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MEMORANDUM

Comments on Inflows Modeling Working Group Preliminary Draft of Hydrology Development and Future Hydrologic Scenarios for the Salton Sea Ecosystem Restoration Program PEIR dated January 13, 2006

Introduction

I applaud the effort by the Inflows Modeling Working Group to include an uncertainty analysis of future Salton Sea inflows. All too often, this type of analysis is ignored despite numerous recommendations of its importance.[1] Investments of the magnitude considered for Salton Sea restoration demand just such an analysis in order to produce a robust design that has the flexibility to be adjustable over the wide range of possible future inflows. Historical evidence and current trends unequivocally point to greater water conservation in the future. Design and construction of a managed Salton Sea ecosystem that ignores this reality will lead to either very costly structural modifications before the half-life of the 75-year project-planning horizon, non-attainment of environmental/habitat goals, or the necessity for the State to acquire conserved water for inflows. A comprehensive uncertainty analysis of future inflows, coupled with the immediacy of the environmental issues, necessitates the choice of a highly scalable restoration design that can garner both regional and statewide acceptance.

Corrections to the Imperial Valley annual average inflows probability calculations and inclusion of the widely documented IID system conservation potential reduces the lower bound of average annual inflows from the Imperial Valley to less than 195 KAF. Coupled with lower bounds on average annual inflows from Mexico of 0 KAF and Coachella Valley below 50 KAF, with local watershed inflows about 20 KAF, average annual inflows to the Salton Sea could ultimately be reduced below 265 KAF.

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[1] See for example, *Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis*, M. Granger Morgan and Max Henrion, Cambridge University Press, 1990; and *Ground Water Models, Scientific and Regulatory Applications*, National Research Council, National Academy Press, Washington, D.C., 1990

The timing of these inflow reductions will depend on economic, political, and legal incentives to conserve water. If farmers are exposed to the economic opportunity cost of using water as expressed in numerous policy statements (referenced below) through proposed changes in effective water rights control and full exposure to the incentives to conserve water created by Section 1011 of the California Water Code, on-farm conservation could proceed at a rapid pace.

Ultimately with an efficiently managed distribution system and incentives for on-farm conservation, Salton Sea inflows originating in the Imperial Valley would be reduced to the tilewater leaching requirement, a small amount of system seepage through concrete lined canals, municipal return flows, surface runoff and subsurface inflow, net of evaporation and phreatophyte ET in the drainage system. With further incentives and improved management created by accurate measurement of all flows and diffusion of knowledge about the most practically successful conservation methods, average annual inflows from the Imperial Valley may be reduced to 200 to 250 KAF within 10 to 20 years.

The implication of these reduced inflows for the surface area of the no-action alternative Salton Sea is presented in the maps in Attachment B. The maps show the steady-state surface area of the Salton Sea under inflow assumptions of 200, 400, and 600 KAF/yr, the middle map approximating the more likely no-action outcome were this scenario to occur.[2]

The following comments are submitted for the purpose of supporting the wise uncertainty analysis approach undertaken by the Inflows Modeling Working Group and improving some of the technical details and practical interpretations of the generated inflows probability distributions.

The remainder of these comments discuss: 1) the types of future inflows uncertainty, 2) technical problems with the probability calculations, 3) the proposed probability distributions in light of historical evidence and current trends, 4) the timing of uncertain inflows reductions, and concludes with 5) some requests for clarification.

Types of Uncertainty

There are three main types of uncertainty and variability regarding future Salton Sea inflows:

1) Uncertain future annual mean flows
2) Inter-annual variation in flows
3) Intra-annual or seasonal variation in flows

In addition, there are modeling uncertainties tied to the assessment of each of these.

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[2] Maps produced by Dennis Coady. Sea surface area is calculated by balancing inflows with a total evaporation rate of 5.8 AF/AC, as well as a lower comparison value of 5.3 AF/AC. Neither decreases in evaporation resulting from higher salinity nor increases in evaporation resulting from temperature increases arising from climate change have been included in this calculation. The map is drawn based on the elevation equivalent to the surface area obtained from the surface elevation/surface area/storage volume relationship calculated by the U.S. Bureau of Reclamation and included in Appendix F of the IID, January 2002, QSA Draft EIR.

Each type can be assessed using probability distributions and the sources of uncertainty differ for the three main types. Type (2) and (3) variability will be important for design sizing of treatment and conveyance facilities in the Salton Sea Restoration Plan, but type (1) uncertainties are the key for long-term sustainability of any plan—ultimately any long-term equilibrium (with seasonal and inter-annual variation about mean water levels) is defined by the equivalence of mean inflows and mean evaporation (including evapotranspiration in any wetlands). Probability distributions for types (2) and (3) can be estimated with historical data, but these distributions may change dependent on the causes of any changes in future annual mean flows.

Given the economic, technological, environmental, political, and legal sources of uncertainty, the type (1) probability distribution can only be estimated with subjective probability distributions. The Hydrology Report Draft does a commendable job of pursuing this analysis approach. However, there are a number of technical problems with the probability calculations. Furthermore, given the wide range of probable expert and lay opinions about the relative probabilities of different outcomes, one must be careful in interpreting the resultant distributions too literally. The most fruitful approach would identify all the factors that could affect future annual mean inflows and then create a Salton Sea Restoration Plan that is robust over the range of identified mean annual inflows.

Technical Problems with Probability Calculations

The following discussion focuses solely on the uncertainty related to future annual mean inflows. The annual variability modeled with random selection of a sequence from the hydrological record should not affect the annual mean inflows distributions as presented in Figures 16, 20, 23, and 26. Since the long-term average inflow is most important for the long-term viability of any restoration project design, these comments focus on the 2018-2077 probability distributions.

Replication of the analysis in the Hydrology Report suggests that long-term variability of inflows reductions, as implied by the probability distributions in Figures 15, 18, 19, 22, and 24, are applied only in the 2018-2077 time frame, thus leading to shifts in the inflows distribution between the 2003-2077 and 2018-2077 analysis periods as evidenced in Figures 16, 20, 23, and 26. In other words, these figures imply a judgment that no additional reduction of tailwater or conservation in Mexico is possible prior to 2018 (i.e. the variability distributions in Figures 15, 18, and 19 do not apply to the time period 2003-1017. If this assessment is correct, it should be explicitly stated in the document. This apparent assumption raises a number of important timing issues which are discussed in the Timing of Inflows Reductions section below.

Possible Inflows from Mexico Under No Action Alternative - Variability Conditions

There are no problems replicating the analysis for Figure 16—Inflows from Mexico—based on the assumptions presented. The average annual inflows from Mexico for the period 2018-2077 have a minimum of 0 AF and a maximum of 97,044 AF.

Possible Inflows from Coachella Valley Under No Action Alternative - Variability Conditions
The average annual inflows point estimate from the Coachella Valley for the period 2018-2077 is 138,446 AF. The probability distribution for reduction of inflows from Coachella is uniform between 0 and 90,000 AF (Figure 22). Therefore, the lower bound of the long-run distribution should be 138,446 – 90,000 = 48,446 AF. The resultant cumulative probability distribution should be linear as in Figure 23, but it should extend down to 48,446 AF at 0% cumulative frequency.

Possible Inflows from Imperial Valley Under No Action Alternative - Variability Conditions
The analysis in this section has a number of problems that need to be resolved.

First, I present an alternative analysis that should elucidate the issues involved. For the period 2018-2077, the projected average annual inflow from the Imperial Valley prior to inclusion of QSA adjustments is 994,894 AF. The Hydrology Report states that tailwater represents between 39% and 68% of Imperial Valley inflows, or equivalently annual tailwater is between 388,009 AF and 676,528 AF. Figure 18 presents a uniform distribution for the reduction in tailwater between 0% and 100%. If tailwater is 68% and 100% of tailwater is conserved, then resulting average annual inflows from the Imperial Valley will be 318,366 AF (= 994,894 – 676,528). This must be the lower bound of the Imperial Valley inflows when taking into account only the conservation of tailwater.

There is a discrepancy between the text and Figure 18. The text states the distribution should be uniform up to a 90% reduction in tailwater. Even if this range is applied, the lower bound is still incorrect through a similar analysis. However, according to IID analysis of conservation potential: "Properly managed, drip irrigation systems conserve water by applying very close to the crop water requirement, which reduces tailwater and evaporation losses to nearly zero…drip irrigation often increases yield and crop quality" and "Linear tracking is a system of sprinkler irrigating a field using a linear move sprinkle…linear tracking system is assumed to have tailwater of one percent."[3] The same report states the current system capacity could accommodate converting 50% of the land area to drip and linear tracking systems; conversion of greater than 50% would require system updates. Moreover, MWD notes that tailwater is not prevalent in other irrigation districts in the western U.S. where there are similar soils.[4] Therefore, the long-term tailwater reduction probability distribution should retain a maximum reduction at or very near 100%.

There is no explicit provision for system conservation within IID in the Hydrology Report analysis. Scott reviews seven studies and finds a range of system conservation potential between 99,300 AF and 167,300 AF with a mean conservation potential of 125,300 AF.[5] In 1996, IID estimates system conservation potential as 122,600 AF[6] and some alternatives evaluated in the January 2002 QSA Draft EIR include 100,000 AF of system conservation. At a minimum, system conservation potential of 125,000 AF should be included in the

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[3] IID, January 1996, "Water Requirements and Availability Study, Draft," p. 46-48.

[4] MWD, May 2003, "Colorado River Part 417 Submittal," p. 28.

[5] Scott, John, May 2003, "Previous Investigations of Imperial Irrigation Districts net diversion requirements," Table 1, p. 3. A supporting document for MWD, May 2003, "Colorado River Part 417 Submittal."

[6] IID, January 1996, "Water Requirements and Availability Study, Draft," p. 75.

analysis (and perhaps as much as 167,300 AF). Assuming 125,000 AF system conservation potential and combining this with maximum tailwater reduction results in a minimum bound for the average annual inflow cumulative probability distribution from the Imperial Valley of 193,366 AF (= 318,366 – 125,000).

Now, to review the current Imperial Valley inflows analysis in the Hydrology Report Draft, one critical analytical issue is how the QSA is implemented within the calculation while still maintaining the stated conservation potential as expressed by the probability distributions.

Once the QSA is implemented, some of the conservation measures become certain, and the remaining probability distributions for future uncertain conservation need to be updated accordingly (Attachment A discusses the necessary updating procedure and produces a corrected version of Figure 20, which still needs to be modified for potential system conservation). As indicated in Table 6, once the QSA transfer is reduced to 250 KAF in 2047 an additional 50 KAF of conservation potential would need to be added back in, hence my recommendation to develop an analysis period from 2047-2077 to examine long-term steady state once all planned changes have occurred, to avoid these unwieldy dynamic probability calculations.

An initial system conservation potential probability distribution needs to be added to the analysis. A uniform distribution between 0 and 125 or 167 KAF would accord with the tailwater reduction distribution assumption. The shapes of these probability distributions are discussed further in the Interpretation of the Proposed Probability Distributions below.

Furthermore, the source of conservation for QSA deliveries should be specified as coming from either on-farm tailwater reductions or system loss reductions or a combination of both. The 300 KAF transfer anticipated in the QSA was analyzed in the January 2002 QSA Draft EIR based on an assumption of 200 KAF on-farm conservation and 100 KAF system conservation (see attached spreadsheet produced using IIDSS results from Appendix F of the January 2002, QSA Draft EIR). According to the schedule in Table 6, the QSA level of conservation would decline from 303 KAF to 250 KAF in 2047, thus this reduction in conservation (which is very unlikely to actually ever happen) would have to be reassigned to either tailwater or system conservation potential.

The assumption of the source of QSA conservation will reduce the remaining conservation potential for that source. For example, if the QSA includes 100 KAF of system conservation, the initial uniform distribution for system conservation between 0 and 125 KAF would need to be updated after a certain 100 KAF of system conservation to a uniform distribution between 0 and 25 KAF. (See also Attachment A for the procedure for updating the joint tailwater percent / tailwater reduction percent distribution)

In addition to conserving water for transfer, implementation of the QSA caps IID annual diversions at 3.1 MAF. The analysis in the Draft EIR indicates that this cap alone causes an annual inflows reduction of 59,161 AF (see attached spreadsheet Table 1). Future impacts of the cap on inflows under greater tailwater reductions depend on whether conserved water is transferred under Section 1011 of the California Water Code.

Finally, conservation could possibly be even greater through reclamation of drain water or reclamation of municipal return flows. IID's 1996 report referenced above contains conservation estimates for reclamation of drain water. Reclamation of municipal return flows for golf courses is likely as this industry develops similar to the pattern of golf course irrigation in the Coachella Valley.

Interpretation of Proposed Probability Distributions

The proposed probability distributions for future average annual inflows have two important properties: 1) the range of possible outcomes, and 2) the relative probability of the outcomes.

Since complete consensus about the relative probability of different outcomes will not occur due to the nature of these probability distributions (discussed below), their most important use will be as a tool to examine design flexibility based on the range of possible outcomes rather than a strict interpretation of the relative probability assigned to each outcome. Therefore, design sizing based on an arbitrary 80% exceedance probability is unwise, when there is no consensus agreement about the relative probabilities displayed in these distributions.

If the relative probability of the outcomes is to be used in restoration design analysis, such as using 80% exceedance probability to evaluate design response, then the input probability distribution for future tailwater and system conservation of inflows from IID need to be modified. With respect to the uniform tailwater reduction probability distribution between 0% and 100%, the Hydrology Report Draft states, "A uniform distribution was adopted since no compelling argument could be made to suggest one value was more likely than another."[7] Historical evidence and current trends contradicts this statement. A more accurate statement would be: "Over the course of the 75-year time horizon of the proposed restoration project, the least likely outcome is that no more water will be conserved beyond the currently planned QSA; in fact, near the end of this time horizon no additional conservation has zero probability of occurrence." Nearly every conceivable factor and trend points to greater water conservation in the future.

Economic, technological, farm management, political, and legal factors all point to greater water conservation and more efficient irrigation over time.

Historically, technological change in irrigation equipment and improvements in water management practices have always worked in the direction of greater irrigation efficiency. The pace of change depends on the magnitude of economic incentives either through the cost lowering aspect of technological change or as the price of water continues to increase. If IID implements the first recommendation of the USBR in its Part 417 Determination to develop an accurate system of water measurement, historical evidence in other areas indicates that accurate measurements are typically followed by more conservation. This historical evidence needs to be analyzed.

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[7] Inflows Modeling Working Group, January 13, 2006, "Preliminary Draft of Hydrology Development and Future Hydrologic Scenarios for the Salton Sea Ecosystem Restoration Program PEIR," p. 44.

While many of the identified water conservation methods proposed by USBR and MWD consultants during the Part 417 process are not cost effective under current institutional constraints and economic incentives, over the course of the restoration 75-year planning horizon, they are more likely than not to become cost effective under evolving water institutions and economic incentives based on the following documented trends.

There exists a long-standing policy trend toward allocative efficiency of water use through development of institutions that facilitate interregional or intra-regional transfers, such as water markets and water banks. This trend is supported by the stated policy of the U.S Department of the Interior,[8] by U.S. Federal Reserve Board economists,[9] by the U.S. Congress in the Central Valley Project Improvement Act, by the Congressional Budget Office for the reform of Bureau of Reclamation water supply policies,[10] by a National Research Council Committee formed under the auspices of the National Academy of Sciences,[11] by the California Business Roundtable with the California Chamber of Commerce, the California Farm Bureau Federation, and the California Manufacturers Association ,[12] and by environmental groups such as the Environmental Defense Fund.

The force behind this trend arises from the differences in the marginal value of water in alternative uses. Over the next 75 years as the population of California continues to grow, the difference between the marginal value of water in urban uses (greater than $250/AF) and agricultural uses ($18/AF in the Imperial Valley) will only continue to grow in the absence of more water transfers from California agriculture to California urban areas. This difference will continue to create political and economic pressure to transfer water to urban areas. Based on the direction of evolving water institutions, farmers will be able to lease conserved water under Section 1011 of the California Water Code and use the proceeds to invest in the conservation of tailwater while maintaining and potentially improving productivity through greater control of water and fertilizer application.

Over the next 75 years, the value of water will only increase. This one indisputable fact creates economic incentives to conserve, which will further reduce inflows to the Salton Sea. As these trends continue, the most reasonable conclusion is that in the future the sea will eventually have to be allocated water in order to maintain a managed ecosystem.

These are the forces that will shape the future amount of water conservation and inflows to the sea.

While I do not expect complete consensus in quantifying these trends, hence my recommendation to interpret average annual inflows probability distributions more for the range expressed than the relative probabilities, if I am asked to quantify the relative

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[8] U.S. Department of the Interior, May 5, 2003, *Water 2025: Preventing Crises and Conflict in the West.*

[9] Ronald H. Schmidt, Senior Economist, Federal Reserve Bank of San Francisco, “Diamonds and Water: A Paradox Revisited,” *FRBSF Weekly Letter*, December 4, 1992.

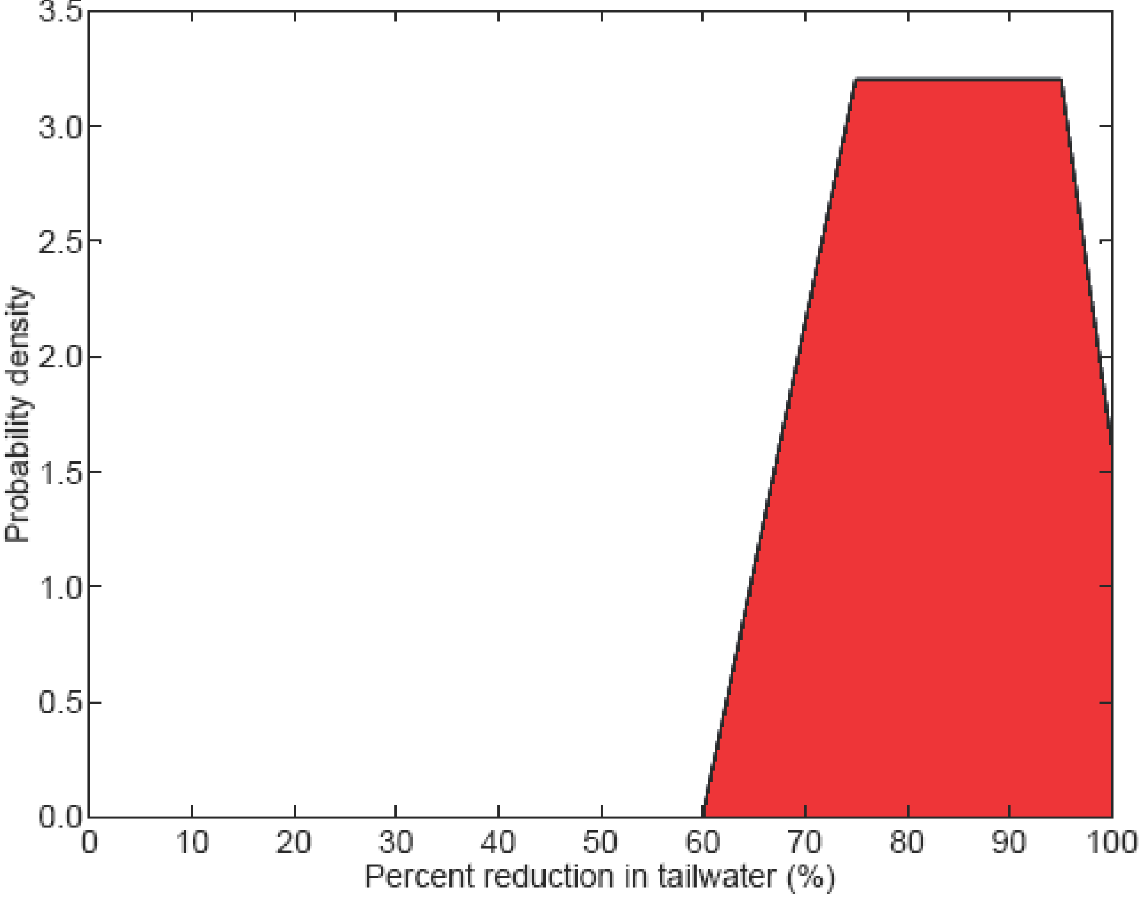
[10] Congressional Budget Office, *Water Use Conflicts in the West: Implications of Reforming Bureau of Reclamation’s Water Supply Policies*, August 1997, p. 16.

[11] Committee on Western Water Management, National Research Council, *Water Transfers in the West: Efficiency, Equity, and the Environment*, National Academy Press, Washington, DC, 1992, p. 3 and p. 249.

[12] California Business Roundtable, *A Model Water Transfer Act for California,* May 1996.

probabilities for reductions in tailwater for the 2047-2077 period after implementation of QSA reductions, my considered professional judgment is presented in the following graph for the midrange estimate of tailwater as a percent of inflows. (Description: 0% probability that less than 60% of the additional tailwater will be conserved, linear increase until 75%, uniform between 75 and 95%, and linear decrease from 95% to one-half the uniform probability magnitude at 100% conservation of tailwater.

Figure 1 - Distribution of Possible IID Tailwater Reductions 2047-2077



Timing of Uncertain Inflows Reductions

In reality, conservation and inflows reductions will occur over time. Since elicitation of probability distributions over time for future conservation percentages would be too unwieldy, the analysis should at a minimum be complemented with a discussion of timing issues.

For example, averages across time when conditions are changing are not very meaningful or informative for restoration design. An average annual inflow of 500 KAF over a 75-year time horizon from 2003 to 2077 could include inflows of 1000 KAF in 2003 and 200 KAF in 2077. In this case, targeting a project design to 500 KAF would be foolhardy.

Perhaps the analysis should be adjusted to reflect the uncertainty in the long-term steady state once all planned changes have occurred. This would appear to be the period 2047-2077 based on Table 6, after the QSA conservation declines to 250 KAF. Of course, inter-annual and intra-annual variability would remain. [Also, this 53 KAF reduction in conservation will never occur but can be handled by changing the conservation potential probability distributions.]

At the other end of the time horizon, the Hydrology Report Draft presupposes the implementation of the QSA despite challenges to its official validation. If the QSA is not validated based on its diminishment of the value of landowner water rights, landowners may gain control of the dispensation of their conservation. This would unleash economic incentives for landowners to conserve tailwater under Section 1011 of the California Water Code potentially causing a more rapid and greater magnitude tailwater conservation response than that envisioned in the district controlled QSA program. This possible situation deserves some analysis for its implications on Salton Sea restoration design.

Document clarifications

1) There is a discrepancy between the text on page 44 and Figure 18. The figure with its possibility of 100% tailwater reduction is the preferred to the text limiting reduction to 90%. The text and analysis should reflect this.
2) Replication of the analysis in the Hydrology Report suggests that long-term variability reductions such as conservation are applied only in the 2017-2077 time frame, thus leading to shifts in the distribution between the 2003-2077 and 2017-2077 analysis periods as evidenced in Figures 16, 20, 23, and 26. If this assessment is correct, it should be explicitly stated in the document.
3) Request for clarification of the final 30-year transfer to CVWD. The IID January 2002 QSA Draft EIR Table 2-5 and the “Colorado River Water Delivery Agreement” of Federal QSA Exhibit B both indicate a 100KAF transfer from IID to CVWD in the final 30 years while the text in the IID January 2002 QSA Draft EIR as well as the “Compromise IID/SDWCA and QSA Delivery Schedule” table included in numerous regional agreements that make up the October 2003 QSA indicate that 50KAF of this water is the responsibility of MWD from a yet unnamed source. Does the IDSS anlaysis on which the IID January 2002 Draft EIR is based include this transfer from IID as indicated in Table 2-5 or is this an error?

Attachment A

Since the Hydrology Draft Report does not discuss system conservation for IID, I will assume that all of the 270,950 AF average annual conservation which lowers Imperial Valley average annual inflows from 994,894 AF to 723,944 AF derives from tailwater reductions in the reports calculation.

Given that the percentage of tailwater is uncertain between 39% and 68%, updating the tailwater conservation distribution is somewhat problematic. Figure A1 shows the original joint uniform distribution domain for tailwater percent and conservation percent, a rectangle from 39% to 68% and from 0% to 100%, respectively. Lines of equal conservation volumes are also displayed on the graph, spaced at 30 KAF. The updated distribution domain is that part of the original domain beyond the approximately 270 KAF of average annual conservation for the 2018-2077 period. Numerically integration over this remaining conservation potential yields the cumulative distribution function for average annual inflows from the Imperial Valley when only tailwater conservation is considered as shown in Figure A2. Note that minimum annual inflows are 318,366 AF, and maximum annual inflows are 723,944 AF. In reality, there is a different conditional distribution each year since conservation envisioned in Table 6 varies from 193 KAF in 2018 to 303 KAF in 2026 and dropping to 250 KAF in 2047.

To implement this calculation with Monte Carlo integration, note that the distribution for the percent of the tailwater as inflows remains uniform between 39% and 68%, but that the bounds of the residual uniform distribution for tailwater reductions is now conditional on the percent of tailwater as inflows. For example at x = 39%, the range of y remaining is different than if x = 68% and varies continuously in between.

Figure A1 - Integration domain

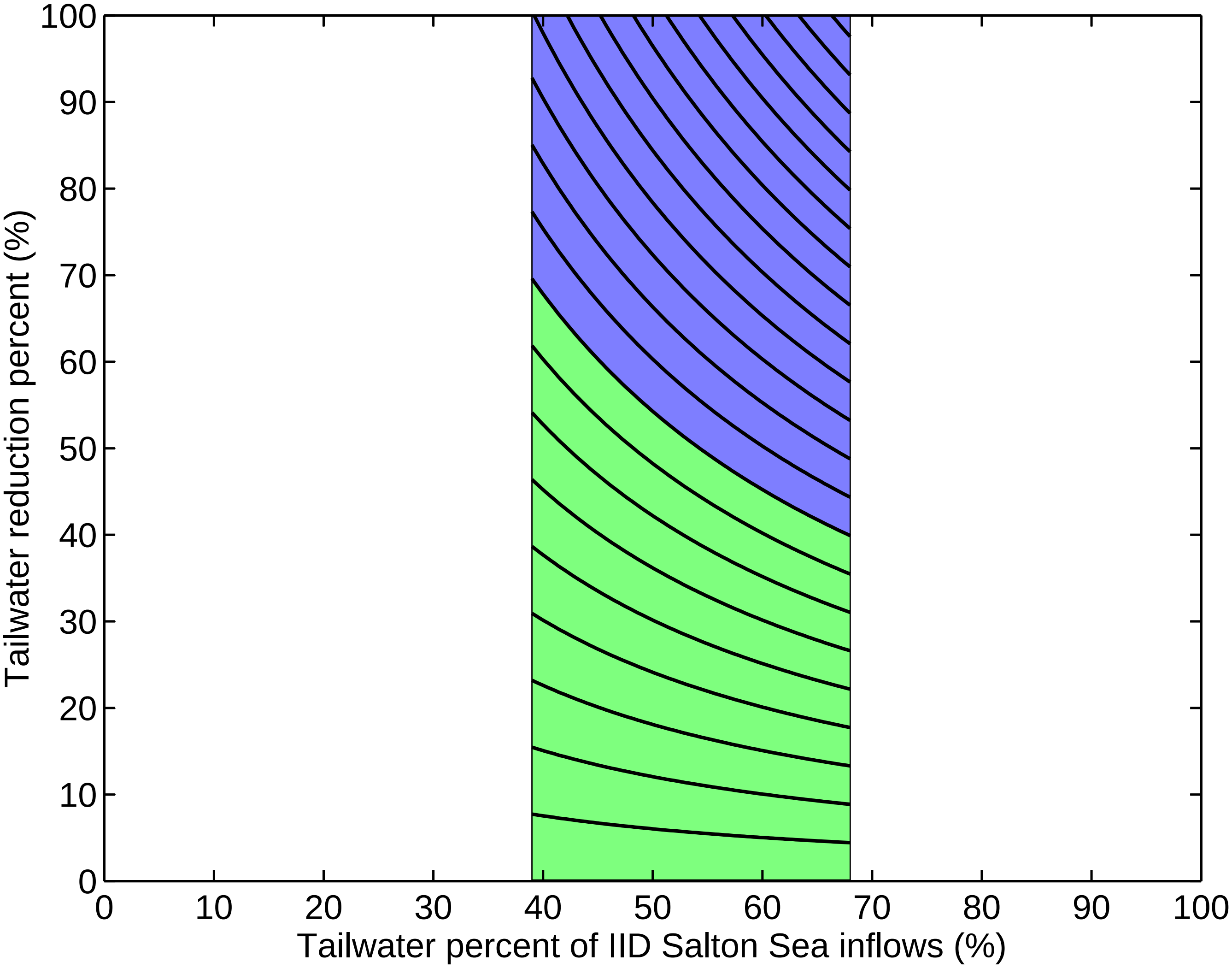
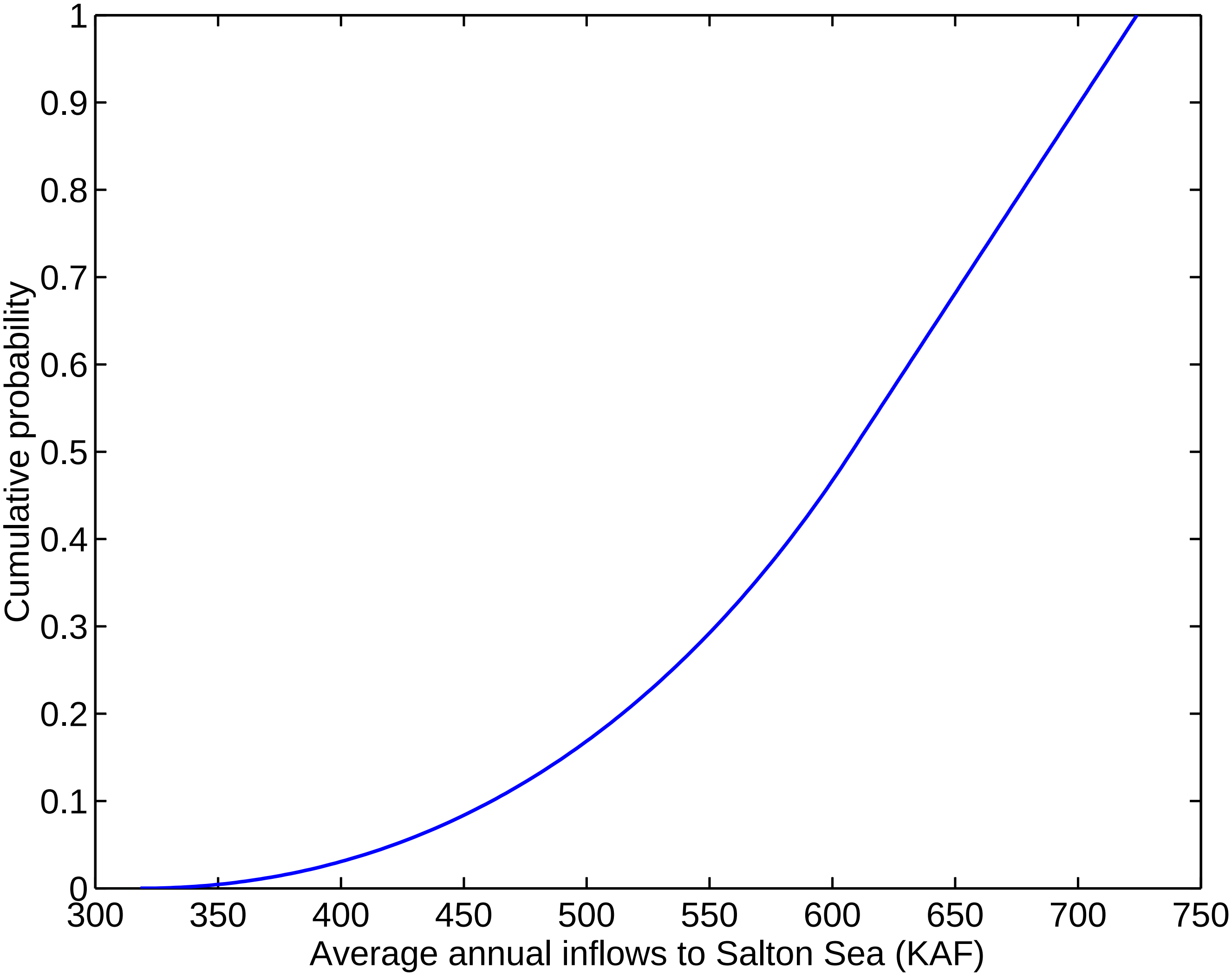


Figure A2 - CDF for average annual inflows from Imperial Valley
Tailwater conservation only



Attachment B – Steady-state surface elevation of no-action alternative Salton Sea over range of inflows and evaporation rates