249,190
1971	138,831	87,913	3,395	8,798	2,292	1,923	243,152	20,466	263,618
1972	115,983	84,256	2,891	7,350	2,217	3,052	215,749	23,812	239,561
1973	163,692	110,555	6,201	10,373	2,755	4,338	297,914	12,120	310,034
1974	88,147	49,069	2,022	5,586	1,497	577	146,898	19,820	166,718
1975	157,876	115,644	4,854	10,005	2,858	2,804	294,041	16,366	310,406
1976	100,681	67,563	3,705	6,380	1,876	1,716	181,921	23,673	205,593
1977	81,921	45,203	1,424	5,191	1,487	60	135,287	9,970	145,257
1978	108,470	69,205	3,105	6,874	1,638	1,176	190,468	20,575	211,042
1979	98,717	63,074	3,226	6,256	1,986	1,608	174,867	18,020	192,887
1980	136,389	92,079	6,778	8,643	2,378	2,995	249,261	17,215	266,476
1981	113,290	68,771	3,666	7,179	1,901	3,160	197,967	17,313	215,280
1982	152,371	95,173	4,691	9,656	2,440	2,700	267,031	23,207	290,238
1983	235,231	151,297	7,710	14,907	3,589	4,780	417,513	747	418,260
1984	159,958	101,082	5,243	10,137	2,561	3,580	282,559	12,660	295,219
1985	127,656	82,844	4,256	8,090	2,188	5,313	230,346	21,370	251,716
1986	179,309	119,000	7,523	11,363	2,928	7,430	327,553	13,775	341,328
1987	136,886	89,030	4,880	8,675	2,314	3,802	245,587	18,796	264,383
1988	68,584	45,941	1,742	4,346	1,433	128	122,174	11,055	133,229
1989	57,932	38,356	1,407	3,671	1,277	979	103,622	9,347	112,969
1990	95,817	64,215	2,817	6,072	1,806	1,593	172,320	17,938	190,258
1991	108,229	69,527	2,635	6,858	1,915	857	190,021	15,151	205,171
1992	58,418	52,360	2,238	3,702	1,564	1,159	119,441	11,588	131,029
1993	112,839	75,305	3,816	7,151	2,034	2,148	203,292	15,438	218,730
1994	59,899	56,723	2,487	3,796	1,654	1,059	125,618	7,666	133,284
1995	194,334	142,151	6,592	12,315	3,401	4,164	362,958	11,731	374,688
1996	72,240	65,496	2,743	4,578	1,833	952	147,842	24,463	172,305
1997	118,848	92,394	4,871	7,531	2,384	3,591	229,619	21,680	251,299
1998	178,338	128,202	6,783	11,301	3,116	4,598	332,338	11,226	343,564
1999	192,211	115,666	6,115	12,180	2,859	3,729	332,760	16,555	349,316
2000	77,001	61,682	2,953	4,880	1,754	1,772	150,042	17,173	167,215
2001	135,987	87,330	5,277	8,618	2,280	4,451	243,942	20,281	264,223
2002	37,219	32,416	1,154	2,359	1,155	0	74,303	8,382	82,685
2003	66,311	62,813	2,826	4,202	1,779	1,186	139,116	16,237	155,353
2004	57,072	56,555	2,390	3,617	1,650	1,030	122,312	14,498	136,810
2005	237,977	158,013	10,432	15,081	3,725	9,956	435,184	11,440	446,623
2006	98,591	67,444	3,607	6,248	1,873	2,639	180,401	16,973	197,374
Total	7,180,530	4,713,439	233,703	455,030	124,531	154,259	12,861,491	838,101	13,699,593
Average	125,974	82,692	4,100	7,983	2,185	2,706	225,640	14,704	**240,344**

Uinta River: 1930-83 near Neola (9297000); 1984-1995 monthly correlation distributed daily
1996-2006 Uinta River below powerplant (09296800) plus Moon Lake diversion
Whiterocks River: White Rocks River near Whiterocks (9299500)
Farm Creek: Farm Creek near Whiterocks (9298000) reduced by 460 AF/yr to meet requirements of 178 acres
Pole Creek: Computed by State to be 0.06337 of the Uinta Gage near Neola (9297000)
Deep Creek: Estimated at 40% of Deep Creek at HWY 246 near Lapoint (9299900)
Dry Gulch Creek: Dry Gulch Creek near Neola (9301000)
Yellowstone Feeder Canal: Taken from River Commissioner's Reports

FIGURE 2-2
Total Available Water Supply Uinta River Drainage

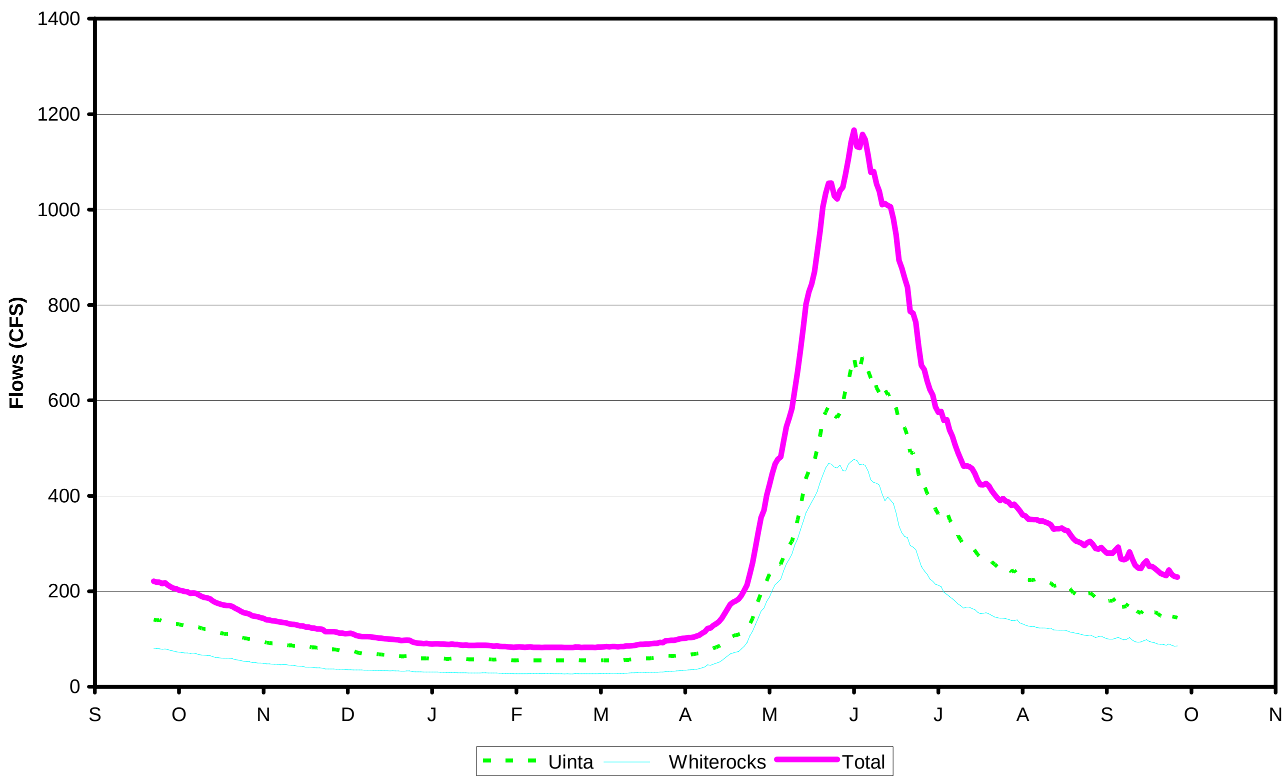


Runoff Hydrographs

Typical annual hydrographs were developed for the Unita and Whiterocks Rivers system for an average year. These hydrographs are shown on Figure 2-3.

Approximately 50-percent of the annual runoff from the Uinta and Whiterocks River watersheds occurs during the May-June snowmelt runoff period. In a typical year, peak runoff occurs during a 2- to 3-week period from late-May through mid-June. There is significant diurnal fluctuation in streamflow, particularly during the snowmelt runoff season. As shown on Figure 2-3, the average peak day flow is about 700 cfs for the Uinta River and about 475 cfs for the Whiterocks River.

FIGURE 2-3
Uinta/Whiterocks Typical Runoff Hydrology



2.2 Water Delivery Systems

The hydrologic model prepared by the UDWR separates the project area into 19 areas that have water righted acreage. A second Hydrologic model has also been prepared by CH2M Hill. The UDWR model is a custom built Fortran model. The CH2M Hill model uses Goldsym as the platform to create the hydrologic model. The Goldsym model has been prepared using the same model areas and input data. The Goldsym model has been prepared based on the UDWR Fortran model so that it agrees with the UDWR model but provides a more user friendly platform for future modeling efforts. Both models are being used as part of this project. It is expected that only the Goldsym model will be utilized in the future. The model area numbering convention is the same for both models. For example, model area 6 refers to the area served by the TN Dodd Canal in both models. The model areas in both models are typically identified by the major canal or ditch that serves the area. Model areas may also refer to one or more of the following:

- An area serviced by a particular irrigation company;
- An area serviced by Bureau of Indian Affairs' (BIA) facilities;
- A portion of an area serviced by a particular irrigation company;
- An area served by a specific ditch or canal;
- An area with a certain storage right; and
- Multiple geographic areas that have direct flow rights with the same priority but serviced by different irrigation companies.

An added complication is that many of the model areas geographically overlap because the models areas have been created based on whether an area is serviced by tribal or secondary water rights. Tribal and private land is mixed throughout the project area. Although referencing the hydrologic model areas for the water delivery discussion is not ideal, it will allow a common basis for the water demand analysis and allow direct comparison of water development alternatives to the baseline condition. This approach will also allow exchange options between different areas to be modeled more easily. Where possible the various model areas will be grouped according to irrigation companies. A map showing the various areas can be seen on Figure 2-4. The numbers indicated for each area on Figure 2-4 and within this section refer to the number of the model area. Areas with multiple numbers indicate that lands with tribal and secondary rights are located in the same geographic area. Geographic areas with the same diversion priority have been combined into the same model area. The direct flow diversion priorities and the reservoir filling priorities are discussed in Section 2-3. A letter has been added to the model area number to help identify the area discussed in this section and the areas identified on Figure 2-4. Please note the model numbers are between 1 and 28 but not all model area numbers are being used. Unused model area numbers are areas that have been divided into multiple areas to provide better results or areas that will be used to represent new demands when alternatives are being evaluated.

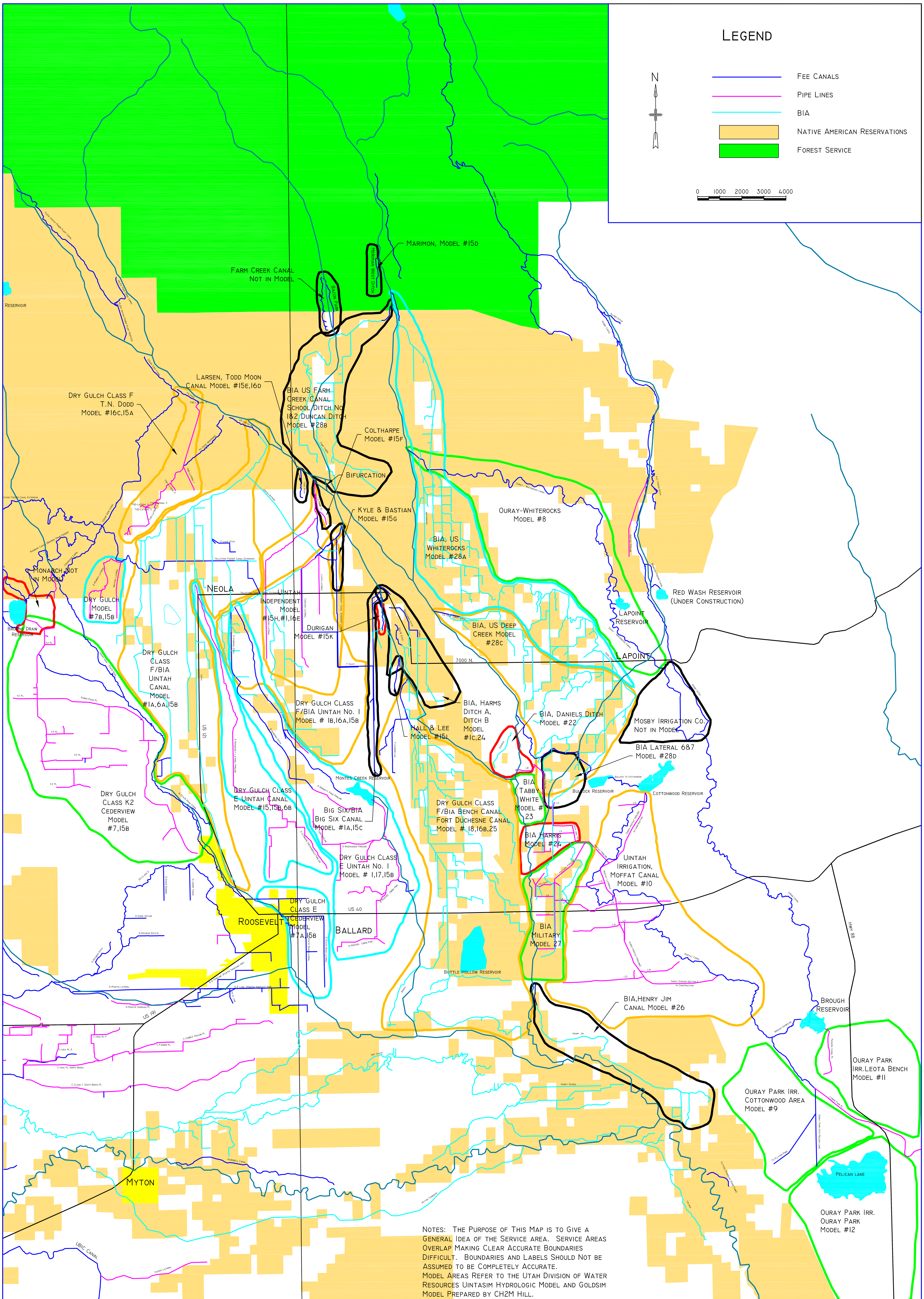


Figure 2-4

Delivery Systems and Model Areas

DATE:	January 24, 2007
SCALE:	

smaller areas.dwg
H:\CLIENT\4-Uintah Basin Area\Uinta-Green River Water Dev\Task 4 Demands\Drawings

LAYOUT: Figure 2-4

Uintah and Green River Water Development

FRANSON CIVIL ENGINEERS

As part of the delivery system discussion, the acreages served by the various canals and ditches will be given, and related to, the various model area(s). The Goldsym acreages for the various model areas are being presented in this report. The distribution of the model area acres in the Goldsym model has been modified from the UDWR model area acreages to better represent how the irrigation system in the project area is currently being operated. The total acreages for tribal water rights are the same as in the UDWR model. The total secondary water right acreages are 29 acres larger than in the UDWR model. Since the purpose of this section is to discuss the current delivery systems it was decided to present the Goldsym model area acreages.

Dry Gulch Irrigation Company

The Dry Gulch Irrigation Company serves the lands north of Roosevelt and west of the Uintah River with a small area between Roosevelt and Ballard. Dry Gulch Irrigation Company shareholders hold one share of Moon Lake Water Users Association (MLWUA) stock for every share of Dry Gulch Irrigation Company they hold. The shares in the MLWUA provide storage rights in the Moon Lake system which is delivered through the Yellowstone Feeder Canal. Dry Gulch Irrigation Company shareholders in the project area receive on average 14,700 ac-ft of water annually through the Yellowstone Feeder Canal. Additional MLWUA Storage is also provided in Brown’s Draw Reservoir, Big Sand Wash Reservoir, Twin Pots Reservoir and also HML on the Yellowstone and Lake Fork Rivers. Brown’s Draw Reservoir is filled using the Yellowstone Feeder Canal and/or the Cedarview Canal. Brown’s Draw Reservoir is typically filled during the winter. However, if high water is available during spring runoff that water can be used to fill the Reservoir as well. According to the UDWR the first 3,526 ac-ft of storage in Brown’s Draw has a filling priority second only to the high mountain lakes. The rest of Brown’s Draw has a filling priority after Montes Creek, Brough, Cottonwood, and Pelican Lake on the Uinta River. Brown’s Draw Reservoir currently has a capacity of 5,670 ac-ft. The Yellowstone Feeder Canal draws water from the Yellowstone River. The Yellowstone Feeder Canal has a capacity of 90 cfs and diverts an average of 14,700 ac-ft into the Uinta River drainage annually. The Cedarview Canal draws water from the Uintah River. In addition to storage rights associated with the MLWUA shares, the Dry Gulch Irrigation Company also has storage in HML in the Uinta River drainage. The HML controlled by the Dry Gulch Irrigation Company are:

- Fox Lake, 1,126 ac-ft capacity
- Crescent Lake, 182 ac-ft capacity
- Lake Atwood, 2,553 ac-ft capacity
- Lower Chain Lake, 796 ac-ft capacity, and
- Upper Chain Lake, 507 ac-ft capacity.

The combined capacity of these HML is 5,164 ac-ft. Dry Gulch Irrigation Company also has direct flow rights on the Uintah River secondary to the tribal direct flow rights.

Although every share of the Dry Gulch Irrigation Company holds rights to the use of MLWUA shares, not all areas can receive water directly from the Yellowstone Feeder Canal or Brown’s Draw Reservoir. Areas that can only receive water from the Uintah River are referred to as the “East Side” and have the highest priority within the company for receiving the company’s direct flow rights on the Uinta River and storage in the HML in the Uinta River drainage.

The Dry Gulch Irrigation Company serves areas within the Uinta and Lake Fork River drainages. The area served by the Dry Gulch Irrigation Company in the Uinta River drainage is divided into three areas. These areas are referred to as classes. The classes are E, F, and K2. The specific model areas generally have been broken out according to these classes. Unfortunately, in some cases a model area includes lands from two classes. In this case, the model area will be discussed under the class with the largest acreage.

CLASS K2

The Class K2 lands are the lands southeast of the Brown's Draw Reservoir. These lands are supplied through Brown's Draw Reservoir.

Cedarview #7: This model area is composed mostly of Class K2 lands (3,116.75 acres) but also has an area of Class E land between Roosevelt and Ballard. The Class K2 lands are served through the Brown's Draw Reservoir. Pipelines originating at the Brown's Draw Reservoir supply all Class K2 lands. The smaller area of Class E lands (2,180 acres) near Roosevelt are supplied their natural flows from the Cedarview (via the Yellowstone Canal to Clear Gulch) to the State Road Canal diversion. These canals can receive water from the Yellowstone Feeder Canal. A turnout from the Class K2 & Class E pipeline, out of Brown's Draw, also allows water from Brown's Draw to be diverted into the State Road Canal for use in the area by Roosevelt.

CLASS F

Portions of Class F lands can be supplied by the Yellowstone Feeder Canal. However, there are areas of Class F lands that can only be supplied by diversion from the Uinta River. The only storage available for these areas is the HML located in the Uinta River drainage.

TN Dodd #16C and #15A: The TN Dodd area includes two model areas. Model area #16 represents water rights associated with the MLWUA and Dry Gulch Class F (501.5 shares). Model area #15 is the TN Dodd lands that are supplied only from the Uinta River (482 acres). Water diverted from the Uinta River is supplied either by direct flow or exchange rights to the TN Dodd Canal and Roosevelt Lateral canals. Also TN Dodd owns 500 shares of MLWUA stock and receives this water through exchange from Yellowstone Canal. The TN Dodd is all open canal.

Uintah No. 1 #16A: This entire area (2,002 acres Class F and 729 acres, Harding and Bennett Pond) can only be supplied through the US Uintah No. 1 Canal. The only storage available to this area is the HML in the Uintas, except the land under the Montes Creek Reservoir. None of the supply system of canals and ditches for this area (above Montes Creek) has been replaced by pipelines. All of the delivery system below Montes Creek has been piped (1,528 acres). (See area #17 below Class E.)

Bench #16B: The Bench area covers the southeast end of the Dry Gulch Irrigation Company and serves 882 acres. The Bench area can only receive water diverted from the Uinta River by the Bench Canal. The only storage available for this area is the HML in the Uinta River drainage. The majority of land and canals in this area are controlled by the BIA. Very few of the water delivery systems have been replaced by pipelines.

Uintah No. 2 #6A: The US Uintah No. 2 Canal (also known as Uintah Canal), area #6, delivers water to 2,648 acres Class F and 663 acres Class E-Roosevelt Lateral. These areas can receive water from either the Yellowstone Extension Canal or directly from the Uinta River. Only small parts of the Class F delivery system have been piped.

CLASS E

Some Class E lands can be supplied by either the Yellowstone Feeder Canal or by direct diversion from the Uinta River.

Uintah #7B (Class E Murray-Whiting): As with other areas (271 acres Class E) served by the Dry Gulch Irrigation Company, the lands in this area can be supplied by either the Yellowstone Feeder Canal or the Cedarview Canal by direct diversion from the Uinta River. Water diverted from the Uinta River is conveyed through the Cedarview Canal. None of the supply system of canals and ditches has been replaced by pipelines.

Uintah No. 1 #17 and #15B: This area (Montes Creek 1,528 acres) is supplied by the US Uintah No. 1 Canal. Much of the water delivery systems in this area have been replaced by pipelines. The lower portions of this area (1,528 acres) can be supplied from storage in Montes Creek Reservoir. Montes Creek Reservoir can be filled from the US Uintah No. 1 Canal. The reservoir is typically filled during the non-irrigation season but may also be filled during spring runoff if excess flow is available in the Uintah River.

Uintah #15B (Roosevelt Lateral): This area or the Roosevelt Lateral (1,947 acres) can be supplied through the Yellowstone Feeder Canal Extension or by the US Uintah No. 2 Canal. If water is available on the Uinta River, this area will be supplied completely from the Uinta River. Otherwise, this area will be supplied through the Yellowstone Feeder Canal. Most of the water delivery systems in this area have been replaced by pipelines other than the upper portion of the Roosevelt Lateral.

Uintah #15B (Dry Gulch): Dry Gulch rights (1,965 acres) are delivered throughout the Class K2, Class F, and Class E systems; these rights have no storage associated with them, only later priority natural flow.

Big 6 Irrigation Company #15C: The Big 6 Canal serves 860 acres with secondary water rights. These lands are served by direct diversion from the Uinta River. The secondary water right land in this area has no associated storage. The secondary water rights are filled after all tribal water rights and after all the Dry Gulch Irrigation and Moffat water rights. The water delivery system is composed of an open canal and ditches, no pipelines have been installed.

Marimon Irrigation Company #15D: The Marimon East and West Ditches serve 320 acres with secondary water rights. The Marimon area is located north of the Indian Reservation on the Whiterocks River in a small area of private land surrounded by the National Forest.

These lands are served by direct diversion from the Whiterocks River. This area has no storage rights and has not piped any of their ditches.

Larsen #15E and #16D: The Larson area is composed of 640 acres on the west side of the Uinta River above the bifurcation structure. The Larsen area is served by the Todd Moon ditch. This area is served by direct diversion from the Uinta River. 620 acres are direct flow only with no storage rights. 20 acres in this area have HML storage. The canal and ditches have not been piped in any of this area.

Coltharpe #15F: The Coltharpe area is composed of 320 acres on the west side of the Uinta River near the bifurcation structure. The Coltharpe area is served by the Coltharpe Pipeline. This area is served by direct diversion from the Uinta River. This area has no storage rights, has piped their ditches, and is using sprinklers for irrigation.

Kyle and Bastian #15G: These areas are adjacent to each other. These areas are located on the west side of the West Channel of the Uinta River downstream of the bifurcation structure. The Kyle area has 160 acres. These lands only have direct flow rights from the Uinta River and no storage rights. The Bastian area (255 acres) also has no storage rights. Both areas are served by the Keith Bastian Ditch, which has not been piped.

Independent *#1, #15H, and #16E*: The Independent area is southwest of the bifurcation structure and overlaps some Dry Gulch Irrigation Company Class F lands served by the US Uintah No. 1 Canal. The Independent area includes 3,545 acres. This area is served by the US Uintah No.2 Canal (through the Center Ditch) and the Independent Canal from water diverted directly from the Uinta River. 3,525 acres of the secondary water rights associated with this area do not have any storage rights. 20 acres in this area have storage rights in the HML. There is also 228 acres of Indian water rights served from the Independent Canal.

Whiterocks Irrigation Company #8: The Whiterocks Irrigation Company serves 5,253 acres northeast of the confluence of the Whiterocks River and Uinta River. The area is served by the Ouray – Whiterocks Canal which also delivers water to the Ouray Park area. This canal is also used to fill the Lapoint Reservoir which has a capacity of 1,700 ac-ft. The Whiterocks Irrigation Company has direct flow rights on the Whiterocks River as well as storage in HML in the Whiterocks River drainage. Whiterocks Irrigation Company controls five HML. The lakes and their capacities are as follows:

- Chepeta Lake, 2,780 ac-ft capacity
- Moccasin Lake, 122 ac-ft capacity
- Papoose Lake, 58 ac-ft capacity
- Wigwam Lake, 88 ac-ft capacity
- Paradise Park Lake, 3,330 ac-ft capacity

Total storage capacity of 6,378 ac-ft

The Whiterocks Irrigation Company has the first storage priority for filling its HML. However, the Lapoint Reservoir has the lowest priority. All reservoirs are filled using winter water. The Whiterocks Irrigation Company is in process of obtaining funding for the Renn

Smith Reservoir. The Renn Smith Reservoir will be located in the valley northeast of Tridell. The reservoir will be filled by the Ouray-Whiterocks Canal. Much of this area has been piped and is under sprinkler irrigation.

Hall *and Lee #15I*: The Hall and Lee Area is composed of 155 acres on the west side of the Uinta River just below 7000 North (Lapoint Highway). The Hall and Lee Area is served by the Hall/Lee Filing. This area is served by direct diversion from the Uinta River. This area has no storage rights and has not piped any of its ditches.

Durigan #15K: This area is located on the west side of the West Channel just below Neola Road. The Durigan area has 127 acres and was served by the Durigan Canal which diverted water directly from the West Channel of the Uinta River. The canal and ditches for this area have been abandoned. The Durigan water right has been converted to M&I water, is owned by Roosevelt City, and is pumped from a well into their culinary system.

Indian Compact Areas

In the model, the Indian Compact Water Rights have been separated out from the secondary water right areas although in many cases the actual geographic areas are similar. In many cases, water deliveries to tribal and secondary rights are conveyed in the same canal or ditch. Many of these canals or ditches are jointly controlled by individual irrigation companies and the BIA. The tribal water rights have the highest priority for direct diversion from the Uinta and Whiterocks Rivers as well as Farm Creek and Deep Creek. However, other than stock water, the tribal rights only provide water during the irrigation season (March 1 to October 31). Other than those areas served by the Combined Canal Project, hardly any canals or ditches serving tribal water right lands have been piped. Tribal areas are discussed individually below. Tribal areas served by the Combined Canals Project are discussed in the Combined Canals Section following these tribal areas.

Uintah Canal #1A: This area generally corresponds to the Dry Gulch Irrigation Company Class F lands (Uintah #6 discussed above) served from the Uinta Canal (also referred to as the US Uintah No. 2 Canal). This area contains 8,002 acres that are supplied directly from the Uinta River.

Uintah No. 1 Canal #1B: This area generally corresponds to Dry Gulch Irrigation Company Class F lands served by the US Uintah No. 1 Canal. There is a small amount of Indian land in the Class E area that is also contained in this area. This area contains 3,380 acres that are supplied directly from the Uinta River.

Harms Canal, Ditches A and B #1C: This area is on the east side of the West Channel of the Uinta River directly south of the confluence of the Uinta River and Whiterocks River. This area does not correspond to a secondary water rights area since nearly all land in this area is tribal lands. The Harms Canal serves 712 acres, Ditch “A” serves 68 acres, and Ditch “B” serves 417 acres. These areas are served by direct diversion from the West Channel of the Uinta River.

Big Six Canal #1D: This is the same geographic area as the Dry Gulch Irrigation Company Class E lands served from the Big Six Canal identified above. The Big Six Canal serves 228 acres of tribal lands directly from the Uinta River.

Bench Canal #18: This area is essentially the same as the Bench Area discussed as part of the Dry Gulch Irrigation Company discussed previously. The Bench Area is bounded by the Duchesne River on the south, the Uinta River on the east, and Montes Creek on the west. The north end of this area is the diversion from the West Channel of the Uinta River into the Bench Canal. Tribal and private lands are mixed throughout this area. Tribal and secondary water are conveyed in the same canals and ditches. The primary canal supplying water from the Uinta River is the Bench Canal. The tribal lands in this area are composed of 5,787 acres.

Fort Duchesne #25: Although this area is identified separately in the model, it is part of the area served by the Bench Canal. Water rights identify this area separately because this area had its own diversion from the Uinta River at one time. The 572 acres in this area are now served through the Bench Canal.

US Whiterocks #28A: This area starts near the reservation/Forest Service boundary on the Whiterocks River and extends generally along the east side of the Whiterocks and Uinta Rivers to just above Bullock Reservoir. The area is a mix of private and tribal lands that are supplied from the Whiterocks River. The primary canal supplying water to the area is the US Whiterocks Canal. This canal supplies water for 4,091 acres of tribal lands.

US Farm Creek, School Ditches No. 1 and 2, Duncan Ditch #28B: These areas are served mostly from the Whiterocks River. Although, if water is available in Farm Creek it will also be diverted into the US Farm Creek Canal. These areas are located east and west of Farm Creek, upstream of the confluence with the Uinta River. Combined, the four areas include 1,902 acres of tribal and private land. US Farm Creek Canal serves 1,409 acres. The Duncan Ditch and School Ditches No. 1 and 2 serve 141, 340, and 12 acres respectively.

US Deep Creek #28C: This area is along the east side of the Uinta River between the Whiterocks River and just southeast of Deep Creek. The area is a mix of private and tribal lands that are supplied primarily from diversion from the Uinta River into the Deep Creek Canal. This area includes 5,621 acres. The US Deep Creek diversion is a Whiterocks River diversion and is supplied from the Whiterocks River in accordance with a 1923 decree.

Henry Jim #26: The Henry Jim lands are tribal lands located between Highway 40 and Highway 88, south of the proposed Ouray Pipeline. The 1,406 acres are irrigated from a diversion on the Uinta River, south of the Combined Canal Project, and conveyed in a canal to area lands.

West Side Combined Canal Salinity Project

The West Side Combined Canal Salinity Project (Combined Canal Project), located between the Uinta and Green Rivers in western Uintah County, combined seven individual canals into a single gravity-fed pressurized pipeline. The canals included in this project are Daniels, parts of Laterals 6 & 7 of the Deep Creek Canal, Tabby White, Harris, Military, Moffat, and Ouray Park.

The Combined Canal Project also combined the existing diversions for these canals into a single location on the Uinta River. Diverted water is conveyed to an inlet pond where it enters the pipeline system.

The completed project will provide water to all lands presently served by existing systems. The Combined Canal Project has been divided into six pipelines; including the Uinta Pipeline, Military Pipeline, Moffat Pipeline, Ouray-Moffat Pipeline 1, Ouray-Moffat Pipeline 2, and the Ouray Pipeline. The pipelines are operated and maintained by the following entities:

- Uinta and Military Pipelines: BIA
- Moffat Pipeline: Uintah River Irrigation Company
- Ouray-Moffat Pipeline 1 and Ouray-Moffat Pipeline 2: Uintah River Irrigation Company and Ouray Park Irrigation Company
- Ouray Pipeline: Ouray Park Irrigation Company

The pipelines have the following pipe sizes and maximum flow capacities:

- Uinta Pipeline: 42-inch and 40 cfs
- Military Pipeline: 21-inch and 12 cfs
- Moffat Pipeline: 42-inch and 40 cfs
- Ouray-Moffat Pipeline 1: 48-inch and 70 cfs
- Ouray-Moffat Pipeline 2: 48-inch and 70 cfs
- Ouray Division Section 2: 48-inch and 70 cfs

A pipeline very likely to be added to the above system is the Brough Pipeline. The Brough Pipeline will connect to the Ouray Division Section 2 Pipeline and deliver water to Brough Reservoir. The Brough Pipeline will likely be a 28-inch pipeline with a maximum capacity of 20 cfs. The Brough Pipeline would be operated by the Ouray Park Irrigation Company.

Daniels Ditch #22: Daniels lands are located between the Uinta River and Deep Creek north of their confluence. Lateral 1, a 10-inch line from the Uinta Pipeline, serves the 140 acres.

Laterals 6 & 7 #28C: Portions of Laterals 6 & 7 lands located along the east side of Deep Creek and west of Bullock Reservoir, are supplied with water from the Uinta Pipeline. The section of Lateral 6 lands includes 55 acres and Lateral 7 lands include 708 acres. The upper reaches of both laterals serve additional lands that are outside of the Combined Canal Project but still receive water from those laterals. Prior to the Combined Canal Project, these areas were served through the US Deep Creek Canal.

Tabby White Canal #23: Tabby White lands are supplied water from the 12-inch Lateral 5 off the Uinta Division pipeline. Tabby White lands, located between the Uinta River and Deep Creek just north of their confluence, include 206 acres.

Harris Ditch #24: Water for the 377 acres of Harris lands is supplied by Lateral 2, a 15-inch lateral from the Uinta Pipeline. Lands are located northeast of the confluence of Deep Creek and the Uinta River.

<u>*Military Ditch #27*</u>: The Military area is tribal lands located east of the Uinta River around Highway 40. Water for the 852.3 acres is supplied by Laterals A, B, and C from the Uinta Pipeline. The Laterals A and C are 12-inch and Lateral B is 15-inch.

<u>*Moffat #10*</u>: The 2,044 acres of Moffat lands are supplied by direct diversion of Uinta River water from Ouray-Moffat Pipelines 1 and 2. Lateral 14, a 12-inch pipeline off the Ouray-Moffat Pipeline 1, supplies water to 320 acres south of Cottonwood Reservoir. The following laterals from the Ouray-Moffat Pipeline 2 serve the following acreage of Moffat lands, located east of the Uinta River around Highway 40:

Lateral 15	10-inch	63 acres
Lateral 9	15-inch	180 acres
Lateral 8	18-inch	273 acres
Lateral 10	18-inch	137 acres
Lateral 11	18-inch	554 acres
Lateral 13	21-inch	469 acres
Lateral 16	16-inch	270 acres

<u>*Ouray Park and Leota Bench #9, #11, and #12*</u>: The Ouray Park Irrigation Company has two main canal delivery systems and three reservoirs in the valley to provide irrigation water to stockholders in Leota Bench and Ouray Park. Leota Bench lands, located along the bench north of Highway 88, include 2,995 acres. Ouray Park lands, located south of Highway 88, are divided into an area served through Cottonwood Reservoir and an area served through Pelican Lake. The area served from Cottonwood Reservoir includes 3,856 acres. The area served from Pelican Lake has 5,249 acres.

The Ouray Park Canal begins at the Uintah River, approximately 3.6 miles southwest of the town of Lapoint, Utah, and generally flows in a southeastern direction. The canal has a capacity of 100 cfs directly. Diverted water flows through Bullock Reservoir, which is owned and operated by the Division of Fish and Wildlife, and continues in the canal to Cottonwood Reservoir, which is owned and operated by the Ouray Park Irrigation Company. Water continues from the reservoir through the canal to supply water to the Leota and Ouray Park lands either directly or for storage in Pelican Lake for later use.

The Whiterocks-Ouray Valley Canal diverts water from the Whiterocks River northwest of Tridell. Water is carried downstream 12 miles where near Lapoint the canal becomes the Whiterocks-Ouray Valley Canal, which eventually flows into Brough Reservoir. The Whiterocks-Ouray Valley Canal then takes water to Pelican Lake for use by irrigators. The capacities of the reservoirs in this canal system are:

- Cottonwood Reservoir, 6,126 ac-ft capacity
- Brough Reservoir, 3,996 ac-ft capacity
- Pelican Lake. 15,874 ac-ft capacity (12,750 ac-ft active storage)

The Ouray Pipeline is scheduled for construction in fall of 2007, which will allow portions of the Ouray Park Canal to be abandoned. Under project operation, the canal will divert water from the

Uinta River and Deep Creek, and convey water through Bullock Reservoir to Cottonwood Reservoir. From there, water will go into the Ouray-Moffat Pipeline 1, to Ouray-Moffat Pipeline 2, to the Ouray Pipeline, and then into the existing canal.

2.3 Water Right Priority

Water usages in the Uintah Basin area are dependent upon the priority date of a given water right. A water right establishes the legal documentation for a landowner to utilize a specific amount of water during a given period of time. These times and dates are specified on the landowner's water right. The priority of when a landowner can use the water is based upon the priority date of their water right. The earlier the priority date stated on the water right, the sooner a landowner can utilize their right. Whether a water right holder receives any water is often dependent on how wet the year is. If the water season is dryer than usual, all available water may be diverted by the water rights holders with the earliest priority, leaving no water available for water right users who hold a later priority date on their water right.

Table 2-3 show the irrigation company, or individual primary diversion canal, and source of water for the irrigation companies in the project area as well as the model area number for the area. The table also shows the order in which water rights are filled, with the highest priority at the top of the table.

The BIA water rights are entitled to divert water from the Uinta and Whiterocks Rivers until their full flow right is filled. However, other than stock water, they can only divert during the irrigation season (March 1 to October 31). After the Tribal direct flow water rights are satisfied, the secondary water rights are then filled according to the order seen on Table 2-3. Most companies and areas receive water only from the Uinta River and its tributaries. However, the Dry Gulch Irrigation Company also holds shares in the MLWUA which provides water through exchange from the Yellowstone River through the Yellowstone Feeder Canal. Although Dry Gulch Irrigation Company can pull water from both the Uinta and Yellowstone Rivers they are still limited to 1 cfs per 70 acres of water righted lands whether it is being diverted from one or both of the rivers.

All flows are given in units of cubic feet per second (cfs) as shown on Table 2-3. These flows are calculated based on a maximum diversion of 1 cfs per 70 acres of water right land being served. Therefore acreage divided by 70 equals flow in cfs.

Irrigation Companies with secondary water rights typically have storage water rights to provide water when the natural flow in the rivers is insufficient to fill all the water rights. The priority in which these reservoirs are filled are as follows:

1. Whiterocks and Uinta Rivers HML;
2. First 3,526 ac-ft in Brown's Draw Reservoir (Uinta River and/or Yellowstone Feeder Canal);
3. Montes Creek Reservoir (Uinta River);
4. Brough Reservoir (Whiterocks River);

5. Cottonwood Reservoir and Pelican Lake (Uinta River);
6. Remaining Brown's Draw storage (Uinta River and/or Yellowstone Feeder Canal); and
7. Lapoint Reservoir (Whiterocks River).

These reservoirs are typically filled during the non-irrigation season using the rivers base flows. However, if early season irrigation uses stored water, that water can be replaced by the high spring flows if all other flow rights are being met.

TABLE 2-3
Direct Flow Diversion Priority

COMPANY	CANAL	Model #	SOURCE	FLOW	AREA (AC)
BIA	Uintah	1	Uinta River	114.3	8,002
BIA	Deep Creek	28	Uinta River	80.3	5,621
BIA	Uintah No. 1	1	West Channel Uintah River	48.3	3,380
BIA	Ditch A & B	1	West Channel Uintah River	6.9	485
BIA	Harms Canal	1	West Channel Uintah River	10.2	712
BIA	Big Six	1	West Channel Uintah River	3.3	228
BIA	Bench Canal	18	West Channel Uintah River	82.7	5,787
BIA	U.S. Farm Creek	28	Whiterocks/Farm Creek	20.1	1,409
BIA	U.S. Whiterocks	28	Whiterocks River	58.4	4,091
BIA	Duncan	28	Whiterocks/Farm Creek	2.0	141
BIA	Tabby White	23	Uinta River	2.9	206
BIA	Military	27	Uinta River	12.2	852
BIA	Daniels	22	Uinta River	2.0	140
BIA	Harris	24	Uinta River	5.4	377
Uintah River	Moffat	10	Uinta River	25.0	2044
Dry Gulch	Uintah No. 1	16 & 17	Uinta River/YellowStone Feeder Canal	60.8	4259
Dry Gulch	Uintah	6 & 15	Uinta River/YellowStone Feeder Canal	75.4	5276
Dry Gulch	Cedarview	7 & 15	Uinta River/YellowStone Feeder Canal	107.4	7515
Upper Uinta Area	TN Dodd	15 & 16	Uinta River	14.0	983
Upper Uinta Area	Hall & Lee	15	Uinta River	2.2	155
Upper Uinta Area	Durigan	15	Uinta River	1.8	127
Upper Uinta Area	Big Six	15	Uinta River	12.3	860
Upper Uinta Area	Colthorpe	15	Uinta River	4.6	320
Upper Uinta Area	Kyle & Bastian	15	Uinta River	5.9	415
Upper Uinta Area	Independent	15 & 16	Uinta River	50.6	3545
Upper Uinta Area	Larson	15 & 16	Uinta River	9.1	640
Whiterocks	Whiterocks	8	Whiterocks River	92.6	6483
Whiterocks	Marimon	15	Whiterocks River	4.6	320
Ouray Park	Ouray Park	9, 11 & 12	Uinta River	100.0	12,100
Uintah River	Moffat	10	Uinta River	5.0	

Note: In most cases the flow is determined by calculating 1 cfs for every 70 acres of land served.

2.4 Depletion

The water right applications for the Flaming Gorge water right have been broken out into total diversions and actual depletions. The depletion is the maximum amount of water that can be lost to the Green River system. Water depletion is defined as "the part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment". Of the 51,800 ac-ft water right requested for UWCD, only 25,176 ac-ft can be depleted from the river system. For DCWCD, 31,160 ac-ft of the 47,600 ac-ft can be depleted. Some of this water has already been separated out to individual water users along the Green River.

There are no stipulations for where the water will be used. DCWCD's water has been designated as follows: 2,500 ac-ft for M&I (municipal) use, 4,000 ac-ft for M&I (Industrial) use, and 41,100 acre-feet for supplemental irrigation. UWCD's 51,800 ac-ft allocation has been designated for supplemental irrigation. The average depletion percentage used by the state water resources engineer was 72% for municipal, 65% for agricultural, and 100% for oil well injection.

2.5 Water Rights

Water Rights Law

Utah Water Law is based on the principle that those who first made beneficial use of water should be entitled to continued use in preference to those who came later. This fundamental principal is known as the Doctrine of Prior Appropriation. This means those with earliest priority dates, who have continuously used the water since that time, have the right to water from a certain source before others with later priority dates. The concept of beneficial use is also a critical component of the law.

The State Division of Water Rights is the state agency that regulates appropriation and distribution of water in the state of Utah. It is an office of public record. All waters in Utah are public property. A water right is a right to the use of water based upon: 1) quantity, 2) source, 3) priority date, 4) nature of use, 5) point of diversion, and 6) physically putting water to beneficial use.

In general, the right to the use of water in the State of Utah must be established through the water appropriation process administered by the State Engineer's office. The steps to this process are as follows:

- Apply to appropriate water with the State Engineer.
- Application is advertised and protests and rebuttals heard.
- State Engineer evaluates application, protests, and other pertinent information and renders a decision on the application based upon principles established in State statute.
- If approved, the applicant begins developing water. When fully developed, the applicant files proof with the State Engineer stating the details of development.
- The State Engineer, after reviewing proof, issues a Certificate of Appropriation.

The State Engineer has an Area Office in Vernal, which administers the day-to-day implementation of the water rights.

There are numerous water rights associated with the Uinta River and its tributaries which all have a priority date, location of diversion, type of use, time of use, and quantity of use. Thus, these water rights, individually and collectively, define the use of water within the basin. For example, the Indian water rights have the highest priority during the irrigation season, but only stock water diversion rights during the winter when most storage associated with the secondary water rights is filled. The Indian water rights do not include storage rights.

3. BASELINE HYDROLOGIC MODEL

3.1 Model Development

Two computer simulation models have been created to understand the hydrologic conditions in the study area. The first model developed is referred to as the UintaSim model which was developed by the UDWR. The second model was developed by CH2M Hill in conjunction with this study. UintaSim has been used for many years to model the hydrologic system in the study area. However, modifying the model to evaluate water development alternatives was very difficult. In order to evaluate water development alternatives and provide a tool for water management in the study area, the GoldsSim model was developed. The UintaSim model was used as a basis for the creation of the GoldSim model and UDWR personnel provided assistance and review services during the creation of the GoldSim model. Most of the raw data used by the GoldSim model came directly from the UintaSim model.

A detailed discussion of the GoldSim model development will not be included in this document. A separate document is being prepared to fully explain the development and operation of the GoldSim Model. However, a summary of the results of the Baseline GoldSim model follows.

3.2 Available Water Supply

Available water supply is the total water available for development in the area. A more detailed description of available water supply is presented in Section 2., Water Supply Analysis, of this memorandum. Available water supply consists of water naturally available from rivers and streams, water diverted by canal or pipeline from other drainages, and water that can be pumped into the area for direct diversion or exchange.

Rivers and Streams

Estimates for the available water supply to the project area were developed primarily from USGS gaging station historical records on the Uinta and Whiterocks Rivers and major tributaries to these rivers. The Uinta and Whiterocks Rivers provide most of the incoming surface water with average annual flows of about 126,000 and 82,700 ac-ft per year, respectively. The total average annual inflow from the major tributaries, including the Yellowstone Feeder Canal, add about 31,700 ac-ft per year for a total project area natural water supply of about 240,300 ac-ft per year.

Of the total 240,300 ac-ft per year available in the Uinta River system, an estimated average of 41,500 ac-ft per year flows into the Duchesne River without being diverted or stored – 24,400 ac-ft on the Uinta River and 17,400 ac-ft on the Whiterocks River (see Table 3-1). This is the unused winter and spring runoff water that currently bypasses the two USGS gages on the Uinta and Whiterocks Rivers. Total system surplus that spills into the Duchesne River averages about 41,500 ac-ft per year (see Table 3-1). This surplus water in the Uinta River system has the potential to be developed.

TABLE 3-1
Water Supply Available for Storage or Exchange
1950-2006 Average
Units: Acre-feet per Year

Total Available	Uinta River Near Neola		Whiterocks near Whiterocks		Total Surplus
	Total	Available	Total	Available	
240,300	126,000	24,400	82,700	17,400	41,500

Green River Pumping

The GoldSim model allows for the pumping of water from the Green River to supply agricultural, municipal, and industrial demands in the Ouray Park area. Modeling various alternatives will assist in determining how much water can be pumped from the Green River.

Water Demands and Deliveries

The water demands in the GoldSim model are based on water rights. Nearly all demands are for agricultural purposes. A more specific discussion of the demands is contained in Section 4.1. Total acreage, demands, and diversions for each of the 31 areas served are shown in Table 3-2.

TABLE 3-2
Service Area Demands and Diversions
1950-2006 Average

Service Area	Model Area	Acres	Demand	Indian Diversion	Secondary Diversion	Stockwater Diversion	Total Diversion	Ave. Delivery AF/Acre	Shortage
Upper Uinta River Tribal	1	12,807	38,421	35,400		2,616	38,016	2.8	3,021
Cedarview Dry Gulch	6	3,311	9,933		8,400		8,400	2.5	1,533
Brown;s Draw, Dry Gulch	7	5,568	16,704		14,800		14,800	2.7	1,904
Whiterocks	8	6,483	19,449		16,400		16,400	2.5	3,049
Ouray Park, Cottonwood	9	3,856	11,568		9,200		9,200	2.4	2,368
Moffat	10	2,044	6,132		4,200		4,200	2	1,932
Ouray Park, Leota Bench	11	2,995	8,985		8,400		8,400	2.8	585
Ouray Park, Pelican Lake	12	5,249	15,747		14,600		14,600	2.8	1,147
Upper Uinta, Non Tribal	15	10,736	32,208		11,600		11,600	1.1	20,608
Uinta River, Dry Gulch	16	4,154	12,462		9,400		9,400	2.3	3,062
Montes Creek, Dry Gulch	17	1,528	4,584		4,300		4,300	2.8	284
Bench Canal, Tribal	18	5,787	17,361	16,000		1,182	17,182	2.8	1,361
Daniels Ditch	22	140	420	400		29	429	2.8	20
Tabby White Ditch	23	206	618	600		42	642	2.8	18
Harris Ditch	24	377	1,131	1,000		77	1,077	2.8	131
Fort Duchesne Canal	25	572	1,716	1,600		117	1,717	2.8	116
Henry Jim Canal	26	1,406	4,218	3,900		287	4,187	2.8	318
Military Ditch	27	852	2,556	2,300		174	2,474	2.7	256
Whiterocks River, Tribal	28	11,614	34,842	31,100		2,373	33,473	2.7	3,742
Totals		79,685	239,055	92,300	101,300	6,897	200,497		45,455
Total Demand by Type				101,283	137,772	6,897	245,952		45,455
Shortage by Type				8,983	36,472	0	45,455		

3.3 Model Output Summary

The "Baseline" model indicates that there are currently a total of about 240,300 ac-ft per year of water available in the Uinta River system. Approximately 193,600 ac-ft of this water (see Table 3-2) is used for existing irrigation (92,300 for Indian lands and 101,300 for secondary lands). An additional 6,900 ac-ft of water is diverted to fill Indian stockwater rights. Approximately 5,300 ac-ft per year of water is lost through evaporation. The remaining, approximately 44,000 ac-ft per year, is lost to the system through spills to the Duchesne River (27,000 ac-ft from the Uinta River and 17,000 ac-ft from the Whiterocks).

The model therefore shows that there is water available for development within the Uinta and Whiterocks Rivers system through adding new storage, implementing upstream exchanges with water from the Green River, or a combination of both.

Figure 3-1 demonstrates existing (baseline) conditions.

Uinta & Green River water Balance
Baseline (Existing) Condition
1950-2006 Average Units% Acre Feet

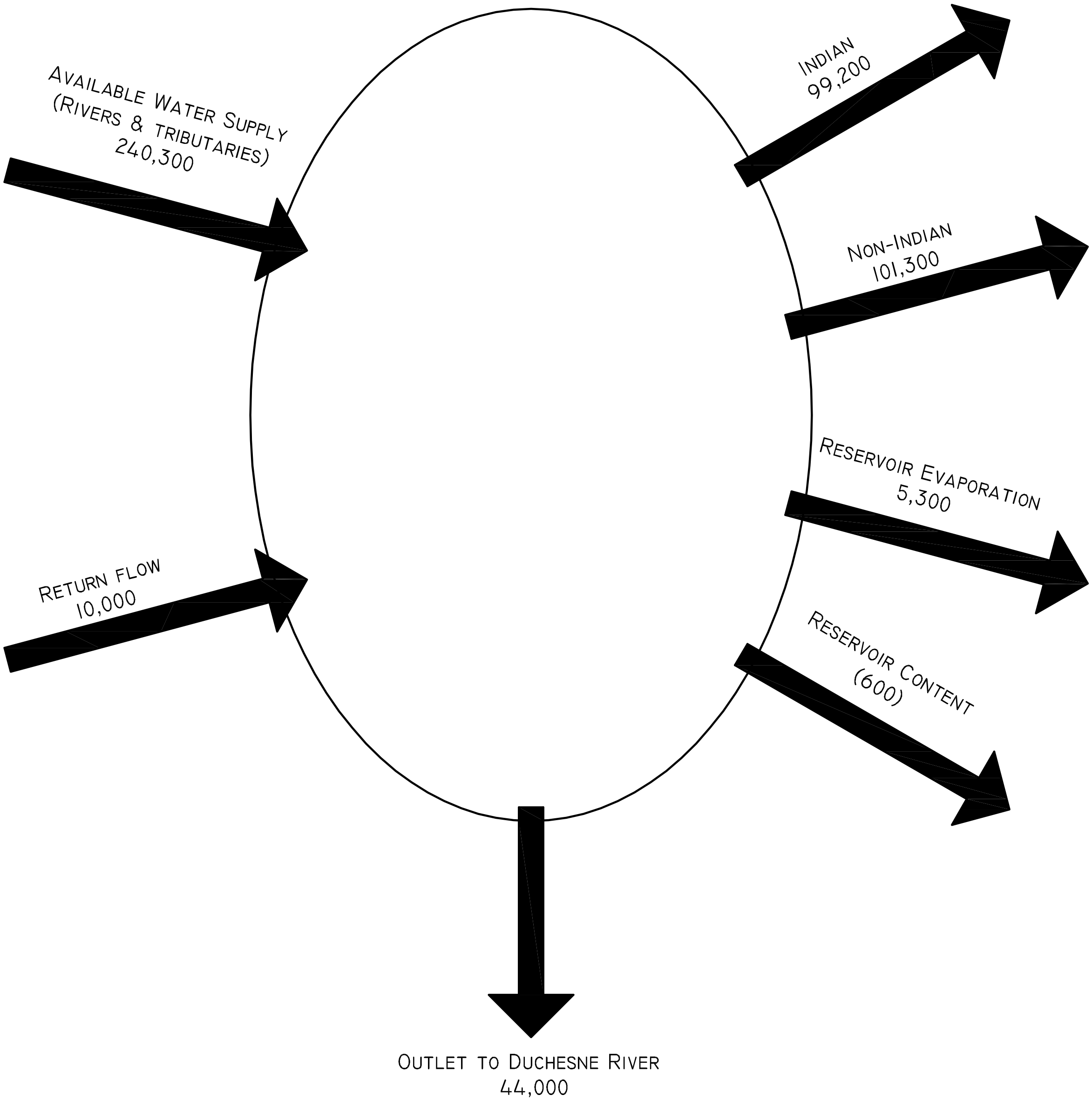


Figure 3-1 Uinta & green river Water Balance	PROJECT LEADER: Layne Jensen DRAFTSMAN: Matt Gurr DATE: January 23, 2007 Fig.3-1 H:\CLIENT\4-Uintah Basin Area\Uinta-Green River Water Dev\Task 4 Demands\Drawings LAYOUT: Layout1	Uinta and Green River Water Development	FRANSON CIVIL ENGINEERS

4. WATER DEMAND ANALYSIS

4.1 Agricultural Demand

The agricultural demands are based on water right acreage. The 1923 Federal Court Decree specifies that lands served from the Uinta River drainage can receive no more than 3 ac-ft per acre. Hence the total demand is the water right acreage multiplied by 3 ac-ft per acre. The challenge comes in determining the water right acreage. None of the sources referenced for this project agree on the water right acreage within the project area. Estimates range from 79,685 acres in the UDWR model of the Uintah River drainage to 85,257 acres in the Uintah Unit Replacement Project Feasibility Study (1997). For the purpose of this study, the acreages identified in the UDWR model (model), which agree with the acreages in the GoldSim model presented in this report, will be used. The model acreages have been chosen for the following reasons:

- The Indian compact acreages were provided to UDWR by Jerry Olds, the Utah State Engineer;
- One of the main purposes of this study is to demonstrate to UDWR that the Green River Allotment for the UWCD and DCWCD can be put to beneficial use and should be given to the Districts. Hence, the study should use acreages accepted by UDWR as part of the justification;
- The model is being used to evaluate the effectiveness of various water development alternatives. All aspects of the study should be consistent so that comparisons are valid;
- The acreages identified in the model have been divided based on diversions and water right priority. The greater detail will be beneficial when exploring possible exchanges;
- The total acreage in the model is the lowest total found in the various references. Using the model acreages will provide a conservative estimate of the current agricultural demand. The 1992 Central Utah Completion Program, Summary Report, Task 9: Inventory Resources, used River Commissioner Reports to identify a maximum acreage served of 80,392 acres. Hence, agricultural demands based on model acreages will likely underestimate the actual current demand.
- The model will provide a consistent reference throughout the study report

The model acreages as presented in the model can be seen on Table 4-1. The agricultural demand for the various areas, based on the acreage, can also be seen on Table 4-1. The total agricultural demand subject to the 3 ac-ft/acre limitation is 239,100 ac-ft. In addition to the demand to water crops there is a stock watering demand that must be met year round. The stock watering demand is 6,900 ac-ft. The total agricultural demand is 246,000 ac-ft. The average water supply from the Uinta River and its tributaries as seen on Table 2-2 is 225,600 ac-ft. An additional 14,700 ac-ft, on average, is brought into the project area from the Yellowstone River by the Yellowstone Feeder Canal. The average total water supply is 240,300 ac-ft. Thus, if all water available in the project area could be developed there would be an average shortage of 5,700 ac-ft before filling municipal, industrial, and environmental demands. It should also be noted that the 3 ac-ft per acre limitation refers to the volume of water diverted from the rivers and not the amount applied to the fields. The volume of water applied to fields is generally less than the diverted volume due to canal losses and evaporation.

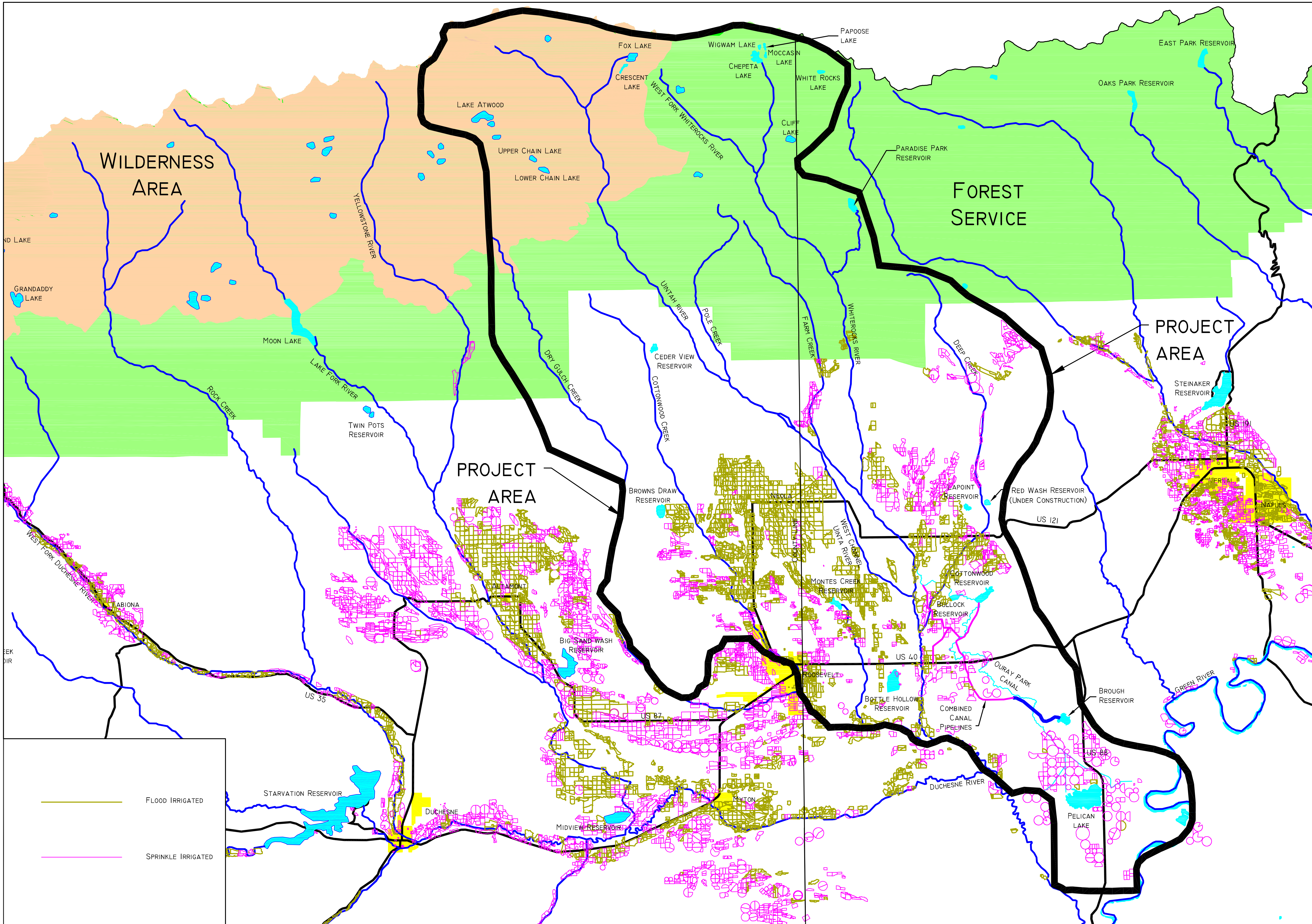
TABLE 4-1
Agricultural Demands

Area	Model #	Acreage	Demand
Indian Compact Area			
Uintah Canal	1	8,002	24,006
Uintah No. 1 Canal	1	3,380	10,140
Ditch A	1	68	204
Ditch B	1	417	1,251
Harms Canal	1	712	2,136
Bench Canal	18	5,787	17,361
Harris Canal	24	377	1,131
Henry Jim Canal	26	1,406	4,218
Fort Duchesne Canal	25	572	1,716
US Whiterocks	28	4,091	12,273
US Farm Creek Canal	28	1,409	4,227
Duncan Ditch	28	141	423
School Ditch No. 1	28	340	1,020
School Ditch No. 2	28	12	36
Big Six Canal	1	228	684
Deep Creek Canal	28	5,621	16,863
Daniels Ditch	22	140	420
Tabby White Canal	23	206	618
Military Ditch	27	852	2,556
Total Indian Compact		**33,761**	**101,283**
Secondary Water Users			
Larsen	15 & 16	640	1,920
Moffat	10	2,044	6,132
Whiterocks	8	6,483	19,449
Marimon	15	320	960
Hall & Lee	15	155	465
Durigan	15	127	381
Big Six	15	860	2,580
Uinta No. 1(Montes Creek)	17	1,528	4,584
Uinta No. 1(Uinta River)	16	2,731	8,193
Coltharpe	15	320	960
Bastian	15	255	765
Independent	15 & 16	3,545	10,635
Kyle	15	160	480
Uintah (Dry Gulch)	6	3,311	9,933
Uintah (Uinta River Direct)	15	1,965	5,895
T.N. Dodd (Dry Gulch)	16	501	1,503
T.N. Dodd (Uinta River Direct)	15	482	1,446
Cedarview (Brown's Draw)	7 & 15	7,515	22,545
Bench	16	882	2,646
Ouray Park - Cottonwood	9	3,856	11,568
Ouray Park - Brough	11	2,995	8,985
Ouray Park - Pelican Lake	12	5,249	15,747
Total Secondary		**45,924**	**137,772**
Total		**79,685**	**239,055**

Between 2001 and 2006, the UDWR used satellite imagery to identify lands under flood and sprinkler irrigation. This information has been placed in the State Geographic Information System. Figure 4-1 shows the land being irrigated in the Uintah Basin between 2001 and 2006. Within the study area (the area supplied by the Uinta River and its tributaries) there are 26,632 acres irrigated by sprinklers and 35,434 acres are still flood irrigated. The total irrigated acreage identified is 62,067 acres. The actual irrigated acreage has increased recently due to the nearing completion of the Combined Canal Project. With fewer canal and evaporation losses, more water is available for irrigation. The Combined Canal Project also provides pressurized water so that sprinkler irrigation is now possible in the areas served by this project. Thus, lands that have not been irrigated for many years are, or will soon be, irrigated.

Beyond the agricultural demand to meet existing water rights, there are new lands that may be brought into production if there is a consistent water source. Many lands with good soil conditions have not been developed because topography prevented effective flood irrigation. With improvements in irrigation techniques, many lands currently without water rights could be brought into production if there was a reliable water supply. A large portion of the lands that could be brought into production are in the Ouray Park area. These are lands that could potentially be served directly from the Green River. Although, the lands in the Ouray Park area or along the Green River will be directly served from the Green River, new land in other areas higher up in the system can be brought into production through exchanges. UWCD has accepted applications for new lands adjacent to the Green River as well as in the Moffat, Whiterocks, Ouray Park, Leota Bench, and Harris areas. New land that has been identified as being suitable for development in the Ouray Park/Leota area as well as applications for Green River water to supply new lands are as follows:

- Leota Bench previously has had approximately 670 acres of new private land identified as being available for irrigation. However, applications for 899 acres (3,547 ac-ft) of new land in the Leota area have been approved by the UWCD Board. Most of the approved land would be served directly from the Green River and would have a duty of 4 ac-ft per acre;
- The area north and west of Pelican Lake has approximately 3,300 acres of private land that could be developed. Applications for 1,057 acres (3,475 ac-ft) have been approved by the UWCD Board for the Ouray Park Area. Some lands in this group have a duty of 4 ac-ft per acre;
- The area south of Pelican Lake has approximately 1,100 acres of private land and 2,700 acres of Bureau of Land Management (BLM) and State land that could be developed.
- The UWCD Board has approved applications for 176 acres (529 ac-ft) of new land in the Harris Ditch area;
- The UWCD Board has approved applications for 324 acres (1,101 ac-ft) of new land in the Moffat area;
- The UWCD Board has approved applications for 253 acres (506 ac-ft) of new land in the Whiterocks area;
- The UWCD Board has approved applications for 1,428 acres (5,472 ac-ft) of new land adjacent to the Green River including small areas outside the previously mentioned areas (116 acres and 202 ac-ft).



FRANSON CIVIL ENGINEERS

Uintah and Green River Water Development Report

Date:	May 4, 2007
Scale:	1" = 8000'

shape map.dwg
H:\CLIENTS\4-Uintah Basin Area\Uinta-Green River Water Dev\Task 4 Demands\Drawings
LAYOUT: Figure 4-1

Figure 4-1

Flood and Sprinkler Irrigated Areas

The new lands supplied from the Green River would not be limited to 3 ac-ft per acre by the 1923 Federal Court Decree. Lands served from the Green River have a duty of 4 ac-ft per acre. With total potential new lands of 7,770 acres in the Ouray Park and Leota Bench areas, there is a potential new demand of 31,080 ac-ft. The new lands identified here do not include lands that have been and will be developed adjacent to the Green River or new land in the Moffat, Harris, and Whiterocks areas. The UWCD has requested applications for their portion of the Green River Water Allocation. In addition to applications approved in the Ouray Park and Leota areas are applications for lands adjacent to the Green River as well as lands outside of the Ouray Park and Leota area. The applications for a portion of UWCD's Green River Water Allocation are discussed further in Section 4.4.

In addition to the agricultural demands discussed above, there are approximately 800 acres (656 acres currently being irrigated) west of Pelican Lake that are currently irrigated from the Duchesne River. These lands could be irrigated from Pelican Lake or the Ouray Park Canal. The water rights used to irrigate this land allow a diversion up to 15 cfs (approximately 4,600 ac-ft) which results in the Duchesne River being dry dammed at times. Minimum in-stream flows for the Duchesne River are in process of being established. These minimum in-stream flows on the Duchesne River will likely cause the need to irrigate these lands from the Ouray Park Irrigation System instead of the Duchesne River. This change would essentially add up to 800 acres and 4,600 ac-ft of demand to the above mentioned demands.

4.2 Municipal Demands

In 2006, CH2M Hill completed a Culinary Water Master Plan for the Duchesne and West Uintah Counties. This master plan identified existing demands and projected demands in 2050 based on projected population growth. The projections on population growth were made prior to the current energy boom in the area and likely underestimate the population growth. Recent decisions by the State Engineer have also affected the Roosevelt City and Neola Water and Sewer District's firm source capacity. Roosevelt and Neola have paper water rights for more than double their projected demands. However, the firm source capacity of the system is less than current demands. Roosevelt City recently tried to change the point of diversion for some of their water rights to increase production. Their request was rejected by the State Engineer; thereby, leaving Roosevelt in a difficult situation. The municipal capacities for the various agencies presented in this section are based on the firm source capacity identified in the Culinary Water Master Plan and not on water rights. The current demands, firm source capacity, and projected demands are presented in Table 4-2. The source of water for the various systems is also presented in this table. As can be seen, many of the water systems were having difficulty meeting demands in 2004 before the energy boom hit the area. To meet projected demands in 2050, at least 4,554 ac-ft of water needs to be obtained by the various water systems. With actual population gains much higher than projected in the Culinary Water Master Plan, the actual municipal demand is likely to be higher than shown in Table 4-2.

TABLE 4-2
Municipal Demands

Water System	Water Source	2004 Demand (AF)	2004 Capacity (AF)	2050 Projected Demand (AF)	Shortage (AF)
Johnson WID	SRCWUA, Well	439	724	1,081	357
Cedarview SSD	Private wells or hauled in, no existing system	368	0	906	906
Neola Water & Sewer Dist.	Wells and Springs (same source as Roosevelt)	236	224	580	356
Roosevelt City	Wells and Springs	2,115	2,009	3,662	1,653
Ballard WID	Ute Tribe	342	490	787	297
Tridell-Lapoint WID	Whiterocks Irrigation Co. (Ouray Valley Canal)	425	880	1,348	468
Town of Whiterocks	Ute Tribe	143	143	352	209
Town of Randlett	Ute Tribe	86	86	211	125
Ouray Park WID	Ute Tribe, contract has lapsed tribe hasn't renewed	74	0	183	183
	Totals	4,228	4,556	9,110	4,554

Notes:
SRCWUA = Starvation Reservoir Culinary Water Users Association
Current capacity data for 2004

4.3 Energy Industry Demands

Industrial water demands will likely increase dramatically as energy resources in the Uintah Basin are further developed. Oil shale and tar sand deposits in Utah and Colorado have been estimated to have more oil than all of the OPEC nations combined. Technological advances and higher crude oil prices (over $90/barrel with prices expected to increase) are combining to make large scale development of oil shale and tar sands resources likely. Extraction costs for a barrel of oil from oil shale or tar sands are estimated to be in the range of $50/barrel. A June 10, 2007 article in the Deseret News details what three large oil companies are doing to develop the oil shale reserves. The Deseret News article, as well as other newspaper articles related to this topic, can be found in Appendix B. In the Energy Policy Act of 2005, Congress funded a study on development of America’s strategic unconventional fuel resources. Portions of the report, relevant to oil shale and tar sand development, are included in Appendix B. Fact sheets prepared by the Department of Energy on the oil shale and tar sand development have also been included in Appendix B.

The oil, oil shale, and tar sand industries will be the largest industrial users of water. In addition to industrial water used to produce oil, the Ute Indian Tribe is proposing to build a refinery designed to process the type of crude oil generated in the Uintah Basin. No estimates have been made as to how much water such a refinery would need. However, the former Pennzoil Refinery in Roosevelt had water rights for 350 ac-ft of industrial water. Both the UWCD and DCWCD have been approached by companies interested in building power plants in the Uintah Basin. The four potentially large industrial water users are discussed below.

Oil Industry

At least two oil companies in the area are injecting water into poorly producing wells to increase production in adjacent wells. Inland Oil and Petroglyph Oil are injecting water into the oil fields in southern Duchesne and Uintah Counties. The Culinary Water Master Plan indicates that Petroglyph Oil is using 130 gpm (210 ac-ft annually). The Culinary Water Master Plan does not indicate that the water usage by Petroglyph Oil is expected to increase. However, the water usage by Newfield Oil is expected to increase dramatically from 1.0 million gallons a day (MGD) to 4.5 MGD (5,040 ac-ft annually) for its existing oil field. To meet future demands, Newfield Oil has contracted with DCWCD to use up to 2,900 ac-ft of DCWCD's Green River water allotment. Water deliveries of Green River water to Newfield Oil began in May, 2007. In addition to their water needs for their current oil field, Newfield Oil has acquired from DCWCD the option to purchase an additional 1,100 ac-ft of Green River water for use in an oil field east of the Green River. To fill the projected demands of their current oil field, Newfield Oil will need to acquire an additional 2,140 ac-ft of water.

In addition to Newfield and Petroglyph Oil there are other oil companies such as Shenandoah Oil and D.G.T that may also want to acquire Green River water rights to increase production from their oil fields. The demands for these oil fields, if realized, should be similar to Newfield Oil, approximately 5,000 ac-ft.

Oil Shale

In 1973, the UDWR prepared what is generally referred to as the White River Report. The White River Report discussed the water needs for oil shale development along the White River and how Utah's allotment of Colorado River water could be used to fill the water demands for oil shale development. At the time of the report, UDWR estimated that 30,000 to 160,000 ac-ft of Utah's Colorado River water allotment could be used for oil shale development. At the time of the report, the BLM had set aside two tracks of land in Southeastern Uintah County near the White River for the demonstration of oil shale development technologies. Efforts were made to develop oil shale in this area until the price of oil made development of oil shale economically unfeasible. With increased oil prices, the BLM has received renewed interest in developing oil shale resources in the area. Oil Shale Exploration Company (OSEC) has been selected by BLM to demonstrate their oil shale processing technology and is currently in the process of demonstrating the feasibility of their retort technology at the White River Mine. OSEC's retort technology is expected to require approximately 2.3 barrels of water for every barrel of oil produced. Other technologies for the development of oil shale, that utilize far less water, are being tested in Colorado, but OSEC's technology appears to be most effective for the type of high quality oil shale (25 gallons/ton or greater) found in south Uintah County and southeastern Duchesne County. Given an oil shale production of 500,000, 1,000,000, and 1,500,000 barrels of oil per day, the annual (process only) water needs would be approximately 54,000, 108,000, and 162,000 ac-ft respectively. The actual oil shale production is dependent on many factors, such as the price of oil, many of which cannot be estimated with confidence at this time. However, given the very high price of oil (over $90/barrel and expected to go higher) all indications are that the oil shale industry will grow rapidly.

The Energy Policy Act of 2005 created a Task Force on Strategic Unconventional Fuels (Task Force). The Task Force issued a report in September of 2006 which identified specific oil shale deposits and their expected development. The report indicates that all near future development is expected in Utah and Colorado with some future development in Wyoming after processes have been refined in Utah and Colorado. The mining and surface processing of oil shale is expected to occur in Utah, specifically in Uintah and Duchesne Counties, with in-situ (i.e. oil shale is processed in place without mining) development occurring in Colorado and later in Utah. The oil shale deposits to be developed in Utah all occur in Uintah and Duchesne Counties. Therefore, oil shale development and associated water use identified by the Task Force in Utah, will occur in Uintah and Duchesne Counties. The Task Force identifies an oil production by mining and surface processing in Utah of approximately 200,000 barrels/day by 2018 with an additional 200,000 barrels/day by 2030. In-situ production in Utah is projected to be 250,000 to 500,000 barrels/day by 2025. As mentioned above mining and surface processing is expected to require 2.3 barrels of water for each barrel of oil produced. In-situ production will require little water to produce the oil unless it involves steam injection. However, the support of both surface and in-situ production will require significant water use. Support water use includes water for increased population, worker use on site, dust control, development water, etc. Future municipal water demands identified in the Culinary Water Master Plan used population projections that did not account for rapid growth to support oil shale and tar sand development. Thus, municipal water demands associated specifically with oil shale development are included in this section. A Department of Energy Fact Sheet indicates that approximately 2,920 ac-ft of water will be needed for support services for every 100,000 barrels/day of oil production. This water use is in addition to water used for production. Based on the Task Force Report the near future, likely, and possible water demand for oil shale production is 27,480 ac-ft, 36,280 ac-ft, and 54,000 ac-ft respectively. The Task Force report addresses oil shale development in the next 20 to 25 years. Department of Energy Fact Sheets appears to be taking a longer term view and identify an eventual oil shale production of 2.5 million barrels/day. This estimate exceeds the production identified by the Task Force. With the vast majority of oil shale development occurring in Utah and Colorado, it is reasonable to expect oil shale production in Utah to exceed 1.5 million barrels/day at some point in the future.

Recently representatives of major oil companies, such as Chevron-Texeco, have met with local leaders in the Uintah Basin and have indicated a development of oil shale resources that exceed the Department of Energy and Task Force estimates. Based on this more recent information the project sponsors feel that the production levels will approach 500,000, 1,000,000, and 1,500,000 barrels/day for the near future, likely, and possible conditions. Table 4-4 portrays industrial water demands based on these production levels. However, whether using the water demand based on the Task Force production estimates or the estimates in Table 4-4, the near future water demand will significantly exceed the available water supply.

Oil/Tar Sands

Tar sands, like oil shale, have to be processed to separate the oil from the sands. Depending on the process used to release the oil, water usage will likely be similar to the water usage needed to process oil shale (i.e. 2.3 barrels of water for each barrel of oil). In 2008, Temple Mountain Energy will begin commercial development of oil sand deposits on Asphalt Ridge in Uintah County. The UWCD has approved a 5000 ac-ft application for Temple Mountain Energy.

Temple Mountain Energy has since contacted UWCD about acquiring an additional 15,000 ac-ft of water for the processing of tar sands. With the experience gained from developing tar sand deposits in Alberta the development of tar sands is Utah is expected to be faster than for oil shale. However, with tar sand deposits being smaller than oil shale deposits, oil shale production may ultimately exceed oil production from tar sands. Given tar sand production of 500,000, 1,000,000, and 1,500,000 barrels of oil per day, the annual (process only) water needs would be approximately 54,000, 108,000, and 162,000 ac-ft respectively.

The Task Force and Department of Energy have prepared similar reports and fact sheets for tar sands as were prepared for oil shale. The majority of tar sand deposits in the United States occur in Utah. Of the five major tar sand deposits identified in Utah two are in Uintah and Duchesne Counties. Between the two deposits, a production of 100,000 barrels/day, in addition to the Temple Mountain production, is expected by 2018. Production is expected to increase by 125,000 barrels/day by 2030. Production water use is expected to be less than the 3 barrels of water for each barrel of oil produced seen in Alberta. Water use is expected to be similar to that for oil shale. Although not specifically identified for tar sand, water used to support the tar sand industry is also expected to be similar to water needs for oil shale. Based on the Task Force Report the near future, likely, and possible water demand for tar sand production is 28,740 ac-ft, 17,175 ac-ft, and 30,000 ac-ft respectively. The fact sheets and Task Force report used to generate expected water demand were prepared in 2005 and 2006 respectively, before oil prices approached $100/barrel. Recent meetings between large oil companies and local leaders suggest that the Task Force likely underestimated the rate and extent of tar sand development in Uintah and Duchesne Counties. Table 4-4 represents the production rate felt to be more representative by the project sponsor. Regardless of which production numbers are used, the water demand will significantly exceed the available water resources.

Power Generation

The DCWCD and UWCD have been contacted regarding water for proposed power plants. Two companies proposing power plants mentioned a need for 12,000 ac-ft while one company mentioned a need for 50,000 ac-ft.

4.4 Requests for Use of Green River Water Allocation

Uintah Water Conservancy District

UWCD requested that persons interested in acquiring a portion of the Green River Water Allocation submit applications including $10 for each ac-ft of water requested. The UWCD has received applications for nearly 50,000 ac-ft of Green River water. The UWCD Board of Directors has approved applications for approximately 42,000 ac-ft. Most applicants received approval for their total request. However, some applicants received only half of their request. Six applications totaling 7,648 ac-ft have been rejected. In most cases, the applications were rejected because a mechanism to deliver the water could not be found. Approved applications were for the Leota, Ouray Park, Harris Canal, Moffat, and Whiterocks areas as well as for lands adjacent to the Green River. Table 4-3 summarizes the applications received by the UWCD that were not completely rejected. Table 4-3 also shows how much of the Green River Water Allocation has already been segregated. Segregation of the water right is continuing to occur and the segregated amount will be increasing. With the interest shown in the Green River Water Allocation, UWCD has awarded an engineering contract for the design of a pumping plant and pipeline to deliver 8,500 ac-ft of water to the Ouray Park area from the Green River.

TABLE 4-3
UWCD Application Summary

			Approved				
Summary by Area	Total applied for	Segregated	New	Supplemental	Municipal	Industrial	Total
Direct	11,570	5,480	5,270	1,300		5000	11,570
Leota Bench	5,823	2,060	3,547	2,276			5,823
Ouray Park	17,585.1	280.0	3,475.1	8,110	6,000		17,585
Harris	838.44	0.00	529.11	309.33			838
Moffat	2,453	200	1,101	1,352			2,453
Whiterocks	2,335.5	0.0	506	711.0	500		1,717
Other/Unknown	1,912.0	152.0	202	300		1360	1,862
Total	42,517.04	8,172	14,630.21	14,358.33	6,500	6360	41,849

Duchesne County Water Conservancy District:

DCWCD has not requested petitions from water users interested in obtaining a portion of their Green River Water Allotment as the UWCD has. However, as mentioned above, Newfield Oil has contracted with DCWCD to obtain 4,000 ac-ft of water from the Green River. Of the 4,000 ac-ft contracted for, 2,900 ac-ft has already been segregated

4.5 Environmental Demands

In most cases, the environmental demands are not mandated but are water uses that would improve water quality or habitat for fish and wildlife. To build future projects some environmental mitigation may be required that could require some of the water that could be developed. Opportunities for environmental improvement include: providing a more consistent water supply to the Ouray National Wildlife Refuge, additional water supply to improve water quality in Pelican Lake, water by exchange for endangered fish species in the Duchesne River, and stabilization of HML in wilderness areas. Some of these environmental enhancement opportunities may need to be implemented to get approval and funding for the proposed projects. These opportunities are discussed below.

Ouray National Wildlife Refuge

The Ouray National Wildlife Refuge, located southeast of Pelican Lake, currently has shares in the Ouray Park Irrigation Company (705 acres, 2,115 ac-ft). These water shares are filled by pumping water from Pelican Lake into a pipeline that delivers the water to the refuge. In addition to the Ouray Park Irrigation Company shares, the refuge also has direct diversion rights from the Green River. The water from Pelican Lake and the Green River is used to irrigate agricultural land on the refuge and to provide ponds and other habitat for the wildlife populations. The refuge could benefit from the development of Green River water because a more stable source of water could be provided from the Green River.

The Ouray National Wildlife Refuge is also experiencing problems with high selenium concentrations on the western boundary where a small drainage comes in to the refuge. There are several roadside ponds maintained by the refuge where high selenium concentrations and wildlife problems have been observed. The most likely source of the problem is either discharge of deep and geologically old groundwater from a regional aquifer, return flows from irrigation, or a combination of both.

The solution to the selenium problem could be to deliver enough water to the refuge so that the selenium concentration is diluted below the State’s 5 ug/l standard. This could be accomplished by transfer of water through the refuge and back to the Green River. The flow rate and concentration of selenium of the water going under the road by the roadside ponds has been monitored for several years. Analysis of this data showed that a flow rate of 10 cfs would accomplish the needed dilution for 21 of the 25 measurements made over a 4 year period. A flow rate of 10 cfs amounts to approximately 7,300 ac-ft per year.

Pelican Lake

Pelican Lake is noted as a world class bluegill fishery. However, there has been a decline in the fishery and winter fish kills have occurred. A potential cause of the decline of the fishery is the low water levels during the fall and early winter before the lake is refilled. Green River water could be used to maintain a higher water level in the lake and to provide a constant inflow to improve dissolved oxygen concentrations. The actual demand for this would be the water lost to evaporation. Since the higher water level would be maintained in the fall and early winter, the evaporation would be relatively low. The greater need would be to pump more from the Green River to compensate for a reduced active storage volume. The amount of water needed has not been quantified. For the purposes of this report, it will be assumed that 4,000 ac-ft per year would be sufficient.

Lower Duchesne River

The US Fish and Wildlife Service has conducted a study to determine the minimum in-stream flows needed to maintain endangered fish species in the Lower Duchesne River. Although the last 2.5 miles of the Duchesne River has been identified as the most critical, all in-stream recommendations are for the section of the Duchesne River between the confluence of the Uinta River and the Green River. The in-stream flow recommendations are based on current conditions which meet the minimum recommended flows. However, any water development projects that modify current conditions will need to maintain the current flow levels. Base flow recommendations have been made for two periods, March 1 to June 30 and July 1 to February 28. Between March 1 and June 30, the target flow should be similar to the recent period of record with a target flow of 115 cfs or greater. In addition to specifying this minimum flow, it is also recommended that flows in excess of the 6-year event, or 4000 cfs, occur during this period. Between July 1 and February 28, the flow should be similar to the recent period of record and have a target flow of 50 cfs or greater. Since endangered fish have been found upstream of the confluence of the Uinta River, the US Fish and Wildlife Service recommends that a “significant portion of the water delivered to the target reach (below Randlett) be delivered from the Duchesne River above the confluence with the Uinta River".

Pumping from the Green River could supply water to the approximately 800 acres of land irrigated from the Duchesne River west of Pelican Lake. These lands irrigated from the Duchesne River have a water right for 15 cfs (approximately 4,600 ac-ft). Replacing water from the Duchesne River with Green River water through Pelican Lake would fill a significant portion of the recommended base flow.

Uinta River In-Stream Flows

The Uintah Unit Replacement Project Feasibility Study related to the construction of a Lower Uinta Reservoir, accounted for minimum in-stream flows on the Uinta River. The Feasibility Report identifies a minimum winter (October to March) flow of 27 cfs and minimum summer (April to September) flow of 73 cfs down to the bifurcation structure. Below the bifurcation structure, in the West Channel to the Bench Canal Diversion, the minimum flow was 14 cfs during the winter and 41 cfs during the summer. Whether the minimum in-stream flows have to be made up from storage is dependent on the inflow to a potential Upper Uinta Reservoir. In years that natural flow does not meet minimum in-stream flow requirements, the in-stream flows would become a demand on the system. The Feasibility Report did not identify the average demand resulting from minimum in-stream flows on the Uinta River. For the purpose of this study it will be assumed that an average of 5 cfs (3,620 ac-ft) from the potential Upper Uinta Reservoir would be released to maintain minimum in-stream flows in the Uinta River.

In addition to the minimum in-stream flows that may be established as part of the mitigation for the construction of an Upper Uinta Reservoir, a portion of the in-stream flow on the Lower Duchesne River will possibly need to come from the Uinta River. Although the US Fish and Wildlife Service identifies that a significant portion of the water to meet in-stream flows comes from the Duchesne River above the confluence, no specific flows from the Uinta River were identified. However, the recommended in-stream flow for the Duchesne River was based on the actual flow in the Duchesne River in the recent past (1977-2002). A portion of the measured flow used to set the in-stream flow was from the Uinta River. As the water resources of the Uinta River drainage are further developed, the minimum in-stream flow in the Duchesne River will be a demand that must be met. Since the Uinta River is typically dry dammed during the irrigation season, and in winter until the canals filling the off stream reservoirs freeze, the time at which the Uinta River was contributing flow to the Lower Duchesne River is limited to the late winter and spring. Assuming the Uinta River contributed 20% of the flows used to generate the in-stream flow requirement for the Duchesne River, between January 1 and June 30 the Uinta River provided on average 10 cfs (20% of the 50 cfs required for this time period) for 59 days between January 1 and February 28 and 23 cfs (20% of 115 cfs) on average for 122 days between March 1 and June 30. This corresponds to a flow volume of approximately 6,700 ac-ft. This does not represent the total flow from the Uinta River into the Duchesne River. It is only a rough estimate of the volume of water needed from the Uinta River to meet Duchesne River in-stream flows during non spring runoff conditions. This estimate does not include all of the demand on the Uinta River to meet Duchesne River in-stream flows since the US Fish and Wildlife Service has also recommended a flow of 2,500 cfs for at least 7 days during an average year. Assuming 20%, or 500 cfs, of that flow comes from the Uinta River, another 6,900 ac-ft will be needed to meet Duchesne River in-stream flows. As the water resources of the Uinta River drainage are further developed, a more in depth analysis will be needed to identify the actual amount of water from the Uinta River needed to meet the Lower Duchene River's in-stream flow requirement.

The in-stream flows that may be required, as a result of the Upper Uintah Reservoir, would be in addition to the flows needed for the Duchesne River. This is because the Uinta River in-stream flows are roughly for the period when it was assumed that the Uinta River has not been contributing to flows in the Duchesne River. On average, approximately 42,988 ac-ft of water currently flows into the Duchesne River from the Uinta River. A significant portion of the 42, 988 ac-ft of water may need to be used to generate in-stream flow.

4.6 Demand Summary

A summary of the demands discussed previously can be seen in Table 4-4. The existing total demand within the project area is approximately 261,882 ac-ft. Some of this total demand is municipal, and is being supplied from wells and the Starvation Reservoir Culinary Water Users. Currently, approximately 200,500 ac-ft on average is being diverted from the Uinta River, Whiterocks River, and Yellowstone Feeder Canal. Without additional storage, existing water supplies in the Uinta River drainage cannot be utilized. To fully meet existing demands, the Green River Water Allocation will need to be used, and development of water resources on the Uinta River will also need to occur.

Demands likely to be realized in the near future total approximately 131,500 ac-ft. Existing demands exceed the average supply from the Uinta River Drainage and Yellowstone Feeder Canal by over 79,000 ac-ft. The combination of near future and existing demands will exceed the supply from the Uinta River Drainage and the Green River Water Allocation. When considering that most of the near future demand will be industrial, with a 100% depletion, the shortfall will be even greater.

TABLE 4-4
Demand Summary Table

Demand	Probababilty of Demand Being Realized (Acre-Feet)				
	Existing	Near Future	Likely	Possible	Total
Agricultural					
Existing Agriculture (see notes below)	239,055				239,055
Existing Stockwater	6,897				6,897
New Ouray Park Agricultural Land	280	3,195	24,173		27,648
New Leota Bench Land		1,987			1,987
Lands Adjacent to Green River	7,040	1,090			8,130
New lands Harris Area		529			529
New Whiterocks Area		506			506
New Lands Moffat Area		1,101			1,101
Other Areas New Lands (wells)	152	50			202
Agricultural Sub-Total	253,424	8,458	24,173		286,055
Municipal					
Existing Municipal	4,228				4,228
New Municipal		4,054			4,054
New Municipal Whiterocks		500			500
New Ouray Park Area (Four Star Ranch)		6,000			6,000
Municipal Sub-Total	4,228	10,554			14,782
Industial					
Oil	1,330	2,120	5,000		8,450
Water Segragated for oil (DCWCD)	2,900				2,900
Oil Shale		54,000	54,000	54,000	162,000
Oil Shale with Approved UWCD Appl.		1,360			1,360
Oil/Tar Sands		50,000	54,000	54,000	158,000
Oil Sands with Approved UWCD Appl.		5,000			5,000
Refinery				350	350
Power Plants			12,000	50,000	62,000
Industrial Sub-Total	4,230	112,480	125,000	158,350	400,060
Environmental					
Ouray Nation Wildlife Refuge				7,300	7,300
Duchesne River			4,600		4,600
Uinta River In-stream flow				3,620	3,620
Uinta River portion of Duchesne River In-stream flow				13,600	13,600
Pelican Lake				4,000	4,000
Environmental Sub-Total			4,600	28,520	33,120
Totals	261,882	131,492	153,773	186,870	734,017

Notes:

1. The existing agricultural demand includes applications for supplemental water. Supplemental Green River water rights allows the landowner to obtain water from the Green River if flow on the Uinta River is insufficient to provide 3 ac-ft/acre. However, the total water diverted is still limited to 3 ac-ft/acre regardless of source. Although 14, 358 ac-ft of supplemental applications have been approved the total demand for these lands has not changed.

2. Blue and yellow highlighted demands represent applications approved by the UWCD Board. Blue highlighted cells represent the portion of UWCD approved applications that have been segregated.
3. Lands adjacent to the Green River represent lands served directly from the Green River that are not included in the existing or new agricultural lands. These lands have applied for and/or received a portion of the UWCD Green River Water Allocation.
4. Supplemental adjacent to the Green River represents direct diversion from the Green River to meet supplemental demands. These lands are not included in the existing agriculture demands.
5. **13,600** ac-ft is the estimated Uinta River flow needed to meet Lower Duchesne River in-stream flow recommendations.

5. WATER DEVELOPMENT

5.1 Water Available for Development

The water available for development is the water from the Uinta River and its tributaries that flows into the Duchesne River and is not being used to fulfill existing water rights. The undeveloped water typically represents winter flows after all reservoir storage has been filled and high spring flows that exceed all demands or capacity of diversion structures. This water is not being used because there is insufficient storage or diversion capacity to capture the water when it is available. According to the GoldSim model, there is approximately 44,000 ac-ft on average in the Uinta River drainage that is not currently being used to meet existing water rights. Duchesne County WCD and Central Utah WCD have storage rights on the Upper Uinta River that can be used to develop this water. As discussed in Section 4.5, some of this water may be needed to meet in-stream flow requirements for the Duchesne River. Some of this unused water may also be used as part of the mitigation efforts for a reservoir on the Uinta River. Ultimately the water available within the Uinta River drainage for development will be dependent on how much water is needed to meet in-stream flow requirements and the ability to divert and store high flows. Hence, not all water currently spilling to the Duchesne River can be developed.

5.2 Green River and Uintah River Exchange Concept

With entities working together to create a benefit for all parties in the project area, many beneficial opportunities can be created through the Green River and Uintah River Exchange Concept. The basic idea behind the exchange concept is to use and store water where it is natively found rather than conveying it further downstream. An alternate source would then supply water for downstream users replacing the water they normally would receive.

For example, Pelican Lake is filled from the Uinta River and Deep Creek. The diversion from the Uinta River is located over 12 miles northwest of Pelican Lake. Currently diverted water travels over 12 miles in canals and through reservoirs to fill Pelican Lake. Rather than divert this water high in the watershed for Pelican Lake water users, water would remain for use higher in the drainage. Water from the Green River would then be used to fill Pelican Lake or directly supply water users. The project costs to pump water from the Green River to Pelican Lake would be born by the parties benefiting from this new water source. The only pumping costs to be born by the Pelican Lake water users would be the cost to pump supplemental water above what they historically receive from the Uinta River and Deep Creek.

This exchange concept has many benefits including:

- Supplying areas with new water historically not available to them,
- Conserving water in the current system by reducing water seepage and evaporation,
- Increase potential for supplying water during the peak irrigation months, and
- Additional storage facilities to supply water for when it’s needed.

Many scenarios can be created using this exchange concept, which could benefit the entire project area. Subsequent reports will identify specific alternatives and evaluate these alternatives.

5.3 Shortage Criteria Concept

A shortage criteria is how water will be delivered when natural flows and storage are insufficient to meet demands. Typically this is determined by the water right priorities of the various parties. However, the exchange of Green River water for Uinta River water will make a shortage criteria more difficult. Due to Flaming Gorge Reservoir and minimum in-stream flows, the availability of water in the Green River will be far more consistent than water from the Uinta River. A shortage criteria will need to be agreed to as part of any exchanges that take place.

5.4 Water Conservation Practices and Goals

Implementing effective water conservation measures and programs is critical to satisfying Utah's future water needs. The State of Utah has prepared a water conservation program that has a goal to conserve water whenever possible. It is believed that our state’s increasing population will cause the largest increase in water demands in the future. The state set a M&I water conservation goal to reduce the per capita water demands on public water systems by 12.5-percent by 2020 and a total of 25-percent before the year 2050. This is equivalent to a total decrease in demand of about 400,000 ac-ft per year by the year 2050. The state recognizes that water conservation measures and programs are needed now to meet this goal.

Recent projects in the Uinta Basin are already conserving water for local water users. These projects include:

- The Combined Canals project, which consolidated many miles of canals into a combined pipe serving several canal companies.
- In connection with this project, many farmers have changed from flood irrigation to sprinkler irrigation thereby saving water through more efficient irrigation practices.
- Several municipalities have converted sewage lagoons to sewage treatment plants. Thus providing treated water that can be reused.

The Uinta Development project has a number of other potential areas to conserve water including: implementing the exchange concept, directly using water on crops rather than storing the water for later use, thereby reducing lake evaporation and the continuation of converting to more efficient irrigation practices. To obtain maximum benefit from the State’s scarce water resources; efficient use of dams, reservoirs, and water systems is essential to obtaining their maximum benefit.

APPENDIX A

Table A-1
Water Supply
Uinta River Near Neola
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	7,115	5,994	4,806	3,933	3,479	4,116	7,527	24,530	38,424	19,650	10,550	7,527	137,651
1951	5,984	4,818	4,086	3,235	3,029	3,283	3,380	16,631	27,721	14,876	19,029	8,489	114,561
1952	6,544	4,756	4,241	3,570	3,221	3,497	7,065	35,373	51,800	25,948	22,602	14,485	183,102
1953	8,817	5,871	4,917	4,096	3,247	3,646	3,437	6,377	31,987	13,797	12,409	6,746	105,346
1954	5,219	4,508	3,737	3,257	3,217	3,182	5,599	23,704	13,258	13,357	8,212	7,882	95,131
1955	6,538	4,919	3,880	3,578	2,922	3,543	3,707	16,263	22,622	10,865	11,098	6,639	96,571
1956	4,770	3,580	3,378	3,469	3,186	3,602	4,445	28,618	28,770	12,992	9,326	5,693	111,828
1957	4,354	3,818	3,314	2,725	2,454	3,767	3,475	6,306	47,583	21,509	12,615	12,153	124,072
1958	9,923	6,549	4,915	3,729	3,505	4,015	5,046	38,634	33,804	11,000	10,144	9,332	140,596
1959	6,313	5,119	4,320	3,241	2,914	3,189	3,806	10,030	26,682	12,421	13,640	8,985	100,661
1960	7,914	5,451	4,326	3,570	3,263	3,915	5,748	17,578	22,298	11,956	7,688	6,169	99,876
1961	6,686	5,107	3,856	3,178	2,541	2,666	2,914	13,406	15,132	9,552	9,979	17,726	92,743
1962	14,600	9,683	6,071	4,096	3,658	3,491	9,824	27,128	52,600	23,328	12,887	9,209	176,575
1963	7,785	5,260	4,060	3,166	2,993	3,662	3,461	21,806	23,962	14,630	13,803	13,962	118,550
1964	9,061	5,219	4,316	3,168	2,682	2,918	3,695	30,702	42,327	26,981	14,495	8,023	153,586
1965	4,927	3,904	3,816	3,308	2,700	2,981	4,629	15,614	84,893	51,350	28,167	16,336	222,625
1966	12,210	7,938	5,889	4,608	3,467	4,901	7,057	26,737	19,267	17,143	13,388	10,719	133,325
1967	8,616	5,671	4,790	3,642	3,068	3,959	4,106	22,316	51,830	37,394	17,451	11,728	174,571
1968	8,035	5,389	4,592	3,501	3,596	3,959	4,328	11,173	70,304	26,452	21,422	12,883	175,632
1969	9,235	6,190	4,649	4,005	3,535	3,713	7,803	47,657	38,513	19,722	14,995	10,590	170,606
1970	6,930	4,921	4,155	3,562	3,229	3,308	3,102	20,700	31,208	19,676	14,138	14,735	129,665
1971	7,496	5,042	4,108	3,548	2,882	2,969	4,142	15,418	47,131	19,771	16,257	10,068	138,831
1972	7,734	5,673	4,060	3,709	3,031	4,110	5,141	19,085	30,569	15,453	10,259	7,160	115,983
1973	5,248	5,030	5,449	4,631	3,489	3,552	4,193	30,468	44,920	24,702	19,396	12,613	163,692
1974	7,861	5,387	4,489	4,026	3,398	3,681	3,429	16,620	14,588	11,558	8,150	4,961	88,147
1975	4,899	3,856	3,021	2,938	2,579	2,828	2,914	9,864	55,956	43,392	16,641	8,989	157,876
1976	5,689	4,463	4,255	3,781	3,217	3,455	3,648	18,478	25,337	12,734	8,616	7,010	100,681
1977	5,679	4,110	3,352	2,739	2,575	2,825	3,697	7,097	23,663	11,125	8,783	6,278	81,921
1978	4,949	3,828	3,378	3,305	2,880	3,594	4,092	10,070	44,541	13,279	8,172	6,383	108,470
1979	5,046	4,100	3,743	3,277	2,874	3,312	4,423	21,816	22,197	11,958	10,193	5,778	98,717
1980	4,887	4,005	3,759	3,164	3,382	3,225	4,768	14,955	54,958	19,728	10,693	8,866	136,389
1981	6,579	4,840	4,441	3,390	2,700	3,152	4,850	19,454	32,031	13,791	9,584	8,479	113,290
1982	8,370	6,360	5,000	3,550	2,980	3,660	4,680	20,690	40,570	24,570	15,461	16,481	152,371
1983	15,431	8,170	6,091	5,295	4,015	4,909	5,381	14,497	91,577	43,223	23,388	13,256	235,231
1984	11,588	7,097	5,158	3,351	4,145	4,382	4,483	32,082	26,280	18,575	26,666	16,151	159,958
1985	8,929	4,856	2,737	2,955	2,872	3,729	9,263	26,202	18,742	18,255	13,599	15,518	127,656
1986	6,435	5,541	3,559	2,746	3,878	5,219	6,811	36,005	63,028	19,803	16,254	10,031	179,309
1987	8,240	5,603	5,570	3,724	3,270	3,310	5,193	27,857	32,778	18,433	15,290	7,619	136,886
1988	5,088	4,759	3,293	2,280	1,599	1,662	3,562	12,061	14,068	9,335	5,283	5,596	68,584
1989	3,542	2,784	3,182	3,172	2,387	2,317	4,993	7,494	10,986	7,025	5,241	4,811	57,932
1990	4,317	2,753	2,083	2,140	2,023	2,342	4,441	13,945	32,080	13,831	8,102	7,760	95,817
1991	1,740	1,060	1,080	2,170	2,140	1,770	2,600	9,550	39,100	16,440	15,480	15,101	108,229
1992	6,610	2,490	850	760	920	1,320	2,380	16,390	11,180	8,000	3,870	3,650	58,418
1993	2,281	2,250	1,760	1,610	1,140	1,630	1,830	32,950	38,110	13,780	10,360	5,140	112,839
1994	2,560	2,280	2,070	1,830	1,460	1,810	2,680	16,610	13,520	6,150	4,799	4,130	59,899
1995	5,386	2,759	1,944	1,874	1,666	2,478	2,485	7,879	88,280	52,363	16,560	10,659	194,334
1996	4,210	3,050	2,030	1,859	1,500	1,730	1,990	13,150	20,390	12,250	5,940	4,141	72,240
1997	3,080	2,570	1,650	1,890	1,491	1,920	2,460	24,080	34,190	13,480	13,870	18,169	118,848
1998	10,980	5,430	3,411	3,378	3,051	2,811	3,179	14,959	52,280	42,280	21,821	14,758	178,338
1999	8,788	6,498	5,301	3,818	2,238	2,584	2,882	23,232	73,364	34,044	13,864	15,597	192,211
2000	6,480	3,430	2,990	2,291	2,170	2,240	3,250	23,810	11,771	6,870	5,470	6,231	77,001
2001	5,159	4,270	3,458	3,339	2,892	3,080	4,170	46,607	29,282	15,859	11,032	6,839	135,987
2002	4,451	1,724	1,603	1,375	1,115	1,366	2,841	6,409	6,706	3,309	1,718	4,602	37,219
2003	3,090	1,580	920	820	730	840	1,190	22,440	15,190	9,650	6,060	3,800	66,311
2004	2,000	1,170	860	890	591	1,220	1,990	14,310	12,530	11,480	6,100	3,930	57,072
2005	3,594	2,983	1,706	1,442	1,269	1,511	3,759	57,818	97,008	39,285	16,637	10,965	237,977
2006	4,951	3,170	2,270	2,450	2,060	2,010	3,180	31,820	23,830	10,000	6,940	5,910	98,591
Total	374,938	259,637	206,742	174,150	152,507	173,865	241,123	1,197,453	2,067,716	1,080,379	714,585	537,436	7,180,530
Average	6,578	4,555	3,627	3,055	2,676	3,050	4,230	21,008	36,276	18,954	12,537	9,429	125,974

Table A-2
Water Supply
Whiterocks River near Whiterocks
QX019 (Supply from HML on Whiterocks R) + QX021 (Reach Gains below HML) + QX023 (Unused gains) + QX098 (Inflow to Ouray Park HML Reservoir)
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	3,963	3,098	2,656	2,297	1,932	2,182	4,546	20,836	27,971	11,659	7,410	4,661	93,211
1951	2,987	2,313	1,974	1,845	1,607	1,577	1,597	15,443	18,591	8,676	11,607	4,772	72,988
1952	3,644	2,402	2,103	1,906	1,682	1,777	4,249	30,311	35,960	15,400	13,589	7,367	120,389
1953	4,205	2,368	2,140	1,783	1,569	1,799	2,124	5,802	23,201	8,832	6,369	3,192	63,384
1954	2,765	2,174	1,686	1,555	1,452	1,628	3,618	19,109	8,029	6,885	4,749	4,233	57,882
1955	3,612	2,481	2,104	1,962	1,466	1,587	1,863	13,781	12,325	6,791	7,575	4,794	60,341
1956	3,459	2,303	2,039	1,890	1,599	1,712	2,442	23,415	14,775	6,776	4,036	2,727	67,172
1957	2,404	1,995	1,765	1,379	1,268	1,605	1,375	4,598	31,750	13,404	11,062	7,601	80,204
1958	5,869	4,439	3,287	2,287	1,666	1,908	3,138	30,105	21,852	9,003	4,774	3,975	92,303
1959	2,638	2,156	1,710	1,400	1,228	1,438	1,813	8,815	14,563	9,312	9,441	6,716	61,230
1960	4,959	2,438	1,741	1,533	1,363	1,628	3,001	11,883	12,899	8,281	4,320	3,499	57,545
1961	3,197	2,184	1,660	1,422	1,065	1,093	1,440	11,927	12,789	7,323	7,765	11,296	63,162
1962	6,546	3,731	2,969	2,162	1,823	1,831	7,000	22,078	34,211	14,083	8,864	4,903	110,200
1963	3,588	1,932	1,513	1,212	1,091	1,291	1,497	16,378	14,592	9,168	6,379	7,194	65,835
1964	4,830	2,761	2,186	1,855	1,575	1,599	1,829	19,143	25,168	12,220	9,408	5,143	87,715
1965	2,870	2,025	2,061	1,789	1,440	1,747	2,337	9,713	46,923	23,835	12,177	8,315	115,232
1966	5,713	3,368	2,640	2,249	2,003	2,297	5,012	22,489	11,169	9,590	6,119	5,314	77,962
1967	3,769	2,176	2,261	1,870	1,565	1,779	2,164	18,075	36,506	18,934	11,474	7,186	107,760
1968	3,201	1,942	1,805	1,551	1,492	1,609	1,916	9,338	49,109	14,432	11,324	7,486	105,203
1969	3,705	2,287	1,898	1,646	1,404	1,551	3,892	35,340	20,664	13,224	10,013	6,131	101,754
1970	4,509	2,991	1,994	1,597	1,369	1,458	1,607	16,286	23,689	14,348	10,102	7,676	87,624
1971	3,620	2,325	2,015	1,831	1,579	1,632	2,043	12,411	32,660	13,482	9,239	5,078	87,913
1972	3,308	2,440	2,241	1,807	1,454	2,285	2,547	20,192	25,930	10,671	6,694	4,687	84,256
1973	5,139	3,376	2,951	2,218	1,704	1,650	2,386	24,871	35,576	14,107	10,032	6,546	110,555
1974	3,598	2,632	2,116	1,874	1,585	1,652	1,625	13,829	7,865	5,359	3,759	3,176	49,069
1975	2,854	1,845	1,500	1,353	1,166	1,313	1,365	6,787	48,688	32,866	9,804	6,103	115,644
1976	2,950	1,880	1,666	1,363	1,206	1,260	1,567	18,857	16,679	9,451	6,716	3,969	67,563
1977	3,146	1,976	1,508	1,182	944	1,168	2,168	4,681	11,713	5,816	6,248	4,655	45,203
1978	2,878	1,704	1,490	1,295	1,111	1,595	2,134	10,387	26,678	9,818	6,300	3,816	69,205
1979	2,265	1,710	1,601	1,388	1,101	1,275	2,291	18,542	13,779	8,943	6,442	3,737	63,074
1980	2,906	1,986	1,728	1,357	1,208	1,252	2,614	12,419	41,084	12,964	7,650	4,913	92,079
1981	4,479	2,537	2,067	1,690	1,480	1,539	4,320	16,852	14,947	7,452	7,327	4,082	68,771
1982	4,038	2,737	2,271	1,597	1,408	1,561	2,269	18,768	27,884	14,293	8,327	10,021	95,173
1983	9,348	4,072	3,072	2,602	1,900	2,112	2,295	11,232	70,080	28,106	10,715	5,762	151,297
1984	7,039	3,909	2,710	1,892	2,041	2,204	2,888	25,916	17,290	11,119	14,624	9,449	101,082
1985	5,417	2,767	1,710	1,718	1,561	1,946	6,258	21,305	12,002	10,939	8,128	9,094	82,844
1986	3,902	3,124	2,047	1,626	1,938	2,519	4,532	29,004	43,083	11,806	9,453	5,966	119,000
1987	5,002	3,146	2,878	2,051	1,714	1,787	3,392	22,598	21,846	11,044	8,969	4,604	89,030
1988	3,076	2,717	1,942	1,432	1,079	1,164	2,241	10,193	8,717	5,925	4,001	3,453	45,941
1989	2,138	1,716	1,894	1,813	1,377	1,410	3,249	6,601	6,557	4,620	3,979	3,003	38,356
1990	2,614	1,704	1,440	1,373	1,244	1,416	2,862	11,669	21,364	8,450	5,399	4,681	64,215
1991	2,823	1,708	1,184	1,091	1,123	1,180	1,807	9,703	23,349	8,170	9,051	8,339	69,527
1992	3,616	1,809	1,339	1,398	1,428	1,430	2,954	12,918	9,727	7,202	4,415	4,124	52,360
1993	2,803	1,730	1,813	1,708	1,113	1,412	2,198	20,505	17,853	9,751	9,180	5,240	75,305
1994	3,295	2,541	2,374	1,591	1,388	1,686	2,688	13,666	9,374	8,436	5,191	4,495	56,723
1995	6,048	3,800	2,319	2,005	1,603	2,299	2,638	8,281	59,958	35,232	10,126	7,843	142,151
1996	3,497	2,093	1,605	1,696	1,293	1,452	2,261	14,648	13,438	11,203	7,196	5,115	65,496
1997	2,985	2,067	1,250	1,325	1,027	1,791	2,755	24,367	22,522	9,235	10,177	12,893	92,394
1998	8,846	4,259	3,043	2,588	1,986	2,350	2,773	19,890	44,285	20,501	9,431	8,249	128,202
1999	6,542	3,495	2,741	2,644	1,827	1,918	2,055	16,288	48,323	11,460	7,813	10,560	115,666
2000	3,174	2,352	2,255	1,874	1,644	1,807	2,969	16,663	11,048	7,991	5,153	4,750	61,682
2001	4,239	3,461	2,118	1,924	1,601	1,811	3,394	28,509	18,212	11,482	6,906	3,674	87,330
2002	2,602	1,962	1,640	1,301	1,089	1,375	1,906	5,774	4,895	3,451	2,912	3,509	32,416
2003	3,199	2,253	1,773	1,438	1,248	1,418	2,301	15,961	13,394	10,548	5,131	4,147	62,813
2004	2,624	2,015	1,763	1,640	1,337	2,003	2,751	13,010	9,828	9,414	5,595	4,574	56,555
2005	4,971	3,917	3,457	2,711	2,465	2,737	4,524	41,100	51,231	22,280	10,903	7,716	158,013
2006	4,009	2,501	1,781	1,726	1,519	1,702	3,170	21,162	9,584	9,668	6,075	4,548	67,444
Total	227,419	145,827	117,493	99,312	84,145	96,208	156,645	964,419	1,368,178	675,429	447,618	330,748	4,713,439
Average	3,990	2,558	2,061	1,742	1,476	1,688	2,748	16,920	24,003	11,850	7,853	5,803	82,692

Table A-3
Water Supply
Pole Creek
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	451	380	305	249	221	261	477	1,554	2,435	1,245	669	477	8,723
1951	379	305	259	205	192	208	214	1,054	1,757	943	1,206	538	7,260
1952	415	301	269	226	204	222	448	2,242	3,283	1,644	1,432	918	11,603
1953	559	372	312	260	206	231	218	404	2,027	874	786	428	6,676
1954	331	286	237	206	204	202	355	1,502	840	846	520	500	6,029
1955	414	312	246	227	185	225	235	1,031	1,434	689	703	421	6,120
1956	302	227	214	220	202	228	282	1,814	1,823	823	591	361	7,087
1957	276	242	210	173	156	239	220	400	3,015	1,363	799	770	7,862
1958	629	415	312	236	222	254	320	2,448	2,142	697	643	591	8,910
1959	400	324	274	205	185	202	241	636	1,691	787	864	569	6,379
1960	502	345	274	226	207	248	364	1,114	1,413	758	487	391	6,329
1961	424	324	244	201	161	169	185	850	959	605	632	1,123	5,877
1962	925	614	385	260	232	221	623	1,719	3,333	1,478	817	584	11,190
1963	493	333	257	201	190	232	219	1,382	1,519	927	875	885	7,513
1964	574	331	274	201	170	185	234	1,946	2,682	1,710	919	508	9,733
1965	312	247	242	210	171	189	293	990	5,380	3,254	1,785	1,035	14,108
1966	774	503	373	292	220	311	447	1,694	1,221	1,086	848	679	8,449
1967	546	359	304	231	194	251	260	1,414	3,285	2,370	1,106	743	11,063
1968	509	342	291	222	228	251	274	708	4,455	1,676	1,358	816	11,130
1969	585	392	295	254	224	235	495	3,020	2,441	1,250	950	671	10,811
1970	439	312	263	226	205	210	197	1,312	1,978	1,247	896	934	8,217
1971	475	320	260	225	183	188	262	977	2,987	1,253	1,030	638	8,798
1972	490	360	257	235	192	260	326	1,209	1,937	979	650	454	7,350
1973	333	319	345	294	221	225	266	1,931	2,847	1,565	1,229	799	10,373
1974	498	341	284	255	215	233	217	1,053	925	732	517	314	5,586
1975	311	244	191	186	163	179	185	625	3,546	2,750	1,055	570	10,005
1976	361	283	270	240	204	219	231	1,171	1,606	807	546	444	6,380
1977	360	260	212	174	163	179	234	450	1,500	705	557	398	5,191
1978	314	243	214	209	183	228	259	638	2,823	842	518	405	6,874
1979	320	260	237	208	182	210	280	1,383	1,407	758	646	366	6,256
1980	310	254	238	201	214	204	302	948	3,483	1,250	678	562	8,643
1981	417	307	281	215	171	200	307	1,233	2,030	874	607	537	7,179
1982	530	403	317	225	189	232	297	1,311	2,571	1,557	980	1,044	9,656
1983	978	518	386	336	254	311	341	919	5,803	2,739	1,482	840	14,907
1984	734	450	327	212	263	278	284	2,033	1,665	1,177	1,690	1,024	10,137
1985	566	308	174	187	182	236	587	1,660	1,188	1,157	862	983	8,090
1986	408	351	226	174	246	331	432	2,282	3,994	1,255	1,030	636	11,363
1987	522	355	353	236	207	210	329	1,765	2,077	1,168	969	483	8,675
1988	322	302	209	145	101	105	226	764	892	592	335	355	4,346
1989	225	176	202	201	151	147	316	475	696	445	332	305	3,671
1990	274	174	132	136	128	148	282	884	2,033	877	513	492	6,072
1991	110	67	68	138	136	112	165	605	2,478	1,042	981	957	6,858
1992	419	158	54	48	58	84	151	1,039	709	507	245	231	3,702
1993	145	143	112	102	72	103	116	2,088	2,415	873	657	326	7,151
1994	162	145	131	116	93	115	170	1,053	857	390	304	262	3,796
1995	341	175	123	119	106	157	158	499	5,594	3,318	1,049	676	12,315
1996	267	193	129	118	95	110	126	833	1,292	776	376	262	4,578
1997	195	163	105	120	95	122	156	1,526	2,167	854	879	1,151	7,531
1998	696	344	216	214	193	178	202	948	3,313	2,679	1,383	935	11,301
1999	557	412	336	242	142	164	183	1,472	4,649	2,157	879	988	12,180
2000	411	217	190	145	138	142	206	1,509	746	435	347	395	4,880
2001	327	271	219	212	183	195	264	2,954	1,856	1,005	699	433	8,618
2002	282	109	102	87	71	87	180	406	425	210	109	292	2,359
2003	196	100	58	52	46	53	75	1,422	963	612	384	241	4,202
2004	127	74	55	56	37	77	126	907	794	728	387	249	3,617
2005	228	189	108	91	80	96	238	3,664	6,147	2,490	1,054	695	15,081
2006	314	201	144	155	131	127	202	2,016	1,510	634	440	375	6,248
Total	23,760	16,453	13,101	11,036	9,664	11,018	15,280	75,882	131,031	68,464	45,283	34,057	455,030
Average	417	289	230	194	170	193	268	1,331	2,299	1,201	794	597	7,983

Table A-4
Water Supply
Deep Creek
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	121	200	242	248	273	346	277	115	154	148	140	136	2,400
1951	100	165	200	205	226	286	230	95	128	123	116	113	1,987
1952	149	246	298	305	337	426	342	142	190	182	172	168	2,956
1953	90	149	180	184	204	258	207	86	115	110	104	102	1,789
1954	85	140	169	173	191	242	194	80	108	104	98	95	1,677
1955	87	144	174	178	197	249	200	83	111	107	100	98	1,727
1956	94	155	188	192	213	269	216	90	120	115	109	106	1,867
1957	108	178	215	220	243	307	246	102	137	132	124	121	2,134
1958	120	198	240	246	271	343	275	114	153	147	139	135	2,382
1959	88	145	176	180	199	251	202	84	112	108	102	99	1,746
1960	84	139	168	172	190	240	193	80	108	103	97	95	1,670
1961	90	148	180	184	203	257	206	86	115	110	104	102	1,786
1962	139	228	277	283	313	396	318	132	177	170	160	156	2,747
1963	93	153	185	190	210	265	212	88	118	114	107	104	1,839
1964	116	190	230	236	260	329	264	110	147	141	133	130	2,287
1965	144	237	287	294	325	410	330	136	184	176	166	162	2,851
1966	106	174	210	215	238	300	241	100	134	129	122	119	2,088
1967	136	224	272	278	307	388	312	129	174	167	157	153	2,698
1968	134	220	266	273	301	381	306	127	170	163	154	150	2,645
1969	130	214	260	266	293	371	298	123	166	159	150	146	2,575
1970	116	190	230	236	260	329	264	110	147	141	133	130	2,286
1971	116	190	231	236	261	330	265	110	148	142	134	130	2,292
1972	112	184	223	228	252	319	256	106	143	137	129	126	2,217
1973	139	229	278	284	314	397	318	132	177	170	160	156	2,755
1974	76	124	151	154	170	216	173	72	96	92	87	85	1,497
1975	144	238	288	295	326	412	330	137	184	176	166	162	2,858
1976	95	156	189	193	214	270	217	90	121	116	109	106	1,876
1977	97	80	190	185	247	140	107	100	89	93	89	69	1,487
1978	71	107	138	163	189	316	101	87	123	122	98	124	1,638
1979	91	237	186	179	146	280	382	58	117	102	110	98	1,986
1980	120	198	240	245	271	342	275	114	153	147	138	135	2,378
1981	96	158	192	196	216	274	220	91	122	117	111	108	1,901
1982	123	203	246	252	278	351	282	117	157	151	142	139	2,440
1983	181	298	362	370	409	516	415	172	231	222	209	204	3,589
1984	129	213	258	264	292	369	296	123	165	158	149	146	2,561
1985	110	182	220	226	249	315	253	105	141	135	128	124	2,188
1986	148	244	295	302	334	422	338	140	188	181	170	166	2,928
1987	117	192	233	239	264	333	268	111	149	143	135	132	2,314
1988	72	119	144	148	163	206	166	69	92	88	84	82	1,433
1989	64	106	129	132	146	184	148	61	82	79	74	72	1,277
1990	91	150	182	186	206	260	209	86	116	112	105	103	1,806
1991	97	159	193	198	218	276	221	92	123	118	112	109	1,915
1992	79	130	158	161	178	225	181	75	101	97	91	89	1,564
1993	103	169	205	210	232	293	235	98	131	126	118	116	2,034
1994	84	138	166	170	188	238	191	79	106	102	96	94	1,654
1995	172	283	343	351	388	490	393	163	219	210	198	193	3,401
1996	92	152	185	189	209	264	212	88	118	113	107	104	1,833
1997	120	198	240	246	272	343	276	114	153	147	139	136	2,384
1998	157	259	314	321	355	449	360	149	200	192	182	177	3,116
1999	144	238	288	295	326	412	330	137	184	177	166	162	2,859
2000	88	146	177	181	200	252	203	84	113	108	102	100	1,754
2001	115	190	230	235	260	328	263	109	147	141	133	130	2,280
2002	58	96	116	119	132	166	134	55	74	71	67	66	1,155
2003	90	148	179	183	202	256	206	85	114	110	104	101	1,779
2004	83	137	166	170	188	238	191	79	106	102	96	94	1,650
2005	188	310	376	384	424	536	430	178	240	230	217	212	3,725
2006	94	156	189	193	213	270	216	90	120	116	109	106	1,873
Total	6,288	10,353	12,548	12,839	14,184	17,929	14,390	5,966	8,014	7,692	7,253	7,077	124,531
Average	110	182	220	225	249	315	252	105	141	135	127	124	2,185

Table A-5
Water Supply
Dry Gulch Creek
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	0	0	0	0	0	37	2,087	1,672	1,205	5	0	0	5,006
1951	0	0	0	0	0	0	5	380	357	7	2	0	751
1952	0	0	0	0	0	0	2,514	4,084	1,720	3	0	0	8,320
1953	0	0	0	0	0	0	6	7	136	0	0	0	149
1954	0	0	0	0	0	3	25	348	1	0	0	0	376
1955	0	0	0	0	0	0	14	557	26	0	0	0	597
1956	0	0	0	0	0	0	70	1,002	430	0	0	0	1,502
1957	0	0	0	0	0	0	0	82	1,751	10	0	0	1,842
1958	0	0	0	0	0	24	435	3,142	885	0	0	0	4,486
1959	0	0	0	0	0	0	0	0	191	2	1	0	193
1960	0	0	0	0	0	0	767	273	65	1	0	0	1,105
1961	0	0	0	0	0	0	0	280	57	0	0	0	337
1962	0	0	0	0	0	12	4,174	1,865	1,677	8	0	0	7,737
1963	0	0	0	0	0	0	0	975	193	2	0	0	1,170
1964	0	0	0	0	0	0	0	1,406	993	6	1	0	2,406
1965	0	0	0	0	0	7	205	0	2,638	20	1	0	2,871
1966	0	0	0	0	0	45	2,479	1,929	0	3	0	0	4,456
1967	0	0	0	0	0	9	51	1,241	1,851	14	1	0	3,167
1968	0	0	0	0	0	0	0	0	2,804	8	1	0	2,813
1969	0	0	0	0	0	0	1,525	3,936	652	7	1	0	6,121
1970	0	0	0	0	0	0	0	961	881	8	1	0	1,851
1971	0	0	0	0	0	0	0	355	1,560	8	1	0	1,923
1972	0	0	0	0	0	44	384	1,570	1,051	4	0	0	3,052
1973	0	0	0	0	0	0	247	2,301	1,781	8	1	0	4,338
1974	0	0	0	0	0	0	0	577	0	0	0	0	577
1975	0	0	0	0	0	0	0	0	2,772	31	0	0	2,804
1976	0	0	0	0	0	0	0	1,363	351	3	0	0	1,716
1977	0	0	0	0	0	0	60	0	0	0	0	0	60
1978	0	0	0	0	0	0	26	40	1,107	3	0	0	1,176
1979	0	0	0	0	0	0	162	1,313	131	2	0	0	1,608
1980	0	0	0	0	0	0	435	357	2,197	7	0	0	2,995
1981	0	0	0	0	0	0	1,891	1,049	220	0	0	0	3,160
1982	0	0	0	0	0	0	145	1,349	1,198	8	0	0	2,700
1983	0	0	0	0	0	32	162	171	4,390	25	0	0	4,780
1984	0	0	0	0	0	38	673	2,465	397	5	2	0	3,580
1985	0	0	0	0	0	21	3,544	1,744	0	4	0	0	5,313
1986	0	0	0	0	0	60	2,070	2,946	2,348	5	1	0	7,430
1987	0	0	0	0	0	10	1,099	1,947	742	5	0	0	3,802
1988	0	0	0	0	0	0	119	9	0	0	0	0	128
1989	0	0	0	0	0	0	979	0	0	0	0	0	979
1990	0	0	0	0	0	0	648	240	705	1	0	0	1,593
1991	0	0	0	0	0	0	0	0	855	1	0	0	857
1992	0	0	0	0	0	0	724	435	0	0	0	0	1,159
1993	0	0	0	0	0	0	85	1,620	439	3	1	0	2,148
1994	0	0	0	0	0	3	503	552	0	1	0	0	1,059
1995	0	0	0	0	0	45	460	0	3,625	34	0	0	4,164
1996	0	0	0	0	0	0	137	705	106	5	0	0	952
1997	0	0	0	0	0	10	562	2,223	793	2	1	0	3,591
1998	0	0	0	0	0	49	571	1,523	2,439	16	1	0	4,598
1999	0	0	0	0	0	19	0	961	2,744	5	0	0	3,729
2000	0	0	0	0	0	11	741	1,019	0	1	0	0	1,772
2001	0	0	0	0	0	11	1,099	2,870	467	5	0	0	4,451
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	171	910	102	4	0	0	1,186
2004	0	0	0	0	0	24	554	449	0	3	0	0	1,030
2005	0	0	0	0	0	76	2,061	4,836	2,964	18	0	0	9,956
2006	0	0	0	0	0	3	912	1,722	0	3	0	0	2,639
Total	0	0	0	0	0	591	35,579	63,758	53,993	321	17	0	154,259
Average	0	0	0	0	0	10	624	1,119	947	6	0	0	2,706

Table A-6
Water Supply
Yellowstone Feeder Canal
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	0	0	0	0	0	0	147	2,249	2,184	3,219	3,271	1,083	12,153
1951	948	0	0	0	0	0	901	2,350	1,823	3,477	2,783	2,551	14,832
1952	736	0	0	0	0	0	0	0	0	1,254	2,037	1,293	5,320
1953	0	0	0	0	0	0	18	3,140	2,648	2,946	4,409	4,088	17,248
1954	0	0	0	0	0	0	290	2,545	1,630	3,767	1,755	0	9,987
1955	0	0	0	0	0	0	0	1,785	0	3,860	3,842	1,020	10,506
1956	0	0	0	0	0	0	0	2,805	908	4,586	4,427	3,890	16,616
1957	758	0	0	0	0	0	0	930	1,662	1,329	4,489	1,541	10,709
1958	706	0	0	0	0	0	0	2,475	423	4,681	4,756	3,759	16,800
1959	1,010	0	0	0	0	0	1,882	1,033	0	2,648	3,741	0	10,314
1960	0	0	0	0	0	0	0	926	647	5,084	2,513	0	9,170
1961	0	0	0	0	0	0	0	0	3,104	2,233	908	0	6,246
1962	0	0	0	0	0	0	0	0	125	1,575	5,050	3,517	10,266
1963	0	0	0	0	0	0	0	2,779	780	5,185	5,476	1,541	15,761
1964	0	0	0	0	0	0	342	2,536	0	3,115	5,266	4,792	16,050
1965	0	0	0	0	0	0	0	879	0	0	0	0	879
1966	0	0	0	0	0	0	962	1,410	3,810	5,203	5,553	4,572	21,508
1967	0	0	0	0	0	0	914	3,627	65	996	4,790	4,670	15,061
1968	1,239	0	0	0	0	0	0	1,268	2,367	2,942	3,110	3,393	14,318
1969	663	0	0	0	0	0	0	2,382	384	4,594	5,545	5,387	18,955
1970	35	0	0	0	0	0	1,180	3,322	727	4,637	4,958	1,817	16,676
1971	0	0	0	0	0	0	0	3,739	2,455	4,207	5,290	4,775	20,466
1972	285	0	0	0	0	0	507	4,246	2,927	5,078	5,640	5,128	23,812
1973	0	0	0	0	0	0	0	0	0	3,354	4,469	4,297	12,120
1974	935	0	0	0	0	0	414	4,855	5,146	5,236	3,235	0	19,820
1975	0	0	0	0	0	0	0	3,033	1,934	82	5,709	5,609	16,366
1976	2,077	0	0	0	0	0	224	4,041	2,902	6,261	5,667	2,502	23,673
1977	0	0	0	0	0	0	0	2,093	4,630	3,111	136	0	9,970
1978	0	0	0	0	0	0	0	4,271	2,341	5,549	5,301	3,114	20,575
1979	0	0	0	0	0	0	0	3,039	2,909	5,732	5,967	374	18,020
1980	0	0	0	0	0	0	94	968	846	4,207	6,220	4,881	17,215
1981	1,317	0	0	0	0	0	1,753	4,239	4,224	4,917	864	0	17,313
1982	1,826	0	0	0	0	0	1,798	3,434	3,841	2,887	5,058	4,363	23,207
1983	747	0	0	0	0	0	0	0	0	0	0	0	747
1984	0	0	0	0	0	0	0	0	0	3,490	5,281	3,889	12,660
1985	1,252	0	0	0	0	0	230	3,666	3,034	5,165	5,394	2,629	21,370
1986	0	0	0	0	0	0	0	0	0	2,819	5,784	5,172	13,775
1987	84	0	0	0	0	0	470	2,948	399	5,410	6,111	3,375	18,796
1988	0	0	0	0	0	0	0	3,270	3,681	2,964	0	1,141	11,055
1989	1,691	0	0	0	0	0	0	3,288	3,967	0	0	402	9,347
1990	3,050	0	0	0	0	0	176	3,190	3,202	2,761	4,952	608	17,938
1991	3,941	0	0	0	0	0	0	1,737	1,972	2,710	3,826	966	15,151
1992	3,285	0	0	0	0	0	66	1,425	3,689	3,124	0	0	11,588
1993	0	0	0	0	0	0	2,264	1,003	0	3,974	3,770	4,428	15,438
1994	307	0	0	0	0	0	0	1,325	3,066	2,968	0	0	7,666
1995	1,959	0	0	0	0	0	144	2,560	159	75	3,771	3,063	11,731
1996	3,922	0	0	0	0	0	0	3,472	4,775	5,620	5,262	1,412	24,463
1997	3,322	0	0	0	0	0	1,186	0	199	5,840	5,949	5,184	21,680
1998	0	0	0	0	0	0	0	2,251	0	1,571	3,601	3,803	11,226
1999	3,610	0	0	0	0	0	115	1,616	127	2,826	4,290	3,971	16,555
2000	1,818	0	0	0	0	0	0	2,692	5,540	5,168	1,955	0	17,173
2001	3,467	0	0	0	0	1,238	1,312	602	2,278	4,711	5,999	675	20,281
2002	0	0	0	0	0	468	1,222	3,914	2,778	0	0	0	8,382
2003	2,123	1,356	0	0	0	1,013	1,620	1,179	3,485	4,298	285	878	16,237
2004	2,188	1,600	0	0	0	418	717	1,964	4,315	2,060	0	1,236	14,498
2005	4,143	430	0	0	0	0	0	718	0	1,461	1,154	3,533	11,440
2006	187	0	0	0	0	0	0	819	2,491	3,854	4,676	4,944	16,973
Total	53,632	3,386	0	0	0	3,136	20,945	120,037	106,593	190,816	204,294	135,263	838,101
Average	941	59	0	0	0	55	367	2,106	1,870	3,348	3,584	2,373	14,704

Table A-7
Water Supply
Farm Creek
Units: Acre-Feet

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1950	222	219	212	206	175	210	860	2,944	951	260	155	167	6,579
1951	250	264	265	258	217	231	227	1,191	603	162	119	131	3,919
1952	193	190	193	188	173	209	393	3,436	1,001	244	196	189	6,604
1953	232	208	212	219	180	188	193	327	382	115	124	121	2,499
1954	182	192	194	174	162	202	244	985	235	101	103	105	2,879
1955	168	175	184	179	150	174	205	836	267	94	107	118	2,656
1956	165	174	171	168	152	165	183	1,070	270	75	79	92	2,764
1957	164	166	163	160	148	172	181	196	1,703	227	148	154	3,581
1958	189	202	190	172	159	168	230	3,147	721	178	122	132	5,608
1959	192	196	194	173	151	171	185	247	130	64	104	111	1,916
1960	178	160	162	166	160	185	207	525	198	77	66	86	2,168
1961	143	150	154	138	117	144	144	203	96	36	45	75	1,444
1962	138	160	157	141	121	146	663	2,347	1,049	235	145	144	5,446
1963	193	189	184	181	162	174	170	663	328	93	107	137	2,579
1964	186	191	197	187	154	143	156	995	705	168	111	112	3,305
1965	163	166	165	160	134	140	163	857	2,595	504	229	178	5,452
1966	215	206	180	157	140	164	350	1,510	353	121	106	124	3,625
1967	182	179	171	160	138	154	176	1,695	2,710	502	228	167	6,460
1968	194	178	181	180	167	172	188	883	3,112	375	246	177	6,054
1969	231	231	210	201	162	179	382	3,349	1,174	367	179	177	6,840
1970	219	211	208	207	172	185	166	668	459	132	118	127	2,870
1971	174	181	185	185	164	173	170	911	952	122	87	92	3,395
1972	158	166	161	154	135	168	189	1,027	443	97	93	100	2,891
1973	176	195	187	166	130	158	171	3,322	1,090	259	190	156	6,201
1974	191	198	220	201	170	189	167	325	107	66	89	100	2,022
1975	155	113	116	106	83	98	95	262	2,817	680	177	152	4,854
1976	191	179	185	185	161	172	182	1,315	734	164	113	126	3,705
1977	161	167	161	154	137	141	145	90	75	40	66	88	1,424
1978	139	149	154	154	132	147	159	671	1,042	149	109	102	3,105
1979	151	156	152	141	123	141	180	1,280	578	109	112	105	3,226
1980	152	148	144	143	132	142	193	1,856	3,154	384	166	165	6,778
1981	210	214	207	195	182	201	269	1,260	523	145	126	133	3,666
1982	191	198	196	164	148	164	196	1,580	1,242	271	135	206	4,691
1983	336	260	245	252	195	213	198	570	4,473	652	180	134	7,710
1984	273	252	223	190	209	222	271	2,537	431	183	255	197	5,243
1985	229	199	162	175	163	199	676	1,919	36	178	131	190	4,256
1986	187	216	183	167	199	251	468	2,950	2,406	202	156	138	7,523
1987	217	217	234	204	177	185	331	2,093	780	181	147	115	4,880
1988	165	197	176	150	116	127	193	431	-	40	52	95	1,742
1989	139	150	173	183	145	150	314	-	-	13	52	88	1,407
1990	152	149	145	144	132	151	267	629	742	110	79	116	2,817
1991	158	149	129	120	120	129	141	366	895	102	149	178	2,635
1992	180	154	139	147	150	152	278	797	0	75	60	107	2,238
1993	157	150	168	174	119	150	188	1,813	474	146	151	126	3,816
1994	171	188	202	164	146	176	247	897	-	109	75	113	2,487
1995	246	247	200	200	166	231	241	175	3,699	848	169	170	6,592
1996	176	167	155	173	137	154	195	1,028	136	186	113	124	2,743
1997	163	166	134	140	112	185	255	2,330	831	132	170	254	4,871
1998	322	269	244	251	204	236	256	1,730	2,498	442	156	176	6,783
1999	259	233	225	256	189	197	170	1,248	2,807	193	125	215	6,115
2000	167	179	196	188	170	187	280	1,298	-	97	74	117	2,953
2001	197	231	187	193	166	187	331	2,884	501	193	108	99	5,277
2002	152	161	158	138	117	147	152	-	-	2	31	96	1,154
2003	168	175	166	150	133	151	200	1,204	132	168	74	107	2,826
2004	152	164	165	168	141	204	254	809	-	136	83	114	2,390
2005	217	253	270	261	250	271	466	4,570	3,030	491	184	168	10,432
2006	190	186	166	176	159	177	304	1,900	-	143	92	114	3,607
Total	10,819	10,782	10,458	10,084	8,803	9,996	14,451	76,145	55,665	11,637	7,164	7,700	233,703
Average	190	189	183	177	154	175	254	1,336	977	204	126	135	4,100

APPENDIX B

September 18, 2007 • Vol. 92 No. 38 THE BASIN'S NEWSPAPER www.ubstandard.com •

TEMPLE MOUNTAIN ENERGY ON ASPHALT RIDGE

Commercial oil sand venture begins

By Lezlee E. Whiting

Utah is home to 24 billion plus barrels of oil sand reserves, and much of those reserves lie in the Uintah Basin with 1 billion barrels along located along Asphalt Ridge. In 2008, Temple Mountain Energy (TME) will begin commercial production of 150 million barrels of proven oil reserves based on its pilot project located in Uintah County.

Larry Clynch, CEO of the Minnesota-based company that specializes in unconventional fuels, said Temple Mountain's innovative oil sands development process has proven technical solutions to tap into the vast domestic petroleum reserves lying idle just outside Vernal.

"This is a different market place than ever before, caused by high demands from China and India."

– Larry Clynch, CEO Temple Mountain Energy

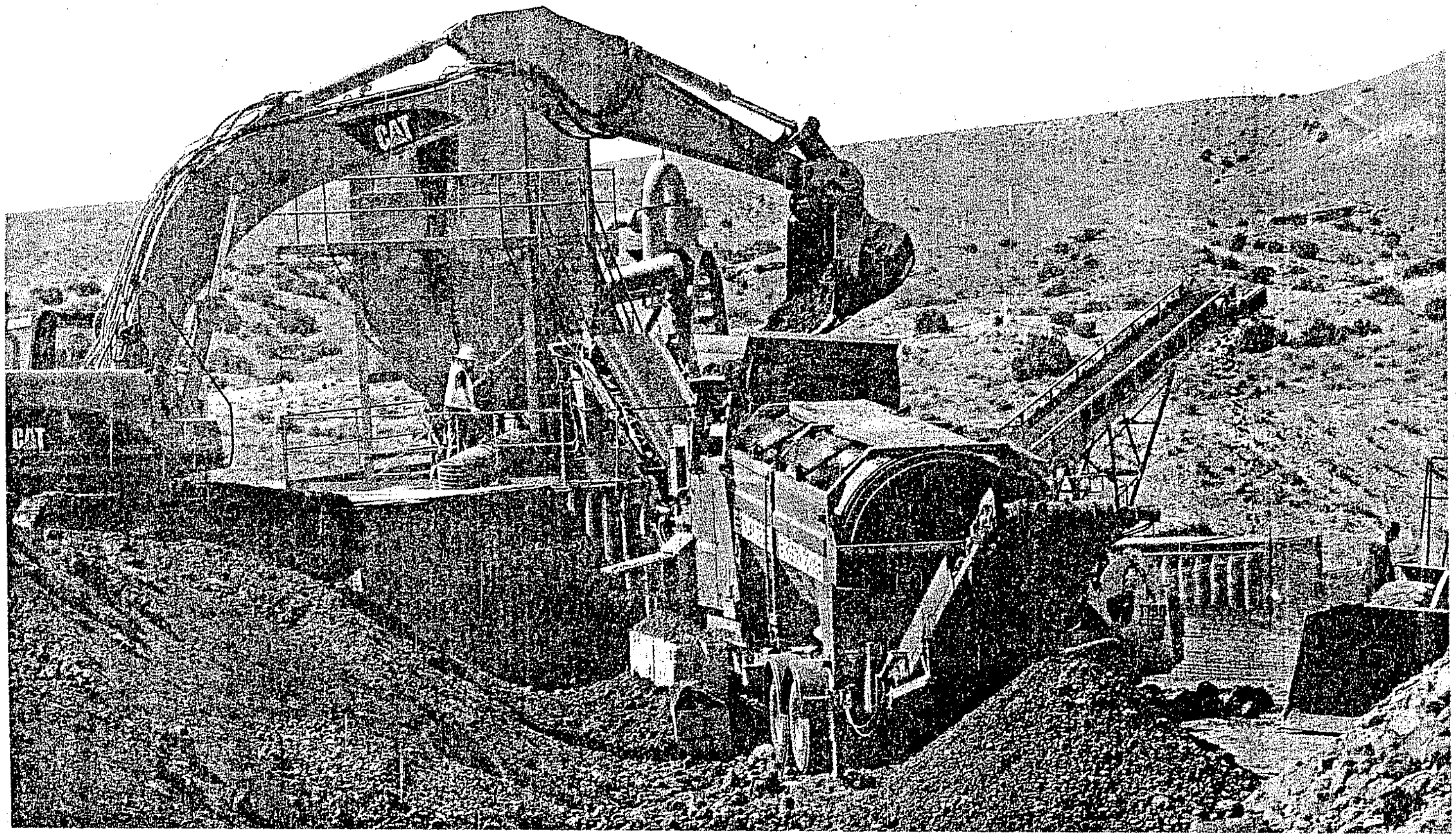
Commercial Production

"With the completion of design, engineering and economic evaluation, TME is ready to construct the first production module on the site in 2008 along side its pilot plant," said Clynch, who has 40 years of a wide range of experience in crude oil operations in both the U.S. and Russia including pipelines and terminals.

Temple Mountain has been operating on two small mine permits and its pilot plant since June on their leases 7 miles south of Vernal. A large mine permit is in process of approval by the State of Utah.

During a tour last Tuesday of the pilot production and mining site, Clynch told government officials, investors, industry analysts, community and academic leaders that the pilot project has

SEE OIL SANDS on page 5



Duchesne Fire SS won't have tax po

VOTE POSTPONED FOR CO FIRE, EMERGENCY DISTR

By Preston McConkie

Two Duchesne County commissioners assured the public that a proposed special service district for fire, emergency and ambulance services would not be supported by taxes, but postponed a vote to place the proposed district on the November ballot when they could not answer specific questions about what the resolution said.

As currently worded, the resolution for a fire, emergency and ambulance services district would empower the commission to levy taxes to support it, though commissioners Kirk Wood and Rod Harrison said the commission only intends to use mineral lease money to pay for increased emergency protection. The resolution says the district would be authorized to **"annually impose fees and charges to pay for all or a part of the services to be provided by the District" and that it "may also receive federal mineral lease funds."**

Commissioners explained last Monday that the SSD had to be legally formed be be used to redirec mineral leases.

Asked what wc mineral lease mo Harrison respond have to cross that we come to it." H "We don't want it entity."

Wood agreed rent commission the district to cre obligations to a county.

Uintah Basin ter Assistant A Roger Marrett, the meeting said, the district's crea sought, despite his for the county's o service. Marrett as be deciding how t spent.

"I met with the chiefs and charg task of deciding money would be u responded. "Som

SEE FIRE

DOCTORS' DEPARTU LEAVE QUESTION

Services for vet

OIL SANDS

Continued from page 1

enjoyed tremendous success at the economic level by producing an array of products from the oil sands, while remaining environmentally sound.

The pilot plant, expected to be in full operation by December, will process 100 tons of oil sands an hour. Starting next year, four production modules will follow – one every six months, capable of processing 250 tons of oil sands per hour each, working 20-hour days, for a full production capacity of 1,000 tons per hour.

Temple Mountain holds leases on 1,280 acres on Asphalt Ridge presently – where there are 150 million barrels of known oil sands reserves in place. The large mine permit for the commercial mining operation covering 300 acres,

More than 80 million barrels are surface-mineable oil, said Clynch. That means the deposits are found at or just below the surface and are up to 200 feet thick.

This is not the first continuous oil sands production in the U.S., but it is the first of its size that uses technology that has its grounding in soil reclamation from difficult sites to process the oil sands. In the most simplistic of terms, the process involves separating oil from sand through a highly technical system that employs water, vibration and flotation.

The process used by TME needs little or no heat or steam, thereby reducing cost. Water is used in a closed-loop system, which allows 85 percent to be recycled. The 15 percent water loss is evaporation and water that is held by the resulting clean sand.

The low sulfur content in oil sands on Asphalt Ridge makes it even more desirable. Oil sands in Alberta, Canada, have high sulfur content.

A New Generation

"Temple Mountain Energy first got involved with solving the high viscosity problem with heavy oil production and then realized it also has solutions for oil sands production," said Jim Runquist, TME board chairman.

The company conducts its business in a way that "minimizes their carbon footprint." The technology itself doesn't produce a negative impact on the environment in the production or manufacturing phases, said Clynch, noting that because of the closed-loop system, there are no carbon dioxide or other emissions as a result of the separation process.

The company's separation and reclamation process was designed by David Bower who has spent the last 15 years designing, building and operating soil reclamation and clean-up projects in the global market, predominantly in Europe. These techniques have been used successfully in Europe for years.

Bower, who is vice president of technology and processes for TME is a native of Great Britain, and still calls it home, splitting his time between Vernal, Minnesota and Nottingham, England.

"The Europeans are approximately 10 to 15 years ahead of us in the soil remediation industry because of the excessive environmental regulation," said Runquist.

The commercial venture is of great importance, not only to TME's future in terms of economic success, technology development and production viability, but to the nation's future as it struggles to loosen the grip of dependence on foreign oil.

At its peak, the commercial plant will have the ability to process 1,000 tons per hour of oil sands every hour and there is approximately half a barrel of bitumen oil per ton of oil sands. The recovery project has an estimated life-span of 15 to 20 years.

Temple Mountain's pilot plant is capable of operating five days a week, eight hours a day. Next year, a second shift will be added, said Clynch.

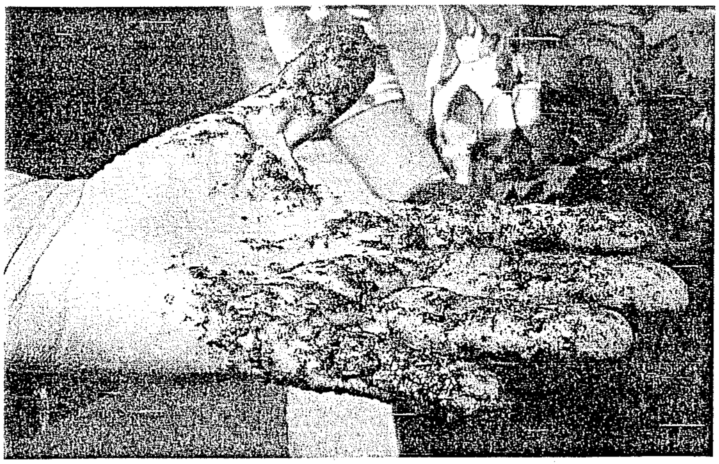
"Temple Mountain is part of a new generation of emerging energy companies, working collaboratively with both federal and state government prior to operation and larger energy companies to tap the potential of crude oil left stranded by a domestic petroleum industry in transition," said Runquist.

While Temple Mountain is intent on helping the nation reduce their dependence on foreign oil, they haven't put all their proverbial eggs in one basket.

"We didn't want to be locked into strictly the crude oil market," said Clynch. "We have a very good market for everything we can make. This is a different market place then ever before, caused by high demands from China and India."

The company's mining, processing and logistics (storage, transportation and sales) operations means even more jobs – some 250 – that may be added to the Basin's booming economy.

Bill Johnson, director of energy development for Uintah County, said Temple Mountain's commercial venture will have untold financial benefits for the county.



This hand is covered with bitumen – the sticky, oily component of oil sand. Paving companies in Salt Lake City are paying $500 a ton for raw bitumen for use as a component in asphalt mixtures.

RECYCLING

Continued from page 1

his company doesn't have enough room or equipment to have a truck sitting around waiting to be filled with plastic or paper.

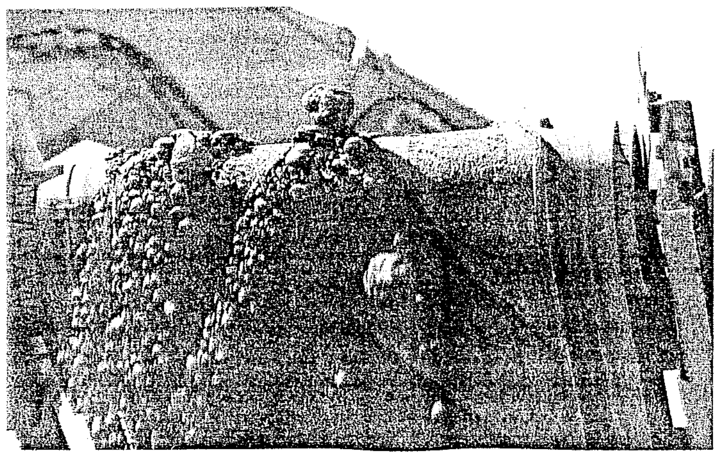
Much of the garbage collected by K & K is taken to the Duchesne Landfill 10 miles north of Duchesne on the road to Altamont. Giles has spent 15 years working at the collection site. He sees three or four semi-trucks hauling close to 18 tons a piece pull in from Duchesne County locations. Wasatch County, which owns half of this particular landfill, brings in approximately four to six trucks of the same size to be emptied.

Shirin Spangenberg, who, with her husband Dirk, owns they come by the center and drop off their own," said Spangenberg, defending the low percentage of users. She admitted, however, that her company makes its money in the hauling. "The center isn't paying for itself. There just isn't enough profit margin."

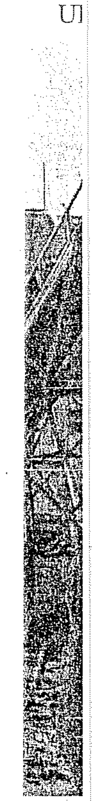
Nevertheless, Spangenberg wants Basin residents to know that there is not a fee to drop off recyclables.

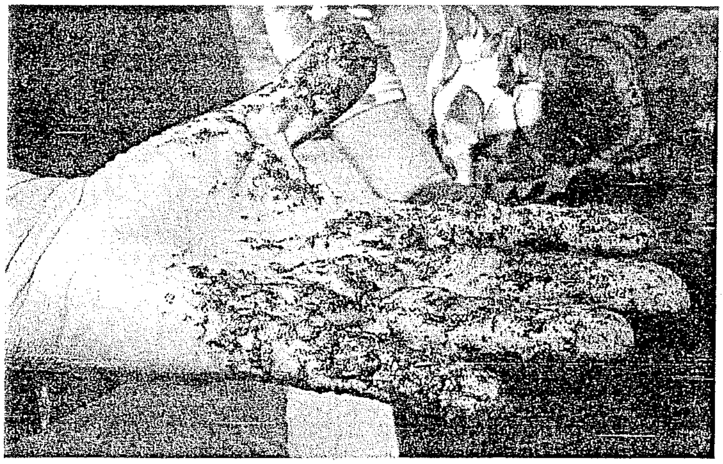
"We want to get it all to a home and reuse it," Spangenberg echoes what recycling enthusiasts have been promoting. "The real argument is, 'Why are we throwing things away after using them only one time?'"

For many people the money has never been the obvious incentive, but rather a strong desire to



This conveyor belt carries oil sands up to the processing units of a pilot plant that cleans and converts the sands for use as crude oil, frac sand, and bitumen. Temple Mountain Energy's





This hand is covered with bitumen – the sticky, oily component of oil sand. Paving companies in Salt Lake City are paying $500 a ton for raw bitumen for use as a component in asphalt mixtures.

mately 10 to 15 years ahead of us in the soil remediation industry because of the excessive environmental regulation," said Runquist.

The commercial venture is of great importance, not only to TME's future in terms of economic success, technology development and production viability, but to the nation's future as it struggles to loosen the grip of dependence on foreign oil.

At its peak, the commercial plant will have the ability to process 1,000 tons per hour of oil sands every hour and there is approximately half a barrel of bitumen oil per ton of oil sands. The recovery project has an estimated life-span of 15 to 20 years.

Temple Mountain's pilot plant is capable of operating five days a week, eight hours a day. Next year, a second shift will be added, said Clynch.

"Temple Mountain is part of a new generation of emerging energy companies, working collaboratively with both federal and state government prior to operation and larger energy companies to tap the potential of crude oil left stranded by a domestic petroleum industry in transition," said Runquist.

While Temple Mountain is intent on helping the nation reduce their dependence on foreign oil, they haven't put all their proverbial eggs in one basket.

"We didn't want to be locked into strictly the crude oil market," said Clynch. "We have a very good market for everything we can make. This is a different market place then ever before, caused by high demands from China and India."

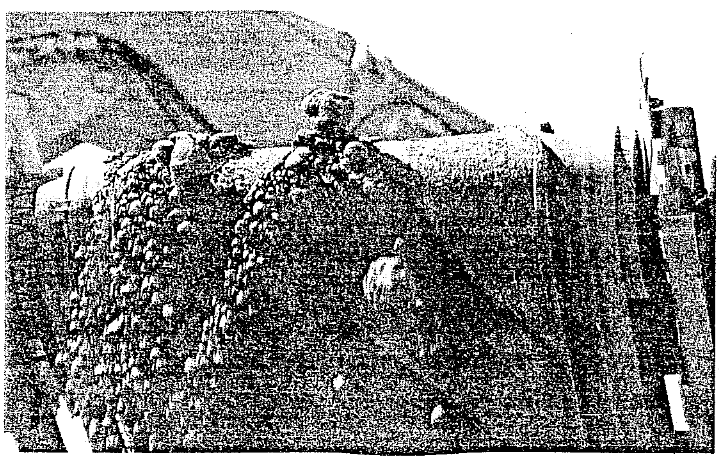
The company's mining, processing and logistics (storage, transportation and sales) operations means even more jobs – some 250 – that may be added to the Basin's booming economy.

Bill Johnson, director of energy development for Uintah County, said Temple Mountain's commercial venture will have untold financial benefits for the county.

Officials from Temple Mountain Energy hosted a tour of their oil sands processing pilot plant last week and announced the beginning of large-scale commercial continuous production of low-sulfur crude oil from oil sands early next year. Crude oil is just one product of oil sands that will be processed on Asphalt Ridge.

"It's huge because of the potential economic impact, there will be jobs and taxes that will roll back in," said Johnson. "There are also spin-off energy companies that could base out of here. At this point it's a value you can't get a handle on."

This is the second time the county has had an oil sand project. A few years ago CROWN Energy built a pilot plant that is now defunct. Commercial production never got underway.



This conveyor belt carries oil sands up to the processing units of a pilot plant that cleans and converts the sands for use as crude oil, frac sand, and bitumen. Temple Mountain Energy's operations at Asphalt Ridge in Uintah County will soon begin

Comment wanted on measures to curb deaths during pandemic

The Utah Department of Health has posted information on its Web site outlining recommendations that may be implemented during an influenza pandemic.

The issue has been studied and debated by many over the past year and state health officials believe these steps will be important to reduce the number of deaths in Utah.

A study published in the Aug. 8 issue of the Journal of the American Medical Association looked at public records from the 1918-1919 influenza pandemic. That study demonstrated that school closures and other community strategies were the most effective in reducing the possibility of spreading disease between people during an epidemic.

"Communities that were measures," according to Dr. Robert Rolfs, state epidemiologist. "These strategies are particularly important because the intervention most likely to provide the best protection against pandemic influenza, a vaccine, will most likely not be available at the beginning of the outbreak."

Rolfs said in order for the proposed restrictions to be most effective, health officials have to rely on the public's willingness to make some substantial changes in day-to-day life.

"We hope that people will look at the restrictions, learn about what they'll need to do during the next pandemic, and tell us if we need to make any changes for this plan to work," Rolfs said.

To read and make comments

deseretnews.com

Deseret Morning News, Wednesday, January 31, 2007

Oil-shale project nears Uintah test phase

By Lezlee E. Whiting
For the Deseret Morning News

VERNAL — A unique project that ultimately expects to prove that oil can be economically extracted from shale rock is moving closer to its test phase.

The public comment period is complete, and following the release of an environmental assessment by the Bureau of Land Management's Washington, D.C., office, Oil Shale Exploration Co. anticipates signing a lease for 160 acres of federal land in Uintah County.

"The lease is in the system, and we believe that signing is imminent," said Amy Hansen, a consultant with Georgia-based OSEC. "After that our goal is to get 1,000 tons of shale to Calgary, Canada."

In Calgary the shale from the existing White River mine in northern Uintah County will be put through myriad analyses while tests are performed on the rock as it is processed in a pilot plant through the ATP (Alberta Taciuk Process) — the state-of-the-art retort technology approved for use in the initial run-through, Hansen said.

"Every shale property is different, so they will test it and make minor adjustments based on water weight and geological water weight," she said. "We are hoping that within six months or near that time we will ship the pilot plant to the White River mine and set up a 65-barrel-a-day pilot plant on site in Uintah County."

The BLM awarded environmental approval to three oil companies in Colorado last August, giving the green light to their plans to produce oil from shale. In Colorado, the extraction process involves heating layers of rock using electric oven-like elements, steam injection or hot natural gas.

Both the Colorado and Utah shale projects are on the BLM's "fast track" in terms of moving through red tape and bureaucracy. Utah's project is lagging a bit behind Colorado because it had an extra step to go through when more than one company bid on the lease rights. In addition, Utah's is the only mining project where the oil shale will be brought to the surface, crushed into gravel and fed into a facility known as a "retort." The retort process allows shale to be heated and converted into a petroleum product.

In both states, the mandated "research, development and demonstration" process will ensure that the projects are economically viable before any commercial production can begin. "Economics is always a concern, that is why we are going through this research development process with the BLM. ... We can take our time through the phases to look at it," Hansen said.

The phased approach allows environmental effects to be tested and assessed in a controlled setting, prior to determining if commercial operations should be authorized. A 30-day public comment on environmental concerns recently ended.

C. Stephen Allred, assistant secretary of interior, land and minerals management, is expected to sign the EA soon, said BLM environmental coordinator Stephanie Howard.

One crucial aspect the EA will address — that of cultural resources at the site — was documented and addressed in the late 1970s.

The BLM also had a great deal of information already assembled on ways to deal with the estimated 1.2 million tons of "spent shale" that will be produced during the life of the project, according to Howard. The spent shale that becomes a byproduct of the retort process is chalky, and when wet it turns hard, but it is easily broken so it would not be useful as a cement. Thirty-eight acres on the 160-acre lease site in Uintah County have been identified as suitable for disposal of the spent shale, Howard said.

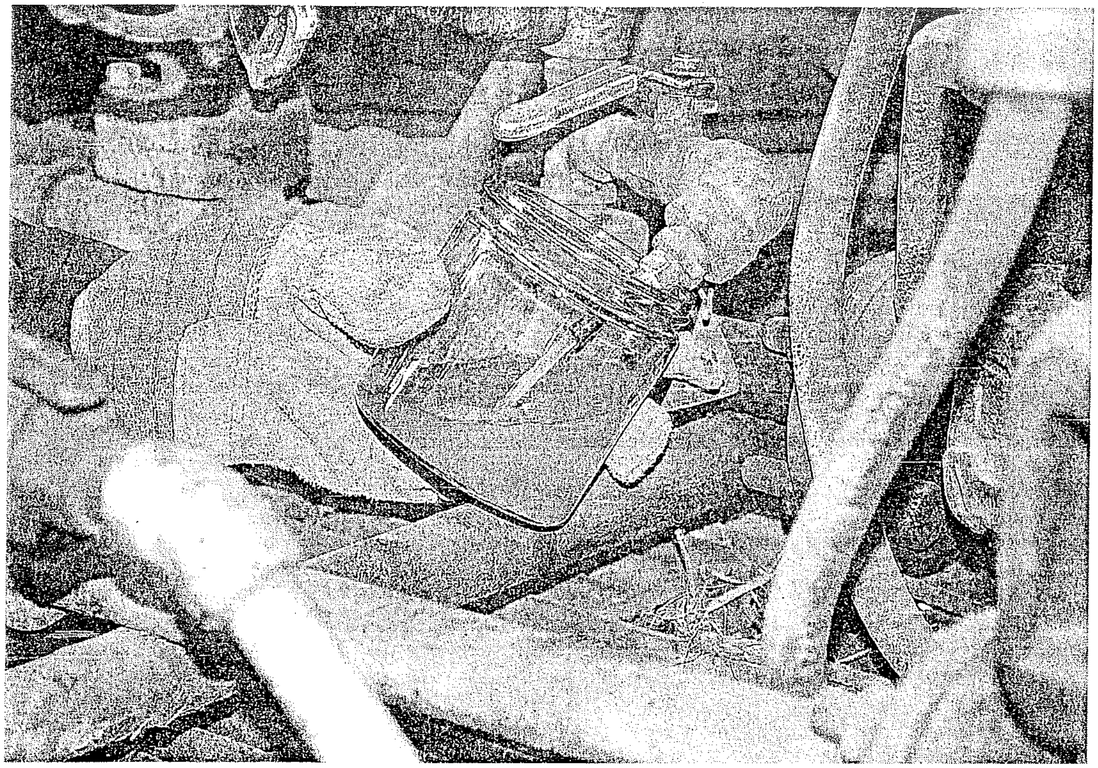
"If the spent shale is of such a quality that water getting into it will cause contaminants, then that area will be lined," she stated.

During the public comment period nine letters were submitted to the BLM and a total of 98 comments were included in those letters, Howard said.

Two main concerns dealt with air and water quality issues, Howard said. OSEC contracted with a third party to do the air quality modeling. Their findings were addressed and reviewed in the EA.

It's estimated that 172 million gallons of water — or an average of 220,000 gallons a day — will be needed over the life of the project, once it is up to full production, Howard said. Water will be taken from the White River.

E-mail: ubsnews@ubtanet.com



A worker fills a jar with oil extracted from oil shale taken from the White River Mine southeast of Vernal. Officials with Oil Shale Exploration Co. said last week initial tests confirm the shale will yield about 30 gallons of oil per ton.

White River oil shale tests confirm initial predictions

By Les Bowen
Uintah Basin News Service

Tests of oil shale at the White River Mine research facility have confirmed a yield of 30 gallons per ton from local shale, according to mine spokeswoman Amy Hansen.

The White River Mine site is leased from the Bureau of Land Management by the Oil Shale Exploration Co. based in Calgary, Canada, for research and development of oil shale. The program was allowed by the BLM under the 2005 Energy Act and permits companies to convert successful research and development projects to full-scale commercial operations.

An estimated 2 trillion barrels of oil resides in oil shale reserves over a 16,500-square-mile region in eastern Utah, western Wyoming and Colorado. An estimated 800 million barrels may be recoverable.

OSEC officials invited Basin representatives to its White River Mine facility earlier this month to see the oil-extraction process in action. Visitors reported positive results during last Monday's Uintah County Commission meeting.

According to information released by OSEC: "The rich oil shales of the Green River Formation will typically yield from 15 to 60 gallons of shale oil per ton of rock. The normal assay method is referred to as the Modified Fischer Assay. In the White River Mine the shale will average about 30 gallons per ton from a 58-foot mining zone."

OSEC's method of extraction involves the mining of oil shale before above ground processing. Other research and development projects currently underway involve the extraction of oil directly from the shale without removing it from the ground.

Sen. Kevin Van Tassell, R-Vernal, said he was impressed by his visit to the Canadian-owned processing facility. The senator noted how little energy was consumed in the extraction process. Other oil shale projects in the western U.S. use large amounts of energy to heat rock below the surface.

Van Tassel also said the diverse methods being researched by OSEC would likely result in more than one extraction method being used once full production gets underway at the mine.

White River's Hansen cautioned against reading too much into the test results. She said the results are preliminary and final figures from phase one tests will not be available until the end of the year.

Still, she said OSEC is in the process of obtaining the permits for phase two of the project. As part of the second phase, OSEC plans to bring a trailer-mounted processing facility from Canada to the White River Mine site.

"After three months of site preparation and setup, the plant will operate for 10 to 11 months," according to OSEC's press release. "Initially, shale will come from the surface stockpiles. Late in the program the oil shale will come from the reopened underground mine. Phase two will take about 14 months to complete."

OSEC anticipated that, at the final stages of operation, the company may temporarily employ several hundred people to haul material, transport extracted products, work underground and build and operate facilities at the mine site. In phase two, the company expects to employ 10 miners and 25 plant operators.

Teleth
Prof
anxi

By Lezlee E.

Dr. Kim
was an expe
who was sev
military whil
an airplane,
find a bette
mental heal
those who
where it is r
Openshaw, a
family and h
at Utah Sta
his theory to
selecting th
determine if
sisted interv
feasible way
suffering fro

"It is one t
in a metropo
is another th
get services
far away," sa

Tel
Depre

Openshaw
simple one. C
cameras wer
USU-Uintah
in Vernal an
a room on t
Through the
munications
with their t
face" without
of long-distar

"This new
therapists lo
reach out to
via a telethera
to as techn
intervention
shaw. "TAI pe
at a remote l
time, speak w
TAI also all
and client to
draw out dia
lists."

TAI makes
and available
"as people l
experience it
acceptable."

In his firs
ago Opensh
women who w
depression a
participate in
seling session
telecommuni

Seventeen
esne and Uin
ticipated in t
vast majority
changes," ac
shaw.

THE DARK MAGIC OF OIL SANDS

Canada's Alberta province has oil reserves second only to Saudi Arabia's, but they're not a liquid asset. We visit Fort McMurray, the boomtown where oil-rich sands are mined--and a black-gold rush is on.

By ABRAHM LUSTGARTEN
October 3, 2005

FORTUNE

(FORTUNE Magazine) –

Pedro Mujica settles in low over home plate, his golden Caracas jersey fluttering in the wind. The pitch comes in fast, and Mujica swings, lining the softball to left field. "Aut, aut," a throng of Venezuelan and Colombian players chant from the sidelines as Mujica is tagged out sliding into second.

It's a familiar scene, except that this August day is cold and blustery, and the field we're on is far from South America--about as far north as you can get and still play ball. It might seem strange to find 40 families from Venezuela living here in Fort McMurray, Alberta, a former fur-trading outpost closer to the Arctic Circle than to the northern border of the U.S. But lately people have been flooding in from places like Newfoundland and South Africa and Indonesia. "They've given me a second chance here," says Mujica, who lost his engineering job in Venezuela when Hugo Chavez came to power in 1998 and who was hired by Shell Canada in January.

More from FORTUNE

Global 500: World's largest companies

Blair drops in on the ultimate networking party

iMeme: Most 'infectious' ideas

FORTUNE 500

Current Issue

Subscribe to Fortune

Downtown Fort McMurray, where residential side streets hang like fish bones off a strip-mall spine, is bursting. Buying a cup of coffee at Starbucks can take 45 minutes, and bars like Diggers and the Oil Can are packed most nights. New F-150s, Durangos, and Excursions fill the parking lots, and it's not just workers who are coming. It's investment dollars, international corporations, and entrepreneurs, all looking for a stake in Canada's booming oil-sands industry.

Unlike the smooth crude oil that spurts from wells in Kuwait and Texas, oil sands are essentially black mud. "It's like you took a bucket of sand and dumped your old motor oil in it," says Peter Duggan, a manager at the Aurora mine, which is operated by Syncrude, a partnership of Exxon, ConocoPhillips, and several other companies. Through a complicated series of steps (see following diagram) the mud is transformed into gas you can put in your car.

Canadian companies have been mining Alberta's oil sands for nearly 40 years, but since production costs run seven times higher than for the cheapest conventional crude, the frenzy didn't really get going until oil prices spiked. "The oil-sands potential is huge," says Frederick Lawrence, a vice president of the Independent Petroleum Association of America. Oil & Gas Journal estimates that Alberta has 174.5 billion barrels of recoverable reserves in its oil sands, enough to meet Canada's needs for 250 years. That figure is second only to Saudi Arabia's estimated reserves of 264 billion barrels. All told, including deposits beyond the reach of today's technology, there could be 1.6 trillion barrels of oil embedded in Alberta.

The race to lock up those riches has begun in earnest. "The oil sands is the most significant development in crude oil in North America and one of the most significant worldwide," says Richard Kinder, CEO of the American pipeline company Kinder Morgan, which last month agreed to pay $5.6 billion for Canadian tar-sands player Terasen. "We've been looking for the right way in for a year." The day after that deal was announced, French oil giant Total put down $1.1 billion for Deer Creek Energy, another Canadian company. Those buys follow a string of new Chinese stakes: Sinopec acquired 40% of Synenco in May, and CNOOC invested in MEG Energy as well as in a pipeline project.

China's investments in the sector, about $255 million, are little more than a dabble so far, but a proposed venture with Canadian pipeline builder Enbridge to pipe 400,000 barrels a day from Fort McMurray to a Pacific port is widely believed to have caught Washington's attention. In July, Treasury Secretary John Snow toured the area. In August a delegation of U.S. Senators paid a visit. And Vice President Dick Cheney had scheduled a September trip before Hurricane Katrina forced him to change plans. Canada sends two million barrels a day to the U.S., from both oil sands and conventional drilling sites. That accounts for almost 16% of U.S. imports and 99% of Canada's oil exports. As Robert Esser, director of global oil and gas resources at Cambridge Energy Research Associates, puts it, Canada is the only U.S.-friendly country on earth where lots more oil is expected to come online. The White House's 2001 report on national energy policy, spearheaded by Cheney, called Canada's oil sands "a pillar of sustained North American energy and economic security."

In this context, the likelihood of increased Chinese investment--possibly leading to an acquisition of Canada's Suncor Energy, the pioneer in oil-sands development and one of the last companies still up for grabs--gives some observers pause. "If we have to share this oil with China, we are going to have to pick up the slack somewhere else," says Gal Luft, co-director of the Institute for the Analysis of Global Security, a Washington think tank. "That will be the Mideast, and that becomes a national security issue."

The oil sands are only a small piece of America's energy puzzle. But with production expected to triple to three million barrels a day by 2020, it's an important one. Over the same period, U.S. domestic production is projected to fall, and the U.S. is clearly anxious to protect its backyard supply lines. Congressional delegations are new to the oil-sands patch, which has historically been considered a quixotic bet suited only to high-stakes mavericks. Since the mid-1980s, though, incremental improvements have driven down the cost of production from $30 a barrel to $20, according to Neil Camarta, senior vice president of oil sands for Shell Canada, the lead partner in Albian Sands, along with Chevron Canada and Western Oil Sands, a Canadian company. That's still a lot compared with the $3 it takes to produce a barrel in parts of the Middle East. But with costs coming down, technology improving, and the price of oil rising, the oil sands are becoming downright mainstream. More than a dozen companies are planning to spend $60 billion on new projects and expansions over the next decade.

To call what's happening in Fort McMurray a boom implies an inevitable bust, and that rankles local leaders. "This is something that will help define Canada's economy for 50-plus years," says Steve Williams, executive vice president for oil sands at Suncor. But plenty could go wrong. The mining and upgrading processes rely heavily on natural gas--as much as the equivalent of a fifth of a barrel of oil is required to extract one barrel from the sands. So a combination of lower crude prices and higher natural-gas prices would be devastating.

Fort McMurray also faces a critical shortage of labor, especially to meet the more optimistic forecasts, which stretch as high as 11 million barrels a day by 2047. And there are real questions about what level of growth the town can sustain. Its schools and health-care system are already under stress, and the planned expansions will further strain sewage-treatment facilities, air quality, and the region's environment. On a national scale, higher emissions related to oil-sands growth could undermine Canada's commitment to the Kyoto accord.

Alberta's oil sands lie like a black ribbon across a 120-million-year-old seashore, now buried below lush wetlands and virgin boreal forest. Where the Athabasca River Valley cuts deep into that ribbon, the sands near the surface can be strip-mined, cleaned, and transformed into a stiff tar called bitumen. But as much as 80% of Alberta's recoverable reserves lie deeper. They have to be coaxed out of the ground by costly in situ technologies, in which the sand is heated with steam until the oil drips off it and can be sucked out.

From atop the crumbling rim of Syncrude's Aurora mine, 40 miles north of Fort McMurray, one peers into a dark hole, two miles wide and a mile and a half long, that cuts nearly 200 feet into the limestone bedrock. From the sides of the mine, mechanical shovels claw black blocks that resemble chunks of city pavement. The cargo is loaded into dozens of dump trucks that look like ants as they ferry loads up ramping roads to crushers that break the clumps into small pieces, mix them with a watery slurry, and shoot the stuff through a pipeline for separation and eventual upgrading into real oil. It is an expensive, environmentally brutal, and time-consuming process. From the time the first shovel is turned for an oil-sands facility, it takes about seven years to see the first barrel of oil.

When you descend into the depths of the pit, the gargantuan scale of the operation becomes apparent. Duggan's Chevy Suburban shudders on a corduroy road imprinted by tire treads; mounted on his rear bumper is a six-foot-high orange flag, or buggy whip, so he won't be run over. These dump trucks are the largest vehicles in the world. Their tires, weighing 40,000 pounds each, are 14 feet tall, and you have to climb two flights of stairs to reach the driver's seat. In the cab of one of those trucks, operator Jim Locke shouts over the roar as the tractor's 3,700 horses strain under the 397 tons of dirt in the cargo box. Steering the truck, he says, is "like coming home, walking up two flights of stairs to your third-floor bedroom, then driving your house downtown."

The scale of this machinery and the mobility of the trucks have helped drive down production costs. "This is a widget business," Shell's Camarta says. "The bitumen molecule--you tear it out of the ground, knock the sand off it, and sell it to a refinery. There's a lot of steps in there, and the more efficient and reliable I can make them, the more the unit costs come down." The bucket wheels and conveyor belts of old have been replaced with more flexible trucks and mechanical shovels; upgraders have begun to reuse byproducts and filter emissions; and production, which has nearly doubled since 2001, is finally at a volume that makes the oil sands worthwhile. Whether production is profitable when oil is at $27 a barrel, as the industry claims, is debatable, but at $65, it's a clear winner.

When Oil & Gas Journal, a respected industry publication that ranks world reserves, recognized Alberta's estimates in 2003, the deposit gained credibility. That was an important factor in attracting new investment, according to Alberta energy minister Greg Melchin. Each of the established companies is in the midst of a major expansion project. But to make all this happen, the industry will need 30,000 new employees. It is recruiting in South America, flying in commuters from New Brunswick, and paying bonuses that draw oil workers like Mujica from around the world. "We're looking for 700 people a year, each year, for the next ten years," says Shell spokesperson Janet Annesely. "That's a recruiting machine."

The growth puts a steady pressure on Fort McMurray. At 5:30 A.M. at the Tim Hortons doughnut shop, there's a line out the door. The waitresses' T-shirts say JOIN US--a nod to understaffing's role in the long wait. It's the same story at McDonald's, Safeway, Starbucks. Wal-Mart recently installed automated checkout counters. And it's not just retail staff; there's a shortage of doctors and government employees too.

In 1961, six years before Suncor began mining, Fort McMurray had 1,100 residents. In 1996 there were 36,000. Now there are 61,000, a figure that could reach 100,000 in a few years--a rate of growth far beyond what the city ever expected to absorb. The highway that runs though the region got a second lane a few years ago, but the community remains short on traffic lights, sewage capacity, classrooms, and emergency-room beds. The housing vacancy rate is near zero. "If we're going to be a city of 100,000 people, we have to look like a city, not a mining town. That's a big shift to make," says the region's planning superintendent, Beth Sanders.

When Suncor recruited Ana Sanchez from her job at Venezuela's PDVSA, the toughest part of her move was finding a place to live. A one-bedroom apartment in Fort McMurray can rent for $1,700 a month, and the average cost of a new home has doubled in the past two years, to north of $360,000. "We must have bid on ten houses before we got this one," says her husband, José DeSilva, standing in their new three-bedroom house with fresh, green sod out front. The couple, both 31, and their baby daughter moved to Fort McMurray last November. They learned tough lessons about winter living--things like how to plug in your car and why you shouldn't touch your tongue to a metal railing. They also learned how to bid if they wanted a house. "We heard about it New Year's Eve and made an offer the next morning," DeSilva says.

While Sanchez went straight to work, DeSilva enrolled in English classes. There he met a diverse group of students from as far away as China. Each aspired to learn enough English to be able to work in the oil-sands business. Industry wages are good--chemical engineers like Sanchez can make up to $100,000--but most other jobs in town barely cover living costs.

That doesn't stop people from coming. Brian Wonnocott, 22, clean-cut and baby-faced, moved here on a whim in July from Blackstock, Ontario. "My first impression was, 'Nice scenery--there's not much to do,'" he says. "After a few days I started thinking I'd made a mistake." But in a boomtown, top jobs often go to those who show up at the right time. By the start of his third week, Wonnocott had five offers, some for as much as $27 an hour. His eyes light up as he recounts the sum--"a pantload of money." The job he took, driving a bulldozer for a Suncor contractor, was offered to him on the spot. "They're like, 'That guy didn't come in. Can you handle a loader?'" he says. To double down on his luck, Wonnocott now trades stock in Canada's oil companies. "It's nice to ride the coattails," he says.

What is talked about less often in a town reliant on oil and reveling in growth is the environmental price being extracted along with the sands. Fort McMurray is an oil town: Everyone either works in the industry or serves those who do. As investment pours in, though, the downsides of the industry are increasingly finding their way into discussion. On a recent August day thunderheads ran red with emissions that made a late-afternoon sky look like sunset, and local radio deejay Kyle Reedman took notice: "Hopefully they'll have come up with some magic technology that will just make all this stuff go away."

Producing oil from the tar sands is an energy-intensive process that puts a lot of bad stuff in the air. While companies have made progress reducing per-barrel emissions in recent years, they still spew out significant quantities of everything from benzene, a carcinogen, to lead. "At some point you will reach a tipping point, where there will be irreversible impacts to the people and species in the surrounding area," says Dan Woynillowicz, a researcher at the Pembina Institute for Appropriate Development, a Canadian think tank.

Top on the list of worries are greenhouse-gas emissions. The industry emits about 26 million metric tons of CO_2 per year, a figure that could grow to as much as 82 million metric tons by 2020, according to Bob Dunbar, president of Calgary oil-sands consulting firm Strategy West. Under the Kyoto Protocol, a global agreement to reduce greenhouse gases that Canada ratified (over strong objections from Alberta), the nation is obliged to reduce greenhouse-gas emissions to 6% below its 1990 level, or 560 million metric tons, by 2012. Total emissions in 2003 reached 740 million metric tons.

In April, Canada's federal government released a comprehensive $8.5 billion strategy for greenhouse-gas reductions that it says will more than do the job. Not everyone is convinced. "It's just not possible for the industry to grow the way it's been growing and for Canada to meet its commitments at the same time," says Dunbar, adding that only a hefty purchase of CO_2 credits would enable Canada to comply. Yet any trading mechanism for CO_2--Canada hopes to start one early next year--would probably raise the price of production for oil-sands companies. "Emissions are only going to go up multitudes, unless you want to shut it all down and put a sign up that says, WE'RE CLOSED," concludes energy minister Melchin. "That's not going to be our response. How do we stick to 1990 emissions levels when our population is greater and our opportunity is many times greater?"

What comes out of the smokestack is just one of the concerns. At a turnout a couple of miles before Highway 63 slices through the heart of Syncrude's operations, a trail leads off into young forest. Spruce, birch, and aspen have been planted here, and buffalo graze an idyllic pasture. This land was once a mine pit, and 20 years later, it is a small first model of how the earth can be restored. The oil companies are required to reclaim land disturbed by mining and have speeded up efforts to do so. But new mining operations are increasing much faster. And after 38 years of operations, not a single acre has been certified "restored" by the Canadian government.

A wooden lookout deck near the forest presents a different view: a panoramic expanse of tailings ponds--flat, brackish water held in by 100-foot-high levees. They stretch for miles. Roughly a dozen of these ponds are hidden from public view and road access, but satellite images reveal that their footprint can be as large as the city of Fort McMurray. They are the waste from a water-intensive process that can require an average of four barrels of water to produce one barrel of oil. (The industry's annual water allotment is enough for a city the size of Houston.) Improvements in technology are allowing much of that water to be cleaned up, but the cumulative effect--up to 15% of the flow of the Athabasca River--is huge. And because the wastewater is held in the ponds, very little is returned to nature.

It's not known exactly what will become of these ponds, which contain salts, trace metals, and oil. Along the levees, propane cannons fire at regular intervals. The cannon and scarecrows dressed in old mining uniforms (called bitu-men) are intended to ward off migrating birds. Some ponds are slowly being reclaimed, filled in with sand scrubbed clean as a white beach after the most toxic sediments are pumped into smaller ponds. The industry, which has made efforts to mitigate a wide range of environmental effects, plans to cap and seal these ponds with clay. But a 2004 study by Canada's National Energy Board says, "The ponds must be constructed to last indefinitely, [as] there is no demonstrated means to reclaim fluid fine tailings."

At Fort McKay, a tiny, palpably poor town of fewer than 500 people 30 miles north of Fort McMurray, the encroachment of oil is strongly felt. Fred MacDonald, a Metis tribal elder who lives in this First Nation community, used to fish from the shores of the Athabasca River and wander for weeks through the bogs of the boreal forest, laying traps for mink and beaver. The only use he had for the saturated sands was to waterproof his canoe.

Fort McKay used to be in wilderness, with miles between the community and the pits. Now the mines are closing in. From MacDonald's kitchen, a plume from Syncrude's Mildred Lake upgrader--the plant that converts the bitumen to synthetic crude oil--is visible 17 miles to the south. Directly behind the town is the new Total property. Canadian Natural Resources is investing $18.5 billion to develop 115,000 acres into a strip-mining operation that will compare with Syncrude's largest; next spring the company will begin landing four 737s a day there. Just across the river, Imperial Oil, an Exxon subsidiary, plans to open four mines on a similarly sized lease beginning in 2007, at a cost of $6.7 billion. And these are just the large projects. Some 40 new lease developments are also planned. Within a few years, Fort McKay will be surrounded.

Like the rest of the Alberta, whose strong growth has allowed the province to pay off debt and stash billions away, Fort McKay has reaped substantial economic benefit from oil sands. Syncrude makes a point of providing jobs to First Nation workers, and a handful of local companies have sprung up to service the industry. But the growth has begun to strike some people as overwhelming. "If they had just the few plants here, we could live with that," says MacDonald, who worked at Suncor for several years. "But it will never stop."

For now, exuberance about the area's new riches trumps the obstacles that might come the industry's way. Notes Michel Sauver, a doctor who has been outspoken about the effects of the oil boom: "This is a one-industry town." Concerns about civic infrastructure, finding labor, or stewardship of the land and water are running a distant second to a more tantalizing goal. Standing atop a mine pit, feet sinking into the mud amid the stench of hydrocarbons, Shell's Annesely fans the air with her hands. "Smell that?" she asks. "That's the smell of money."

FEEDBACK alustgarten@fortunemail.com

deseretnews.com

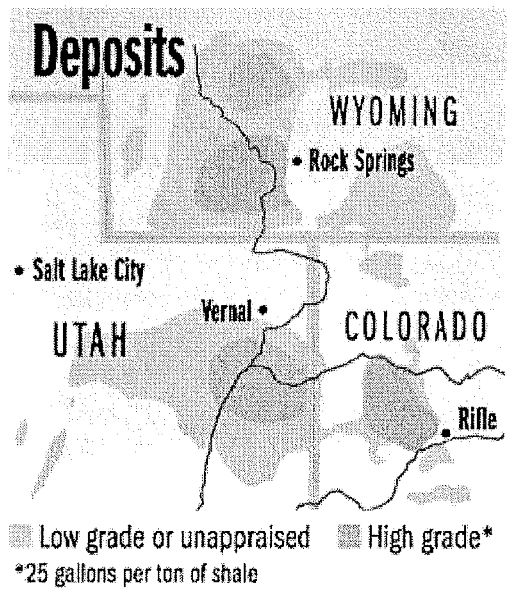
Deseret Morning News, Sunday, June 10, 2007

Oil shale — Colorado, Utah deposits rival OPEC reserve

By Joe Carroll
Bloomberg News

Colorado and Utah have as much oil as Saudi Arabia, Iran, Iraq, Venezuela, Nigeria, Kuwait, Libya, Angola, Algeria, Indonesia, Qatar and the United Arab Emirates combined.

That's not science fiction. Trapped in limestone up to 200 feet thick in the two Rocky Mountain states is enough so-called shale oil to rival OPEC and supply the U.S. for a century.



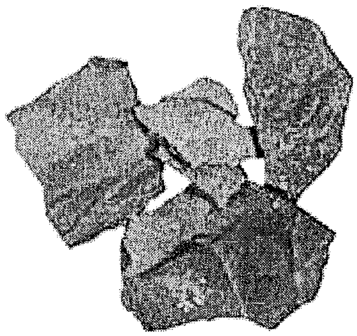
Exxon Mobil Corp. and Chevron Corp., the two biggest U.S. energy companies, and Royal Dutch Shell Plc are spending $100 million a year testing new methods to separate the oil from the stone for as little as $30 a barrel. A growing number of industry executives and analysts say new technology and persistently high prices make the idea feasible.

"The breakthrough is that now the oil companies have a way of getting this oil out of the ground without the massive energy and manpower costs that killed these projects in the 1970s," said Pete Stark, an analyst at IHS Inc., an Englewood, Colo., research firm. "All the shale rocks in the world are going to be revisited now to see how much oil they contain."

The U.S. imports two-thirds of its oil, spending $300 billion a year, or 40 percent of the record trade deficit. Every $10 increase in a barrel of crude costs an American household $700 a year, according to the Rand Corp., founded in 1946 to provide research for the U.S. military. Oil prices have risen 63 percent since 2004, and higher fuel costs have slowed growth in the world's largest economy to the lowest in four years.

The last effort to exploit the Colorado and Utah shale fields foundered in the 1980s after crude prices tumbled 72 percent, resulting in a multibillion-dollar loss for Exxon. Techniques developed to coax crude from tar sands in Alberta, 1,600 miles to the north, may help the U.S. projects' engineers.

"The potential for shale is large," said Joseph Stanislaw, senior energy adviser for Deloitte & Touche LLP and co-author with oil analyst Daniel Yergin of "The Commanding Heights: The Battle for the World Economy" (Simon & Schuster, 464 pages, $26). "Assuming the technology proves out, the size and scale of the reserves are significant."



Energy providers are investing in shale oil production because the reserves are large enough to generate higher returns than smaller fields in Oklahoma and Texas, where output is declining after eight decades.

Shale is also a more attractive investment than new U.S. refineries, which Shell and Chevron say may lose money as rising use of crop-based fuels such as ethanol lowers domestic gasoline demand. Exxon says it isn't interested in building new fuel plants in the U.S. because the company expects North American fuel consumption to peak by 2025.

"You're going to build refineries where demand is increasing, and that's the developing world," Scott Nauman, Exxon's manager of economics and energy planning, said in a May 18 presentation at a University of Chicago oil conference.

Shell's project

In the high desert near Rifle, Colo., Shell engineers are burying hundreds of steel rods 2,000 feet underground that will heat the shale to 700 degrees Fahrenheit, a temperature at which Teflon melts.

The heat will be applied for the next four years to convert the hydrocarbons from dead plants and plankton, once part of a prehistoric lake, into high-quality crude that is equal parts jet fuel, diesel and naphtha, the main ingredient in gasoline.

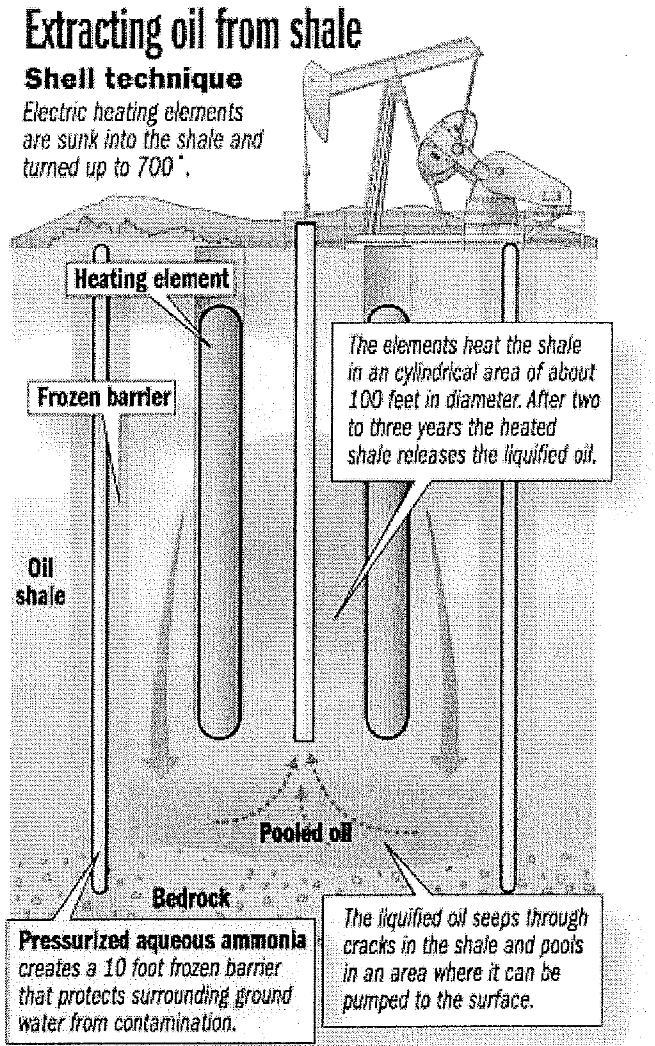
Chevron, which helped build the Saudi Arabian energy industry when it struck oil in the kingdom in 1938, plans to shatter 200-foot thick layers of shale deep underground, said Robert Lestz, the company's oil-shale technology manager.

Rather than using heat to transform the shale into crude, Chevron plans to saturate the rubble with chemicals to convert it. The method will reduce power needs and production costs, Lestz said in a May 24 interview. Using chemical reactions to get oil from shale also means fewer byproducts such as ash and fewer greenhouse gases, he said.

Chevron scientists are working with researchers at the Los Alamos National Laboratory in New Mexico to determine which chemicals work best for converting shale to crude oil. Shell's heating technique amounts to "a brute-force approach," said Lestz, who is based in Houston.

Raytheon Co., the maker of Tomahawk missiles and the first microwave ovens, is developing a process that would use radio waves to cook the shale.

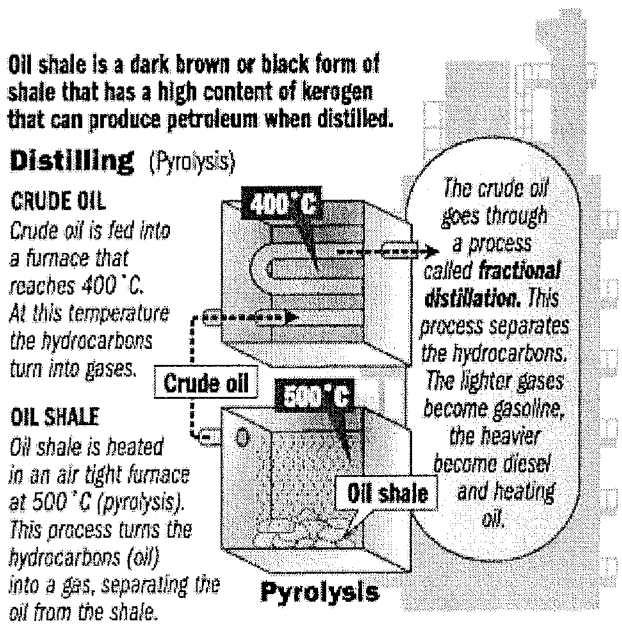
Exxon Mobil, based in Irving, Texas, plans to shoot particles of petroleum coke, a waste by-product of oil refining, into cracks in the shale. The coke will be electrically charged to create a subterranean hot plate that will cook the shale until it turns into crude. The company declined to discuss the progress of its oil shale tests.



'Oil is here'

"These are quite remarkable technological approaches," said Jeremy Boak, a geologist at the Colorado School of Mines in Golden, Colo., who spent 11 years cleaning up radioactive waste and disposing of weapons-grade plutonium at U.S. government sites. "The oil companies don't have the exploration problem of finding resources to drill. We know the oil is here. It's just a matter of getting it out."

U.S. oil shale deposits likely hold 1.5 trillion barrels of oil, according to Jack Dyni, a geologist emeritus at the U.S. Geological Survey. All 12 OPEC countries combined have proved crude oil reserves of about 911 billion barrels, led by Saudi Arabia, with 264.2 billion barrels, according to statistics compiled by BP Plc.



Skeptics of the potential for shale oil include Cathy Kay, an organizer for the environmental group Western Colorado Congress, who says the techniques will drain water supplies, scar the landscape and require so much power the skies will be choked with smoke from coal-fed generators.

"They are going to do absolutely massive environmental damage," said Kay, a South Africa native who's been spearheading the Grand Junction, Colo., group's anti-shale campaign since September.

"Why don't these companies invest these giant sums of money developing the cheapest, cleverest solar panel or geothermal process, instead of chasing this elusive oil?" Kay asked.

Shell, based in the Hague, estimates it can extract oil from Colorado shale for $30 a barrel, less than half the recent price of about $66 for benchmark New York futures.

Shell's process includes surrounding each shale field with an underground wall of ice. The so-called freeze walls are to prevent groundwater from swamping the heating rods and to protect the local water supply from contamination as the organic material in the rocks turns to oil, according to Terry O'Connor, the Shell vice president in charge of the company's Colorado shale project.

500,000 barrels

"There's a lot of testing to be done," O'Connor said in a May 24 interview. "We're proceeding cautiously."

O'Connor declined to say how much oil Shell expects it could produce from shale. Stark at IHS and other analysts said Shell expects to get 500,000 barrels a day from its project, 25 percent more than comes from Alaska's Prudhoe Bay, the largest U.S. oil field.

"This is an amazing resource," said James Bartis, an oil analyst at Rand, based in Santa Monica, Calif. Bartis says that success in the Rockies could cut crude prices by 5 percent, saving American consumers $20 billion a year.

"It's been raised before as a panacea for impending shortages, but never before has it been shown to be competitive with conventional oil," Bartis said.

Drillers, pipe-makers and metal fabricators such as Nabors Industries Ltd. and closely held UOP LLC will be the first to profit as Shell, Chevron and Exxon drill thousands of wells a half-mile underground by 2011.

The oil companies may begin pumping commercial quantities of oil from Colorado shale within a decade,

about as long as Chevron will need to develop the 500 million-barrel Jack prospect in the deepwater Gulf of Mexico, according to Stark, who is a former Mobil Corp. geologist.

"Given the state of the oil market, more and more effort is being put into making shale a viable source," said Stanislaw. He estimated it will take six to eight years before oil companies perfect their extraction methods. "The timeframe is very long," he said.

In the 1970s, oil shale efforts involved mile-wide strip mines and factory-size cookers to boil giant limestone boulders. This time, no company expects to bring in front-loaders, heavy-duty dump trucks or thousands of miners to haul shale from open pits.

"The old technique required them to dig the equivalent of a new Panama Canal every month," said former Colorado Gov. Richard Lamm, whose tenure from 1975 to 1987 included the last attempt to extract oil from shale.

'More sane process'

"This new approach is a much more sane process, but that's all relative," Lamm said in an interview. "They're doing this in an immensely fragile area where wagon ruts from the Oregon Trail in the 1840s are still visible. It doesn't excite me because I think they're about to indelibly change our state."

Local residents are also leery, recalling the ghost towns and job losses left behind from the last shale boom and bust.

Battlement Mesa, Colo., a town Exxon built to house an expected 25,000 shale workers, was abandoned when the company shut its mine on May 2, 1982, a day locals still refer to as "Black Sunday." The town is now a retirement community.

"I don't think this is going to go anywhere," said John Savage, an attorney in Rifle whose father started a shale-oil company in 1956. "It's just too tough to get that oil out of the ground. There's trillions of barrels down there, but there's too much rock on top of it."

Oil companies also are exploring shale fields in Jordan, Morocco and Australia, though preliminary assessments indicate none is as oil-rich as the Colorado and Utah deposits. The final approval for full-scale projects in the U.S. won't be made until after 2010.

"If we waited a few million years, all this stuff would turn to oil," Rand's Bartis says. "Some people don't want to wait that long."

asin
dard

THE BASIN'S NEWSPAPER www.ubstandard.com • 50¢

Townsend on a Tear

Union High whips Morgan, 5-0, to take second place in Region 10.

C-1

E FALLEN

lace a marker honoring her husband, Kevin Orr, during Miller Campus in Sandy last Thursday. Orr, a detective uffered in a helicopter crash in November 2006 during ted with her husband's Purple Heart by Uintah County

d for lease

LAND OWNERS WORRIED

Development of oil sands slated for Whiterocks Canyon?

By Lezlee E. Whiting

The private property owners in Whiterocks Canyon are about as different as the unique flora and fauna that grows on their forested lands 27 miles north of Roosevelt, but they have found common ground in their protest of plans by a Las Vegas-based energy company to strip mine the canyon's rich oil sands deposits.

Last month Black Sands Holding Company sent notification letters to land owners outlining their plans to exercise the mineral lease rights they have purchased from the privately held Whiterocks Energy LLC.

According to Alan Propp, senior engineer for Black Sands, the first item on their agenda will be to conduct core drilling on the private mineral leases after obtaining the proper permitting from the Utah Division of Oil, Gas and Mining. Black Sands was formed two and a-half years ago, company CEO is Frank Glinton, who resides in Boulder, Colo.

> Black Sands Energy is a young company with no track record to support their claims.

According to one Web site, Black Sands Energy Corp. is a joint venture partner with Nevtah Capital Management Corp. Korean investors are financing their exploratory work in Whiterocks Canyon and other sites to produce oil from oil sands to the tune of $29 million.

There have been rumors for decades that exploration for the rich oil sands deposits in

SEE OIL SANDS on page 4

Rehearing requested in monument battle

ASKING FOR JUDGES TO LISTEN 'EN BANC'

By Lezlee E. Whiting

ment monument in the park, but the small plot of land it sits on is

OIL SANDS

Continued from page 1

canyon were imminent. So far nothing has ever materialized except for the rather benign core drilling that has gone on from time to time. However with oil prices at around $62 a barrel and rising, those who want to protect the canyon from an intrusion of wide scale mineral extraction are organizing and examining their options.

Black Sands "notice of intent to explore has been overwhelmingly met with shock and great alarm," Tammy Bostick-Cooper wrote in a nearly three page letter to state and local officials. Concerns addressed in the letter from the Whiterocks Property Owners Association, include everything from environment to aesthetics, economic and legal issues.

Uintah County commissioners have heard nothing of the plans of Nevtah/Black Sands and have invited members of the property owners association to meet with them, said commissioner Darlene Burns.

Bostick-Cooper and her husband Lewis are one of three property owners who live in the canyon year-round. They moved there seven years ago to live "off the grid ... gently on the land" on their 20 acres. Like many private property owners in the canyon their land is surrounded by Ashley National Forest in an area zoned recreation, forestry and mining.

Bostick-Cooper, who grew up on a ranch in Neola, said she isn't about cart blanche protests when it comes to energy development, but does want to ensure it is done right.

"We are not against oil exploration, we are for environmentally sustainable and environmentally sound exploration," she said. "We all put gas in our cars and until that changes, let us do it responsibly."

Nevtah/Black Sands Energy boasts that the company's "patented, closed-loop production process" can do just that by economically extracting oil from oil sands without the extensive use of water.

"The joint venture's process utilizes benign, non-toxic solvents which are recycled in a closed-loop system so that both cost and environmental impact issues are met," according to the letter Propp has sent to property owners.

According to Propp, direct mining and extraction processing costs hover between $12 to $13 per barrel. However, it could be awhile before extraction begins. He said the company has the pre-commercial version of the technology using their multi-pod production units and will be putting together the commercial version, which is undergoing "some modifications."

"The beauty of our system is that it can be deployed fairly easy on a small scale. Our process is small and modular," he said.

Black Sands plans to put into production <u>10,000 barrels</u> per day to begin and stay with the extraction project for five to 10 years. In the letter to property owners, he said the company's production process is not only low-cost and low-energy, but also "low-emission, low-manpower, earth friendly, easy-to-operate and leaves a small footprint and rapid payout."

Those with surface rights should know that Black Sands Energy will be a "good neighbor," said Propp, and will reclaim all the land that is disturbed "under all applicable regulations."

Because the young company has no track record to support their claims, Propp said that canyon private property owners will just have to trust Black Sands.

"They won't know it until we get out and prove what kind of guys we are," he said. "Unfortunately to some extent they will have to take our word that we are going to be good caretakers with the land."

Bostick-Cooper said the ramifications of a project that would mine oil sands in the canyon are immense and practically immeasurable. The greatest concern, however, lies with the water table disruption and possible contamination.

"There are these little loopholes ... if you do these very small areas or refining they never have to have an environmental study," Bostick-Cooper has discovered.

Propp confirmed that. "You can disturb up to five acres without being regulated by Environmental Assessment requirements," he said, adding that operations would eventually expand to the point where the company "would be required to identify and account for any environmental problems that would arise ."

Matt Cazier, director of Planning and Zoning for Uintah County, said as far as he knows his office has not been contacted by Nevtah/Black Sands for any regulatory permits.

"If it was," said Cazier, "all of those property owners within 1,000 feet would have been notified.

Propp said he doesn't believe that rules require Black Sand to obtain permits from Uintah County.

Bostick-Cooper said despite assurances through Propp's letter, questions remain. She said she is pleased about one thing - the proposed mineral extraction has brought the canyon's private property owners together as a cohesive unit to protect their lands.

"While we have this on the table let's do something that will protect it (the canyon) forever ... all the land owners are very different ... and they have all come together, different political philosophies have come together to say "not here, not in Whiterocks Canyon," said Bostick-Cooper, "it's very heartening."

CLEAN UP

Continued from page 1

parents' home in Myton for a few days to allow his son's lungs to heal. He said during the stay at his grandparents' home Greysen had no symptoms of asthma.

"The odor that comes off (the dirt pile) is just unbearable," Monks said. "It burns your eyes and it smells terrible. We're concerned that whatever is causing evaporating off of there is causing problems with the air quality."

El Paso company officials said Tuesday that the contaminated soil they are cleaning up is part of a "flare pit" – an earthen basin used to collect and burn-off byproducts of oil and gas production. The pit, which El Paso never used, is located at a compressor station acquired in a 2001 merger with another oil and gas company. El Paso halted its remediation efforts Saturday after the reports surfaced that nearby residents were becoming ill.

"Our desire is to make sure that the area is safe and that the public is not harmed in any way, that's why we suspended [the cleanup]," said El Paso spokesman Richard Wheatley.

Monks said he's concerned not only about what's in the air that's making his family and others sick, but the possibility that groundwater in the area may be contaminated. The well that provides the Monks family with water is only 40 feet deep. El Paso has already dug at least 20 feet down, according to public health officials, and is still finding contamination.

"We drink bottled water," Monks said. "We haven't drunk our tap water for a year now."

Janet Panas can see the El Paso site from the back porch of the home she's lived in since 1990. Panas had to take her 1-year-old grandson Atticus Panas, who also has a history of asthma, to the emergency room in respiratory distress on Friday. Doctors were able to stabilize the boy without hospitalizing him, but Panas said she's tired of feeling ill all the time and having the smell of natural gas saturating her home almost daily.

"I love where I live, I'm just get sick of dealing with the stuff we're dealing with," Panas said. "I just wish they would have been open and up front with us about this from the beginning instead of being so secretive."

Jim Springer, spokesman for the state Division of Oil, Gas and Mining, said the agency approved El Paso's remediation plan before issuing a permit for the cleanup. He said the division will now wait for findings from environmental health officials before allowing any future work at the site.

"What's being done on site there is pretty common to other sites," Springer said of the cleanup, "so what might be happening there, we're really at a loss to say. We'll just have to wait for the report."

BATTLE

Continued from page 1

Duchesne cases are wrong, and

focus on ness growth

information, marketing and brand awareness, and acquiring small business capital.

Attendees can network and interact with representatives of local and regional companies while viewing products and services on display at the conference's business exposition.

Attendance at the conference is $25 and includes all sessions, lunch and a reception on May 30, and breakfast on May 31. The conference will be held in the Taggart Student Center and adjacent buildings on the campus of Utah State University in Logan. For more information visit www.ruralutah.com, or contact Senator Bennett's office at (801) hospitals.

Child said the reason a local, county-owned hospital like the UMBC is able to invest in such state-of-the-art equipment is simple: The UBMC is a not-for-profit facility. At the end of the year and after all expenses have been paid, instead of returning profits to stockholders, the UBMC reinvests all excess resources into the community and hospital.

Using generated profits, the hospital provides about $2 million a year in charity care for patients without insurance who fall within required income categories. Each year, UBMC administration also spends a healthy amount on capital expenditures — money used to help upgrade services and technology. Last year's capital expenditure tally alone came to $2.14 million.

"Because we are a not-for-profit facility, we take all the funding that we do generate and invest it in the equipment that makes health care in the Basin attended training sessions for the equipment in New York City, and company representatives from Johnson and Johnson spent about a month in the Basin making sure the equipment was perfectly tweaked and producing accurate results.

"The end user's benefit is that we can now do a lot more varied testing without having to rely on other labs as much," Hansen said. "The turn-around time will be much faster, and most tests can essentially be done the same day without having to wait a week or two for results to come back. What that means for patients is that they can get back to their doctor and start treatment that much sooner."

In addition to purchasing the new laboratory equipment, Child said capital expenditure funds were also used during the past year to purchase newer, more comfortable hospital beds, improved surgical equipment, and a central monitoring system for the O.B. department.

Green River water will help squeeze out oil

By Lezlee E. Whiting

An agreement forged between Newfield Production and the Duchesne County Water Conservancy District will provide the water needed to extend the life of a portion of Newfield's Monument Butte field located near the Pariette Wetlands, 12 miles south and 9 miles east of Myton.

The Houston, Texas-based Newfield Production, has contracted with the water conservancy district for 61,000 barrels of water a day from the Green River. The water will be pumped to Newfield's injection facilities and used to water flood the oil field, said Mike Guinn, spokesman for Newfield. The water pressure helps move oil through fractures so it can be recovered.

The company has made a $2 million investment in infrastructure in piping, pumps and wells. The pipeline was completed in December and an 85-foot deep "collector well" with an outer diameter of 16 feet, is expected to be completed in April. The Green River Water Flood Project has a life expectancy of 50 years, said Guinn.

"The collector well sits adjacent to the Green River, the pipeline goes from the collector well for 13 miles and ties into the present infrastructure of the injection system," said Guinn. "We will pump the water up to our injection facilities and use it as flood water for the oil field.".

Newfield finished pouring the last "caisson" or section of the collector well, last month, he said. The caisson is 11 feet tall. According to Randy Crozier, manager of the water conservancy district, the agreement the district has with Newfield is a win-win for the company and the district which has ample water available from the Green River.

"Our district has some water rights out of the Green River, so they came to us and we worked out a long-term agreement," said Crozier. "They only pay for the water that they take at $20 an acre foot. They can use up to 2,900 acre feet per year in a 30 year agreement with the right of extension. It's a very minute portion of what the district owns in water shares."

An electric generation facility that is currently under construction, will power the pumps, said Guinn, "We will build and own it, it will be driven by natural gas."

The secondary recovery project should be operational by April.

TASK FORCE ON STRATEGIC UNCONVENTIONAL FUELS

DEVELOPMENT OF AMERICA'S STRATEGIC UNCONVENTIONAL FUELS RESOURCES

INITIAL REPORT TO THE PRESIDENT AND THE CONGRESS OF THE UNITED STATES

PREPARED IN RESPONSE TO SECTION 369(h) (5)(A) OF THE ENERGY POLICY ACT OF 2005 (P.L. 109-58)

September 2006

APPENDIX B

Major Assumptions for Estimating Production under Various Policy and Fiscal Scenarios

Oil Shale Resource Characteristics: Resources in Colorado have received the most industrial attention because of the thickness and richness of the beds. Not surprisingly, the initial attention of the major oil companies has been focused on Colorado oil shale. Room and pillar mining and surface processing are possible along the southern reaches of the deposit where erosion has exposed the beds along the Colorado River drainage. Outcrops in the northwestern portions of the Piceance Creek Basin are potentially amenable to surface mining and processing. Historically, tract Ca of the prototype leasing program was contemplated to be a surface mine with surface processing. The deeper and thicker central parts of the basin are more amenable to in-situ recovery such as what Shell is proposing. In-situ recovery can conceivably be used in shallower and thinner deposits as well.

Some of the richest zones, with yield up to 60-70 gallons per ton (gpt) are found in Utah, although these zones are not very thick. The oil shale outcrops on the southern and eastern margins of the deposit. The southern margins are amenable to surface mining. The eastern outcrops are exposed by canyon erosion and are accessible through room and pillar mining. Near the center of the deposit and points west and north, the overburden becomes thick and in-situ processes are thought to be more suitable. The Wyoming deposits, while extensive and accessible to the surface, do not have the level of richness seen in Utah or Colorado.

- **Measured Case:** First production from an in-situ project in Colorado on highly attractive resource by 2016 ramping up to 500K Bbl/d by 2022. A second in-situ project in Colorado, also on highly attractive property first producing in 2020, ramping up to 500K by 2026. A third in-situ project in Utah or Colorado, beginning in 2021 and ramping up to 250K by 2027. Fourth and fifth in-situ projects in Utah or Colorado beginning in 2023 and 2025, respectively and ramping up to 250K each.
- First production from a surface process at a demo scale of 10K/d in Utah or Colorado by 2012, expanding to 100K Bbl/d by 2015.
- Second through fifth surface processes in Utah, Colorado, or Wyoming, each at 100K Bbl/d beginning in 2018 and start times offset by 3 years for each successive plant. After plant reaches full design capacity add 2% growth from debottlenecking, improved efficiency, and minor expansions.
- **Accelerated Case:** Move up the timetable for in-situ schedule by 3 years. Move up the timetable to first-generation surface processing by 2 years. Simultaneous construction of the second and third plants (ideally in two different states) and after 3 years simultaneous construction of two more plants. Add one more in-situ and two more surface plants in the out-years. After plant reaches full design capacity add 3% growth from debottlenecking, improved efficiency, and minor expansions.

Coal-to Liquids Resource Characteristics: Coal characteristics are well-known and include bituminous and anthracitic coal in the east, higher sulfur Illinois basin coal in the Midwest, lignite's in N. Dakota, Wyoming and Montana and low sulfur, bituminous coals in Utah. Of importance is the amount of coal that can be strip mined vs. underground mined. For purposes of this example, these details were not considered, but as the nation pursues coal-to-liquids, these characteristics will be key to the viability of achieving production goals. At present there is quite a bit of interest in Integrated Gasification Combined Cycle power and Fischer-Tropsch liquids production. A commercial demonstration facility is being built in Pennsylvania. Other States such as Illinois, Ohio, W. Virginia, N. Dakota, Wyoming, Montana, and Utah have projects that are in various stages of discussion, plant siting, and engineering.

- **Measured case:** Complete the Pennsylvania project by 2010 (5000 Bbl/d), add 3 other 'first-generation' projects by 2013 for a total capacity of 100K (full scale modules are on the order of 34K Bbl/d, which may be replicated in expansions). Add 3 'second-generation' plants by 2016. Expand all facilities to 100K Bbl/d by adding 34K Bbl/d modules every 4 years. Assume plants in 10 different States; ultimately achieve 1M Bbl/d by 2026. After plants reach full design capacity add 2% annual growth from debottlenecking, improved efficiency, and minor expansions.

- **Accelerated Case:** Cut 1 year from 1st generation facilities and 2 years from 2nd generation facilities. Expansion schedule adds a commercial module every 3 years. Add 3 additional States in the out-years. Achieve 1.3M bbl/day by 2027. After plants reach full design capacity add 3% annual growth from debottlenecking, improved efficiency, and minor expansions.

Tar Sands Resource Characteristics: For this initial productivity estimation only Utah resources were considered. Interestingly, recent State leases have attracted bonus bids far in excess of those attracted for oil shale. Clearly there are a number of entrepreneurs interested in developing these deposits. Of benefit to the development is the requirement by EPACT 2005 that the BLM conduct a programmatic EIS on tar sand lands, and make these lands available for leasing by 2007.

The primary deposits are:

Asphalt Ridge - Characterized by SOHIO as holding about 1 billion barrels recoverable and supporting about a 50K bbl/day facility. In the meantime growth in the community of Vernal has partially encumbered some of the resource. There are two high richness locations that could produce high yields of bitumen but in more modest quantities than contemplated by SOHIO. It is assumed that adaptations of the Alberta technology will be used on the unconsolidated sands from the rich zones.

- **Measured Pace:** Assume a first generation facility of 10K/d will be built by 2010 and expanded to 20K/d by 2013. Product will be asphalt and possibly byproducts.

- **Accelerated Pace:** Go directly to a 20K facility in 2010.

Sunnyside **-** Contains enough recoverable reserve to support a 100K bbl/d operation. Chevron was interested in this deposit two decades ago. Technology may require either thermal or solvent as the ore is consolidated.

- **Measured Pace:** Assume a first generation facility of 50K bbl/day by 2014 producing syncrude, expanding to 100K by 2018.

- **Accelerate Pace:** Assume full development of 100K facility by 2015.

PR Spring - This sizeable resource is close to the surface, but is fragmented by erosion and multiple beds. It is also in an environmentally primitive area, which may slow development. The northern margins of the PR Spring deposit lie under the southern margins of the oil shale deposits. It is possible that these tar sands will be co-produced as part of an oil shale venture.

- **Measured Pace:** Co-production of 25K Bbl/d by 2015 for syncrude using retort technologies. Additional grass roots plant producing 50 MBbl/d using surface processing similar to Sunnyside by 2018.

- **Accelerated pace:** Co-production by 2013. Additional 50K plant by 2016.

Tar Sand Triangle: TST is the largest deposit in Utah, in terms of barrels in-place. The bitumen is characterized by high sulfur, similar to Alberta oil sands and unlike the Uinta Basin deposits described above, which are low in sulfur. TST is also located near Canyon lands national park, and development is likely to meet with challenge. Nevertheless, there appears to be interest in this deposit for in-situ recovery. Assume that product would initially be transported by truck and rail in bitumen, or diluted bitumen state. Ultimately product would need to be upgraded to syncrude.

- **Measured Pace:** 2 MBbl/d by 2015, expanding to full production of 80 MBbl/d by 2021.
- **Accelerated Pace:** Cut 2 years from measured timeline.

Heavy Oil Resource Characteristics: Heavy, and extra heavy oil will require heat to be produced. In this regard, technologies such as SAGD, Vapex, and CSS, commercially practiced in Canada for recovering bitumen may be useful. The following are for new developments using advanced technologies.

- **Measured Case:** Achieve 200 MBbl/year by 2010 and annual growth of 5% year over year thereafter until 2030. This rate yields 530 MBbl/d by 2030.
- **Accelerated Case:** Achieve 200 MBbl/year by 2009 and annual growth of 7% year-over-year until 2030, achieving production of 828 MBbl/year

Efficiency Improvements

While efficiency improvements fall under a different level of responsibility within DOE, the overall supply and demand picture is not complete unless efficiency is included. In this context, "efficiency" is defined as accomplishing the same job with less energy. "Conservation" is defined as changing the way we accomplish tasks as a means of saving energy.

Efficiency Components: Given that the issue is with liquid fuels, the most fruitful place to look for efficiency improvements is light vehicle use. (Heavy vehicles, commercial, and aircraft efficiency improvements are already factored into the AEO 2006 consumption scenarios). Increases in efficiency have been about 30% over the past 20 years; however, efficiency gains have gone into greater curb weight and more horsepower. AEO assumes that these efficiency gains will continue. The difference is that we advocate engaging the public to convert these efficiency gains to greater mileage. With the advent of hybrid vehicles, this should be possible. In order to implement a measured and accelerated pace of reducing imports there are new initiatives that are needed that involve public cooperation. These are:

- Procurement of vehicles yielding higher efficiency.
- Improving driving and maintenance habits (total possible estimated at 7%).

Conservation Components: These improvements deal with greater telecommuting, ridesharing, mass transit using electric power transit, driving fewer miles per capita per year.

Population increase – The projected growth rate in population in the US is 0.0823%/year. All calculations allow for this, and as can be seen by the graphs, after the initial efficiency and conservation is achieved the population increases begin to overwhelm the remaining efficiency savings.

- **Measured Case:** Improve overall mileage by 20% over 17 years. Seventeen years is the mean life of the light vehicle fleet. In practice, this means that each buyer, on the average needs to buy a vehicle that is 1.2% more efficient for each year of trade up. Increase driving and maintenance habits with a public compliance rate of 3% (of those previously not complying) per year. Target improve conservation by 20% over a 20 year period with compliance rate of 3% per year yielding actual conservation savings of 11.6% in 30 years.
- **Accelerated Pace:** Improve overall mileage by 30% over 17 years, requiring purchase decisions to buy vehicles with 1.8% more efficient for each year of trade up. Public compliance for driving and maintenance is 5% per year under this scenario. Boost conservation targets to 30 % over a 20 year period with compliance rate of 5% per year yielding actual conservation savings of 22.3 % in 30 years.

REFERENCES

[1] "OSD Clean Fuel Initiative", Department of Defense. Barna, Theodore; Sheridan, Ted; Harrison III, William.

[2] "Findings and Recommendations of the ad hoc Steering Committee on Oil Shale" provided to U.S. Department of Energy, Office of Petroleum Reserves, 2005.

[3] "Strategic Significance of America's Oil Shale Resource", Volumes I and II, U.S. Department of Energy, Office of Petroleum Reserves, March 2004.

[4] Energy Information Administration, Annual Energy Outlook, 2006.

[5] Data in Figure 2 is derived from the following sources:

- Petroleum Already Consumed – Energy Information Administration, "Annual Energy Review", http://www.eia.doe.gov/emeu/aer/pdf/pages/sec4_5.pdf.
- Petroleum Reserves – Energy Information Administration, Annual Energy Outlook 2006 (U.S. DOE).
- Remaining Original Oil in Place - Comprehensive Oil and Gas Analysis Model (COGAM) DOE National Energy Technology Laboratory, 2004.
- Oil Shale - J. R. Dyni, Oil Shale, USGS 2003.
- Tar Sands - Lewin and Associates, Inc. "Major Tar Sand and Heavy Oil Deposits of the United States", Interstate Oil and Gas Compact Commission, July 1983 – as reported by the U.S. Department of Energy, Office of Oil and Gas, February 2006. p. 18-20.
- Heavy Oil - Comprehensive Oil and Gas Analysis Model (COGAM) DOE National Energy Technology Laboratory, 2004.
- Coal Consumed - http://www.cslforum.org/usa.htm.
- Coal Resources – 'Identified resources' from publication DOE/EIA-0529(97)

[6] Oil and Gas Journal, "Hubbert Revisited-5", August 9, 2004, PennWell Energy.(3-State Map); and "Final Environmental Impact Statement for the Oil Shale Prototype Leasing Program", U.S. Department of the Interior, 1973.

[7] Analysis of Strategic Unconventional Fuels Task Force applying DOE National Strategic Unconventional Resources Model. DOE Office of Petroleum Reserves, 2006.

[8] ibid

[9] EIA's Annual Coal Report, 2004, Tables 1 and 15, http://www.eia.doe.gov/cneaf/coal/page/acr/acr_sum.html and personal correspondence from Richard Bonskowski, U.S. EIA to Darren Mollot, February 16, 2006.)

[10] United States Geological Survey, Coalfields of the United States, 1960-1961; Texas Bureau of Economic Geology, Lignite Resources in Texas, 1980; Louisiana Geological Survey, Near Surface Lignite in Louisiana, 1981; Colorado Geological Survey, Coal Resources and Development Map, 1981; and Mississippi Bureau of Geology, 1983.

[11] Gray, David "Producing Liquid Fuels from Coal", presented to National Academy of Sciences , National Research Council, Workshop on Trends in World Oil Supply and Demand, October 2005.

[12] "Coal: America's Energy Future" Vol. I, The National Coal Council, Washington, D.C. March 2006. p. 31

[13] DOE NETL COGAM, 2004.

[14] ibid

[15] Heinemann, Robert, "Presentation to National Academy of Sciences Workshop on Unconventional Fuels" April 2005.

[16] International Centre for Heavy Hydrocarbons, 1993 U.S. Bitumen Database, http://www.oildrop.org.

[17] Based on estimates prepared by James W. Bunger and Associates, Inc. for the DOE Office of Petroleum Reserves, December 2005. The primary deposits are:

> **Asphalt Ridge** - Characterized by SOHIO as holding about 1 billion barrels recoverable and supporting about a 50 MBbl/d facility. In the meantime growth in the community of Vernal has partially encumbered some of the resource. There are two rich locations that could produce high yields of bitumen but in more modest quantities than contemplated by SOHIO. It is assumed that adaptations of the Alberta technology will be used on the unconsolidated sands from the rich zones.
>
> **Sunnyside -** Contains enough recoverable reserve to support a 100 MBbl/d operation. Technology may require either thermal or solvent treatment because the ore is consolidated.
>
> **PR Spring** - This sizeable resource is close to the surface, but is fragmented by erosion and multiple beds. It is also in an environmentally primitive area, which may slow development. There are a few rich zones that could each support modest size developments on the order of 25 to 50 MBbl/d.
>
> **Tar Sand Triangle (TST):** TST is the largest deposit in Utah, in terms of barrels in-place. The bitumen is characterized by high sulfur, similar to Alberta oil sands but, unlike the Uinta Basin deposits described above, which are low in sulfur. TST is also located near Canyon lands national park, and development is likely to meet with challenge. Nevertheless, there appears to be interest in this deposit for in-situ recovery. Assume that product would initially be transported by truck and rail in bitumen, or diluted bitumen state. Ultimately product would need to be upgraded to syncrude.
>
> Cumulative production from tar sands under both the measured pace and accelerated pace scenarios is 340-352 Mbbl/d by 2025. No further expansion is contemplated under foreseeable oil prices. Should there be very high prices, then leaner and more fragmented resources might come into production. Also, resources in other States are not included in this initial scenario, and clearly tar sand in other states may also qualify for production.

[18] International Centre for Heavy Hydrocarbons (1993 U.S. Bitumen Database)

[19] DOE NETL COGAM, 2004.

[20] Moritis, Guntis "CO2 Injection Gains Momentum", Oil and Gas Journal, April 17, 2006.

[21] INTEK, Inc" CO_2 Enhanced Oil Recovery Potential in the United States" June 2005.

[22] Undeveloped Domestic Oil Resources: The Foundation for Increased Oil Production and a Viable Domestic Oil Industry" DOE Office of Fossil Energy, February 2006.

http://www.fe.doe.gov/programs/oilgas/eor/ten_basin-oriented_co2-eor_assessments.html

[23] "Findings and Recommendations of the Oil Shale Steering Committee", submitted to the U.S. Department of Energy, Office of Petroleum Reserves, June 2005.

[24] "Strategic Significance of America's Oil Shale Resource", Volumes I and II, U.S. Department of Energy, Office of Petroleum Reserves, March 2004.

[25] "Findings and Recommendations of the Oil Shale Steering Committee", submitted to the U.S. Department of Energy, Office of Petroleum Reserves, June 2005.

DOE Office of Petroleum Reserves – Strategic Unconventional Fuels

Fact Sheet: U.S. Oil Shale Economics

Economic Requirements for Oil Shale Feasibility

- Oil shale technologies must be demonstrated at commercial scale before definitive capital and operating costs of oil shale projects will be known.
- Oil shale projects must demonstrate capability to achieve a minimum rate of return at expected sustained average world oil prices.

What are the Major Cost Elements of Oil Shale Projects?

For Mining and Surface Retorting:

- Mine development: surface or underground
- Retorting & upgrading facilities: design, manufacture, and construction of facilities
- Infrastructure: roads, pipelines to upgrading plants and refineries, powerlines, utilities, storage tanks, waste treatment and pollution control.

For In-Situ (underground) Processing:

- Subsurface facilities: wells or shafts to access and heat the shale, recover liquids and gases, and isolate and protect subsurface environments.
- Surface facilities: production pumps and gathering systems, process controls, process power, and upgrading facilities.

How Big is a Commercial Scale Project?

- Commercial oil shale projects could range in size from 10,000 to 50,000 barrels per day for surface retorts to as much as 300,000 barrels per day for full-scale in-situ projects.

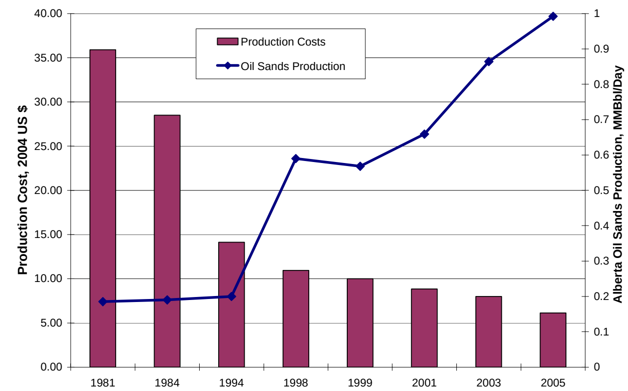
How Much Will Commercial Projects Cost?

- Cost estimates will vary according to the oil shale resource and the process selected. In the 1980s, cost estimates for a 100,000 barrel/day surface retort plant ranged from \$8 - \$12 billion (2005\$)[1]. Capital costs are expected to be less today, i.e., \$3.0 to \$10.0 billion (2005\$).

Can Costs be Expected to Decrease Over Time?

- Yes. Capital and operating costs can be expected to decrease over time with operating experience, improved understanding, design enhancements, and improved operating efficiencies, analogous to the experience of the Province of Alberta in developing its oil sands resources.

Figure 1 – Canadian Oil Sand Economics and Production



Production Costs: Oil & Gas Journal, July 14, 2003, V. 101.27
Production Volumes: Canadian Association of Petroleum Producers, Historical Statistics

- Production costs in Alberta's oil sands declined by as much as 80 percent between 1980 and 2003. Oil shale cost reductions of 40 to 50 percent could occur as lessons from first of a kind facilities are learned and applied (Figure 1)[2].
- Mining capital costs have risen with the trend toward more mechanized mining operations. Mine operating costs have decreased significantly as mining efficiency has improved.
- Rapid industry growth may tax limited resources of skilled labor, materials, and manufacturing facilities for retorting technologies and mining and processing equipment, increasing costs.

What Sustained Oil Prices are Required for Oil Shale Projects to be Economic?

- First of a kind mining and surface retorting plants may eventually be economic, providing a minimum 15% rate of return, at sustained average world oil prices above \$54.00 per barrel.
- In-situ processes may be economic at sustained average world oil prices above \$35 per barrel.

What are the Potential Public Economic Benefits of Oil Shale Development?

- The Federal treasury, State and local governments, and the overall domestic economy stand to benefit from the direct contributions of a domestic oil shale industry and from the additional economic activity and growth that will result from industry development.
- Direct benefits can be measured in terms of: (1) Direct Federal revenues (from lease bonuses, Federal taxes and the Federal share of royalties) (2)

Direct state/local revenues (from State and local taxes and the state share of Federal royalty); (3) Contributions to Gross Domestic Product (GDP), and (4) the value of avoided oil imports.

- At a sustained production of about 2.5 million barrels of shale oil per day, the cumulative value of these benefits over a 25 year period could exceed $500 billion.

With Oil Prices at $60/ Bbl, What are the Impediments to Investment in Oil Shale?

- Large initial capital requirements
- Insufficient private tracts of high-grade oil shale
- Restricted access to resources on public lands
- Oil price uncertainty and volatility
- Technology not demonstrated at commercially-representative scale
- Competing investment opportunities, including investments in other conventional and unconventional oil and gas resources

How Have Current Oil Shale Economics Been Modeled by DOE?

- DOE has performed an analysis of the economics of oil shale. DOE developed a model to evaluate project economics for the application of oil shale technologies to selected resource tracts, and the impacts of various incentives on project economics.
- As there are no commercial facilities currently operating in the United States, capital cost and production cost data used in the analyses were updated from past technology processes and from current vendor cost information to construct plausible cost scenarios.
- The analysis applied resource characterization data from surveys conducted by the U.S. Geological Survey in preparation for the 1974 Prototype Oil Shale Leasing Program.
- The economic analysis examined 27 USGS defined resource tracts, which were nominated by industry, to determine the most efficient technology approach for use at each location.
- The production cost and resource characterization data were then used to calculate minimum economic prices.
- The minimum economic price is defined as the breakeven price assuming a return on capital of 15 percent, and represents our best cost estimates for a mature industry.
- These cost estimates do not take into account research and development costs, permitting costs, land access issues, or production inefficiencies that are characteristic of first-of-a-kind plants. All of these other factors could add significantly to early development costs and have the potential to double production costs for the first plants.
- The model estimates cash flow for the various projects by evaluating plant capacity, development schedule, market prices for oil and natural gas, leasing royalty structure, operating costs, capital costs, and tax structure.
- The model determines the minimum economic cost shown and breakeven prices for a given technology for each resource tracts where it is being applied.
- Capital costs are the sum of investments needed per barrel of installed capacity. These costs include investments in mining, retorting, solid waste disposal, refining and upgrading, plant utilities, and other facilities.
- Operating costs include fuel, operating and maintenance personnel, consumable equipment and other non-capital costs for mining, retorting, refining and upgrading,
- The components of both capital and operating costs are different for various technologies used for mining, retorting, and upgrading. These costs were derived from information available from a variety of sources, particularly the Prototype Leasing Program in the early 1980's. These costs were escalated to 2004 dollars using Bureau of Labor Statistics data and were further validated with current vendor quotes.

References

[1] U.S. Office of Technology Assessment. "An Assessment of Oil Shale Technologies", 1980.
[2] Oil and Gas Journal, July 13, 2003.

Fact Sheet: Oil Shale Water Resources

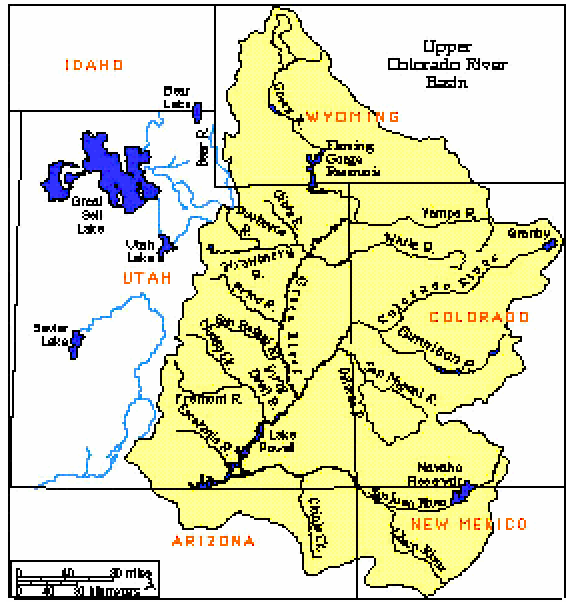
What Water Resources Will Be Needed for Oil Shale Industry Development?

- Development of Western oil shale resources will require significant quantities of water for mine and plant operations, reclamation, supporting infrastructure, and associated economic growth.
- Initial process water requirement estimates of 2.1 to 5 barrels of water per barrel of oil, first developed in the 1970s, have declined. More current estimates based on updated oil shale industry water budgets suggest that requirements for new retorting methods will be 1 to 3 barrels of water per barrel of oil.[1] Some processes may be net producers.
- For an oil shale industry producing 2.5 MMBbl/d, this equates to between 105 and 315 million gallons of water per day (MGD). (See Table 1). These numbers include water requirements for power generation for in-situ heating processes, retorting, refining, reclamation, dust control and on-site worker demands.
- Municipal and other water requirements related to population growth associated with industry development will require an additional 58 million gallons per day.
- A 2.5 MMBbl/d oil shale industry would require 0.18 million to 0.42 million acre feet of water per year, depending on location and processes used.[2]
- Water supply issues will be less critical for eastern oil shales where water supply is ample.

Where Will the Water Come From?

- In the West, water will be drawn from local and regional sources. The major water source is the Colorado River Basin, including the Colorado, Green, and White Rivers (Fig. 1)[3]. The Colorado flows between 10 and 22 million acre feet/yr.
- Water may also be purchased from other existing reservoirs. Transfers may be possible from other water basins, including the Upper Missouri.
- Western oil shale has high water content. Some oil shale contains 30-40 gallons per ton of shale. More typically it holds 2-5 gallons of water per ton. Much of this water can be recovered during processing and used to support operations. Produced water will contain organic and in-organic substances that can be removed with conventional filtering technologies.

Figure 1. Upper Colorado River Basin Water Resources[1]



- Recycling and re-use of process water will help to reduce water requirements.

How are Water Rights Allocated?

- Water in the West is treated much the same as other commodities – it can be bought and sold in a competitive market.
- Interstate "compacts" control the amount of river water each state is entitled to use. They allocate 5.3 to 5.9 million acre feet to the states. States are expected too use about 4.8 million acre feet of their allocations by 2020. If all industry water were withdrawn from the river, oil shale development would increase withdrawals by 0.18 to 0.42 million acre feet / year. Use of connate water and water re-use could reduce this volume.
- A system of rights and seniority has been established that allocates expected resources. Many private companies previously engaged in oil shale development retain very senior rights they obtained during the 1970s. Because Federal lands and prospective future leases will not come with water rights, some lessees may need to negotiate water purchases to advance projects.

Are Available Water Supplies Adequate to Support a Domestic Oil Shale Industry?

- Initial estimates indicate that enough water will be available to support oil shale industry development in the Western states. However, variability of

Table 1. Estimated Water Demand for Oil Shale Production and Associated Population Growth.						
Water Requirement (Bbl Water Used/ Bbl Oil Produced)	**Oil Shale Production Rate** (Thou Bbls/d)	**Oil Shale Industry Water Demand** (Mil Gals/d)	**Projected Population Growth** (People)	**Additional Water to Support Population (mil gals/d)**	**Total New Water Demand** (Mil Gals/ d)	**Total New Water Demand** (Mil acre-ft/yr)
1-3	500	21 to 63	96,000	13	34 to 76	0.04 to 0.09
1-3	1,000	42 to 126	177,000	24	86 to 150	0.10 to 0.17
1-3	2,500	105 to 315	433,000	58	163 to 373	0.18 to 0.42

supply during low flow years may cause conflicts among water users.

- As the industry grows, additional water resources for human consumption and for oil shale processes will likely be required.
- The water consumption growth will slow as oil shale technologies become more efficient.
- For a mature industry, substantial water storage and water transfers may be required over time.

Allocation of Water Rights

The overall allocation of water today is governed by the Colorado River Compact, originally agreed to on November 24, 1922. Currently there is a mix of both absolute and conditional water rights.

- Absolute rights are those that have been decreed by the state Water Court available for use.
- Conditional rights are rights that have not been through the Court process and therefore have not been decreed. They cannot be used until a decree has been granted and the rights have been determined to be absolute. Conditional rights only preserve a holder's seniority in accordance with the doctrine of first in time, first in right. In addition, conditional rights must undergo a diligence test every six years to preserve the conditional right.
- An absolute right is still subject to being curtailed (a call) in the event the water balance is insufficient for all rights and a senior right holder is being injured.
- To help assure supply, it is customary to file an Augmentation Plan which may consist of a plan for reservoir storage and release or purchase of senior rights that can be provided to a senior right holder.

A recent (October, 2003) agreement between the State of California and the Upper Basin States returns about 0.8 million-acre feet per year to the Upper Basin States that was being over-used by the State of California. This 0.8 million acre-feet/year increment could help support an oil shale industry, if the water were largely allocated to this use.[4]

References

1 Cameron, C., M. Hightower, J. Hoffmann and C. Wilson, 2006, Energy Demands on Water Resources, Report to Congress on the Interdependency of Energy and Water, DRAFT, July 2006, Sandia National Laboratories.
Donnell, J. R. 1991. Oil Shale. Pages 183-188 *in* H. J. Gluskoter, D. D. Rice, and R. B. Taylor, editors. The Geology of North America, Economic Geology, U.S. Geological Society of America, Boulder, Colorado.
Office of Technology Assessment (OTA). 1980. An Assessment of Oil Shale Technologies. Washington, D.C.
Vinegar, H., 2006. Shell's *in-situ* conversion process for oil shale. Oral presentation, 26th Oil Shale Symposium, October 16-20, Colorado School of Mines, Golden, CO.
2 Wood, Thomas "Water Resources for Oil Shale" Battelle, 2006.
3 www.engineering.usu.edu/uwrl/atlas/ch7/ch7upcolcom.html
4 Bunger, J.W., P.M. Crawford, and H. Johnson, *"Strategic Significance of America's Oil Shale Resource – Volume II: Oil Shale Resources, Technology and Economics"* U.S. department of Energy, Office of Deputy Assistant Secretary for Petroleum Reserves, March 2004.

Fact Sheet: U. S. Tar Sands Potential

Background

- Tar sands (referred to as oil sands in Canada) are a combination of clay, sand, water, and bitumen, a heavy, black, asphalt-like hydrocarbon.
- Bitumen from tar sands can be upgraded to synthetic crude oil and refined to make asphalt, gasoline, jet fuel, and value-added chemicals.
- U.S. tar sands tend to be lean and the mineral matter consolidated (sand grains are cemented together with minerals). While lessons may be learned from the experience in Alberta, modifications in those technologies may be necessary to cost-effectively produce synthetic oil from U.S. tar sands.

U.S. Tar Sand Resources

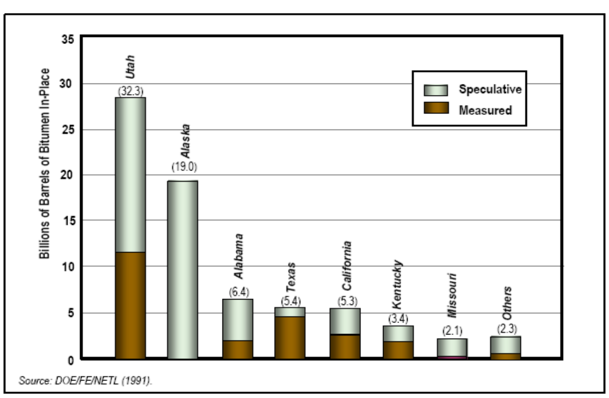
- U.S. tar sands resources are estimated at 60 to 80 billion barrels of oil; some 11 billion barrels may be recoverable[1]. The resource could support 500 M Bbl/d of production. The richest deposits are found in Utah (Table 1) and California.
- Current access, technology, and investment constraints make near-term production unlikely.
- Government action and incentives could catalyze an industry of 350,000 Bbl/d by 2035.

Table 1 - Utah Tar Sands Resources (MMBbl)

Deposit	Known Resource	Additional Potential
Sunnyside	4,400	1,700
Tar Sand Triangle	2,500	13,700
PR Spring	2,140	2,230
Asphalt Ridge	820	310
Circle Cliffs	590	1,140
Other	1,410	1,530
Total	**11,860**	**20,610**

Source: DOE/FE/NETL (1991)

Figure 1 – Distribution of U.S. Tar Sands



Tar Sands Technology

- Recovery technology options depend on grade, viscosity and depth. Shallow, colder resources are more viscous, but may be surface mineable.
- Deeper, warmer resources are less viscous, but may require in-situ processes to produce.
- Steam injection, including Steam Assisted Gravity Drainage (SAG-D), has been the favored in-situ method in Alberta;
- Other processes include solvent vapor, THAI, or Cold Heavy Oil Production with Sand (CHOPS).
- Bitumen may be separated from the sands by hot-water or cold-water or hot-water extraction processes, depending on the composition of the resource.
- But neither may work on U.S. tar sands that are “oil-wet”, and consolidated.
- New technology solutions or adaptations of those used in Alberta may be necessary to produce oil from U.S. tar sands.
- About two tons of tar sands yield one barrel of oil - roughly 90 % of the bitumen is recovered.

Figure 2 – Cyclic Steam Injection

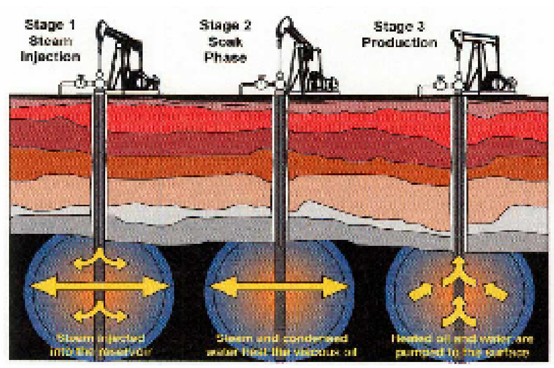
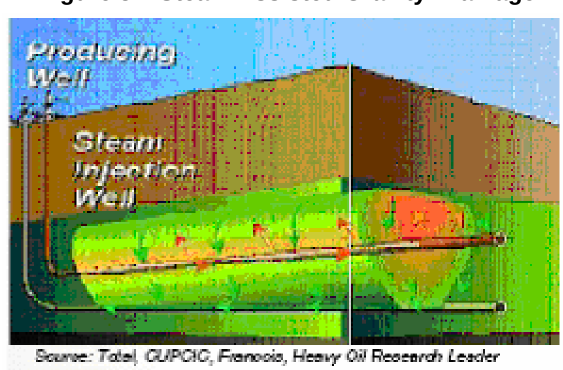


Figure 3 – Steam Assisted Gravity Drainage



Tar Sands Economics

- U.S. tar sands production costs are expected to be similar to or higher than costs in Alberta
- Costs may be higher as technologies are tailored to meet the characteristics of U.S. tar sands.
- Alberta oil sands costs declined steadily as lessons learned made project design, construction and operations more efficient.
- Projects require large capital investments. Capital costs depend on the production technology chosen. Mining is more capital intensive than alternative in-situ processes. (Table 2)
- Recently, capital and operating costs for Alberta oil sands projects have increased due to increased demand and tight supplies of skilled labor and construction materials. (Table 3)

Table 2 - Capital Costs of Tar Sands Projects in Canada ($2006 USD)

Project Type	Cost per Barrel of Daily Capacity
Integrated mining, extraction and upgrading	$37,940
Mining and extraction	$17,070
Steam Assisted Gravity Drainage (SAG-D)	$11,380
Cyclic Steam Soak (CSS)	$17,070

Source: National Energy Board of Canada, An Energy Market Assessment, 2004. Costs converted to U.S. dollars and escalated to 2005 by INTEK, Inc.

Table 3 - Alberta Oil Sands Costs / Barrel ($2006 USD)

Process / Technology	Product	Operating Costs ($/Bbl)	Total Supply Cost** ($/Bbl)
Cold Production	Bitumen	4-7	9-13
Cold Heavy Oil Production with Sand	Bitumen	6-9	11-15
Cyclic Steam Stimulation	Bitumen	8-13	12-17
Steam Assisted Gravity Drainage	Bitumen	8-13	10-16
Mining / Extraction	Bitumen	6-9	11-15
Integrated Mining / Upgrading	Syncrude	11-17	21-27

** Total Supply Cost includes capital and operating expenses.

Source: National Energy Board of Canada, An Energy Market Assessment, 2004. Costs converted to U.S. dollars and escalated to 2005 by INTEK, Inc.

Markets for Oil from Tar Sands

- Bitumen from tar sands produced in Utah would be refined in PADD IV.
- PADD IV refining capacity (600 M Bbl/d, projected to double by 2025) could fully absorb potential Utah syncrude production if expanded.
- Refineries in the region now process 555 M Bbl/d of crude; 260 M Bbl/d from Canada.
- Utah tar sands must compete with Alberta syncrude for market share on a $/bbl basis

Tar Sands Environmental Data

Emissions

- Bitumen and syncrude manufacture produces a slate of gases that includes carbon dioxide, sulfur dioxide, and nitrous oxides.
- Technology is available to control and reduce emissions. Scrubbers on coking units can reduce sulfur emission to acceptable levels, given the bitumen is low in sulfur (~0.6 %) to begin with.

Land Disturbance

- The area of disturbance depends on mining versus in-situ processing. A 50 M Bbl/d surface operation would require 10,000 acres. Land can later be reclaimed with cleanup and rejuvenation efforts.

Water Impacts

- Depending on the process, a large volume of water may be needed to extract and process tar sands and bitumen, albeit because of favorable mineral composition, less than the 3 bbl/bbl current used in Alberta.
- Use of substantial volumes of water could affect regional water supplies.
- The release of treated water, could affect the regional water quality and supply.

References

[1] International Centre for Heavy Hydrocarbons, 1993 U.S. Bitumen Database, http://www.oildrop.org.

Conceptual Analysis of Uinta and Green River Water Development Projects

Technical Memorandum #3

Establish Selection Criteria

Prepared by:

CH2MHILL

&

FRANSON
CIVIL ENGINEERS

July 2007

TABLE OF CONTENTS

INTRODUCTION

The objective of this technical memorandum is to outline the criteria that will be used to compare alternatives. Key issues and project constraints will be taken into consideration. This memo will also describe the procedure that will be used to quantitatively evaluate each alternative based on a rating and weighting system.

1. PROJECT OBJECTIVES

A. Key Issues

There are several key issues that need to be considered in the formulation and evaluation of a project to develop water from the Uinta and Green Rivers. One of the primary issues is the need for water. This need not only includes water for agricultural shortages but also includes growing municipal and industrial demands, especially those involved with the energy industry. Another main issue is the availability of Green River water. Both the Uinta Water Conservancy District (UWCD) and the Duchesne County Water Conservancy District (DCWCD) have been allocated water from the Flaming Gorge water right and need to show that it can be put to beneficial use. In addition to utilizing the Flaming Gorge water right the effective use of UWCD, DCWCD, and Central Utah Water Conservancy District (CUWCD) water rights is a priority. Other issues to be considered include environmental enhancement, economic development, and political and social unification.

B. Project Constraints

As with all water development projects, certain obstacles are present that may make project implementation more challenging. One such constraint for this project is land ownership as it relates to location of facilities. There are certain areas that will be unavailable or less feasible for certain project facilities due to political, environmental, and social factors.

2. EVALUATION CRITERIA

In order to provide an organized and systematic approach to evaluating alternatives, a set of criteria has been developed. These criteria fall under four categories used to test if an alternative is viable. It is assumed that an alternative must be complete, effective, efficient, and acceptable in order to be viable. This section provides definitions for each test of viability and explanations for each criterion.

A. Four Tests of Viability

Completeness

Completeness is the extent to which a given alternative provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness

Effectiveness is the extent to which an alternative alleviates the specified problems and achieves the specified opportunities.

Efficiency

Efficiency is the extent to which an alternative is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities.

Acceptability

Acceptability is the workability and viability of an alternative through the perspective of State and Federal agencies, local entities, and the public, as well as the compatibility with existing laws, regulations, and public policies.

B. Completeness Criteria

Agricultural Shortages

Does the given alternative reduce agricultural water shortages? To what extent are the shortages reduced? Are shortages reduced in all of the project area, or just in certain locations? In which of the following areas are shortages reduced?

- Upper Uinta
- Whiterocks
- Gusher Area
- Dry Gulch Area
- Leota/Ouray
- Etc.

Late Season Agricultural Demands

To what extent are the agricultural shortages reduced in relation to timing of the irrigation season? Does the alternative provide a means to meet the demands later in the irrigation season when direct flow is no longer sufficient?

Early Season Agricultural Demands

To what extent are the agricultural shortages reduced in relation to timing of the irrigation season? Does the alternative provide a means to meet the demands early in the irrigation season prior to spring runoff?

Use of Districts' Water Rights

The Central Utah Water Conservancy District, UWCD, and DCWCD all have right to water that can be developed through this project. Does the given alternative maximize the use of the Districts' water rights in both the Uinta and Green Rivers? Does the alternative effectively utilize water from the Flaming Gorge water rights with respect to the diversion and depletion amounts allocated by the Utah Board of Water Resources? How much of the Districts' allocations will be put to beneficial use? Does the given alternative effectively utilize depletion allowance from the Uinta River as discussed in the biological opinion for the Duchesne River?

High Mountain Lake Stabilization

Does the given alternative provide opportunity to stabilize lakes in the high mountain wilderness area? How many of the lakes can be stabilized? How much of the storage can be transferred into an alternate storage facility?

Energy Industry Demands

To what extent does the alternative provide water for the growing energy industry? Does the alternative include development of water for injection into oil wells, and processing of oil shale and tar sands?

Municipal and Industrial (M&I) Demands

Does the given alternative include meeting the growing culinary demands throughout the Uintah Basin? To what extent does the alternative meet industrial demands? Is culinary and industrial water available in all of the project area, or just in certain locations? In which of the following areas are M&I demands met?

- Neola/Cedarview
- Roosevelt/Ballard
- Tridell/Lapoint
- Randlett/Ouray
- Other

New Agricultural Lands

Does the given alternative provide enough water to develop new areas for irrigation in addition to meeting the existing demands?

C. Effectiveness Criteria

Diurnal Fluctuations

To what extent does the alternative address diurnal fluctuations? Will the alternative reduce or eliminate diurnal fluctuations during spring runoff? Does the alternative allow utilization of the short duration peak flows during spring runoff?

Environmental Benefits

To what extent does the alternative address environmental issues such as in-stream flows in the Uinta and Duchesne Rivers, water conservation, wetlands, wildlife habitat, and endangered fish species?

Water Yield

How much water will be developed by the given alternative?

Shortage Priority

To what extent does the alternative equitably address whom gets water when the Uintah River, Whiterocks River and their tributaries are down but the Green River still has good flow available due to Flaming Gorge Reservoir? To what extent does the alternative equalize supply within specific service areas with the same priority? Will areas with the same diversion priority receive the same amount of water at the same time?

Economic Development

To what extent does the given alternative benefit the economic development of the Uintah Basin? Does the alternative provide opportunity for growth in the energy industry, support population growth, and allow for more efficient agricultural practices?

Reliability

Is the alternative reliable? To what extent will the project features be utilized over a long period of time? Will the alternative provide water in dry years? Does the alternative provide opportunity for carryover storage?

Flexibility in Operation

How flexible is the operation of project features? If demands change, such as nature and place of use, will the operation of facilities be able to be adapted to fit new demands? For example, how easily can water for agricultural uses be converted to municipal or industrial uses? Does the alternative minimize pumping? To what extent does the given alternative maximize the storage of winter water to meet demands?

D. Efficiency Criteria

Capital Costs

What are the costs to implement the given alternative?

Annual Operating Costs

What is the annual cost to operate the given alternative?

Present Worth (Direct and Per Acre-foot Developed)

Taking both the capital and operating costs into account, what is the cost of the given alternative? The present worth of the alternatives should be compared directly as well as on a present worth per acre-feet of water delivered basis. The direct present worth should be compared because the present worth per acre-feet delivered may be good but the total cost may be far more than can be repaid by the water users. The present worth per acre-feet delivered should be compared to find the most efficient alternative. For example, an alternative that has a low present worth per acre-feet delivered would be the most efficient use of resources if the total cost was not prohibitive.

Funding/Repayment

This criterion takes into consideration the chance a given alternative provides for funding that will decrease the capital costs that will need to be repaid by the water users. To what extent does the given alternative provide for funding opportunities?

E. Acceptability Criteria

Water Conservancy Districts

To what extent do the water conservancy districts deem the given alternative acceptable? To what extent does the given alternative coincide with the project objectives that have been set for water development in the Uintah Basin? To what extent is the given alternative compatible with the districts' regulations and policies?

Agencies (Federal and State)

To what extent does the given alternative address regulations and policies set forth by all Federal and State agencies? How easy will it be to implement the given alternative with respect to agency requirements (permitting)?

Environmental Groups

To what extent will the given alternative be deemed acceptable by environmental groups? To what extent does the given alternative provide mitigation for environmental consequences?

Local Citizens (Water Users)

To what extent will the given alternative be deemed acceptable by water users? Will they support the given alternative? Will they pay the related operating and repayment costs associated with the given alternative?

Tribe

To what extent will the given alternative be deemed acceptable by the Tribe? Will they support the given alternative?

3. RATING AND WEIGHTING SYSTEM

A computer model has been developed to rapidly and transparently display the results of the alternative evaluation. The evaluation consists of prioritizing the criteria by assigning weights based on input from the Districts and stakeholders. Then, for each alternative, the criteria are rated on a scale from 0 to 10 based on how well the Districts and stakeholders believe the alternative meets each criterion.

A. Weighting the Criteria

In order to consider the importance and relativity of the criteria, a weighting factor has been assigned to each criterion. The weighting factor is a whole integer between the numbers 1 and 5 (1, 2, 3, 4, or 5). A weighting factor of 1 signifies that the criteria is important enough to be rated but not a high priority. A weighting factor of 5, however, signifies that the criterion is a very important consideration in evaluating the alternatives.

Since the weighting factors are to be multiplied by the rating, it is important to note that a weighting factor of 2 means that the criterion is twice as important as a criterion with a weighting factor of 1. Similarly, a 4 is twice as important as a 2. Some criteria will have the same level of importance and, therefore, can be assigned the same weighting factor. If there is one criterion that is clearly the most important, it should be the only one assigned a 5.

All criteria are weighted on the same 1 to 5 scale regardless of which test of viability they are categorized. Therefore, the weighting factors need to be considered relative to all criteria even those that fall under a different category of viability.

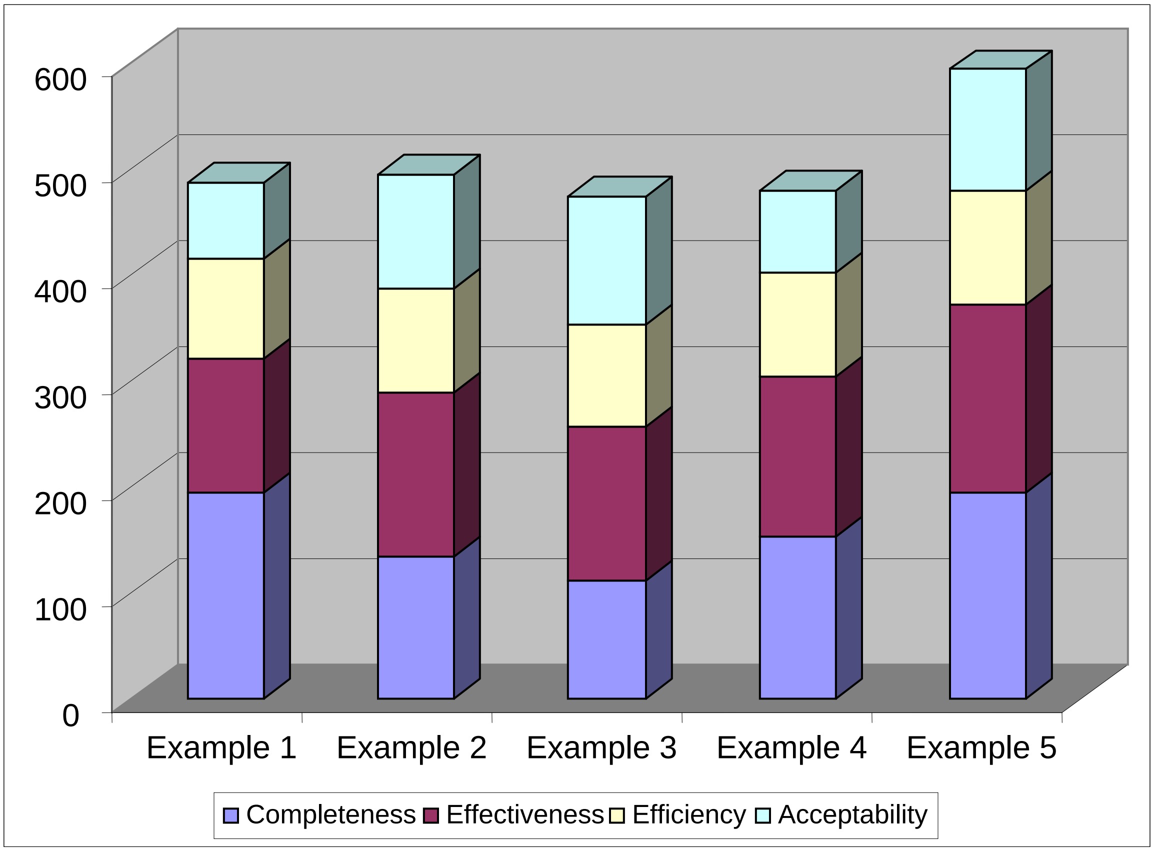
B. Rating the Alternatives

Once the weighting factors have been assigned to the individual criteria, the alternatives can be evaluated by assigning a rating of each criterion for each alternative. The rating is a whole integer between 0 and 10. If the alternative does not meet the criteria at all, it is rated at 0. If the criterion is met completely or most effectively, then it can be rated a 10. Ratings in between 0 and 10 show the extent to which that alternative meets that criterion.

Once each criterion has been rated for the alternative, the ratings are multiplied by the weighting factor to obtain a point value. The point values for all of the criteria in each viability category are added up for a categorical score. The four categorical scores are then added to determine an overall total score for each alternative. This process is illustrated for an example alternative in the attached table.

C. Displaying the Results

Total scores for each alternative will be displayed in a bar graph like the one shown below. The bar will be divided to show the sub-total score for each category.


600
500
400
300
200
100
0
Example 1
Example 2
Example 3
Example 4
Example 5
Completeness
Effectiveness
Efficiency
Acceptability

Conceptual Analysis of Uinta and Green River Water Development Projects

Technical Memorandum #3 - Addendum

Establish Selection Criteria – Rate Alternatives

Prepared by:

CH2MHILL

&

FRANSON
CIVIL ENGINEERS

November 2007

TABLE OF CONTENTS

RATING AND WEIGHTING SYSTEM

In addition to the baseline, nine project alternatives were modeled. The alternatives were named Scenario 2 through Scenario 10. The process for evaluating the alternatives, based on weighting the criteria and rating the alternatives as described in Technical Memorandum #3, has been completed. The purpose of this addendum is to display the results of the weighting and rating process.

Weighting the Criteria

Each criterion was assigned a weighting factor, which is a whole integer between the numbers 1 and 5, with 5 being the most significant. The assigned factors can be seen on Table 1 - Alternative Rating Matrix.

All criteria were weighted on the same 1 to 5 scale regardless of which test of viability they were categorized under. How the criteria were weighted determined the importance of each viability test. For example, completeness received about 33% of the weighting factor points, effectiveness 23%, efficiency 15%, and acceptability 29%.

Rating the Alternatives

Once the weighting factors had been assigned to the individual criteria, the alternatives were evaluated by assigning a rating to each criterion for each alternative. Ratings were assigned based on how well the scenario met basin-wide needs. Therefore, although Scenarios 8 through 10 are quite viable for a localized area, the lower ratings reflect the bigger picture.

The ratings were multiplied by the weighting factors to determine point values, which were added up for an overall total score for each alternative. The results are listed in the alternative rating matrix and illustrated on Figure 1 - Evaluation Bar Chart.

The scenarios are listed in order of their total scores in the following table.

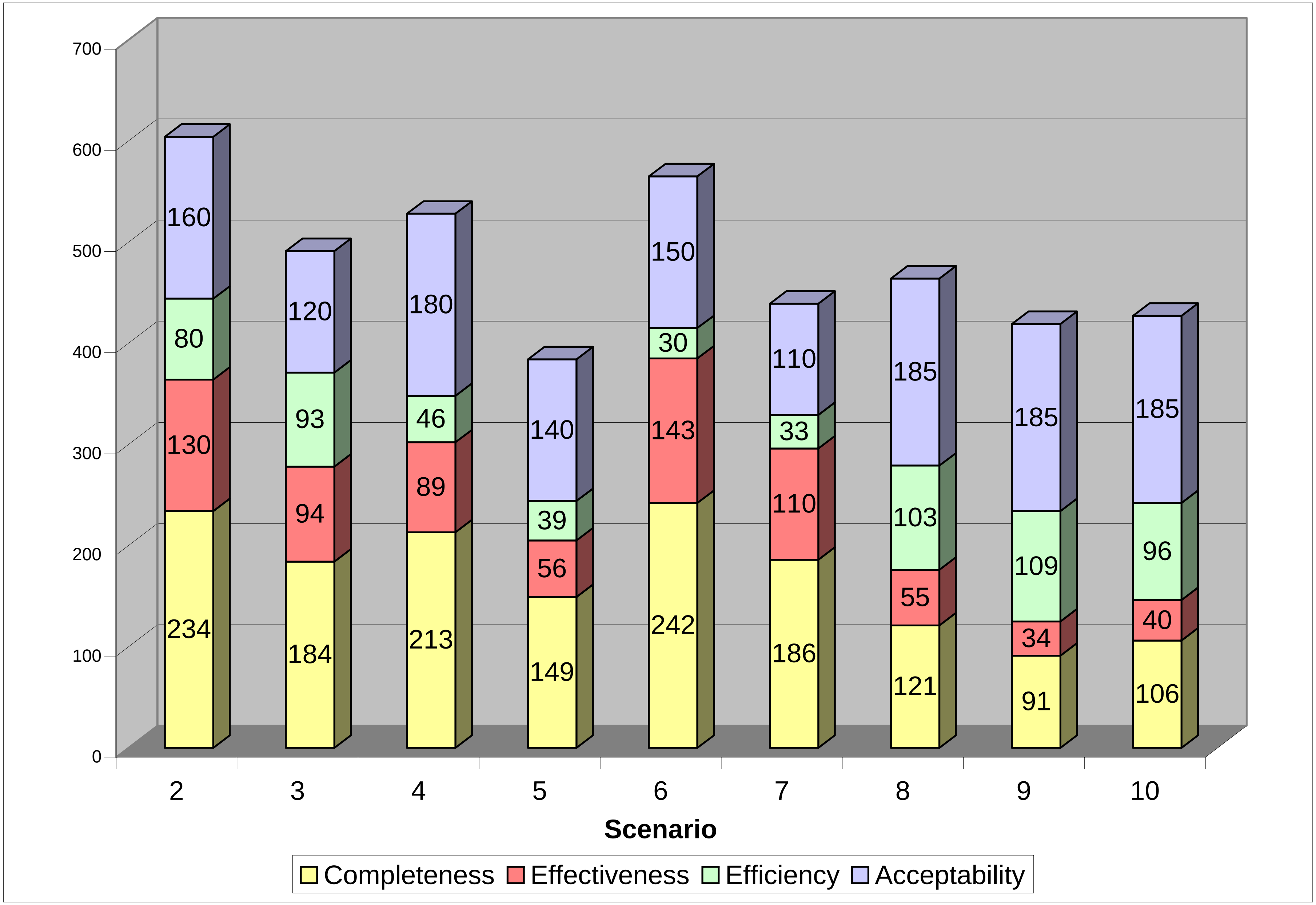
Scenario	Description	Total Score
2	Main stem with pumping	593
6	Main stem plus off-stream storage with pumping	565
4	Off-stream storage with pumping	525
3	Main stem without pumping	486
8	Pump to Pelican Lake and Cottonwood service area	464
7	Main stem plus off-stream storage without pumping	439
10	Pump to Pelican Lake and from Pelican Lake to Cottowood service area	427
9	Pump to Pelican Lake only	419
5	Off-stream storage without pumping	384

TABLE 1
Alternative Rating Matrix

Alternatives		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8		Scenario 9		Scenario 10	
Criteria	Weighting Factor	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points	Rating 0 to 10	Points
COMPLETENESS																			
Reduce agricultural shortages	5	7	35	5	25	7	35	5	25	7	35	6	30	6	30	4	20	5	25
Meet late season agricultural demands	5	7	35	6	30	6	30	5	25	8	40	7	35	3	15	3	15	3	15
Meet early season agricultural demands	5	7	35	7	35	6	30	6	30	8	40	8	40	3	15	3	15	3	15
Maximize use of Districts' water rights	5	8	40	1	5	7	35	1	5	7	35	1	5	8	40	4	20	6	30
Stablize high mountain lakes	5	10	50	10	50	10	50	10	50	10	50	10	50	0	0	0	0	0	0
Provide water for energy development*	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5
Provide water for M&I development	3	8	24	8	24	6	18	3	9	9	27	7	21	2	6	2	6	2	6
Provide water for new agricultural land	2	5	10	5	10	5	10	0	0	5	10	0	0	5	10	5	10	5	10
	35		**234**		**184**		**213**		**149**		**242**		**186**		**121**		**91**		**106**
EFFECTIVENESS																			
Diurnal fluctuations	5	6	30	6	30	2	10	2	10	8	40	8	40	0	0	0	0	0	0
Environmental benefits*	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4
Water yield	3	10	30	4	12	7	21	2	6	10	30	5	15	3	9	0	0	2	6
Shortage priority	3	5	15	5	15	3	9	3	9	6	18	6	18	1	3	1	3	1	3
Economic development*	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
Reliability	3	8	24	5	15	7	21	4	12	8	24	5	15	6	18	4	12	4	12
Flexibility in operation	3	8	24	5	15	7	21	4	12	8	24	5	15	6	18	4	12	4	12
	24		**130**		**94**		**89**		**56**		**143**		**110**		**55**		**34**		**40**
EFFICIENCY																			
Capital costs	2	7	14	7	14	3	6	4	8	0	0	0	0	10	20	10	20	10	20
Annual operating costs	2	2	4	10	20	2	4	9	18	0	0	8	16	4	8	7	14	4	8
Present worth - Direct	2	6	12	7	14	3	6	4	8	0	0	1	2	10	20	10	20	9	18
Present worth - Per acre-feet developed	5	9	45	8	40	5	25	0	0	5	25	2	10	10	50	10	50	9	45
Funding/Repayment*	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5
	16		**80**		**93**		**46**		**39**		**30**		**33**		**103**		**109**		**96**
ACCEPTABILITY																			
Water conservancy districts	5	8	40	4	20	8	40	4	20	8	40	4	20	6	30	6	30	6	30
Federal agencies	5	6	30	6	30	7	35	7	35	5	25	5	25	8	40	8	40	8	40
State agencies	5	6	30	6	30	7	35	7	35	5	25	5	25	8	40	8	40	8	40
Environmental groups	5	3	15	3	15	5	25	5	25	3	15	3	15	8	40	8	40	8	40
Local citizens - water users	5	8	40	4	20	8	40	4	20	8	40	4	20	6	30	6	30	6	30
Tribe*	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5
	30		**160**		**120**		**180**		**140**		**150**		**110**		**185**		**185**		**185**
Total	**105**		**604**		**491**		**528**		**384**		**565**		**439**		**464**		**419**		**427**

* Not enough information currently to rank by this criterion.

FIGURE 1
Evaluation Bar Chart



Scenarios and Cost Estimates

PREPARED FOR: Central Utah Water Conservancy District
Uintah Water Conservancy District
Duchesne County Water Conservancy District

PREPARED BY: CH2M HILL

DATE: December 6, 2007

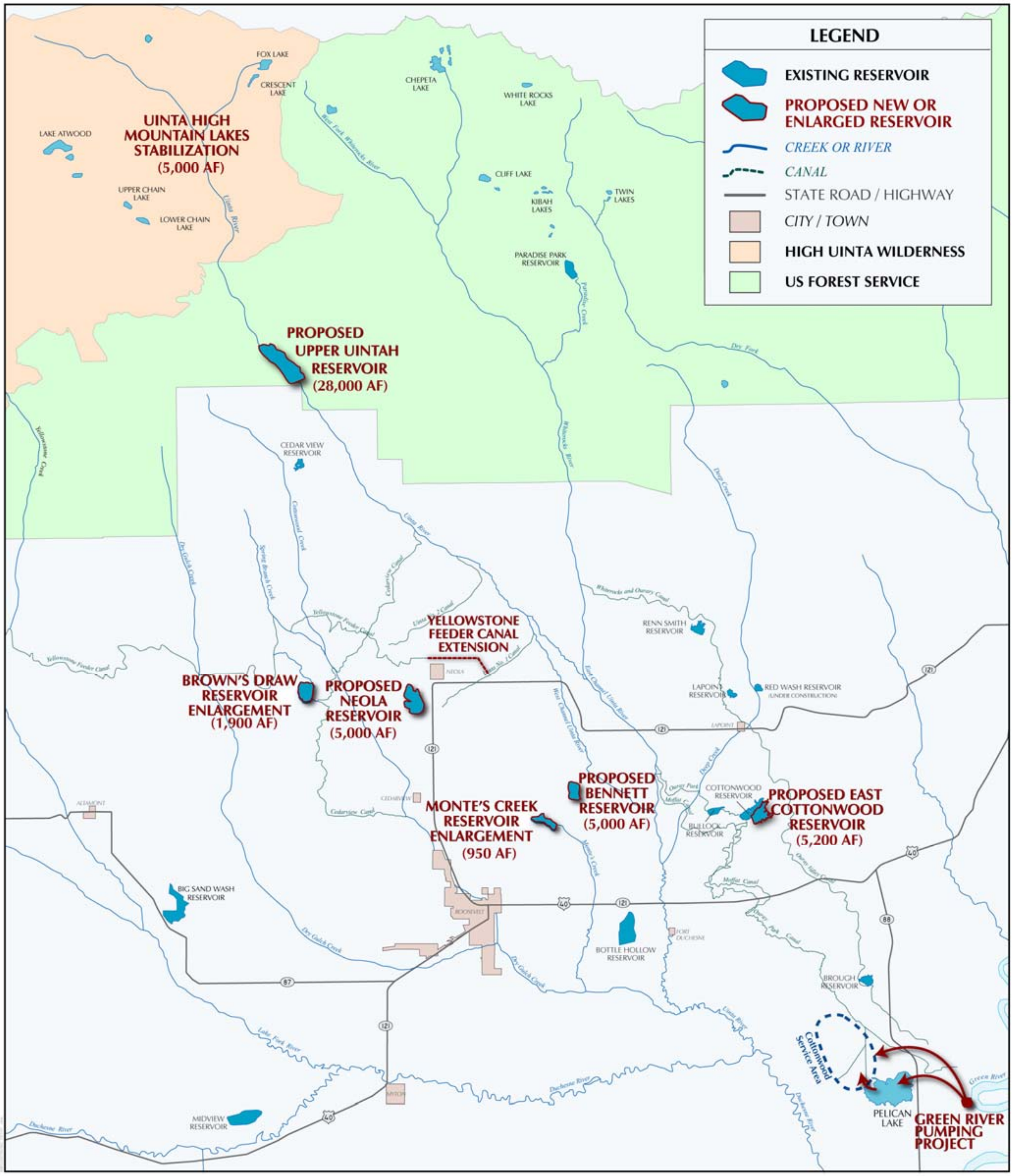
Contents

Introduction

The purpose of this technical memorandum is to present the scenarios that have been developed to meet the future water demands of the Uinta Basin. Ten scenarios (Scenario 1 through Scenario 10) were identified during a meeting attended by Franson Civil Engineers, CH2M HILL, Central Utah Water Conservancy District (WCD), Uintah WCD, Utah Department of Water Rights, and Duchesne County WCD in August, 2007. These scenarios are described in this document at a conceptual design level. Figures showing these scenarios are provided in Attachment 1. A cost estimate was generated for each scenario and is summarized within each section. More detailed cost estimates are provided in Attachment 2. CH2M HILL developed a water balance model to estimate total developed water of these scenarios. This model is described in Technical Memorandum 5.

The project facilities evaluated include four new reservoir sites, two enlarged reservoirs, an extension of the Yellowstone Feeder Canal, pumping from the Green River, and multiple water right exchanges. The four potential new reservoirs include Upper Uinta Reservoir, Neola Reservoir, Bennett Reservoir, and East Cottonwood Reservoir. The proposed reservoir enlargements include Montes Creek Reservoir and Brown's Draw Reservoir. Green River pumping options evaluated include pumping from Green River to Pelican Lake, pumping from Green River to the Cottonwood Service Area, pumping from Pelican Lake to the Cottonwood Service Area, and combinations of these options. An overview of these project features is shown in Figure 1.

FIGURE 1
Overview of Project Features



Scenarios

Various combinations of features were considered for delivering water; each combination of features is referred to as a scenario. A summary of the project features included in each scenario is summarized in Table 1.

TABLE 1
Summary of Scenarios

Scenario	Project Features Included
1	No Improvements
2	Upper Uinta Reservoir, Uinta High Mountain Lakes Stabilization, and Green River Pumping
3	Upper Uinta Reservoir and Uinta High Mountain Lakes Stabilization
4	Enlarge Brown’s Draw & Montes Creek Reservoirs, Bennett, Neola, & East Cottonwood Reservoirs, Yellowstone Feeder Canal Extension, Uinta High Mountain Lakes Stabilization, and Green River Pumping
5	Enlarge Brown’s Draw & Montes Creek Reservoirs, Bennett, Neola, & East Cottonwood Reservoirs, Yellowstone Feeder Canal Extension, and Uinta High Mountain Lakes Stabilization
6	Enlarge Brown’s Draw & Montes Creek Reservoirs, Upper Uinta Reservoir, Bennett, Neola, & East Cottonwood Reservoirs, Yellowstone Feeder Canal Extension, Uinta High Mountain Lakes Stabilization, and Green River Pumping
7	Enlarge Brown’s Draw & Montes Creek Reservoirs, Upper Uinta Reservoir, Bennett, Neola, & East Cottonwood Reservoirs, Yellowstone Feeder Canal Extension, and Uinta High Mountain Lakes Stabilization
8	Green River Pumping Only: Pump to Pelican Lake and Pump to Cottonwood Service Area
9	Green River Pumping Only: Pump to Pelican Lake
10	Green River Pumping Only: Pump to Pelican Lake and Pump from Pelican Lake to Cottonwood Service Area

Scenario 1

Scenario 1 is the baseline scenario and proposes no improvements.

Scenario 2

Project Features. Scenario 2 proposes constructing a main stem storage facility and pumping from the Green River. This scenario includes the following features:

- Stabilization of high mountain lakes
- Construction of Upper Uinta Reservoir
- Pumping from Green River to Cottonwood Service Area and to Pelican Lake
- Water right exchanges between upstream and downstream users and exchanges between high priority diverters and new storage rights

Stabilization of High Mountain Lakes. A total of five high mountain lakes would be stabilized under this scenario. Stabilization of these lakes involves removing existing dams and returning the lakes to their original level.

Upper Uinta Reservoir. The Upper Uinta Reservoir would be constructed on the Uinta River approximately 1 mile north of Big Spring Recreation Area (see Figure 2). This reservoir would be located entirely within the boundaries of the Ashley National Forest. This reservoir will serve the following purposes:

- Provide storage for seasonal high flows
- Provide consistent stream flows for fishery enhancement
- Provide improved irrigation delivery
- Provide storage for water that has historically been stored in smaller lakes and reservoirs in the High Uinta Wilderness
- Develop additional water supply for irrigation
- Provide incidental flood control

The Upper Uinta Reservoir would have a capacity of 28,000 acre-feet, which includes 5,000 acre-feet for storage exchanged from the Uinta High Mountain Lakes and a 3,000-acre-foot conservation pool. The dam would be a zoned, earth-and-rock-fill-structure 135 feet high with a crest elevation of 7,615 feet. The dam would have a crest length of 2,720 feet, a crest width of 20 feet, and consist of about 560,000 cubic yards of embankment material. At full pool, the reservoir would have a surface area of approximately 430 acres, be about 2 miles long, and have about 6 miles of shoreline. Reservoir mean and maximum depths would be about 22 and 130 feet, respectively, at full pool. Since this reservoir is located on the Uinta River, the spillway will need to be designed for the probable maximum flood from the upper Uinta watershed.

A summary of the physical features of the Upper Uinta Reservoir and Dam is provided in Table 2.

TABLE 2
Upper Uinta Reservoir Features

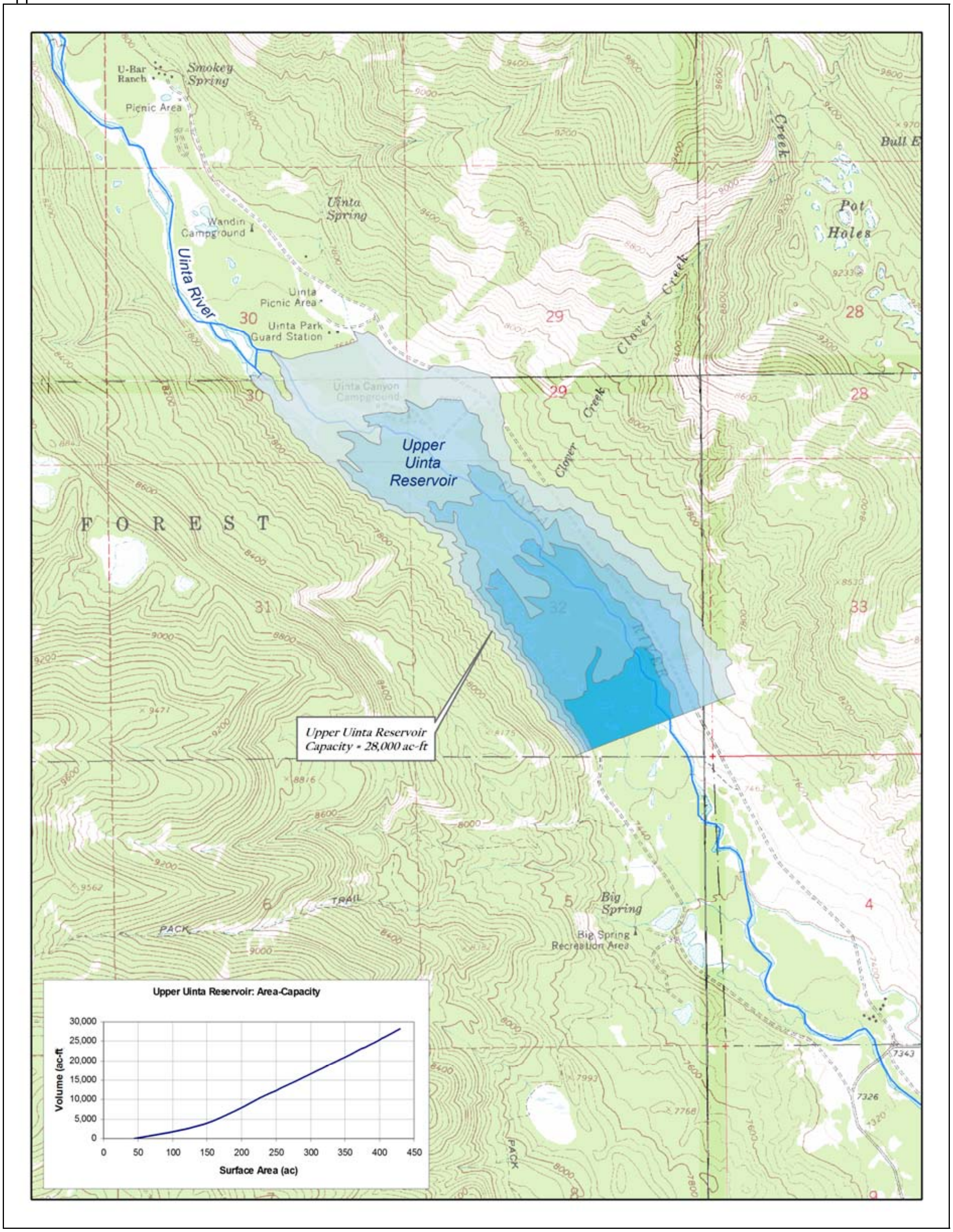
Feature	Value
General	
Water Source	Uinta River
Storage (acre-feet)	
Conservation Pool	3,000
Active Pool	25,000
Total Storage	28,000
Dam	
Type	Earth-fill Embankment
Structural Height (feet)	135
Crest Elevation (feet above mean sea level)	7,615
Crest Length (feet)	2,720
Crest Width (feet)	20
Embankment Volume (cubic yards)	560,000
Reservoir (at full pool)	
Elevation (feet above mean sea level)	7,605
Length (miles)	2
Surface Area (acres)	430
Shoreline Length (miles)	6
Maximum Depth (feet)	130
Mean Depth (feet)	22

The Upper Uinta Reservoir option would require stabilization of the high mountain lakes. There are currently 5,000 acre-feet of water rights stored in these lakes that would instead be stored in the Upper Uinta Reservoir. Beginning October 1, the Upper Uinta Reservoir would begin storing Uinta River water. Once 5,000 acre-feet are stored, water would be delivered to high priority users. After these water rights are satisfied, the reservoir would begin storing the remaining 23,000 acre-feet.

The results of the GoldSim model (discussed in Technical Memorandum 5) show that the reservoir will reach capacity during normal to wet years. However, during dry years the reservoir may only receive the 5,000 acre-feet from high mountain lakes. It is anticipated that the reservoir would drain every year by July or August.

Figure 2 shows the general location and storage capacity curve of the reservoir.

FIGURE 2
Upper Uinta Reservoir



Pumping from the Green River to Cottonwood Service Area and Pelican Lake. This pumping feature would require one pump station at the Green River to deliver water to the Cottonwood Service Area and Pelican Lake as well as approximately 3.2 miles of pipelines (see Figure 3).

Water would be pumped directly from the Green River Pump Station to the Cottonwood Service Area. Water would not be buffered by Pelican Lake, so pumping would be based on the demand of the service area. To deliver water to this service area, approximately 2.2 miles of 36-inch pipeline would be required to connect the Green River Pump Station to a junction (Junction 1) on the existing Lower Park Pipeline. The alignment of the proposed pipeline has not been established, but an alignment is shown in this map for discussion purposes. The Lower Park Pipeline currently delivers water from the Park Canal to the Cottonwood Service Area and would continue to be used as part of this pumping feature.

Water would also be pumped from the Green River Pump Station to Pelican Lake and delivered to the Ouray Park Area. Under this feature, water would also be pumped from the Green River Pump Station to Junction 1, but would then be diverted to Pelican Lake at a new turnout at the junction. Water is currently pumped from Pelican Lake and delivered to the Ouray Park Area, so this pumping feature would not require any change in pumping operations from Pelican Lake. This feature requires 1 mile of 20-inch pipeline to connect the 36-inch pipeline, which terminates at the turnout at Junction 1, to Pelican Lake. Flows pumped to Pelican Lake will not peak as high as flows to the Cottonwood Service Area because of the buffering affect of the Lake. Flow rates to both of these areas were estimated in the model created by CH2M HILL as documented in Technical Memorandum 5.

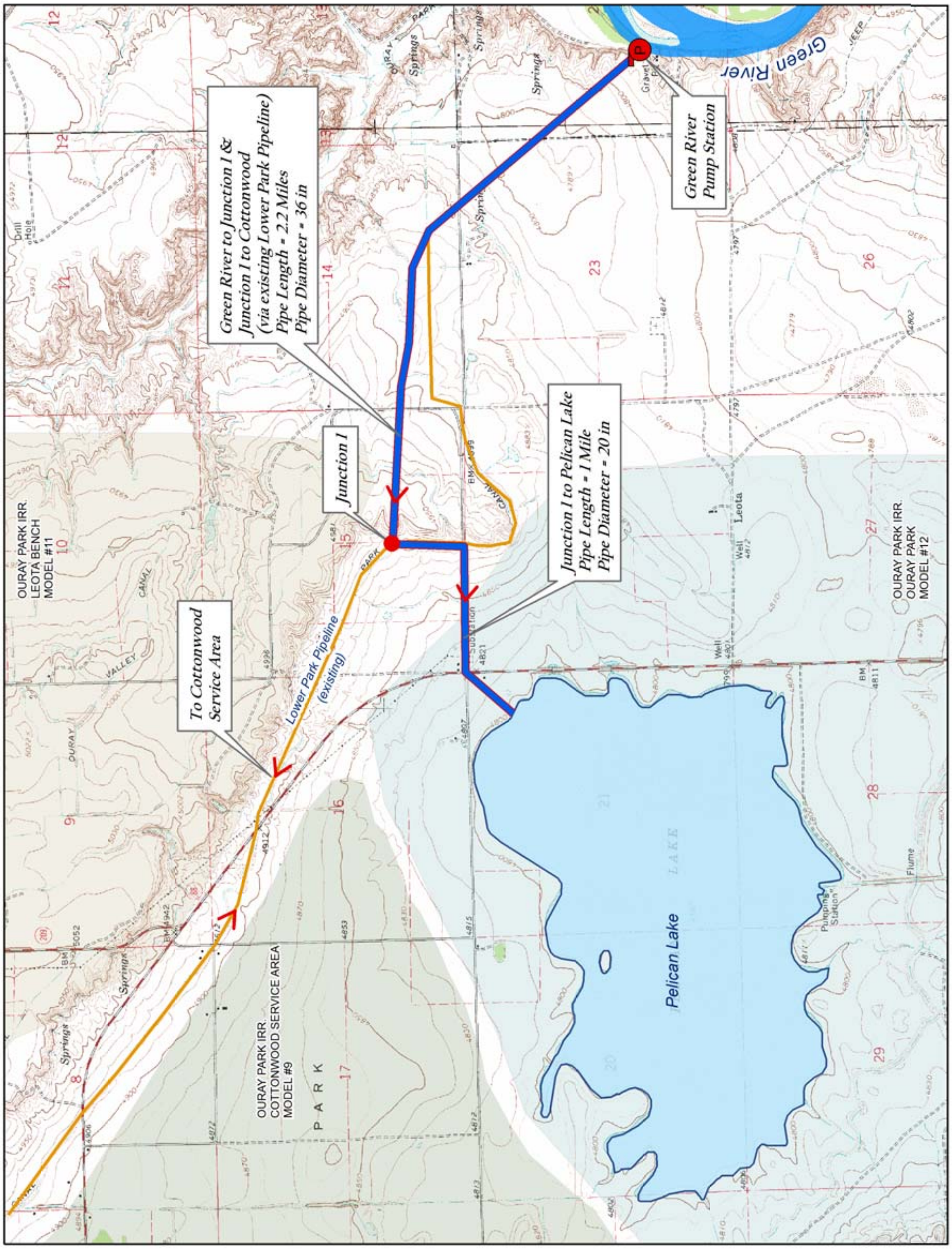
Cost Estimate. A cost estimate for Scenario 2 (which includes the project features described above) is summarized in Table 3.

TABLE 3
Scenario 2 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$63,280,000
Total Pipeline Cost	$4,188,800
Total Pump Station Cost	$5,120,000
Contingency @ 30%	$23,276,600
Subtotal (Total Construction Cost)	***$100,865,400***
Engineering and Administration @ 20%	$20,173,100
Right-of-Way and Easements	$2,239,100
Total Capital Cost	***$123,277,600***
Annual Operation and Maintenance Costs	$144,300
Annual Power Costs @ 7.0 cents per kilowatt-hour	$756,000
Total Present Value Cost of Project (n=50, i=6%)	***$137,468,000***
Total Present Value per acre-foot of Developed Water	***$6,200***

NOTE:
Total Water Developed for this Scenario = 22,300 acre-feet

FIGURE 3
Scenario 2 Green River Pumping



Scenario 3

Project Features. Scenario 3 proposes constructing main stem storage without pumping from the Green River. This scenario includes the following project features:

- Stabilization of high mountain lakes
- Construction of the Upper Uinta Reservoir

Stabilization of High Mountain Lakes. See Scenario 2 for the description of stabilizing high mountain lakes.

Upper Uinta Reservoir. See Scenario 2 for the description of the Upper Uinta Reservoir.

Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 4.

TABLE 4
Scenario 3 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$63,280,000
Contingency @ 30%	$20,484,000
Subtotal (Total Construction Cost)	***$88,764,000***
Engineering and Administration @ 20%	$17,752,800
Right-of-Way and Easements	$2,227,500
Total Capital Cost	***$108,744,300***
Annual Operation and Maintenance Costs	$63,300
Total Present Value Cost of Project (n=50, i=6%)	***$109,742,000***
Total Present Value per acre-foot of Developed Water	***$8,700***

NOTE:
Total Water Developed for this Scenario = 12,600 acre-feet

Scenario 4

Project Features. Scenario 4 proposes constructing off-stream storage and pumping from the Green River. This scenario includes the following project features:

- Stabilization of high mountain lakes
- Construction Bennett Reservoir
- Construction of Neola Reservoir
- Construction of East Cottonwood Reservoir
- Enlargement of Brown's Draw Reservoir
- Enlargement of Montes Creek Reservoir
- Pumping from Green River to Cottonwood Service Area and Pelican Lake
- Water right exchanges between upstream and downstream users and exchanges between high priority diverters and new storage rights

Stabilization of High Mountain Lakes. See Scenario 2 for the description of stabilizing high mountain lakes.

Bennett Reservoir. Bennett Reservoir is an off-stream storage site located approximately 1 mile southeast of Bennett (see Figure 4). This reservoir would receive water from the West Channel Uinta River via the Bench Canal and a new 30-inch pipeline. The new pipeline would connect to the Bench Canal and extend south for 1 mile to the Bennett Reservoir. The purpose of this reservoir is to allow for exchange with high priority water rights with storage rights to benefit secondary water users.

A new pump station located near the outlet of the reservoir and approximately 0.8 mile of 24-inch pipeline would be required to deliver water from the reservoir to the Bench Canal. Delivering water to the Bench Canal by gravity rather than pumping was investigated. However, more than 4 miles of new pipeline would be required to overcome headlosses, making pumping a less expensive alternative.

Bennett Reservoir would have a capacity of 5,000 acre-feet. The dam would be a zoned, earth-and-rock-fill-structure 60 feet high with a crest elevation of 5,410 feet. The dam would have a crest length of 2,460 feet, a crest width of 10 feet, and consist of about 90,000 cubic yards of embankment material. A 1,610-foot-long dike would also be required on the west side of the reservoir. The dike would consist of an additional 30,000 cubic yards of material. At full pool, the reservoir would have a surface area of approximately 220 acres, be about 1 mile long, and have about 2.5 miles of shoreline. Reservoir mean and maximum depths would be about 13 and 50 feet, respectively, at full pool.

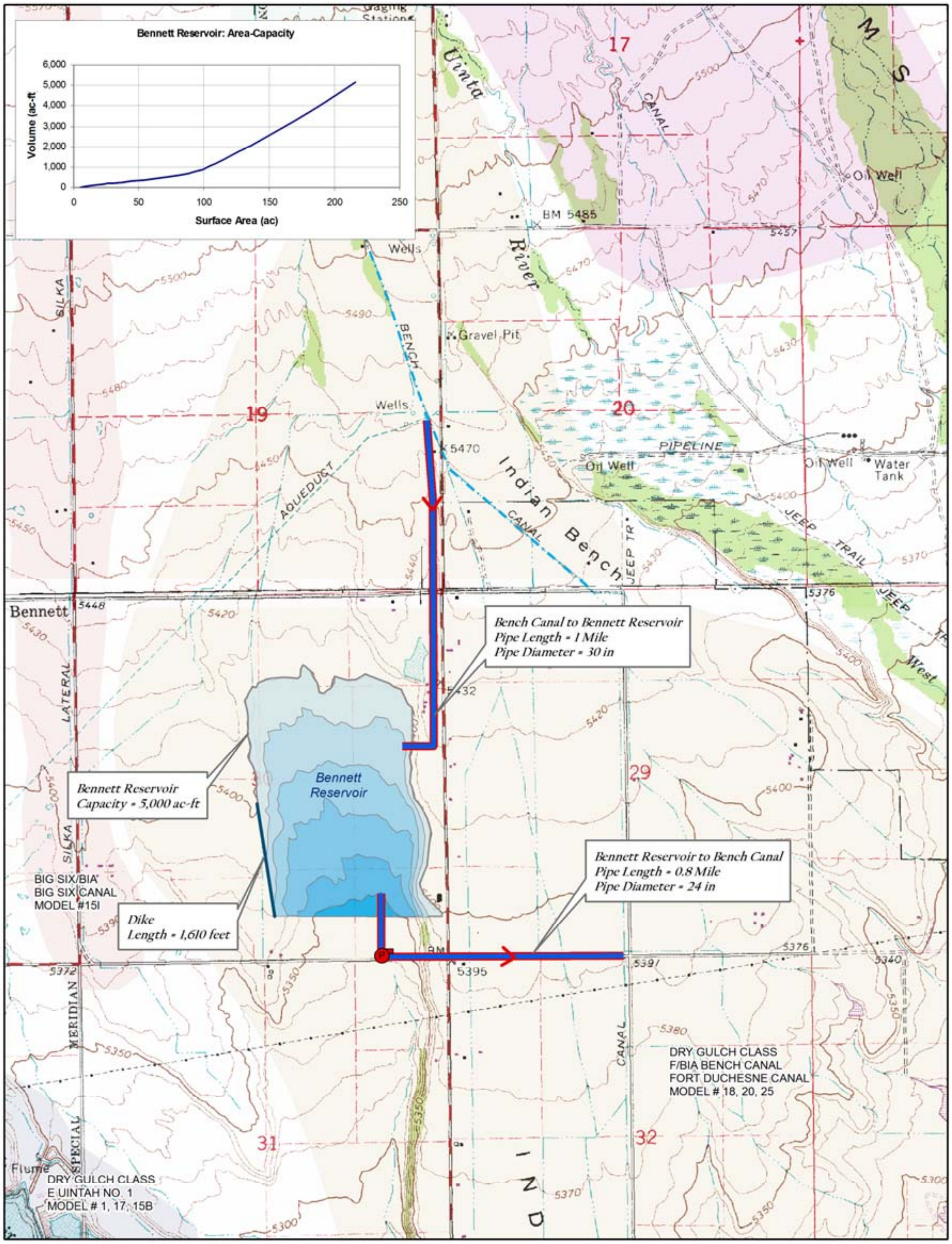
Table 5 summarizes the physical features of Bennett Reservoir and Dam. Figure 4 shows the general location, required pipelines, and storage capacity curve of the reservoir.

TABLE 5
Bennett Reservoir Features

Feature	Value
General	
Water Source	West Channel Uinta River
Storage (acre-feet)	
Conservation Pool	0
Active Pool	5,000
Total Active	5,000
Dam/Dike	
Type	Earth-fill Embankment
Structural Height (feet)	60
Crest Elevation (feet above mean sea level)	5,410
Crest Length (feet)	2,460 / 1,610*
Crest Width (feet)	10
Embankment Volume (cubic yards)	90,000 / 30,000*
Reservoir (at full pool)	
Elevation (feet above mean sea level)	5,400
Length (miles)	1
Surface Area (acres)	220
Shoreline Length (miles)	2.5
Maximum Depth (feet)	50
Mean Depth (feet)	13

NOTE:
* Dam/Dike

FIGURE 4
Bennett Reservoir



Neola Reservoir. Neola Reservoir is an off-stream storage site located approximately 1 mile southwest of Neola (see Figure 5). This reservoir would receive water from the Uinta River via a new 7.4-mile, 36-inch pipeline. The pipeline would parallel the Uintah Canal from the Uinta River, then head south and parallel to Lateral 2½. The purpose of this reservoir is to reduce the water shortage of lower priority secondary water users by allowing for exchange with water delivered to Indian lands with storage rights to benefit secondary water users.

Neola Reservoir would have a capacity of 5,000 acre-feet. A reservoir larger than 5,000 acre-feet could be developed at this site, but it was found in the model developed by CH2M HILL (see Technical Memorandum 5) that there would rarely be enough water in the Uinta River to fill Neola Reservoir above 5,000 acre-feet. The dam would be a zoned, earth-and-rock-fill-structure 85 feet high with a crest elevation of 5,825 feet. The dam would have a crest length of 1,410 feet, a crest width of 10 feet, and consist of about 90,000 cubic yards of embankment material. At full pool, the reservoir would have a surface area of approximately 180 acres, be about 1 mile long, and have about 2.5 miles of shoreline. Reservoir mean and maximum depths would be about 11 and 75 feet, respectively, at full pool. A summary of the physical features of Neola Reservoir and Dam is provided in Table 6.

Water is currently diverted from the Uinta River to Indian lands via the Uintah Canal. With the addition of the Neola Reservoir, water diverted from the Uinta River would instead be delivered to lower priority secondary users and to Neola Reservoir. Indian lands would then receive their water from Neola Reservoir rather than directly from the Uinta River. The diversion at the Uinta River would be adjusted based on the water level of the reservoir. Various delivery methods are shown in Figure 5 and described as follows:

- **Neola Reservoir Outlet to Yellow Feeder Canal.** A new pump station and approximately 2.6 miles of 36-inch pipeline would deliver water from Neola Reservoir to the Yellowstone Feeder Canal, where it could then be delivered to project lands located to the east of Neola Reservoir. This alternative was not included in the cost estimate since the other delivery options are more likely to be implemented.

- **Yellowstone Feeder Extension.** The Yellowstone Feeder Canal currently terminates at Lateral Number 2, allowing water to be delivered south of this intersection. Extending the Yellowstone Feeder Canal for 2.6 miles to the Uinta Number 1 Canal would allow water to be delivered to a much larger area.

- **Neola Reservoir Outlet to East. Roosevelt Lateral.** Approximately 1.8 miles of 24-inch pipeline would be required to deliver water from the Neola Reservoir outlet to the East Roosevelt Lateral.

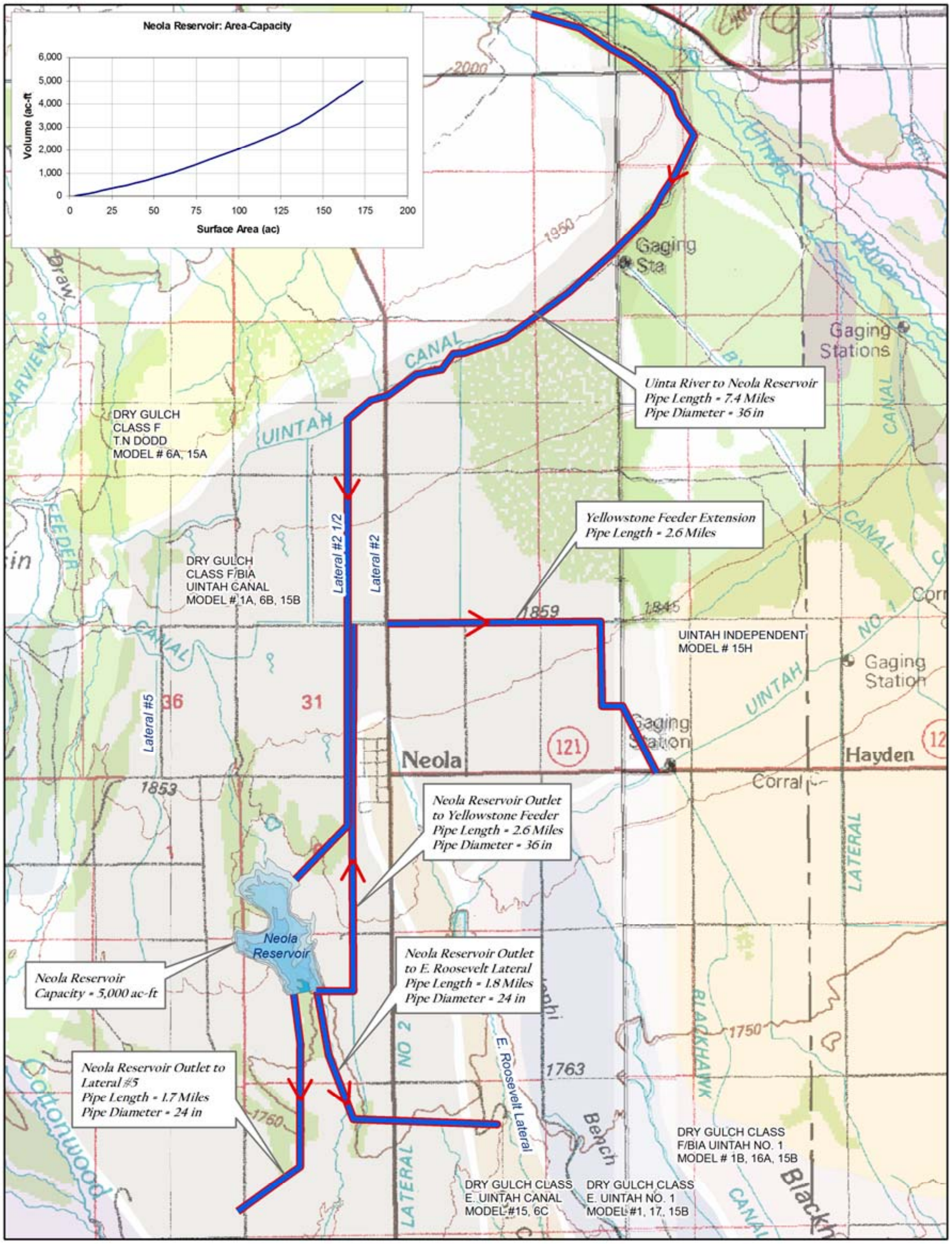
- **Neola Reservoir Outlet to Lateral Number 5.** Approximately 1.7 miles of 24-inch pipeline would be required to deliver water from the Neola Reservoir outlet to Lateral Number 5.

Figure 5 shows the general location and storage capacity curve of the reservoir as well as the various delivery options described previously.

TABLE 6
Neola Reservoir Features

Feature	Value
General	
Water Source	Uinta River
Storage (acre-feet)	
Conservation Pool	0
Active Pool	5,000
Total Active	5,000
Dam	
Type	Earth-fill Embankment
Structural Height (feet)	85
Crest Elevation (feet above mean sea level)	5,825
Crest Length (feet)	1,410
Crest Width (feet)	10
Embankment Volume (cubic yards)	90,000
Reservoir (at full pool)	
Elevation (feet above mean sea level)	5,815
Length (miles)	1
Surface Area (acres)	180
Shoreline Length (miles)	2.5
Maximum Depth (feet)	75
Mean Depth (feet)	11

FIGURE 5
Neola Reservoir



East Cottonwood Reservoir. East Cottonwood Reservoir is an off-stream storage site located just east of the existing Cottonwood Reservoir (see Figure 6). There are two ways that water can be delivered to the proposed East Cottonwood Reservoir:

- Water can continue to be diverted from the Uinta River through the existing Ouray Park canal into the existing Cottonwood Reservoir. Water would then spill from Cottonwood Reservoir into East Cottonwood Reservoir
- Water can be diverted from the Whiterocks River through the existing Whiterocks-Ouray Valley Canal into an existing draw. Water would flow through 1¼ miles of the draw into East Cottonwood Reservoir.

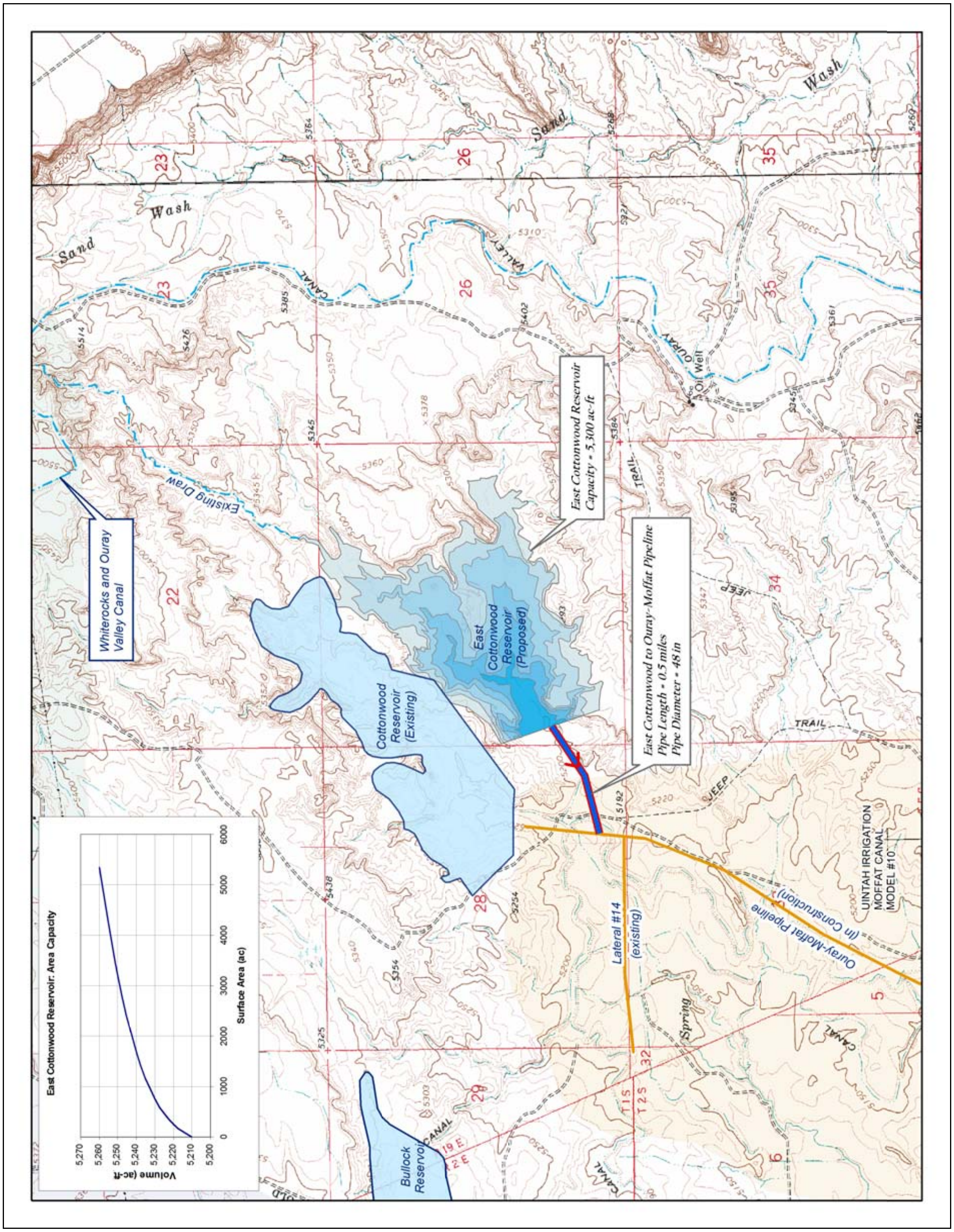
A new 0.5-mile, 48-inch pipeline would be required to deliver water from the East Cottonwood Reservoir outlet to the existing Ouray-Moffat Pipeline. The proposed East Cottonwood Reservoir has a capacity of 5,300 acre-feet. This reservoir site is located adjacent to the existing Cottonwood Reservoir and the two dams would share an abutment. The existing spillway of Cottonwood Reservoir would spill into East Cottonwood Reservoir. The East Cottonwood Reservoir Dam would be a zoned, earth-and-rock-fill-structure 60 feet high with a crest elevation of 5,270 feet. The dam would have a crest length of 2,700 feet, a crest width of 10 feet, and consist of about 110,000 cubic yards of embankment material. At full pool, the reservoir would have a surface area of approximately 240 acres, be about 0.8 mile long, and have about 5 miles of shoreline. Reservoir mean and maximum depths would be about 13 and 50 feet, respectively, at full pool.

Table 7 summarizes the physical features of East Cottonwood Reservoir and Dam. Figure 6 shows the general location, required pipeline, and storage capacity curve of the reservoir.

TABLE 7
East Cottonwood Reservoir Features

Feature	Value
General	
Water Source	Uinta River and/or Whiterocks River
Storage (acre-feet)	
Conservation Pool	0
Active Pool	5,300
Total Active	5,300
Dam	
Type	Earth-fill Embankment
Structural Height (feet)	60
Crest Elevation (feet above mean sea level)	5,270
Crest Length (feet)	2,700
Crest Width (feet)	10
Embankment Volume (cubic yards)	110,000
Reservoir (at full pool)	
Elevation (feet above mean sea level)	5,260
Length (miles)	0.8
Surface Area (acres)	240
Shoreline Length (miles)	5
Maximum Depth (feet)	50
Mean Depth (feet)	13

FIGURE 6
East Cottonwood Reservoir



Enlarge Brown's Draw Reservoir. Brown's Draw is an existing off-stream reservoir site located approximately 5 miles west of Neola (see Figure 7). This option would include rehabilitating and enlarging the existing dam to increase the reservoir capacity by almost 25 percent. Water would continue to be diverted from the Yellowstone River through the existing Yellowstone Feeder Canal and from Uinta River through the existing Cedarview Canal. The enlarged reservoir would allow for additional storage of low priority water rights from the Uinta River. This water would be delivered to secondary users, reducing their shortage.

The existing dam at Brown's Draw Reservoir is an 80-foot-high, earth-fill embankment. The dam is approximately 1,100 feet long and the adjoining dike is about 2,200 feet long and 30 feet high. The current water surface elevation is 6,050 feet. The existing reservoir has a capacity of 5,900 acre-feet and inundates 185 acres.

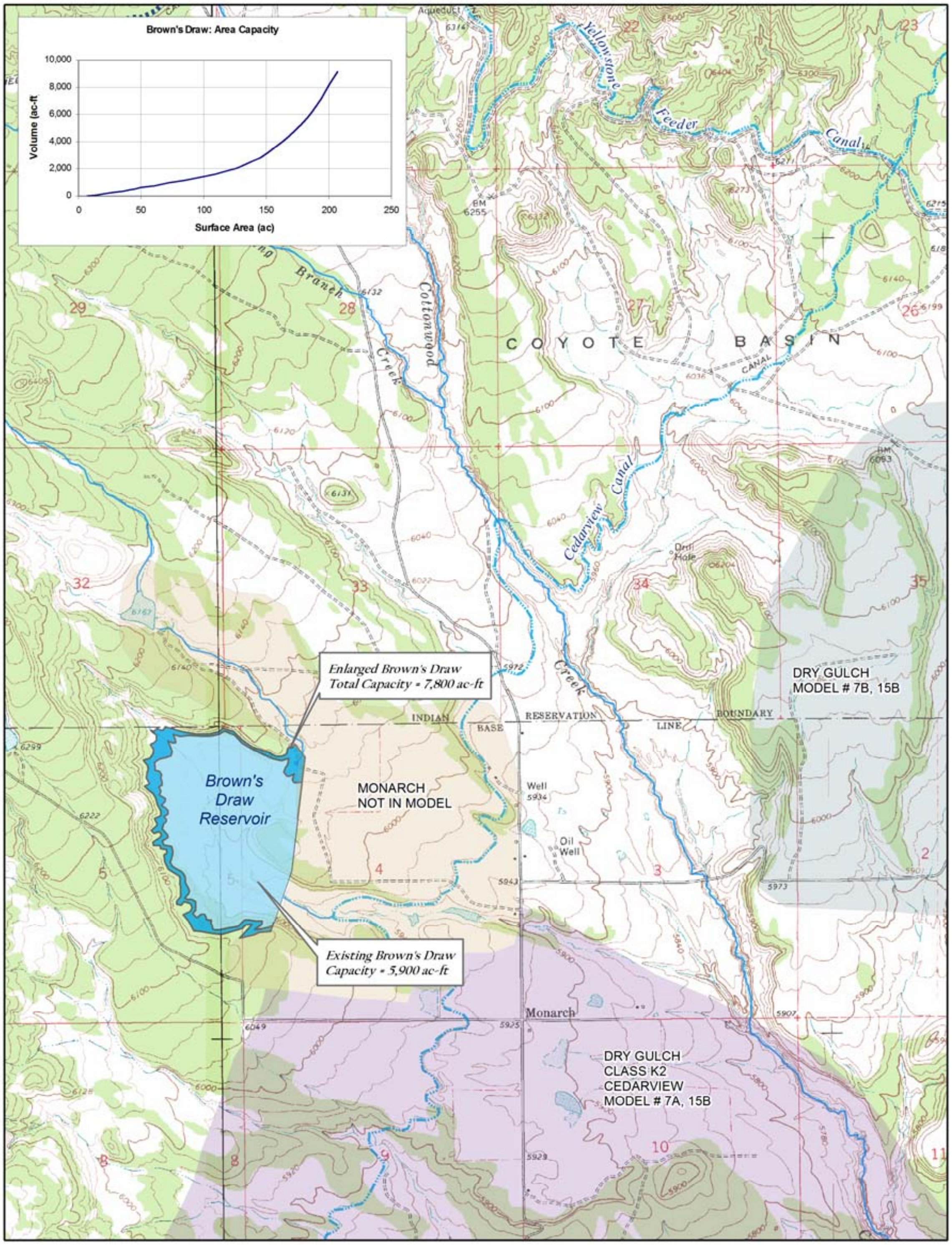
Raising the dam 10 feet would bring the water surface elevation to 6,060 feet and would increase the reservoir capacity to 7,800 acre-feet. The enlarged dam would be 90 feet high with a crest length of 1,460 feet and a crest width of 10 feet. The adjoining dike would be raised to 40 feet high. Approximately 30,600 cubic yards of embankment material would be required for the enlargement. At full pool, the enlarged reservoir would have a surface area of approximately 210 acres, be about 0.75 mile long, and have about 2.8 miles of shoreline. Reservoir mean and maximum depths would be about 21 and 80 feet, respectively, at full pool.

Table 8 summarizes the physical features of Brown's Draw Reservoir and Dam. Figure 7 shows the general location and storage capacity curve of the reservoir.

TABLE 8
Enlarged Brown's Draw Reservoir Features

Feature	Value
General	
Water Source	Yellowstone River and Uinta River
Storage (acre-feet)	
Conservation Pool	100
Active Pool	7,800
Total Active	7,800
Dam	
Type	Earth-fill Embankment
Structural Height (feet)	90
Crest Elevation (feet above mean sea level)	6,070
Crest Length (feet)	1,460
Crest Width (feet)	10
Embankment Volume (cubic yards)	30,600 additional material
Reservoir (at full pool)	
Elevation (feet above mean sea level)	6,060
Length (miles)	0.75
Surface Area (acres)	210
Shoreline Length (miles)	2.8
Maximum Depth (feet)	80
Mean Depth (feet)	21

FIGURE 7
Brown's Draw Enlargement



Enlarge Montes Creek Reservoir. Montes Creek Reservoir is an existing off-stream reservoir site located approximately 4 miles northeast of Roosevelt (see Figure 8). This option would include removing the existing dam and replacing it with a larger dam, which would increase the reservoir capacity by over 40 percent. Water would continue to be diverted from the Uinta River through the Uintah Number 1 Canal into Montes Creek. The enlarged reservoir would allow for additional storage of low priority water rights from the Uinta River. This water would be delivered to secondary users, reducing their shortage.

The existing dam at Montes Creek Reservoir is a 50-foot-high, earth-fill embankment. The dam is approximately 600 feet long and the adjoining dike is about 1,800 feet long and 10 feet high. The current water surface elevation is 5,352 feet. The existing reservoir has a capacity of 1,250 acre-feet and inundates 105 acres.

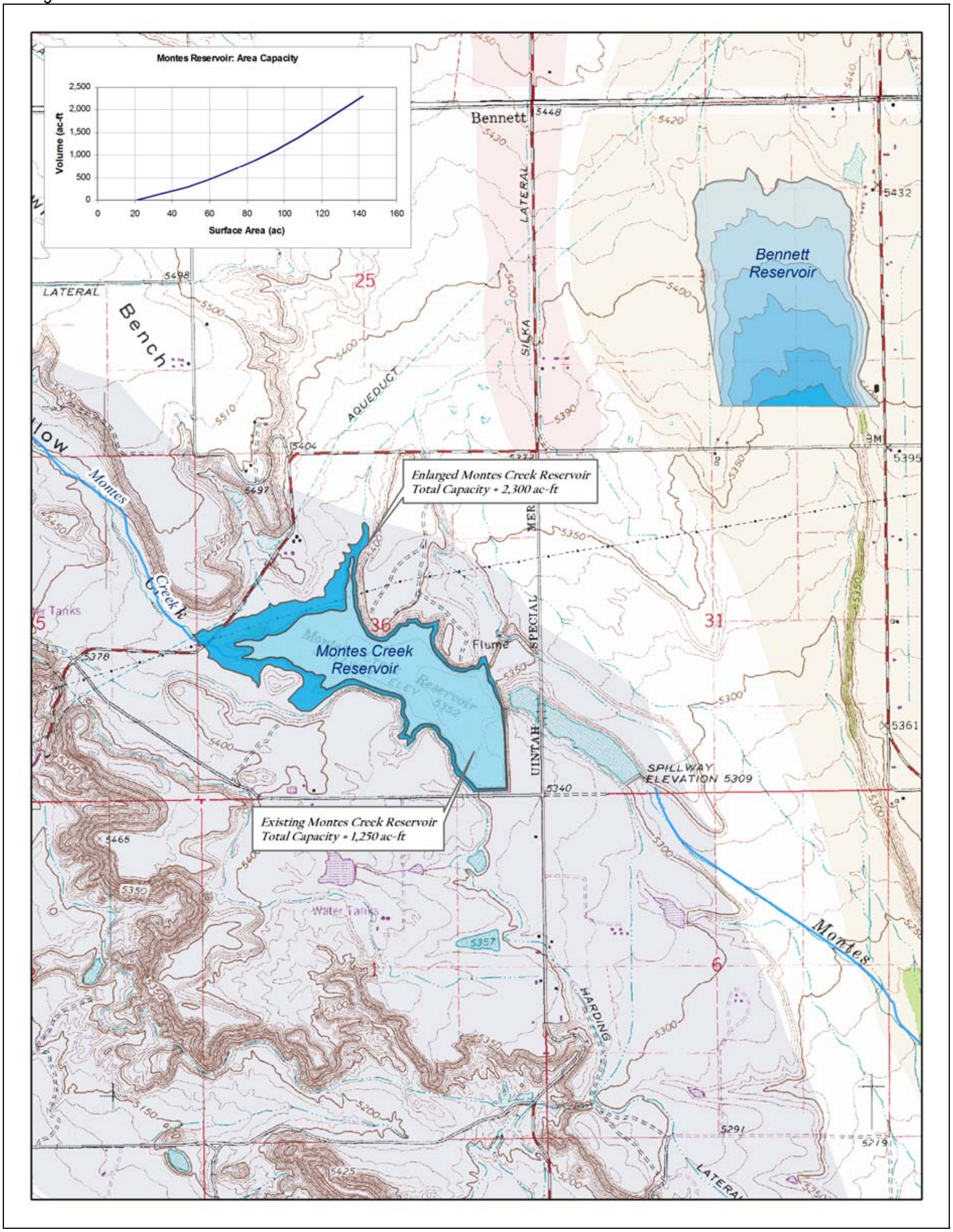
Raising the dam would bring the water surface elevation to 5,360 feet and would increase the reservoir capacity to 2,300 acre-feet. The enlarged dam would be 60 feet high with a crest length of 810 feet and a crest width of 10 feet. The adjoining dike would also be raised and would be approximately 2,250 feet long. Approximately 20,800 cubic yards of embankment material would be required for the enlargement. At full pool, the enlarged reservoir would have a surface area of approximately 140 acres, be about 0.9 mile long, and have about 3.5 miles of shoreline. Reservoir mean and maximum depths would be about 8 and 30 feet, respectively, at full pool.

Table 9 summarizes the physical features of Brown's Draw Reservoir and Dam. Figure 8 shows the general location and storage capacity curve of the reservoir.

TABLE 9
Enlarged Montes Creek Reservoir Features

Feature	Value
General	
Water Source	Uinta River
Storage (acre-feet)	
Conservation Pool	0
Active Pool	2,300
Total Active	2,300
Dam	
Type	Earth-fill Embankment
Structural Height (feet)	60
Crest Elevation (feet above mean sea level)	5,370
Crest Length (feet)	810
Crest Width (feet)	10
Embankment Volume (cubic yards)	20,800
Reservoir (at full pool)	
Elevation (feet above mean sea level)	5,360
Length (miles)	0.9
Surface Area (acres)	140
Shoreline Length (miles)	3.5
Maximum Depth (feet)	30
Mean Depth (feet)	8

FIGURE 8
Enlarge Montes Creek Reservoir



Pumping from the Green River to Cottonwood Service Area and Pelican Lake. This pumping feature would operate the same as described in Scenario 2, with one exception. The 1 mile of pipeline from Junction 1 to Pelican Lake would be 24 inches rather than 20 inches as shown in Figure 9.

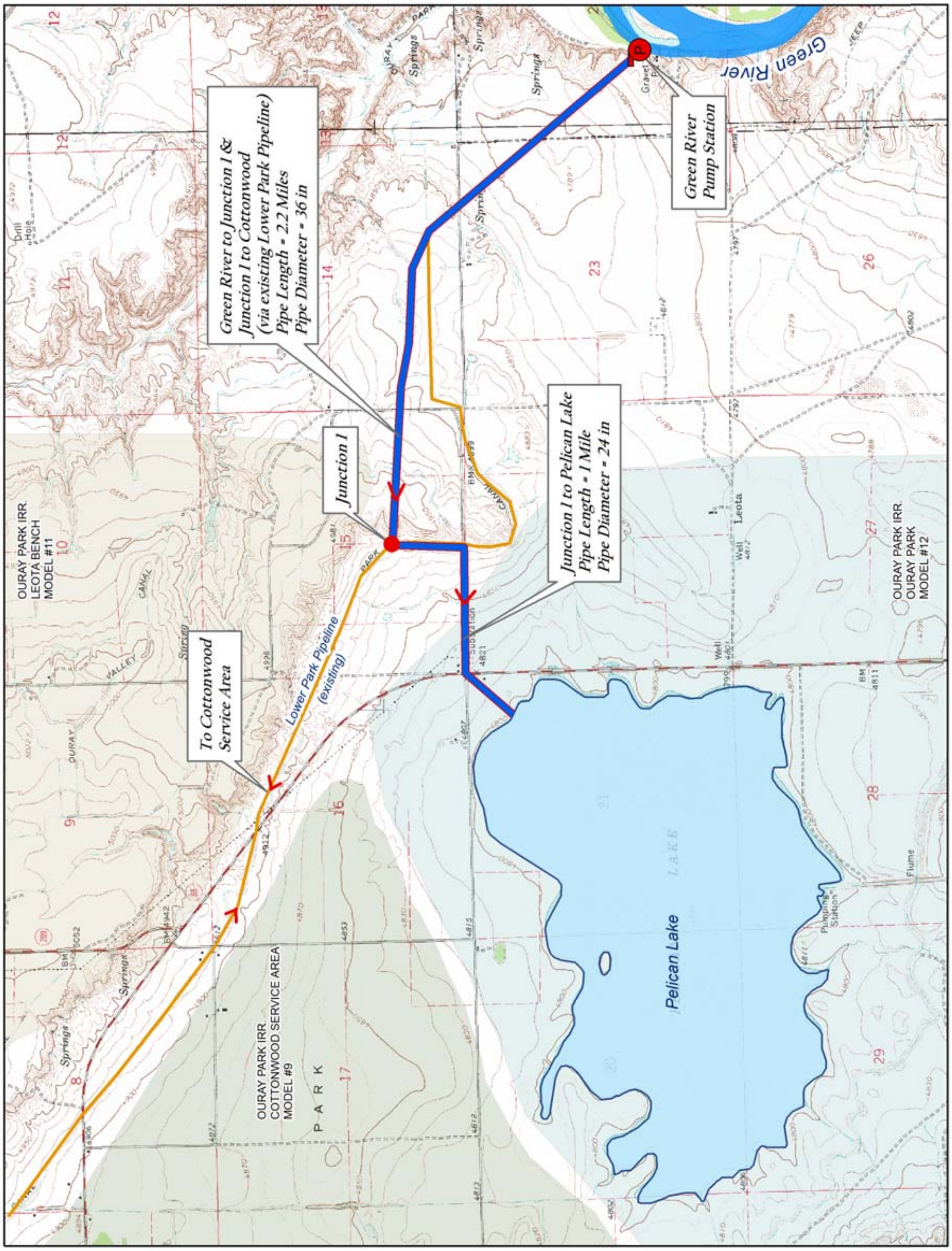
Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 10.

TABLE 10
Scenario 4 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$112,654,000
Total Pipeline Cost	$25,195,200
Total Pump Station Cost	$6,609,200
Contingency @ 30%	$44,837,500
Subtotal (Total Construction Cost)	***$194,295,900***
Engineering and Administration @ 20%	$38,859,200
Right-of-Way and Easements	$3,862,300
Total Capital Cost	***$237,017,400***
Annual Operation and Maintenance Costs	$237,000
Annual Power Costs @ 7.0 cents per kilowatt-hour	$705,000
Total Present Value Cost of Project (n=50, i=6%)	***$251,865,100***
Total Present Value per acre-foot of Developed Water	***$14,100***

NOTE:
Total Water Developed for this Scenario = 17,900 acre-feet

FIGURE 9
Scenario 4 Green River Pumping



Scenario 5

Project Features. Scenario 5 includes the following project features:

- Stabilization of high mountain lakes
- Construction Bennett Reservoir
- Construction of Neola Reservoir
- Construction of East Cottonwood Reservoir
- Enlargement of Brown's Draw Reservoir
- Enlargement of Montes Creek Reservoir
- Exchanges between high priority diverters and new storage rights

Stabilization of High Mountain Lakes. See Scenario 2 for the description of stabilizing high mountain lakes.

Bennett Reservoir. See Scenario 4 for the description of Bennett Reservoir.

Neola Reservoir. See Scenario 4 for the description of Neola Reservoir.

East Cottonwood Reservoir. See Scenario 4 for the description of East Cottonwood Reservoir.

Brown's Draw Reservoir. See Scenario 4 for the description of the Brown's Draw Reservoir enlargement.

Montes Creek Reservoir. See Scenario 4 for the description of the Montes Creek Reservoir enlargement.

Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 11.

TABLE 11
Scenario 5 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$112,654,000
Total Pipeline Cost	$20,836,800
Total Pump Station Cost	$1,444,200
Contingency @ 30%	$41,980,500
Subtotal (Total Construction Cost)	***$181,915,500***
Engineering and Administration @ 20%	$36,383,100
Right-of-Way and Easements	$3,850,600
Total Capital Cost	***$222,149,200***
Annual Operation and Maintenance Costs	$155,200
Annual Power Costs @ 7.0 cents per kilowatt-hour	$10,000
Total Present Value Cost of Project (n=50, i=6%)	***$224,753,100***
Total Present Value per acre-foot of Developed Water	***$25,300***

NOTE:
Total Water Developed for this Scenario = 8,900 acre-feet

Scenario 6

Project Features. Scenario 6 includes the following project features:

- Stabilization of high mountain lakes
- Construction of Upper Uinta Reservoir
- Construction Bennett Reservoir
- Construction of Neola Reservoir
- Construction of East Cottonwood Reservoir
- Enlargement of Brown's Draw Reservoir
- Enlargement of Montes Creek Reservoir
- Pumping from Green River to Cottonwood Service Area and Pelican Lake
- Water right exchanges between upstream and downstream users and exchanges between high priority diverters and new storage rights

Stabilization of High Mountain Lakes. See Scenario 2 for the description of stabilizing high mountain lakes.

Upper Uinta Reservoir. See Scenario 2 for the description of Upper Uinta Reservoir.

Bennett Reservoir. See Scenario 4 for the description of Bennett Reservoir.

Neola Reservoir. See Scenario 4 for the description of Neola Reservoir.

East Cottonwood Reservoir. See Scenario 4 for the description of East Cottonwood Reservoir.

Brown's Draw Reservoir. See Scenario 4 for the description of the Brown's Draw Reservoir enlargement.

Montes Creek Reservoir. See Scenario 4 for the description of the Montes Creek Reservoir enlargement.

Pumping from the Green River to Cottonwood Service Area and Pelican Lake. See Scenario 4 for the description of this pumping option.

Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 12.

TABLE 12
Scenario 6 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$175,934,000
Total Pipeline Cost	$25,195,200
Total Pump Station Cost	$6,609,200
Contingency @ 30%	$63,821,500
Subtotal (Total Construction Cost)	***$276,559,900***
Engineering and Administration @ 20%	$55,312,000
Right-of-Way and Easements	$6,089,800
Total Capital Cost	***$337,961,700***
Annual Operation and Maintenance Costs	$300,200
Annual Power Costs @ 7.0 cents per kilowatt-hour	$814,000
Total Present Value Cost of Project (n=50, i=6%)	***$355,523,600***
Total Present Value per acre-foot of Developed Water	***$13,600***

NOTE:
Total Water Developed for this Scenario = 26,200 acre-feet

Scenario 7

Project Features. Scenario 7 includes the following project features:

- Stabilization of high mountain lakes
- Construction of Upper Uinta Reservoir
- Construction of Bennett Reservoir
- Construction of Neola Reservoir
- Construction of East Cottonwood Reservoir
- Enlargement of Brown's Draw Reservoir
- Enlargement of Montes Creek Reservoir
- Exchanges between high priority diverters and new storage rights

Stabilization of High Mountain Lakes. See Scenario 2 for the description of stabilizing high mountain lakes.

Upper Uinta Reservoir. See Scenario 2 for the description of Upper Uinta Reservoir.

Bennett Reservoir. See Scenario 4 for the description of Bennett Reservoir.

Neola Reservoir. See Scenario 4 for the description of Neola Reservoir.

East Cottonwood Reservoir. See Scenario 4 for the description of East Cottonwood Reservoir.

Brown's Draw Reservoir. See Scenario 4 for the description of the Brown's Draw Reservoir enlargement.

Montes Creek Reservoir. See Scenario 4 for the description of the Montes Creek Reservoir enlargement.

Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 13.

TABLE 13
Scenario 7 Cost Estimate

Description	Cost
Stabilize High Mountain Lakes	$5,000,000
Total Reservoir Cost	$175,934,000
Total Pipeline Cost	$20,836,800
Total Pump Station Cost	$1,444,200
Contingency @ 30%	$60,964,500
Subtotal (Total Construction Cost)	***$264,179,500***
Engineering and Administration @ 20%	$52,835,900
Right-of-Way @ $5,000 per acre	$6,022,500
Pipeline Easement – 30 feet wide @ $1,000 per acre	$55,600
Right-of-Way and Easements	$6,078,100
Total Capital Cost	***$323,093,500***
Annual Operation and Maintenance Costs	$218,400
Annual Power Costs @ 7.0 cents per kilowatt-hour	$11,000
Total Present Value Cost of Project (n=50, i=6%)	***$326,709,300***
Total Present Value per acre-foot of Developed Water	***$20,200***

NOTE:
Total Water Developed for this Scenario = 16,200 acre-feet

Scenario 8

Project Features. Scenario 8 includes the following project features:

- Pumping from Green River to Cottonwood Service Area and Pelican Lake
- Water right exchanges between upstream and downstream users

Pumping from the Green River to Cottonwood Service Area and Pelican Lake. See Scenario 2 for the description of this pumping option.

Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 14.

TABLE 14
Scenario 8 Cost Estimate

Description	Cost
Total Pipeline Cost	$4,188,800
Total Pump Station Cost	$5,250,000
Contingency @ 30%	$2,359,700
Subtotal (Total Construction Cost)	***$11,798,500***
Engineering and Administration @ 20%	$1,769,800
Right-of-Way and Easements	$11,600
Total Capital Cost	***$13,579,900***
Annual Operation and Maintenance Costs	$83,000
Annual Power Costs @ 7.0 cents per kilowatt-hour	$650,000
Total Present Value Cost of Project (n=50, i=6%)	***$25,133,300***
Total Present Value per acre-foot of Developed Water	***$2,600***

NOTE:
Total Water Developed for this Scenario = 9,800 acre-feet

Scenario 9

Project Features. Scenario 9 includes the following project feature:

- Pumping from Green River to Pelican Lake
- Water right exchanges between upstream and downstream users

Pumping from the Green River to Pelican Lake. This pumping feature would require one pump station at the Green River as well as approximately 3.2 miles of 20-inch pipeline to deliver water to Pelican Lake (See Figure 10).

Water would be pumped from the Green River Pump Station to Pelican Lake and delivered to the Ouray Park Area. Water is currently pumped from Pelican Lake and delivered to this area, so this pumping feature would simply reduce their shortage.

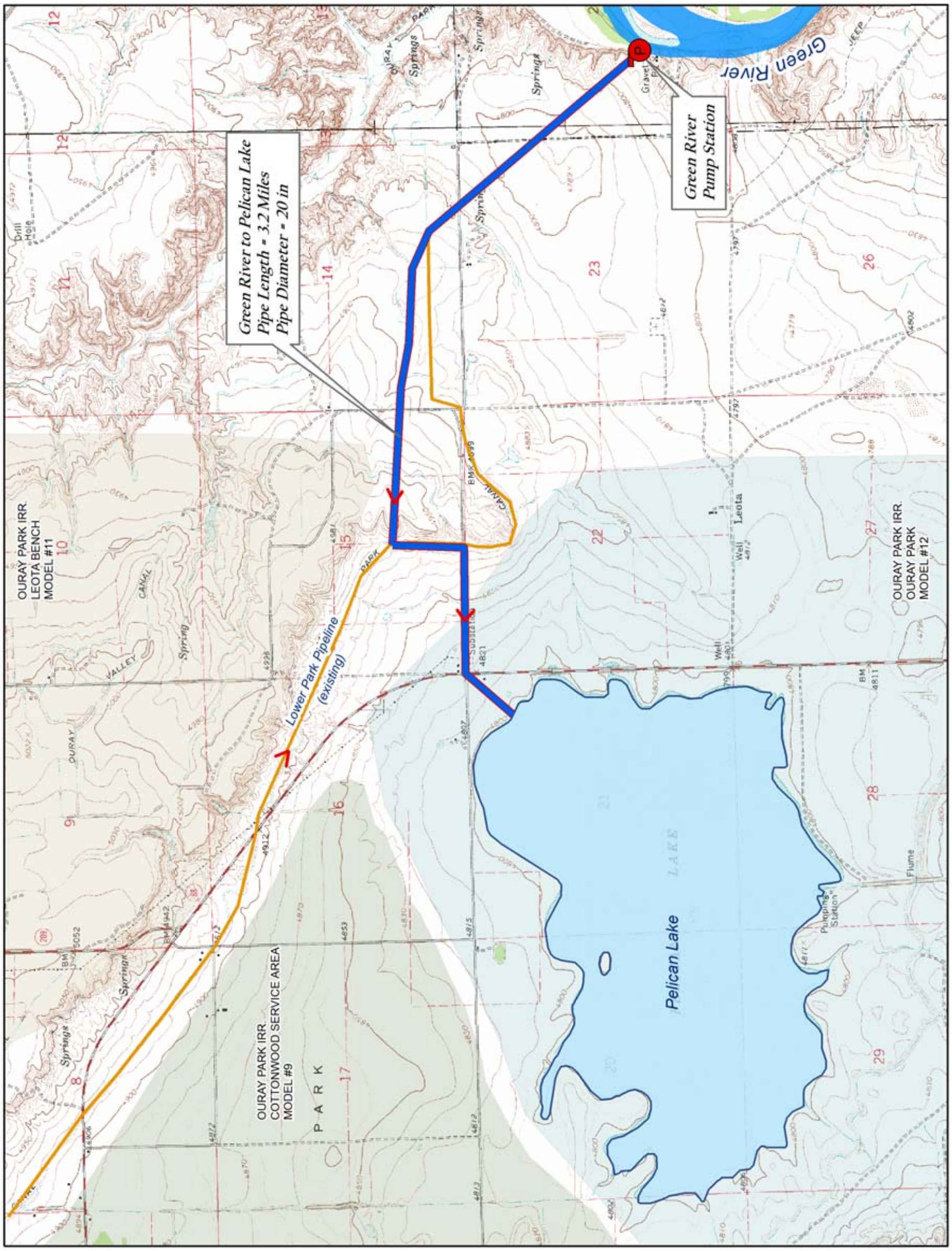
Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 15.

TABLE 15
Scenario 9 Cost Estimate

Description	Cost
Total Pipeline Cost	$2,704,000
Total Pump Station Cost	$3,059,000
Contingency @ 30%	$1,728,900
Subtotal (Total Construction Cost)	***$7,491,900***
Engineering and Administration @ 20%	$1,498,400
Right-of-Way and Easements	$11,600
Total Capital Cost	***$9,001,900***
Annual Operation and Maintenance Costs	$48,600
Annual Power Costs @ 7.0 cents per kilowatt-hour	$338,000
Total Present Value Cost of Project (n=50, i=6%)	***$15,095,400***
Total Present Value per acre-foot of Developed Water	***$3,600***

NOTE:
Total Water Developed for this Scenario = 4,200 acre-feet

FIGURE 10
Scenario 9 Green River Pumping



Scenario 10

Project Features. Scenario 10 includes the following project features:

- Pumping from Green River to Pelican Lake
- Pumping from Pelican Lake to Cottonwood Service Area
- Water right exchanges between upstream and downstream users

Pumping from the Green River to Pelican Lake. This pumping feature would require one pump station at the Green River as well as approximately 3.2 miles of 30-inch pipeline to deliver water to Pelican Lake (see Figure 11).

Water would be pumped from the Green River Pump Station to Pelican Lake and delivered to the Ouray Park Area and to the Cottonwood Service Area. Water is currently pumped from Pelican Lake and delivered to this area, so this pumping feature would simply reduce the existing shortage.

Pumping from Pelican Lake to Cottonwood Service Area. This pumping feature would require a pump station at Pelican Lake and 2 miles of 36-inch pipeline to connect the Pelican Lake Pump Station to the Cottonwood Service Area.

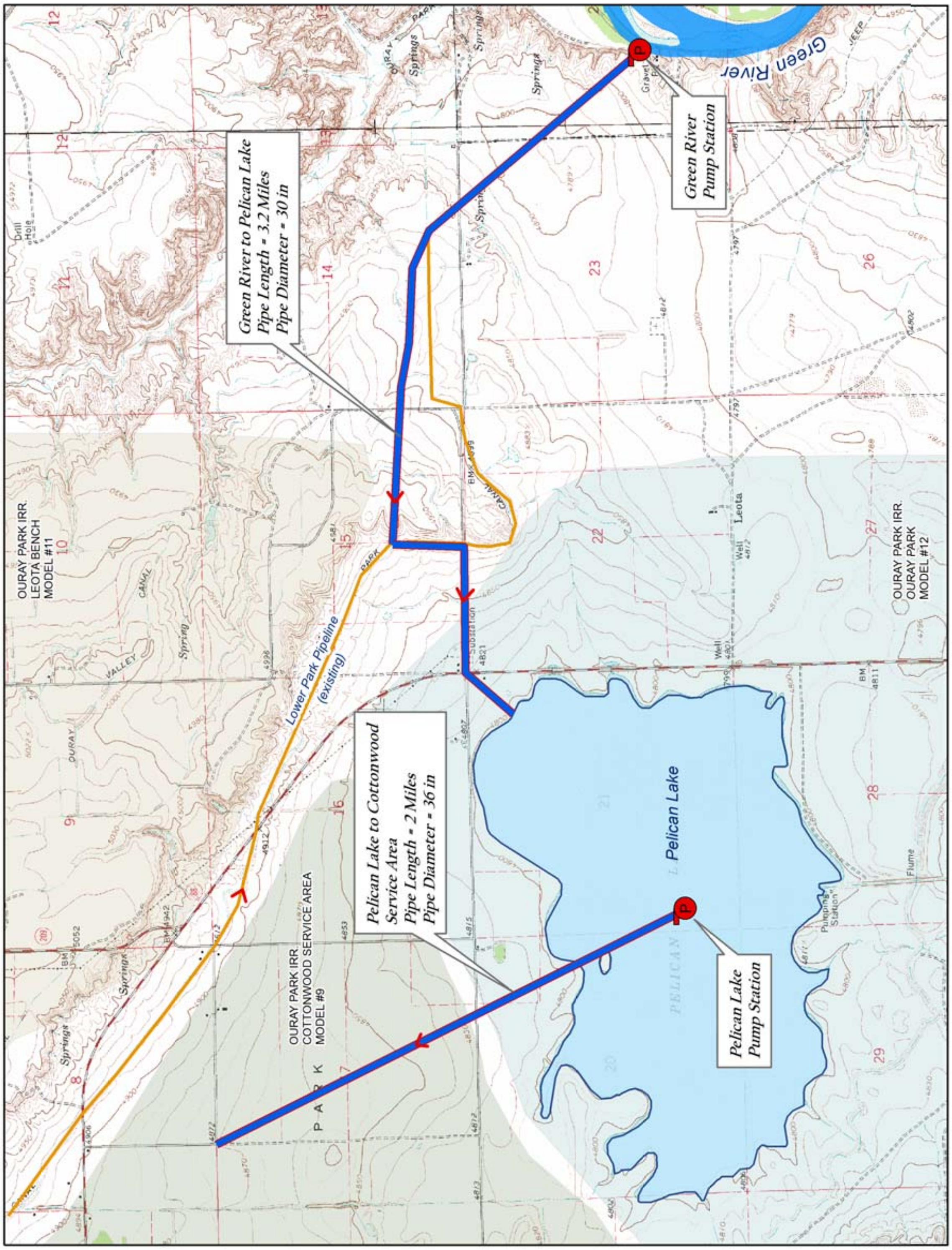
Cost Estimate. A cost estimate was generated based on the project features described previously and is provided in Table 16.

TABLE 16
Scenario 10 Cost Estimate

Description	Cost
Total Pipeline Cost	$7,108,800
Total Pump Station Cost	$8,912,000
Contingency @ 30%	$4,806,200
Subtotal (Total Construction Cost)	***$20,827,000***
Engineering and Administration @ 20%	$4,165,400
Right-of-Way and Easements	$18,900
Total Capital Cost	***$25,011,300***
Annual Operation and Maintenance Costs	$140,800
Annual Power Costs @ 7.0 cents per kilowatt-hour	$555,000
Total Present Value Cost of Project (n=50, i=6%)	***$35,978,400***
Total Present Value per acre-foot of Developed Water	***$4,300***

NOTE:
Total Water Developed for this Scenario = 8,400 acre-feet

FIGURE 11
Scenario 10 Green River Pumping

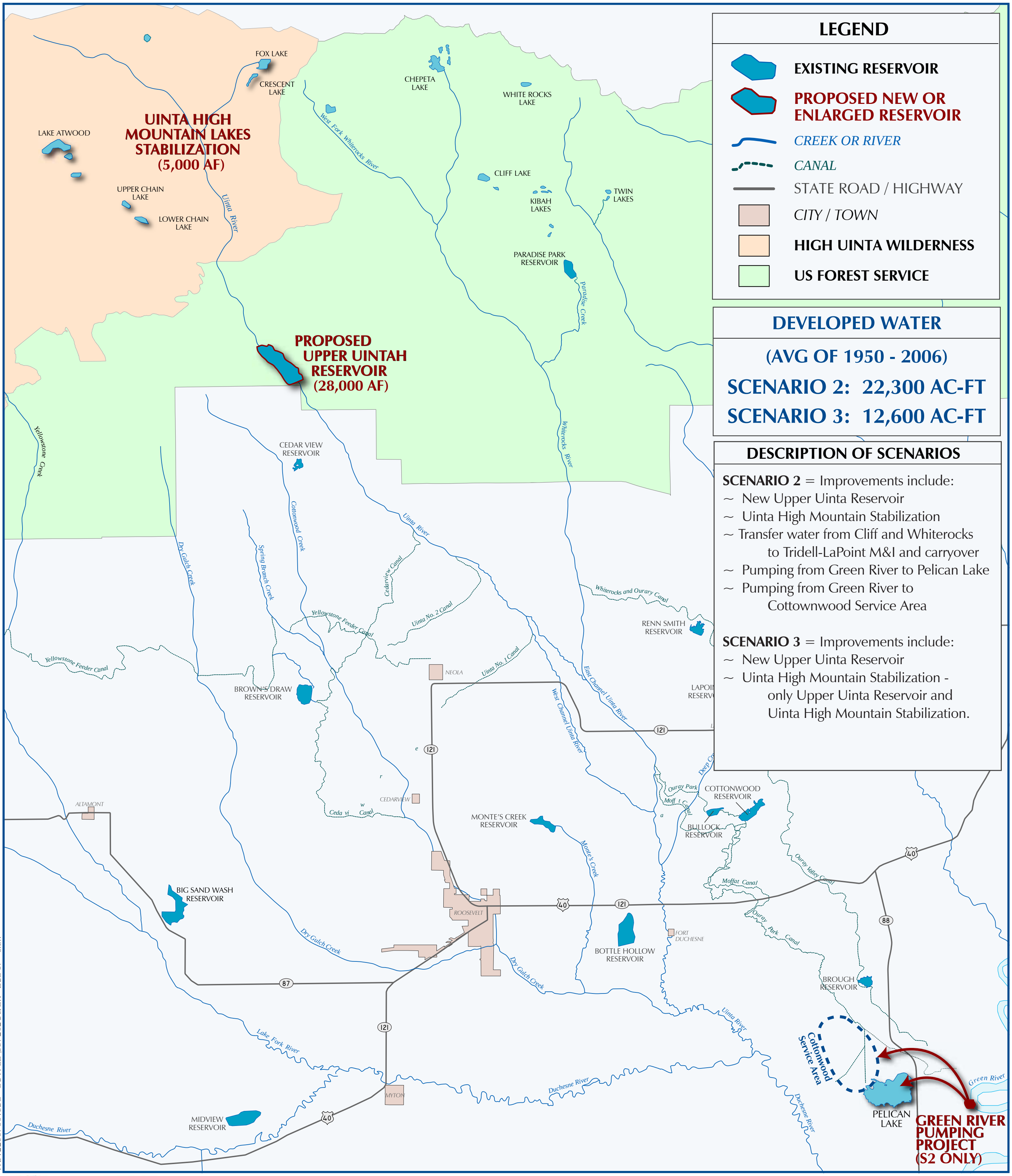


ATTACHMENT 1

Scenario Overview Figures

Uinta-Green River Project

Scenarios 2 & 3:
Main Stem Storage with & without Green River Pumping



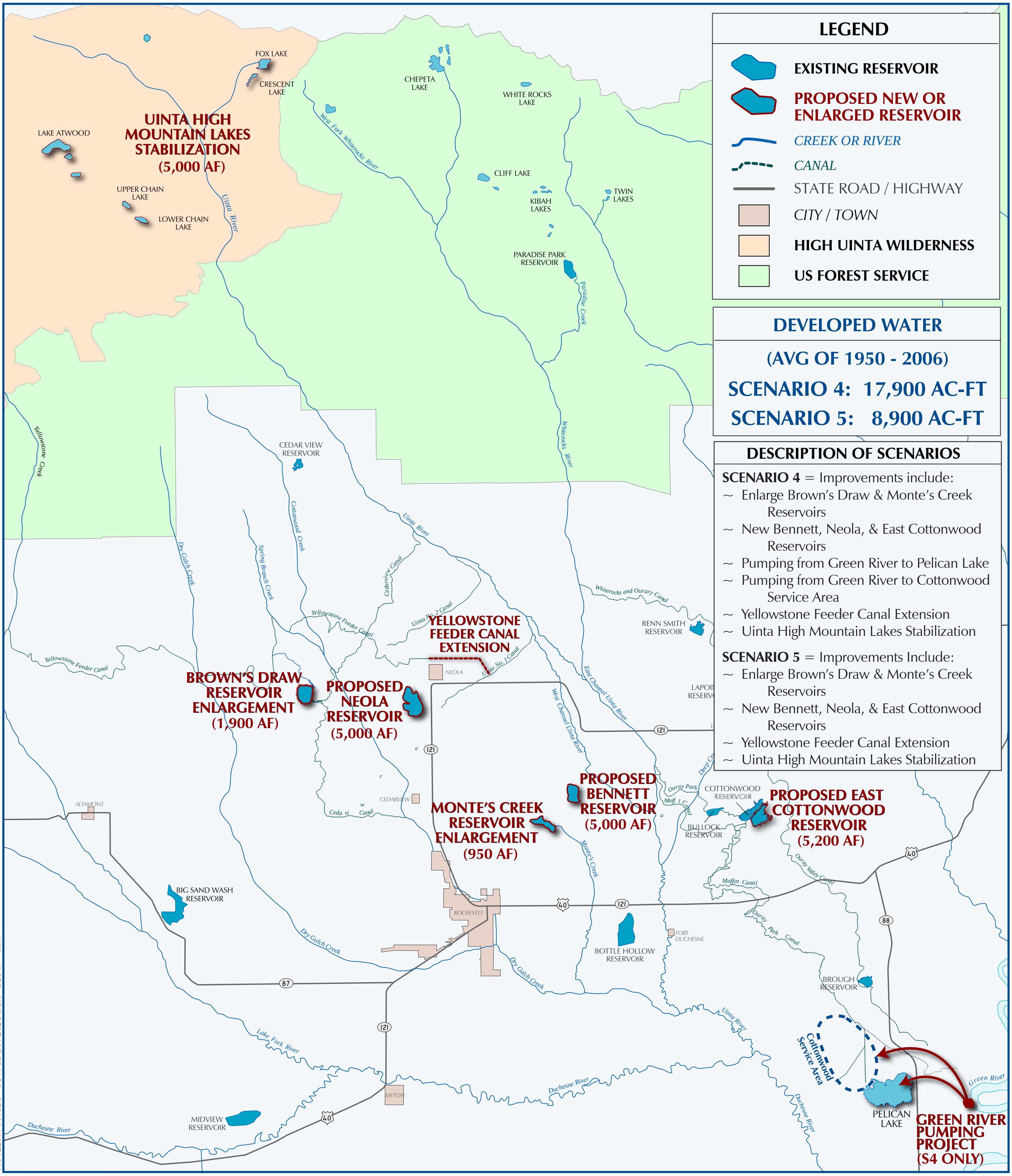
WB12007001SLC CUWCD357202U&GR DEC-07 ckm

FRANSON CIVIL ENGINEERS

CH2MHILL

Uinta-Green River Project

Scenarios 4 & 5:
Off-stream Storage with & without Green River Pumping



LEGEND

- EXISTING RESERVOIR
- PROPOSED NEW OR ENLARGED RESERVOIR
- CREEK OR RIVER
- CANAL
- STATE ROAD / HIGHWAY
- CITY / TOWN
- HIGH UINTA WILDERNESS
- US FOREST SERVICE

DEVELOPED WATER

(AVG OF 1950 - 2006)

SCENARIO 4: 17,900 AC-FT

SCENARIO 5: 8,900 AC-FT

DESCRIPTION OF SCENARIOS

SCENARIO 4 = Improvements include:
- ~ Enlarge Brown's Draw & Monte's Creek Reservoirs
- ~ New Bennett, Neola, & East Cottonwood Reservoirs
- ~ Pumping from Green River to Pelican Lake
- ~ Pumping from Green River to Cottonwood Service Area
- ~ Yellowstone Feeder Canal Extension
- ~ Uinta High Mountain Lakes Stabilization

SCENARIO 5 = Improvements Include:
- ~ Enlarge Brown's Draw & Monte's Creek Reservoirs
- ~ New Bennett, Neola, & East Cottonwood Reservoirs
- ~ Yellowstone Feeder Canal Extension
- ~ Uinta High Mountain Lakes Stabilization

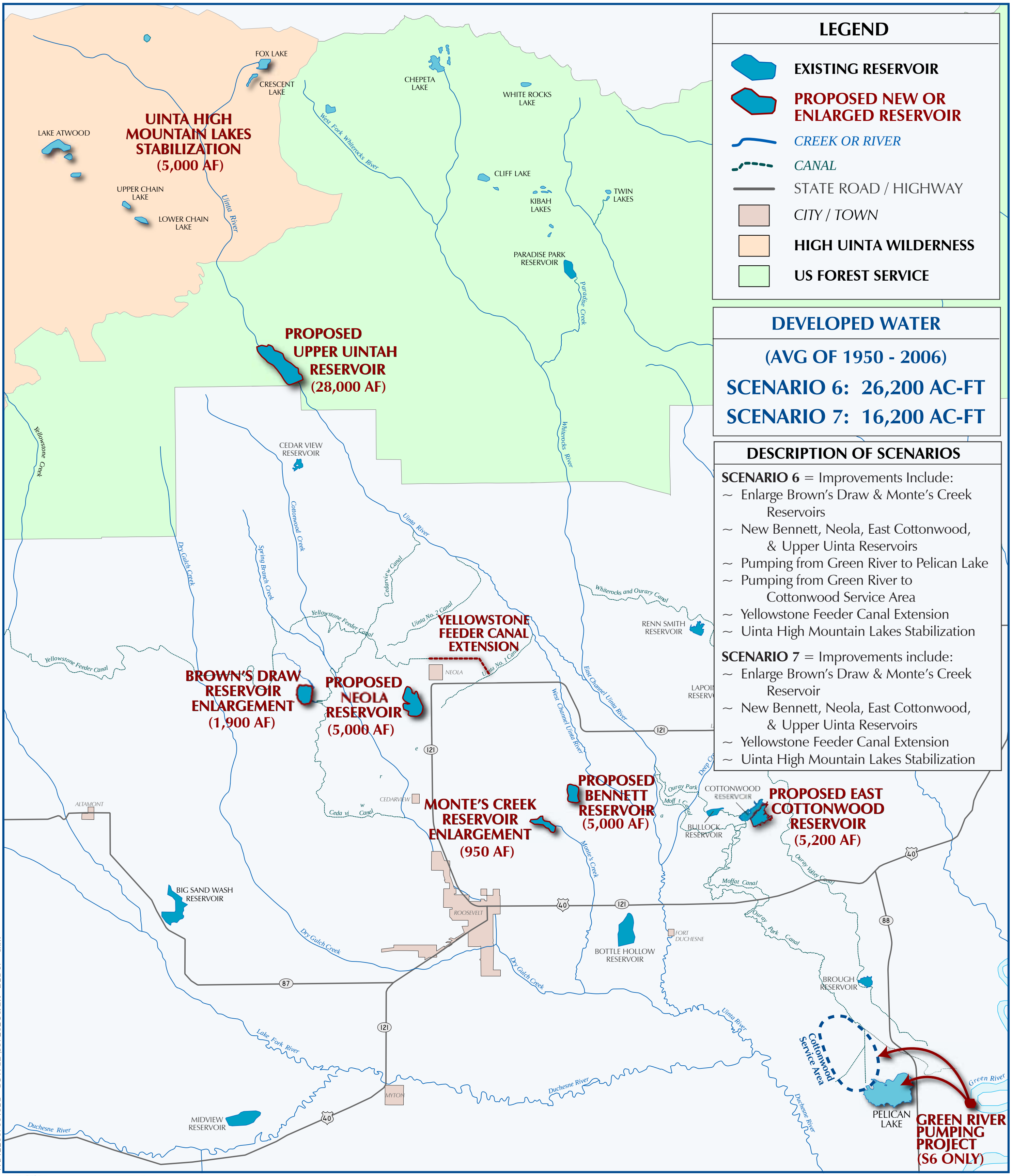
WB12207001SLC CUWCD357202U&GR DEC-07 ckm

FRANSON CIVIL ENGINEERS

CH2MHILL

Uinta-Green River Project

Scenarios 6 & 7:
Main Stem and Off-stream Storage with & without Green River Pumping



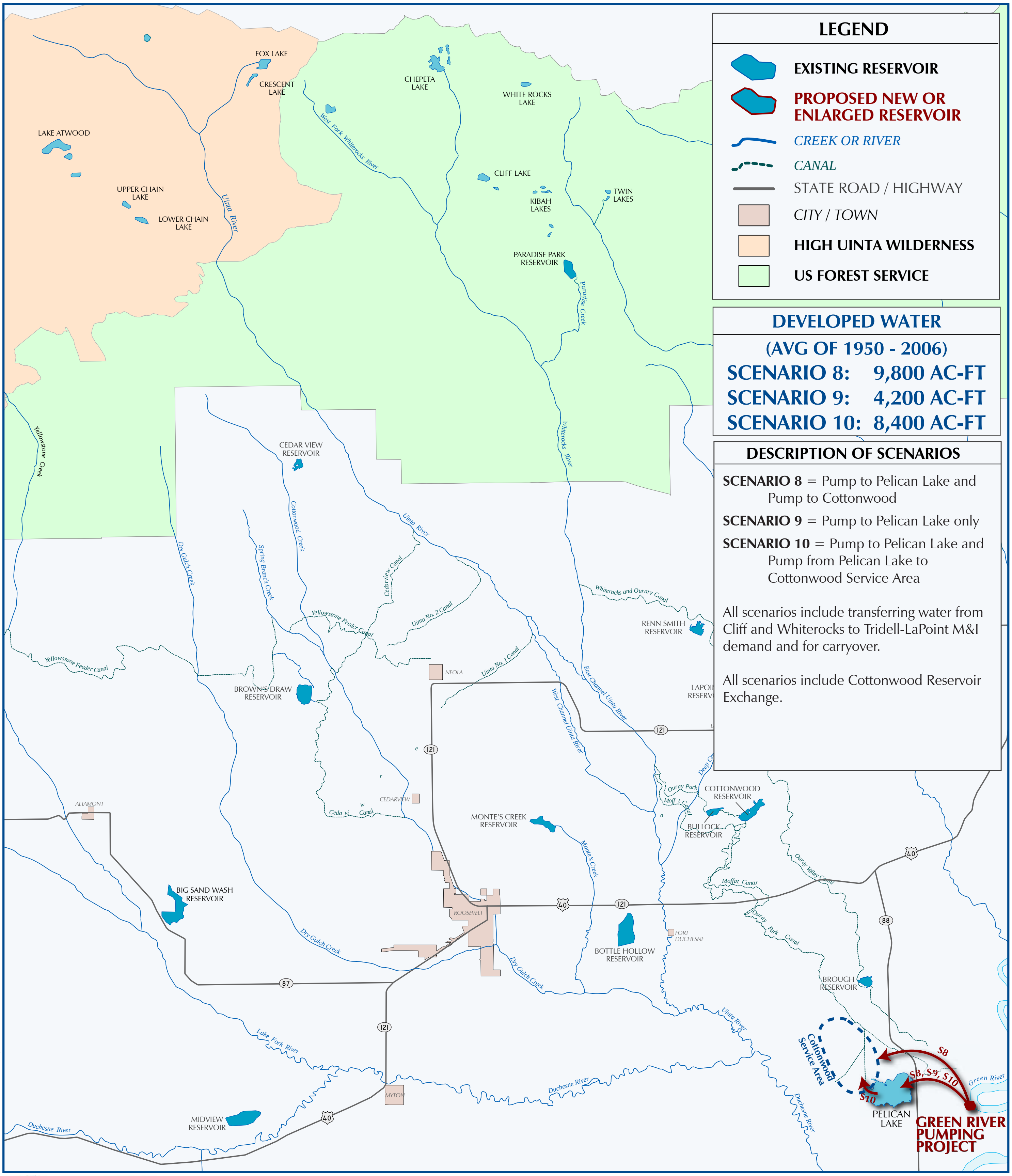
WB122007001SLC CUWCD357202U&GR DEC-07 ckm

FRANSON CIVIL ENGINEERS

CH2MHILL

Uinta-Green River Project

Scenarios 8, 9, & 10:
Various Pumping Scenarios



LEGEND

- EXISTING RESERVOIR
- PROPOSED NEW OR ENLARGED RESERVOIR
- CREEK OR RIVER
- CANAL
- STATE ROAD / HIGHWAY
- CITY / TOWN
- HIGH UINTA WILDERNESS
- US FOREST SERVICE

DEVELOPED WATER

(AVG OF 1950 - 2006)

SCENARIO 8:	9,800 AC-FT
SCENARIO 9:	4,200 AC-FT
SCENARIO 10:	8,400 AC-FT

DESCRIPTION OF SCENARIOS

SCENARIO 8 = Pump to Pelican Lake and Pump to Cottonwood

SCENARIO 9 = Pump to Pelican Lake only

SCENARIO 10 = Pump to Pelican Lake and Pump from Pelican Lake to Cottonwood Service Area

All scenarios include transferring water from Cliff and Whiterocks to Tridell-LaPoint M&I demand and for carryover.

All scenarios include Cottonwood Reservoir Exchange.

WB122007001SLC CUWCD357202U&GR DEC-07 ckm

FRANSON CIVIL ENGINEERS

CH2MHILL

ATTACHMENT 2

Cost Estimates

Cost Estimates

As the project develops in detail, the accuracy of the cost estimates also becomes more dependable. Rough overall construction cost estimates of project features are commonly made during the reconnaissance stage for the purpose of comparing alternative sites and determining/comparing the size and scope of development. The feasibility of any project can only be established after completion of survey, geologic investigation, drilling, and sampling and testing of foundation and borrow materials. Even then, there can still be surprises during construction that may result in change orders.

Cost estimates are broken down into the major project features, including:

- Reservoirs
- Pipelines
- Pump Stations
- Stabilization of High Mountain Lakes
- Contingency
- Right-of-Way and Easements
- Variable Other Costs (engineering, administration, legal, etc.)
- Operation and Maintenance and Power Costs

Cost estimating for each of these features is discussed in detail below. A cost estimate for each scenario is provided at the end of this attachment.

Reservoirs

Because new reservoir siting and development projects are not common in today's political environment, the non-field costs related to permitting, environmental documentation, or mitigation are unknown at this time. Total costs for project implementation would be substantially larger than the estimated field construction costs.

All field costs are escalated to 2010 dollars and include allowances for mobilization, unlisted items, and contingencies as a percentage of the subtotal field construction cost, as follows:

- Mobilization at 5 percent
- Unlisted items at 10 percent

Construction costs for a reservoir primarily represent the cost of the dam or dikes plus the hydraulic structures; this can represent a significant cost. For the reconnaissance level cost estimating, many assumptions must be made because specific information (such as detailed topography and geology) is not available. For evaluating the option of using a reservoir, we have used a very general cost per acre-foot for this initial screening. A collection of construction costs for a broad variety of projects constructed over the past several decades by various agencies was used to develop a cost table that was escalated to the present using annual price indexes, and escalated to 2010 dollars using 5 percent inflation per year.
Unit costs taken from the curves and adjusted are summarized in Table 1.

TABLE 1
Unit Costs for Reservoirs

Reservoir Capacity (acre-feet)	Unit Cost ($ per acre-foot)
700	$11,700
4,000	$4,700
10,000	$2,800
60,000	$1,200
150,000	$800

Civil engineering works of this type are very site specific. After the initial screening discussed previously, more detailed evaluations are generally made including map studies, reconnaissance level site visits, concept development, detailed site visits, survey, geology, and preliminary and final design.

Pipelines

A pipeline base unit cost of $8 per diameter-inch per linear foot was used to prepare the pipeline cost estimates presented in this study. This cost is based on recent average construction costs for large-diameter pipelines in Utah. This estimate assumes a mortar-lined, tape-coated, welded steel pipe with a pressure class of 150 pounds per square inch.

Pump Stations

The cost for the Bennett Reservoir Pump Station was developed using actual construction costs from recent projects. Costs were adjusted using bid dates and corresponding *Engineering News Record* Construction Cost Index values. The flow rate (Q in cubic feet per second) based equation is as follows:

$$\text{Cost (\$)} = 157{,}500\ Q^{0.7461}$$

The Green River Pump Station is much larger than the Bennett Reservoir Pump Station. This cost was developed using cost equations developed by Robert L. Sanks in his book *Pumping Station Design (1998)*. The flow rate (Q in gpm) based equation is as follows:

$$\text{Cost (\$M)} = 105.26Q - 83884.21$$

Stabilization of High Mountain Lakes

Included in this cost estimate is the stabilization of five high mountain lakes. Stabilization of these lakes involves removing existing dams and returning the lakes to their original character and size. It is estimated that this will cost approximately $5,000,000.

Contingency

A 30 percent contingency was added to the total construction cost to account for any unknown or unforeseen costs at this time.

Right-of-Way and Easements

Land costs involve the cost of easements, other right-of-ways, and actual fee purchase of property. It is assumed that for largely underground construction work (such as pipelines), the best approach would be acquiring easements that allow some surface uses and provide access for proper maintenance. For reservoir facilities, purchasing the site would be the best approach.

It was assumed that a 30-foot-wide easement would be required for pipelines and would cost $1,000 per acre. For reservoirs, it was estimated that the surface area of the reservoir plus an extra 10 percent of that acreage would need to be purchased. This land was estimated to cost approximately $5,000 per acre.

Variable Other Costs

Variable other costs, such as engineering and administration, can be significant and are included in the overall project cost estimate. For this project, 20 percent of the total construction cost was estimated to account for these variable costs.

Operation and Maintenance and Power Costs

Annual operation and maintenance costs were estimated as a percentage of capital cost, as follows:

- Dams: 0.1 percent
- Pipelines: 0.1 percent
- Pump Stations: 1.5 percent

Annual power costs for pump stations were estimated to be 7 cents per kilowatt-hour.

TABLE 2
Cost Estimate for Scenario 2

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Upper Uinta Reservoir	28,000	acre-feet	$2,260	$63,280,000
Pipelines				
Green River to Lower Park Pipeline – 36 inches	11,600	LF	$288	$3,340,800
Lower Park Pipeline to Pelican Lake – 20 inches	5,300	LF	$160	$848,000
Pump Stations				
Green River Pump Station	1	each	$5,120,000	$5,120,000
Contingency @ 30%				$23,276,600
	Subtotal (Total Construction Cost)			***$100,865,400***
Engineering and Administration @ 20%				$20,173,100
Right-of-Way @ $5,000 per acre				$2,227,500
Pipeline Easement – 30 feet wide @ $1,000 per acre				$11,600
Total Capital Cost				***$123,277,600***
Annual Maintenance Costs for Dams @ 0.1%				$63,300
Annual Maintenance Costs for Pipelines @ 0.1%				$4,200
Annual Maintenance Costs for Pump Station @ 1.5%				$76,800
Annual Power Costs @ 7.0 cents per kilowatt-hour				$756,000
Total Present Value Cost of Project (n=50, i=6%)				***$137,468,000***
Total Present Value per acre-foot of Developed Water				***$6,200***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 22,300 acre-feet

TABLE 3
Cost Estimate for Scenario 3

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Upper Uinta Reservoir	28,000	acre-feet	$2,260	$63,280,000
Contingency @ 30%				$20,484,000
	Subtotal (Total Construction Cost)			***$88,764,000***
Engineering and Administration @ 20%				$17,752,800
Right-of-Way @ $5,000 per acre				$2,227,500
Total Capital Cost				***$108,744,300***
Annual Maintenance Costs for Dams @ 0.1%				$63,300
Total Present Value Cost of Project (n=50, i=6%)				***$109,742,000***
Total Present Value per acre-foot of Developed Water				***$8,700***

NOTE:
Total Water Developed for this Scenario = 12,600 acre-feet

TABLE 4
Cost Estimate for Scenario 4

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Enlarge Brown's Draw	7,800	acre-feet	$3,520	$27,456,000
Enlarge Montes Creek Reservoir	2,300	acre-feet	$8,300	$19,090,000
Bennett Reservoir	5,000	acre-feet	$4,380	$21,900,000
Neola Reservoir	5,000	acre-feet	$4,380	$21,900,000
East Cottonwood Reservoir	5,200	acre-feet	$4,290	$22,308,000
Pipelines				
Yellowstone Feeder Canal Extension – 36 inches	13,700	LF	$288	$3,945,600
Bench Canal to Bennett Reservoir – 30 inches	5,300	LF	$240	$1,272,000
Bennett Reservoir to Bench Canal – 24 inches	4,200	LF	$192	$806,400
Uinta River to Neola Reservoir – 36 inches	39,100	LF	$288	$11,260,800
Neola Reservoir to Lateral #5 – 24 inches	9,000	LF	$192	$1,728,000
Neola Reservoir to E. Roosevelt Lateral – 24 inches	9,500	LF	$192	$1,824,000
Green River to Lower Park Pipeline – 36 inches	11,600	LF	$288	$3,340,800
Lower Park Pipeline to Pelican Lake – 24 inches	5,300	LF	$192	$1,017,600
Pump Stations				
Bennett Reservoir Pump Station	1	each	$1,444,200	$1,444,200
Green River Pump Station	1	each	$5,165,000	$5,165,000
Contingency @ 30%				$44,837,500
	Subtotal (Total Construction Cost)			***$194,295,900***
Engineering and Administration @ 20%				$38,859,200
Right-of-Way @ $5,000 per acre				$3,795,000
Pipeline Easement – 30 feet wide @ $1,000 per acre				$67,300
Total Capital Cost				***$237,017,400***
Annual Maintenance Costs for Dams @ 0.1%				$112,700
Annual Maintenance Costs for Pipelines @ 0.1%				$25,200
Annual Maintenance Costs for Pump Station @ 1.5%				$99,100
Annual Power Costs @ 7.0 cents per kilowatt-hour				$705,000
Total Present Value Cost of Project (n=50, i=6%)				***$251,865,100***
Total Present Value per acre-foot of Developed Water				***$14,100***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 17,900 acre-feet

TABLE 5
Cost Estimate for Scenario 5

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Enlarge Brown's Draw	7,800	acre-feet	$3,520	$27,456,000
Enlarge Montes Creek Reservoir	2,300	acre-feet	$8,300	$19,090,000
Bennett Reservoir	5,000	acre-feet	$4,380	$21,900,000
Neola Reservoir	5,000	acre-feet	$4,380	$21,900,000
East Cottonwood Reservoir	5,200	acre-feet	$4,290	$22,308,000
Pipelines				
Yellowstone Feeder Canal Extension – 36 inches	13,700	LF	$288	$3,945,600
Bench Canal to Bennett Reservoir – 30 inches	5,300	LF	$240	$1,272,000
Bennett Reservoir to Bench Canal – 24 inches	4,200	LF	$192	$806,400
Uinta River to Neola Reservoir – 36 inches	39,100	LF	$288	$11,260,800
Neola Reservoir to Lateral #5 – 24 inches	9,000	LF	$192	$1,728,000
Neola Reservoir to E. Roosevelt Lateral – 24 inches	9,500	LF	$192	$1,824,000
Pump Stations				
Bennett Reservoir Pump Station	1	each	$1,444,200	$1,444,200
Contingency @ 30%				$41,980,500
	Subtotal (Total Construction Cost)			***$181,915,500***
Engineering and Administration @ 20%				$36,383,100
Right-of-Way @ $5,000 per acre				$3,795,000
Pipeline Easement – 30 feet wide @ $1,000 per acre				$55,600
Total Capital Cost				***$222,149,200***
Annual Maintenance Costs for Dams @ 0.1%				$112,700
Annual Maintenance Costs for Pipelines @ 0.1%				$20,800
Annual Maintenance Costs for Pump Station @ 1.5%				$21,700
Annual Power Costs @ 7.0 cents per kilowatt-hour				$10,000
Total Present Value Cost of Project (n=50, i=6%)				***$224,753,100***
Total Present Value per acre-foot of Developed Water				***$25,300***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 8,900 acre-feet

TABLE 6
Cost Estimate for Scenario 6

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Enlarge Brown's Draw	7,800	acre-feet	$3,520	$27,456,000
Enlarge Montes Creek Reservoir	2,300	acre-feet	$8,300	$19,090,000
Bennett Reservoir	5,000	acre-feet	$4,380	$21,900,000
Neola Reservoir	5,000	acre-feet	$4,380	$21,900,000
East Cottonwood Reservoir	5,200	acre-feet	$4,290	$22,308,000
Upper Uinta Reservoir	28,000	acre-feet	$2,260	$63,280,000
Pipelines				
Yellowstone Feeder Canal Extension – 36 inches	13,700	LF	$288	$3,945,600
Bench Canal to Bennett Reservoir – 30 inches	5,300	LF	$240	$1,272,000
Bennett Reservoir to Bench Canal – 24 inches	4,200	LF	$192	$806,400
Uinta River to Neola Reservoir – 36 inches	39,100	LF	$288	$11,260,800
Neola Reservoir to Lateral #5 – 24 inches	9,000	LF	$192	$1,728,000
Neola Reservoir to E. Roosevelt Lateral – 24 inches	9,500	LF	$192	$1,824,000
Green River to Lower Park Pipeline – 36 inches	11,600	LF	$288	$3,340,800
Lower Park Pipeline to Pelican Lake – 24 inches	5,300	LF	$192	$1,017,600
Pump Stations				
Bennett Reservoir Pump Station	1	each	$1,444,200	$1,444,200
Green River Pump Station	1	each	$5,165,000	$5,165,000
Contingency @ 30%				$63,821,500
Subtotal (Total Construction Cost)				***$276,559,900***
Engineering and Administration @ 20%				$55,312,000
Right-of-Way @ $5,000 per acre				$6,022,500
Pipeline Easement – 30 feet wide @ $1,000 per acre				$67,300
Total Capital Cost				***$337,961,700***
Annual Maintenance Costs for Dams @ 0.1%				$175,900
Annual Maintenance Costs for Pipelines @ 0.1%				$25,200
Annual Maintenance Costs for Pump Station @ 1.5%				$99,100
Annual Power Costs @ 7.0 cents per kilowatt-hour				$814,000
Total Present Value Cost of Project (n=50, i=6%)				***$355,523,600***
Total Present Value per acre-foot of Developed Water				***$13,600***

NOTES:
LF = linear feet
Total Developed Water for this Scenario = 26,200 acre-feet

TABLE 7
Cost Estimate for Scenario 7

Description	Quantity	Unit	Unit Cost	Capital Cost
Stabilize High Mountain Lakes	1	each	$5,000,000	$5,000,000
Reservoirs				
Enlarge Brown's Draw	7,800	acre-feet	$3,520	$27,456,000
Enlarge Montes Creek Reservoir	2,300	acre-feet	$8,300	$19,090,000
Bennett Reservoir	5,000	acre-feet	$4,380	$21,900,000
Neola Reservoir	5,000	acre-feet	$4,380	$21,900,000
East Cottonwood Reservoir	5,200	acre-feet	$4,290	$22,308,000
Upper Uinta Reservoir	28,000	acre-feet	$2,260	$63,280,000
Pipelines				
Yellowstone Feeder Canal Extension – 36 inches	13,700	LF	$288	$3,945,600
Bench Canal to Bennett Reservoir – 30 inches	5,300	LF	$240	$1,272,000
Bennett Reservoir to Bench Canal – 24 inches	4,200	LF	$192	$806,400
Uinta River to Neola Reservoir – 36 inches	39,100	LF	$288	$11,260,800
Neola Reservoir to Lateral #5 – 24 inches	9,000	LF	$192	$1,728,000
Neola Reservoir to E. Roosevelt Lateral – 24 inches	9,500	LF	$192	$1,824,000
Pump Stations				
Bennett Reservoir Pump Station	1	each	$1,444,200	$1,444,200
Contingency @ 30%				$60,964,500
			Subtotal (Total Construction Cost)	***$264,179,500***
Engineering and Administration @ 20%				$52,835,900
Right-of-Way @ $5,000 per acre				$6,022,500
Pipeline Easement – 30 feet wide @ $1,000 per acre				$55,600
Total Capital Cost				***$323,093,500***
Annual Maintenance Costs for Dams @ 0.1%				$175,900
Annual Maintenance Costs for Pipelines @ 0.1%				$20,800
Annual Maintenance Costs for Pump Station @ 1.5%				$21,700
Annual Power Costs @ 7.0 cents per kilowatt-hour				$11,000
Total Present Value Cost of Project (n=50, i=6%)				***$326,709,300***
Total Present Value per acre-foot of Developed Water				***$20,200***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 16,200 acre-feet

TABLE 8
Cost Estimate for Scenario 8

Description	Quantity	Unit	Unit Cost	Capital Cost
Pipelines				
Green River to Lower Park Pipeline – 36 inches	11,600	LF	$288	$3,340,800
Lower Park Pipeline to Pelican Lake – 20 inches	5,300	LF	$160	$848,000
Pump Stations				
Green River Pump Station	1	each	$5,250,000	$5,250,000
Contingency @ 30%				$2,359,700
			Subtotal (Total Construction Cost)	***$11,798,500***
Engineering and Administration @ 20%				$1,769,800
Pipeline Easement – 30 feet wide @ $1,000 per acre				$11,600
Total Capital Cost				***$13,579,900***
Annual Maintenance Costs for Pipelines @ 0.1%				$4,200
Annual Maintenance Costs for Pump Station @ 1.5%				$78,800
Annual Power Costs @ 7.0 cents per kilowatt-hour				$650,000
Total Present Value Cost of Project (n=50, i=6%)				***$25,133,300***
Total Present Value per acre-foot of Developed Water				***$2,600***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 9,800 acre-feet

TABLE 9
Cost Estimate for Scenario 9

Description	Quantity	Unit	Unit Cost	Capital Cost
Pipelines				
Green River to Lower Park Pipeline – 20 inches	11,600	LF	$160	$1,856,000
Lower Park Pipeline to Pelican Lake – 20 inches	5,300	LF	$160	$848,000
Pump Stations				
Green River Pump Station	1	each	$3,059,000	$3,059,000
Contingency @ 30%				$1,728,900
	Subtotal (Total Construction Cost)			***$7,491,900***
Engineering and Administration @ 20%				$1,498,400
Pipeline Easement – 30 feet wide @ $1,000 per acre				$11,600
Total Capital Cost				***$9,001,900***
Annual Maintenance Costs for Pipelines @ 0.1%				$2,700
Annual Maintenance Costs for Pump Station @ 1.5%				$45,900
Annual Power Costs @ 7.0 cents per kilowatt-hour				$338,000
Total Present Value Cost of Project (n=50, i=6%)				***$15,095,400***
Total Present Value per acre-foot of Developed Water				***$3,600***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 4,200 acre-feet

TABLE 10
Cost Estimate for Scenario 10

Description	Quantity	Unit	Unit Cost	Capital Cost
Pipelines				
Green River to Lower Park Pipeline – 30 inches	11,600	LF	$240	$2,784,000
Lower Park Pipeline to Pelican Lake – 30 inches	5,300	LF	$240	$1,272,000
Pelican Lake to Cottonwood Service Area – 36 inches	10,600	LF	$288	$3,052,800
Pump Stations				
Green River & Pelican Lake Pump Stations	1	each	$8,912,000	$8,912,000
Contingency @ 30%				$4,806,200
			Subtotal (Total Construction Cost)	***$20,827,000***
Engineering and Administration @ 20%				$4,165,400
Pipeline Easement – 30 feet wide @ $1,000 per acre				$18,900
Total Capital Cost				***$25,011,300***
Annual Maintenance Costs for Pipelines @ 0.1%				$7,100
Annual Maintenance Costs for Pump Station @ 1.5%				$133,700
Annual Power Costs @ 7.0 cents per kilowatt-hour				$555,000
Total Present Value Cost of Project (n=50, i=6%)				***$35,978,400***
Total Present Value per acre-foot of Developed Water				***$4,300***

NOTES:
LF = linear feet
Total Water Developed for this Scenario = 8,400 acre-feet

Uinta-Green River Water Resources Model

PREPARED FOR: Central Utah Water Conservancy District
Uintah Water Conservancy District
Duchesne County Water Conservancy District

PREPARED BY: Jason Lillywhite/CH2M HILL
Rahul Agarwal/CH2M HILL

DATE: December 7, 2007

Contents

Background and Purpose

The purpose of this project—the Conceptual Analysis of Uinta and Green River Water Development Projects—is to identify and develop alternatives that can meet the existing and future water needs of the Uinta River Basin. Due to the complexity of the Uinta River system, a water rights simulation model was created by the Utah Department of Water Resources (DWR) to gain a better understanding of the system. The model, called the Uinta River Simulation (UintaSim) Model, simulates diversions along the Uinta and Whiterocks River system using hydrologic data from 1949–2006, on a daily time step. The model also simulates the operation of the existing reservoirs in the system. The *Uinta River Simulation Water Right Model and Green River Pumping Project Simulation Documentation* (DWR, 2004) provides additional information on the UintaSim model.

A new model, called the Uinta-Green River Water Resources (URWR) model, was developed as a tool to support the Conceptual Analysis of Uinta and Green River Water Development Projects study. The objective of this model was to create a user-friendly, visually enhanced tool that could assist in screening water development project alternatives. The main steps in developing this tool were to replicate the logic of the UintaSim model, validate the model by comparing results with those of the UintaSim model, and then simulate future scenarios as required by the scope of this project. This new model incorporates existing facilities and has the ability to evaluate up to thirteen scenarios of proposed facilities in the Uinta River system, including the proposed Uinta Reservoir and the Green River pumping project.

The updated URWR model was built using the GoldSim dynamic simulation software platform. GoldSim is a user-friendly, graphical program that runs dynamic simulations in various scientific, engineering, and management fields. It is much easier to compare and visualize different options in Goldsim because of its visual graphics enhancements.

System Description

The project area is located within Uinta and Duchesne Counties, about 150 miles east of Salt Lake City. This area comprises a large portion of what is known as the Uinta Basin, extending from the Upper Uinta Wilderness to the Green River. The Uinta River Basin is comprised of two main river systems, which include the Uinta River, Whiterocks River, and multiple tributaries (see Figure 1). Tributaries to the main rivers include Deep Creek, Pole Creek, Farm Creek, and Dry Gulch Creek, which also contribute to the Basin. Additionally, supplies from the Yellowstone Feeder Canal also contribute to the water supplies of the Basin. The existing reservoirs in the Uinta River Basin are listed as follows:

- Uinta High Mountain Lakes
- Ouray Park High Mountain Lakes
- Whiterocks High Mountain Lakes
- Brown’s Draw Reservoir
- Montes Creek Reservoir
- Brough Reservoir
- Pelican Lake
- Cottonwood Reservoir
- LaPoint Reservoir

The proposed reservoirs include Bennett, Neola, East Cottonwood, Upper Uinta, and Renn Smith. Renn Smith is noted as a proposed reservoir because it is not included in the existing conditions URWR model, but this facility is already under construction. Existing reservoirs that could be enlarged include Brown’s Draw and Montes Creek Reservoirs. The model accounts for diversions to demand areas that include secondary users, Indian compact users, and future municipal and industrial (M&I) demands. Pumping from the Green River to the Cottonwood Service Area and Pelican Lake are also implemented in the model.

The project area is divided into 19 demand areas with a combined acreage of approximately 80,000 acres, out of which 46,000 acres is owned by secondary users and the remainder by Indians. The Indian compact areas have the highest priority to divert water directly from the Uinta River. Indians are entitled to divert water from the Uinta and Whiterocks Rivers until their full allocation is met. The river system, reservoirs, and demand areas are connected in the model in a node-to-link methodology to visually enhance the connectivity of the model.

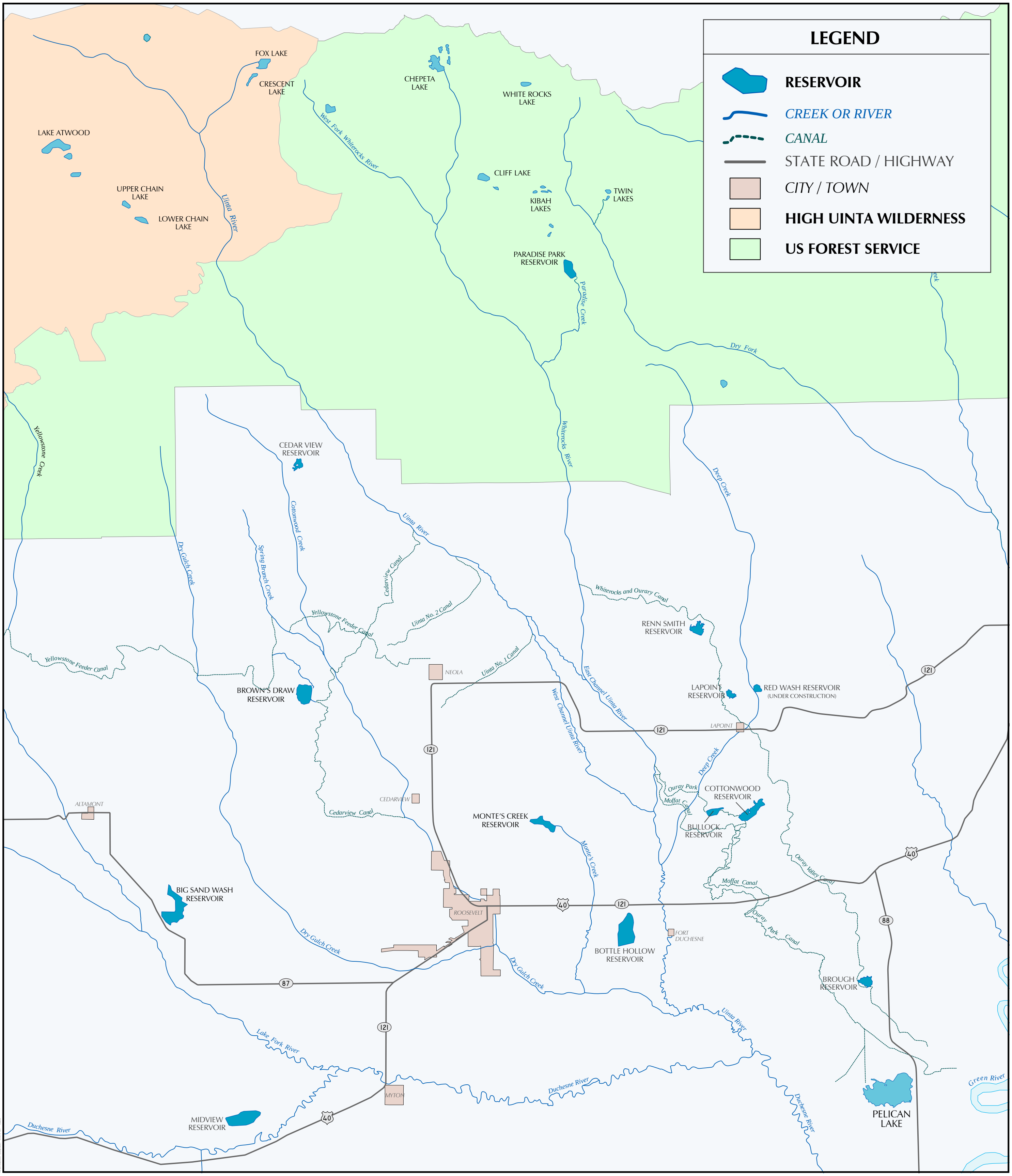


FIGURE 1
UINTA–GREEN RIVER PROJECT AREA
UINTA-GREEN RIVER CONCEPTUAL ANALYSIS REPORT

Basic Modeling Approach

The modeling approach of the URWR model was to pattern it after the approach used in the UintaSim model for existing conditions, and then build upon the model to incorporate proposed scenarios. One of the objectives of the URWR model was to provide a more user-friendly and visual platform to display results of scenario comparisons. For the sake of simplicity and easier understanding of the system, the Uinta River System was divided into two sections in the model—the Uinta and Whiterocks sections. The Uinta section was further subdivided into Upper Uinta and Lower Uinta subsections. Demand areas, reservoirs, and nodes form the basic structure for each section. Each entity in a subsection was modeled separately and then tied into the main section. Individual sections were then combined to represent the overall continuity of the model.

The project area has been categorized into 31 demand areas representing Indian and secondary irrigation demands and proposed M&I demands; the demand areas are aggregated into 19 model areas following the same methodology used in the UintaSim model. The diversions from the river system to the demand areas are based on a maximum allocation of 3 acre-feet per acre. Available water is appropriated to the demand areas based on the priorities of allocation. The priority is determined by the decreed water rights held by the demand areas. Water rights are allocated on the Uinta River system separately from water rights along the Whiterocks River system. Smaller tributaries that do not have significant contributions are combined with the supplies of the major river systems and also allocated to demands in similar fashion.

The model consists of several reaches, nodes, demand areas, and reservoirs (see Figure 2). At each node the total inflow and the demand is calculated and excess flow is sent to the next downstream node. Each demand area is either directly or indirectly connected to a node. If the demand area has a direct flow water right, then it is directly connected to the node; otherwise, the demand area is connected to the node through a reservoir. Diversions from nodes to demand areas are determined by an allocator component that determines the quantity of water each area would receive based on the existing supplies. If a demand area has more than one supply option, it receives its supplies based on the allocation from the first source and the deficit amount is represented as a shortage and then receives water from the next source. This process is repeated until the entire demand is met or the demand area receives its allocation. The supply to reservoirs is also based on a priority system of allocation, though most reservoirs are filled from the water supplies in the winter months. The reservoirs also receive additional water that is left after the demands for the demand areas are met or until the reservoir is filled. Reservoirs used to deliver water to demand areas that do not have any direct flow rights are filled based on the priority of the demand area.

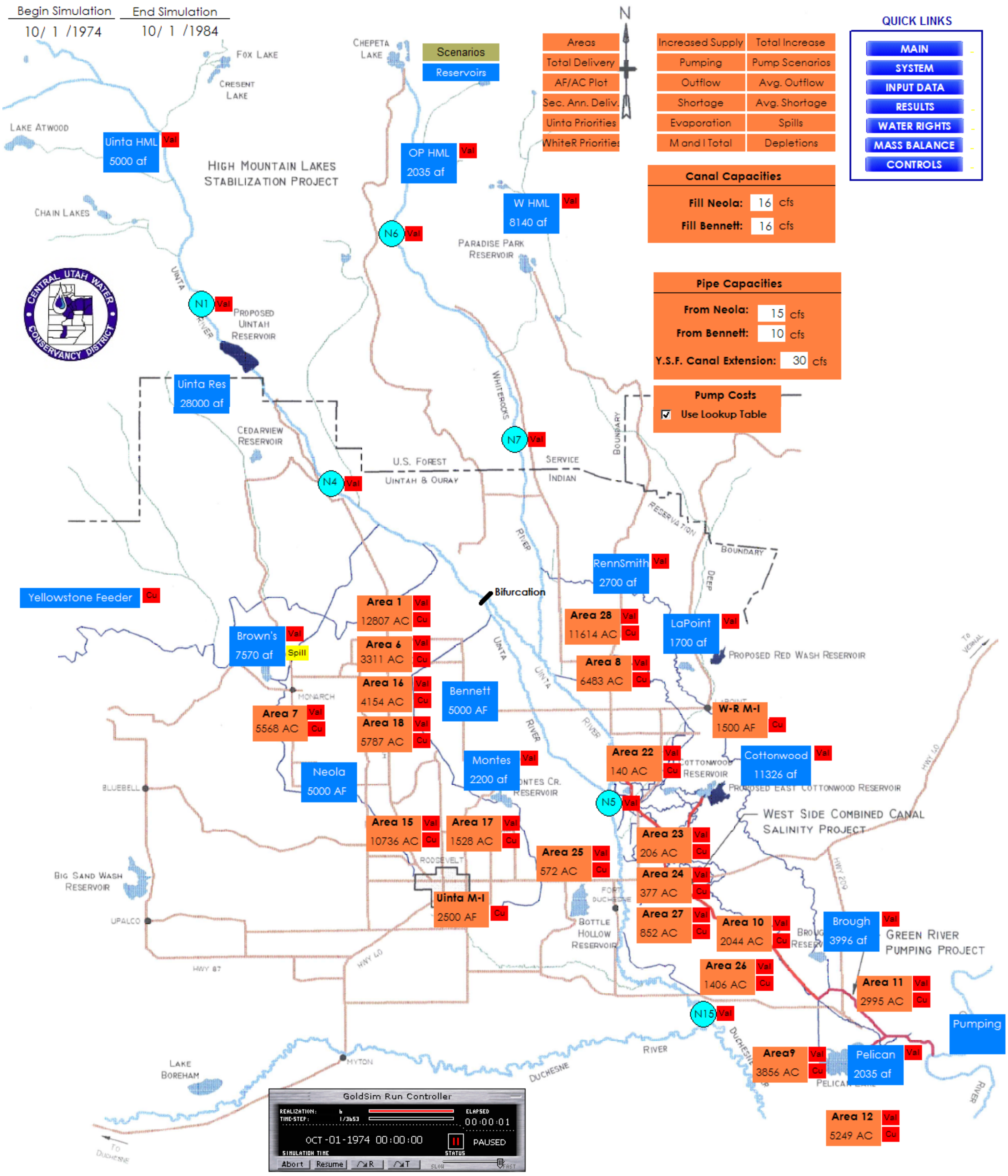
Mass balance checks are incorporated at each river node, river subsection, demand area, and the overall system so that the overall integrity of the system is maintained. The mass balance checks are critical in this model and ensure that all water is being accounted for. The model has a built-in error check system that alerts the user if mass in and out of the system at any point in the model does not balance.

The general equation for mass balance checking is as follows:

$$Q_{in} - Q_{out} = \Delta \text{ storage}$$

THIS PAGE INTENTIONALLY LEFT BLANK

FIGURE 2
Screenshot of the URWR Model Schematic and Controls Page



THIS PAGE INTENTIONALLY LEFT BLANK

Hydrology

Average daily streamflow data were obtained from the UintaSim model input database. These data include streamflow for Uinta River, Whiterocks River, Pole Creek, Farm Creek, Deep Creek, Yellowstone Feeder Canal, and Dry Gulch Creek. The time range of the data begins on October 1, 1949 and ends on October 1, 2006, which is the simulation time period used in both the UintaSim and URWR models.

Demand Areas

Thirty-one demand service areas are aggregated into 19 model demand areas. The numbering convention of these areas in the URWR model matches the convention used in the UintaSim model. A summary of the areas and the naming convention used in the model is shown in Table 1. The first row of the table represents the naming convention used in the model. The acreages of each area used in the model were obtained from UintaSim model documentation, and were further verified by Randy Crozier of the Duchesne County Water Conservancy District and Scott Ruppe of the Uintah Water Conservancy District.

At present, the existing and future conditions models include the following:

- Agricultural Demands
- Indian Stock Water Demands
- Municipal and Industrial Demands

The agricultural demands are the most significant demands on the system. These demands are based on water-righted acreage. The 1923 Federal Court Decree specifies that lands served from the Uinta River Drainage can receive no more than 3 acre-feet per acre. Therefore, the total demand is the water-righted acreage multiplied by 3 acre-feet per acre. It should also be noted that the 3 acre-feet-per-acre limitation refers to the volume of water diverted from the rivers and not the amount applied to the fields. The volume of water applied to the fields is generally less than the diverted volume due to canal losses and evaporation.

THIS PAGE INTENTIONALLY LEFT BLANK

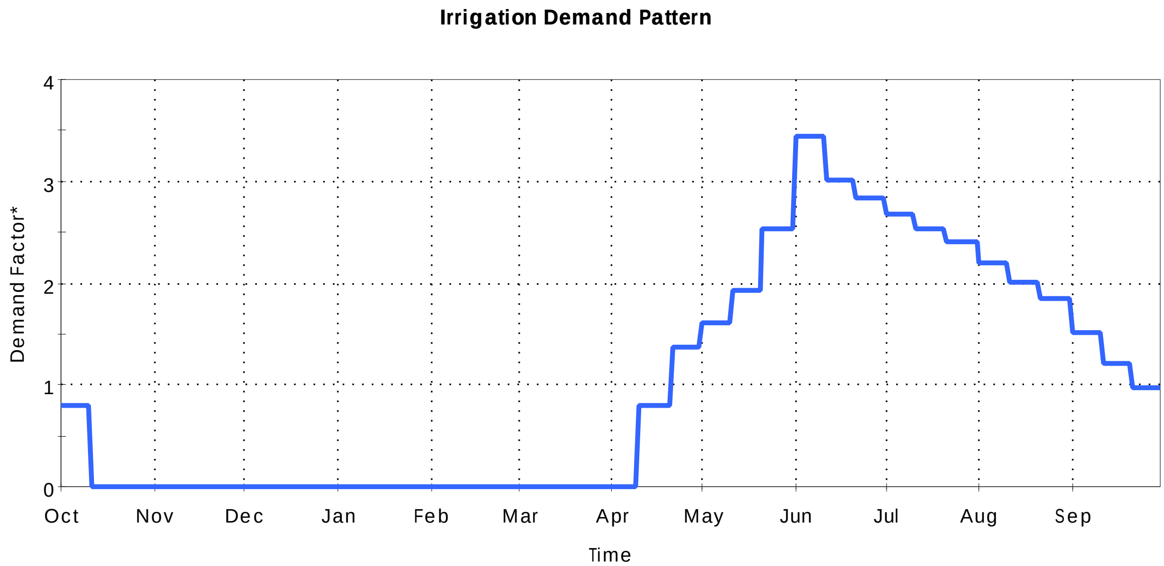
TABLE 1
Summary of Areas Used in Model (areas shown in units of acres)

	Model Demand Area Numbers																							
Service Area	**1**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**15**	**16**	**17**	**18**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**30**	**31**	**Subtotals**		
Uintah Canal	8,002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,002		
Uinta No 1 Canal	3,380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,380		
A-Ditch	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68		
B-Ditch	417	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	417		
Harms Canal	712	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	712		
Big Six Canal	228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	228		
Bench Canal	0	0	0	0	0	0	0	0	0	0	0	5,787	0	0	0	0	0	0	0	0	0	5,787		
Harris Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	377	0	0	0	0	0	0	377		
Henry Jim Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,406	0	0	0	0	1,406		
Fort Duchesne Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	572	0	0	0	0	0	572		
Daniels Ditch	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0	0	0	140		
Tabby White Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	206	0	0	0	0	0	0	0	206		
US Whiterocks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,091	0	0	4,091		
Farm Creek Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,409	0	0	1,409		
Duncan Ditch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	141	0	0	141		
School Ditch 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	340	0	0	340		
School Ditch 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	12		
Deep Creek Canal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,621	0	0	5,621		
Military Ditch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	852	0	0	0	852	**33,761**	**Total Indian**
Larsen	0	0	0	0	0	0	0	0	620	20	0	0	0	0	0	0	0	0	0	0	0	640		
Marimon	0	0	0	0	0	0	0	0	320	0	0	0	0	0	0	0	0	0	0	0	0	320		
Hall and Lee	0	0	0	0	0	0	0	0	155	0	0	0	0	0	0	0	0	0	0	0	0	155		
Big Six	0	0	0	0	0	0	0	0	860	0	0	0	0	0	0	0	0	0	0	0	0	860		
Coltharpe	0	0	0	0	0	0	0	0	320	0	0	0	0	0	0	0	0	0	0	0	0	320		
Bastion	0	0	0	0	0	0	0	0	255	0	0	0	0	0	0	0	0	0	0	0	0	255		
Independent	0	0	0	0	0	0	0	0	3,525	20	0	0	0	0	0	0	0	0	0	0	0	3,545		
TN Dodd	0	0	0	0	0	0	0	0	482	501	0	0	0	0	0	0	0	0	0	0	0	983		
Uintah	0	3,311	0	0	0	0	0	0	1,965	0	0	0	0	0	0	0	0	0	0	0	0	5,276		
Kyle	0	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	0	0	0	160		
Moffat	0	0	0	0	0	2,044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,044		
Durigan	0	0	0	0	0	0	0	0	127	0	0	0	0	0	0	0	0	0	0	0	0	127		
Uintah No 1	0	0	0	0	0	0	0	0	0	2,731	1,528	0	0	0	0	0	0	0	0	0	0	4,259		
Bench	0	0	0	0	0	0	0	0	0	882	0	0	0	0	0	0	0	0	0	0	0	882		
Cedarview	0	0	5,568	0	0	0	0	0	1,947	0	0	0	0	0	0	0	0	0	0	0	0	7,515		
Ouray Park—Cottonwood	0	0	0	0	3,856	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,856		
Ouray Park—Brough	0	0	0	0	0	0	2,995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,995		
Ouray Park—Pelican	0	0	0	0	0	0	0	5,249	0	0	0	0	0	0	0	0	0	0	0	0	0	5,249		
Whiterocks	0	0	0	6,483	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,483	**45,924**	**Total Secondary**
TOTALS	**12,807**	**3,311**	**5,568**	**6,483**	**3,856**	**2,044**	**2,995**	**5,249**	**10,736**	**4,154**	**1,528**	**5,787**	**140**	**206**	**377**	**572**	**1,406**	**852**	**11,614**	**0**	**0**		**79,685**	**Grand Total**

THIS PAGE INTENTIONALLY LEFT BLANK

The average daily demand pattern was obtained from the existing UintaSim model, which is shown in Figure 3.

FIGURE 3
Typical Agricultural Demand Pattern Representing the Fraction of the Total Demand

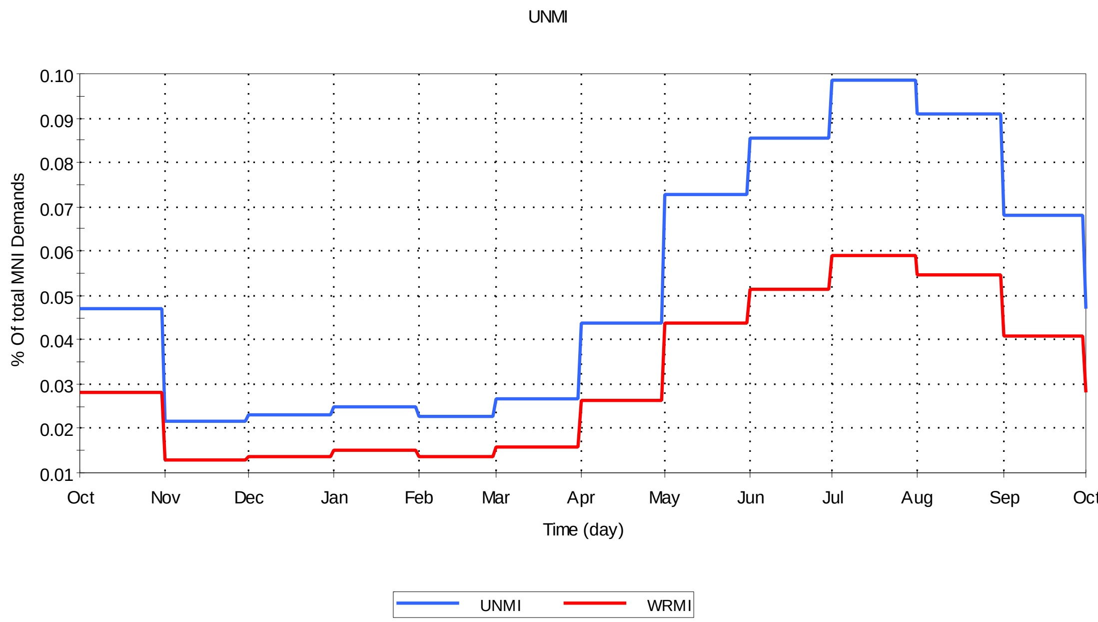


*Note: Demand Factor is multiplied times the average annual water demand in AF to develop daily flow rates

Indian stock water demands form a small portion of the water demand during the winter. These demands are restricted to a maximum diversion of 1 cubic foot per second (cfs) per 1,000 acres. Constant flow rates based on the acreages for Indian demand areas were added to the Indian agricultural demands to obtain a total demand pattern.

Municipal demands are included in future scenario runs of the model, and are restricted to a total maximum diversion of 2,500 acre-feet per year on the Uinta River section and a total diversion of 1,500 acre-feet per year on the Whiterocks River section. The municipal demand patterns were obtained from the Central Utah Water Conservancy District. A typical municipal demand pattern is shown in Figure 4. Water supplied to municipal demands comes from new storage facilities. All new storage facilities in the system have the most junior water right. However, municipal water demands have the highest priority to divert water from these new storage facilities. Model area numbers 30 and 31 are used as placeholders for simulation of these demands.

FIGURE 4
Typical Municipal Demand Pattern on the Uinta and Whiterocks Sections



Water Rights

Water is diverted to 19 demand areas, which comprise a total project area of approximately 80,000 acres, out of which 46,000 acres is owned by secondary users and the remainder by Indians. The Indian compact areas have the highest priority to divert water directly from the Uinta River. Indian compact diverters are entitled to divert water from the Uinta and Whiterocks Rivers until their full allocation is met. However, other than stock water they can only divert water during the irrigation season (April 10^{th} to October 15^{th}). The demand areas and the reservoirs on the Uinta and Whiterocks Rivers receive direct flows based on their water right priorities. Water right priorities were obtained from the existing UintaSim model documentation. All Indian demand areas have the highest priority on direct flows; the priorities of the secondary users and the reservoirs are determined by their water right. Water right priorities on the Uinta and Whiterocks Rivers are summarized in Table 2.

TABLE 2
Demand Areas Summer and Winter Priorities

Demand Area	Summer Priority [a]	Winter Priority [a]
Uinta River Priorities		
Indian Demand Areas [b]	1	2
Area 10	3	3
Area 16	4	4
Area 17	5	5
Area 6	6	6
Area 7	7	7
Area 15	8	8
Area 9 [c]	9	9
Area 12 [c]	10	10
Whiterocks River Priorities		
Indian Demand Areas [b]	1	1
Area 10	2	4
Area 8	3	5
Area 11	4	6

NOTES:
Lower numbers indicate higher priority than higher numbers
[a] The summer priority timeframe is April 11–October 14 and the winter priority timeframe is October 15–April 10.
[b] Indian Demand Areas include Areas 1, 18, 23, 24, 25, 26, 27, 28
[c] Demand Areas 9 and 12 priorities change to lowest priority in Green River Pumping Scenarios

The water right priorities for the reservoirs are listed in Table 3. During the winter time, the reservoirs receive water at higher priorities because the Indian stock water demand is the only demand on the system.

TABLE 3
Reservoir Filling Priorities

Reservoir Name	Summer Priority [a]	Winter Priority [a]
Uinta River Priorities		
Uinta High Mountain Lakes	11	1
First 3,526 acre-feet of the existing Brown’s Draw	12–16	2
Enlarged portion of Brown’s Draw	19	19
Montes Creek	5	5
Enlarged portion of Montes Creek	19	19
Cottonwood [b]	14	4
East Cottonwood [b]	19	19
Pelican Lake [b]	14	4
Neola	19	19
Bennett	19	19
Upper Uinta	19	19
Whiterocks River Priorities		
Brough	5	2
Pelican Lake [b]	6	2
Cottonwood [b]	7	2
East Cottonwood [b]		
LaPoint	8	3
Renn Smith	9	4

NOTES:
Lower numbers indicate higher priority than higher numbers
[a] The summer priority timeframe is April 11–October 14 and the winter priority timeframe is October 15–April 10.
[b] Pelican Lake and Cottonwood Reservoir priorities change to lowest priority in Green River Pumping scenarios

Reservoir Operations

The data used to control operations of reservoirs in the model are presented in Table 4. These values were obtained from UintaSim model documentation. East Cottonwood Reservoir is simulated in the model by increasing the capacity of the existing Cottonwood Reservoir by the volume of East Cottonwood Reservoir.

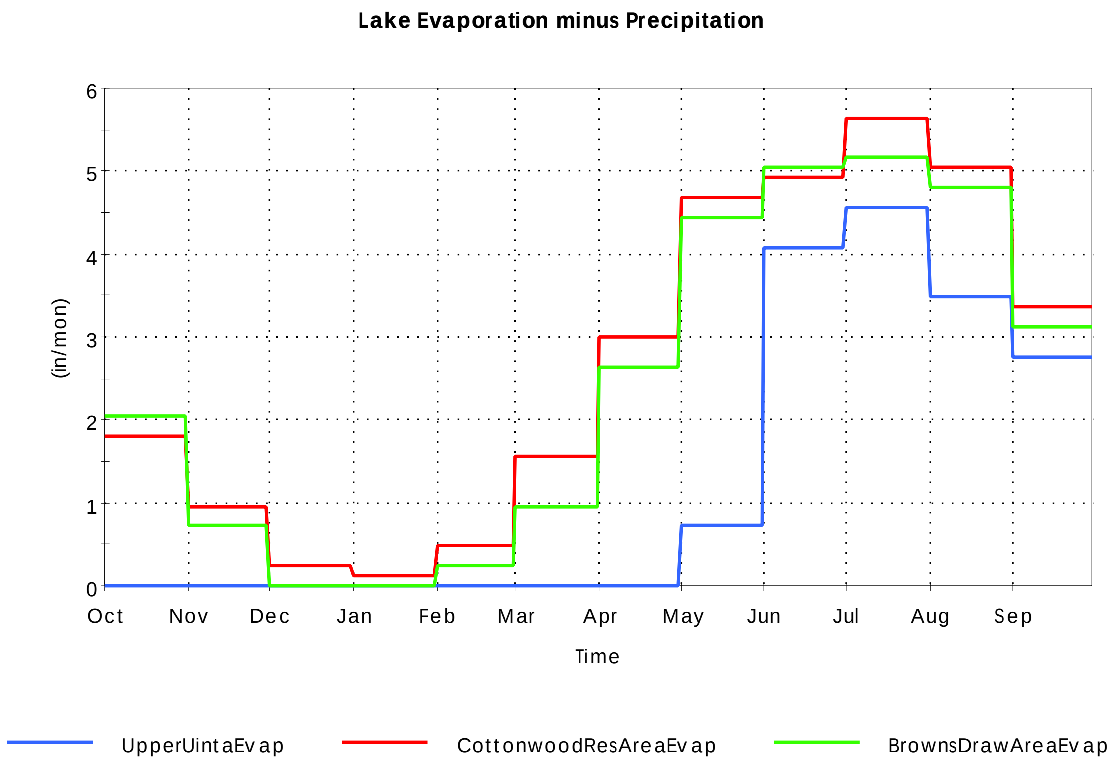
TABLE 4
Reservoir Volumes and Inflow Capacities

Reservoir	Dead Pool Volume (acre-feet)	Capacity (acre-feet)	Maximum Inflow Capacity (cfs)
Uinta High Mountain Lakes	10	5,000	13
Brown's Draw	100	5,670	60
Enlarged Brown's Draw [a]	100	7,570	60
Montes Creek	0	1,250	50
Enlarged Montes Creek [a]	0	2,200	50
Upper Uinta [a]	3,000	28,000	No limit
Neola [a]	0	5,000	16
Bennett [a]	0	5,000	16
Whiterocks High Mountain Lakes	70	8,140	100
Ouray Park High Mountain Lakes	0	2,035	100
LaPoint	0	1,700	50
Brough	1,245	3,996	50
Renn Smith [a]	0	2,700	50
Cottonwood	100	6,126	200
Pelican Lake	4,000	15,874	70
East Cottonwood [a]	0	5,200	50

NOTES:
cfs – Cubic Feet per Second
[a] Added to the future conditions model

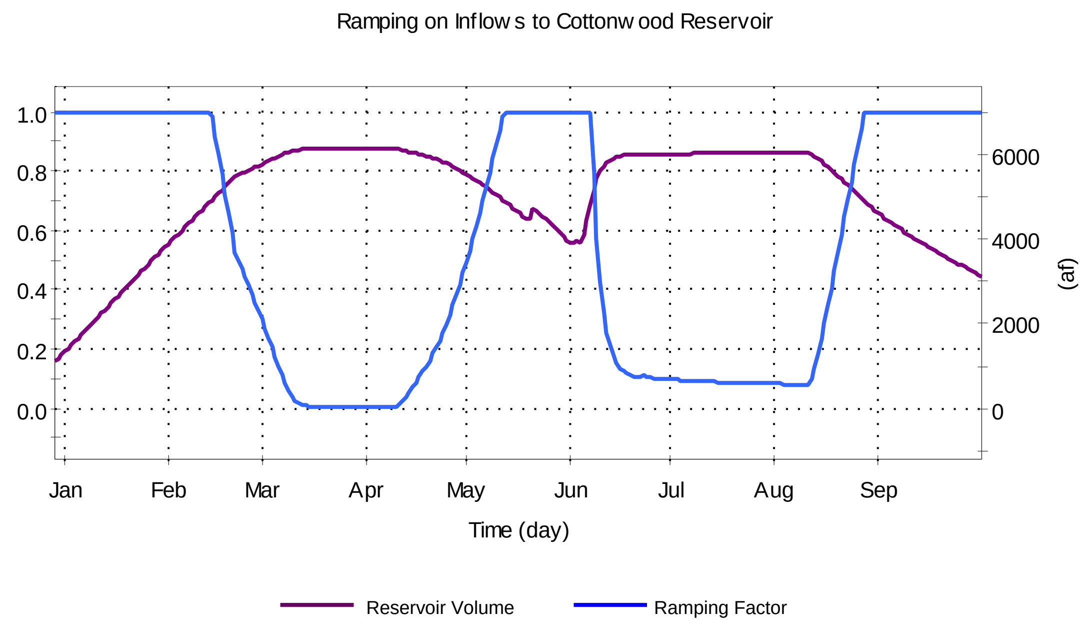
Reservoir evaporation and precipitation are dependent on the surface area of each reservoir. Evaporation is subtracted from precipitation then multiplied times the surface area of the stored water in the reservoir using storage-area relationships. The evaporation minus precipitation is referred to as net evaporation in the model and is the same as that used in the UintaSim model. Since all the reservoirs are located at different altitudes, the net evaporation rates are also different. Net evaporation and precipitation patterns used in the model are shown in Figure 5.

FIGURE 5
Typical Combined Evaporation and Precipitation Rate for the Reservoirs



Reservoirs in the model receive their allocated supplies based on a demand goal. The demand goal for a reservoir is limited by the capacity of the canal feeding the reservoir and are reduced to zero if the reservoir fills up. Outflows from the reservoirs are dependent on the total demands on the reservoirs, but are constrained by the maximum outflow capacity of the reservoir. Ramping rates are applied to the inflows and outflows at reservoirs so that the reservoirs do not overfill or drain to less than zero. The ramping rate varies between zero and one, and is dependent on the maximum and minimum values for the reservoir. If a reservoir is nearly full, the ramping rate drops to a value of less than one, which reduces the inflow to the reservoir and stops it from filling up too fast. Similarly, when a reservoir is nearly empty, the ramping rate on the outflow drops to a value less than one, which reduces the outflows from the reservoir and stops it from draining too fast. The typical ramping rate on inflows to Cottonwood Reservoir along with the reservoir volume is shown in Figure 6. As shown in the figure, the value of the ramping rate is one until the reservoir reaches a certain volume and it goes to zero once the reservoir is full. When the reservoir starts draining due to the demands, the ramping rate again goes up.

FIGURE 6
Ramping on the Inflows and Reservoir Volume for Cottonwood Reservoir



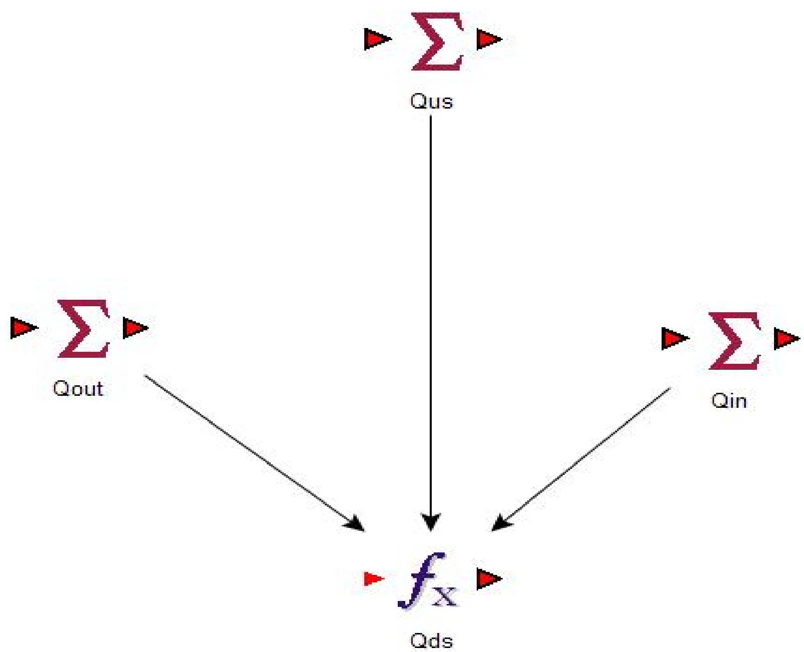
Supply Allocation

Supply allocation to demand areas and reservoirs is controlled in the model by two main allocator units. The first allocation unit controls the direct flows from the Uinta River and the second allocation element controls the direct flows from the Whiterocks River. The allocator unit adds up the total available supplies in the river and distributes it among the various demands based on the individual priorities. If sufficient supplies are not available to meet all the demands on the section, the allocator ensures that the higher priority demands are met before any water is allocated to lower priority demands.

River Nodes

The river nodes in the model play a major role in ensuring the supply of water to a particular demand. Figure 7 shows a typical node in the model. The Qus element receives the flow from a node upstream of the node, Qin represents all the inflows coming to the node, Qout represents the sum of all the demands on a node, and the Qds is the amount of water going downstream to the next node. Qds is calculated as Qus + Qin - Qout.

FIGURE 7
Typical Node in URWR Model



Each demand area receives its allocated supply from direct flows at the node it is connected to. A complete listing of the sources of supplies and the nodes each demand area or reservoir is connected to is shown in Tables 5 and 6. Demand areas and reservoirs take water from sources in the order they are numbered in the following tables. Refer to Attachment 2 for a screen capture of the model that shows all the river nodes within the system.

TABLE 5
Source of Water Supplies and Source Nodes for Demand Areas

Demand Area	Supply Source 1	Supply Source 2	Supply Source 3	Supply Source 4	Supply Source 5	Source Node
Area 1	Uinta River					1
Area 6	Uinta River	Yellowstone Feeder Canal	Upper Uinta Reservoir [a]	Neola Reservoir [a]		2
Area 7	Uinta River	Brown's Draw Reservoir	Upper Uinta Reservoir [a]			–[b]
Area 8	Whiterocks River	LaPoint Reservoir	Renn Smith [a]			7
Area 9	Uinta River	Pelican Lake [a]	Green River [a]	Cottonwood Reservoir	Upper Uinta Reservoir [a]	13
Area 10	Uinta River	Upper Uinta Reservoir [a]	Cottonwood [a]			9
Area 11	Whiterocks River	Cottonwood Reservoir	Brough Reservoir			7
Area 12	Uinta	Pelican Lake	Upper Uinta Reservoir			14
Area 15	Uinta River	Upper Uinta Reservoir [a]	Bennett Reservoir [a]	Neola Reservoir [a]	Yellowstone Feeder Canal [a]	1
Area 16	Uinta River	Uinta High Mountain Lake	Upper Uinta Reservoir [a]	Yellowstone Feeder Canal [a]		1
Area 17	Montes Creek Reservoir					–[b]
Area 18	Uinta River					4
Area 22	Uinta River					9
Area 23	Uinta River					9
Area 24	Uinta River					9
Area 25	Uinta River					9
Area 26	Uinta River					15
Area 27	Whiterocks River					9
Area 28	Uintah River					7
Area 30 [c]	Renn Smith Reservoir [a]					–[b]
Area 31 [c]	Upper Uinta Reservoir [a]	Neola Reservoir [a]	Bennett Reservoir [a]			–[b]

NOTES:
[a] Included in the future conditions model
[b] Demand area does not receive direct flows either from Uinta or Whiterocks Rivers
[c] Municipal demand

TABLE 6
Source of Water Supplies and Source Nodes for Reservoirs

Reservoir	Supply Source 1	Supply Source 2	Supply Source 3	Supply Source 4	Supply Source 5	Node
Uinta HML [a]	Uinta River					1
Brown’s Draw	Uinta River	Yellowstone Feeder Canal				3
Montes Creek	Uinta River	Uinta HML	Uinta Reservoir [a]			4
Uinta [b]	Uinta River					1
Neola [b]	Uinta River					1
Bennett [b]	Uinta River					1
Whiterocks HML	Whiterocks River					6
Ouray Park HML	Whiterocks River					6
LaPoint	Whiterocks River	Ouray Park HML	Whiterocks HML		Yellowstone Feeder Canal [a]	7
Brough	Whiterocks River	Ouray Park HML	Cottonwood			9
Renn Smith [b]	Whiterocks River	Ouray Park HML				7
Cottonwood	Whiterocks River	Uinta River	Ouray Park HML			7
Pelican Lake	Uinta River	Cottonwood	Green River [a]	Area 12[b]	Area 9[b]	14

NOTES:
HML – High Mountain Lakes
[a] Included in the future conditions model
[b] Return Flows

Looping Algorithm

If a river node does not have sufficient inflows to meet demands, it requests the upstream node to release water to meet its deficit demand. It is mandatory for the node upstream to release the amount of water requested by the downstream node. If the upstream node does not have sufficient supplies to meet the requested demands, the outflow from that node is restricted. The model uses an iterative process to ensure that the downstream flow from any node is not negative. If the computed downstream flow at any important node becomes negative, the model reduces the available supply to the allocator element by 1 cfs on each iteration. This results in a reduction of the allocations to each demand area.

The model also ensures that all Uinta Indian demand areas receive the same amount of water on an acre-feet-per-acre basis irrespective of their location within the Uinta River System. The same condition holds true for Whiterocks Indian demands.

Model Validation

The existing conditions model closely replicates the results produced by the UintaSim model for the period from October 1949 to September 2006. Validation plots provided in Attachment 1 compare the outputs of URWR and UintaSim models.

Scenarios

The existing conditions model was modified to incorporate the simulation of up to thirteen scenarios for evaluation of proposed facilities in the Uinta River system. These scenarios are comprised of one or more options that are aimed at developing the water supplies that typically come from available winter flows after all reservoirs have been filled and from high spring flows that exceed all demands or capacity of diversion structures. This water is not currently being used because there is insufficient storage or diversion capacity to capture the water when it is available.

The project features incorporated in the future conditions model are as follows:

- Uinta High Mountain Lake storage transfer to the new Uinta Reservoir
- Uinta High Mountain Lake storage transfer to the new Bennett and Neola Reservoirs
- Construction of the Upper Uinta Reservoir
- Enlargement of the existing Brown’s Draw Reservoir
- Enlargement of the existing Montes Creek Reservoir
- Construction of Bennett Reservoir
- Construction of Neola Reservoir
- Exchanging Cottonwood Reservoir supplies with Renn Smith Reservoir supplies
- Construction of Renn Smith Reservoir
- Carrying over the existing volume of Ouray Park High Mountain Lakes to the next year
- Construction of East Cottonwood Reservoir
- Extending Yellowstone Feeder Supplies to Demand Area 16
- Filling Pelican Lake from Green River pumping
- Meeting the demands of Demand Area 9 by directly pumping from Green River
- Meeting the demands of Demand Area 9 by directly pumping water from Pelican Lake

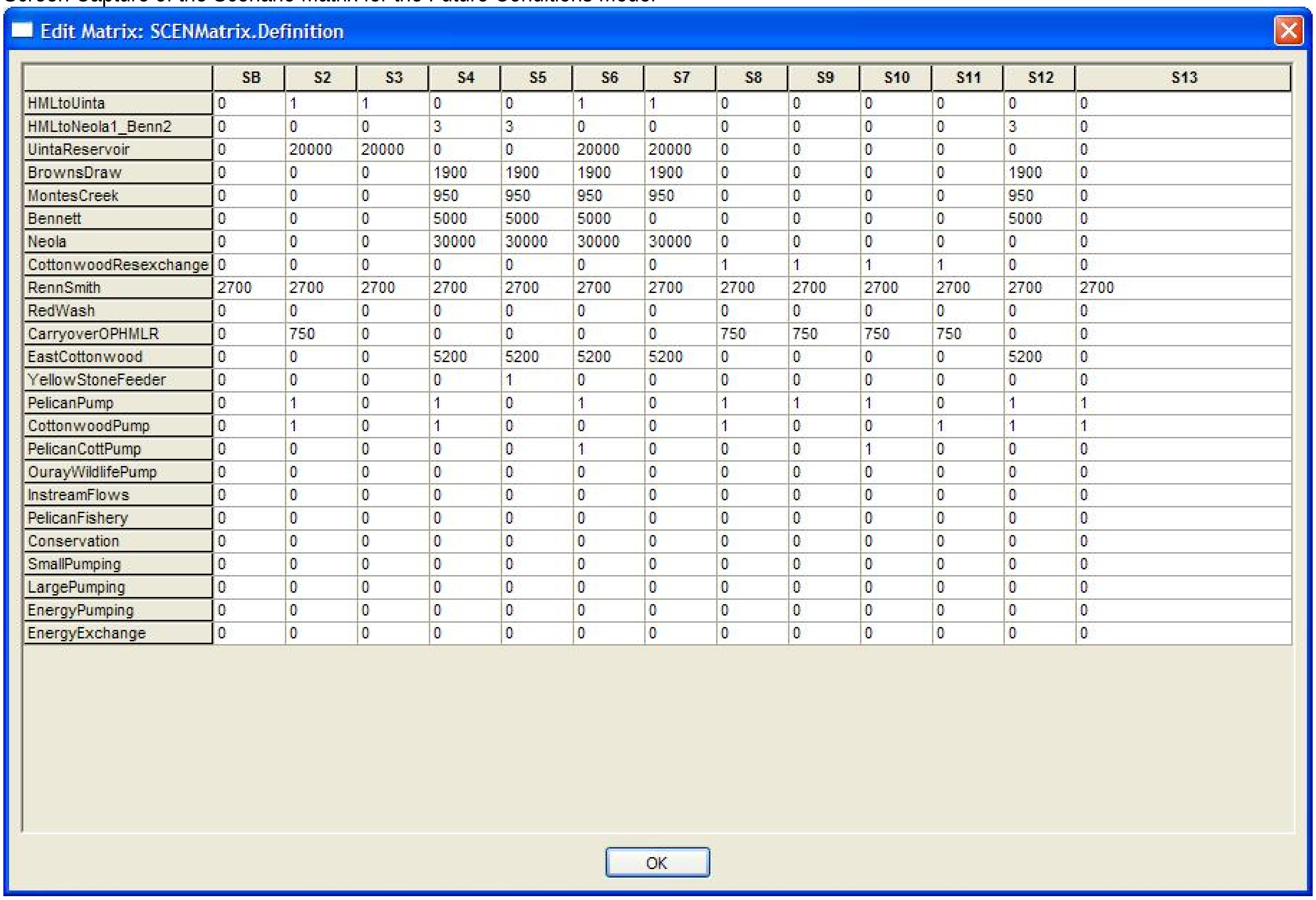
The model simulates the impact of these new project features on the existing water supplies. A comparison is made between the future condition simulation and the existing condition simulation to gauge the improvement in supplies. In addition to the previously mentioned project features, the following additional components could be implemented in the future versions of UintaSim model:

- Imposing restrictions on the minimum in-stream flow
- Improving Pelican Lake fishery
- Implementing water conservation
- Small and large pumping projects
- Exchange agreements with the Energy suppliers
- Pumping to the Energy suppliers

Future scenarios are incorporated in the model interactively. The user can choose among different scenarios and components by changing a spreadsheet element, which is a 24-by-16 matrix consisting of all the components in rows and all the scenarios in columns. This matrix is named as Scenario Matrix in the model and is editable on the initiation of the model run. The user has the option of either running one scenario at a time or running all scenarios in a single run. The scenario matrix is shown in Figure 8.

All the components in the matrix can be changed in the cell corresponding to a particular component and a scenario. Component 2, which represents the transfer of High Mountain Lake storage to Bennett or Neola Reservoirs or both, can have a value of either 1, 2, or 3, where 1 represents the transfer to Bennett, 2 represents transfer to Neola, and 3 represents transfer to both Bennett and Neola. Enlargements of reservoirs or addition of new reservoirs can be entered directly by putting the volume by which the reservoir has to be enlarged or the volume of the new reservoir directly. The model reads the scenario matrix and changes the status of the new components to either on or off to simulate its effect. The addition of these new components results in the change of the existing priority system. This change is incorporated in the model through a series of if and else statements. All proposed reservoirs and enlargements of existing reservoirs are given the least priority among the reservoirs on direct flows.

FIGURE 8
Screen Capture of the Scenario Matrix for the Future Conditions Model



	SB	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
HMLtoUinta	0	1	1	0	0	1	1	0	0	0	0	0	0
HMLtoNeola1_Benn2	0	0	0	3	3	0	0	0	0	0	0	3	0
UintaReservoir	0	20000	20000	0	0	20000	20000	0	0	0	0	0	0
BrownsDraw	0	0	0	1900	1900	1900	1900	0	0	0	0	1900	0
MontesCreek	0	0	0	950	950	950	950	0	0	0	0	950	0
Bennett	0	0	0	5000	5000	5000	0	0	0	0	0	5000	0
Neola	0	0	0	30000	30000	30000	30000	0	0	0	0	0	0
CottonwoodResexchange	0	0	0	0	0	0	0	1	1	1	1	0	0
RennSmith	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700
RedWash	0	0	0	0	0	0	0	0	0	0	0	0	0
CarryoverOPHMLR	0	750	0	0	0	0	0	750	750	750	750	0	0
EastCottonwood	0	0	0	5200	5200	5200	5200	0	0	0	0	5200	0
YellowStoneFeeder	0	0	0	0	1	0	0	0	0	0	0	0	0
PelicanPump	0	1	0	1	0	1	0	1	1	1	0	1	1
CottonwoodPump	0	1	0	1	0	0	0	1	0	0	1	1	1
PelicanCottPump	0	0	0	0	0	1	0	0	0	1	0	0	0
OurayWildlifePump	0	0	0	0	0	0	0	0	0	0	0	0	0
InstreamFlows	0	0	0	0	0	0	0	0	0	0	0	0	0
PelicanFishery	0	0	0	0	0	0	0	0	0	0	0	0	0
Conservation	0	0	0	0	0	0	0	0	0	0	0	0	0
SmallPumping	0	0	0	0	0	0	0	0	0	0	0	0	0
LargePumping	0	0	0	0	0	0	0	0	0	0	0	0	0
EnergyPumping	0	0	0	0	0	0	0	0	0	0	0	0	0
EnergyExchange	0	0	0	0	0	0	0	0	0	0	0	0	0

Model Results

After finalizing and validating the URWR model, some results were selected and documented in this technical memorandum to demonstrate how the model assisted in evaluation of the scenarios. This section does not include an exhaustive documentation of all the results developed in this model. Demand and diversion results from the existing conditions scenario are shown in Table 7. The table shows the total deliveries to different service areas in thousand acre-feet and also on an acre-feet-per-acre basis.

TABLE 7
Demands and Diversions from the Existing Conditions Scenario

Service Area	Annual Stock Water Demand[a]	Average annual Diversion[b]	Average Delivery[c]
Area 1	2,616	35.4	2.8
Area 6		8.4	2.5
Area 7		14.8	2.7
Area 8		16.4	2.5
Area 9		9.2	2.4
Area 10		4.2	2
Area 11		8.4	2.8
Area 12		14.6	2.8
Area 15		11.6	1.1
Area 16		9.4	2.3
Area 17		4.3	2.8
Area 18	1,182	16	2.8
Area 22	29	0.4	2.8
Area 23	42	0.6	2.8
Area 24	77	1	2.8
Area 25	117	1.6	2.8
Area 26	287	3.9	2.8
Area 27	174	2.3	2.7
Area 28	2,373	31.1	2.7

NOTES:
[a] acre-feet per year
[b] 1,000 acre-feet per year
[c] acre-feet per acre

Average annual spills from the Uinta and Whiterocks Rivers to the Duchesne River are shown in Table 8.

TABLE 8
Average Annual Spills

Spill Type	Spill Amount[a]
Spill from Whiterocks River	17
Spill from Uinta (including spills from Brown’s Draw)	27
Grand Total	**44**

NOTE:
[a] acre-feet per year

Table 9 shows the comparison between the total developed water and the actual increase in the supplies to service areas on an acre-feet-per-acre basis.

TABLE 9
Comparison Between the Total Developed Water and Actual Increase in the Supplies to Service Areas

Scenarios	Description	Total Developed Water[a]	Area Deliveries to Secondary Users (Acre-feet/Acre)									
			Area 6	**Area 7**	**Area 8**	**Area 9**	**Area 10**	**Area 11**	**Area 12**	**Area 15**	**Area 16**	**Area 17**
S1 (Baseline)	No Improvements	0	2.5	2.7	2.5	2.4	2.0	2.8	2.8	1.1	2.3	2.8
UintaSim Model	No Improvements	0	2.8	2.8	1.9	2.5	2.1	2.2	2.6	1.3	2.4	2.4
S 2	Main stem with pumping	22,300	2.7	2.7	2.8	3.0	2.5	2.9	3.0	2.1	2.6	2.9
S 3	Main stem without pumping	12,600	2.6	2.7	2.7	2.4	2.3	2.8	2.8	1.9	2.4	2.8
S 4	Off-stream storage with pumping	17,900	2.6	2.8	2.6	3.0	2.7	3.0	3.0	1.7	2.4	2.9
S 5	Off-stream storage without pumping	8,900	2.6	2.7	2.6	2.6	2.0	2.9	2.8	1.5	2.3	2.9
S 6	Main stem plus off-stream storage with pumping	26,200	2.7	2.8	2.6	3.0	2.8	3.0	3.0	2.4	2.6	2.9
S 7	Main stem plus off-stream storage without pumping	16,200	2.6	2.7	2.6	2.6	2.3	2.9	2.8	2.0	2.4	2.9
S 8	Pump to Pelican Lake and Cottonwood Service Area	9,800	2.5	2.7	2.8	3.0	2.4	2.9	3.0	1.2	2.3	2.8
S 9	Pump to Pelican Lake only	4,200	2.5	2.7	2.8	2.4	2.1	2.8	3.0	1.1	2.3	2.8
S 10	Pump to Pelican Lake and from Pelican Lake to Cottonwood	8,400	2.5	2.8	2.8	2.7	2.3	2.9	3.0	1.2	2.4	2.9

NOTE:
[a] acre-feet per year
In Scenarios 2, 4, and 6, pumping refers to pumping from Green River to Pelican Lake and from Green River to Cottonwood Service area

THIS PAGE INTENTIONALLY LEFT BLANK

The comparison between the deliveries to Indian Lands on an acre-foot-per-acre basis in the URWR and the UintaSim models is shown in Table 10.

TABLE 10
Indian Land Delivery Comparisons

Demand Area	URWR[a]	UintaSim[a]
Area1	2.8	2.8
Area 18	2.8	2.8
Area 22	2.8	2.4
Area 23	2.8	2.4
Area 24	2.8	2.4
Area 25	2.8	2.4
Area 26	2.8	2.4
Area 27	2.7	2.8
Area 28	2.7	2.8

NOTES:
[a]acre-feet-per-acre
URWR = Uinta-Green River Water Resources Model
UintaSim = Uinta River Simulation Model

The comparison between the total diversions to the Indian Lands and the secondary users in the Goldsim and UintaSim models is shown in Table 11.

TABLE 11
Total Diversion Comparisons

	URWR[a]	UintaSim[a]
Total Indian	99	100
Total Secondary	101	101
Grand Total	**200**	**201**

NOTES:
[a]1,000 acre-feet
URWR = Uinta-Green River Water Resources Model
UintaSim = Uinta River Simulation Model

New and Enlarged Reservoirs

The following result plots are intended to show an example of how new and enlarged reservoirs performed in the model. In order to limit the length of this document, only a single scenario has been chosen for each reservoir.

Figure 9 is a plot of the Upper Uinta Reservoir in Scenario 2 for the years 1975 through 1985.

FIGURE 9
Upper Uinta Reservoir, Scenario 2, 1975–1985

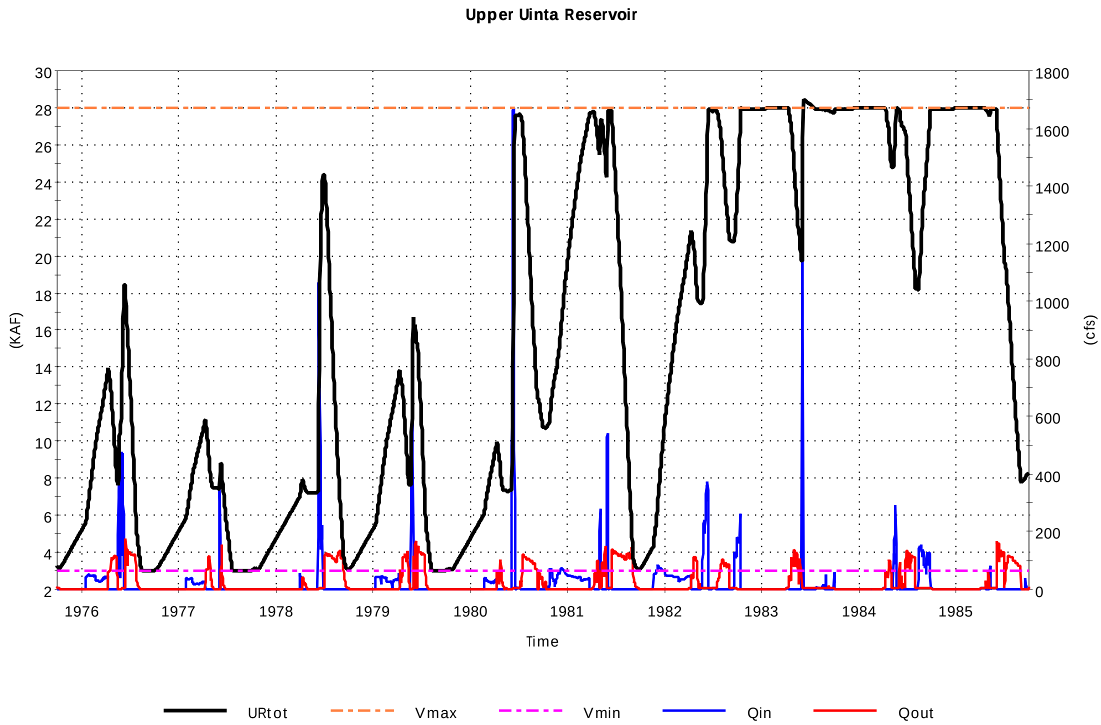


Figure 10 is a plot of the enlarged Brown's Draw Reservoir in Scenario 4 for the years 1975 through 1985.

FIGURE 10
Brown's Draw Reservoir, Scenario 4, 1975–1985

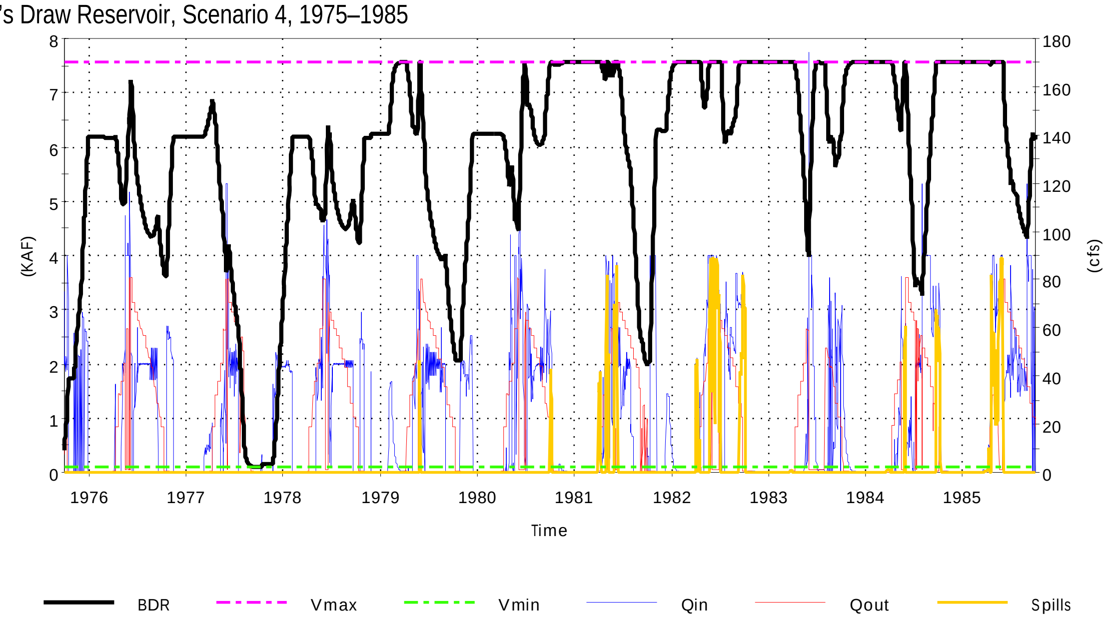


Figure 11 is a plot of the enlarged Montes Creek Reservoir in Scenario 4 for the years 1975 through 1985.

FIGURE 11
Montes Creek Reservoir, Scenario 4, 1975–1985

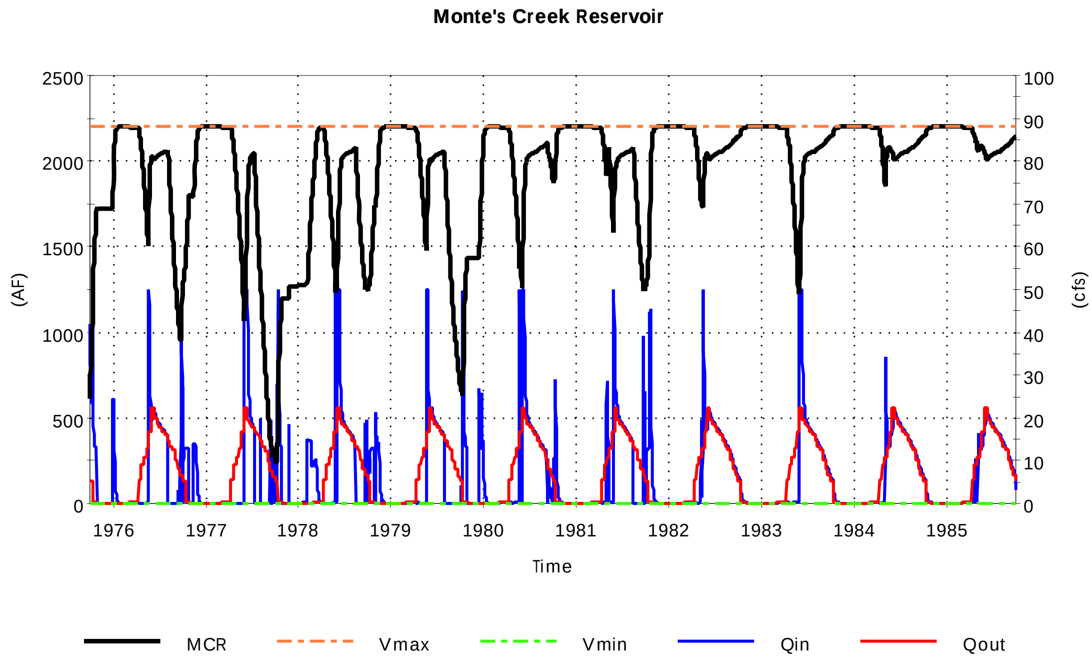


Figure 12 is a plot of Neola Reservoir in Scenario 4 for the years 1975 through 1985.

FIGURE 12
Neola Reservoir, Scenario 4, 1975–1985

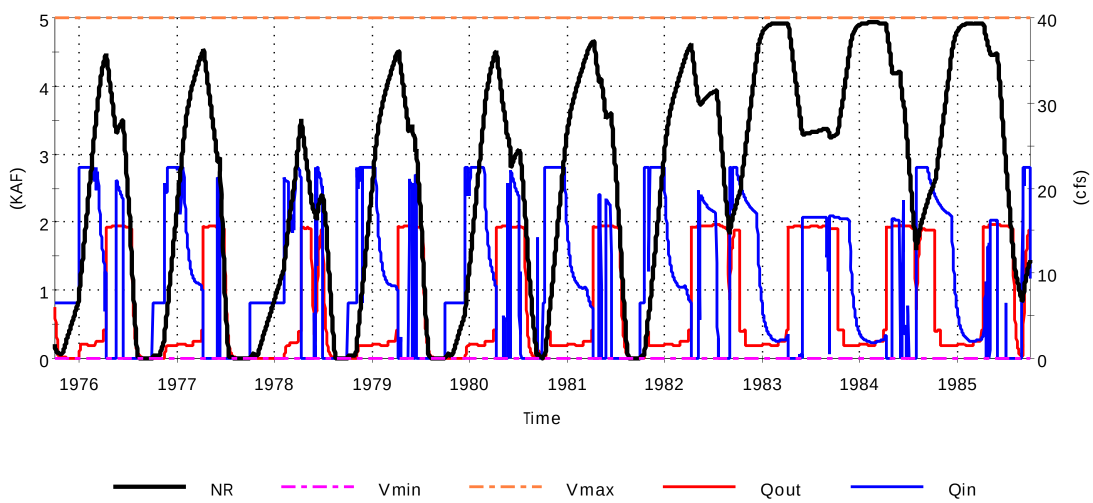


Figure 13 is a plot of Bennett Reservoir in Scenario 4 for the years 1975 through 1985.

FIGURE 13
Bennett Reservoir, Scenario 4, 1975–1985

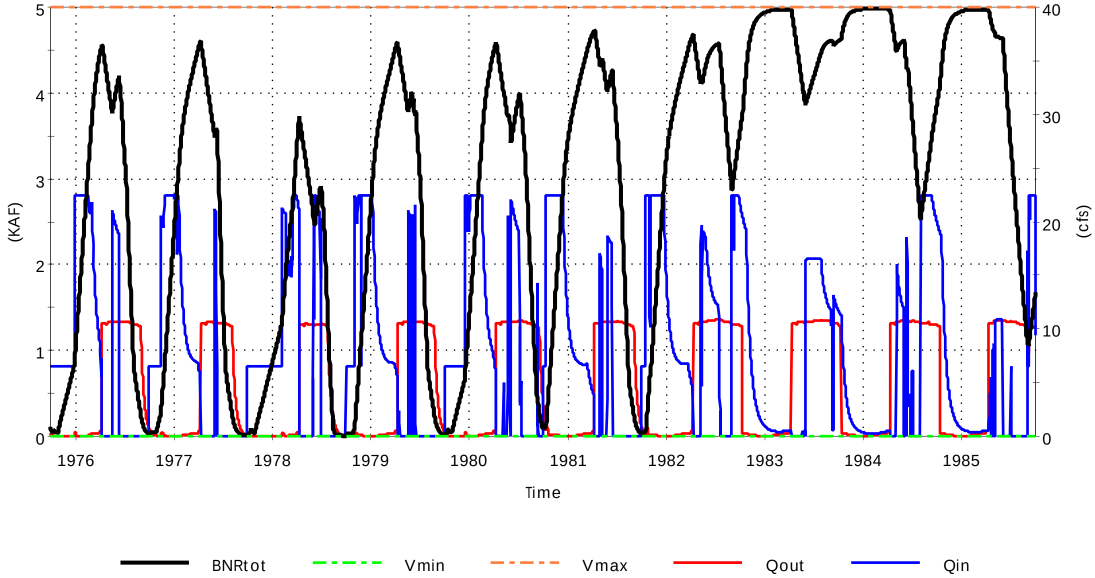
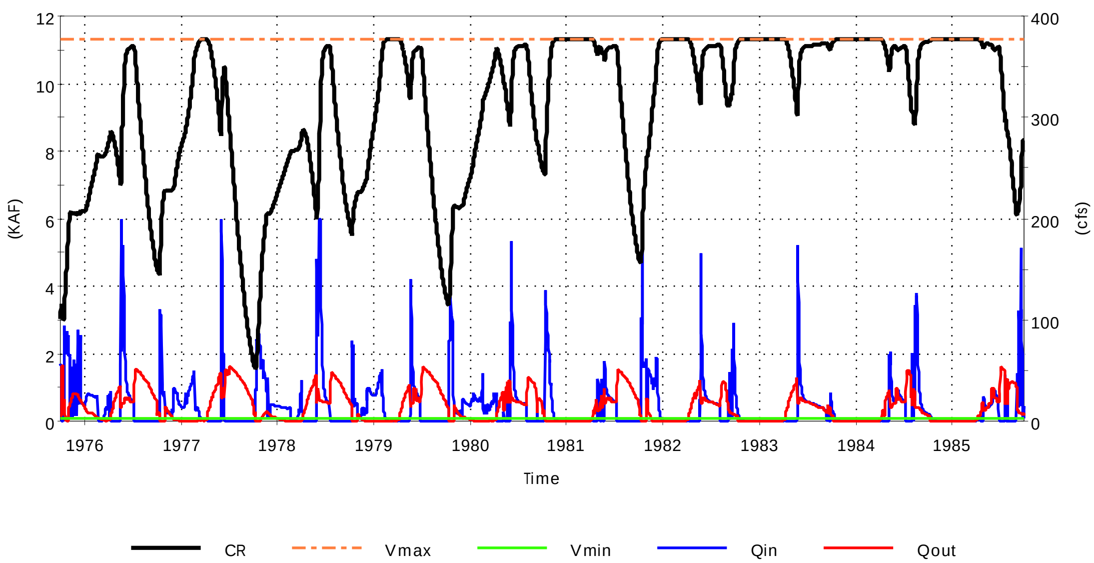


Figure 14 is a plot of East Cottonwood Reservoir (combined with the existing Cottonwood Reservoir) in Scenario 4 for the years 1975 through 1985.

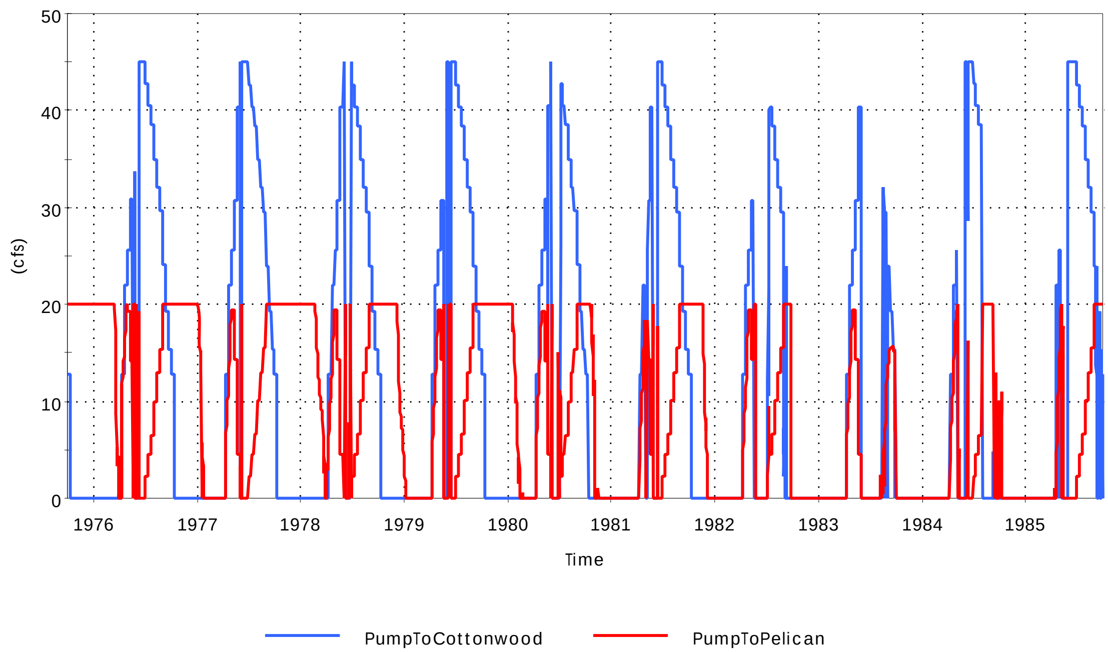
FIGURE 14
East Cottonwood and Existing Cottonwood Combined Reservoirs, Scenario 4, 1975–1985



Green River Pumping Results

Figure 15 is a plot of Green River pumping in Scenario 4 for the years 1975 through 1985. Pumping from the Green River to Pelican Lake is shown separately from pumping from the Green River to the Cottonwood Service Area even though the water would travel through the same pipe from the pump station at the River. The maximum total pumping from the Green River is set at 45 cubic feet per second for this scenario.

FIGURE 15
Green River Pumping, Scenario 4, 1975–1985



References

Utah Division of Water Resources (DWR). 2004. *Uinta River Simulation Water Right Model and Green River Pumping Project Simulation Documentation*. February 2004.

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT 1

Model Validation Plots

Model Validation Plots

The following validation plots compare the outputs of the URWR and UintaSim models (years 1975–1985 shown for clarity); the UintaSim model outputs are shown in red. Note that references to UintaSim results in the legends of the following plots use the name GRES.

FIGURE 1
Comparison between URWR and UintaSim Models for Demand Area 1

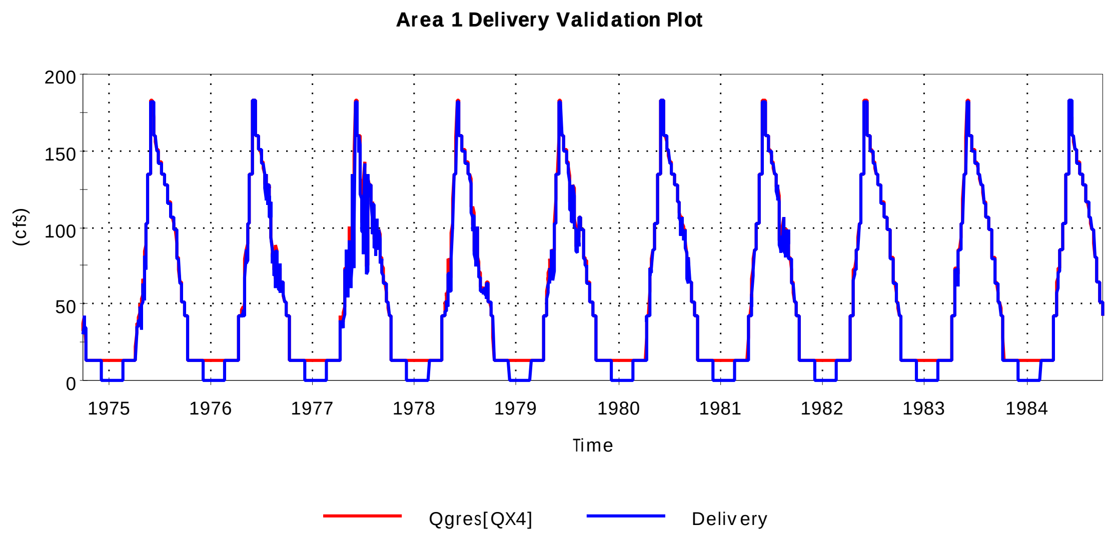


FIGURE 2
Comparison between URWR and UintaSim Models for Demand Area 6

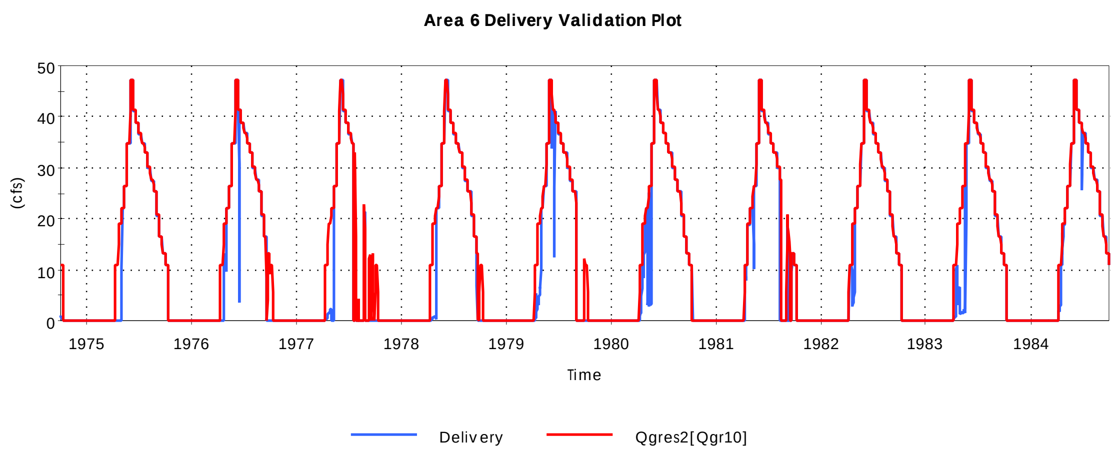


FIGURE 3
Comparison between URWR and UintaSim Models for Demand Area 7

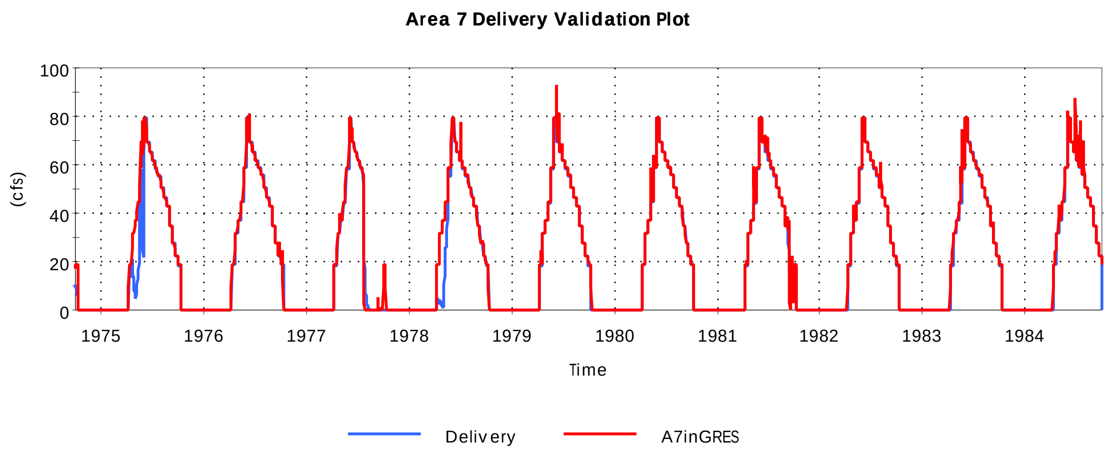


FIGURE 4
Comparison between URWR and UintaSim Models for Demand Area 8

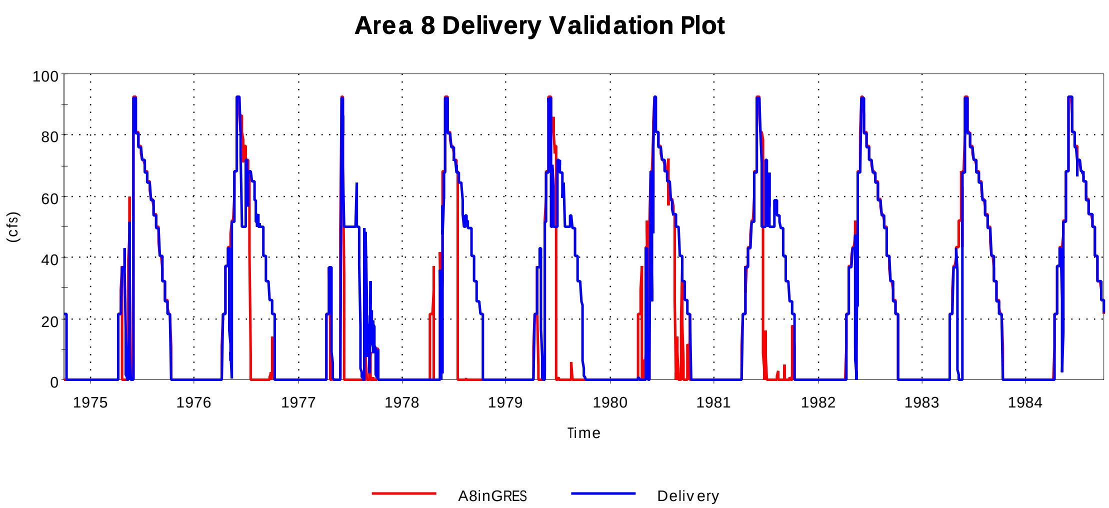


FIGURE 5
Comparison between URWR and UintaSim Models for Demand Area 9

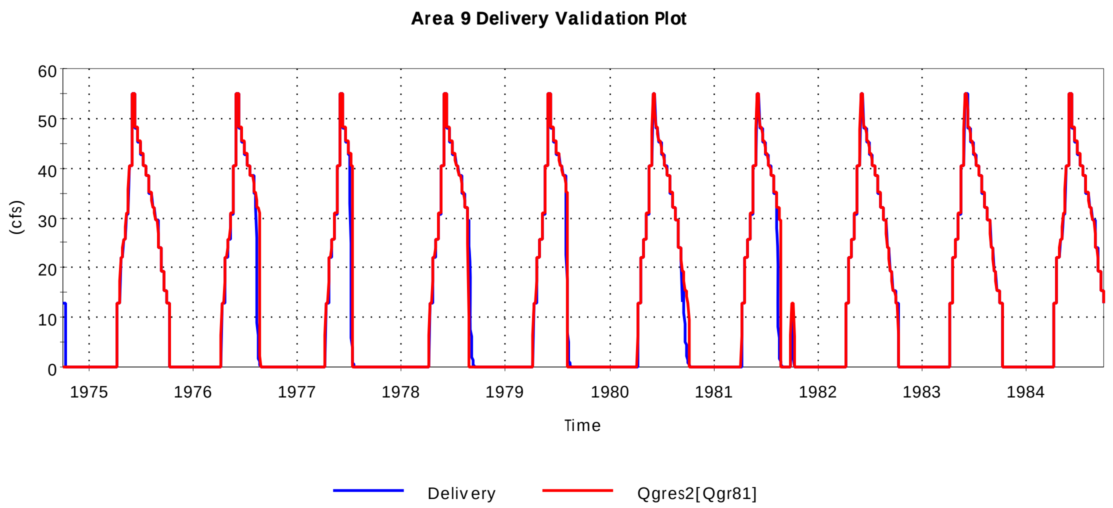


FIGURE 6
Comparison between URWR and UintaSim Models for Demand Area 10

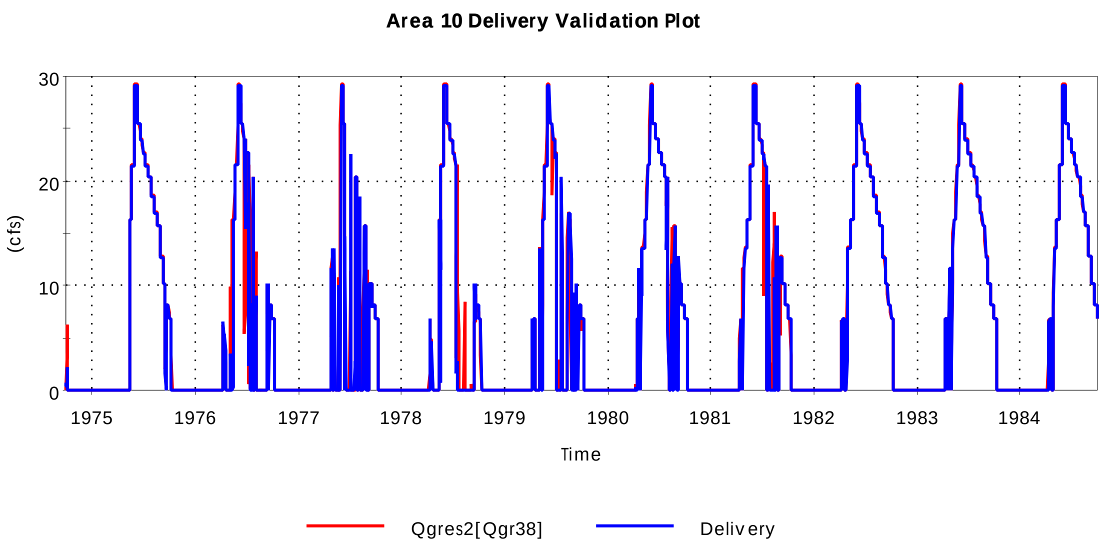


FIGURE 7
Comparison between URWR and UintaSim Models for Demand Area 12

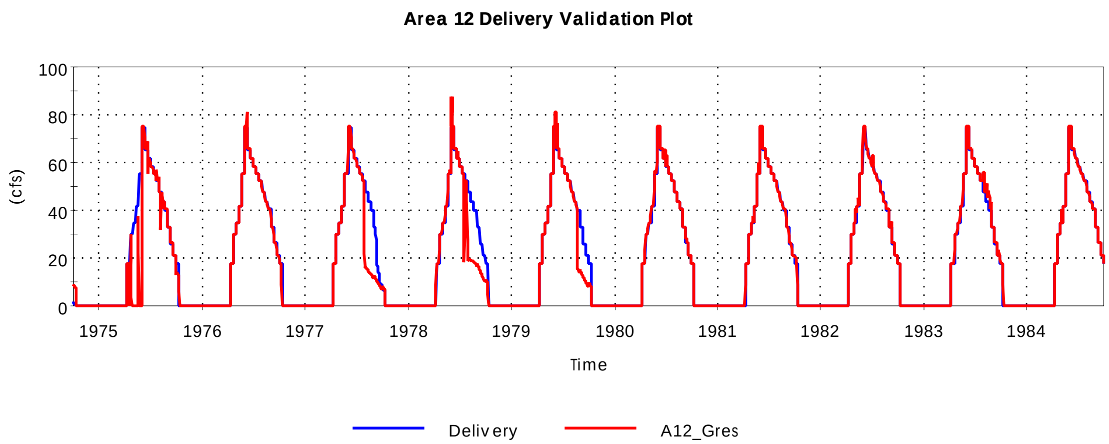


FIGURE 8
Comparison between URWR and UintaSim Models for Demand Area 15

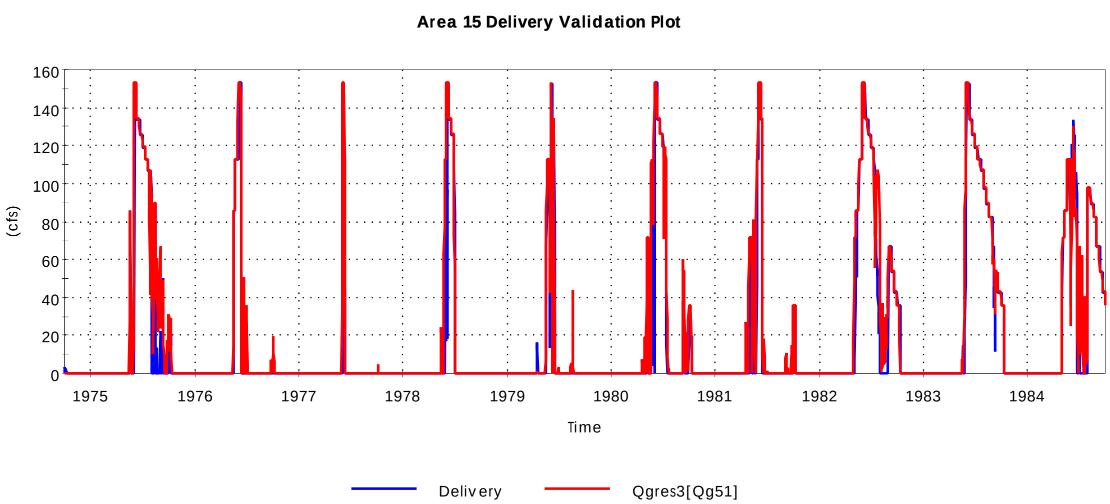


FIGURE 9
Comparison between URWR and UintaSim Models for Demand Area 16

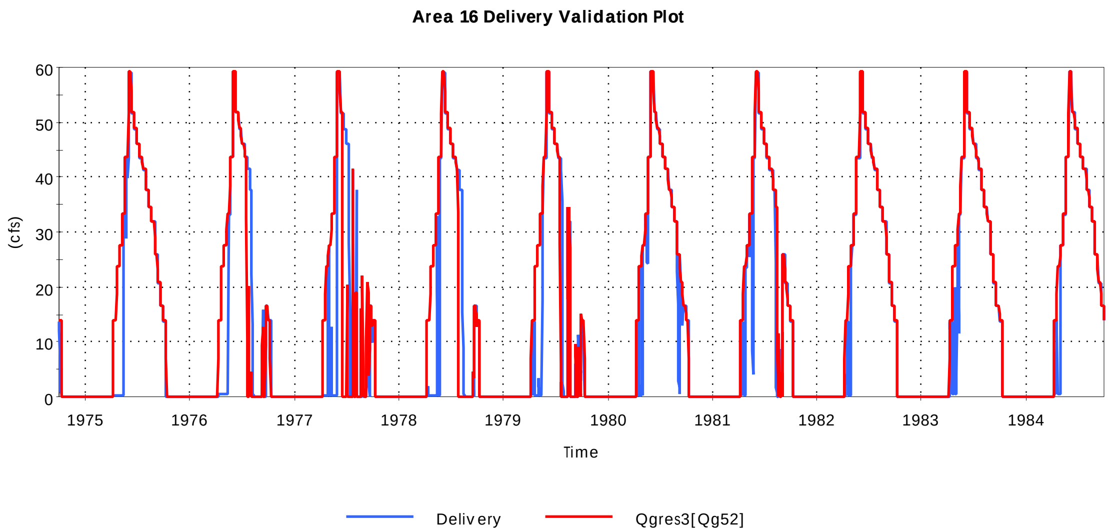


FIGURE 10
Comparison between URWR and UintaSim Models for Demand Area 17

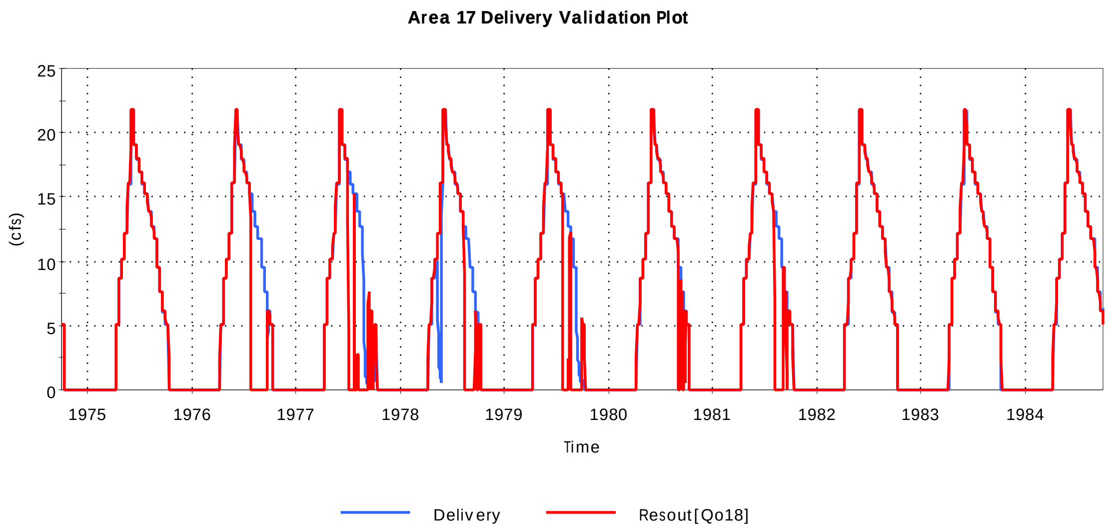


FIGURE 11
Comparison between URWR and UintaSim Models for Demand Area 18

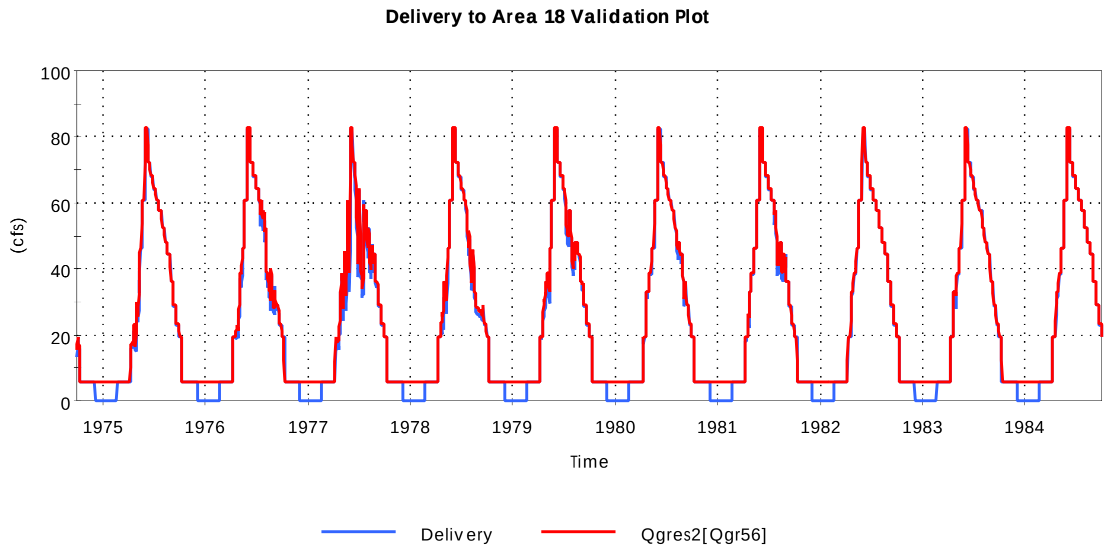


FIGURE 12
Comparison between URWR and UintaSim Models for Demand Area 26

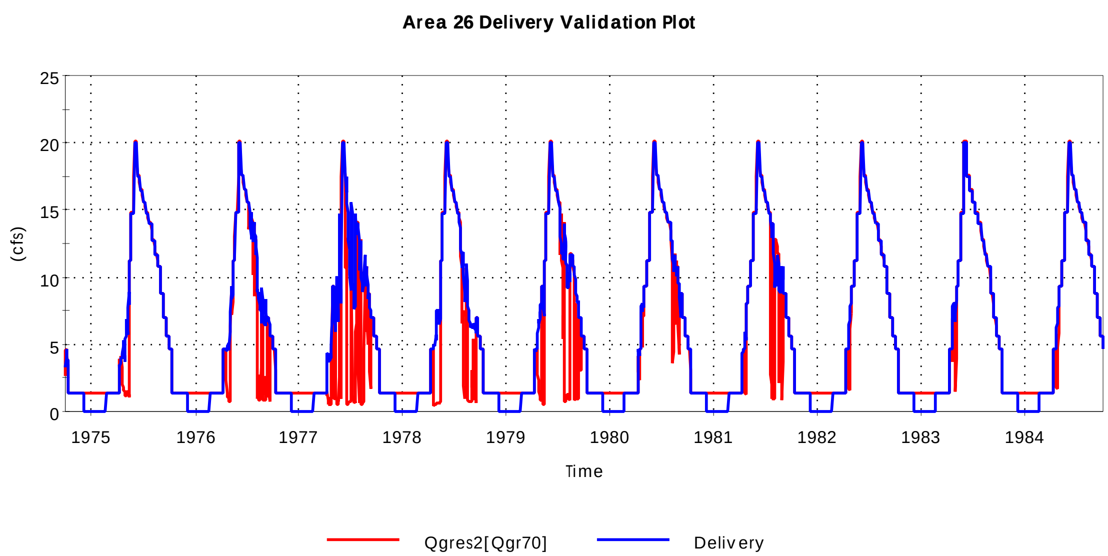
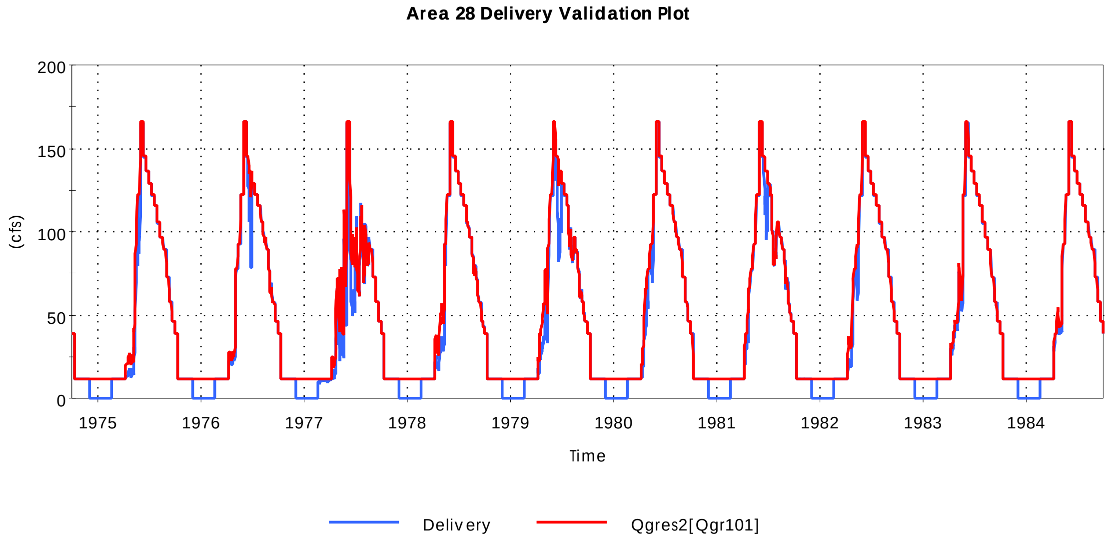


FIGURE 13
Comparison between URWR and UintaSim Models for Demand Area 28



The results from the GRES and URWR models are very similar for the deliveries to demand areas, except that in the URWR model the Indian stock water demand is being cut back from December 5 to February 15 each year but it stays the same in the GRES model. The comparison between the return flows from Demand Areas 8, 9, and 12 are shown in Figures 14 through 16.

FIGURE 14
Comparison between URWR and UintaSim Models Return Flows from Demand Area 8

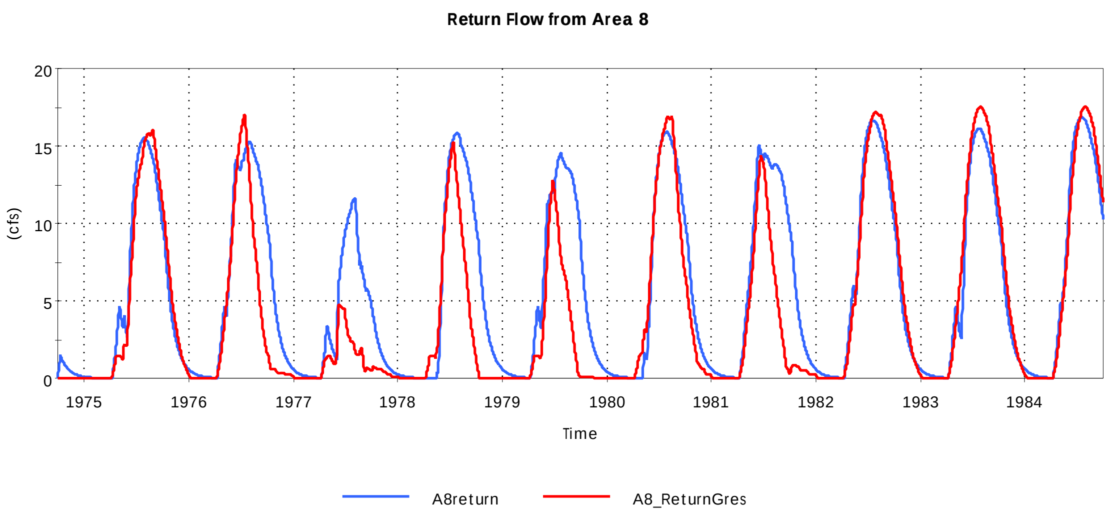


FIGURE 15
Comparison between URWR and UintaSim Models Return Flows from Demand Area 9

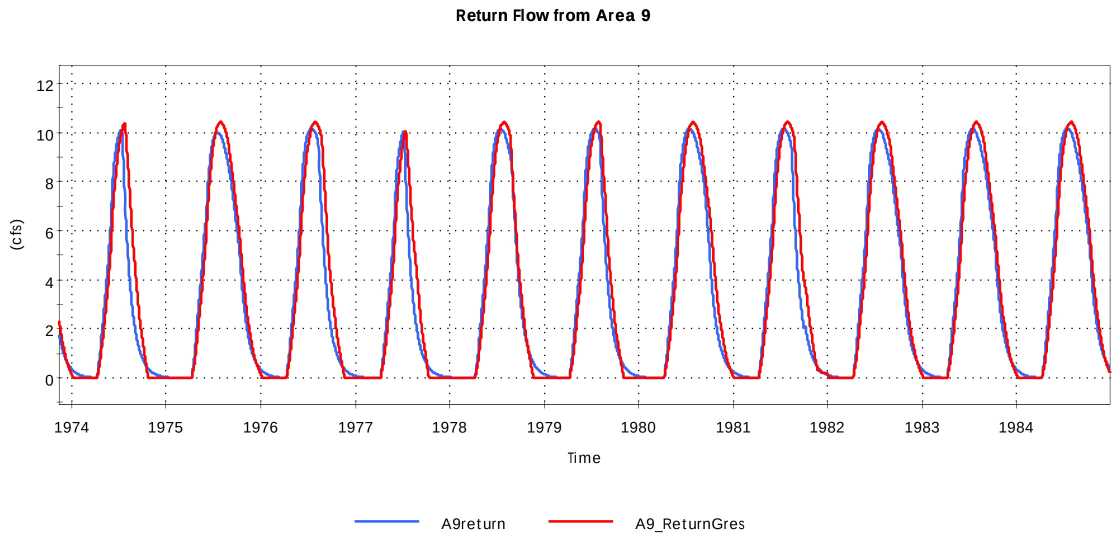


FIGURE 16
Comparison between URWR and UintaSim Models Return Flows from Demand Area 12

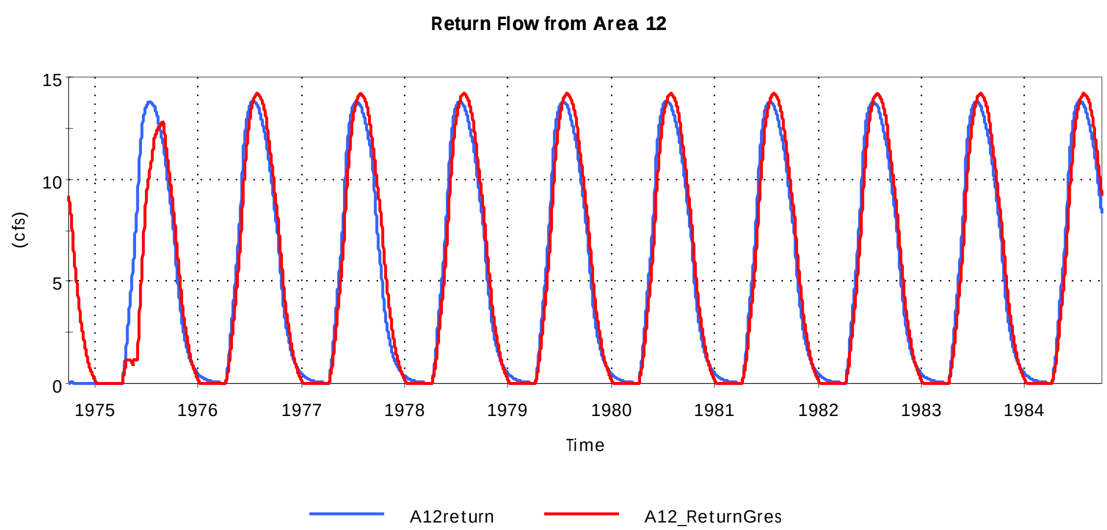


FIGURE 17
Validation Plot for Uinta High Mountain Lakes

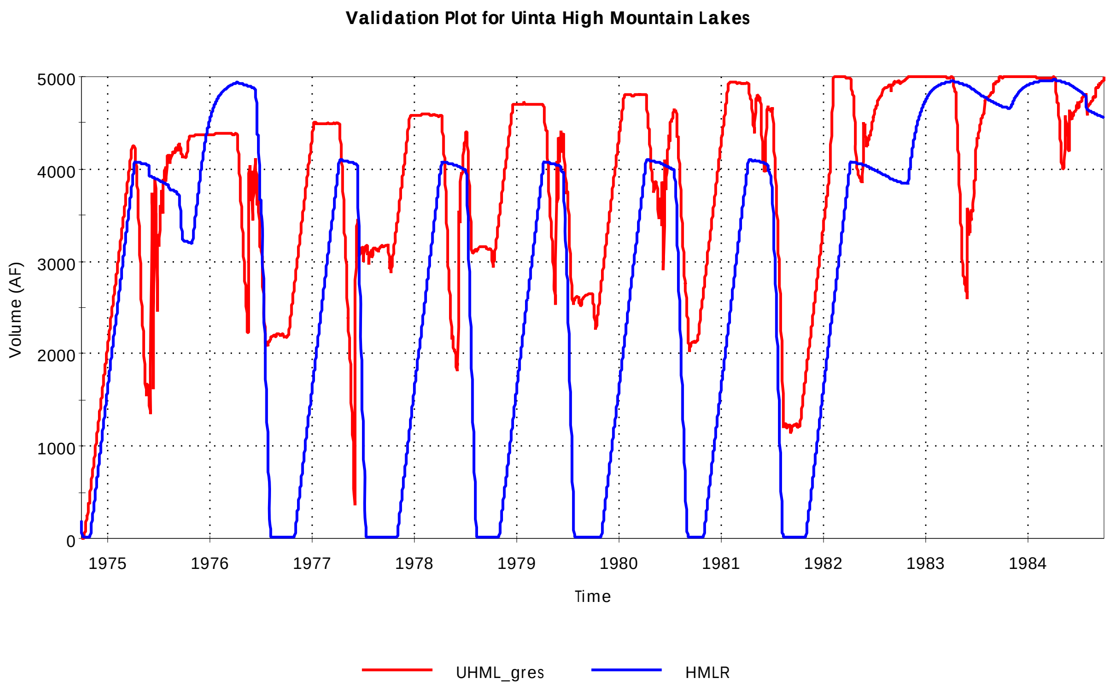


FIGURE 18
Validation Plot for Ouray Park High Mountain Lakes

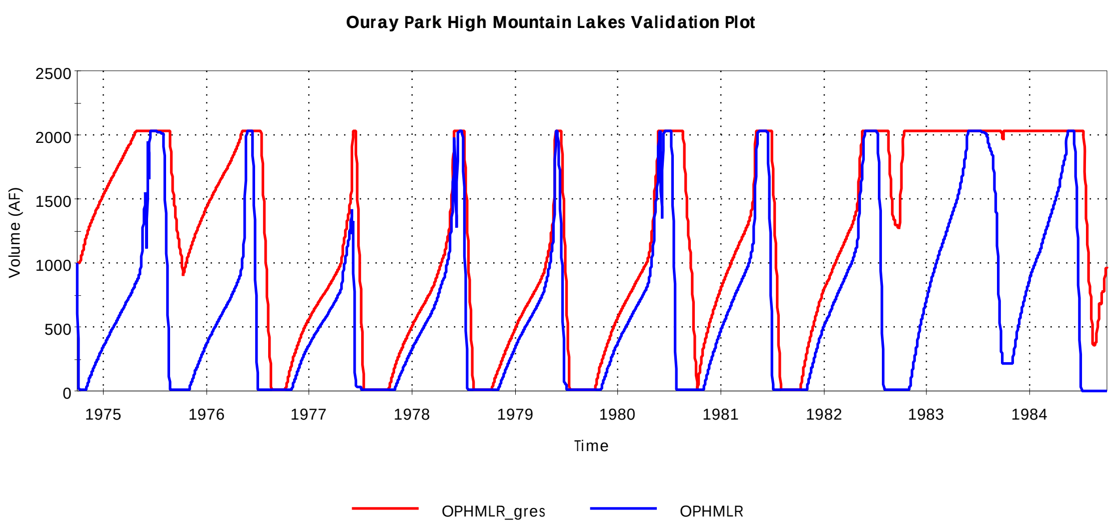


FIGURE 19
Validation Plot for Whiterocks High Mountain Lakes

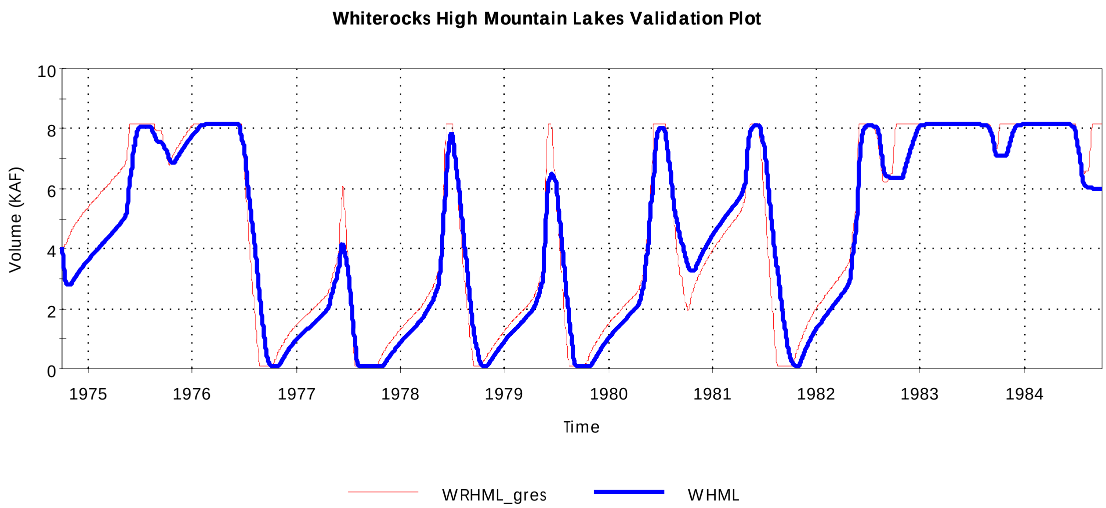


FIGURE 20
Validation Plot for Brown's Draw Reservoir

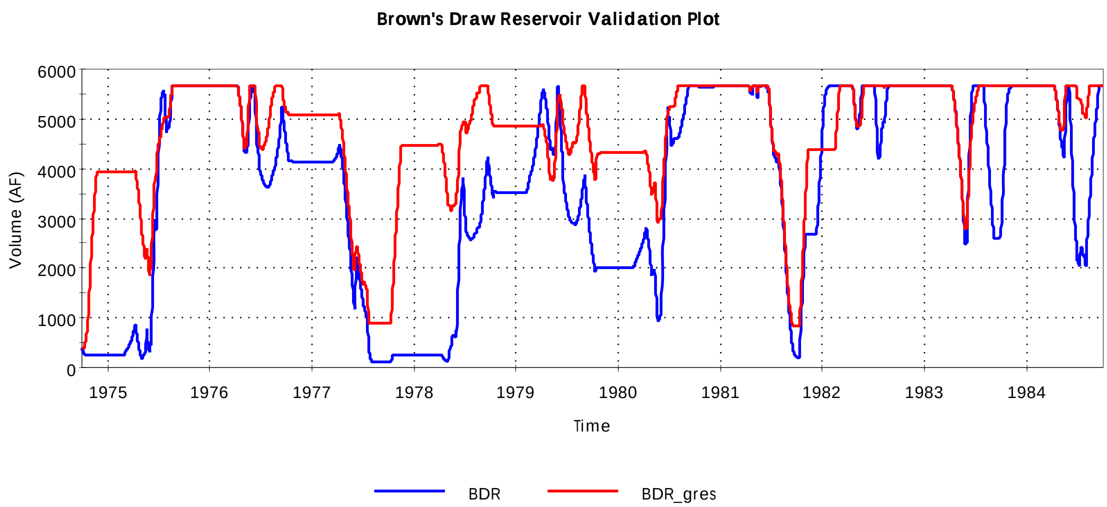


FIGURE 21
Validation Plot for Montes Creek Reservoir

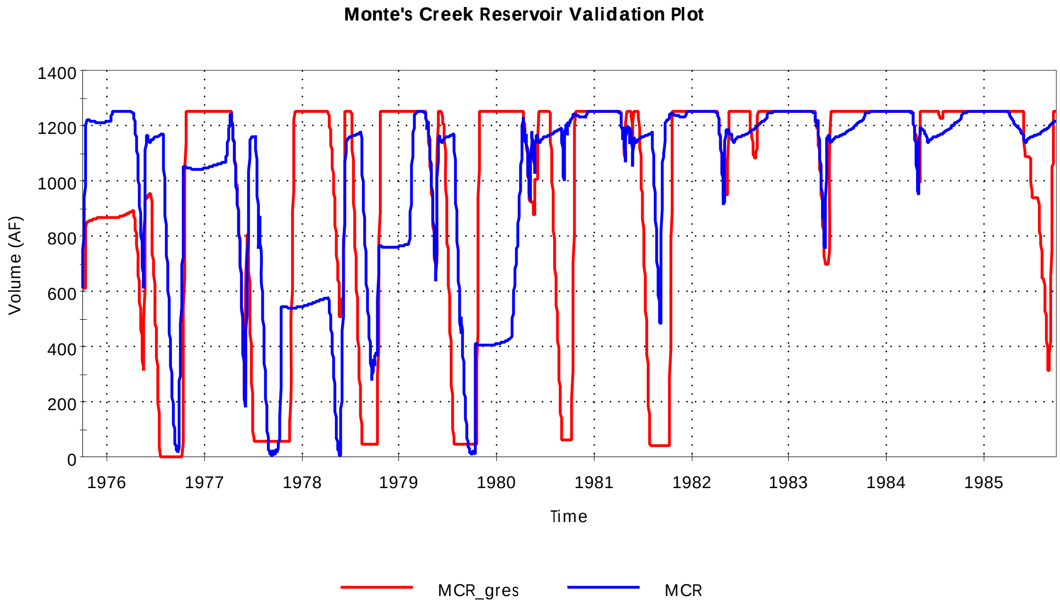


FIGURE 22
Validation Plot for LaPoint Reservoir

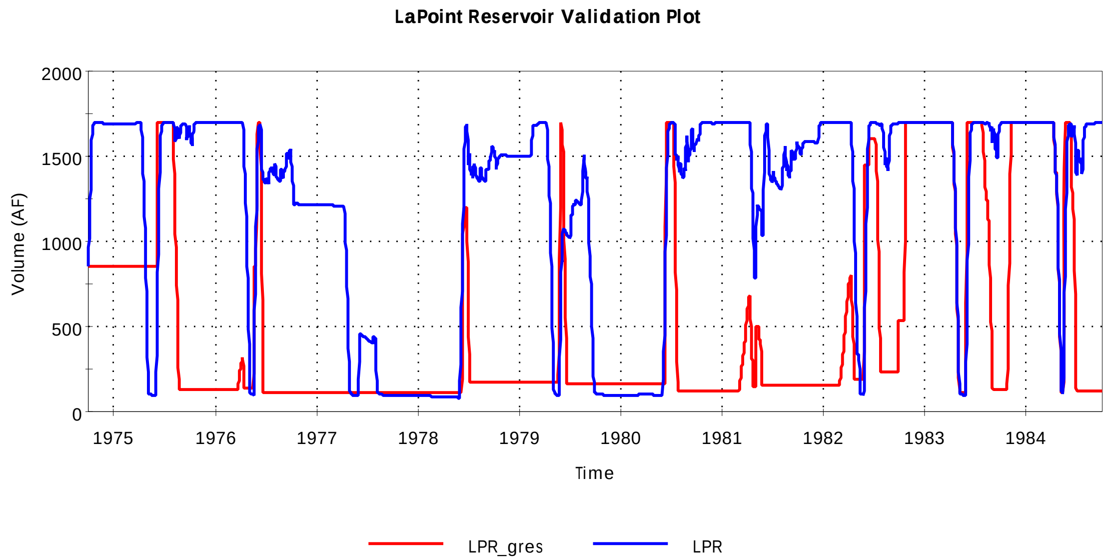


FIGURE 23
Validation Plot for Cottonwood Reservoir

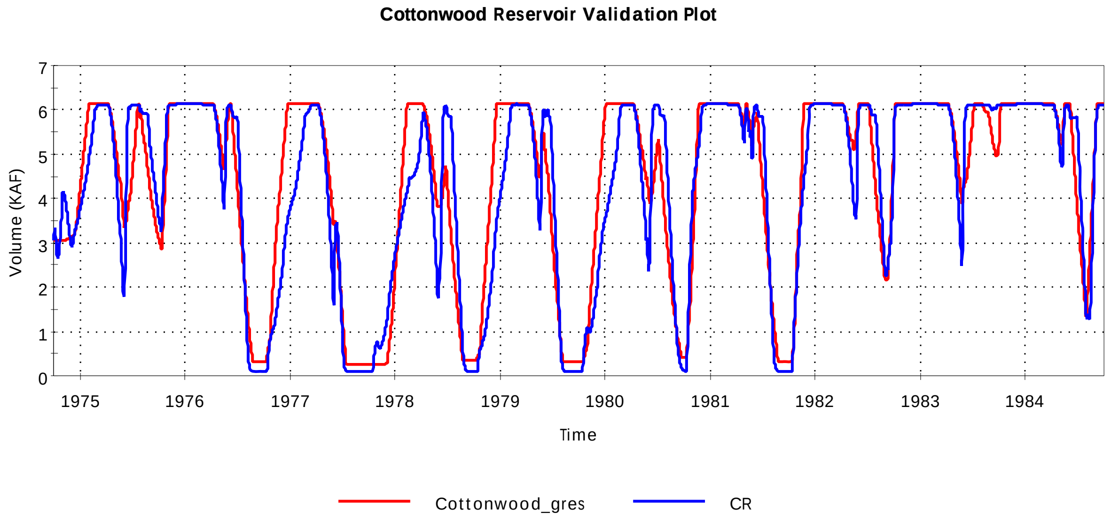


FIGURE 24
Validation Plot for Brough Reservoir

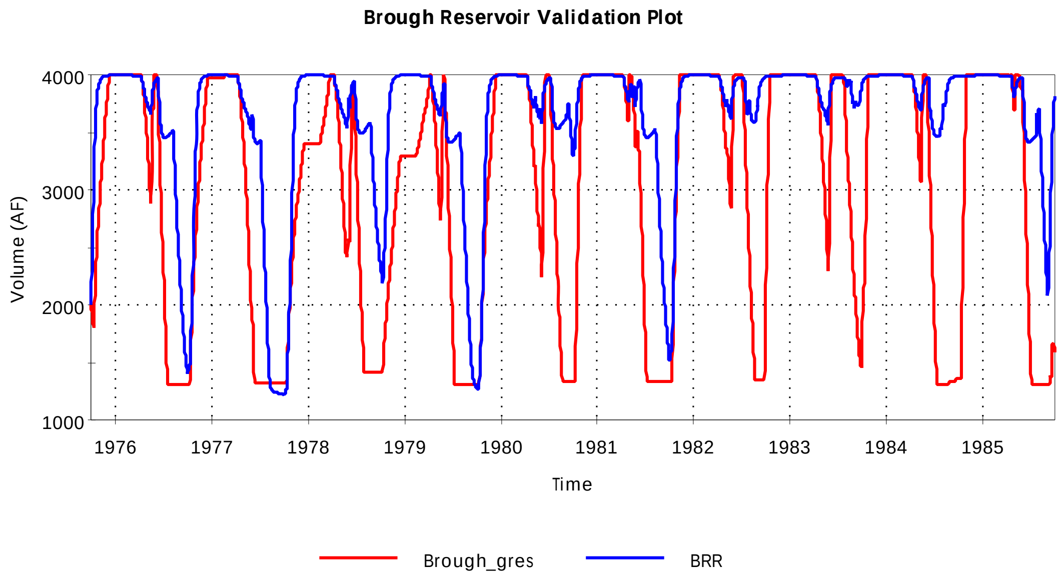


FIGURE 25
Validation Plot for Pelican Lake

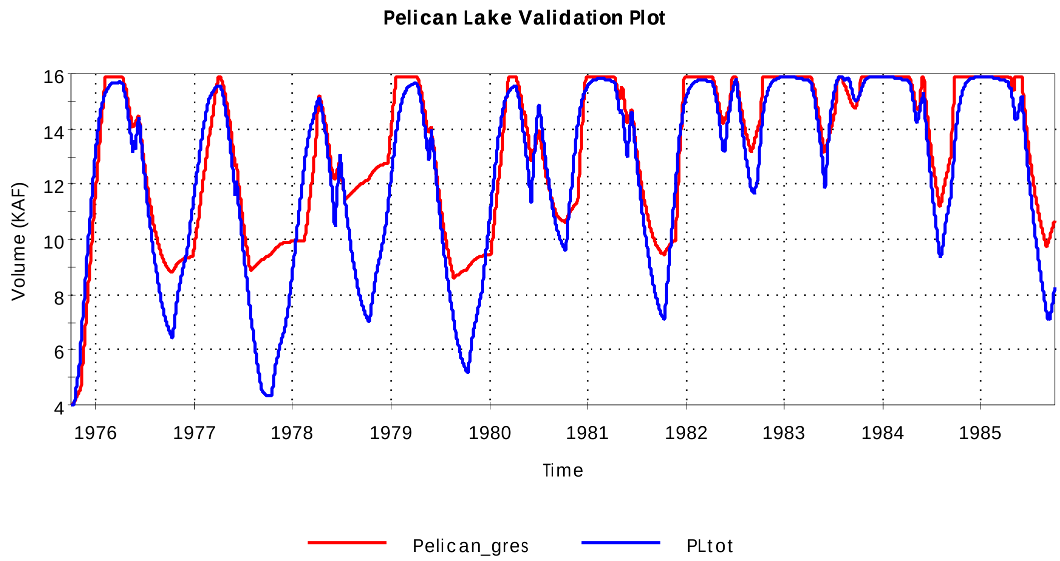
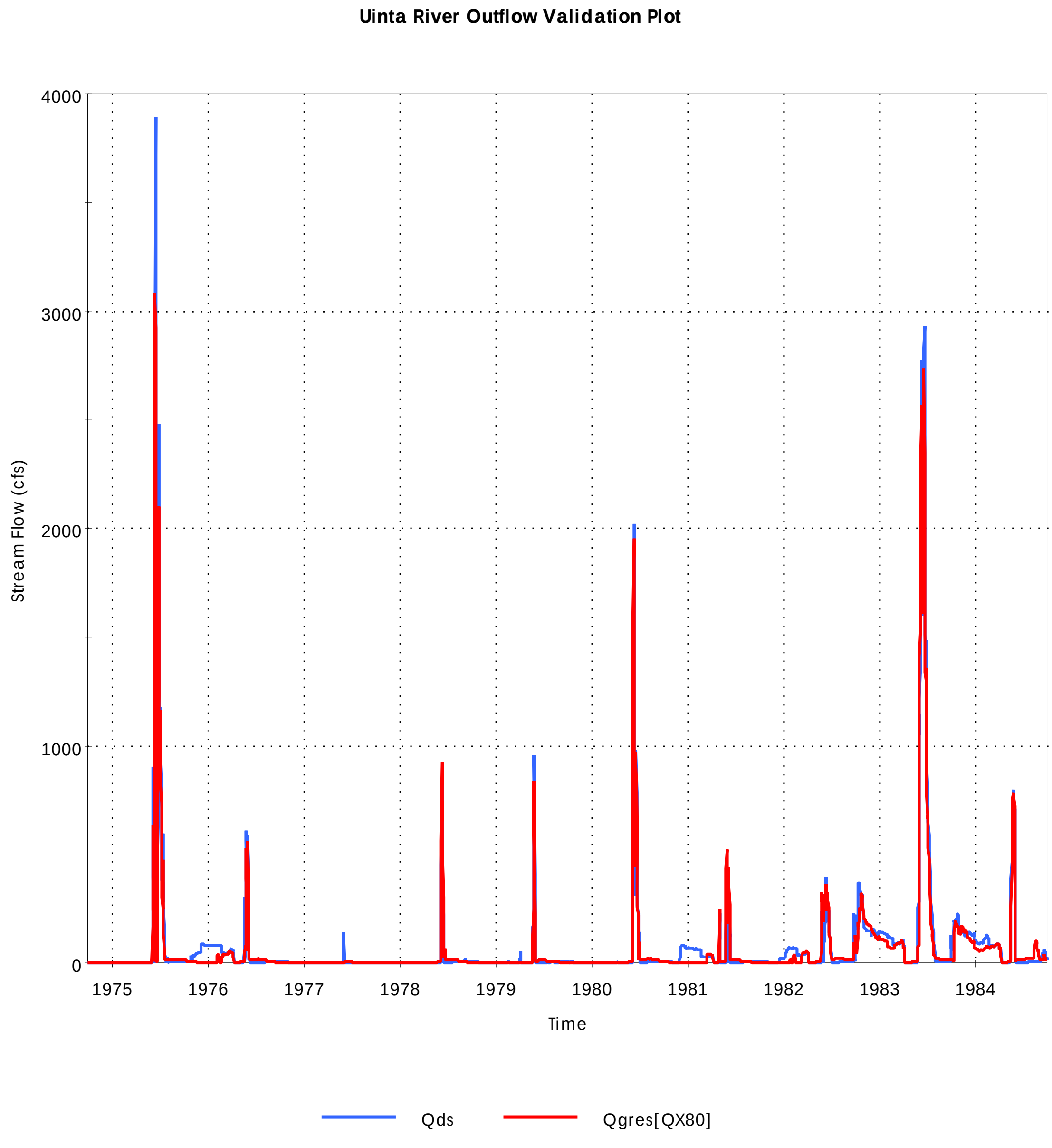
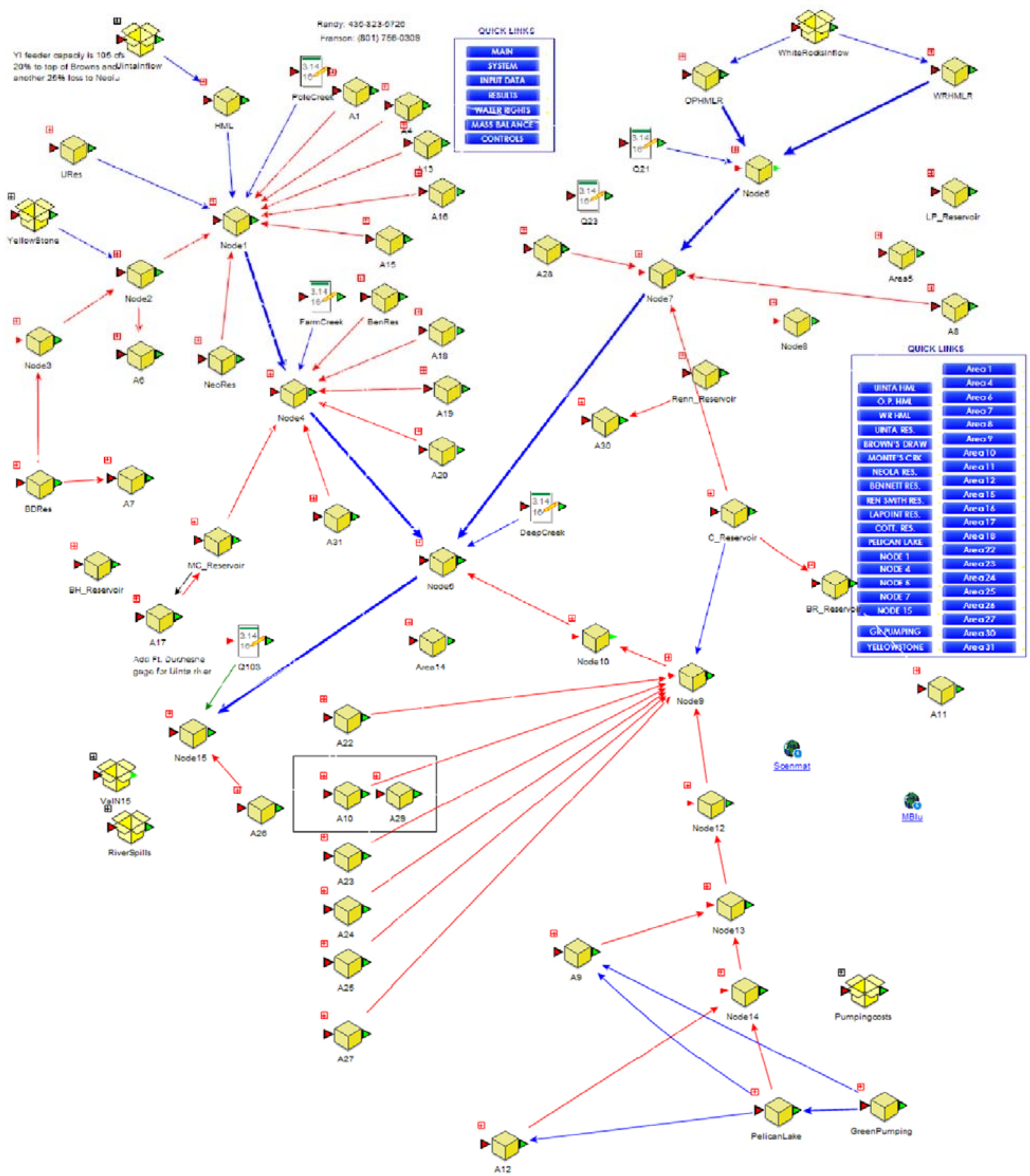


FIGURE 26
Validation Plot for Uinta River Outflow



ATTACHMENT 2

Model Screen Capture



Randy: 435-823-0720
Franson: (801) 756-0309
YI feeder capacity is 105 cfs
20% to top of Browns and
another 25% loss to Neola
QUICK LINKS
MAIN
SYSTEM
INPUT DATA
RESULTS
WATER RIGHTS
MASS BALANCE
CONTROLS
Add Ft. Duchesne gage for Uinta river

THIS PAGE INTENTIONALLY LEFT BLANK