MEMORANDUM

To: Jane Whalen, Conserve Southwest Utah

cc:

From: Ben Harding, Lynker Technologies, LLC

Subject: Lake Powell Pipeline, Draft Environmental Impact Statement

Date: July 28, 2020

Introduction and summary

This memorandum addresses water supply for the Lake Powell Pipeline Project and the adequacy of the Draft Environmental Impact Statement for the Project (DEIS).

The Lake Powell Pipeline Project (the Project) is proposed to deliver 86,249 acre-feet (af) of water annually from Lake Powell to Washington County, Utah. The DEIS infers that this full amount would be available every year, but in fact in many years the Project would almost certainly be limited to a lower or to no yield by curtailments under the Colorado River Compact and the Upper Colorado River Basin Compact arising from a flow shortfall on the Colorado River at Lee Ferry (Castle and Fleck, 2019; Harding, 2019). These curtailments would reduce the reliability of the project (and its average, long-term yield) and would consequently reduce the ability of the project to fulfill its declared purpose and need and would reduce its water supply benefits. What is generally unrecognized is that these curtailments are also mechanisms whereby operation of the Project can impair the operation of other more senior Colorado River water rights in Utah, and Colorado River water rights in the States of the Lower Division, impacts that have not been addressed in the DEIS.

The DEIS has also employed analytical methodological choices that overstate the performance of the project and understate its impact on other water rights, and it has not reported analytical results that directly quantify the expected reliability and impacts of the project. The results that are presented in the DEIS suggest that the Project would not be able to deliver its full yield, and possibly any yield, on average about every 4 to 7 years. In any year in which the Project is fully curtailed an impairment of other water rights would almost certainly occur.

The DEIS is deficient for the following reasons:

- It assumes that the Project will be 100% reliable, that is that it will supply its nominal yield of 86,249 af every year during its operational life. The available evidence and analyses suggest that the project yield will be reduced or eliminated in many years due to curtailments of water use in Utah under the Colorado River Compact and the Upper Colorado River Basin Compact;
- It does not evaluate and describe the degree to which curtailments caused by the Project would cause impairment of senior water rights within Utah;
- It does not evaluate and describe the degree to which depletions from Lake Powell by the Project could impair water rights in the Lower Basin;
- It does not evaluate and quantify the effect of climate change on the performance of the Project; it simply assumes that the Project will be able to deliver its nominal yield in every year during its operational life;

- The hydrology analyses on which the DEIS is based, and Reclamation's 2012 Basin Supply and Demand Study suggest that the project will be unable to deliver its full yield or any yield at all in many years in the future, but the results of these analyses are ignored in the DEIS;
- The hydrology analyses on which the DEIS is based and Reclamation's 2012 Basin Supply and Demand Study have methodological shortcomings that result in overstatement of the performance of the Project and understatement of its impacts.

These issues are addressed in detail in the rest of this memorandum.

1. Stated Purpose and Need for the Project

The project is to supply 86,249 af of water annually to new uses in Washington County. A full supply of water from the Project is proposed to be available by 2060 and presumably to continue indefinitely over the unspecified operational life of the Project.

The Project proponents intend for the project to meet these additional planning objectives:

1. Diversifying the regional water supply portfolio by providing a second source of water for Washington County;
2. Providing for system reliability by developing a secure source of water;
3. Providing for system redundancy in the event of system failure due to disasters or aging infrastructure;
4. Accounting for climate change scenarios; and
5. Accounting for long-term uncertainty when considering the summed effect of the vulnerability to the water supply.

Objectives 1-3 require that the Project supply water reliably. The Purpose and Need Report (Table 7.2-2; page 16) assumes that the project would supply its full yield of 86,249 af 100% of the time. The DEIS provides an estimate of benefit due to water supply reliability of $1.9 billion (Table 3.2-8; page 241). These benefits are all attributable to the Project; no water reliability benefits are attributed to the No Action Alternative. The DEIS provides no analysis of the reliability of the Project but the hydrologic modeling results found in various DEIS documents suggest that the Project would be substantially unreliable.

2. The mechanism and effects of compact curtailment of Utah water rights.

2.1. The law of the river (after Harding, 2019).

The Colorado River system is managed and operated in accordance with the "Law of the River", which consists of compacts, treaties, federal and state statutes, court decisions and decrees, contracts, and regulations. See MacDonnell, et al. (1995), Wilbur and Ely (1933), Wilbur and Ely (1948), Nathanson (1978) and Verburg (2010). A comprehensive and convenient compilation is at Weisheit (2010).

The Colorado River Compact (CRC; 1922) and the Upper Colorado River Basin Compact (UCRBC; 1948), the principal elements of the Law of the River, set constraints on consumptive use of water in the Upper Basin of the Colorado River. A water treaty with Mexico (1944) created a federal obligation to deliver water from the Colorado River system at the international border.

Article II of the Colorado River Compact defines the Colorado River System and divides it into the Upper Basin and the Lower Basin. Lee Ferry, a point on the Colorado River main stem one mile below the mouth of the Paria River, divides the two basins. Article II also partitioned the states into the States of the Upper Division (Upper Division: Colorado, New Mexico, Utah and Wyoming) and the States of the Lower Division (Lower Division: Arizona, California and Nevada)

Article III(a) of the Colorado River Compact apportions to each basin 7.5 million acre-feet (maf) per year of consumptive use of the waters of the River. Article III(b) grants an additional apportionment of 1 maf per year of consumptive use to the Lower Basin.

The Mexican Water Treaty of 1944 established a federal obligation to deliver 1.5 maf of water per year to Mexico. Article III(c) of the Colorado River Compact sets out terms by which that treaty obligation would be shared between the Upper Division and the Lower Division--some portion of that federal delivery obligation may be the responsibility of the Upper Division. Interpretation of these provisions is controversial (CRGI, 2010). The federal obligation is often assumed to be equally apportioned between the Upper and Lower Divisions, but under the most severe interpretation, the Upper Division may bear transit losses on its share of the delivery obligation and may thus owe more than 0.75 maf/year at Lee Ferry. A conventional interpretation of Article III(c) is that the Mexican Treaty delivery is an annual obligation.

Article III(d) of the Colorado River Compact sets out the terms of an obligation on the Upper Division not to cause the 10-year cumulative flow at Lee Ferry to be depleted below 75 maf. This flow obligation will likely be the principal limiting constraint on consumptive use in the Upper Basin. The framers of the Compact expected that annual natural flows at Lee Ferry would typically substantially exceed 16 maf, which would satisfy the apportionments in Article III(a) and (b), and the obligations in Articles III(c) and (d), and leave a surplus, but that expectation is now understood to have been optimistic (Kuhn and Fleck, 2019). The delivery obligation of the States of the Upper Division for a share of the Mexican Treaty under Article III(c), and the non-depletion flow obligation under Article III(d) constitute a "combined flow obligation".

Article VIII of the Colorado River Compact exempts Present Perfected Rights (PPRs) in the Upper Basin from the apportionment and obligations set out in Article III[1].

The Upper Colorado River Basin Compact (UCRBC) apportions water among the Upper Basin states and sets out principles for curtailment in the event of a flow shortfall in Article III of the Colorado River Compact. Note that the UCRBC refers to Article III of the CRC in its entirety, and thereby incorporates shortfalls to any delivery required to satisfy any obligation of the States of the Upper Division to meet the federal Mexico Treaty delivery obligation.

Article III of the UCRBC sets out the apportionment of water among the States of the Upper Division and Arizona. Arizona is apportioned a fixed 50,000 af; the apportionments among the States of the Upper Division are set out as percentages of, "…the total quantity of consumptive use per annum apportioned in perpetuity to and *available for use each year* by Upper Basin under the Colorado River Compact and remaining after the deduction of the use, not to exceed 50,000 acre-feet per annum, made in the State of Arizona" [emphasis added], which are: State of Colorado, 51.75%; state of New Mexico, 11.25%, state of Utah, 23.00%; and state of Wyoming, 14.00%. The term "available for use each year" in Article III recognizes that, under some hydrologic conditions, the amount of water available for consumptive use in the States of the Upper Division may be less than the amounts set out in Article III(a) of the CRC, due to operation of Articles III(c) (treaty obligation to Mexico) and III(d) (Upper Division obligation) of the CRC, however those might be interpreted.

Article IV of the UCRBC sets out the procedures and requirements for curtailment of use in the States of the Upper Division (no provision is made to curtail any overuse in Arizona). Several parts of that

[1] PPRs will not be curtailed even if the flow obligation at Lee Ferry or the federal delivery obligation to Mexico are unmet.

article are important. First it requires the immediate "repayment" of over-consumption (relative to its or their percentage apportionment) by a state or states prior to any additional curtailment of use in other states. Second, after repayment of overconsumption, apportionment of any necessary curtailment is based on actual water use during the water year immediately preceding rather than on the percentages set out in Article III(a)(2). Third, it defines Present Perfected Rights according to the date of adoption of the CRC by the negotiators on November 24, 1922.

The principal reservoir in the Upper Basin is Lake Powell, with a current active capacity of approximately 20 maf, impounded behind Glen Canyon Dam, about 18 miles above Lee Ferry. Construction of Glen Canyon Dam, closed in 1963, added another layer to the Law of the River in the form of operating rules (Reclamation, 1970) legislated as part of the Colorado River Basin Project Act (1968), as subsequently updated (Verburg, 2010).

What might be the future interpretation of each of the elements of the Law of the River, and how they may be implemented, is broadly contentious and their precise nature will only be resolved by negotiation or prolonged litigation, or both (Robison and Kenney, 2012).

2.2. Curtailment of consumptive use in the Upper Division under the Colorado River Compact

In general terms, if the flow at Lee Ferry falls below the combined flow obligations set out in Article III(c) and Article III(d)--however these may eventually be interpreted--consumptive use in the Upper Basin must be curtailed to the degree necessary to offset any flow shortfall, except that PPRs are not subject to curtailment, according to the principles set out above under Article IV of the UCRBC.

2.3. Curtailment of water use by Utah under the Upper Colorado River Basin Compact.

In the event of a flow shortfall at Lee Ferry and a consequent curtailment of consumptive use among the States of the Upper Division, if Utah has, over the previous ten years, consumptively used more than 23% of the water determined to have been available for consumptive use in the States of the Upper Division, it would immediately have to curtail use (or deliver stored water) until that amount has been offset. If, after repayment of all overconsumption, a shortfall still remains at Lee Ferry, Utah (along with the other States of the Upper Division) would have to curtail its use or deliver stored water in the proportion that its consumptive use in the previous year bears to the total consumptive use in the previous year among the States of the Upper Division.

2.4. Curtailment of use under water rights within Utah

Should curtailment of consumptive use in the State of Utah become necessary, the Utah Division of Water Resources would have the responsibility of curtailing use under Utah water law, according to priority of appropriation date, subject to preferences in the event of a declared temporary water shortage emergency (Utah Code Ann. § 73-3-21.1). Curtailment of consumptive use under water rights perfected prior to November 24, 1922 (Present Perfected Rights) would not be necessary.

2.5. Utah's apportionment of water will vary depending on hydrology

The quantity of water available for consumptive use in the Upper Basin in any year is a function of the hydrology over the period between the time when reservoir storage above Lee Ferry is full and the reservoir is spilling and the time of a shortfall in the combined flow obligation at Lee Ferry. In general terms, the amount of water available for consumptive use in the Upper Basin during a dry spell is the water stored in reservoirs above Lee Ferry (primarily Lake Powell) plus the cumulative natural flow of the river at Lee Ferry, less cumulative evaporative losses and less the cumulative combined flow obligation. The quantity of water available for consumptive use in Utah during this period is 23% of the total amount available to the Upper Basin (after subtracting the fixed 50,000 af/year apportioned to Arizona).

The amount of water available for consumptive use in the States of the Upper Division, and thus in Utah, can only be known exactly at the time of a flow shortfall (Harding, 2019). The time between a reservoir spill[2] and a flow shortfall can range over decades, and it is impossible to predict hydrology over more than a seasonal time frame with useful skill. If the exact amount of water available for consumptive use were known at the time a spill ends, then water rights could be administered in perfect priority to avoid a curtailment but perfect, or even useful foreknowledge is impossible. The event of a flow shortfall is evidence that water rights have not been administered perfectly, and administration of the payback of over-consumption, or of curtailment to maintain flow at Lee Ferry would cause undue harm to senior water rights (Harding, 2019).

3. The Project would not be 100% reliable at the nominal yield.

The Project would be susceptible to curtailment, and the available information suggests that it would be curtailed at a significant frequency, but the DEIS does not address this probability. Without an evaluation of the reliability of the Project, its ability to meet its proposed purpose cannot be evaluated. The DEIS must quantify the reliability of the project in the face of compact curtailments and operation of a drought contingency plan (DCP).

As described above, the Project is susceptible to curtailment under the terms of the CRC and the UCRBC. Curtailment could reduce or even eliminate yield from the project for a year or more. As described below, evidence in the Project documents and the Colorado River Basin Supply and Demand Study (Reclamation, 2012) cited in the DEIS and its supporting documents, suggests that the Project could be curtailed at a significant frequency.

A DCP includes both a Demand Management Storage Agreement (DMSA), allowing for use of unfilled space in federal reservoirs, and demand management programs (DMP) for the Upper and Lower Basins. No Upper Basin DMP currently exists—its feasibility and potential scope is currently the subject of study by at least some states of the Upper Division. Reclamation (2019) contains a conceptual statement of purpose for an Upper Basin DMP.

> "The purpose of an Upper Basin Demand Management Program will be to temporarily reduce Consumptive Uses in the Upper Basin or augment supplies with Imported Water, if needed in times of drought, to help assure continued compliance with Article III of the Colorado River Compact without impairing the right to exercise existing Upper Basin water rights in the future." (Reclamation, 2019)

Augmentation of supplies would be extraordinarily expensive and politically complex and is unlikely to occur. Accordingly, without augmentation the Upper Basin DMP is solely a mechanism for prospective administration of consumptive use, so as to reduce the probability of a shortfall to the combined flow obligation at Lee Ferry. As such, operation of an Upper Basin DMP can be thought of as a pre-emptive curtailment, and diversions by the Project would likely be reduced when the DMP is in operation.

4. In the event of a curtailment, the Project would likely impair senior Utah water rights

As described above, and in Harding (2019), except in extraordinary circumstances, a curtailment will result in impairment of senior rights due to the accumulation of depletions by more junior rights. Because years or decades may pass between curtailments, the effect of excess consumptive use by

[2] A "spill" as used herein means that the reservoir is full. The infrastructure at Glen Canyon Dam is such that water may be released down the spillways when the reservoir is not full, but in the terminology adopted herein those flows would be considered "releases".

junior rights accumulates in Lake Powell. If the cumulative over-consumption under a junior right is more than its annual consumptive use, curtailment would extend to senior rights, thus impairing those rights (Harding, 2019).

For illustration, assume that the Project operates at its full annual capacity for ten years, and that it is the most junior water Colorado River water right operating in Utah. Over that time it will deplete about 860,000 af from the Colorado River, and those annual depletions will accumulate in Lake Powell with the result that the reservoir will be 860,000 af lower than if the Project had not been operating. If, at the end of that period Lake Powell is empty, and a shortfall in the combined flow obligation in the amount of 500,000 af results, that shortfall will be entirely due to operation of the Project over that ten-year period; absent the effect of the project, the reservoir would have been able to release 500,000 af, so no shortfall would have occurred, and still have contents of 360,000 af. But the Project, even if shut down completely, would make up only 86,000 af of that shortfall in one year; the remainder would have to be made up by curtailing other, senior water rights.

Even prospective administration, such as against "triggers" as contemplated by DMPs would likely impair senior rights. Only an after-the-fact settlement may be able to make senior rights whole (Harding, 2019).

5. The Project could cause impacts to Lower Basin water rights

A curtailment is intended to maintain flow at Lee Ferry sufficient to meet the combined flow obligation there. This may not be possible in in very severe conditions, particularly because consumptive use under Present Perfected Rights cannot be curtailed even if that means that the flow at Lee Ferry will drop below the combined flow obligation. In the event that the combined flow obligation at Lee Ferry is not fully met, the amount of water available for storage or use in the Lower Basin would be reduced, potentially impairing water rights there. Shortfalls to the combined flow obligation are possible based on analysis of prehistoric flow reconstructions (Harding, 2019) and will increase in frequency if climate change or megadroughts reduce flows of the Colorado River further.

6. DEIS ignores the effect of climate change on Project yield.

The DEIS adopts projections of hydrologic conditions under five future climate scenarios to show that Washington County Water Conservancy District (WCWCD) would experience 2060 supply deficits ranging from approximately 54,000 af to approximately 113,000 af, or more. These projected deficits are used to establish the need for the project. The project purpose is to supply water to the WCWCD to eliminate or reduce these deficits.

However, the DEIS applies inconsistent analytical approaches for the assessment of need and purpose. In assessing need, the DEIS quantifies the effect of climate change on water supply shortfalls to WCWCD, as noted above, but it ignores the effect of climate change when assessing the ability of the Project to deliver water, and assumes that the nominal annual yield claimed for the Project, 86,249 af, would be available in every year. The very research cited in support of the assessment of need offers a dire picture of future water supply on the Colorado River and suggests that the yield of the project is highly uncertain. Further, the hydrology studies incorporated into the DEIS documents suggest that the yield of the Project would not be reliable.

The DEIS cites recent published research by Udall and Overpeck (2017) and Milly and Dunne (2020) to support projections of lower flows on the Virgin River, and thus larger WCWCD supply shortfalls. However, the results in both Udall and Overpeck and Milly and Dunne encompass the entire Upper Colorado River Basin, and can be directly applied to natural flow at Lee Ferry. Both papers offer estimates of projected change in runoff (directly comparable to change in natural flow at Lee Ferry) due to projected changes in temperature. The expected value of flow changes at 2050 ranged from -7% to -

27% for Udall and Overpeck and -14% to -31% for Milly and Dunne. Very roughly speaking, these projections translate to reductions in water available to Utah of 240 thousand af (kaf) to 1 maf[3]. Both groups of authors state that it is possible that these reductions could be moderated by increases in precipitation, but that it is unlikely that those increases could fully counter the temperature-induced reductions.

Note that these projections are for changes to average flow. Multi-decadal-scale droughts are amply represented in the historical record, and more severe and sustained droughts are contained in the prehistoric record. Drought would compound the flow reductions due to projected changes average temperature. For example, Udall and Overpeck note a 16% reduction in flow during a 25-year drought in the prehistoric record.

7. The DEIS hydrology analyses are not based on sound science and sound assumptions

The DEIS reports results of hydrology modeling on the Colorado River. Two hydrology scenarios are used to generate this result, a historical scenario and a climate change scenario. However, these analyses are unrealistic, as they assume that a substantial part of the expected increase in basinwide consumptive use will not occur. In Appendix C-10 (Reclamation, 2020), Reclamation writes:

> In this modeling, Colorado Basin future total annual depletions are significantly lower than those modeled in the 2012 Basin Study and the 2007 Final EIS of the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (Interim Guidelines EIS; Reclamation 2007a). This is because for the purposes of this analysis all depletions except the Southern and Highway Alternatives and those identified as reasonably foreseeable held at 2060 levels were held constant at 2020 depletion levels.

Elsewhere in Appendix C-10 and in the DEIS, Reclamation characterizes this modeling decision as providing “the maximum impact”, but this is simply wrong. Each one of the seven Colorado River states plans to utilize fully all water that is physically and legally available to it. No justification is provided for this assumption of reduced basin-wide depletions, but even if one could be offered the assumption is scientifically incorrect and completely implausible, and renders useless the hydrology results on which the DEIS is based.

Reclamation did include a “sensitivity analysis” wherein full basinwide projected demands were used to simulate the Project, but only against the historical inflow scenario. Using the full basinwide projected demands is the correct demand assumption, but that assumption should be used in the main analysis. (The use of the direct natural flows to represent “historical” conditions overstates the performance of the Project, as is described more fully below.)

In the DEIS and in Appendix C-10, it is not clear exactly what depletions from the Colorado River were simulated in modeling the No Action Alternative. See the specific language below.

8. The DEIS does not provide a direct assessment of the reliability of the Project

As described above, the Project will be susceptible to curtailment by operation of the Colorado River Compact and the Upper Colorado River Basin Compact. The DEIS does not report, as part of its hydrology analyses, results that allow a direct assessment of the reliability of the Project. What is necessary are estimates of the frequency and severity of curtailments. A presentation of results that would provide this information would be a set of curves of the magnitude of 10-year cumulative flows

[3] Based on a long-term average flow at Lee Ferry of 15 maf. A 7% reduction of 15 maf is 1.05 maf, which would be borne by the Upper Division states. Utah is apportioned 23% of the water available to the Upper Division states; its share of the 7% reduction is thus about 240,000 af.

at Lee Ferry, for the 10th, 5th and 2nd percentile (corresponding to return intervals of 10, 20 and 50 years)[4].

9. What other DEIS hydrology analyses suggest about Project reliability

Three analyses of the water supply for the Project from the Colorado River are available: the presumably final analysis in Appendix C-10; Final Study Report 18, Surface Water Resources, dated April 2016; and Draft Study Report 18, Surface Water Resources, dated November, 2015. Each provides information beyond what is contained in the DEIS itself.

9.1. Appendix C-10: Hydrology

This analysis is the source of three charts presented in the DEIS showing model results for Lake Powell water surface elevation (WSE) in December. Very important modeling results were provided in Appendix C-10 but not included or even mentioned in the DEIS. In addition to the December WSE results, Appendix C-10 provides results for the probability that Lake Powell would fall below minimum power pool, and water-year release volume from Glen Canyon Dam. In addition, Appendix C-10 presents results for another scenario using a conventional assumption of full development in the Upper Basin[5] and the climate change hydrology. Results for that scenario are shown in the following figures.

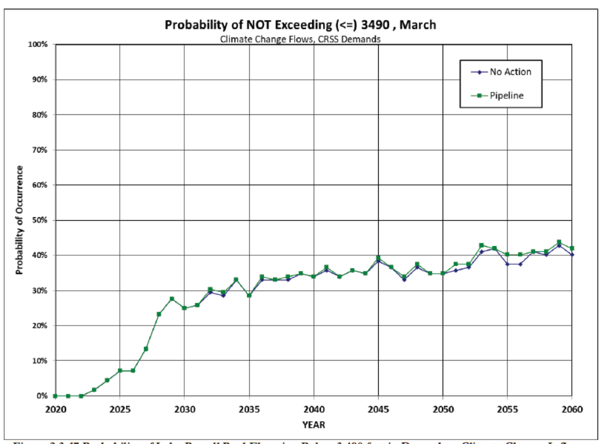

Figure 2.3-17 Probability of Lake Powell Pool Elevation Below 3,490 feet in December. Climate Change Inflows, 86kaf Lake Powell Pipeline Maximum Depletion.

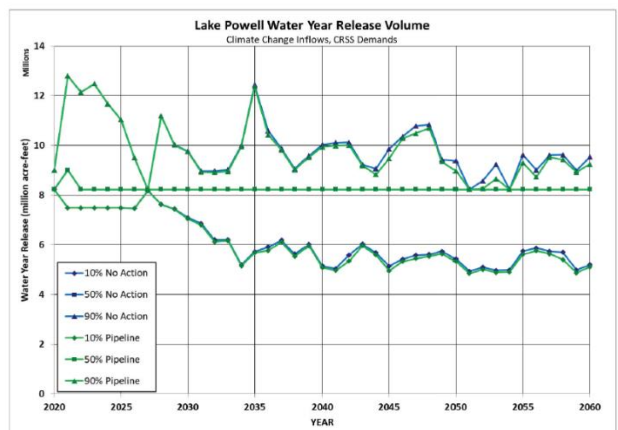

Figure 2.3-18 Lake Powell Water Year Release. Climate Change Inflows, 86kaf Lake Powell Pipeline Maximum Depletion.

Figure 2.3-17 (left) shows the probability of not exceeding the WSE of minimum power pool in Lake Powell (3,490 ft). Minimum power pool is the elevation at which generation at the hydroelectric plant at Glen Canyon Dam must cease, causing severe operational and financial impacts. A primary objective of an eventual Upper Basin DMP would be to maintain Lake Powell at or above minimum power pool. Figure 2.3-17 shows that the probability that Lake Powell would be at or below minimum power pool increases with time, and reaches 40% at 2060. Demand management practices (e.g. fallowing) act slowly, over a year or more, so this result suggests that an Upper Basin DMP would have to be active at all times, so the yield of the Project would likely be substantially reduced.[6]

[4] This would be similar to Figure 2.3-9 of Appendix C-10, Hydrology, but for the ten-year cumulative flow and for at least the three percentiles noted.

[5] Virtually every previous study of water availability in the Colorado River has included evaluation of what is termed "full development" in the Upper Basin. See, for example, Reclamation, 2007 and Reclamation, 2012.

[6] The agreement about Colorado River drought contingency management, Reclamation, 2019, sets a target level of 3,525 ft as the elevation when actions will be contemplated to protect against excessively low levels in Lake Powell. While this is an operational target, it illustrates that action will be contemplated well before the Reservoir

Figure 2.3-18 (right) shows the distribution of releases from Lake Powell during the study period. Of interest is the lower set of lines—releases from Lake Powell (through Glen Canyon Dam) were simulated to be at or below the levels shown in those lines ten percent of the time. (For example, in 2043, the simulation shows that in both the No Action and Pipeline cases the annual release would be less than or equal to 6 maf.) Under normal operations, an annual release of 8.23 maf from Glen Canyon Dam is considered sufficient to meet the combined flow obligation at Lee Ferry[7] and this is the usual operation. Releases below this level will lead to a flow shortfall to the combined flow obligation at Lee Ferry, which would precipitate a curtailment. Even a single year of low flow could cause a curtailment if the release over the previous nine years has been at the nominal level of 8.23 maf. Figure 2.3-18 shows that after about 2032 there would be a 10% probability that releases would be at or below 5 to 6 maf. These results suggest that the Project could be susceptible to curtailment one out of every ten years, on average.

Appendix C-10 adopted the same assumption about future basinwide depletions as the DEIS:

> Those depletions that cannot be defined as reasonably foreseeable remained constant at the 2020 depletion levels associated with the Basin Study Current Projected demand scenario. Those depletions assumed reasonably foreseeable are held constant at 2060 levels, and include the Central Utah Project, Animas-La Plata, Dolores Project, Navajo-Gallup, Ute Indian Compact, and Navajo Indian Irrigation Project.

Appendix C-10 describes the No Action Alternative this way:

> Under the No Action Alternative, the LPP would not be built and no other planned projects described in the No Action Alternative in Chapter 2 of this DEIS would affect the Colorado River. Therefore, there would be no effect to the Colorado River under this alternative.

Without a detailed report of the modeled depletions the disposition of the Colorado River supply for Project in the No Action Alternative is uncertain. A comparison of DEIS Figure 3.8.1, Appendix C-10 Figure 2.3-1 and Final Study Report 18 Figure 1 show similar differences between the Action and No Action alternatives, which implies that Appendix C-10 and the DEIS assumed that the water supply for the Project would not be developed elsewhere by Utah under the No Action alternative. The relatively small, and increasing magnitude of the differences between the Action and No Action alternatives in this modeling is attributable to the transient nature of the analysis and its arbitrary stopping point in 2060. This is only an inference, however—this imprecision in the DEIS prevents an assessment of the impacts of the Project.

9.2. Final Study Report 18, Surface Water Resources

Final Study Report 18 (UBWR, 2016) is based on hydrologic modeling conducted by Reclamation (Reclamation, 2015) included therein as Attachment 2, DRAFT Lake Powell Pipeline Hydrologic Modeling. The approach and results in Reclamation, 2015 are consistent with but not identical to

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approaches minimum power pool. This provides a perspective on the degree of conservatism that can reasonably be expected in an Upper Basin DMP.

[7] The combined flow obligation at Lee Ferry is assumed to be met if the flow at Lee Ferry is 8.25 maf annually, as this will provide 75 maf over a ten year period to meet the CRC Article III(d) obligation and 0.75 maf annually to meet the assumed Upper Division share of the federal obligation to Mexico. The Paria River joins the Colorado River between Glen Canyon Dam and Lee Ferry and contributes an annual average of 20,000 af (0.02 maf). Thus, the usual operation at Glen Canyon Dam is an annual release of 8.23 maf. Higher or lower releases are made under specific conditions.

results in Appendix C-10 and the DEIS. One difference in approach is that depletions that are not considered "reasonably foreseeable" are held at 2015 levels.

Reclamation, 2015 is explicit about whether water contemplated for diversion by the Project is assumed to be used elsewhere in Utah. It describes the No Action alternative this way.

> The No Action alternative assumes that if the Lake Powell Pipeline is not developed, Utah's unallocated water would not be developed somewhere else in the state. This analysis isolates the effect of adding a new project (Lake Powell Pipeline) to the mix of existing and reasonably foreseeable depletions in the Colorado River system.

9.3. Draft Study Report 18, Surface Water Resources

Draft Study Report 18 (UBWR, 2015) is based on hydrologic modeling conducted by Reclamation (Reclamation, 2010) included therein as Attachment 2, DRAFT Lake Powell Pipeline Hydrologic Modeling. Reclamation, 2010 differs in substantial ways from the subsequent reports described above.

It adopted two scenarios of future basinwide depletions, each with different assumptions about the No Action alternative:

- Final Planning Analysis: Assumes that future water development in the Upper Colorado River Basin would occur according to projections provided by the Upper Basin States. In this analysis the No Action alternative assumes that if Utah does not develop the Lake Powell Pipeline, that water *would* be developed somewhere else in the state.
- No Additional Depletion Analysis: Assumes water use in the Colorado River basin would remain constant at current levels, except for reasonably foreseeable future projects, which are held constant at 2009 depletion levels. In this analysis, the No Action alternative assumes that if the Lake Powell Pipeline is not developed, that water *would not* be developed somewhere else in the state.

As explained below, the No Additional Depletion scenario is not plausible and is not considered further here.

Reclamation, 2010 adopted two scenarios of future hydrology:

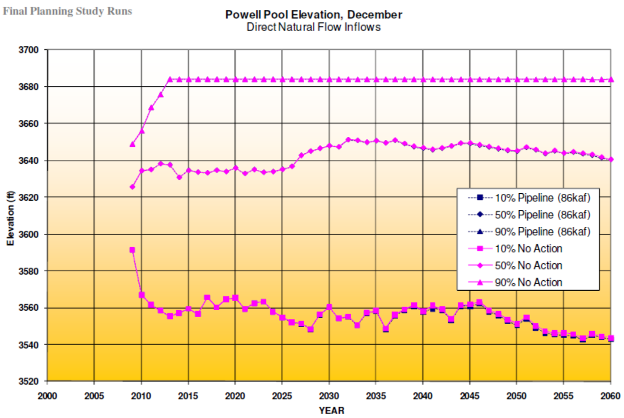
- Direct Natural Flow, Index Sequential Method (ISM): The future hydrology used as input to the model in this scenario consisted of samples taken from the historic record of natural flow in the river system over the 101-year period from 1906 through 2006.
- Nonparametric Paleo-conditioned (NPC) inflows: This inflow hydrology scenario uses paleo-hydrologic state information (i.e., wet or dry) to conditionally sample from the historic natural flow record. The paleo-hydrologic state information was derived from annual streamflow reconstructions from tree-ring chronologies of the years 762 to 2005 on the Colorado River at Lees Ferry (Meko *et al.,* 2007).

See Reclamation (2007) for details of the Index Sequential Method (Chapter 4) and the Non-Parametric Paleo-conditioned method (Appendix N).

The most notable result from Reclamation 2010 is the substantial difference in simulated Project performance between model runs using the ISM and the NPC hydrology, as shown in the following figures ("Selected results…"). The first row shows Figure 1 (left, based on direct natural flows, DNF/ISM) and Figure 7 (right, based on NPC) from Reclamation, 2010. These two figures show estimates of the future probability of Lake Powell WSE. Note that the two figures have very different

Selected results from Reclamation, 2010 (Draft Study Report 18, Surface Water Resources, Attachment 2)

Results based on Direct Natural Flows (ISM)



Lake Powell Pool Elevation, December. Direct natural flow inflows, 86kaf Lake Powell Pipeline maximum depletion.

Figure 1

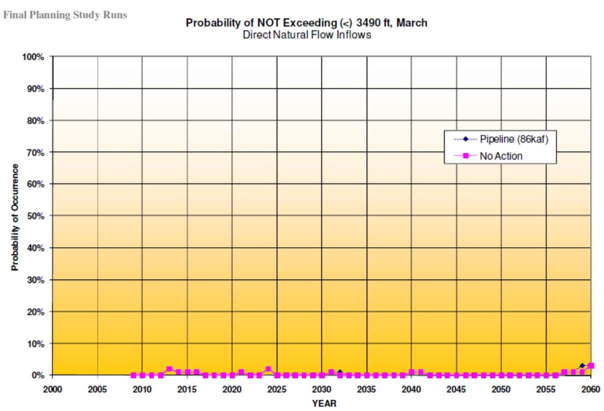
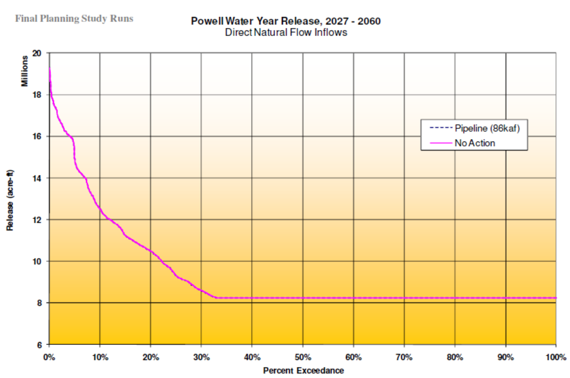


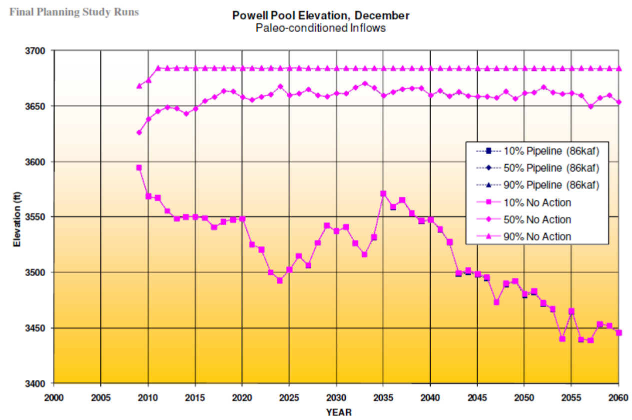
Figure 2. Probability of Lake Powell pool elevation being below 3490 ft in March. Direct natural flow inflows, 86kaf Lake Powell Pipeline maximum depletion.



(b)

Figure 4. Lake Powell water year release, flow duration curve throughout time during the Interim Guidelines period (a) and during the post-Interim Guidelines period (b). Direct natural flow inflows, 86kaf Lake Powell Pipeline maximum depletion.

Results based on paleo-conditioned flows (NPC)



Lake Powell Pool Elevation, December. Paleo-conditioned inflows, 86kaf Lake Powell Pipeline max depletion.

Figure 7

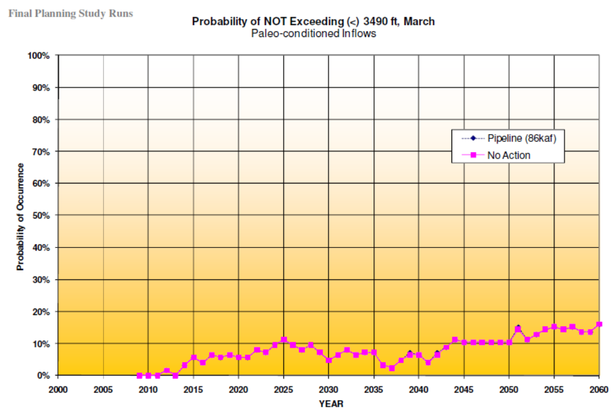
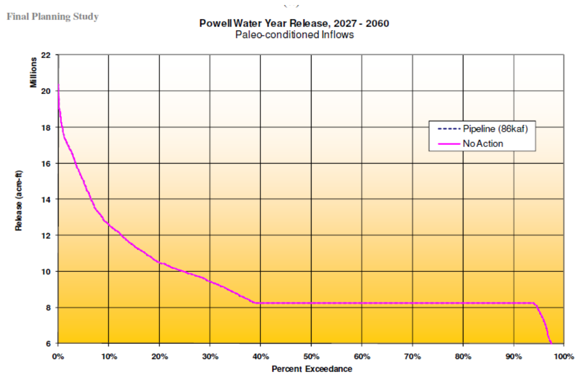


Figure 8. Probability of Lake Powell pool elevation being below 3490 ft in March. Paleo-conditioned inflows, 86kaf Lake Powell Pipeline max depletion.



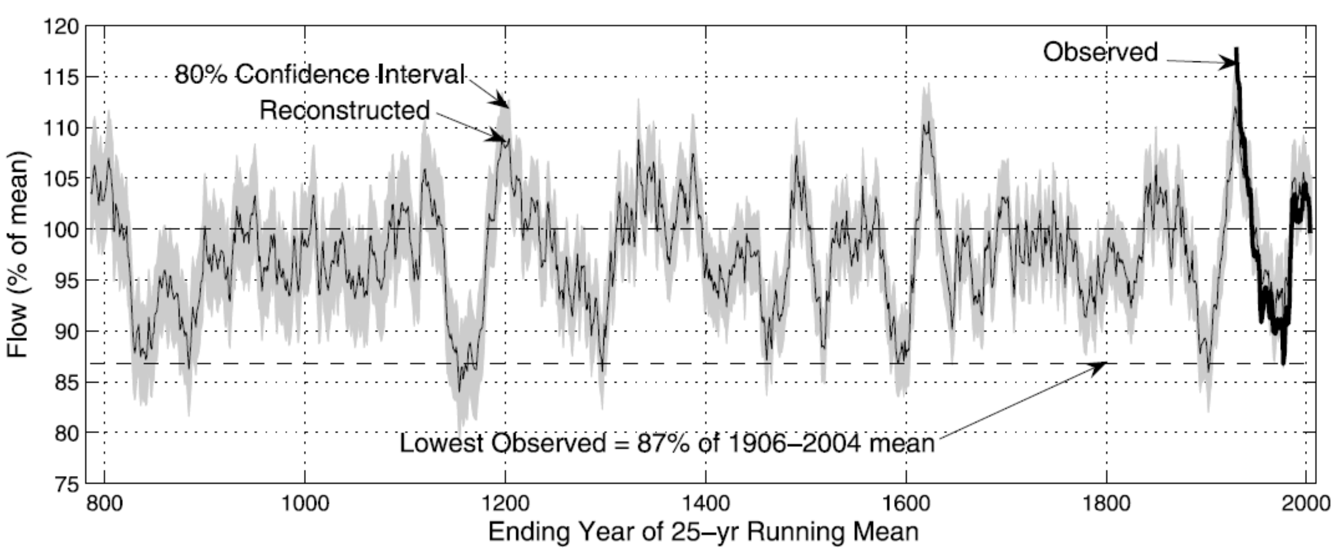
(b)

Figure 10. Lake Powell water year release, flow duration curve throughout time during the Interim Guidelines period (a) and during the post-Interim Guidelines period (b). Paleo-conditioned inflows, 86kaf Lake Powell Pipeline maximum depletion.

vertical axes. The 10th percentile WSE for the NPC scenario decreases dramatically after 2035, falls below minimum power pool in about 2050, and is decreasing when the analysis ends in 2060. The second row shows the probability that Lake Powell WSE would fall to or below minimum power pool. Figure 8 (right, NPC) shows the probability that Lake Powell WSE would fall to or below minimum power pool to be about 10% by 2045 (one out of every ten years) and 15% by 2060 (approximately one out of every seven years; the corresponding probability in Figure 2 (left, DNF/ISM) is virtually zero. The third row shows the cumulative distribution of annual water-year releases from Glen Canyon Dam. Figure 10 (right, NPC) shows the probability that Glen Canyon water-year releases would fall below 8.23 MAF to be about 5% (approximately 1 in every 20 years); the corresponding probability in Figure 4 (left, DNF/ISM) is zero (flows are at or above 8.23 MAF 100% of the time). Note that lowest value shown on the vertical axis of Figure 4 is 6 MAF and flows reach that level, or below, three percent of the time.

The results from the NPC analysis suggest that the Project would be vulnerable to reductions or elimination of yield due to operation of DCP/DMP or due to curtailment. The tenth percentile of Lake Powell WSE (first row, right) drops steadily after 2035 and drops below minimum power pool around 2050. The tenth percentile value is the elevation at which the reservoir will be *at or below* one year out of ten, on average. That the tenth percentile WSE is dropping in 2060 is an indication that the system is not sustainable and that the study period must be extended to adequately characterize the long-term performance and reliability of the Project. The probability of not exceeding minimum power pool (WSE of 3490 ft; second row, right) rises above 10% before 2045, reaches about 15% in 2055 and is still increasing in 2060. This result is consistent with Figure 7. The frequency distribution of water year releases from Glen Canyon Dam (third row, right) drops below the normal annual release of 8.23 maf about 5% of the time. This is equivalent to a flow shortfall in one out of every 20 years.

The differences between the results from the DNF and NPC scenarios are due to the peculiar nature of the historical record. The natural flow record on the Colorado River begins in 1906 and from that time until the 1920's the river enjoyed a sustained wet period. The ISM method steps through the historical hydrology record (101 years long, at the time of these analyses), first starting a simulation in 1906 that runs until 2006, then starting a second simulation that runs from 1907 through 2006 and then wraps around and includes 1906, and so on. This produces 101 separate simulations, the last one starting in 2006 and then wrapping around to pick up 1906 through 2005. However, each of the 101 simulations includes the wet period in the first part of the 20th Centurym, but that wet period was a very rare event—it is singular in the reconstructed period reaching back to year 762. Figure 2 from Meko *et al.*, 2007 illustrates this.



The Meko *et al.,* 2007 reconstructed record indicates that the early 20th Century wet period is wettest period in more than 1,200 years. Assuming only for illustration that the climate over the next 1,200 years would remain the same as it was in the last 1,200 years, then we could expect to see one wet period equivalent to that of the early 20th Century over that 1,000-year period. But, *each* of the 101 simulations from the DNF/ISM hydrology contains that wet period as one or two wet spells. This introduces a non-conservative bias into the evaluation of the performance and impacts of the Project. On the other hand, the NPC hydrology preserves the mean flow from the historical record within a few percent, but generates many unique synthetic flow sequences that are consistent with the variability shown in the Meko *et al.,* 2007 reconstruction. Because it was a very rare event, the NPC flow sequences do not contain a wet spell comparable to the early 20th Century. For this reason, the NPC method is the scientifically sound approach to evaluate the performance and impacts of the project under the current climate.[8]

9.4. The DEIS hydrology studies adopted assumptions and methods that overestimate reliability of the Project

9.4.1. Understating basin-wide depletions

The DEIS bases its assessment of the benefits and impacts of the Project on an analysis that does not reflect full development of all basin states. It offers a “sensitivity analysis” that does reflect full development as an ancillary analysis but that is actually the more appropriate analysis. The assumption in the DEIS that full development would not take place is simply not plausible, and constitutes an egregious error in the analysis of the performance and impacts of the Project. This assumption evaluates the Project in the context of a system where there is less competition for water than is plausible, so the Project will appear to be more reliable and to have less impact than would likely be the true case.

Beyond that bias, the DEIS does not quantify the degree to which basinwide depletions have been underestimated. The hydrology studies do provide a list of the model “nodes”[9] that have been included in the analysis, but to quantify the degree to which the decision to exclude other expected depletions has understated future basinwide development would require a high degree of expertise and access to the Reclamation models and datasets. While this is surely possible, the DEIS is deficient because it conceals this important information from the general public.

The DEIS rationalizes its assumption of less-than-full development on a narrow technical interpretation of what projects are “reasonably foreseeable”. Even though the development of an individual project may be uncertain, and therefore it is judged not to be “reasonably foreseeable”, full development by each Upper Division state of its available water supply is inevitable. Because the impact of any individual project on the water balance above Lee Ferry depends primarily on its consumptive use of water, and not on its location or other details, generic “placeholder” projects should be used to provide a realistic context for evaluation of the Project.

9.4.2. Use of DNF/ISM method

As noted above, the ISM method used to construct the flow sequences used as input in modeling of the Direct Natural Flow scenario always includes the anomalous wet period from the early 20th Century (Meko *et al*, 2007) so it overstates the reliability of the project because Lake Powell fills completely at least once in every trace. The NPC hydrology provides a better foundation for evaluating the

[8] The NPC does not reflect the future impact of climate change on the flows of the Colorado River. Rather, it provides a less-biased representation of the past long-term variability of the flow of the Colorado River.
[9] These are locations where depletions are simulated to occur in the Colorado Rivers Simulation System (CRSS) Model used by Reclamation.

performance of the project under an assumption of climate stationarity (i.e. an assumption that the future climate will be similar to that of the past 1,200 years).

9.4.3. Using transient climate-change analysis through 2060 overstates reliability of project

Reclamation consistently uses direct simulation of projected future natural flows based on future climate conditions projected by global climate models (GCMs; also called general circulation models) that are converted into natural inflows using a hydrology model; see Reclamation, 2012. This methodological choice overstates the performance (reliability) of the project for two reasons.

The first reason is related to the short study period used in the DEIS hydrology analyses, all of which end in 2060. The development plan for the Project does not have it begin diversions until 2027 and then depletions start at low levels and increase only gradually and do not reach full yield until 2049, so the Project's full impact is only simulated for eleven years. Projected changes in natural flow develop progressively throughout this century, with conditions at mid-century being substantially less severe than conditions at the end of the century (see, e.g., Harding *et al.*, 2012). Thus, the performance of the Project is being evaluated over a very short period that is not representative of the conditions that are projected to occur during the substantial majority of its service life. A proper evaluation of the reliability and impacts of the Project would use a "period-change" approach (Brekke, 2011) with a simulation period extending for at least the expected service life of the project after full development. The period change approach adjusts historical streamflows to reflect the projected average conditions at some future time. The period change approach has been used in numerous studies, including the Colorado River Water Availability Study (CWCB, 2012) and several studies by Reclamation: the St. Mary-Milk Basin Study (Reclamation 2010a), a yield study of selected reservoirs in Oklahoma (Reclamation 2010b), and the Northwest Area Water Supply Project, in North Dakota (Reclamation 2012a). The use of the period change approach has precedence in the DEIS as it was used in the Virgin River Climate Change Analysis as part of the "period composite delta" method (Reclamation, 2014; UBWR, 2016a). An appropriate future time frame for this analysis would be, at a minimum, at the mid-point of the expected service life of the project, but a more conservative choice would be at the end of its expected service life.

The second reason is that the current climate models understate decadal to multi-decadal (D2M) variability in precipitation in historical simulations of the climate of the Western United States, and elsewhere (Ault *et al.,* 2012). It is precisely D2M variability that is most critical for the performance of Lake Powell in the Upper Colorado River Basin. Paleo studies (such as the Meko, *et al.*, 2007 reconstruction) indicate that estimates of D2M prominence based only on the 20th century record may themselves understate the long-term condition. Thus, a future expectation of more severe and sustained drought overlaid on top of changes in mean hydrology is supported by research. The DEIS analysis does not adequately incorporate the current, accepted science about this issue.

10. Reclamation 2012 Supply & Demand Study suggests the Project would have poor reliability

The DEIS refers to Reclamation's 2012 Supply and Demand Basin Study (2012 Basin Study; Reclamation, 2012) to support the statement of need for the Project. Specifically, the DEIS cites to Reclamation, 2012 to rationalize the argument that in the face of climate change WCWCD should have a second source of water. However, the DEIS notably ignores the large body of results in Reclamation, 2012 that quantifiy the likely effect of climate change to reduce water availability from the Colorado River.

10.1. Reported curtailment frequency, volume

The 2012 Basin Study offers quantitative estimates of the frequency and severity of flow shortfalls at Lee Ferry. (Reclamation, 2012, Figure G-5.) Such flow shortfalls trigger curtailments of consumptive use in the States of the Upper Division. These results suggest that the reliability of the Project would be significantly less than 100%: After about 2040, the frequency of years with flow shortfalls in climate change scenarios range from about 17% to about 25% (roughly, on average, every fifth year) depending on the development scenario. The NPC scenario results in between 2% and 8% (roughly, on average, every 50th to every 12th year) depending on the development scenario. The distribution of the severity of curtailments is generally not influenced by the supply or development scenario: If there is a deficit, 10% of the time it wouldn't exceed 500,000 AF, 50% of the time it wouldn't exceed 2 MAF and 90% of the time it would not exceed 3.5 MAF. Conversely, 10% of the time the magnitude of the curtailment will exceed 3.5 maf. Any deficit would require repayment of overdrafts or curtailment of like amounts of consumptive use in the Upper Division. Multiply the basin-wide deficit by 23% (Utah's share under the UCRBC) to get a rough magnitude for Utah's share of a curtailment. As described below, the flow shortfalls at Lee Ferry, and therefore the volume of projected curtailments, from Reclamation, 2012, are understated due to omission of the Upper Division obligation to supply a share of the federal Mexico Treaty obligation.

10.2. Methodological shortcomings in the 2012 Supply & Demand Study

The 2012 Basin Study adopted methodological choices that understate the frequency, duration and magnitude of flow shortfalls and thus curtailments. Like the hydrology analyses for the DEIS, the 2012 Basin Study also uses a transient analysis framework and direct simulation of hydrology time series based on GCM outputs. As noted above (Section 8.4.3), these choices reduce the apparent hydrological stress on Lake Powell and therefore understate the frequency, severity and duration of flow shortfalls.

A more significant shortcoming, is that the 2012 Basin Study uses a non-depletion flow obligation at Lee Ferry of 75 MAF over ten years. The conventional assumption used in most analyses by Reclamation, and that is incorporated into the operating rules for Lake Powell, is that under most conditions the minimum release from Glen Canyon dam will be 8.23 maf, which is sufficient to provide an annual flow at Lee Ferry of 8.25 maf, which in turn is sufficient to meet the non-depletion obligation in CRC Article III(d) (75 maf over ten years) and an assumed equal share of the federal obligation to Mexico (0.75 maf, annually). See Section 2.1, above for context. The assumption of a ten-year flow obligation of 75 maf at Lee Ferry in Reclamation, 2012 ignores the obligation of the Upper Division to contribute some share to the federal Mexico Treaty delivery obligation (Reclamation, 2012c, Chapter 5). How that share will be quantified is in dispute, but there is no plausible argument that it will be zero; the conventional assumption is that the Upper Division will be required to deliver 0.75 maf (one-half of the federal Mexico Treaty obligation) each year at Lee Ferry. Thus, the modeling conducted in Reclamation, 2012, understates the amount of water that must be released from Lake Powell by 7.5 maf over every ten-year period. This results in a low bias in estimates of both frequency and severity of curtailments.

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