Warren H. Brock Reservoir Conservation Summary Report

Interior Region 8: Lower Colorado Basin

U.S. Department of the Interior **December 2020**

Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Cover Photo: Warren H. Brock Reservoir. (Reclamation)

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Executive Summary

Warren H. Brock Reservoir, previously known as Drop 2 Reservoir, is an 8,000 acre-foot (AF) capacity regulatory water storage facility located in southern California, 25 miles west of Yuma, Arizona, adjacent to the All-American Canal near the Drop 2 Power Plant. Construction of the facility was authorized on December 20, 2006 with the purpose to augment regulatory storage capacity in the Colorado River system for flows below Parker Dam.

In accordance with Contract No. 07-XX-30-W0516 (Contract) dated December 13, 2007, the facility was substantially completed in September 2010. This summary report has been prepared consistent with Section 10 of the Contract to include a financial summary and estimates of water conserved by Brock Reservoir during its first six years of operation (2013 through 2018). An additional year of information for 2019 was available at the time this summary report was developed and is also included in this report.

The capital cost of the Project was $142,350,000, with an additional $9,056,000 expended for the facility design. For fiscal years 2013 through 2019, expenditures for operations, maintenance, repair and replacement (OMR&R) were $3,468,563 in total, an average of $495,509 annually, with 11 percent expended for operations and 89 percent expended for maintenance. Future routine OMR&R costs can be estimated based on the average annual OMR&R expenditures of $495,509 plus a projected two percent annual cost escalation for inflation. Additional costs for anticipated future work activities in addition to routine OMR&R are provided in Table 3 and do not include any unforeseen maintenance that might be necessary.

The Bureau of Reclamation worked with Hydros Consulting Inc. to develop a model to estimate the volume of water conserved by Brock Reservoir. The model simulates the change in storage in Senator Wash Reservoir[1] as if only Senator Wash Reservoir existed, then computes the difference between the combined net change in storage in Brock and Senator Wash reservoirs based on actual operations and the simulated change in storage if only Senator Wash Reservoir existed. The difference equates to the estimated volume of water conserved by Brock Reservoir.

Based on the model, it is estimated that during calendar years 2013 through 2019 Brock Reservoir conserved approximately 389,339 AF. During this time, flows to Mexico in excess of treaty obligations averaged 27,423 AF annually, as compared to the annual average of approximately 114,081 AF during the period from 1974 through 2012 (excluding major flood years) and the previous 10-year annual average of 82,853 AF (2003 through 2012).

[1] Senator Wash Reservoir, an off-stream pumping and storage facility, is located about 18 miles northeast of Yuma, Arizona, on the California side of the Colorado River two miles upstream from Imperial Dam. More information is available online at: https://www.usbr.gov/projects/index.php?id=328.

In addition, based on an average annual volume of 55,620 AF, Brock Reservoir is projected to conserve an additional 2,392,000 AF over the remaining life of the Project. The actual volume can be larger or smaller depending on year-to-year variability of hydrologic conditions, rainfall events, and other operational considerations along the lower Colorado River.

In comparison, a 2007 Study[2] estimated that approximately 73,000 AF of water could be conserved annually by the construction of an 8,000 AF regulatory reservoir (previously Drop 2 reservoir) on the All-American Canal. Several factors account for the differences in conserved volumes estimated by the 2007 Study and the estimated volumes in this Summary Report. These factors include differences in modeling methodologies, impacts of actual operations (such as outages and downtime for repairs), the periods of record utilized in the two analyses, changes in the operational regime, and differing hydrologic conditions. Even with these differences, the estimated annual volume of water conserved by Brock Reservoir during the period from 2013 through 2019, although on average less than the volume estimated in the 2007 Study, fits within the interquartile range[3] of annual values from that study as shown in Appendix A, Figure A1.

In summary, the operation of Brock Reservoir has conserved an estimated 389,339 AF of non-storable flows in total, or 55,620 AF annually, and is projected to conserve an estimated 2,392,000 AF over the remaining life (43 years) of the Project. Flows to Mexico in excess of treaty obligations decreased from an annual average of 82,853 AF during the previous 10-year period (2003 through 2012) to an annual average of 27,423 AF from 2013 through 2019. Water conserved by the operation of Brock Reservoir, coupled with improved operational efficiency provided by the facility, underscore the Project's success and projected future benefits.

Consistent with the Contract, the estimated annual volume of water conserved by Brock Reservoir will be reported in future Decree Accounting Reports, beginning with the 2020 Colorado River Accounting and Water Use Report: Arizona, California, and Nevada.[4] Following issuance of this Summary Report, the parties to the Contract will meet and consult regarding the quantity of water conserved by the Project and may also include, among other things, possible modifications to the operations of the Project to increase efficiency. Reclamation also recognizes the potential benefit of further increasing regulatory storage to improve system operations below Parker and Imperial dams.

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[2] *Appendix C - Assessment of Flows Passing Morelos Dam with Future Drop 2 Reservoir Operations* of the 2007 *Final Environmental Assessment for the Drop 2 Storage Reservoir Project*. Available online at: https://www.usbr.gov/lc/region/programs/drop2/envdocs/finalea/feaappC.pdf.

[3] In statistics, the interquartile range describes the middle 50 percent of values when ordered from lowest to highest.

[4] More information is available online: https://www.usbr.gov/lc/region/g4000/wtracct.html.

Purpose and Use of Report

This report has been prepared in accordance with Section 10 of Contract No. 07-XX-30-W0516[5] (Contract) dated December 13, 2007, which states, in part, that after six years of operation of the reservoir project (Project), Reclamation shall prepare a summary report (Summary Report). It continues, "Such Summary Report will include, but is not limited to, a summary of the Project's total capital and operation, maintenance, repair and replacement costs, projected operation, maintenance, repair and replacement costs for the remaining life of the Project, the total quantity of water conserved by the Project and the projected quantity of water that will be conserved over the remaining useful life of the Project as of the date of the Summary Report." This Summary Report meets this contract stipulation. An additional year of information for 2019 was available at the time this Summary Report was developed and, as such, this report includes the period from 2013 through 2019.

Section 10 of the Contract also notes this Summary Report will be made available to the signatories to the Contract (Parties). Section 10 provides that "Following the issuance of the Summary Report, and taking into account the current storage in the Colorado River system reservoirs, the Parties will meet and consult regarding the quantity of water conserved and projected to be conserved by the Project." Reclamation consulted with the Parties during the development of the Summary Report and additional consultation will occur as needed to meet the stipulations outlined in the Contract.

Background

The Lower Colorado River Drop 2 Storage Reservoir Project was authorized by Sections 396 and 397 of Public Law 109-432, dated December 20, 2006.[6] Public Law 109-432 provides for, among other things, authorization for the Secretary of the Interior to design, construct, operate, and maintain a regulated water storage facility (including all incidental works that are reasonably necessary to operate the storage facility) to provide additional storage capacity to reduce nonstorable flows on the Colorado River below Parker Dam, to be located at or near the All-American Canal (AAC). In September 2010, the Secretary of the Interior approved the renaming of the Project to the Warren H. Brock Reservoir (Brock Reservoir).[7]

Funding and construction of Brock Reservoir was made in accordance with the Contract among the Parties, the Bureau of Reclamation, the Southern Nevada Water Authority (SNWA), The Metropolitan Water District of Southern California (MWD), and the Central Arizona Water Conservation District (CAWCD). In exchange for Project funding and based proportionally on the amount of funding provided, SNWA received 400,000 acre-feet (AF)

[5] Available online at: https://www.usbr.gov/lc/region/programs/strategies/agreements/Drop2Funding.pdf.
[6] Public Law 109-432 is available online at: https://uscode.house.gov/statutes/pl/109/432.pdf.
[7] More information is available online at:
https://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=33743.

of Intentionally Created Surplus (ICS) water credits, and MWD and CAWCD each received 100,000 AF of ICS water credits. Consistent with Exhibit D of the Contract, the delivery of the ICS credits developed through this funding is limited to 65,000 AF per year through 2036.

Brock Reservoir is located 25 miles west of Yuma, Arizona (Figure 1) and was constructed to augment regulatory storage capacity in the Colorado River system for flows originating below Parker Dam. This storage capacity, along with Senator Wash Reservoir,[8] allows Reclamation to capture a portion of flows that might otherwise become flows to Mexico in excess of treaty obligations. Imperial Dam is the last diversion structure on the Colorado River in the U.S. and its impoundment maintains a fairly constant water level to facilitate diversions at the AAC and the Gila Gravity Main Canal. Flows arriving at Imperial Dam in excess of the current day's demand for U.S. water users are either captured by Brock and Senator Wash reservoirs or flow to Mexico in excess of treaty obligations. The water captured and temporarily stored in Brock Reservoir is later delivered to the Imperial Irrigation District (IID) as part of its normal water order, thereby reducing deliveries from Lake Mead.

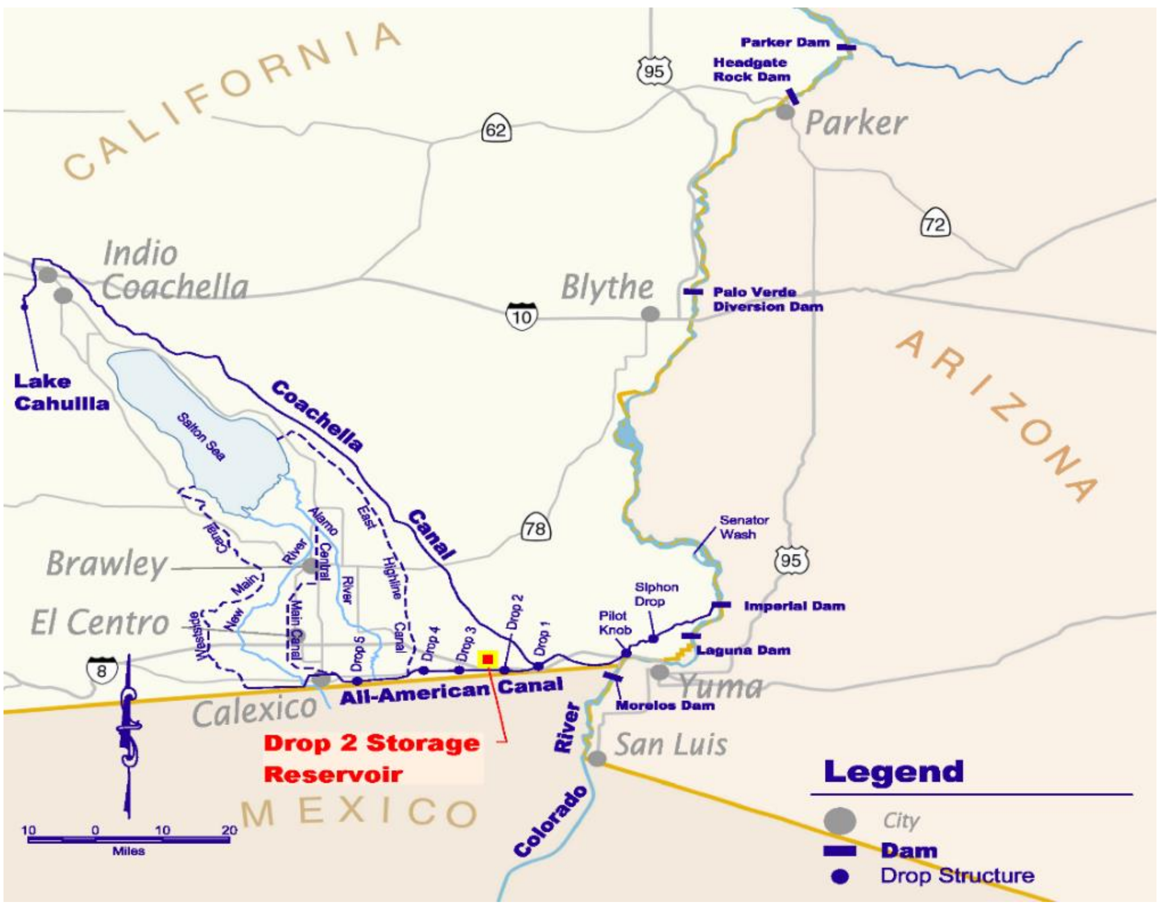

Figure 1. Location of the Warren H. Brock Storage Reservoir (denoted as "Drop 2 Storage Reservoir" on the figure).

[8] Senator Wash Reservoir, an off-stream pumping and storage facility, is located about 18 miles northeast of Yuma, Arizona, on the California side of the Colorado River two miles upstream from Imperial Dam. More information is available online at: https://www.usbr.gov/projects/index.php?id=328.

Brock Reservoir's design capacity is 8,000 AF, split between two 4,000 AF cells. Water is diverted from the AAC at a turnout structure at Drop 1 into a 6½-mile-long inlet canal to the Reservoir. Water released from Brock Reservoir is returned to the AAC below the Drop 2 Power Plant through two buried pipelines under U.S. Interstate 8. Brock Reservoir can be filled in approximately two days and emptied in approximately three days. The dam is constructed of earthen embankments lined with 60-millimeter thick geomembrane material (lining). Approximately seven million cubic yards of soil were moved to construct the Project, and the bottom and sides of the resulting reservoir were covered with 1,800 rolls of lining and nine inches of soil cement to prevent seepage. Excavated material was primarily used to construct canal and reservoir embankments, resulting in limited waste material.

Construction began in October 2008, and the Project was substantially completed in September 2010. Operational testing of Brock Reservoir, refinement of operational procedures, and facility inspections were performed from September 2010 through April 2012. In 2013, Brock Reservoir's status was updated to operations, maintenance, repair and replacement (OMR&R) status.

Total Costs

The estimated Project cost, as noted in the Contract, was $172,000,000. During construction of the Project, the non-Federal Parties to the Contract (SNWA, MWD, and CAWCD) provided $171,041,000 of construction funds to Reclamation. The Project was completed at an actual cost of $141,391,000, including the original construction cost of approximately $140,231,000 and facility and design improvement costs of approximately $1,160,000. Reclamation refunded $22,250,000 to the funding parties and retained $7,400,000 for OMR&R activities. Additionally, Reclamation expended approximately $9,056,000 of Federal funding for the facility design. The total costs for Brock Reservoir are summarized in Table 1.

Table 1. Brock Reservoir Total Costs, including Design, Construction, Facility and Design Improvements, and OMR&R

Description of Cost	Total Costs, Federal and Non-Federal	Itemized Costs, Non-Federal
Original funding provided by non-Federal Parties	$171,041,000	
Amount refunded to non-Federal Parties	-$22,250,000	
Total, funding provided by non-Federal Parties	$148,791,000	
Total, construction/facility and design improvements		$141,391,000
Original construction cost		*$140,231,000*
Facility and design improvement costs		*$1,160,000*
Amount transferred to OMR&R[9]		$7,400,000
Design costs provided from Federal funding	$9,056,000	

[9] Consistent with the Contract, OMR&R costs refer to, and are limited to, the $7.4 million contributed towards the operation, maintenance, repair and replacement of the Project during the interim period (through December 31, 2025).

Operational testing of Brock Reservoir, refinement of operational procedures, and facility inspections were performed from September 2010 through April 2012. As a result of this operational testing and the facility inspections, the following facility and design improvements were made.

- During the initial facility inspection in August 2011 after the facility was placed into operation, excessive thermal expansion was noted through the length of the inlet canal concrete lining. Large temperature swings during the spring and summer months resulted in displacement of the rubber backer rod and joint sealant in the original 75 one-inch expansion joints. A second lining inspection was conducted in April 2012 to further document the condition of the expansion joints. As the result of the second inspection, a contract was awarded to Lillard and Clark Construction to re-establish the original 75 joints and to add an additional 75 one-inch expansion joints for a contract cost of $704,339. Funding for this work was provided from the original construction funds. Since this work was completed, inspections confirm the additional joints have reduced the impacts of thermal expansion of the concrete lining panels.

- In 2011, the actuators for the gates that allow water to flow from the inlet canal into Brock Reservoir failed. The root cause of the gate actuator failures was traced to the frequency of gate use resulting from a tight operating elevation band programmed into the Supervisory Control And Data Acquisition (SCADA) system. Reprogramming the SCADA system resulted in a broader operating elevation range and therefore less frequent gate adjustment. The gate actuators were replaced in September 2011 at a cost of $72,100. Funding for this work was provided from the original construction funds.

- Inspections of the outlet pipelines performed in January 2011 and August 2013 revealed significant deterioration of the anodes and their supports as well as abrasive damage to portions of the epoxy coating lining the pipe. Reclamation's Technical Service Center (TSC) developed proposed solutions, which were implemented in 2017. Installation of new anode support brackets and new anodes, and recoating of damaged portions of the pipeline epoxy lining were completed during the September 2017 reservoir outage at a cost of $2,050,518. Of this cost, $1,667,010 was provided from maintenance funds (expended in fiscal year [FY] 2018) and $383,508 was provided from the remaining construction funds.

Table 2 provides the OMR&R expenditures for the Project for FYs 2013 through 2019.[10] The average annual OMR&R expenditure for the Project was $495,509, with 11 percent expended for operations and 89 percent expended for maintenance. Also, on an average annual basis, labor made up 18 percent of OMR&R expenditures, material made up 8 percent, contracts made up 69 percent, and other expenditures 5 percent.

[10] The Federal Government's FY is the 12-month period extending from October 1 through September 30. FYs 2013 through 2019 reflect the seven-year period from October 1, 2012 through September 30, 2019.

Table 2. Brock Reservoir OMR&R Expenditures – Fiscal Years 2013 through 2019

Warren H. Brock Reservoir Operations & Maintenance Expenditure Report	Labor	Material	Contract	Other	Total
FY 2013					
Operations	$ 5,809.00	$ 67,508.72	$ 11,905.48	$ 8,934.00	$ 94,157.20
Maintenance	$ 36,415.00	$ 118,464.93	$ 13,358.25	$ -	$ 168,238.18
Total	**$ 42,224.00**	**$ 185,973.65**	**$ 25,263.73**	**$ 8,934.00**	**$ 262,395.38**
FY 2014					
Operations	$ 15,815.85	$ 44.93	$ 24,872.70	$ 13,707.72	$ 54,441.20
Maintenance	$ 2,779.66	$ 6,473.76	$ 137,801.73	$ 2,574.75	$ 149,629.90
Total	**$ 18,595.51**	**$ 6,518.69**	**$ 162,674.43**	**$ 16,282.47**	**$ 204,071.10**
FY 2015					
Operations	$ 21,615.09	$ -	$ 3,718.58	$ 15,193.26	$ 40,526.93
Maintenance	$ 63,016.30	$ 1,396.46	$ 90,512.86	$ 21,009.07	$ 175,934.69
Total	**$ 84,631.39**	**$ 1,396.46**	**$ 94,231.44**	**$ 36,202.33**	**$ 216,461.62**
FY 2016					
Operations	$ 12,393.02	$ -	$ 948.69	$ 11,940.77	$ 25,282.48
Maintenance	$ 61,230.10	$ 17,561.83	$ 140,565.61	$ 7,343.00	$ 226,700.54
Total	**$ 73,623.12**	**$ 17,561.83**	**$ 141,514.30**	**$ 19,283.77**	**$ 251,983.02**
FY 2017					
Operations	$ 16,170.31	$ -	$ 1,134.66	$ 13,597.43	$ 30,902.40
Maintenance	$ 107,558.81	$ 7,975.73	$ 176,815.88	$ 11,164.34	$ 303,514.76
Total	**$ 123,729.12**	**$ 7,975.73**	**$ 177,950.54**	**$ 24,761.77**	**$ 334,417.16**
FY 2018					
Operations	$ 16,990.98	$ 408.45	$ 1,134.66	$ 15,831.39	$ 34,365.48
Maintenance	$ 114,738.63	$ 5,730.79	$ 1,639,413.07	$ 6,810.62	$ 1,766,693.11
Total	**$ 131,729.61**	**$ 6,139.24**	**$ 1,640,547.73**	**$ 22,642.01**	**$ 1,801,058.59**
FY 2019					
Operations	$ 65,875.94	$ 12,569.01	$ 3,204.00	$ 15,691.55	$ 97,340.50
Maintenance	$ 92,603.75	$ 44,854.05	$ 148,148.89	$ 15,229.24	$ 300,835.93
Total	**$ 158,479.69**	**$ 57,423.06**	**$ 151,352.89**	**$ 30,920.79**	**$ 398,176.43**
Operations	$ 154,670.19	$ 80,531.11	$ 46,918.77	$ 94,896.12	$ 377,016.19
Maintenance	$ 478,342.25	$ 202,457.55	$ 2,346,616.29	$ 64,131.02	$ 3,091,547.11
Total O&M	**$ 633,012.44**	**$ 282,988.66**	**$ 2,393,535.06**	**$ 159,027.14**	**$ 3,468,563.30**

Following are descriptions for each column in Table 2:

- **Labor** consists of maintenance work performed by Reclamation personnel and facility operations performed by IID personnel. IID operates the facility and performs operations and maintenance on the IID-owned SCADA system. Reclamation personnel maintain all reservoir and appurtenant facilities other than the SCADA system.
- **Material** consists of hardware, steel, wood, concrete, lubricants, paints, sealants, wire, and other parts or substances used while operating or maintaining the facility.
- **Contract** consists of agreements with third parties to provide specialized Project services related to maintenance and construction. Examples of such contracts include: agreements with Reclamation's TSC and the United States Geological Survey, as well as contracts for heavy equipment use and repairs of equipment and instrumentation.
- **Other** consists of expenditures that are not readily allocable to labor, material, or contracts. Examples of other expenditures include: utilities, telecommunications services, travel, and vehicle use charges. Under Agreement No. 11-XX-30-W0560,[11] power for operation of the Project is provided by IID and is invoiced to Reclamation on a monthly basis at the standard commercial rate.

As of the end of FY 2019, the remaining OMR&R funds balance was $3,931,467.

Projected Costs for the Remaining Life of the Project through 2062

Section 10 of the Contract calls for reporting projections of future"… costs for the remaining life of the Project." Average historic actual OMR&R expenditures from FYs 2013 through 2019 are $495,509 and can be used as a base indicator of what future routine OMR&R expenditures might be. As the facility ages, these costs are likely to increase and Reclamation anticipates a two percent annual cost escalation for inflation.

The Project is inspected on an annual basis in accordance with Reclamation Manual Directives and Standards FAC 01-07, *Review/Examination Program for High and Significant Hazard Dams.*[12] Reclamation anticipates that these inspections will reveal the need to conduct additional OMR&R activities that will result in future costs.

Reclamation has identified future work activities in addition to routine OMR&R and estimated these costs as follows:

[11] Available online at: https://www.iid.com/home/showdocument?id=18149.

[12] Consistent with FAC 01-07, a Comprehensive Review (CR) occurs every 8 years; a Periodic Facility Review (PFR) occurs every 8 years, alternating with CRs every 4 years; and an Annual Site Inspection occurs every year when neither a CR nor PFR occurs. More information is available online at: https://www.usbr.gov/recman/fac/fac01-07.pdf.

- Sediment removal will be necessary periodically over the life of the Project. At the current rate of sediment accumulation Reclamation estimates maintenance costs ranging from $500,000 to $700,000 approximately every 10 years. Surveys indicate sediment removal from the Reservoir's cells may be required in 2022.

- Concrete scouring has occurred at the location where water leaves Brock Reservoir's forebay, drops 14 feet, and enters the outlet pipes. Reclamation anticipates that steel wear plates or some other alternative will need to be installed at this location to protect the pipes. The one-time installation of wear plates is estimated at $1,200,000 to $2,000,000. No date has been identified for installation and the status of this potential work will be monitored during future outages.

- Inspections have revealed some cracking of the soil cement used on the slopes of the storage cells. Instrumentation has been installed to monitor the largest cracks; necessary soil cement repairs will be dictated by the results of that monitoring and could be required within the next several years and periodically thereafter. Such repairs are estimated at $500,000 to $700,000 approximately every 15 years.

- As noted earlier, the original gate actuators were replaced in September 2011. In the coming years, six gate stems, drive bushings, and gate controllers may require additional extraordinary maintenance or replacement. Such repairs are estimated at $2,400,000 to $3,000,000 approximately every 15 years.

A summary of projected costs for routine OMR&R and future work activities is shown in Table 3. These projected costs do not include any unforeseen maintenance that might be necessary.

Table 3. Brock Reservoir Projected Costs for Routine OMR&R and Future Work Activities for the Remaining Life of the Project (through 2062)

Future OMR&R and Work Activities	Estimated Costs	Frequency of Activities
Routine OMR&R	$495,509	Annually, including 2% cost escalation for inflation
Sediment removal from reservoir cells	$500,000 to $700,000	Every 10 years
Installation of wear plates	$1,200,000 to $2,000,000	One time only
Repair soil cement of storage cells	$500,000 to $700,000	Every 15 years
Replacement of gate stems, gate controllers, and drive brushings	$2,400,000 to $3,000,000	Every 15 years

Water Conserved 2013 through 2019

Brock Reservoir is one of two regulatory facilities, in addition to Senator Wash Reservoir, used to capture flows arriving at Imperial Dam in excess of water user demands. A portion of this water, if not captured, flows to Mexico in excess of treaty obligations. The volume of water stored by Brock Reservoir that could not otherwise be stored in Senator Wash Reservoir is conserved water attributable to the operation of the Brock Reservoir. In other words, the volume of water conserved by Brock Reservoir is assumed to be the difference between the total volume of water actually captured in Brock Reservoir and Senator Wash Reservoir, and the total volume of water that would have been captured if Brock Reservoir did not exist and only Senator Wash Reservoir existed.

To compute the volume of water that would have been captured if Brock Reservoir did not exist, Reclamation hired Hydros Consulting, Inc. (Hydros) to develop a model to estimate the volume of water conserved. Modeling to estimate the amount of conservation by Brock Reservoir was completed in 2017, and subsequently updated in 2018 and 2019. Appendix A: Modeling Description provides a detailed description of the modeling and analysis that was conducted by Hydros. A summary of the modeling methodology is provided below.

The primary inputs to the model are observed daily storage data for Brock and Senator Wash reservoirs and the daily operational limits for Senator Wash Reservoir. On a daily timestep, the model computes the combined actual net change in storage in Brock and Senator Wash reservoirs and compares this value to the net change in storage, as simulated by the model, if only Senator Wash Reservoir existed. The difference between the combined actual net change in storage in Brock and Senator Wash reservoirs and the simulated change in storage if only Senator Wash Reservoir existed is the estimated volume of water conserved by Brock Reservoir.

For each day, inputs to the model include limits on potential water stored or released based on available storage capacity, water in storage, minimum and maximum operating levels and system limitations (e.g., pumping limits at Senator Wash Reservoir). Limits in the model are changed as appropriate if actual operations, as documented by the Yuma Area Office (YAO) Water Operations Group, differed from the standard operating limits (i.e., temporary limits placed on the minimum and/or maximum operating levels at Senator Wash Reservoir due to maintenance activities).

Table presents the estimated annual volume of water conserved by Brock Reservoir as tabulated from the daily model results. Collection of data on the volume of water stored began January 1, 2013, and, therefore, the seven-year period from January 1, 2013 through December 31, 2019 was analyzed. During this seven-year period, the operation of Brock Reservoir resulted in the conservation of an estimated total of 389,339 AF of water, an average volume of 55,620 AF annually. A discussion of the uncertainties in this calculation is provided in Appendix A.

Table 4. Brock Reservoir Estimated Annual Water Conservation

Calendar Year	AF
2013	49,651
2014	54,826
2015	65,416
2016	40,497
2017	51,995
2018	82,923
2019	44,031
Total	**389,339**
Average	**55,620**

Note that previous Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada (Water Accounting Report) published by Reclamation have reported annual volumes of water stored, not conserved, by Brock Reservoir. The volume of water stored by Brock Reservoir, as published in past Water Accounting Reports through 2019, reflects actual operations and includes water conserved as well as flows and deliveries made for non-conservation operational purposes.[13] As required by the Contract, the annual volume of water conserved by Brock Reservoir will be included in future Water Accounting Reports beginning in 2020.

Comparison to 2007 Water Conservation Estimate

Appendix C - Assessment of Flows Passing Morelos Dam with Future Drop 2 Reservoir Operations[14] (2007 Study) of the Final Environmental Assessment for the Lower Colorado River Drop 2 Storage Reservoir Project estimated that on average approximately 73,000 AF of water could be conserved by the Project annually. As presented in Table 4, the average annual volume of water conserved by Brock Reservoir, using the model and methodology described in

[13] For the CYs from 2011 through 2019, the Water Accounting Report provided the annual volume of water stored by Brock Reservoir. Section 10 of the Contract requires that "Reclamation will annually determine the quantity of water conserved by the Project and include such determination in Reclamation's Decree Accounting Report." Reclamation will begin reporting the volume of water conserved by Brock Reservoir in the 2020 Water Accounting Report. Previous Water Accounting Reports are available online at: https://www.usbr.gov/lc/region/g4000/wtracct.html.

[14] Appendix C of the *Final Environmental Assessment for the Lower Colorado River Drop 2 Storage Reservoir Project, Imperial County, California* is available online at: https://www.usbr.gov/lc/region/programs/drop2/envdocs/finalea/feaappC.pdf.

Appendix A of this Summary Report, was 55,620 AF for the period from 2013 through 2019.

These differences can be attributed to the different methodological and modeling assumptions used to estimate the water conserved by the Project in the 2007 Study and the water conserved by Brock Reservoir in this Summary Report. In addition, there are other operational and hydrologic factors that help account for the differences between the conservation volumes estimated by these two models.

- As discussed in the 2007 Study, "… the operational efficiency of a water system is largely dependent upon the ability of the operators to manage water on a real time basis. The more options available to hold, transfer, deliver, and release water, the more responsive and efficient river operations can be." With Brock Reservoir in place, the lower Colorado River system is operated more efficiently now than when the 2007 Study was developed and the amount of flows arriving at Imperial Dam in excess of water user demand has decreased.
    - The addition of Brock Reservoir to the lower Colorado River system has allowed YAO's Water Operations Group to refine reservoir operations and adjust release volumes needed to meet downstream water orders and thus operate the system within tighter tolerances, resulting in decreased excess flows available for capture.
    - In recent years, Reclamation and water users have focused on and reduced the volume of water ordered but not diverted. As a result, excess flows arriving at Imperial Dam have decreased, thereby reducing the amount of flows available for capture.
- The 2007 Study utilized a historical 31-year dataset for the period from 1974 through 2004. The seven-year dataset from 2013 through 2019 to estimate actual conservation by Brock Reservoir is comparatively small.
    - The period from 1974 through 2004 was used in the 2007 analysis because operations under the provisions of Minute 242 with Mexico began in 1974 and this dataset provided a sufficient period of analysis to assess how non-storable flows varied under different hydrologic and operating conditions. The period from 2013 through 2019, by contrast, represents a smaller range of potential hydrologic and operating conditions.
    - This 31-year dataset included more periods of normal and above average precipitation on the lower Colorado River mainstem. Such conditions likely provided more opportunities to capture excess flows than during the period from 2013 through 2019, which is part of the driest 20-year period in recorded history in the Colorado River Basin. For example, the average annual rainfall for four gages along the lower Colorado River mainstem (in the Yuma, Blythe, and Imperial Valley areas) was about 3.9 inches per year for the period from 1975 through 2012. By contrast, the average annual

rainfall for these four gages for the period from 2013 through 2019 was about 2.7 inches per year – about 1.2 inches less per year.

- During the seven years of actual operation from 2013 through 2019, there have been periods during which Brock Reservoir was off-line and non-operational for maintenance, repairs, and rehabilitation activities. The analysis in the 2007 Study did not assume any constraints for downtime or non-operational periods.

Despite these differences, the seven-year period examined in this Study fits within the interquartile range of values from the 2007 Report (see Appendix A, Figure A1). Appendix A provides additional details of the modeling that was conducted for the 2007 Study.

Projected Water Conservation for the Remaining Life of the Project

Based on the analysis conducted in this report, an estimated 389,339 AF of water has been conserved by Brock Reservoir during the period from 2013 through 2019, an average of 55,620 AF per year (see Table 4). During the remaining life of the Project from 2020 through 2062, and based on annual average of 55,620 AF, it is projected that Brock Reservoir will conserve an additional 2,392,000 AF of water in total. The actual volume conserved can be larger or smaller depending on year-to-year variability of hydrologic conditions, rainfall events, and other operational considerations along the lower Colorado River. Reclamation will update estimated volume of water conserved by Brock Reservoir each year and report the estimated volume of water conserved by Brock Reservoir in the Water Accounting Report[15] beginning in 2020.

In exchange for providing funding for construction, design improvements, and OMR&R of the Project, the funding parties (CAWCD, MWD, and SNWA) received 600,000 AF of ICS credits in total, which were credited based on the proportion of funding provided. Through the end of CY 2019, 565,000 AF of these ICS credits remain in storage in Lake Mead. Based on the estimated volume of water conserved through 2019, a volume of 55,620 AF annually, it is projected that Brock Reservoir will have conserved 600,000 AF of water during its 11th year of operation in 2023. As such, it is anticipated that during the Project's estimated 50-year lifespan, Brock Reservoir will conserve water far in excess of the amount of ICS credited to the funding parties.

[15] Water Accounting Reports are available online at: https://www.usbr.gov/lc/region/g4000/wtracct.html.

Summary

The Project was completed in 2010 at a cost of $141,391,000, including the original construction cost of approximately $140,231,000 and facility and design improvement costs of approximately $1,160,000. Consistent with the Contract, Reclamation retained $7,400,000 for OMR&R activities and as of the end of FY 2019 the remaining OMR&R funds balance was $3,860,309. Projected costs for the remaining life of the Project are approximately $495,509 annually with a two percent cost escalation each year for inflation for routine OMR&R. Future maintenance activities in addition to routine OMR&R are outlined in Table 3.

Based on the analysis conducted in this report, 389,339 AF of water has been conserved in total by Brock Reservoir, an average of 55,620 AF per year, during the period from 2013 through 2019. During the remaining life of the Project from 2020 through 2062, and based on an annual average of 55,620 AF, it is projected that Brock Reservoir will conserve an additional 2,392,000 AF of water. This combined volume of conservation to-date and projected conservation (389,339 plus 2,392,000 AF) far exceeds the 600,000 AF of ICS credits provided to the non-Federal funding parties (CAWCD, MWD, and SNWA) for funding the Project. From 2013 through 2019, deliveries to Mexico in excess of treaty obligations averaged 27,423 AF annually, as compared to the annual average of approximately 114,081 AF during the period from 1974 through 2012 (excluding major flood years) and the previous 10-year annual average of 82,853 AF (2003 through 2012). Water conserved by the operation of Brock Reservoir, coupled with improved operational efficiency provided by the facility, underscore the Project's success and projected future benefits.

Consistent with the Contract, the estimated annual volume of water conserved by Brock Reservoir will be reported in future Decree Accounting Reports, beginning with the 2020 Water Accounting Report. Following issuance of this Summary Report, the parties to the Contract will meet and consult regarding the quantity of water conserved by the Project and may also include, among other things, possible modifications to the operations of the Project to increase efficiency. Reclamation also recognizes the potential benefit of further increasing regulatory storage to improve system operations below Parker and Imperial dams.

Appendix A: Modeling Description

Appendix A: Modeling Description

This Appendix describes the modeling approach used to estimate the annual volume of water conserved by Brock Reservoir and the uncertainty associated with these estimates. For reasons described below, this modeling effort has been limited to calendar years 2013 through 2019. Although Brock Reservoir was tested in 2011 and placed into operation during 2012, accurate daily data for observed storage (or pool elevation/level) and discharge did not become available until January 1, 2013. The original location of the instrumentation was not optimal in that the original flow meters were installed inside the outlet pipes and entrained air contained in the discharges prevented the collection of accurate data. Therefore, lacking actual storage data for 2012, estimation of the volume of water conserved by Brock Reservoir during that year is not possible.

The primary objective of operating Brock Reservoir is to capture and store water arriving at Imperial Dam that is in excess of demand for U.S. water users. Without regulatory storage facilities, this water would flow to Mexico at the Northerly International Boundary (NIB) in excess of treaty obligations. By capturing a portion of these flows at Brock Reservoir and Senator Wash Reservoir, such water can be delivered for use in the U.S. later, thereby reducing flows to Mexico in excess of treaty obligations. Based on these operating principles, the annual conservation attributable to Brock Reservoir is the total annual volume of water stored by the reservoir that could not otherwise be stored at Senator Wash Reservoir. This assumes water stored in Brock Reservoir and Senator Wash Reservoir would have resulted in excess flows at the NIB had that water not been stored. Thus, estimating the volume of water conserved by the Brock Reservoir requires an inference regarding how the system would have been operated without Brock Reservoir.

Method of Estimating Brock Reservoir Conservation

A RiverWare model was developed by Hydros Consulting Inc. (Hydros) to estimate the volume of water conserved by the Project in calendar years 2013 through 2019. The model uses, as input, observed daily storage data for Brock Reservoir and Senator Wash Reservoir. Elevation-volume data was used to convert storage to pool elevation given the tables in Reclamation's Hydrologic Database.

Note that Imperial Dam was not considered when estimating the volume of water conserved by Brock Reservoir. This is because Imperial Dam is operated primarily as a diversion dam rather than a storage or re-regulating reservoir. Operational criteria regarding head requirements for deliveries through the All-American Canal and Gila Gravity Main Canal dictate operational decisions. Additionally, there is only approximately 270 AF of available regulatory storage behind Imperial Dam under optimal circumstances. Therefore, given its standard operation and insignificant regulatory storage capacity, it is reasonable to assume that Imperial Dam operations should not be considered when estimating the volume conserved by Brock Reservoir.

For Senator Wash Reservoir, the model uses pumping, generating, and freewheeling curves that delineate pumping and release capacities, per unit, as a function of Senator Wash pool elevation. The values for the minimum and maximum operating levels for Senator Wash Reservoir were determined through discussions with YAO Water Operations staff (see Table A1 below). The value of elevation 238 feet is a maximum value imposed for dam safety purposes (although Senator Wash Reservoir is occasionally allowed to store up to 240 feet for durations less than ten days). The value of 220 feet used for the minimum operating level is a lower bound to ensure that daily demands can be met.

The model reapportions daily water operations data using only Senator Wash Reservoir as a potential storage area. The concept behind this action is to model the system as if Brock Reservoir did not exist. The difference between the actual storage and simulated storage using only Senator Wash Reservoir is theoretically the volume conserved by the Project.

For each day, the model computes the combined net flow to storage or net release from storage for Brock Reservoir and Senator Wash Reservoir given the observed data. This results in a single value for each day that represents the total stored or total released. For example, if Senator Wash released 100 cubic feet per second (cfs) while Brock Reservoir stored 100 cfs, the net stored/released would be zero. If the net daily value is a flow to storage, the model attempts to store that water at Senator Wash Reservoir given full consideration of pumping limitations, available storage, operational restrictions on storage levels, outages of units due to maintenance, etc. Any water that cannot be stored in Senator Wash Reservoir is considered water conserved by Brock Reservoir. The simulated daily volumes are tracked and accumulated to compute an annual volume. If the net daily value is a release, the model releases that water from Senator Wash Reservoir. The model tracks the simulated storage on each day as a result of the “reapportioned” storages and releases.

On each day, the model limits the potential water stored or released based on available storage space, available water in storage, and the pumping and release limits at Senator Wash Reservoir. The following limits on storage at Senator Wash Reservoir were used by the model (see Table A1). These represent the ideal minimum and maximum operating levels. These values can be overridden within the model if notes in the Water Operations Log indicate that an alternative limit should be used for a given day.

Table A1. Senator Wash Reservoir – Min and Max Operating Levels used in Model

Min Operating Level (ft)	Max Operating Level (ft)
220	238

The Water Operations Log in the Mean Daily Flow spreadsheet located in the Yuma Water Operations Group was reviewed to identify times when Senator Wash Reservoir experienced an outage (e.g. one or more units not available) and times when temporary limits were placed on the minimum and/or maximum operating levels for maintenance. This information was incorporated into the model under the assumption that these same outages or limits would have occurred if the system were being operated without Brock Reservoir.

The results of the model simulation are shown below in Table A2. The annual volume of water estimated as conserved by the Project is the difference between the annual sum of net daily water stored in Brock Reservoir and Senator Wash Reservoir (observed) and the annual sum of net daily water stored in the model simulation in Senator Wash Reservoir only.

Table A2. Estimated Annual Volume Conserved by Brock Reservoir (2013-2019)

Calendar Year	Brock Reservoir Conservation (AF)
2013	49,651
2014	54,826
2015	65,416
2016	40,497
2017	51,995
2018	82,923
2019	44,031
Total	**389,339**
Average	**55,620**

Comparison of Conservation Estimates

Appendix C - Assessment of Flows Passing Morelos Dam with Future Drop 2 Reservoir Operations[16] *(2007 Study)* of the Final Environmental Assessment for the Drop 2 Storage Project included an average annual estimate of approximately 73,000 AF of water conserved by Brock Reservoir (at that time, referred to as Drop 2 Reservoir). The annual volume of water conserved by the existing reservoir from 2013 through 2019 presented herein was intended to be analogous to the volume of excess flows that could be captured by the proposed project that was presented in the 2007 Study. The annual conservation volume of 55,620 AF estimated in this 2020 study differs from the prior estimate of approximately 73,000 AF per year. Following are several comments regarding the difference:

- Models tend to be more efficient than real-world operations. For example, a model can compute excess flows to a fraction of a cfs and can store 100 percent of those excess flows provided the storage and release tables allow it. In practice, this is not

[16] Appendix C to the June 2007 Reclamation *Final Environmental Assessment for the Lower Colorado River Drop 2 Storage Reservoir Project Imperial County, California* prepared by the Yuma Area Office.

possible. The model used in the 2007 Study could and did operate the proposed reservoir more efficiently than real-world operations. This resulted in an *overestimation* of the volume of excess flows that could be captured. Conversely, the model used in this study to estimate the 2013 through 2019 average annual volume conserved by the Project could reapportion the observed net daily storage, by storing it at Senator Wash Reservoir only, more efficiently than the Reservoir could be operated in the real world. This could result in an *underestimation* of the volume of water conserved by the Project. However, Reclamation believes that, given the min and max operating levels in Table A1 above, the efficiency of the model is offset by the fact that the entire operating range of Senator Wash Reservoir is not available for use by the model. For example, in real-world operations, Senator Wash Reservoir could theoretically be operated using its entire range from 212 feet (at dead pool) up to 240 feet (for a maximum of 10 days only). While Senator Wash Reservoir is operated outside of the min and max operating levels used by the model in Table A1, the use of this entire range does not occur regularly in real-world operations. The fact that the model uses the limits in Table A1 as an "ideal" operating range offsets to some degree the fact that the model can operate Senator Wash more efficiently than it could be operated in the real world.

- The 2007 Study was based on historical data from 1974 to 2004. This period differed greatly from recent years, both operationally and hydrologically. For example, years with less than normal precipitation will provide fewer opportunities to capture potential excess flows. The average annual rainfall for four gages along the lower Colorado River mainstem (in the Yuma, Blythe, and Imperial Valley areas) was about 3.9 inches per year for the period from 1975 through 2012. By contrast, the average annual rainfall for these four gages for the period from 2013 through 2019 was about 2.7 inches per year – about 1.2 inches per year less.

- In recent years, improved operational efficiency achieved through use of new (since 2011) operational modeling tools has reduced the potential for excess flows at Imperial Dam. Reduction of excess flows at Imperial Dam is discussed further in the section below (*Improved Operational Efficiency above Imperial Dam*). Also, the irrigation districts receiving water from Imperial Dam have attempted to reduce water-ordered-not-diverted (WOND) in recent years. The reduced amount of WOND has also tended to reduce excess flows at Imperial Dam.

- The annual excess flows that could be captured by the Project estimated in the 2007 Study varied considerably from year to year. While the average annual volume over the 31-year period considered in the study (excluding major flood years) was estimated to be 73,000 AF, the range of flows that could be captured in a given year varied from 4,000 to 307,000 AF (see Table A5). This variation, by itself, confounds attempts to draw conclusions when comparing the 2007 Study to the current analysis. Hydros was asked to extend the Brown and Caldwell "Model Reservoir" spreadsheet used in the study to include the years from 2005 through 2010. The range of flows that could be captured by the Project in this period (2005-2010) is

21,000 to 134,000 AF per year (see Table A6). More information is given in the section titled *Results from 2007 Assessment of Future Drop 2 Operations* below.

- While the estimated annual average volume conserved for the period from 2013 through 2019 differs from the average estimate in the 2007 Study by approximately 17,000 AF, analysis shows that this current seven-year period fits within the interquartile range[17] of values from the 2007 report (see Figure A1 below). Furthermore, the estimated annual average volume conserved for the period from 2013 through 2019 is greater than the median value from the 2007 report (see Figure A1). In other words, statistically, the value from the 2013 – 2019 period is consistent with the values from the 2007 Study.

- Lastly, during the seven year period from 2013 through 2019, there have been periods during which the Brock Reservoir was off-line and non-operational due to repair and rehabilitation activities. The model utilized in the 2007 Study, consisting of a series of equations that evaluated the daily flows that could be captured by the Project, did not assume any constraints for downtime or non-operational periods.

To summarize, while the estimated annual volume of water conserved by Brock Reservoir for the period from 2013 through 2019 (55,620 AF) is less than the annual volume estimated in the June 2007 study (73,000 AF), the difference, in part, can be accounted for by the changes in operational regime and overall drier conditions, as noted above, for the more recent seven-year period. Even with these differences, the average annual volume of water conserved by Brock Reservoir during the period from 2013 through 2019 fits well within the interquartile range of values from the 2007 report (see Figure A1 below).

In short, Brock Reservoir is performing as expected and the Project, along with other operational improvements, has reduced excess flows at the NIB. For example, annual average excess flows arriving at the NIB during the period from 2013 through 2019 as documented in the Water Accounting Report (27,423 AF; see Table A3) are significantly less than the annual average of approximately 114,081 AF during the period from 1974 through 2012 (pre-Project years, excluding major flood years) and approximately 82,853 AF during the previous 10-year period (2003 through 2012, which more closely matches the 2013-2019 operational regime).

[17] In statistics, the interquartile range describes the middle 50 percent of values when ordered from lowest to highest.

Table A3. Excess Flows at the NIB (2013 - 2019)

Calendar Year	Excess Flows at the NIB (AF)
2013	71,970
2014	32,151
2015	14,829
2016	9,230
2017	16,688
2018	7,416
2019	39,675
Average	**27,423**

Model Sensitivity and Uncertainty

The method of estimating the volume conserved by Brock Reservoir as described above is sensitive to the assumptions used. Two specific examples are the values used for the operational minimum and maximum pool elevations for Senator Wash Reservoir. If (hypothetically) the maximum operating level is increased from 238 to 240[18] feet, the volume of water conserved by Brock Reservoir is reduced by approximately 7,000 to 11,000 AF annually (depending on the year) due to the increased capacity to capture excess flows at Senator Wash Reservoir. If (hypothetically) the minimum operating level for Senator Wash Reservoir is increased from 220 to 222 feet, the volume of water conserved by Brock Reservoir is increased by approximately 2,000 to 6,000 AF annually (depending on the year).

Improved Operational Efficiency above Imperial Dam

One of the benefits of Brock Reservoir is the effect it has on the operator's ability to "tighten up" orders from Parker Dam with respect to the required/ordered water below Parker Dam (Colorado River Indian Tribes and Palo Verde Irrigation District plus the total flow required above Imperial Dam from the Master Schedule spreadsheet). Storage in Brock Reservoir allows more efficient operation of the system, which can result in decreased orders from Parker Dam. Without Brock Reservoir, operators would be less inclined to count on Senator Wash Reservoir alone in the case of an underage of flow arriving at Imperial Dam (Senator Wash Reservoir could experience an outage at any time) and would therefore tend to err on the side of ordering extra water from Parker Dam.

[18] This change from 238 feet to 240 feet was made to the model for the purpose of evaluating model sensitivity only. It does not imply that the true maximum operating level of Senator Wash Reservoir is 240 feet. It is simply an example presented for the purpose of demonstrating the sensitivity of the model results to these assumptions.

Table A4 below shows the historical releases from Parker Dam with respect to the total order below Parker Dam. For years 2006 to 2009 (before the existence of Brock Reservoir and excluding 2010 which is an outlier due to high levels of precipitation in the area), the releases from Parker Dam were approximately 93 percent of the total orders below Parker Dam. From 2012 to 2019, after the Project began operating, the releases from Parker Dam were approximately 91 percent of the total order. This improved efficiency is arguably due to a number of factors that include the operation of the Project and new operational modeling tools developed in 2011. Determination of the portion of the reduction in releases that is attributable to the Project versus other operational improvements would be difficult to calculate and, to this date, has not been quantified.

Table A4. Orders vs Releases at Parker Dam

Calendar Year	Total Orders below Parker Dam (AF)	Actual Parker Dam Release (AF)	Difference (AF)	Ratio (release/order)
2006	7,246,693	6,721,488	525,206	0.93
2007	7,248,971	6,711,443	537,527	0.93
2008	7,232,438	6,698,607	533,831	0.93
2009	6,868,430	6,390,077	478,353	0.93
2010	7,313,734	6,371,297	942,437	0.87
2011	7,216,699	6,714,304	502,395	0.93
2012	7,372,937	6,711,695	661,242	0.91
2013	6,925,438	6,335,109	590,329	0.91
2014	7,162,668	6,454,797	707,872	0.90
2015	6,942,064	6,276,390	665,673	0.90
2016	6,896,431	6,306,712	589,719	0.91
2017	6,771,625	6,255,691	515,934	0.92
2018	6,804,230	6,285,955	518,275	0.92
2019	6,644,304	6,150,954	493,351	0.93
2006 - 2009 Average	7,149,133	6,630,404	518,729	0.93
2012 - 2019 Average	6,943,409	6,347,163	596,246	0.91

Results from 2007 Assessment of Future Brock Reservoir Operations

Hydros was asked to perform a review of the *Appendix C - Assessment of Flows Passing Morelos Dam with Future Drop 2 Reservoir Operations* (2007 Study) of the Final Environmental Assessment for the Drop 2 Storage Project. Specifically, Hydros focused on the portion of the analysis that examined the Project's potential to capture excess flows before arriving at the NIB.

The model developed by Brown and Caldwell (called the "Model Reservoir" spreadsheet) was reviewed to understand the methods used to estimate the historical excess flows that could be captured by the Project. Data used in the Brown and Caldwell analysis were available for the period of January 1, 1974 through December 31, 2004, and included daily observations of flow at the NIB and daily records of Mexico's scheduled order at the NIB. Only flows exceeding the NIB daily order by 10 cfs or more were considered flows available for storage. The potential to capture excess flows before arriving at the NIB was only evaluated during times when both the Colorado River and Gila River were operating under non-flood flow conditions. Exclusion of flood flow data from the analysis results in a reduced period of 20.68 years, or 7,549 days.

The excess flows evaluated in the Brown and Caldwell analysis included a daily time-step adjustment based on Mexico's monthly order at the NIB. The purpose of this adjustment is to reconcile any differences occurring when comparing daily flows to monthly accounting, e.g. daily over- and under-deliveries are balanced out over each month so that excess flows are only available for storage by the Project if the monthly flow at the NIB exceeds the monthly order.

The results of the Brown and Caldwell analysis are shown in Table A5 below. The purpose of including these results in this report is to provide a point of reference with respect to the variability in annual excess flows that could be captured by the Project based on the Brown and Caldwell model.

Table A5. Annual Excess Flows Captured by Brock Reservoir - Brown and Caldwell Model

Calendar Year	Total Volume Captured (AF) (Adjusted)[1]
1974	19,234
1975	11,573
1976	40,679
1977	27,154
1978	43,786
1979	-
1980	-
1981	40,287
1982	44,007
1983	-
1984	-
1985	-
1986	-
1987	-
1988	135,438
1989	78,984
1990	38,416
1991	19,980
1992	34,016

Calendar Year	Total Volume Captured (AF) (Adjusted)[1]
1993	-
1994	24,380
1995	26,810
1996	4,391
1997	97,656
1998	55,345
1999	124,848
2000	306,980
2001	161,717
2002	101,245
2003	59,806
2004	92,221

1) Excess flow is calculated as the water arriving at the Morelos Diversion Dam plus Cooper Wasteway that exceeds Mexico's scheduled delivery. Excess flow is adjusted on a daily time step to account for over/under-deliveries throughout the course of a month. Years with no reported volume captured are flood years that were excluded from the June 2007 study.

Since the dataset used by the Brown and Caldwell analysis ended in 2004, Hydros extended the analysis to include recent years. The Project began operational testing at the end of 2010. Therefore, Hydros decided to extend the analysis only through December 2010 as the analysis methodology would not apply after the Project became operational.

Daily estimates of Mexico's water order at the NIB and Water Available for Diversion by Mexico were provided to Hydros by the Yuma Area Office. The data were used to extend the Brown and Caldwell analysis to include the years of 2005 through 2010. Excess flows were reconciled on a daily basis as per the Brown and Caldwell analysis parameters so as to not overestimate excess flows based on the monthly NIB water order and the observed monthly flows at the NIB.

The results are shown in Table A6 below. The purpose of including these results in this report is to provide a point of reference with respect to the variability in annual excess flows that could be captured by the Project based on the Brown and Caldwell model and to provide an estimate of the excess flows that could be captured by the Project for all years from 1974 through 2010.

Table A6. Extended Analysis - Annual Excess Flows Captured by Brock Reservoir – Brown and Caldwell Model

Calendar Year	Total Volume Captured (AF)
2005	60,231
2006	35,478
2007	20,858
2008	90,868
2009	64,668

2010	133,531

The data from 1974 through 2010 from Table A5 and Table A6 above were compiled and are presented in a "box and whisker" plot in Figure A1 below. The figure shows that the 2013-2019 average estimated actual conservation falls within the interquartile range of data estimated by the Brown and Caldwell model for the 1974-2010 time period. Furthermore, it is worth noting that the 2013-2019 average actual conservation falls between the average value and the median value from the 1974-2010 time period. This demonstrates that the 2013-2019 estimated actual conservation is consistent with the data from the Brown and Caldwell model and the average estimated conservation from the 2007 report.

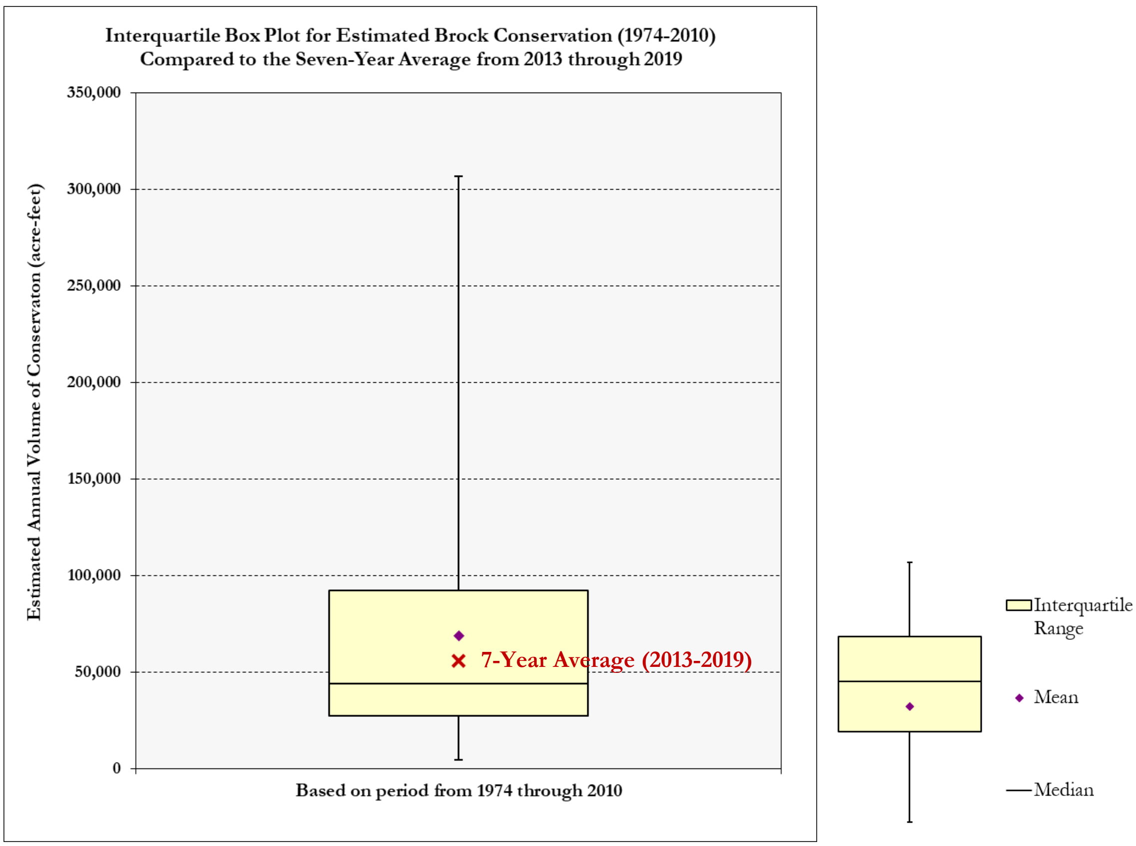

Figure A1: Interquartile Box Plot for Estimated Brock Conservation (1974-2010) Compared to the Seven-Year Average from 2013 through 2019