Appendix F7
Option Characterization – Local Supply

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1.0 Introduction

Local supply options have been proposed to increase the overall water supply of the Colorado River Basin (Basin). A number of local supply options were submitted for consideration in the Colorado River Basin Water Supply and Demand Study (Study). The submittals are summarized in appendix F2 and the original submittals are available via links from the electronic version of appendix F2 on the compact disc that accompanies this report and the version of appendix F2 on the Study website at http://www.usbr.gov/lc/region/programs/crbstudy.html.

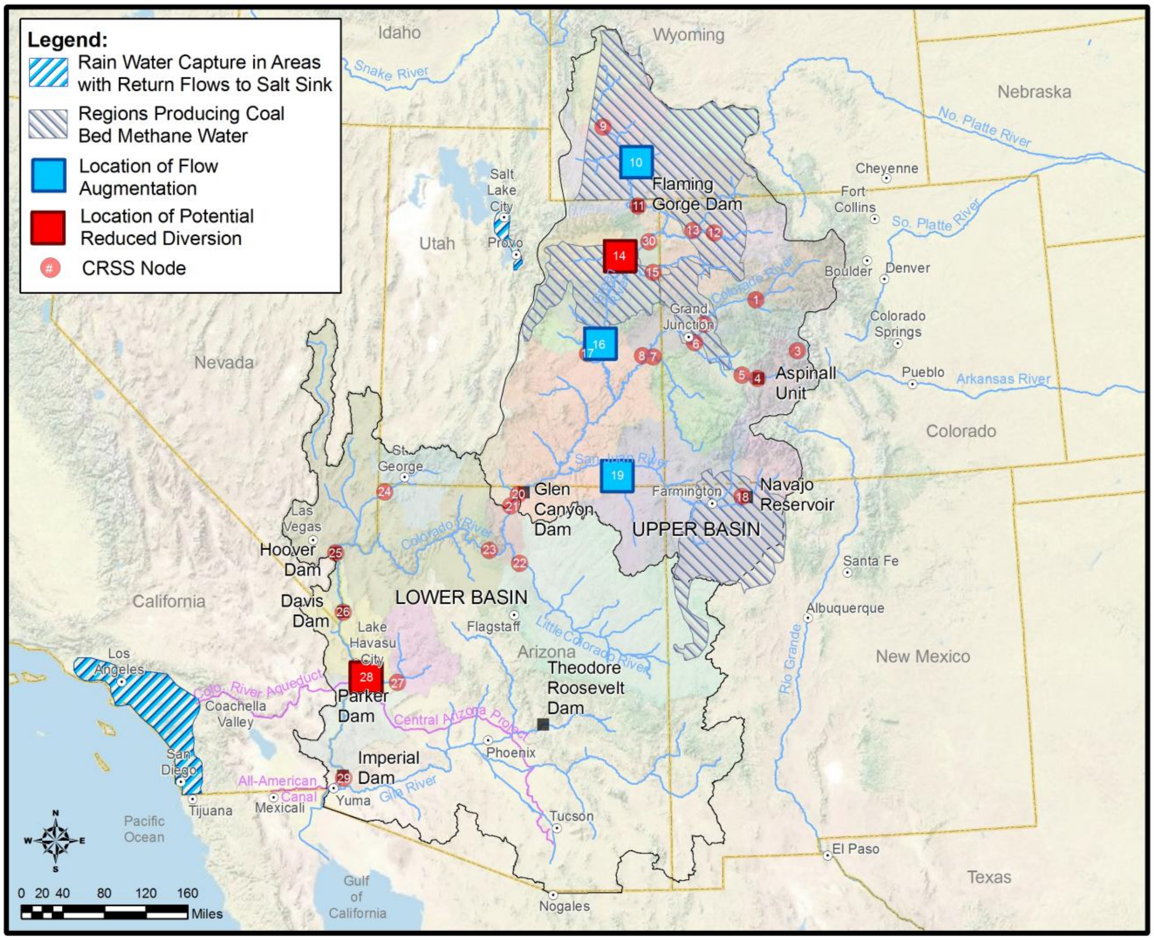
Four options related to local supply were received. These options consisted essentially of two concepts:

- Coal Bed Methane -Produced Water
- Rainwater Harvesting

Because of the scope and level of detail provided in the proposed options, the options groups were also used as representative options for the characterization process. Figure F7-1 shows the general locations of the local supply options. In the figure, the hatched areas indicate the general location of the option implementation and the squares indicate where the supply would augment the river or where the demand would be reduced.

This appendix summarizes the types of options received, the assumptions made and methods used to characterize the options, and the characterization results. Additional detail related to the options characterization is included in appendix F3. Attachment A of appendix F3 contains more detailed descriptions of the ratings. Attachment B provides the methods used for completing the unit cost calculations. Attachment C presents the detailed characterization information and is available on the compact disc that accompanies this report and on the Study website.

FIGURE F7-1
Generalized Locations of Local Supply Options



2.0 Coal Bed Methane-produced Water

Coal Bed Methane (CBM) is natural gas associated with coal deposits. The gas is held in place by the hydrostatic pressure of the water that fills factures (cleats) within a coal deposit. To produce gas from CBM wells, it is first necessary to reduce the hydrostatic pressure within the coal seam by pumping some of the water from the gas-bearing coal seams. As water is pumped out of the formation and the hydrostatic pressure drops, the gas desorbs from the coal into the cleats and migrates into the well. Generally, as the depth of the coal deposit increases, less water is present, and the salinity/total dissolved solids of the water is higher than for shallower deposits.

The CBM industry has generally viewed and treated the produced water associated with gas recovery as a waste product that must be disposed of at the least possible cost, rather than as an asset that potentially could be used beneficially. In most cases, CBM-produced waters are currently disposed of by injection into Class II underground injection wells. This representative option considers treating the relatively high-salinity water and using it to augment supply in the Basin.

Yield estimates for CBM-produced water are based on recent CBM development data and production estimates combined with unit water production data specific to the Rocky Mountain region coal basins. Potential CBM-produced water sources within the Basin are listed in table F7-1.

TABLE F7-1
Location of CBM Sources

<table>
<tr><th rowspan="2">Basin/Location</th><th rowspan="2">CBM Produced Trillion Cubic Feet (TCF)</th><th colspan="2">CBM Reserves (TCF)</th></tr>
<tr><th>Proved</th><th>Total Estimate</th></tr>
<tr><td>San Juan (CO, NM)</td><td>9.464</td><td>8.547</td><td>10.2</td></tr>
<tr><td>Piceance (CO)</td><td>0.039</td><td rowspan="2">1.801</td><td rowspan="2">5.5</td></tr>
<tr><td>Uinta (UT, CO)</td><td>0.413</td></tr>
<tr><td>Greater Green River (WY, CO)</td><td>0.002</td><td>0.162</td><td>2.5</td></tr>
</table>

Source: *Study of Long-Term Augmentation Options for the Water Supply of the Colorado River System.* Colorado River Water Consultants. 2008.

In contrast to conventional gas/oil wells, where water is produced in highest quantities during the later portion of the well's life as production rates decline, CBM well water production is normally greatest immediately after the well is brought online. When first placed online, a CBM well typically produces significant amounts of water (10 to 20 gallons per minute), with little or no gas production. Within several months of initial operation, gas production is initiated, and water production begins to decrease as the coal seams become dewatered. After 1 to 2 years of operation, water production rates per well can fall to as little as a few barrels of water per day as overlapping cones of depression for individual wells form in the producing area.

For all wells (both new and extended production time wells), normalized average well lifetime production rates over approximately 10 years are reported to be between 2.5 and 4 gallons per minute (4 to 6.5 acre-feet per year [afy]). An important factor in evaluating potential CBM-produced water availability is the historical unit water production per well, which also varies considerably across the major coal basins. Table F7-2 summarizes available data for produced water on a unit basis (water obtained per 1,000 cubic feet of CBM production).

TABLE F7-2
Unit Production of CBM-Produced Water

	Typical Production per CBM Well			
			Unit Water Production Per MCF of CBM	
Location	Water (Barrels/day)	Gas Thousand Cubic Feet (MCF per day)	Barrels	Gallons
Powder River Basin (MT, WY)	400	145	2.75	116
Raton Basin (NM, CO)	266	200	1.34	56
Uinta Basin (UT)	215	625	0.34	14
San Juan Basin (NM, CO)	25	833	0.03	1.3

Source: *Study of Long-Term Augmentation Options for the Water Supply of the Colorado River System.* Colorado River Water Consultants. 2008.

Using the CBM reserves data and a conservative unit water production of 5 to 10 gallons per MCF of CBM gas, total potential produced water volumes for the four major coal basins located within the Basin are projected to be between 161,000 and 322,000 acre-feet (af) based on proved reserves and between 279,000 and 558,000 afy based on total estimated reserves. For the purpose of this study, it was estimated that 4,000 and 14,000 afy of potential new supply could be developed considering the geographic distribution of the well sites.

Regarding time required for implementation, existing CBM wells are already producing water. However, the infrastructure needed to treat and convey the water from the well sites to the supply area is required. Additionally, to realize full-scale benefits, more CBM wells would have to be developed. For the Study, the time required to establish this method of treatment as a new supply source was assumed to be 5 years. The needed infrastructure to treat and convey the water was assumed to need another 5 years for construction, and the development of additional wells could take up to 20 years. Therefore, it would take 5 to 10 years to produce any water, and up to 20 years for large-scale benefits to be realized.

Because of typically poor water quality in CBM wells, required treatment facilities are the principal factor in capital costs. To treat 500 gallons per minute of CBM-produced water with a total dissolved solids concentration of 15,000 milligrams per liter, approximately $4 million in treatment facilities are required. Intensive pre-treatment and reverse osmosis result in estimated annual operating costs of $600 to $635 per af of produced water. Depending on well location, additional costs to convey the water could raise the total cost to as high as $5,000 per af. For the Study, an average unit annual cost of $2,000 per af was assumed.

Several other key characterizations were considered for the CBM-produced water option. National Pollutant Discharge Elimination System permits would be required to discharge the treated water into the watershed, and modifications to existing permits would be needed for brine disposal. Permits required for new wells present the most unpredictable permitting issue. Risks involved with implementation include the water source’s dependence on the highly volatile energy sector and the large spacing between wells, which increases operating costs and reduces flexibility. Finally, the process is energy-intensive. Water desalination would require approximately 1,600 kilowatts hours per af, and transporting the water from individual wells to collection sites would most likely be accomplished using trucks.

3.0 Rainwater Harvesting

Rainwater harvesting is the capture, diversion, and storage of rainwater for landscape irrigation and other uses (City of Albuquerque, 1999). This representative option considers how individual household rainwater harvesting can increase local supply in some areas of the Basin, with particular emphasis on those areas that do not return flows to other users downstream. The analysis was limited to major urban areas of southern California, Arizona, and New Mexico that do not return water to the Basin.

Yield estimates for individual rainwater harvesting are based on normal precipitation in specific regions combined with average roof size, landscaped area, and number of households. A simple rainwater harvesting tool was developed that considered monthly precipitation, landscape area, landscape irrigation demand, roof size, and number of households to estimate the potential yield of rainwater harvesting systems. Average roof size was estimated to be 2,000 square feet, and tank size was calculated to optimize yield under varying conditions. Using a 500-gallon collection tank at the household level and assuming supply is only used for outside landscape irrigation purposes, the potential yield was calculated for representative households. The resulting representative household yield was then multiplied by the average number of households in the regions that do not have return flows to the hydrologic basin. A 50 percent adoption rate was also assumed. The resulting basin wide yield estimate is approximately 75,000 afy.

Rainwater harvesting is already being used in some areas of the Basin. The concept is currently feasible; in many cases it does not require permitting and is simple to implement, with very little infrastructure. Therefore, in locations where there is not a water rights issue, the 50 percent adoption rate used to estimate yield could be achieved within 5 years. Rivers providing native water to the adjacent areas of Colorado are over-appropriated; therefore, any rainwater harvesting projects would need to be augmented. Because local supplies are not available, augmentation would increase the use of Colorado River water. Similarly, Utah in particular, broad-scale rainwater harvesting would likely elicit water rights concerns to downstream water users and state law is currently restrictive. In Colorado and Arizona, rainwater harvesting is not legal due to the prior appropriation system upon which Colorado and Arizona's water systems are based. Therefore, rainwater harvesting was not considered as a local supply option in Colorado, Arizona, or Utah.

The cost for purchase and installation of a 500 gallon storage tank and irrigation modifications was assumed to be $1,000 per household. Because of the limited storage capacity and the mismatched timing of rain events and demand, harvested rainwater only delivers approximately 10 percent of outdoor demand, or approximately 0.02 per afy per household. As a result, the calculated unit annual cost of water was estimated as $3,150 per af.

Aside from the high capital cost for individual households, the rainwater harvesting options are easy to implement, are already practiced in many states, have no energy needs, and, depending on state and local laws, do not require any permitting.

4.0 Characterization Results

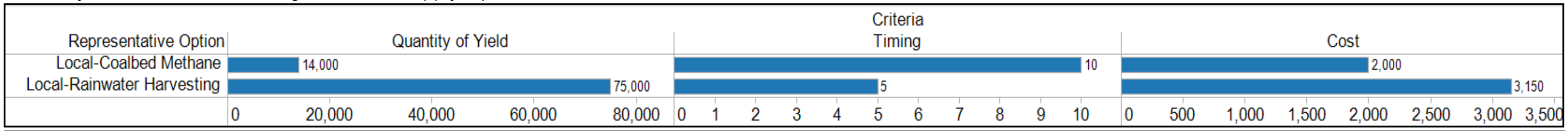
A summary of the characterization findings are shown in table F7-3. The top portion of the table shows the estimated quantity of yield, earliest timing of implementation, and estimated cost. The bottom portion of the table shows the 17 criteria and associated ratings ("A" through "E") and is color-scaled. In general, "C" is typically designated as mostly neutral (yellow); "A" is largely positive (green); and "E" is largely negative (red). Refer to appendix F3 for specific criteria descriptions and rating scales.

5.0 References

City of Albuquerque. 1999. *Rainwater Harvesting Supply from the Sky.*

Colorado River Water Consultants. 2008. *Study of Long-Term Augmentation Options for the Water Supply of the Colorado.*

TABLE F7-3
Summary Characterization Ratings for Local Supply Options



	Criteria																
Representative Option	Quantity of Yield	Timing	Cost	Technical Feasibility	Implementation Risk	Long-Term Viability	Operational Flexibility	Permitting	Energy Needs	Energy Source	Other Environmental	Recreation	Socioeconomics	Policy	Legal	Hydropower	Water Quality
Local-Coalbed Methane	D	B	C	B	B	C	C	B	D	D	C	C	C	B	B	C	C
Local-Rainwater Harvesting	E	A	E	A	A	B	A	A	A	A	B	C	C	B	B	C	C