TECHNICAL EVALUATION OF OPTIONS FOR LONG-TERM AUGMENTATION OF THE COLORADO RIVER SYSTEM

STORMWATER STORAGE AT PAINTED ROCK RESERVOIR TECHNICAL MEMORANDUM

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Purpose

The Seven Colorado River Basin States (Seven States) have authorized Colorado River Water Consultants (CRWC) to provide a Technical Evaluation of Options for Long-Term Augmentation of the Colorado River System (Project). This Technical Memorandum (TM), one of a series of TMs being prepared as part of the Project, presents the Evaluation of Stormwater Storage.

Scope

The TMs are the second step in an iterative process to develop, screen, and evaluate long-term water supply augmentation options. The TMs build upon and expand White Papers developed during the initial weeks of the evaluation process. The purpose of this TM is to evaluate the potential for capturing excess Gila River flows by storage in Painted Rock Reservoir or by diversion of these flows into the Colorado River upstream of Imperial Dam.

Summary of Findings

The findings of this TM are summarized in Table ES-1.

Table ES-1 Summary of Findings Related to Stormwater Storage for Gila River Flows	
Parameter	**Findings**
Location of Supply	Southwest Arizona from Painted Rock Dam on the Gila River to Imperial Dam on the Colorado River.
Quantity of Water Potentially Available	Average available water = 346,000 acre-feet per year (AFY). Maximum available water = 4,787,000 AFY. Painted Rock Storage Capacity = 2,472,824 acre-feet (AF) Dependable Reservoir Yield = 0 AFY.
Water Quality	Major water quality concerns are sediment, pesticides, metals, inorganics, and nutrients.
Technical Issues	Concrete-lined canal, pump station, and pipeline would be required to convey water from Painted Rock Dam to Colorado River.
General Reliability of Supply	Available water exceeds 10,000 AFY 43.5 percent of time. Available water exceeds 100,000 AFY 32.6 percent of time. Available water exceeds 1,000,000 AFY 8.7 percent of time.
Environmental Issues	Environmental issues include the effect of reduced river discharge on the Gila River ecology and the disruption to habitat from the canal construction.
Permitting Issues	Permitting will need to be coordinated with several Federal, State and local agencies. Some include : • U.S. Army Corps of Engineers (USACE). • U.S. Bureau of Reclamation (Bureau) • USFWS • Arizona Game and Fish Department • Arizona Department of Environmental Quality
Cost	Cost estimates are based on a 1978 Bureau study to construct canal and associated facilities from Painted Rock Dam to Colorado River: Total construction cost indexed to 2006 dollars = $266,472,850 Present Worth of Project = $348,399,715

1.0 INTRODUCTION

1.1 Overview

This section describes Project objectives, briefly discusses the program framework within which the evaluation of long-term augmentation options is proceeding, and presents overall Project methodology. Also provided are a brief description of how this TM is organized, a list of abbreviations and acronyms used, and information about the references cited herein.

1.2 Project Rationale (Objectives)

Seperate studies and investigations have projected an increase in demands for Colorado River system water and a reduction in long-term runoff of the Colorado River. As part of their proactive response to this scenario, the Seven States have authorized CRWC to provide a technical evaluation of long-term augmentation options. The States will supplement the technical evaluations with legal, administrative, and/or institutional considerations. All phases of the evaluation are being conducted in close coordination with the States and with the two regional offices of the Bureau.

1.3 Other Ongoing Water Management Efforts

The evaluation of long-term options focuses on both previously-identified concepts and applications of new technology or management options. The evaluation was begun in parallel with the Bureau's development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead under Low Reservoir Conditions. It also should be noted that each of the Seven States has comprehensive water management programs. Concepts being developed under these independent programs will not be evaluated through the Seven States process.

1.4 Methodology

Evaluation of options is an ongoing and iterative process. In the first phase of the evaluation, White Papers were developed for 12 potential long-term augmentation options developed by CRWC in concert with the Seven States. In parallel with White Paper preparation, the CRWC team met with representatives of each State, the Bureau's two regional offices, and other interested parties. A password-protected Project Website was developed, an Expert Panel was convened, and a workshop was held with the Project's Technical Committee. The workshop focus was on the 12 White Paper options and three additional options suggested by the Expert Panel. Grouped by the purpose they achieve and the benefit provided, the initial options were:

- Firm up supply/reduce shortages. Conjunctive use, reservoir evaporation control, vegetation management, weather modification, stormwater storage, and additional storage.

- New supplies. Basin imports/reduction of exports through exchanges, brackish water desalination, coal bed methane produced water, seawater desalination, and water imports using ocean routes.

- Increase water use efficiency/exchange. Reduction of power plant consumptive use, agricultural and urban water reuse, agricultural and urban transfers, and accelerated urban water conservation.

During the workshop with the Technical Committee and a subsequent meeting with the Project Principals, six options were selected for more detailed evaluation at the TM level: brackish water desalination, conjunctive use, ocean water desalination, river imports and exports, stormwater storage, and vegetation management. This TM describes potential for additional water supply from Stormwater Storage on the Gila River.

1.5 Technical Memorandum Organization

The Stormwater Storage Technical Memorandum consists of the sections listed below.

Executive Summary
- Purpose
- Scope
- Findings
- Conclusions

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- 1.3 Other Ongoing Water Management Efforts
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- 1.7 References

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- 2.2 Quantity of Water Potentially Available
- 2.3 Water Quality
- 2.4 Technical Issues
- 2.5 General Reliability of Supply
- 2.6 Environmental Factors
- 2.7 Permitting Issues
- 2.8 Cost

1.6 Abbreviations and Acronyms

The following abbreviations and acronyms are used in this TM.

AF	acre-feet
AFY	acre-feet per year
Bureau	U.S. Bureau of Reclamation
Cfs	cubic feet per second
CRWC	Colorado River Water Consultants
IID	Imperial Irrigation District
Project	Technical Evaluation of Options for Long-term Augmentation of the Colorado River System
Seven States	Severn Colorado River Basin States
TM	Technical memorandum
U.S.	United States
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1.7 References

IID. 2006. Imperial Irrigation District Website for Imperial Dam, http://www.iid.com/Water_Index.php?pid=172

USACE. 2006. Los Angeles District Website for Painted Rock Dam, http://www.spl.usace.army.mil/resreg/images/gila.jpg

USBR. 1978. Reject Stream Replacement Study – Status Report. United States Department of the Interior. Bureau of Reclamation. January.

USFWS. 2006. Website for U.S. Fish and Wildlife Endangered Species. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm

USGS. 2006. United States Geological Survey web site for Gila River below Painted Rock Dam (Gauge 09519800), http://waterdata.usgs.gov/az/nwis/annual/?referred_module=sw

USACE. 1962. Reservoir Regulation Manual for Painted Rock Reservoir. http://www.spl.usace.army.mil/resreg/htdocs/Painted_Rock/ptrk_entire_ext_wcm.pdf

Western Regional Climate Center. 2006. Website for Average Pan Evaporation Data for Yuma Citrus Station, Arizona. http://www.wrcc.dri.edu/CLIMATEDATA.html

2.0 TECHNCIAL DISCUSSION

2.1 Overview

This section provides the technical discussion for the stormwater storage options related to Painted Rock Dam and a diversion canal to Imperial Dam. The quantity of water potentially available is evaluated, as well as issues related to the development of a water supply project, such as general reliability and environmental and permitting requirements.

2.2 Summary of Findings

The findings of this TM are summarized in Table 2-1.

2.3 Location of Supply

Painted Rock Dam and Reservoir is located approximately 20 miles northwest of Gila Bend, Arizona on the Gila River (USACE, 2006). Imperial Dam is located about 20 miles northeast of Yuma, Arizona on the Colorado River (IID, 2006). Figure 2-1 illustrates the general location of the two reservoirs.

Painted Rock Dam is operated as a flood control facility. The dam site is in a gap between the Painted Rock Mountains and the Gila Bend Mountains where the river is confined to a relatively narrow channel. It is the last dam on the Gila River before its confluence with the Colorado River.

Painted Rock Dam has a drainage area of 50,800 square miles, and more than half of the storm runoff coming into the reservoir is unregulated inflow. The regulated inflow is contributed from upstream structures, specifically the Salt River Project System. This system is comprised of seven reservoirs on the Salt and Verde Rivers; Coolidge Dam on the upper Gila River operated by the San Carlos Indian Project; and New Waddell Dam on the Agua Fria River operated by the Central Arizona Project. Painted Rock Dam affords flood control and protection for downstream communities by providing temporary flood storage space in the reservoir for storm runoff and releasing flood flows at a rate no greater than the downstream channel capacity, which is estimated to be 10,000 cubic feet per second (cfs). The project was formulated and operated for flood control purposes. Use of the dam and reservoir would require a reallocation of storage and a revision of the operating plan to allow storage and withdrawal of high inflows when available.

2.4 Quantity of Water Potentially Available

In order to determine the quantity of water potentially available from the Gila River, the USGS gauging station located below Painted Rock Dam was used to obtain average annual flows for the period of record from 1960 -2005. It was assumed that this gauge would accurately represent potential “new” water since it was located downstream of Painted Rock Reservoir and would measure flows that would not otherwise be captured

before entering Mexico. Table 2-2 illustrates the potentially available water from the Gila River based on the USGS flow records (USGS, 2006).

Table 2-1
Summary of Findings Related to Stormwater Storage for Gila River Flows

Parameter	Findings
Location of Supply	Southwest Arizona from Painted Rock Dam on the Gila River to Imperial Dam on the Colorado River.
Quantity of Water Potentially Available	Average available water = 346,000 AFY. Maximum available water = 4,787,000 AFY. Painted Rock Storage Capacity = 2,472,824 AF. Dependable Reservoir Yield = 0 AFY.
Water Quality	Major water quality concerns are sediment, pesticides, metals, inorganics, and nutrients.
Technical Issues	Concrete-lined canal, pump station and pipeline would be required to convey water from Painted Rock Dam to Colorado River.
General Reliability of Supply	Available water exceeds 10,000 AFY 43.5 percent of time. Available water exceeds 100,000 AFY 32.6 percent of time. Available water exceeds 1,000,000 AFY 8.7 percent of time.
Environmental Issues	Environmental issues include the effect of reduced river discharge on the Gila River ecology and the disruption to habitat from the canal construction.
Permitting Issues	Permitting will need to be coordinated with several Federal, State and local agencies. Some include : • USACE • Bureau • USFWS • Arizona Game and Fish Department • Arizona Department of Environmental Quality
Cost	Cost estimates are based on a 1978 Bureau study to construct canal and associated facilities from Painted Rock Dam to the Colorado River: Total construction cost indexed to 2006 dollars = $266,472,850

Figure 2-1 General Location Map

Based on the flow data for the period of record from 1960 to 2005, approximately 346,000 AF of water per year is potentially available from the Gila River on average. The maximum annual flow was 4,787,000 AF in 1993. However, it should be noted that over half of the years have total flow less than 10,000 AF.

The flood control storage capacity of Painted Rock Dam is listed as 2,472,824 AF (USACE, 2006). This storage would capture completely the flow from all but one year, or approximately 97.8 percent, of the annual volumes over the period of record. The one exception is 1993, when approximately 2,300,000 AF would spilled and continued downstream to Mexico. These conclusions are based on the assumptions that no water is released for downstream uses on the Gila River and the captured water is not diverted out of the reservoir. Should water be transferred from the reservoir, it is possible that more available flow from 1993 could be utilized.

Table 2-2
Potentially Available Water from Gila River

Mean Annual Flows		
Year	**Flow Rate (cfs)**	**Volume (AF)**
1960	5.270	3,825.76
1961	0.337	243.98
1962	0.000	0.00
1963	0.105	76.02
1964	1.180	856.62
1965	1.220	883.24
1966	356.200	257,877.02
1967	2.240	1,621.69
1968	20.000	14,519.01
1969	5.200	3,764.63
1970	4.120	2,982.74
1971	4.430	3,207.17
1972	0.000	0.00
1973	570.000	412,661.16
1974	197.100	142,660.00
1975	4.040	2,924.83
1976	6.370	4,624.30
1977	0.905	655.19
1978	152.300	110,260.17
1979	2,205.000	1,596,347.11
1980	3,285.000	2,384,747.11
1981	472.700	342,219.17
1982	12.900	9,339.17
1983	1,273.000	921,609.92

Table 2-2 Potentially Available Water from Gila River		
Mean Annual Flows		
Year	**Flow Rate (cfs)**	**Volume (AF)**
1984	1,049.000	761,521.98
1985	1,279.000	925,953.72
1986	60.900	44,089.59
1987	14.300	10,352.73
1988	4.710	3,419.23
1989	3.370	2,439.77
1990	0.321	232.39
1991	24.200	17,520.00
1992	590.000	428,310.74
1993	6,612.000	4,786,869.42
1994	452.900	327,884.63
1995	906.700	656,420.83
1996	14.600	10,598.88
1997	8.130	5,885.85
1998	10.900	7,891.24
1999	1.980	1,433.45
2000	0.566	410.89
2001	0.073	52.85
2002	0.000	0.00
2003	0.000	0.00
2004	0.000	0.00
2005	866.000	626,955.37
Average	346,133.34	AF/year
Maximum	4,786,869.42	AF/year
Minimum	0.00	AF/year

2.5 Water Quality

Typical of flood flows in the southwest part of the United States (U.S.), the water flowing into Painted Rock Reservoir will contain a great deal of sediment. Along with the sediment, any pollutants attached to the sediment or pollutants in the soil that were eroded will be transported to the reservoir. Water quality information for the Gila River indicates that it is characterized by low dissolved oxygen and contamination with pesticides, metals, inorganics, and nutrients. Painted Rock Reservoir acts as a contaminant sink and has high levels of pesticides, boron, and organochlorines. Fish and wildlife in the vicinity of the reservoir are exposed to a bioaccumulation of toxic substances in contaminated sediments. Pesticide contamination in the Gila River is some of the most significant in the western U.S. As a result of high nutrient inflows and an abundance of sunlight that increases water temperatures; algal growths have depleted oxygen levels at Painted Rock Reservoir and frequently caused anaerobic conditions. This has led to the release of hydrogen sulfide gases causing objectionable odors as well as corrosive conditions impacting the reservoir control facilities.

Should this option be explored further, water quality will need to be examined in greater detail. The construction of a sediment forebay at the upstream end of Painted Rock Dam might be needed to capture the incoming sediment and pollutants.

2.6 Technical Issues

In 1978, the Bureau studied the proposal for Gila River flood flows to be conveyed to the Colorado River. This study noted that the infrequency of floods and the high evaporation loss rate for Painted Rock Dam would require that flows be released immediately after their occurrence. The recommendation was to develop a canal alternative to transport the water from Painted Rock Dam to Imperial Dam on the Colorado River. The concrete-lined canal would include a pump station and pipeline. The Bureau proposed a conveyance capacity of 500 cfs for the canal.

2.7 General Reliability of Supply

Based on the USGS flow data from the gauge below Painted Rock Dam (USGS, 2006), the water available from the Gila River exceeds 10,000 AF only 20 years of the 46-year period of record, or about 43.5 percent of the time over the period of record. The available water only exceeds 100,000 AF 15 years out of the 46-year period of record, or about 32.6 percent of the time. The available water only exceeds 1,000,000 AF 4 years out of the 46-year period of record, or about 8.7 percent of the time. If it can be assumed that the historic record provides trend information for the future, then these percentages can be associated with probabilities of occurrence.

A yield evaluation of the reservoir was performed using the assumption that the storage allocation could be revised to allow 1,000,000 AF of storage for water supply purposes. Using the 46-year flow record from 1960 through 2005, the critical period for

determining yield was found to be from 1996 through 2004, when the average annual inflow was only 2,900 AF. With lake evaporation averaging 78 inches per year and precipitation averaging 6 inches per year, essentially all of the initial storage of 1,000,000 AF and the minimal inflows could be exhausted satisfying the evaporation losses. Hence, the reliable yield of Painted Rock Reservoir based on the most critical period is zero. This means that the use of the reservoir for water supply would be for skimming flood flows during those years when runoff was sufficient. As approximately one-third of the years of record have inflows of more than 100,000 AF, further analysis should be performed to determine if excess flows, when available, could be used to offset deliveries to Mexico. Although further analysis is needed, it was assumed that an average of 40,000 AFY per year could be derived for these purposes.

2.8 Environmental Issues

The environmental issues related to the option of stormwater storage in Painted Rock Reservoir revolve primarily around disruption of habitat. The main potential disruption would be related to the construction for the canal to transport water from Painted Rock Dam. A second environmental concern involves the impact to the Gila River ecology downstream of Painted Rock Dam as less water is released downstream. The river ecology will dramatically change as the majority of the water is captured and diverted.

The USFWS (2006) lists 70 Endangered Species within the State of Arizona. These include 3 amphibians, 22 flowering plants, 3 reptiles, 10 birds, 19 fishes, and 8 mammals. Additional development of this alternative should include further study of the environmental impact on these species.

If this alternative moves forward, it will be necessary and important to accurately assess the impact to the Gila River ecology and to other habitats disrupted by the construction of the canal. Minimum flow releases from Painted Rock Dam may be required to preserve the Gila River ecology downstream of the reservoir.

2.9 Permitting Issues

Permitting issues of this Stormwater Storage alternative will involve a variety of federal, state and local agencies. At a minimum, coordination would be required with the following agencies:

- USACE
- USBR
- USFWS
- Arizona Game and Fish Department
- Arizona Department of Environmental Quality
- Arizona Department of Transportation
- Local environmental and planning agencies

The USACE, operating under Section 404 of the Clean Water Act, would permit the discharge of dredged or fill material in the navigable waters of the U.S. and may issue general permits on a state, regional, or nationwide basis. Under Section 10 of the Rivers and Harbors Act, USACE authorization is required for work or structures in or affecting "navigable waters". Per Section 106 of the National Historic Preservation Act, the Bureau would have jurisdiction over activity occurring in an area where there exists or may exist properties listed or eligible for listing on the National Register of Historic Places. The Bureau would also permit activities that would impact archaeological and Native American sites. The USFWS, through the Fish and Wildlife Coordination Act, would be involved in any project intended to control or modify surface water and would work as necessary in conjunction with the Arizona Game and Fish Department to protect threatened and endangered species and critical habitat. The Arizona Department of Environmental Quality would regulate activities related to pollution prevention during and after construction, while the Arizona Department of Transportation would issue permits related to activity impacting state highways, such as encroachment permits.

Further research of the above requirements and any additional requirements should be conducted if the alternative moves forward.

2.10 Cost

Based on the 1978 Bureau study, the cost to construct the concrete-lined canal from Painted Rock Dam to Imperial Dam on the Colorado River, including land acquisition, pump station, pipeline and canal, was $90,270,000 (Engineering News Record Cost Index 2672). Indexing this cost to December 2006 (Engineering News Record Cost Index 7887.62), the cost in 2006 dollars would be approximately $266,000,000. If constructed, the annual operation and maintenance costs would be about 2 per cent of the construction cost, or about $5.3 million. For estimating unit costs in the final report, the average annual quantity of water available was estimated to be between 30,000 and 40,000 acre-feet, although inflows are highly variable.