MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Office of the General Manager

April 28, 2000

Mr. Tom Kirk
Executive Director
Salton Sea Authority
78-401 Highway 111, Suite T
La Quinta, California 92253

Dear Mr. Kirk:

July 9, 1999 Final Report Entitled *A Study on Seepage and Subsurface Inflows to Salton Sea and Adjacent Wetlands* (Seepage Study)

The Metropolitan Water District of Southern California (Metropolitan) would like to express its deep concerns regarding the recent approval by the Salton Sea Authority (Authority) to receive and file the Seepage Study and its accompanying model. Although Metropolitan was not invited to participate in the study, we could be severely impacted by the outcome of the Seepage Study. As a key stakeholder in the proposed All American and Coachella canal lining projects, Metropolitan conducted an extensive review of the Seepage Study and model. Our conclusion is that the study and model are seriously flawed and cannot be relied upon for making planning decisions. We strongly recommend that technically superior and widely accepted studies conducted by the U.S. Bureau of Reclamation (Reclamation) be used instead.

Funding for the Seepage Study was provided from the State of California's General Fund for the purposes of §12565(a) of the California Water Code. This section of the Water Code stated that:

> "The study shall determine the nature of subsurface and drainage canal water movements from the unlined canals to the Salton Sea and to existing adjacent wetlands, and shall quantify the amount of water that may be lost to the Salton Sea and to those wetlands due to the canal lining projects."

The following two Reclamation reports provide a superior analysis of these matters:

- Bureau of Reclamation; March 1994; *Draft Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project: Geohydrology Appendix*

- Bureau of Reclamation; December 1993; *Draft Environmental Impact Statement/Environmental Impact Report for the Coachella Canal Lining Project: Geohydrology Appendix*

These reports document Reclamation's extensive geohydrologic investigations of the Salton Sea area that included the drilling of numerous wells, collection of groundwater elevation data,

700 N. Alameda Street, Los Angeles, California 90012 • Mailing address: Box 54153, Los Angeles, California 90054-0153 • Telephone (213) 217-6000

chemical and isotope analysis of groundwater samples, procurement and analysis of aerial infrared photography, review and incorporation of past studies, and development of a groundwater model. In Metropolitan's opinion, Reclamation's studies provide a sound basis for decision making with respect to the implementation of the All American and Coachella canal lining projects.

The Seepage Study was dependent on data published in the documents identified above, however, its conclusions significantly disagree with Reclamation's findings. We are concerned that the Seepage Study report did not acknowledge these significant differences and did not investigate and resolve the differences. In addition, Metropolitan is concerned over numerous technical flaws which are summarized in this letter and are detailed in the enclosed observations.

Process by Which the Seepage Study Was Conducted

Shortly after the September 24, 1998 approval of SB 1765 by the Governor, by letter dated October 1, 1998 to the Authority, Metropolitan requested that it be kept informed of the progress of the Seepage Study. We subsequently attended the October 2, 1998 pre-proposal meeting held by the Authority. The next Seepage Study related notice received by Metropolitan was on July 8, 1999, when it received the agenda for the July 15, 1999 meeting of the Authority's Board. The agenda indicated that the Authority's Board would consider the Seepage Study report. A draft of the Seepage Study report's Executive Summary was included with the agenda materials, which reported the conclusions of the Seepage Study.

By letter dated July 14, 1999, Metropolitan informed the Authority that the Seepage Study's conclusions differed from Reclamation's findings and we requested an opportunity to review the Seepage Study documentation and model before the Seepage Study report was to be considered by the Authority. Although Authority staff confirmed receipt of our July 14 letter prior to the July 15, 1999 meeting of the Authority, its Board of Directors approved a motion to receive and file the Seepage Study report without discussion of the merits of Metropolitan's concerns.

Previous Studies Conducted by the U.S. Bureau of Reclamation

In 1994, in accordance with the National Environmental Policy Act (NEPA), Reclamation decided to construct a new concrete-lined canal parallel to 23 miles of the All American Canal. The Imperial Irrigation District similarly approved the project in accordance with the California Environmental Quality Act. These approvals were made with the understanding that there would be a negligible loss of inflow to the Salton Sea. Reclamation based its decision on geohydrologic investigations documented in the reports identified above. In May of 1999, Reclamation's Yuma Area Office completed its reexamination and analysis of the All American Canal Lining Project's Final Environmental Impact Statement/Environmental Impact Report dated March 1994 (EIS/EIR)

and the Record of Decision dated July 1994 (ROD). In that analysis Reclamation determined that "the NEPA compliance for this project remains current and comprehensive. There have been no changes in the Proposed Project/Preferred Alternative, action alternatives, nor significant new circumstances or information relevant to environmental concerns from those disclosed in the 1994 final EIS/EIR and ROD." In his November 22, 1999 memorandum to the Area Manager of the Yuma Area Office, Reclamation's Regional Director, Lower Colorado Region, concurred with these findings and stated that the project's completed environmental documentation remains valid.

With respect to the All American Canal, Reclamation concluded "that the amount of seepage that reaches the Salton Sea is insignificant, and that the [proposed lining] project would not have a significant effect on the level of the Salton Sea."[1] With respect to the Coachella Canal, Reclamation concluded that lining the Coachella Canal from Siphon 7 to Siphon 32 with implementation of mitigation measures "is not expected to change the inflow to the Salton Sea."[2]

Seepage Study Conclusions

The Seepage Study concluded that the reduced inflow to the Salton Sea from lining a portion of the All American Canal and the remaining earthen reaches of the Coachella Canal, including implementation of mitigation measures, could range from 3,000 acre-feet per year to 23,000 acre-feet per year. Page E-5 of the Seepage Study report states that "the most likely estimate for the amount of water that may be lost to the Salton Sea...is 10,000 acre-feet per year". This amount is important because it is over ten percent of the net annual yield anticipated from lining these reaches of the All American and Coachella canals and differs significantly with Reclamation's conclusions.

Contradictions in Findings

The Seepage Study report findings contradict findings published by Reclamation. Other contradictions with findings published by Reclamation and the U.S. Geological Survey include the following:

- Reclamation and the U.S. Geological Survey (and the Seepage Study's peer review panel) have concluded that subsurface inflow to the Salton Sea along its east shore is practically zero. However, the Seepage Study adopted a subsurface flow value of 8,000 acre-feet per year under existing conditions. The Seepage Study report's author appears to have confused prior surface flow estimates as subsurface flow. Furthermore, the Seepage Study model

[1] Bureau of Reclamation; March 1994; *Final Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project*, page III-10
[2] Bureau of Reclamation; December 1993; *Draft Environmental Impact Statement/Environmental Impact Report for the Coachella Canal Lining Project*, page III-11

results, as presented in the report, imply an illogical conclusion that this value increases after lining the All American and Coachella Canals.

- Estimated seepage from the East Highline Canal is poorly described and appears to disagree significantly with Reclamation's published estimate.

- As part of the calibration procedure, groundwater levels along the model's southern boundary in the Mexicali Valley were inappropriately raised from actual levels published by Reclamation by as much as 20 feet in order that the model's simulation of projected flow across this boundary would be closer to the amount anticipated.

The following contradictions within the Seepage Study report are confusing and lessen confidence in its value:

- With respect to lining the All American Canal, the second to last sentence on page 4-34 of the Seepage Study report reads, "...it is likely the actual volume of water lost to the Salton Sea would be significantly less than 6,650 af/yr." With respect to lining the Coachella Canal, the last sentence on page 5-26 of the Seepage Study report reads, "...the amount of water that may be lost from the Salton Sea due to the Coachella Branch is expected to be in the range of 0 to 1,500 af/yr." These values add to a maximum of 8,150 acre-feet per year, which is inconsistent with the Executive Summary's stated "most likely amount" of 10,000 acre-feet per year.

- Figure 3-7 of the Seepage Study report indicates that subsurface flow of water from a point beneath the All American Canal is southward into Mexico, then westward beneath the Mexicali Valley, where the flow turns north toward the Imperial Valley and onward to the Salton Sea. However, staff from HIS Geotrans verbally informed Metropolitan staff that the model assumes that simulated subsurface flow from a point beneath the All American Canal southward into Mexico exits the modeled area and does not return. Furthermore, the model does not include any subsurface flow from beneath the Mexicali Valley northward into the aquifer beneath the Imperial Valley.

Technical Flaws Found in the Seepage Study Report and Modeling

Numerous technical flaws contained in the Seepage Study report and modeling are documented in the enclosed observations. A list of references for each document consulted in Metropolitan's review of the Seepage Study report is attached to the observations. A sampling of those observations is as follows:

- Many comments submitted by the peer review panel were not addressed, most significant of which was the failure of the Seepage Study to include an error analysis of the model's water budget. The confidence interval for the model's output items is not identified.

- The sensitivity of the model's simulated subsurface and drainage canal water movements from the All American and Coachella canals to the Salton Sea and to existing adjacent wetlands was not evaluated.

- The model uses a value of 246 feet below sea level as the deepest portion of the Salton Sea. According to Reclamation, the bottom elevation of the Salton Sea is 278 feet below sea level.

- The canal stage and invert data entered into the model for the All American Canal, Coachella Canal, and the East Highline Canal do not agree with canal design and operational data.

- A water balance analysis to justify the assumed contributions of inflow to the Imperial Irrigation District's drainage system is not provided.

- The Seepage Study failed to verify the estimated seepage from the Coachella Canal by analyzing flow records collected by the Coachella Valley Water District since 1990.

- The effect of recharge to the regional aquifer from flows in the Colorado River below Laguna Dam and below Morelos Dam was not considered.

- The significant decrease in Salt Creek discharge to the Salton Sea since 1993 was not incorporated into the model.

- The Lower Colorado Water Supply Project wellfield was not incorporated into the model.

Reliability of Groundwater Models

Metropolitan agrees with the following statement contained in the June 12, 1999 letter from the Seepage Study's Peer Review Panel to Mr. Thomas F. Field of Tetra Tech:

> "The ground water model's ability to predict the effects of management decisions is limited by several factors. Models have inherent limitations based on translation of the real system to mathematical terms, and they have other limitations based on the quality of the input...The overall effect is to make the model seem more robust than it really may be."

For a model to project reliable results, it is imperative that it accurately incorporates all pertinent physical data. Assuming this can be done with the best accuracy possible, relatively small errors associated for each individual value entered into the model could accumulate such that the output

values contain a significant level of uncertainty. Unfortunately, as documented in the enclosed observations, many of the assumptions incorporated into the model disagreed significantly from findings of other reports. Some input, such as the groundwater contours in the region bounded by the Salton Sea and the Coachella Canal, were developed in the absence of field data. Of the 22 groundwater flows incorporated into the model, as listed in Table 3-1 of the Seepage Study report, Tetra Tech concluded that 12 of the assumed flows had an uncertainty of 20 percent or more, six items had an uncertainty of 10 to 20 percent, and the remaining four had an uncertainty of 5 to 10 percent. Given these uncertainties it would seem possible that the 95 percent confidence interval for projected reduction in inflow to the Salton Sea could be of considerable magnitude.

Water Resource Planning in the Salton Sea Basin

In summary, the modeling results and Seepage Study report are seriously flawed. Reclamation has completed a rigorous analysis of the same matters the Authority was tasked with studying under §12565(a) of the California Water Code. Reclamation's studies are superior and sufficient for decision making regarding the implementation of the All American and Coachella canal lining projects. We encourage the Authority to endorse the use of Reclamation's reports identified in this letter for the purpose of satisfying the requirements specified in Section §12565(a) of the California Water Code.

Very truly yours,

Dennis B. Underwood
Executive Assistant to
the General Manager

JLS:adb
o:\clustr10\mmshared\corres\comment_cover.doc

Enclosure

cc: Mr. William Rinne
Boulder Canyon Operations Office
Lower Colorado Region
U.S. Bureau of Reclamation
Post Office Box 61470
Boulder City, Nevada 89006-1470

Mr. Charles F. Keene
Senior Project Manager
Environmental Planning and Permitting
Department of Water Resources
770 Fairmont Avenue
Glendale, California 91203

Peer Review Panel:

Ms. Alice M. Campbell
Project Manager
SCS Engineers
3711 Long Beach Boulevard, #900
Long Beach, California 90807-3315

Mr. Ernest M. Weber
2726 Timberlake Drive
La Crescenta, California 91214

Mr. Dennis Williams
President
Geoscience Support Services
Post Office Box 220
Claremont, California 91711

Metropolitan's Observations on the
July 9, 1999 Final Report Entitled *A Study on*
Seepage and Subsurface Inflows to Salton Sea and Adjacent Wetlands (Seepage Study Report)

1. The third sentence of the last paragraph on page E-2 of the Seepage Study report reads, "A water balance was estimated for the AAC seepage, and 83 percent of this seepage flowed into Mexico, 8 percent was discharged as evapotranspiration, and 9 percent flowed into East Mesa and Imperial Valley." This statement does not agree with the water balance presented in Table 4-2 of the Seepage Study report. Of the 94,200 acre-feet of the Seepage Study report's estimated seepage from the All American Canal from Pilot Knob to the East Highline Canal, Table 4-2 estimates that 83,972 acre-feet (89 percent) flows to Mexico, 8,609 acre-feet (9 percent) flows to the East Mesa, and 1,619 acre-feet (2 percent) flows to either Yuma or the irrigated area of the Imperial Valley. A further contradiction is contained in the third paragraph on page 4-30 of the Seepage Study report, which reads, "Total consumption of seepage by evapotranspiration is estimated to be 7,669 af/yr, which accounts for only 7 percent of the 106,500 af/yr of seepage from the AAC between Pilot Knob and the East Highline Canal."

2. Figure 2-2 of the Seepage Study report depicts general geologic features for the study area. The source of the figure is indicated to be the California Division of Mines and Geology maps dated 1966, 1967, and 1962. Along the length of the East Highline Canal, Figure 2-2 disagrees with Plate 1 from Loeltz *et al.,* 1975. Figure 2-2 depicts the entire length of the East Highline Canal to be underlain by Quarternary lake deposits. Plate 1 from Loeltz *et al.,* 1975, however, depicts most of the length of the East Highline Canal to be underlain by alluvium. Loeltz *et al.,* 1975, is included in the Seepage Study report's bibliography, however, the Seepage Study report does not discuss this disagreement.

3. The second sentence of the last paragraph on page 2-6 of the Seepage Study report states that the first 49-miles of the Coachella Canal was lined in the late 1970s. From subsequent discussions and tables in the Seepage Study report it appears that it is assumed that the concrete-lined canal that replaced the first 49-miles of the original earthen Coachella Canal was completed in 1979. Actually, water was first turned into the concrete-lined canal on November 18, 1980. Thus on an annual basis it would seem prudent to assume that seepage along the first 49-miles of the earthen canal was first reduced in 1981. However, for the purpose of calibrating the seepage model, the first sentence of Section 6.2.4 of the Seepage Study report reads, "A transient simulation was conducted for the period from 1979, following the lining of the first 49 miles, to 2006." Thus the model assumed seepage along the first 49-miles of the earthen canal was reduced as of 1980, almost a full year earlier than actually occurred. As a result the model calibration adjustments were based on inaccurate baseline conditions.

4. The source of Table 2-1 on page 2-17 is not indicated. The last column of this table is indicated to be "All IID Area: Total flow to the Salton Sea". In actuality, this column represents the sum of the flow to the Salton Sea from the Imperial Valley and the Mexicali Valley in Mexico.

5. The second line on page 2-18 refers to "Salton Sea Authority 1998", however that reference is not listed in the Seepage Study report's bibliography.

6. The fifth sentence of the third full paragraph on page 2-18 states that Imperial Irrigation District "drainage canals" (the Imperial Irrigation District uses the term "drains") receive both tail water and tile drainage. In addition to these waters, the Imperial Irrigation District drains also receive water discharged from irrigation supply canals before it can be delivered to the fields.

7. The last sentence of the third full paragraph on page 2-18 reads, "The majority of the flow in the drain system is agricultural runoff, although some is intercepted groundwater that has moved up into the drains from the deeper aquifer near the east boundary of the irrigated area (Loeltz *et al.* 1975)." The following is the related passage from page K25 of Loeltz *et al.,* 1975:

> "Some of the discharge, however, is water that has moved upward to the drains from the *deeper aquifers*, principally near the east edge of the irrigated area." (italics added for emphasis)

It is noteworthy that Loeltz *et al.,* 1975, documented several alternating layers of sand and clay deposits. The Seepage Study report and model, however, assumes a three layer system consisting of an upper aquifer and a deep aquifer separated by an aquitard. The compilation of well logs from within the irrigated area of the Imperial Valley as contained in Table 4 of Loeltz *et al.,* 1975, depicts several alternating layers of clay and sand as demonstrated by the following two examples:

Well located at Township 14 South, Range 15 East Section 34, tract Q

Soil Type	Thickness (feet)	Depth (feet)
Clay	206	206
Sand	97	303
Clay	38	341
Sand, fine, and silt	83	424
Clay	16	440
Sand	21	461
Clay	4	465
Sand	16	481
Clay	5	486
Sand	24	510

Well located at Township 15 South, Range 16 East Section 29, tract Q1

Soil Type	Thickness (feet)	Depth (feet)
Clay	155	155
Sand	40	195
Clay, soft	65	260
Sand	40	300
Clay	15	315
Sand	9	324
Clay	20	344
Sand	19	363
Clay	22	385
Sand	5	390
Clay	70	460
Sand, fine, and clay streaks	80	540
Clay	14	554
Sand, and clay streaks	62	616

The Seepage Study report does not discuss the numerous alternating layers of sand and clay documented in Loeltz *et al.,* 1975, nor does it evaluate the ability of a three-layer model to accurately project the behavior of the actual multiple-layer geology.

8. The general aquifer description contained in Section 2.1.5.1 of the Seepage Study report ends with the statement, "Well-sorted, fine-to-medium sand of windblown origin overlies the confining lacustrine clay layers (Bureau of Reclamation 1989)." The Seepage Study report does not clarify that this statement was made in reference to the East Mesa only.

9. The first paragraph under Section 2.1.5.3 on page 2-29 lists major sources of recharge to the aquifer considered by the Seepage Study model. Major sources not included in the list include percolation from agricultural fields in Mexico, percolation from the extensive canal network in Mexico including the Alamo Canal which conveys Colorado River water diverted at Morelos Dam, and the Colorado River below Laguna Dam and below Morelos Dam. Although the Seepage Study report includes "percolation in the agricultural fields and the extensive canal network in central Imperial County", much of the Imperial Irrigation District's irrigation distribution system and a large portion of the irrigated area of the Imperial Valley west of the New River are not incorporated into the model. For the irrigated area included in the model, the Seepage Study report fails to quantify inflows into and flows out of the aquifer.

10. The last statement of the fourth paragraph on page 2-33 reads, "In Imperial Valley, approximately 2.9 million acre-feet of water is delivered annually to over 500,000 acres of agricultural land." Note that according to Imperial Irrigation District, undated, "Total Area Farmable" was 480,251 acres in 1996, 479,417 acres in 1997, and 479,327 acres in 1998.

11. The discussion contained in Section 3.2.2 on page 3-4 notes that the water table elevation in the area bounded between the Salton Sea and the Coachella Canal is not well understood. The Seepage Study report states that water level contour maps have not been previously published for the Salton Sea area. Despite this lack of data, groundwater contours were provided for the Seepage Study model. From these hypothesized contours the Seepage Study report arrives at conclusions as to the effect lining of the Coachella Canal would have on these contours and the subsurface inflow to the Salton Sea. The Seepage Study report does not discuss the reliability of the conclusions with respect to the assumed water level contours.

12. According to the text in the first paragraph of Section 3.2.2.1 on page 3-4, the Seepage Study report states that Figure 3-1, entitled "Composite Groundwater Level Contour Map for 1960-1965", is based on water level contours published in Loeltz *et al.,* 1975, Olmsted *et al.*, 1973, and the Bureau of Reclamation (Reclamation) 1991. The 1960 contours published in Figure 30 of Olmsted *et al.*, 1973, span from the Yuma Valley in Arizona to the East Mesa in Imperial County. The 1965 contours from Plate 1 of Loeltz *et al.,* 1975, encompass the Imperial County area from the West Mesa to the Southern Pacific Railroad that lies just east of the Sand Hills. The two contour maps overlap in the area that extends from the southwestern corner of the East Mesa to the vicinity of Pilot Knob. In this area there are considerable differences in the water level contours between 1960 and 1965. For example, Loeltz *et al.,* 1975, depicts the groundwater elevation beneath the turnout of the Coachella Canal from the All American Canal to have been between 100 feet and 120 feet above sea level in 1965. In this same area Olmsted

et al., 1973, shows the elevation to have been between 120 feet and 130 feet above sea level in 1960. The well hydrographs provided in Appendix E of the Seepage Study report indicates the elevation was approximately 112 feet above sea level (well no. 6926) in 1966. Overall, it appears that the area of the All American and Coachella canals encompassed by the 80 foot contour in Figure 3-1 of the Seepage Study report are based on those 1960 contours published by Olmsted *et al.*, 1973, which are approximately 10 feet higher than the 1965 groundwater elevations depicted in Loeltz *et al.,* 1975, and the well hydrographs provided in Appendix E. Thus Figure 3-1 of the Seepage Study suggests that elevations in the study area remained constant from 1960 to 1965 when the data indicates that elevation varied by as much as 10 feet.

In addition, the -60 foot and -40 foot contours depicted over the West Mesa in Figure 3-1 of the Seepage Study report do not correlate with the 1965 groundwater elevations depicted in Loeltz *et al.,* 1975.

13. The last sentence of the first partial paragraph on page 3-8 of the Seepage Study report notes that groundwater elevation in the vicinity of Pilot Knob showed a rising trend in the 1990s. The Seepage Study report attributes this rise to "heavy rainfalls in the 1990s producing the wet conditions observed in the cumulative precipitation departure data." Figure 3-2b of the Seepage Study report, entitled "IID Rainfall and Cumulative Departure from Mean Rainfall", indicates that the annual average rainfall for the study region is 2.93 inches per year. With respect to annual rainfall from 1994 to 1998 (the period in which a rise was observed in well no. 016S021E33E001S) the rainfall was approximately 5 inches, 3 inches, 2.5 inches, 1 inch, and 3.75 inches, respectively. While rainfall during this period was above the mean in 1994 (5 inches) and 1998 (3.75 inches) these values are extremely low from the standpoint of aquifer recharge. It is not self evident that such low rainfall would have a measurable impact on groundwater elevations, particularly if the rainfall was the sum of several relatively short-lived events. The seepage study did not identify the source of the precipitation data shown in Figure 3-2b. However, precipitation records from El Centro, California, (Hydrosphere, 1999) indicate that maximum daily rainfall from January 1990 through May 1998 exceeded one inch on only two occasions occurring in 1992 (1.86 inches and 1.08 inches).

Note that groundwater elevations in this area are influenced by a variety of factors that are more significant than recharge from local precipitation. Principal among these factors are:

- recharge from the Colorado River between Laguna Dam and Morelos Dam,
- recharge from the Colorado River below Morelos Dam,
- recharge from facilities that convey water from the Colorado River to irrigate lands in the Bard, Imperial, and Coachella valleys in California, the Yuma Valley in Arizona, and the Mexicali Valley in Mexico,
- recharge from the application of water to agricultural lands in the Bard Valley in California, the Yuma Valley in Arizona, and the Mexicali Valley in Mexico, and
- groundwater withdrawals from the Mexicali Valley and Yuma Valley.

Of these factors, recharge from the Colorado River below Morelos Dam is the most variable. Typically there is little or no flow in the Colorado River below Morelos Dam unless there are excess deliveries to Mexico. Page 42 of Reclamation, March 1994b, discussed this matter as follows:

> "Flow below Morelos Dam occurs when the upstream storage reservoirs are full and runoff is greater than demand. The frequency and duration of future 'excess flows' is the 'wild card' in predicting the amount of water table decline below pre-canal levels under the AAC at some future point in time. Infiltration (recharge to the delta aquifer) into the river bed along the limitrophe section of the International Boundary below Morelos Dam occurs during excess flows."

Delivery of Colorado River water to Mexico above Morelos Dam at the northerly international boundary is subject to the provisions of the 1944 Mexican Water Treaty, hydrology within the Colorado River Basin, and flood control releases from Lake Mead. Under the 1944 Mexican Water Treaty, Mexico is guaranteed the delivery of 1.5 million acre-feet of Colorado River water. In the event of extraordinary drought or serious accident to the irrigation system in the United States, thereby making it difficult for the United States to deliver the guaranteed quantity of 1.5 million acre-feet, deliveries to Mexico can be reduced in the same proportion as consumptive uses in the United States are reduced. However, if the United States determines that there exists a surplus of waters in the Colorado River in excess of the amount necessary to supply uses in the United States and the delivery to Mexico of the guaranteed amount of 1.5 million acre-feet, Mexico may schedule the delivery of an additional 0.2 million acre-feet. Pursuant to Minute 242 of the International Boundary and Water Commission, approximately 1.36 million acre-feet of the guaranteed amount is delivered upstream of Morelos Dam. Deliveries of Colorado River water that are in excess of the scheduled delivery upstream of Morelos Dam may result in releases from Morelos Dam into the limitrophe section of the Colorado River.

Figure 16 from Reclamation, March 1994b, is a chart of groundwater elevations beneath the Mexicali Valley and the accumulated volume of water withdrawn from the aquifer. From this chart it can be seen that the groundwater elevation began a continuous decline in 1961 to its lowest level in 1976. For calendar years 1979-81 and 1983-87 the groundwater elevation rose. These rises correspond with sustained high flows in the Colorado River at the southerly international boundary below Morelos Dam. During this recovery it can be seen that the annual rate at which water was withdrawn from the aquifer was reduced from approximately 1.2 billion cubic meters (973,000 acre-feet) from 1964 to 1969 to approximately 0.8 billion cubic meters (649,000 acre-feet) in 1985. As shown in Figure 1 to these observations, rising groundwater elevation correlates with the occurrence of flow in the Colorado River at the northerly international boundary that was at or exceeded two million acre-feet per year. Note that flow at the northerly international boundary was less than 1.9 million acre-feet for each year during the 1961 to 1976 decline and the single year decline observed in 1982. The surplus runoff in the Colorado River Basin from 1979 through 1988 was such that Mexico received an additional 0.2 million acre-feet of scheduled deliveries annually above Morelos Dam (except for 1982) plus a total of 56,334,463 acre-feet in excess of its scheduled delivery. In seven of those ten years excess flows exceeded one million acre-feet and in five of those ten years excess flows exceeded five million acre-feet. Based on Figure 16 of Reclamation, March 1994b, it would appear that

groundwater withdrawals from the Mexicali Valley are reduced when there are excess flows at the northerly international boundary. In addition, large volumes of water spread across the bed of the Colorado River below Morelos Dam and infiltrate into the aquifer. The significance of recharge from excess flows to Mexico appears to be well demonstrated.

In 1993 and 1995 there was 3.69 and 0.21 million acre-feet, respectively, of Colorado River water delivered to Mexico at the northerly international boundary in excess of its scheduled delivery. This water was primarily a result of runoff from the Gila River Basin. In 1997 and 1998 flood control releases from Hoover Dam resulted in 1.17 and 3.02 million acre-feet, respectively, of excess deliveries to Mexico. Thus, it is most likely that the observed rise in the groundwater elevation in the vicinity of Pilot Knob during the 1990s was the result of excess flows in the Colorado River at the northerly international boundary.

Another variable is the groundwater elevation in the Yuma Valley in Arizona. The relationship of groundwater elevation in the Yuma Valley and groundwater in the Mexicali Valley was described on page H95 of Olmsted *et al.*, 1973, as follows:

> "The other principal change [since 1960] is the generally lower water levels in Mexicali Valley, which resulted from pumpage for irrigation. These lower water levels together with generally unchanged levels for most of Yuma Valley resulted in an increased westward component of the water-level contours crossing the limitrophe section of the Colorado River. The increased westward component plus an increased ground-water gradient away from the river imply an increased outflow of ground water from the United States…
>
> "Movement of ground water in future years will depend on the changes in recharge to and discharge from the ground-water system. As long as ground-water levels in the United States remain relatively stable or continue to rise and water levels in Mexicali Valley continue to decline, the outflow from the United States will increase."

Note that the Gila River flood of 1993 deposited approximately 10 million cubic yards of sediment in the Colorado River bed from its confluence with the Gila River to Morelos Dam. This sedimentation raised the bed of the river by five feet and has resulted in higher groundwater levels beneath the Yuma and Gila valleys (Reclamation, August 20, 1999). These higher levels, according to Olmsted *et al.*, 1973, may have the effect of increased underflow from the Yuma Valley to beneath the Mexicali Valley.

The Seepage Study report does not identify these variables nor are they incorporated into the model.

14. The first full paragraph on page 3-8 notes that groundwater levels in many East Mesa wells show seasonal fluctuations with the highest levels occurring in March and the lowest levels occurring in September. The Seepage Study report postulates that the seasonal fluctuations are "associated with variations in canal leakage, which dominates the overall water budget in this area." The Seepage Study report continues by stating, "Water levels in the summer months may be falling because the net canal seepage is reduced due to evapotranspiration from the shallow groundwater between Drop 2 and the East Highline Canal." This statement is indicative of the fact that the Seepage Study overlooked the significant effect irrigation activities in Mexico have on the regional aquifer. Note that page III-3 of Reclamation, March 1994a, has estimated that

seepage from the All American Canal from Pilot Knob to Drop 4 comprises only 10 to 12 percent of recharge to the regional aquifer and is less in years when flow in the Colorado River at the northerly international boundary significantly exceeds Mexico's scheduled delivery.

Table 3-1 of the Seepage Study report estimates evapotranspiration from wetlands adjacent to the All American Canal to be 7,760 acre-feet per year. Table 3 from Reclamation, March 1994b, estimates that All American Canal seepage from Rock Section 2 to Drop 4 is 91,569 acre-feet per year. As estimated evapotranspiration losses are less than ten percent of the seepage loss, it is not clearly evident that the seasonal fluctuations are due to seasonal evapotranspiration rates. A more plausible cause of the fluctuation, which was not considered by the Seepage Study, is the groundwater pumping activity in Mexico. The Seepage Study report estimates current groundwater pumping in Mexico at 750,000 acre-feet per year. These extractions from the regional aquifer in Mexico are primarily for agricultural purposes and therefore withdrawal rates would likely be higher in the spring and summer months than in the late fall and winter months. It would seem more likely that pumping in Mexico would be the primary cause of the observed seasonal fluctuations in groundwater levels in the East Mesa rather than net seepage from the All American Canal.

15. The following discrepancies exist between the groundwater level contour map contained in Figure 3-3 and the well hydrographs contained in Appendix E.

a) In 1993 the water level for well 013S018E33A001S was approximately 107 feet above sea level. Figure 3-3 appears to indicate the assumed elevation is between 75 feet and 100 feet above sea level.

b) In the vicinity of Drop 2, Figure 3-3 depicts a groundwater mound that is slightly north of the All American Canal. However, the well hydrograph entitled "East Mesa – AAC Drop 2 Area Well Hydrographs" contained in Appendix E indicates that the water level is highest beneath the All American Canal (approximately 108 feet above sea level at well nos. 6932 and 6835) and decreases northward with increasing distance from the canal (approximately 100 feet above sea level at well no. 6826 and 94 feet above sea level at well no. 6814).

c) Other than a single well located near the Imperial-Riverside county line adjacent to the Salton Sea, the Seepage Study report provided no other hydrographs for the region that lies along the southwestern shore of the Salton Sea. Despite this lack of data, Figure 3-3 depicts contours in this region with a solid line, suggesting it is based on observations rather than inferred. Furthermore, the contours differ substantially from the contours depicted in Plate 1 of Loeltz *et al.,* 1975 (difference is from 20 to 150 feet).

d) In 1993, the water level for well 6730.5 was approximately 25 feet above sea level. Figure 3-3 indicates the assumed elevation in this area is between 40 feet and 50 feet above sea level.

The contours for the irrigated portion of the Imperial Valley are in substantial agreement with the contours depicted in Plate 1 of Loeltz *et al.,* 1975. This lends credence to the Seepage Study report's claim that groundwater elevations in this area are governed by the area's drainage system. Page K28 of Loeltz *et al.,* 1975, states that unconfined groundwater levels have been

stabilized at depths between 5 and 20 feet below land surface. However, page 6-10 of the Seepage Study report states that the model assumes the depth to groundwater beneath the irrigated area of Imperial Valley to be a uniform 6 feet below ground surface.

16. The last sentence on page 3-8 of the Seepage Study report states "the 1993 period was chosen because it is the most recent period with data in Mexicali Valley..." The source of the Mexicali Valley data is not identified here. It appears that the contours in Figure 3-3 are based on the contours shown on the figure contained in Appendix E that is entitled "Mexicali Valley Groundwater Level Contour Map for 1993." The source for these contours is indicated to be the May 1991 Reclamation document entitled *Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project: Geohydrology Appendix*. This document contains no information on 1993 groundwater levels in the Mexicali Valley. The document was updated and re-released in 1994 (Reclamation, March 1994b). However, the updated document did not include information on 1993 groundwater levels in the Mexicali Valley. Furthermore, in the region of the Mexicali Valley along the international boundary and east of Drop 4, elevations for 1993 as depicted in Appendix E do not correlate with the elevations depicted in Figure 3-3.

17. The first sentence of the first full paragraph on page 3-15 of the Seepage Study report reads, "Groundwater contours are generally unchanged from the 1960s data in Imperial Valley, the East Salton Sea area, Mexicali Valley, and the East Mesa Adjacent to the Salton Sea." With respect to the East Salton Sea area, this statement is made without any field observations. With respect to the Mexicali Valley, Figure No. 3 of Attachment D contained in Reclamation, March 1994b, indicates that the mean depth to groundwater elevations in Mexicali Valley fluctuated from 4 meters in 1957 to 10 meters in 1976 and rose to 6 meters in 1988. This contradicts the Seepage Study report's assumption that groundwater contours were generally unchanged from the 1960s data.

18. Figure 3-7 depicts the direction of groundwater movement as hypothesized by the Seepage Study based on contours depicted in Figure 3-1 (see item 12 for comments on Figure 3-1). The assumed direction of flow in the Mexicali Valley region does not appear to take into account the contours that existed beneath the Mexicali Valley as published in Figure 30 of Olmsted *et al.*, 1973, which depicts a southwesterly gradient away from the international boundary. The flow directions do not appear to reflect the effect of pumping in the Mexicali Valley either.

19. In the discussion of groundwater flow rates in the Imperial Valley contained in the first full paragraph of page 3-25, the Seepage Study report refers to "Bureau of Reclamation 1987". This reference was not included in the Seepage Study report's bibliography.

20. The last full paragraph on page 3-25 of the Seepage Study report states that groundwater withdrawals from the American Girl Mine and Mesquite Mine average 9,000 acre-feet per year for each mine. Elsewhere in the Seepage Study report, Montgomery Watson, December 1995, is cited as the source for these estimates. Other documents provide different estimates. With respect to Mesquite Mine, Bureau of Land Management, June 1995, states the following:

> "Mesquite Mine well field is approved for extracting up to 4,033 acre-feet of water per year ([Imperial County Conditional Use Permit] No. 684-84), based on maximum estimates of potential water demands for dust control, heap leaching and evaporation. The actual water use by the Mesquite Mine between 1987 and 1991 has varied from 700 to 1,100 acre-feet per year."

With respect to American Girl Mine, Bureau of Land Management, November 1997, states the following:

> "Ground water usage for the American Girl Mine operations was reported as less than 200 [acre-feet per year] …However, American Girl Mine has recently curtailed mining and milling operations and has substantially reduced its water consumption. The rate of production of water from the Mesquite Mine wells was reported at approximately 1,500 [acre feet per year]…"

Thus it appears that total withdrawals from the regional aquifer from wells operated by the American Girl Mine and Mesquite Mine is less than 2,000 acre-feet per year.

21. The third sentence of Section 3.4.1 on page 3-26 of the Seepage Study report indicates that the elevations of the various aquifer layers as input into the Seepage Study model can be found in Appendix G. Actually the figures that depict these elevations are found in Appendix F. Figure F-1 in Appendix F shows the contours of the top of Layer 1. As described in the Seepage Study report, it would appear that the top of Layer 1 would coincide with the land surface. However, the contours depicted in Figure F-1 show the top of Layer 1 to be approximately 100 feet lower than the land surface contours as depicted on Plate 1 of Loeltz *et al.,* 1975.

Interestingly, with the exception of the Salton Sea, the data from the input files of the Seepage Study report model (*.bcf files) appear to be consistent with actual topography. However, the deepest portion of the Salton Sea is set at -246 feet. Reclamation, May 1997, shows the bottom of the Salton Sea to be -278 feet.

22. The fourth sentence of Section 3.4.1 on page 3-26 of the Seepage Study report indicates that the elevation of the Salton Sea is 235 feet below sea level. According to elevation measurements recorded at U.S. Geological Survey station no. 10254005, the elevation of the Salton Sea ranged from 226.9 feet below sea level to 228.1 feet below sea level during the period October 1, 1997 through September 30, 1998. Indeed, the model results presented in Chapter 6 of the Seepage Study report show the elevation to be approximately 227 feet below sea level. The Seepage Study report does not acknowledge these contradictions.

23. The first paragraph under Section 3.4.2 on page 3-26 of the Seepage Study report lists major sources of recharge to the aquifer and discharge from the aquifer. Not included in the list of sources of recharge are percolation from agricultural fields in Mexico and the extensive canal network in Mexico including the Alamo Canal that conveys Colorado River water diverted at Morelos Dam. Not included in the list of discharges are groundwater withdrawals from beneath the Mexicali Valley.

24. The following observations pertain to Table 3-1 of the Seepage Study report:

a) Seepage from the first 49-miles of the original earthen Coachella Canal is indicated to be 130,500 acre-feet per year. The Seepage Study report notes "Fogg 1989" as the source, and

is described in the bibliography as "Fogg, Graham E., 1989, Modeling the Effects of Seepage on the Coachella Canal, Salton Sea Area." Has "Fogg 1989" been made available to the public? Has it been peer reviewed? Note that Reclamation, March 1984, estimated that seepage from this earthen reach was 141,000 acre-feet per year. The Seepage Study report failed to acknowledge this discrepancy. In addition, under the columns entitled "Timing" and "Comment" the period 1948-1979 is indicated. Note that the concrete-lined canal that replaced this earthen 49-mile reach was placed into service on November 18, 1980.

b) With respect to estimated seepage from "CB second 37 mile", which is interpreted to refer to the reach of the Coachella Canal from Siphon 7 to Siphon 32, "USBR 1992" is indicated as the source of the estimate. However, this reference is not included in the Seepage Study report's bibliography.

c) With respect to the estimated amount of groundwater discharge to the New and Alamo rivers, the column entitled "Timing" reads, "varies as per Table 2-2". There is no Table 2-2 contained in the Seepage Study report. "IID gauge data" is indicated as the source of the estimates under the column entitled "Reference", however, no such reference is included in the Seepage Study report's bibliography. The Seepage Study report does not describe how "IID gauge data" is used to estimate the amount of groundwater that discharges into the New and Alamo Rivers. Note that Loeltz *et al.,* 1975, discussed such discharge as follows:

> "The water-level contours on plate 1 indicate upward leakage of water from the main ground-water body to the Alamo and New Rivers and in the vicinity of the Salton Sea. However, the amount of such leakage averages only a few tens of thousands of acre-feet per year."

The Seepage Study report estimates total groundwater discharge into the New and Alamo rivers is as much as 90,000 acre-feet per year. This amount is significantly more than that estimated by Loeltz *et al.,* 1975.

d) Subsurface inflow into the modeled area from between the Cargo Muchacho and Chocolate mountains is estimated to be 2,000 acre-feet per year. The source of this estimate is indicated to be Olmsted *et al.*, 1973. However, Olmsted *et al.*, 1973, does not discuss nor does it speculate on groundwater movement in this area.

e) As discussed in item 20 above, total withdrawals from the regional aquifer from American Girl Mine and Mesquite Mine is less than 2,000 acre-feet per year.

f) "Recharge in irrigated areas" is indicated to be 50,000 acre-feet. Under the "Comment" and "Reference" columns, "<9 cm/yr" and "Schroeder *et al.*, 1991" is indicated. The meaning of "<9 cm/yr" is not identified by the Seepage Study report. If it were the assumed recharge rate, the resulting annual value for 500,000 acres would be less than 147,636 acre-feet, which could be much higher than the 50,000 acre-feet stated. The relevance of Schroeder *et al.*, 1991, is not clear as that document makes no claims as to recharge in irrigated areas.

25. The following observations pertain to estimates listed in Table 3-3:

a) Table 3-3 is entitled "Water Budget for Salt Creek Area", however the indicated estimate of canal seepage represents estimated seepage from Siphon 7 to Siphon 32, only a fraction of which is in the vicinity of the Salt Creek area. Inflow and outflow estimates are provided for the Hot Mineral Spa area that is outside of the Salt Creek drainage basin. The estimated "Wetland ET" appears to represent estimated evapotranspiration from all mapped wetlands between Siphon 7 to Siphon 32. Therefore it appears that a more appropriate title for this table should be "Water Budget for the East Salton Sea Region Adjacent to the Coachella Canal from Siphon 7 to Siphon 32".

b) The value indicated for "Canal Seepage" of 32,350 acre-feet per year is consistent with the annual amount of seepage from the Coachella Canal between Siphon 7 and Siphon 32 as estimated in Reclamation, December 1993a. The estimated seepage of 32,350 acre-feet per year was based on flow measurements taken upstream of Siphon 7 and downstream of Siphon 32 from 1981 through 1990. Note that after this period, the canal bottom between Siphon 14 and Siphon 15 was lined with a layer of polyvinylchloride and covered by a layer of concrete. The Seepage Study report does not acknowledge this lining which was completed in March 1991. Despite the variance of the annual estimated seepage as identified in Reclamation, December 1993a, and the lining between Siphon 14 and Siphon 15, the Seepage Study report failed to verify the accuracy of the estimate with flow records collected by the Coachella Valley Water District since 1990.

c) The estimated amount of outflow due to "Wetland ET" is indicated to be 38,010 acre-feet per year. The comment associated with this estimate indicates that it is based on an evapotranspiration rate of 5 acre-feet per acre. "CB EIS/EIR" is indicated as the source of the estimate, however this reference is not listed in the Seepage Study report's bibliography. Assuming this reference refers to Reclamation, December 1993a, Table III-4 of this document quantifies existing wetland acreage along Siphon 7 to Siphon 32 of the Coachella Canal at 7,412 acres. At an evapotranspiration rate of five acre-feet feet per acre this value would be 37,060 acre-feet per year, or 950 acre-feet less.

d) "Discharge to the Salton Sea" is estimated to be 8,000 acre-feet per year. The source of this estimate is indicated to be "486 K", which is understood to be Loeltz *et al.,* 1975. However, Loeltz *et al.,* 1975, does not discuss nor does it speculate on groundwater movement in this area. Hely *et al.,* 1966, makes the following observation:

> "Seepage from the Coachella Canal is a source of recharge for aquifers northeast of Salton Sea, but most of the water lost from the canal appears to be discharged by evapotranspiration and surface inflow rather than by ground-water inflow. The average annual loss from the canal in the reach bordering the sea is about 26,000 acre-feet, *of which about 8,000 acre-feet enters the sea from surface channels*. Evaporation from the canal, evapotranspiration from wet areas (chiefly stream channels covered with dense vegetation), and increasing ground-water storage could reasonably account for the rest." (italics added for emphasis)

Hely *et al,.* 1966, did not estimate the amount of subsurface inflow to the Salton Sea along the eastern shore, apparently concluding it was insignificant. Reclamation, December 1993a, makes the following observation about the destination of seepage from the subject reach of the Coachella Canal:

> "Virtually all seepage can be accounted for in consumptive use by phreatophytes, Salt Creek flow, and local uses."

Indeed, in page 2 of its June 12, 1999 letter to Mr. Thomas F. Field of Tetra Tech, the Seepage Study report's Peer Review Panel stated the following:

> "The geology of the northeast shore of the Salton sea precludes any significant subsurface flow to the Salton Sea. The low-permeability lake clays preclude subsurface flow and restrict infiltration of surface water. Other than the active and formerly active channels of Salt Creek, little subsurface flow could be reasonably expected. As a result, the major portion of available water supply is consumed by native vegetation with little or no subsurface flow to the Salton Sea."

With respect to "Discharge as Salt Creek baseflow", Reclamation, December 1993b, estimated that this "base flow" to the Salton Sea (i.e., flow that does not include flash floods) was 2,000 acre-feet per year. However, according to U.S. Geological Survey stream flow gaging station no. 10254050, measured discharge to the Salton Sea from Salt Creek has declined since 1993 to its lowest levels since 1961 when flow recording began (see Figure 2 attached to these observations). Current annual discharge is less than 1,000 acre-feet per year. Reclamation, December 1993b, postulated that Salt Creek discharge at the Salton Sea is a function of the supply inputs upstream and evapotranspiration of phreatophytes downstream of the supply sources. The following observation is documented on pages 32-33 of Reclamation, December 1993b:

> "The general Salt Creek flow is decreasing over the period of record with the latest data suggesting that the flow may be stabilizing. However, there are several cycles of large and rapid increases in creek flow followed by an equally rapid and large decrease. The large increase in Salt Creek base flow in 1981 is probably the result of the new artesian wells installed by Aqua Farms International in the Dos Palmas area in 1980 and 1981.
>
> "The decreases are believed to be caused by increased phreatophyte area induced by the increased flow. Salt Creek flow response in the early 1970's seems to support this hypothesis. Beginning in about 1970, measured loss from the canal increased markedly. From about 1975 to about 1985, the loss remained much higher than in the 1960's. Salt Creek flow also increased rapidly in the early 1970's, obviously in response to the increased leakage. However, there is a significant and subsequent <u>decrease</u> in Salt Creek flow. Whereas the early 1980's decrease in creek flow could have been caused by a decrease in artesian well flow, the 70's decrease could not have been caused by a decrease in available water because the measured canal leakage remained high. Consequently, an increase in phreatophyte area following a significant increase in available water is the likely explanation."

The continuous decline in measured Salt Creek discharge from 1993 to 1997 would be consistent with a gradual increase in the phreatophyte density upstream of the streamflow gaging station. If the decreased discharge to the Salton Sea was due to changed water management practices upstream by Aqua Farms International or other property owners, one would expect a dramatic or discontinuous change in discharge to the Salton Sea rather than the observed continuous decline. Indeed, the daily records from U.S. Geological Survey stream flow gaging station no. 10254050 (see Figure 3 attached to these comments) demonstrates that the general shape of the discharge curve is the same for water years 1987 through 1998. However, the magnitude of the daily flows has decreased steadily from 1993 through 1997 such that there is no flow during the months of May through September. This evidence suggests that the water supply input upstream of the mouth of the Salt Creek has

been consistent since 1987 while the evapotranspiration of this supply has increased. Thus it would appear that discharge to the Salton Sea has been replaced by phreatophyte evapotranspiration.

e) From the text contained in the comment column, it appears that the estimated amount for inflow item, "Salt Creek Area rising geothermal water", was set in order to balance the Table 3-3 water budget. Considering the above observations, it appears this value could be overestimated by 9,000 acre-feet (overestimate of "Discharge to Salton Sea" [8,000 acre-feet] and "Wetland ET" [approximately 1,000 acre-feet]).

26. The first sentence of the second paragraph of Section 4.1.2 on page 4-2 of the Seepage Study report reads, "Seepage rates were assumed to be negligible in the canal section immediately below Pilot Knob because the canal bottom was cut into low permeability rock." It is not clear what point on the All American Canal is referenced by the term "Pilot Knob". If it is in reference to the Pilot Knob Check, note that there are 0.84 miles of earthen canal between Pilot Knob Check and the upstream end of Rock Section 1 and 0.25 miles of earthen canal between Rock Section 1 and Rock Section 2.

The first sentence of the first full paragraph on page 4-5 of the Seepage Study report reads, "The total seepage loss between Pilot Knob check and the East Highline check is estimated to be 94,206 af/yr." Actually, this is the amount of seepage from Rock Section 2 to the East Highline Canal as estimated in Reclamation, March 1994b. The discussion contained in Section 4.1.1 of the Seepage Study report estimated annual seepage from the "upper gauge-defined reach" at 68,600 acre-feet and "lower gauge-defined reach" at 37,900 acre-feet for a total of 106,500 acre-feet. Note that the upper gauge-defined reach is from Station 1117+00 (2,039 feet downstream of the Pilot Knob Check) to Station 1973+00 (6,450 feet downstream of Drop 1). The lower gauge-defined reach extends from Station 1973+00 to the East Highline Canal. Reclamation estimated total seepage along the upper and lower gauge-defined reaches to be 105,322 acre-feet per year (Reclamation, March 1987).

Table 4-1 and Figure 4-2 of the Seepage Study report is inconsistent with past All American Canal seepage studies (Reclamation, March 1994b; Reclamation, March 1987). The following table would be consistent:

Reach	Length (mile)	Seepage* (acre-feet per year)
Pilot Knob Check to Station 1117+00	0.39	1,656
Station 1117+00 to Rock Section 1	0.45	8,566
Rock Section 1	0.14	0
Rock Section 1 to Rock Section 2	0.25	2,550
Rock Section 2	0.18	0
Rock Section 2 to Station 1250+00	1.51	6,464
Station 1250+00 to Drop 1	12.42	52,723
Drop 1 to Drop 2	5.20	17,883
Drop 2 to Drop 3	5.44	7,415
Drop 3 to Drop 4	5.29	7,084
Drop 4 to East Highline Canal	4.00	2,637
Subtotal Station 1117+00 to East Highline Canal	34.88	105,322
Total	35.27	106,978

*Seepage from Rock Section 2 to East Highline Canal based on values published in Reclamation, March 1994b. Seepage from Pilot Knob Check to Station 1117+00 is estimated to be 4,245 acre-feet per year per mile as estimated in Reclamation, March 1994b.

27. The first sentence of the last paragraph on page 4-5 of the Seepage Study report reads, "The preferred alternative for lining the AAC has been identified as the section between 1 mile west of Pilot Knob and Drop 3…" It appears this description was taken from Reclamation, March 1994a. "1 mile west of Pilot Knob" is in reference to the straight-line distance from Pilot Knob Mountain to Station 1250+00. More specifically, the preferred alternative is to replace 23 miles of the earthen All American Canal from Station 1250+00 to Drop 3 with a concrete-lined canal constructed parallel to the All American Canal. Note that Station 1250+00 is 2.92 miles downstream of Pilot Knob Check.

28. In the upper right corner of Figure 4-6, the Seepage Study report notes "1960 groundwater contour". However, this Figure 4-6 is entitled "Groundwater Level Contour Map for 1965." This figure is apparently based on Figure 3-1 of the Seepage Study report. As discussed in item 12 above, it appears that the area of the All American and Coachella canals encompassed by the 80 foot contour in Figure 3-1 and Figure 4-6 of the Seepage Study report are based on those 1960 contours published by Olmsted *et al.*, 1973, which are approximately 10 feet higher than the 1965 groundwater elevations depicted in Loeltz *et al.,* 1975. The Seepage Study report does not acknowledge this discrepancy.

29. The first sentence on page 4-15 of the Seepage Study report reads, "The water level rise in East Mesa wells 7906.37 and 7904.37 indicates that by the 1960s, the rising groundwater table attributable to canal seepage had stabilized in a near steady-state condition." Hydrographs of these wells are shown in Figure 4-4.

For well 7906.37, prior to 1968 the curve shows annual fluctuations suggesting several data points during each year (unfortunately observed data points from which the curve is based are not identified). By the mid 1950s groundwater levels in well 7906.37 peaked at about 117 feet and by the end of the decade declined to about 112 feet. From the mid 1950s through the mid 1960s the groundwater elevation fluctuated within this five-foot range. From 1968 through 1979 the curve for well 7906.37 becomes a straight line which appears to be due to no data points collected during this period. It appears the 1980s portion of the curve is based on a few annual observed data points and thus the annual fluctuations observed from the data collected before the 1970s is not apparent from Figure 4-4.

For well 7904.37, the curve appears to be based on the hydrograph contained in Figure 8 of Reclamation, March 1994b. While no data points were provided from January 1955 through June 1960 in Figure 8 of Reclamation, March 1994b, Figure 4-4 of the Seepage Study report appears to assume that the groundwater elevation declined steadily from the elevation observed in December 1954 to the elevation observed in July 1960. In every year from 1964 through 1968, Figure 8 from Reclamation, March 1994b, indicates that the well was dry for much of the year and thus the actual groundwater elevation was at some unknown depth below 114 feet above sea level. However, Figure 4-4 indicates the groundwater elevation during these periods to be 113 feet above sea level. From 1968 through 1979 the curve for well 7904.37 becomes a straight line which appears to be due to no data points collected during this period. From Figure 4-4 groundwater elevations appear to have fluctuated within a range of 5 to 10 feet during the 1960s and 1980s. As Reclamation, March 1994b, indicates that the groundwater elevation was at some unknown level below 114 feet at times between 1964 and 1968, the actual fluctuation may have been greater.

Note that the observed fluctuations suggest that factors other than seepage from the All American and Coachella canals, as discussed in item 14 above, may also have a significant effect on groundwater levels beneath the All American Canal. Note that the magnitude of the annual fluctuations observed for well 7904.37, which is east of Drop 2, was larger than the annual fluctuations observed for well 7906.37, which is west of Drop 2. This would be consistent with the following discussion contained on page 42 of Reclamation, March 1994b:

> "Holes drilled between Pilot Knob and Drop 1 penetrate a few thin clays which probably have an insignificant areal extent. Hydraulic conductance between this reach and the [Mexicali] wellfield is probably high. Therefore the post lining steady state water table will generally be lower than the pre-canal water table. However, as one moves west of Drop 1, drill holes penetrate more and thicker clay layers. Somewhere between Drops 2 and 3 the thickness and number of clay layers is believed to be sufficient to prevent the post lining wellfield dewatering (reduction in [East] Mesa groundwater storage to less than pre-canal) from reaching west of the Drop 3 area."

Thus there is considerable evidence that suggests that the groundwater levels west of Drop 3 would not change significantly if aquifer recharge east of Drop 2 were decreased.

30. The second sentence of Section 4.2.4 on page 4-15 of the Seepage Study report reads, "In the vicinity of the AAC, water table elevations were generally quite similar to those under 1965 conditions." A similar statement is made in the third sentence of the second paragraph under Section 4.4 on page 4-16 of the Seepage Study report. However, inspection of Figure 4-6 and

Figure 4-9 reveals that along the reach that stretches from Drop 1 to Drop 3 there appears to be a difference of approximately 10 feet between the contours depicted for 1965 and 1993.

31. The last sentence of the first full paragraph on page 4-29 of the Seepage Study report reads, "Because water levels stabilized in the late 1980s following the lining of the first 49 miles of the CB, the 1993 water levels depicted in Figure 4-9 are thought to represent steady state and current conditions." With the exception of well nos. 016S021E31P001, 016S021E33E001S, and 016S020E27C001S, well hydrographs depicted in Appendix E support this statement. However, hydrographs for the previously listed wells show an increase in elevation of 13 feet, 10 feet, and 4 feet respectively. The observed rise is consistent with the other sources of recharge identified in item 13 that have a significant effect on groundwater elevations beneath the All American Canal.

32. The first paragraph of the discussion under Section 4.4.3 on page 4-30 of the Seepage Study report notes the presence of seepage recovery drains along the All American Canal. The most easterly of these drains, All American Canal Drains 2 and 2A, discharge into the East Highline Canal. From its discharge point at the East Highline Canal near the line between Township 16 South and Township 17 South, Drain No. 2 runs parallel to the East Highline Canal southward for about a half mile before making a 90 degree turn eastward and traverses toward the All American Canal. Before crossing under Mesa Lateral 5 (which receives water from the All American Canal approximately one-half mile upstream of the East Highline Canal turnout), Drain No. 2 splits into Drain No. 2 and Drain No. 2A. East of Mesa Lateral 5, Drain 2 runs adjacent to the north side of State Highway 98 for about a half mile before heading northeastward into Section 31 of Township 16 South, Range 17 East, where it terminates about a mile north from the All American Canal. East of Mesa Lateral 5, Drain No. 2A runs for about two miles between the All American Canal and State Highway 98.

Water collected in Drain No. 2 and its upstream branch, Drain No. 2A, is discharged to the East Highline Canal through the Imperial Irrigation District's Drain Pump No. 3. At the intake of Drain Pump No. 3, Drain No. 2 connects with the Mesa 6 Drain. The Mesa 6 Drain runs eastward for about a half mile from the drain pump and is surrounded by irrigated lands served by Mesa Lateral 5. The Mesa 6 Drain receives subsurface drainage from a sump located within Section 36, Township 16 South, Range 16 East. In addition, this drain may receive operational discharges from Mesa Lateral 5.

Page 37 from Imperial Irrigation District, 1990, reports "All-American Canal Seepage Recovery Drain No. 2" for calendar years 1964 through 1990. The method used to determine the amount recovered was not identified, however, it is likely the amount of water estimated to be discharged from Drain Pump No. 3. If this is the case, than the amounts reported would include discharge from the sump discussed above, irrigation drainage, if any, from the adjacent agricultural fields, and possibly operational discharges from Mesa Lateral 5. The Seepage Study's observed value for "EHC, drain seepage" of 10,413 acre-feet per year, as presented in Tables 6-1 and 6-3, is consistent with the values reported by the Imperial Irrigation District as "All-American Canal Seepage Recovery Drain No. 2". It appears the Seepage Study assumes that the water discharged into the East Highline Canal through Drain Pump No. 3 was limited to recovered seepage from the All American Canal upstream of the East Highline Canal.

33. The last sentence of the second paragraph of Section 4.4.3 of the Seepage Study report reads, "Water balances for the aquifer within the IID service area are presented in Section 3." There is no such water balance presented in the Seepage Study report.

34. The discussion contained in the first paragraph of Section 4.4.4 on page 4-31 of the Seepage Study report appears to be a misinterpretation of analysis presented by the Republic of Mexico (this analysis was included in Attachment D of Reclamation, March 1994b) and Reclamation, March 1994a. The Seepage Study report states that Mexico concluded that only 8,900 acre-feet per year, or 8.4 percent of total All American Canal seepage flows north into East Mesa. Actually, Mexico's analysis was limited to the amount of annual seepage from Rock Section 2 to Drop 4 which Mexico assumed to be 113 million cubic meters (MCM) (91,600 acre-feet) per year.[1] Of that amount Mexico concluded that 11 MCM (8,900 acre-feet) or 9.7 percent flows northward to the East Mesa, 97 MCM (78,600 acre-feet) or 85.8 percent flows southward to the Mexicali Valley, and 5 MCM (4,100 acre-feet) is consumed by vegetation along the All American Canal.

With respect to seepage from Rock Section 2 to Drop 4, page II-3 of Reclamation, March 1994a, states the following:

> "Discharge of seepage water occurs by subsurface drainage south toward Mexico (about 90 percent) and north toward the East Mesa (about 10 percent), and by negligible evapotranspiration."

With respect to seepage upstream of Drop 3, page III-10 of Reclamation, March 1994a, states the following:

> "It is estimated that less than 5 percent of the annual seepage from the canal upstream from Drop 3 flows northward under the East Mesa."

Thus Reclamation, March 1994a, estimated that of the 91,600 acre-feet of estimated seepage from Rock Section 2 to Drop 4, approximately 9,160 acre-feet is estimated to flow northward under the East Mesa. The Seepage Study report estimates this amount to be 8,609 acre-feet. With respect to the 84,500 acre-feet of estimated seepage from Rock Section 2 to Drop 3, Reclamation, March 1994a, estimated that approximately 4,225 acre-feet flows northward under the East Mesa. However, Table 4-2 on page 4-32 the Seepage Study report estimates this amount to be 7,226 acre-feet per year. The Seepage Study report does not acknowledge or discuss the discrepancy.

Table 4-2 presents the calculation of flow of All American Canal seepage toward the Mexicali Valley and the East Mesa. The Seepage Study report indicates that the calculation incorporates assumed gradients based on the depiction of the 1993 groundwater contours shown in Figure 4-9 of the Seepage Study report which is based on Figure 3-3 (see item 16 above for observations on Figure 3-3). For section line 3, as depicted on Figure 4-9, flow toward the East Mesa is estimated to be 3,485 acre-feet per year. However, a groundwater mound is depicted on Figure 4-9 to separate the All American Canal from section line 3 across which the flow is assumed to

[1] Mexico's assumed seepage as shown in Figure 9 of its analysis.

occur. The All American Canal is depicted to be on the south side of this mound with the gradient sloping towards Mexico. Considering the high transmissivities in the southeastern corner of the East Mesa and the fact that the All American Canal is the single significant source of recharge in this area, it is not clear how a groundwater mound could develop one mile north of the All American Canal. As discussed in item 16 above, it is possible that the groundwater level contours in Figure 3-3 and Figure 4-9 do not correctly depict actual levels and would thus lead to faulty conclusions as to quantity and direction of groundwater flow.

Table 4-2 appears to be based on the assumption that total annual seepage (footnote 2 to Table 4-2) from Pilot Knob Check to the East Highline Canal is 94,200 acre-feet. However, as discussed in item 26 above, this estimated annual seepage should be 106,978 acre-feet.

35. The first two sentences in Section 4.4.4.1 read, "A total of 4,000 af/yr of AAC seepage was estimated to discharge into the East Highline Canal in the Coachella Canal seepage modeling study (Fogg 1989). While no other studies have estimated the amount of groundwater discharged into the East Highline Canal, an earlier report regarding the East Mesa groundwater system indicated that the canal appeared to be acting as a drain in some areas (LeRoy Crandall and Associates)." The source of the estimated amount of groundwater discharge into the East Highline Canal is reported to be Fogg, Graham E., 1989, *Modeling the Effects of Seepage from Coachella Canal, Salton Sea Area*. Metropolitan would appreciate receiving a copy of this report for review.

Contrary to the Seepage Study report, Reclamation, August 1989, concluded that there was net seepage occurring along a significant length of the East Highline Canal. The following seepage/inflow values along four subreaches of the East Highline Canal were taken from Reclamation, August 1989:

Year	Reach 0	Reach 1	Reach 2	Reach 3	Total
1980	-945	51,597	45,510	-26,855	69,307
1981	7,728	58,713	42,969	-26,563	82,847
1982	9,098	75,431	35,155	-18,403	101,281
1983	2,174	57,449	32,537	-16,172	75,988
1984	20,236	54,979	36,400	-15,554	96,061
Average	7,658	59,634	38,514	-20,709	85,097

The reaches are defined as follows:

	Reach Description	Reach Length (miles)
Reach 0:	Check No. 1 to Check No. 11	7.22
Reach 1:	Check No. 11 to Oak Check	13.54
Reach 2:	Oak Check to Nectarine Check	8.53
Reach 3:	Nectarine Check to Flowing Wells Check	9.53
	Total Length	38.82

The remaining length of the 50-mile East Highline Canal was not included in the study. Note that there was a net water gain in reach zero in 1980 and a trend of increasing seepage from 1981 to 1984. This trend from net gain to increasing seepage is consistent with the replacement of the first 49-miles of the earthen Coachella Canal with a concrete lined canal in November 1980. Note also the net gain observed in Reach 3 declined in each year following November 1980. Reclamation, August 1989, concluded that gross East Highline Canal annual seepage from Check 1 to Nectarine Check (Reaches 0, 1, and 2) is 105,800 acre-feet, and the net annual seepage loss from Check 1 to Flowing Wells Check (Reaches 0, 1, 2, and 3) is 85,100 acre-feet. To account for the amount of water recovered from seepage recovery drains located along the East Highline Canal, Reclamation, August 1989, concluded that the resulting annual net seepage for the length of canal studied was 65,000 acre-feet per year.

The Seepage Study report only provides a single number that suggests there is a net gain of 4,000 acre-feet per year for the entire East Highline Canal. Assuming there is a net gain of 4,000 acre-feet per year, based on the findings contained in Reclamation, August 1989, there would necessarily need to be a net gain of 69,000 acre-feet in the last twelve miles of the East Highline Canal. This rate of gain would be 3.5 times the average rate per mile observed in the reach between Nectarine Check and Flowing Wells Check. Unfortunately, the consistency with Reclamation, August 1989, cannot be verified because the Seepage Study report does not disclose East Highline Canal seepage rates on a reach-by-reach basis.

36. The first sentence on page 4-33 states that the estimated amount of All American Canal seepage that flows northward under the East Mesa ranges from 8,900 acre-feet per year to 10,650 acre-feet per year. However, Table 4-2 of the Seepage Study report indicates this amount to be 8,609 acre-feet per year. The Seepage Study report then claims that by subtracting the amount of seepage estimated to be intercepted by the East Highline Canal, the remaining amount is underflow to the central Imperial Valley. The Seepage Study report does not discuss the possible outflow of groundwater from beneath the East Mesa through evapotranspiration. Reclamation, August 1989, quantified the total acreage of wetlands along the East Highline Canal at 2,400 acres. The Seepage Study report does not acknowledge the existence of these wetlands nor is it apparent that the associated evapotranspiration is incorporated into the model.

37. With respect to underflow into the central Imperial Valley, the last sentence of the first paragraph of Section 4.4.4.2 on page 4-33 of the Seepage Study report reads, "Regional groundwater in the north-central IID area has also been shown to discharge under confining conditions into irrigation return drains (Michel and Schroeder, 1994)." Michel and Schroeder did acknowledge upward movement of regional groundwater in two of eight groundwater-sampling sites located within the irrigated area of the Imperial Valley. However, they stopped short of concluding that "regional groundwater in the north-central IID area has also been shown to discharge under confining conditions into irrigation return drains". Indeed, in discussing the results of a comparison of the ratio of selenium (Se) to chloride (Cl) in Imperial Valley drainwater, Michel and Schroeder make the following statement:

> "The average Se/Cl gravimetric ratio in irrigation water diverted from the Colorado River is 2.2×10^{-5} and that ratio in about 80% of the more than 100 sumps sampled falls within a factor of 2 of this value. Furthermore, where the ratio is very low and might imply dilution by groundwater containing no Se, there is indirect evidence that microbial reduction of Se is the cause of the reduced ratio. The conclusion based

> on these data is similar to that obtained from tritium concentration; that shallow regional ground water is a minor part of the total discharge in subsurface drains and that evaporative concentration of irrigation water accounts for observed selenium concentration in drain water from the sumps."

Furthermore, Schroeder *et al.*, July 1991, states the following:

> "The behavior of Se in the Imperial Valley is distinctly different from its behavior in the extensively studied western San Joaquin Valley, where high Se concentrations in drains result from displacement of selenium-rich regional groundwater by irrigation water (Deverel and Fio, 1990). In the more reducing conditions of the Imperial Valley, not only do regional ground waters contain no Se, but they also contribute little to the total flow of the drains."

The Seepage Study report does not acknowledge these documented findings that regional groundwater, which includes underflow from the East Mesa, contributes little to the flow of the irrigation drains of the central Imperial Valley. With the absence of a discussion of these findings, and the absence of a description of the incorporation of these findings into the model, the Seepage Study report's conclusion that lining the All American and Coachella canals would result in reduced Imperial Valley drain discharge by as much as 12,542 acre-feet per year is inadequately supported.

38. The first sentence of the second paragraph on page 4-33 of the Seepage Study report reads, "As a consequence of low permeability lake sediments in the IID area, artesian discharge areas between the Alamo River and the East Highline Canal, and large groundwater volumes discharged into the New and Alamo Rivers…" These statements appear to serve as the basis for the conclusion contained at the end of this sentence which reads, "…a large fraction of AAC seepage that underflows into the central Imperial Valley is believed to discharge into rivers or drains."

The conclusion that seepage from the All American Canal underflows into the central Imperial Valley is not supported by the Seepage Study report. The low permeability lake sediments in the central Imperial Valley would tend to inhibit the flow of groundwater under the East Highline Canal from the East Mesa. According to Figure 6-6 of the Seepage Study report, the calibrated Seepage Study model's hydraulic conductivity for Layer 1 within the irrigated area of the Imperial Valley appears to range from 1.59 feet per day to 10 feet per day. For Layer 2, the assumed aquitard, the hydraulic conductivity within the irrigated area of the Imperial Valley appears to be uniformly 1.59 feet per day. These values are high when compared to values published in other reports. From pumping tests conducted in two wells in the central Imperial Valley, Loeltz *et al.,* 1975, calculated the hydraulic conductivity to range from 5 to 7 gallons per day per square foot, (or 0.67 to 0.93 feet per day), respectively. Michel and Schroeder, 1994, calculated a percolation rate of 5.3 meters per year, or 0.048 feet per day in the soil strata extending from a depth of 1 meter to a depth of 2 meters. Within core samples collected from borings into the sediment beneath the Salton Sea, it was observed that there was no free water (i.e., not saturated) contained in clay layers found as shallow as a few feet deep from the sea bottom (Vogl, July 29, 1999). These findings suggest a hydraulic conductivity that is orders of magnitude lower than that assumed by the Seepage Study model. It is interesting to note that the hydraulic conductivity in this area was initially assumed to be 0.5 feet per day (Section 3.4.3 on page 3-29). However the magnitude of this factor was apparently increased during model calibration.

The sensitivity analysis could have shed some light on the significance of lower hydraulic conductivity beneath the central Imperial Valley on the model's projected underflows into the central Imperial Valley. Unfortunately the Seepage Study chose not to investigate this matter.

Seepage from the East Highline Canal may serve as a barrier to underflow of groundwater from the East Mesa into the central Imperial Valley. For those reaches in which there is net seepage from the East Highline Canal, it is likely that there is a groundwater mound beneath these reaches. Such a mound would serve as a barrier against underflow from the East Mesa into the central Imperial Valley. As discussed above, Reclamation, August 1989, concluded that there was net seepage occurring in this canal from the first 29.29 miles downstream from Check No. 1. Figure 11 from Loeltz *et al.*, 1975, supports the notion of a groundwater mound beneath this portion of the East Highline Canal. Said Figure 11 depicts the change in groundwater levels in the East Mesa from 1939 to 1960 and shows that a mound developed beneath the Coachella Canal and All American Canal that extended into the East Mesa. However, the mound did not encompass the entire East Mesa. No change in groundwater level was depicted for nearly the entire eastern portion of Township 15 South, Range 17 East. Directly west of this area an increased groundwater elevation of ten feet is shown to have developed beneath the East Highline Canal that extends across both sides of this canal. The mound buildup under the East Highline Canal since 1939 is significant as this canal was in service since at least 1922 (Imperial Irrigation District, 1922). Loeltz *et al.*, 1975, observed that throughout most of the length of the East Highline Canal the change in water levels was small. The large area of no change located between the East Highline Canal and the mound that developed beneath the All American and Coachella canals, coupled with the small rise in the levels directly beneath the East Highline Canal, suggests that the mound beneath the East Highline Canal acts as a hydraulic boundary between the East Mesa and the central Imperial Valley.

With respect to artesian discharges between the Alamo River and the East Highline Canal, Loeltz *et al.*, 1975, concluded that the total annual flow from these artesian discharges "is only a few thousand acre-feet." With respect to "large groundwater volumes discharged into the New and Alamo Rivers," as stated in the Seepage Study report, Loeltz *et al.*, 1975, makes the following statement:

> "The water-level contours on plate 1 indicate upward leakage of water from the main ground-water body to the Alamo and New Rivers and in the vicinity of the Salton Sea. However, the amount of such leakage averages only a few tens of thousands of acre-feet per year."

Loeltz *et al.*, 1975, does not identify what is meant by "the main ground-water body", but it can be reasonably inferred it was in reference to the unconfined water table. As noted above in item 37, the unconfined water table beneath the central Imperial Valley contains no regional groundwater and instead consists entirely of seepage from the Imperial Irrigation District's distribution system and deep percolation from irrigation on farms.

Lastly, Table 6-33 of Boyle, August 1993, estimates subsurface flow from the East Mesa to drains in the Imperial Irrigation District to be 3,000 acre-feet per year. This amount is over 9,000 acre-feet less than the maximum reduction in groundwater discharge to the Imperial

Irrigation District drains after lining the All American and Coachella canals as shown in Table E-2 of the Seepage Study report.

39. The last two sentences on page 4-33 of the Seepage Study report reads, "The AAC EIS/EIR presented a similar estimate of 90 percent of the total AAC seepage, or 83,160 af/yr, for the AAC seepage that flows into East Mesa. In the current study, a value of 83,972 af/yr is estimated in Section 4.4.4 (Table 4-2), based on 1993 water level conditions."

Although "AAC EIS/EIR" is not included in the Seepage Study report's bibliography, it appears to be referring to Reclamation, March 1994a. That study estimated that about 90 percent of the seepage from *Rock Section 2 to Drop 4* flows south *toward Mexico*. The Seepage Study report mistakenly states this amount "flows into East Mesa." Reclamation, March 1994a, was silent on the movement of seepage from the All American Canal that occurs upstream of Rock Section 2 and downstream from Drop 4. See item 34 above for additional comments on the movement of seepage from the All American Canal.

40. As discussed in item 34 above, the discussion in Section 4.4.5.1 and Section 4.4.5.2 on page 4-34 of the Seepage Study report is based on inaccurate assumptions of its estimate of seepage from the Pilot Knob Check Gates to the East Highline Canal.

41. The discussion in Section 5.1 and 5.1.1 on page 5-1 and 5-2 of the Seepage Study report indicates that the estimated amount of Coachella Canal seepage from Siphon 7 to Siphon 32, is 32,350 acre-feet per year as estimated by Reclamation, December 1993a. See item 25 above for a discussion of the Seepage Study report's failure to verify this seepage value.

The discussion in Section 5.1 and 5.1.1 also notes that seepage from the first 49-miles of the earthen Coachella Canal prior to it being replaced by a concrete lined canal is estimated to be 130,500 acre-feet per year. As discussed in item 24 above, Reclamation, March 1984, estimated this seepage was 141,000 acre-feet per year.

42. The first line on page 5-5 of the Seepage Study report directs the reader to Appendix H for geologic cross-sections along the Coachella Canal. These cross-sections are actually contained in Appendix G.

43. In Table 5-1 on page 5-5 of the Seepage Study report, the Total Wetlands acreage for Hydrologic Unit C is indicated to be 2,220 acres. However, Table 5-1 also states that induced wetlands for Hydrologic Unit C is 2,289 acres or 69 acres more than what is assumed to currently exist. While the Seepage Study report does not state the source of the information provided in this table, it appears to be from Reclamation, December 1993b. If so, it appears that the Seepage Study report misinterpreted the content of this report. Footnote 1 on page 2 of Attachment B of that document indicated that the wetland acreage values used in its analysis were based on Pucherelli, *et al.*, September 1988, and were not updated to incorporate the final report which was Pucherelli, *et al.*, September 1989. The reason cited for not using the latter report was that the difference in the estimated seepage rates would have been marginal. The latter study further delineated the wetlands of the subject area existing as of 1989 and its results were incorporated into Table III-5 (desert riparian vegetation) and Table III-6 (marsh) of

Reclamation, December 1993a. The discrepancy between the most updated data and the values shown in the "Total Wetlands" column and "Total ET" column of Table 5-1 of the Seepage Study report is as follows:

	Table 5-1 of Seepage Study Report		Table III-5 and III-6 of Reclamation, December 1993a		Discrepancy	
Unit	Total Wetlands (acres)	Total Annual ET (acre-feet)	Total Wetlands (acres)	Total Annual ET (acre-feet)	Total Wetlands (acres)	Total Annual ET (acre-feet)
A	702	3,510	590	2,950	112	560
B	535	2,675	512	2,560	23	115
C	2,220	11,100	2,814	14,070	(594)	(2,970)
D	4,068	20,340	3,427	17,135	641	3,205
E	77	385	69	345	8	40
Total	7,153	38,010	7,412	37,060	(1,810)	950

Note that the Seepage Study report's sum of the values for each unit in the "Total Wetlands" column of Table 5-1 is 7,602 acres, which is 449 acres greater than the total shown at the bottom of this column. Note also that the first sentence of the last paragraph on page 5-16 of the Seepage Study report quotes wetland acreage that is consistent with the values shown in Table III-5 of Reclamation, December 1993a.

It appears that the values shown in the "Induced Wetlands" column of Table 5-1 of the Seepage Study report is based on Table 3 of Attachment B to Reclamation, December 1993b. As noted above, these values were estimated based on Pucherelli, *et al.*, September 1988, which was revised. A comparison of the estimated 1949 wetland acreage, as documented in Reclamation, December 1993a, and the 1989 wetland acreage, as documented in Pucherelli *et al.*, September 1989, is as follows:

Unit	1949 Wetlands (acres)	1989 Wetlands (acres)	Increased Wetlands (acres)	Increased Evapotranspiration (acre-feet per year)
A	347	590	243	1,215
B	16	512	496	2,480
C	177	2,814	2,637	13,185
D	585	3,427	2,842	14,210
E	11	69	58	290
Total	1,136	7,412	6,276	31,380

The increased wetlands and increased evapotranspiration shown in the above table should not be considered to be entirely the result of seepage from the Coachella Canal. Reclamation, December 1993b, discussed the installation of artesian wells in the area after the canal was placed into service. Outflow from these wells also contributed to the increased wetland acreage since 1949.

Lastly, surface water discharge for Unit D is indicated to be 2,000 acre-feet per year. Although not clearly stated in the Seepage Study report, it appears this is the amount assumed to discharge to the Salton Sea through Salt Creek. As discussed in item 25 above, the observed flow in Salt Creek at the Salton Sea has declined to less than 1,000 acre-feet per year.

44. The discussion of Hydrologic Unit B in the first full paragraph on page 5-5 of the Seepage Study report does not acknowledge that the canal bottom between Siphon 14 and Siphon 15 was completely lined with a layer of polyvinylchloride covered by a layer of concrete in March 1991. Also, the second to last sentence of this paragraph directs the reader to Appendix E for geologic cross-sections along the Coachella Canal. These cross-sections are actually contained in Appendix G. Similar misleading direction is given to the reader in the third sentence of the following paragraph.

45. The last sentence on page 5-5 of the Seepage Study report reads, "These deep lake sediments also extend to the east at least 1,500 feet upslope of the canal and to the west several thousand feet where they pinch out against the ground surface as depicted in the cross-sections in Appendix E." (Note that the cross-sections are contained in Appendix G.) The same statement is also made in item number (2) on page 5-21 of the Seepage Study report. By stating the lake sediments "pinch out against the ground surface" the Seepage Study report appears to describe a layer of lake sediments that thins out when it nears the ground surface. Rather than "pinching out," the geologic cross-sections contained in Appendix G depict a thick layer of lake sediments that extends westward from the Coachella Canal and *outcrops* (i.e., the overlying layer of alluvium thins such that the lake sediments are exposed at the ground surface) at some distance downslope from the canal.

46. The last sentence of the first partial paragraph on page 5-6 of the Seepage Study report states that the estimated seepage from Hydrologic Unit C represents "only the canal water that discharges in the Salt Creek and Oasis Springs areas". This statement related to the location of discharge of canal seepage contradicts Reclamation, December 1993b, which appears to be the source of the discussion. In setting the boundary between Hydrologic Units C and Unit D, page 17 and 18 of Reclamation, December 1993b, states the following:

> "The siphon 23 unit boundary was selected so as to isolate a reach of the canal with an alluvial bottom from the downslope hydrologic complications of the Dos Palmas area."

The Geologic map of this area contained in Attachment A of Reclamation, December 1993b, and reprinted in Appendix G of the Seepage Study report, depicts Oasis Springs and Salt Creek to be downslope of Hydrologic Unit D.

47. The fourth sentence of the first full paragraph on page 5-6 of the Seepage Study report directs the reader to Appendix E for geologic cross-sections along the Coachella Canal. These cross-sections are actually contained in Appendix G.

48. On page 5-15 of the Seepage Study report, Section 5.1.3 reads, "Water is also consumed by native desert scrub and pickleweed communities that were unchanged by the canal. This water is excluded from consideration because no net groundwater recharge or discharge occurs under these communities which subsist on desert precipitation." This statement contradicts the

first sentence of Section 6.1.1.4 on page 6-13, where the Seepage Study report states that recharge in unirrigated areas was specified in the model as a diffuse rate of 0.02 inches per year.

49. Figure 5-5 of the Seepage Study report depicts groundwater level contours in the region of the Coachella Canal from Siphon 7 to Siphon 32 and downslope to the Salton Sea. The discussion contained in Section 5.2.2 on page 5-15 of the Seepage Study report indicates that limited groundwater level data are available for the Coachella Canal between Siphon 7 to Siphon 32, and as a result, the contour lines in Figure 5-5 are dashed to reflect limited water level data in this area. The discussion contained in the first paragraph of Section 5.2.4 on page 5-16 states that "the only water level database available for the East Salton Sea was collected in the mid-1970s for borings installed along the CB." The source of this data is not identified. Although the data is indicated to be from the mid-1970s, Figure 5-5 notes that the contours shown in the East Salton Sea area represent the 1960 groundwater elevations. The second sentence of the first paragraph of Section 5.2.4 on page 5-16 states that "the 1990s conditions are thought to be the same as the 1970s data…" Therefore it appears the Seepage Study report and model assumes that groundwater elevations in the East Salton Sea area were stable from 1960 through the 1990s. Given the expressed limited amount of data, it appears that the contours depicted in Figure 5-5 in the region of the Coachella Canal from Siphon 7 to Siphon 32 and downslope to the Salton Sea were entirely assumed.

Although 42 observation wells were drilled in 1987 and 1988 along the Coachella Canal from Siphon 7 to Siphon 32, as documented in Reclamation, December 1993b, the Seepage Study report does not acknowledge them. Indeed, the contours shown along this reach of the canal as depicted in Figure 5-5 of the Seepage Study report do not agree with the water level observations obtained from those 42 observation wells. For example, Figure 5-5 of the Seepage Study report depicts the groundwater elevation along the Coachella Canal from Siphon 14 to Siphon 15 to be at sea level or slightly less than sea level. Figure 2a from Reclamation, December 1993b, shows the groundwater elevation beneath this reach to range from approximately 30 feet above sea level to approximately 30 feet below sea level. Along the canal from Siphon 25 to Siphon 28, Figure 2c from Reclamation, December 1993b, shows the groundwater elevation to be from 40 to 50 feet below sea level while Figure 5-5 of the Seepage Study report shows the level in this area to be between 0 and 50 feet above sea level.

The groundwater contours of Figure 5-5 show a relatively uniform gradient from the Coachella Canal to the Salton Sea along the entire northeastern shore of the Salton Sea. The water table gradient appears to parallel the ground surface elevation. In estimating the groundwater contours it appears the Seepage Study report did not take into account relative permeabilities of the various geologic formations in the area. For example, Figure 2-2 of the Seepage Study report depicts a distinct geologic formation in the vicinity of Bat Caves Buttes that stretches approximately 10 miles southeastward along the Salton Sea shore from Salt Creek. This structure was indicated to be "Tl-Ql?", which is defined as Tertiary lake deposits (Tl) or Quaternary lake deposits (Ql). This area is clearly discernable from the surrounding area indicated to be Quaternary lake deposits. Plate 1 of Loeltz *et al.*, 1975, indicates this structure to be the "Borrego Formation of Tarbet and Holman (1944)" and described it as "Lacusterine and brackish-water deposits; light gray silt, clay, and sandstone." Slightly upslope of this formation Figure 2-2 indicates another formation as "Qp" which is defined as "Plio-Pleistocene

nonmarine." Reclamation, December 1993b, labeled this structure as "Qnm" and defined it as "sedimentary nonmarine sandstone and claystone." Figure 5-3b of the Seepage Study report also depicts this "Qnm" formation and defines it as "Quarternary Nonmarine Sandstone and Claystone". Another "Qnm" formation is depicted in Figure 5-3b to lie between the Salton Sea and the Coachella Canal in the region north of Salt Creek.

In drawing the contours, the Seepage Study did not appear to consider the formations denoted as "Tl-Ql?" and "Qnm". These formations may have hydraulic conductivities significantly different than that of the surrounding Quarternary lake deposits. Note that Table 5-1 of the Seepage Study report estimated Coachella Canal seepage from Hydrologic Unit A and Unit B to be 163 to 446 acre-feet per year per mile. The discussion in the Seepage Study report notes that these reaches of the Coachella Canal are constructed primarily in clay. Note further that Table 5-1 of the Seepage Study report shows the estimated Coachella Canal seepage from Hydrologic Unit E to be 72 acre-feet per year per mile which is substantially less than Unit A and Unit B. The discussion in the Seepage Study report notes that this reach of the Coachella Canal is constructed in the sandstone and claystone and is depicted in Figure 5-3b to be "Qnm". Thus it would appear that hydraulic conductivity of the geologic structural formation indicated as "Qnm" along the Salton Sea would be significantly lower than the surrounding Quarternary lake deposits. If this formation is significantly less permeable, similar to a boulder in a surface stream, water would likely pond against these features and would tend to flow around them through the relatively less permeable medium. The uniform gradient shown in Figure 5-5 for the region between the Coachella Canal and the Salton Sea, however, suggests a homogenous geologic structure.

50. The first full paragraph on page 5-21 of the Seepage Study report reads, "Prior to the construction of the CB, there were approximately 1,450 acres of wetlands in the area between Siphons 7 and 32 that were primarily associated with artesian groundwater discharge at Andreas Springs, Dos Palmas Springs, Oasis Springs, Hot Mineral Spa, and Frink Springs." However, as discussed in item 43 above, the actual acreage of pre-canal wetlands was 1,136 acres. With respect to the sources of water supporting pre-canal wetlands, page 2 of Attachment B to Reclamation, December 1993b, concluded that approximately 300 acres of wetlands observed in Unit A in 1989 were present in 1949 and were watered from seepage from the East Highline Canal. The last sentence of this paragraph states that canal seepage has resulted in an increase of 5,962 acres. However, as discussed in item 43 above, the volume of increased wetlands from 1949 to 1989 was 6,276 acres. The increase is due to seepage from the Coachella Canal as well as the installation of artesian wells after the canal was placed into service.

51. The first sentence on page 5-22 of the Seepage Study report reads, "The Andreas Spring area is downslope of Siphons 29 and 30." The term "Andreas Spring" appears to refer to the area marked "San Andreas" Springs on the geologic overlay map of Reclamation, December 1993b. This area is actually downslope of Siphon 28 and Siphon 29. The next sentence claims that this spring is located on the San Andreas Fault. However, Figure 2-2 of the Seepage Study report does not depict the San Andreas Fault to cross this area, rather, the Mission Creek Fault is indicated to exist in the general vicinity of this area along the "San Andreas Fault Zone". The Mission Creek Fault lies adjacent to the shore of the Salton Sea about three miles away from the San Andreas Springs area. Figure 2-2 does show an unnamed inferred fault that passes close to

the San Andreas Springs area. Lastly, the final sentence of this paragraph states that "Andreas Spring" supports 525 acres of wetlands. The Seepage Study report does not describe how it reaches this conclusion nor does it cite a source from which it may have come from.

52. The last sentence in the first paragraph under Section 5.3.2 on page 5-22 of the Seepage Study report states that the Dos Palmas Spring currently supports approximately 1,500 acres of wetlands. The Seepage Study report does not describe how it reaches this conclusion nor does it cite a source from which it may have come from.

53. The first sentence of the last paragraph on page 5-22 reads, "In the Dos Palmas area, a lineament has been identified as shown in Figure 5-2." Actually, the lineament is shown in Figure 5-4. The last sentence of this paragraph reads, "Previous studies have documented the presence of groundwater on the eastern side and a groundwater barrier on the western side of faults in Mt. San Jacinto (California State Department of Water Resources 1956)." The Seepage Study report does not discuss the relevance of this point to the Coachella Canal/Salton Sea region. Also, the citation is not included in the Seepage Study report's bibliography.

54. The second sentence of the first paragraph under Section 5.3.3 on page 5-23 of the Seepage Study report states that Oasis Spring is located east of the San Andreas Fault. As noted in item 51 above, Figure 2-2 of the Seepage Study report does not depict the San Andreas Fault to run through this area.

The next sentence of this paragraph postulates that the water discharged at this spring is of geothermal origin, however, the basis of this conclusion is not discussed. Page 29 of Reclamation, December 1993b, notes that Reclamation took water samples from the area for analysis, including a sample from Oasis Spring. The results of the analysis appear in Attachment C to that report.[2] The temperature of the sample was 29.4 degrees centigrade (84.9 degrees Fahrenheit). Geothermal water is typically associated with high temperatures. For example, the temperature of samples collected from the well at the Imperial Hot Mineral Spa were on the order of 75 degrees centigrade (167 degrees Fahrenheit).[3] At the neighboring Bradford Spa, Metropolitan staff have observed a well discharging water that was hot to the touch and was emitting a sulfur aroma. The water was being conveyed in an earthen channel to a pond where it was blended with less saline water. The vegetation that lined this channel appeared to have succumbed from exposure to this water. If similar water was being discharged at Oasis Spring, one would expect limited vegetation in this area rather than the dense foliage that exists. Thus Reclamation's analysis of water samples taken from Oasis Spring and Metropolitan staff's observation at Bradford Spa would suggest that the discharge at Oasis Spring may not be of geothermal origin.

The last sentence of this paragraph states that the Oasis Springs currently support approximately 125 acres of wetlands. The Seepage Study report does not describe how it reaches this conclusion nor does it cite a source from which it may have come from.

---

[2] Oasis Spring is identified as "Goats Well" in Attachment C to Reclamation, December 1993b

[3] Well No. 10 from Hardt and French, July 1976.

55. The fourth sentence under Section 5.3.4 on page 5-23 of the Seepage Study report reads, "These wells and springs tap groundwater in an area where the lakebed clay aquitard pinches out against the ground surface, located along the shoreline of pre-historic Lake Cahuilla (44 ft MSL)." Rather than "pinching out" as stated in the Seepage Study report, this clay layer extends from the Salton Sea eastward to the Coachella Canal and beyond. The wells and spring referenced in this sentence are the Imperial Hot Mineral Spa, Frink Spring, and the Pacific Fish Farms well. According to Reclamation, December 1993b, the wells and spring tap water from the deep artesian aquifer that exist below the near surface lakebed clay that underlies this area.

The following two sentences of this paragraph read, "Investigations have defined faults in the area which have damming effects, causing regional groundwater to rise up to the ground surface. It is likely that groundwater discharge can be attributed to both of these mechanisms at Hot Mineral Spa and Frink Spring, as the presence of both lakebed deposits and faults are well documented in this area." Although this discussion suggests two potential mechanisms by which regional groundwater may rise up to the ground surface, only the damming effect of a fault is specifically mentioned. In addition, the Seepage Study report's claim that the presence of faults in this area is well documented is not supported with a citation. Figure 2-2 of the Seepage Study report does indicate a fault in this area, but depicts it as 'concealed by younger rocks'. Plate 1 from Loeltz *et al.*, 1975, does not indicate the presence of a fault in this area. From Figure 6-3 of the Seepage Study report it appears that the Seepage Study model does not assume the presence of a fault in this area.

56. With respect to the discussion contained in Section 5.3.5 of the Seepage Study report, see item 25 above for a discussion of the declining flow in Salt Creek to the Salton Sea.

57. The first paragraph of the discussion contained in Section 5.4.1 on page 5-25 of the Seepage Study report notes that there is a lack of reliable groundwater level data for the area bounded by the Coachella Canal and the Salton Sea. Because of this the Seepage Study report makes some assumptions as to the depth of the "shallow aquifer" in this region in order to calculate "a very approximate estimate of canal induced aquifer storage…" The primary assumption noted in the first sentence of the second paragraph of this discussion is that "the shallow aquifer is assumed to be 30 feet thick under the known wetlands." However, the maps contained in Attachment A of Reclamation, December 1993b, show that most of the wetlands downslope of the Coachella Canal are located in areas where the Quaternary lake deposits, or clay, are exposed at the surface. This contradicts the Seepage Study report's definition of 'aquifer' as stated on Figure 3-5, which defines it as "sand, silty sand, gravel". In addition, the second to last sentence of the second paragraph of this section reads, "the aquifer thickness between the canal and wetlands in Units C and D would average 65 feet and 60 feet, respectively, because the aquitard is relatively deep in units C and D". (The discussion directs the reader to Appendix E for geologic cross-sections along the Coachella Canal. These cross-sections are actually contained in Appendix G.) However, the geologic cross-sections in Appendix G of the Seepage Study report indicate that there is no layer of Quaternary lake deposits beneath the Coachella Canal in Hydrologic Unit C between Siphon 24 and Siphon 29. Therefore it would appear the aquifer in this area is significantly deeper.

58. The last two sentences on page 5-25 of the Seepage Study report reads, "Using a 5-foot-per-year evapotranspiration rate, the 5,962 acres of induced wetlands consume 29,810 af/yr of canal water." As discussed in item 43 above, the actual documented amount of increased wetlands after construction of the Coachella Canal as observed in 1989 was 6,276 acres. At an evapotranspiration rate of 5 feet per year, total evapotranspiration of the increased wetland acreage would be 31,380 acre-feet.

59. With respect to the discussion contained in Section 5.4.4 of the Seepage Study report, see item 25 above for a discussion of the declining discharge of Salt Creek to the Salton Sea.

60. The discussion contained in Section 5.4.5 on page 5-26 of the Seepage Study report states that as much as 1,540 acre-feet per year of the amount of seepage from Siphon 7 to Siphon 32 of the Coachella Canal is discharged via subsurface to the Salton Sea in addition to the amount discharged in Salt Creek. However, page III-11 from Reclamation, December 1993a, states the following:

> "The amount of groundwater possibly entering the Salton Sea from the [Coachella Canal lining] project area is not expected to change after lining the canal. Virtually all seepage can be accounted for in consumptive use by phreatophytes, Salt Creek flow, and local uses."

Although it appears much of the data used by the Seepage Study report is based on Reclamation, December 1993a, and its supporting documents, the Seepage Study report does not discuss the discrepancies among its conclusions and those found in Reclamation, December 1993a. In addition, the discussion contained in Section 5.4.5 does not incorporate:

- the variance in the estimated annual seepage from the Coachella Canal as discussed in item 25 above,

- the estimated evapotranspiration rate based on the documented amount of increased wetlands as discussed in item 43 above, and

- the reduced Salt Creek discharge to the Salton Sea since 1993 as discussed in item 25 above.

61. From Figure 6-3 of the Seepage Study report, it is evident that, with the exception of the East Highline Canal, the Central Main Canal, and portions of the All American Canal and Westside Main Canal, seepage from the Imperial Irrigation District irrigation distribution system was neglected by the seepage model. In addition, the model also neglects a large portion of the irrigated area in the western portion of lands served by the Imperial Irrigation District. The Seepage Study report does not discuss the rationale for leaving these features out nor does it discuss the consequences on the model's results.

The omission of aquifer recharge and discharge from much of the Imperial Irrigation District's irrigation and drainage facilities and recharge from irrigation on a significant portion of the lands within the irrigated portion of the Imperial Valley may have led to faulty results. For example, as shown in the following table, the sum of the Table 6-1 "Modeled Rate" components for the irrigated area of the Imperial Valley indicates a net outflow of 96,569 acre-feet from the aquifer.

Sum of Table 6-1 "Modeled Rate" Components for the Irrigated Area of the Imperial Valley†
(acre-feet per year)

Feature Name	Flow Into Aquifer	Flow Out of Aquifer
EHC, drain seepage		11,292
EHC, canal seepage	6,975	
New River in USA		18,250
Alamo River in USA		45,249
Discharge to Salton Sea*		2,000
IID irrigation recharge combined with IID riverbed evapotranspiration and discharge into IID drains (Net Total)		38,045
Total	6,975	103,544
Flow Out of Aquifer less Flow Into Aquifer =		96,569

†Seepage from the portions of the Westside Main Canal and the Central Main Canal included in the study area are not included in Table 6-1, therefore flow into or out of the aquifer from these features could not be included in this balance.

*The modeled rate is not indicated in Table 6-1 nor is it identified in the Seepage Study report. Therefore the Observed Rate is assumed for this balance.

As the model assumes the groundwater elevation beneath the central Imperial Valley remains stable at 6 feet below ground surface, this "imbalance" must be met from the model's other sources of flow into the aquifer. With exception of any recharge from the Central Main Canal, and portions of the All American Canal below the East Highline Canal and Westside Main Canal (which was not disclosed by the Seepage Study report), the model's only other sources of inflow to the aquifer are from outside the irrigated area of the Imperial Valley. Chief among the sources outside the central Imperial Valley is seepage from the All American and Coachella canals. However, if the Table 6-1 modeled outflows from the central Imperial Valley are based on observed outflows that incorporate all actual inflows to the aquifer, including recharge from the portions of the irrigation distribution system and the irrigated lands not incorporated into the model, the model would incorrectly conclude that the outflows were met from sources outside the central Imperial Valley in lieu of those sources from within the central Imperial Valley that were not incorporated into the model. Unfortunately, the Seepage Study report does not identify the assumptions behind the determination of observed outflows for each modeled feature of the central Imperial Valley. Therefore the results presented in the Seepage Study report are inconclusive.

62. The last paragraph on page 6-9 of the Seepage Study report reads, "Near the Salt Creek wetlands and the Salton Sea, the Seepage Study model is calibrated to simulate heads above land surface. This agrees with conceptual model data showing flowing springs at Dos Palmas and Andreas Springs, and groundwater seepage into the Salton Sea." As discussed above in item 25, the Seepage Study report has not demonstrated that groundwater is seeping directly into the Salton Sea along the shore that parallels the Coachella Canal.

63. In the third sentence of the first paragraph under Section 6.1.1.3 of the Seepage Study report, it is stated that the heads, or groundwater elevation, specified for the model's southern

boundary were based upon historical water level contours in Mexicali Valley for 1965, 1985, 1989, and 1993. At a workshop for the model held on July 27, 1999, Dennis Jameson of HIS Geotrans, a subsidiary of Tetra Tech responsible for producing the Seepage Study model, stated that for the model's southern boundary, the groundwater elevation specified for model simulations of future without lining conditions was based on the relationship of the elevation observed from 1979 through 1993. Note that the last bullet on page 6-9 states that the Seepage Study model excludes the Mexicali Valley due to limited data available for this area. Thus rather than incorporate the several hydrologic variables that affect groundwater in the Mexicali Valley, the Seepage Study model simply attempts to assign an equivalent groundwater elevation along the model boundary that lies along the northern edge of the Mexicali valley. See item 13 above for a discussion of several hydrologic variables that affect groundwater in the Mexicali Valley.

64. The fourth sentence of the first paragraph under Section 6.1.1.3 of the Seepage Study report reads, "A constant head boundary was used in the shallowest layer in the IID area based on the 6-foot depth of IID tile drainage network." This assumption does not comport with the conclusion of Loeltz, *et al.*, 1975, that unconfined groundwater levels in this area have been stabilized at depths between 5 and 20 feet below land surface.

Notwithstanding this, Figure 6-3 of the Seepage Study report indicates that only a portion of the irrigated area of the Imperial Valley is assigned a constant head boundary. Model cells within this area that are not designated as a constant head boundary include:

- the area that is within four miles of the international boundary,
- a two to three mile wide strip along the East Highline Canal,
- a three to five mile swath of land along the southern shore of the Salton Sea, and
- individual cells distributed throughout the irrigated area that are within the active model area.

The Seepage Study report does not elaborate on rationale for this selective placement of the constant head boundary in cells within the irrigated area of the Imperial Valley.

65. The last full sentence of page 6-10 of the Seepage Study report reads, "No-flow boundaries were used at basin boundaries in the southeast and along the hydrologic streamline separating the groundwater flows on the east and west sides of the New River." With respect to the latter, the Seepage Study report does not elaborate on the rationale for establishing a "hydrologic streamline" below the New River. If one was necessary for the New River it is not clear why another hydrologic streamline was not necessary for the Alamo River. If the purpose of the streamline is to establish a line across which groundwater is not allowed to flow, than its location is inconsistent with the groundwater elevations shown on Plate 1 of Loeltz, *et al.*, 1975. The configuration of the water table contours in that reference depict a hydraulic low point that runs through the central Imperial Valley from the vicinity of Holtville northwestward to the southern shore of the Salton Sea traversing the New River in the vicinity of Brawley and then traversing back to the west side of the New River near the Salton Sea.

66. The second sentence of Section 6.1.1.4 on page 6-13 of the Seepage Study report reads, "Recharge and/or discharge in irrigated areas (IID) was not specified as a flux because this area was treated as a constant head boundary." Given this statement, it is not clear why tables 6-1, 6-3, and 7-3 includes "Irrigation recharge" as a model "Feature Type". If indeed the model ignores inflows to the groundwater system from irrigation activities in the Imperial Valley, as suggested in the quoted statement, than it would appear that the model assumes that irrigation drainage is not a component of subsurface inflow to the Salton Sea along its southern shore. Accordingly, this outflow would have to be supplied from the model's inflow sources, which principally consist of seepage from the All American and Coachella canals.

67. The first sentence of the second paragraph on page 6-16 of the Seepage Study report reads, "Initial hydraulic conductivity values for the seepage study model aquitard layer were defined as 1.0 ft/day based on typical values for the materials within the aquitard." This assumption contradicts the last sentence of Section 3.4.3 of the Seepage Study report which reads, "Areas lacking data are assumed to have a hydraulic conductivity value of 30 feet per day for locations east of the pre-historic Lake Cahuilla Shoreline and 0.5 foot per day for locations west of the pre-historic Lake Cahuilla Shoreline (44 feet MSL)." The statement also contradicts the second sentence of Section 3.4.4 of the Seepage Study report which reads, "Assuming an aquitard vertical hydraulic conductivity value of 0.05 foot per day…"

68. Figure 6-6 of the Seepage Study report indicates a 26-mile long band of hydraulic conductivity ranging from 0.0159 feet per day to 0.159 feet per day along the Coachella Canal upstream of Siphon 7. Figure 2-2 of the Seepage Study report indicates that this area is overlain with either "dune sand" or "Quaternary alluvium". Similarly, Plate 1 from Loeltz *et al.*, 1975, depicts this area to be overlain by "windblown sand" and "alluvium". Pages 75-76 from Reclamation, June 1975, discussed the geology of this area as follows:

> "Logs of test holes drilled near the Coachella Canal show the shallow soils to be more sandy to the south and more silty-clayey to the north; however, sand is the principal constituent everywhere. Clay or silty clay beds are less than 5 percent of the total footage drilled in the upper 20 feet and great lateral continuity of the fine-grained beds is unlikely."

Hydraulic conductivity for sandy soils are typically much higher than 0.159 feet per day. Indeed, for the surrounding areas underlain by the same sand and alluvium the model assumed a hydraulic conductivity of 100 feet per day. Thus for the same material, the model assigns hydraulic conductivities that are three to four orders of magnitude apart. The assumed hydraulic conductivity for this area is the lowest of the entire modeled area, even lower than the thick clay layers that underlie the central Imperial Valley. To the west of the band of low hydraulic conductivity discussed above, Figure 6-6 indicates a trapezoidal shaped area that was assigned a hydraulic conductivity of 6.31 feet per day. Figure 2-2 from the Seepage Study report and Plate 1 from Loeltz, *et al.*, 1975, depicts this area to be overlain by the same material (alluvium and sand) that is adjacent to this area that was assigned a hydraulic conductivity of 100 feet per day. The Seepage Study report does not discuss the rationale for assigning such low hydraulic conductivities that appear to be inconsistent with the documented geology.

69. A review of the Seepage Study model's input files (*.riv files) reveals that the assumed canal stage and invert data do not agree with canal design and operational data. With respect to

the All American Canal, discrepancies for a few selected stations are shown in Attachment A to these observations.

With respect to the Coachella Canal the Seepage Study model assumed the depth of water in the Coachella Canal to be 17 feet for the entire length of the canal located in the modeled area. According to profile drawings contained in Attachment 1 to Reclamation, December 1993b, the design depth of water in the Coachella Canal is 9.07 feet from Siphon 7 to Siphon 24, 8.36 feet from Siphon 24 to Siphon 31, and 8.34 feet from Siphon 31 to Siphon 32. Operation of the Coachella Canal is discussed in Reclamation, December 1993a as follows:

> "The section of the canal [between Siphon 7 and Siphon 32] is presently operated in a less-than-full condition to keep seepage to a practical minimum. The flow rate in the canal is typically 500 ft^3/s, but during the course of the year, the rate of flow may occasionally be greatly reduced for a few days during the winter or rise as high as 800 ft^3/s for a day or two when irrigation water demand is high.
>
> "At the three check structures in the unlined canal (at siphons 15, 24, and 31), the flow is 'checked up' to a depth of 6 feet. Upstream from each check structure, the depth of flow decreases as the ponding effect of the check structure gives way to normal flow depth of 4.8 feet several miles upstream from the check."

Design invert elevations from Siphon 7 to Siphon 32 are depicted in the profile drawings contained in Attachment 1 to Reclamation, December 1993b, and differ markedly from the invert data contained in the Seepage Study's *.riv input files. For example, the design invert elevation on the downstream side of Siphon 7 is 82.02 feet. The elevation assumed by the Seepage Study model was 71.44 feet, or 10.58 feet below design. Assuming a water depth of 5 feet above the design invert the stage elevation would be approximately 87 feet, or approximately 1.5 feet below the 88.44 foot stage assumed by the Seepage Study report model. For the upstream end of Siphon 32, the design invert elevation is 48.71 feet or 12.51 feet higher than the 36.20 foot elevation assumed by the Seepage Study model. Assuming a water depth of 5 feet above the design invert the stage elevation would be approximately 54 feet which is greater than the Seepage Study model's assumed stage of 53.2 feet. Metropolitan does not have information on the stage and invert elevations of the Coachella Canal upstream from Siphon 7.

With respect to the East Highline Canal, in 1970 the observed invert and stage elevations on the downstream side of Check No. 1 were approximately 21 feet and 27.5 feet, respectively. Additionally, the observed high water elevation was 30 feet (Imperial Irrigation District, February 1970). However, the invert and stage elevations assumed by the Seepage Study model were 10.74 feet and 22.74 feet, respectively. On the upstream end of the Oak Check, the 1970 observed invert and stage elevations were approximately -2.5 feet and 3.5 feet, respectively. The observed high water elevation was 3.5 feet (Imperial Irrigation District, February 1970). However, the invert and stage elevations assumed by the Seepage Study model were -22.39 feet and -10.39 feet, respectively.

Insufficient information was available on the Central Main and Westside Main canals. Therefore possible discrepancies between the invert and stage elevations assumed by the Seepage Study model and the actual elevations could not be assessed.

With respect to the hydraulic conductance assigned for the interface between the aquifer and the New and Alamo rivers, the Seepage Study model assumes a significantly higher conductance for

the Alamo River than for the New River. The second sentence of page 6-24 of the Seepage Study report reads, "Modeled drain bed conductances were in the range from approximately 3,000 to 8,000 ft2/d for the Alamo River and from 100 to 1,000 ft2/d for the New River." This statement does not agree with the model's input data which sets minimum and maximum hydraulic conductances for the Alamo River at 482 and 36,390 square feet per day and the New River at 16 and 1,637 square feet per day. The third sentence on page 6-24 of the Seepage Study report reads, "These drain bed conductances reflect the river characteristics, where the Alamo River gains a large volume of flow from groundwater, while the New River gains a smaller volume of flow from groundwater." The Seepage Study report does not provide an analysis nor does it cite a source to support this assumption.

Furthermore with respect to the alignment of the Alamo River "drain boundary", the Seepage Study model assumes that the Alamo River 'drain' extends southward beyond the international boundary into Mexico for over 10 miles. However, Reclamation, April 1976, does not depict the Alamo River to extend beyond the United States. Rather, it depicts the irrigation supply canal known as the "Canal Del Alamo" in this area. Note also that a weir was constructed across the bed of the Alamo River immediately upstream of the international boundary. The result of the weir, completed on September 28, 1995, was to divert the flow of the Alamo River, or a portion thereof, into the New River via the interconnected agricultural drainage system in Mexico (International Boundary and Water Commission, 1996). It does not appear that the Seepage Study model incorporates the weir on the Alamo River.

70. Section 6.1.2.8 on page 6-29 of the Seepage Study report reads, "The two pumping wells located at the Mesquite and All American Mines each have a extraction rate of 9,600 acre-feet per year based upon pumping data in the Imperial County Groundwater Model." It is assumed that "All American Mines" refers to the American Girl Mine discussed earlier in the Seepage Study report. Note that as discussed in item 20 above, total withdrawals from the regional aquifer from American Girl Mine and Mesquite Mine is less than 2,000 acre-feet per year.

71. In justifying the choice of 1979 for a steady state calibration procedure, the second full sentence on page 6-30 of the Seepage Study report reads, "Seepage conditions near the canals, well hydrographs throughout the study area, water levels in Mexicali (Bureau of Reclamation 1991), and elevations of the Salton Sea (Thierry 1999) were relatively stable in 1960 to 1979, so steady-state conditions were chosen for the first calibration event." The use of the term "relatively stable" suggests that the features of concern were not rigidly stable, but stable enough to justify a steady state calibration procedure. However, as described below, some of those features can arguably be described as varying significantly:

a) The second full sentence on page 5-2 of the Seepage Study report acknowledges an increase in seepage from the Coachella Canal between Siphon 7 and Siphon 32 in the 1970s, attributing it to "the removal of the original bentonite liner concurrently with intensive aquatic weed removal efforts in the 1970s and 1980s."

b) Figure 16 of Reclamation, March 1994b, depicts a continuous decline in groundwater elevations beneath the Mexicali Valley from 4.62 meters below ground surface in 1961 to 10.03 meters below ground surface in 1976 for a total drop of 5.41 meters (17.7 feet).

c) Page 64 from Imperial Irrigation District, 1990, shows that the end of year elevation for the Salton Sea rose continuously from -233.75 feet in 1960 to -227.75 feet in 1979 for a total rise of 6 feet.

72. The first full paragraph on page 6-30 of the Seepage Study report indicates the second calibration event is based on the lining of the Coachella Canal in 1979. As discussed above, the first 49-miles of the original earthen Coachella Canal was taken out of service in November of 1980. As the model year begins on July 1, it appears that the model calibration was based on the faulty assumption that seepage from the first 49-miles of the Coachella Canal was reduced 17 months earlier than it actually was.

73. The first sentence of the second full paragraph on page 6-31 of the Seepage Study report reads, "The primary calibration objective was to achieve close agreement with the conceptual model water budget (herein referred to as 'observed' water budget data) given that the model objective is predicting changes in the water budget rather than changes in head." This is a surprising approach considering that many inflow and outflow variables were left out of the model. Such omissions include seepage from a majority of canals in the Imperial Irrigation District and the Mexicali Valley, percolation of water applied to agricultural fields in the Imperial and Mexicali valleys, groundwater withdrawals from the Mexicali Valley, and recharge from the Colorado River below Laguna Dam and below Morelos Dam. For those inflows and outflows that were included in the model, these comments have identified numerous inconsistencies between the Seepage Study values and values documented in other sources. Relative to estimated inflows and outflows, a comparison to observed groundwater elevations would be the better indicator of model accuracy. Indeed, it would have been appropriate to modify certain inflow and outflow parameters as part of the model calibration procedure.

Note that the last sentence of this paragraph states that the final comparison of the calibrated model's water levels and the observed water levels is good. However, the next sentence of the Seepage Study report reads, "During calibration, contours of observed heads in Mexicali Valley (Figures 4-6 and 4-9) were found to be incompatible with estimated groundwater flux values at the La Mesa Drain (Table 3-1)." To correct this, the Seepage Study report declares, without any supporting evidence, that water level contours in the Mexicali Valley are precise to only within 15 feet. The third sentence of this third full paragraph reads, "Thus, the contours were adjusted upwards within this 15-foot tolerance in order for the model to match estimated flux values at the La Mesa Drain." Even if the water level contours in the Mexicali Valley are precise to within 15 feet, the Seepage Study report does not justify its assumption that water level measurements were consistently lower than the actual levels. Furthermore, Figure 6-11D shows that the 1993 contour assigned by the Seepage Study report is as much as 21 feet higher than the observed (i.e., measured) level.

This adjustment from the observed water level contours was made without a discussion of the relative accuracy of the estimated inflow to the La Mesa Drain as compared to the accuracy of water level measurements or other factors that may have led to the discrepancy. Note that the estimated flux into the La Mesa Drain of 24,300 acre-feet per year is based on a single document

published by the Republic of Mexico as found in Attachment D to Reclamation, March 1994b. The value is based on the following statement found in the analysis:

> "…the La Mesa Drain receives some 2000 lps (70 cfs), distributed a 400 lps (14 cfs) from various lateral drains and 1600 lps (56 cfs) directly from ground waters. About 60 per cent of this last flow enters in the first 15 kilometers (9 miles) of the drain beginning in the upper part."

It appears the Republic of Mexico assumed the entire groundwater inflow to the first 9 miles of the La Mesa Drain is seepage from the All American Canal (60 percent of 56 cfs for 365 days is approximately 24,300 acre-feet). The Republic of Mexico did not acknowledge the Canal Del Norte, which runs parallel to the La Mesa Drain, or irrigation activities along the La Mesa Drain. It is possible that percolating water and surface runoff from these features may also be collected in the LaMesa Drain. In, addition, recharge from the Colorado River may also find its way to the La Mesa Drain.

By focusing on water budget items, some of which are associated with a high level of uncertainty, rather than the inherently more accurate observed groundwater elevations to calibrate the model, the reliability of the end product is highly questionable.

74. The following are observations with respect to the values contained in Table 6-1:

a) The modeled All American Canal seepage from "1 mile west of Pilot Knob" to the East Highline Canal is 2,762 acre-feet less than that documented in Reclamation, March 1994b.

b) The modeled seepage from the first 49 miles of the earthen Coachella Canal prior to it being replaced by a concrete lined canal is 10,500 acre-feet less than that documented in Reclamation, March 1984.

c) The Seepage Study report does not identify the meaning of the term "EHC, drain seepage", into which the model concludes that groundwater discharges at a rate of 11,292 acre-feet per year. Assuming "EHC, drain seepage" represents the outflow of water from the aquifer into the seepage recovery drains located along the East Highline Canal, page 39 of Imperial Irrigation District, 1990, shows that this annual inflow from 1974 to 1979 ranged from 17,304 acre-feet to 18,712 acre-feet. However, the Seepage Study report does not discuss these drains nor are they depicted on Figure 6-3. The Seepage Study report does discuss All American Canal Drains 2 and 2A that discharge into the East Highline Canal. If these are the drains referenced, the modeled rate is approximately the same as the observed rate. However, these drains are not depicted on Figure 6-3 and thus apparently not incorporated into the model.

d) The observed and modeled annual seepage from the East Highline Canal is indicated to be 8,000 acre-feet and 6,975 acre-feet, respectively. The Seepage Study report does not identify whether this is gross seepage or net seepage. For example, Reclamation, August, 1989, found that in 1980, the last year of operation of the first 49-miles of the original earthen Coachella Canal, seepage losses in the East Highline Canal were as follows:

Reach	Reach Length (miles)	1980 Seepage or (Gain) (acre-feet)
No. 1 Check to No. 11 Check	7.22	(945)
No. 11 Check to Oak Check	13.54	51,597
Oak Check to Nectarine Check	8.53	45,510
Nectarine Check to Flowing Wells Check	9.53	(26,855)
Total	38.82	69,307

Imperial Irrigation District, 1990, states that the amount of seepage recovered (i.e., groundwater adjacent to the canal) and returned to the East Highline Canal in 1980 was 17,116 acre-feet. Therefore the net seepage was 52,191 acre-feet plus the net seepage (or gain) from the approximate 12-mile reach of the East Highline Canal below the Flowing Wells Check. Unfortunately, no information is available to Metropolitan on seepage or gains in that final reach. There are no seepage recovery drains below the Flowing Wells Check.

In estimating the net loss from the East Highline Canal, the principal factors of consideration are those reaches that lose water, those reaches that gain water, and the amount of groundwater that is recovered and returned to the East Highline Canal. The Seepage Study report does not delve into these matters. Note that for actual total net seepage to be equal to the modeled rate of 6,975 acre-feet, there would necessarily have been a gain of approximately 45,000 acre-feet below the Flowing Wells Check, or almost twice the gain in the reach from the Nectarine Check to Flowing Wells Check. Based on the conductances of this reach as contained in the model's *.riv files, the groundwater elevation would have to be some 90 feet above the normal surface water in the canal in order for the gain in this reach to be 45,000 acre-feet. Thus there appears to be some inconsistencies between the model's conclusions and other documented rates of flow to and from the East Highline Canal.

Not included in this table is the observed and modeled seepage from the All American Canal downstream of the East Highline Canal turnout and portions of the Central Main Canal and Westside Main Canals that were included in the modeled area.

e) The conceptual water budget as presented in Table 3-1 of the Seepage Study report assumed that groundwater discharge into the New River and Alamo River was "(<30,000)" acre-feet and "(<60,000)" acre-feet respectively. However the "observed rate"[4] for these values as presented in Table 6-1 is "(18,500)" acre-feet and "(45,000)" acre-feet. The Seepage Study report does not discuss the rationale for departing from its conceptual water budget for these items.

f) The observed values associated with the "Discharge to Salton Sea" Feature Type are consistent with the conceptual water budget as presented in Table 3-1 of the Seepage Study report with the exception of Coachella Valley. The value for this item from Table 3-1 and Table 6-1 are 30,000 acre-feet and 15,400 acre-feet, respectively. The "Reference" is noted to be "SSP Bulletin 108" which is not included in the Seepage Study report's bibliography.

[4] Note that the second full paragraph on page 6-31 of the seepage study defines the "observed" water budget data in Table 6-1 as the conceptual water budget which is presented in Table 3-1 of the seepage study.

Page 136-137 from Bulletin 108 issued by the California Department of Water Resources estimates that this flow was 33,000 acre-feet in 1935-36 and 27,800 acre-feet in 1956-57. However, the third paragraph on page 6-44 of the Seepage Study report reads, "Table 6-5 shows a summary of prescribed groundwater flux from the Coachella Valley to the Salton Sea, with a reversal in gradient observed in 1998 due to pumping in Coachella Valley." This table is apparently the source of the 15,400 acre-foot value contained in Table 6-1. Neither the determination nor the source of the values provided in Table 6-5 is identified.

With respect to the "East Shore" and "Imperial Valley", there is no value shown under the "Modeled Rate" column. Thus it is not clear if the respective values are zero, the same as that shown under the "Observed Rate" column, or some other value.

g) As discussed in item 43 above, evapotranspiration along the "Coachella Branch" should be 37,060 acre-feet.

h) By its absence from Table 6-1, it appears that evapotranspiration from phreatophytes along the East Highline Canal was not incorporated into the model.

i) The observed rate of "Mountain Front Stream and Geothermal Recharge" indicated for "Salt Creek/Northern CB" is ">13,660" acre-feet. Even with footnote 2 to this table, it is not clear why the greater-than sign was added in this table as it does not appear in Table 3-3 of the Seepage Study report. Indeed, item 25 above provides evidence that the estimated amount of geothermal recharge is about 9,000 acre-feet too high. The modeled rate shown in Table 6-1 is 26,493 acre-feet, which is approximately double what the Seepage Study report calls the "observed" amount. The Seepage Study report does not discuss the implications of this modeled amount on the water balance presented in Table 3-3.

   For "Southern CB", the observed rate and modeled rate is indicated to be 0 and 10,000 acre-feet, respectively. This item includes a footnote that reads, "Rising geothermal water is expected to exist east of the first 49 miles of the CB, but published estimates are not available." The Seepage Study report does not discuss this item elsewhere nor does it provide evidence to support its expectation. It appears that it was found necessary to add this inflow to the groundwater system in order to calibrate the model.

j) With respect to underflow between the Cargo Muchacho and Chocolate mountains, see item 24 above.

k) The observed and modeled rate for underflow "beneath La Mesa Drain, combined with Drain discharge" is 78,600 acre-feet and 90,064 acre-feet. The observed rate is discussed in Chapter 4 of the Seepage Study report and is consistent with documented estimates. However, this item includes a footnote that reads, "1979 underflow is expected to be greater than the published value for 1980 to 1993, because the first 49 miles of the CB was lined after 1979." This statement appears to be added to justify the higher amount concluded by the model. However, the hydrographs for wells adjacent to the All American Canal included in Appendix E of the Seepage Study report indicate that the groundwater mound beneath the All American Canal was relatively stable from the 1970s into the 1990s. Indeed, the last

sentence of Section 4.2.3 on page 4-15 of the Seepage Study report reads, "Although water levels dropped significantly along most of the first 49 miles of the CB after its lining, the water levels immediately along the AAC did not decline in response to the Coachella Branch lining." As the groundwater mound beneath the All American Canal did not change, it would appear the increased underflow predicted by the model does not appear to be justified.

As discussed in item 73 above, the Seepage Study report found it necessary to raise the groundwater levels along this boundary because the "contours of observed heads in Mexicali Valley…were found to be incompatible with estimated groundwater flux values at the La Mesa Drain." After raising groundwater levels in this area from the observed levels, the model's projected groundwater flux values at the La Mesa Drain continued to be at odds with the estimated groundwater flux values.

l) The observed and modeled rate of pumpage from East Mesa production wells is 9,250 acre-feet per year. The Seepage Study report indicates this is due to withdrawals made by the American Girl Mine. However, as noted in item 20 above, the assumed amount of pumping should be 1,500 acre-feet per year.

m) With respect to the observed and modeled amount of precipitation recharge, "Skrivan 1997" is cited as the source. This reference is not listed in the Seepage Study report's bibliography.

n) The last item of this table, "irrigation recharge", is confusing. It appears to provide an estimate of the recharge in the irrigated area of the Imperial Valley and reduces this amount by (i) an estimate of the evapotranspiration of this water from river beds and (ii) an estimate of the amount of this water that is collected by the Imperial Irrigation District's drains. With respect to the "observed" irrigation recharge estimate of 50,000 acre-feet per year, see the last bullet for item 24 above. The observed "IID riverbed evapotranspiration" is estimated to be 50,000 acre-feet per year. The source cited for this value is "Boyle Engineering 1993". This source is not included in the Seepage Study report's bibliography, however, it apparently refers to Boyle Engineering Corporation, August 1993 (as described in the list of references attached to these observations). Table 6-34 of this document presents estimated river evapotranspiration and estimated river phreatophytes' water use for years 1987 through 1992. The average of the sum of these values is 59,300 acre-feet. This value was based on a water balance that includes all sources of recharge into the aquifer beneath the central Imperial Valley. It is not clear how the Seepage Study arrived at 50,000 acre-feet per year. The Seepage Study report provides no discussion of "IID irrigation recharge" and "IID riverbed evapotranspiration".

The space associated with observed "discharge to drains" is filled with a question mark. The modeled sum of these three items is a net "irrigation recharge" of -38,045 acre-feet, which represents an outflow from the aquifer of 38,045 acre-feet per year. The Seepage Study report does not elaborate on the determination of this value nor its reasonableness.

75. The following are observations with respect to the values contained in Table 6-2:

a) The observed and modeled values for "Inflow from Groundwater Discharge" is 35,400 acre-feet and 41,338 acre-feet, respectively. The four components of this feature, East Shore, Imperial Valley, Coachella Valley, and West Shore, are listed in Table 6-1. Table 6-1 indicates the modeled rate for the Coachella Valley and West Shore to be 15,400 acre-feet and 10,000 acre-feet, respectively. However, for the East Shore and Imperial Valley the modeled rate values were left blank in Table 6-1. By not providing the individual amounts in Table 6-1 and providing the total only in Table 6-2, the Seepage Study report masked what the modeled rates were for the East Shore and Imperial Valley. In order for the total discharge to the Salton Sea to equal 41,338 acre-feet, the sum of the modeled values for the East Shore and Imperial Valley must be 15,938 acre-feet. From the Imperial Valley, the 2,000 acre-foot per year observed rate of discharge is documented by Loeltz *et al.*, 1975. The Seepage Study report does not provide any arguments nor does it suggest that the modeled rate should vary from 2,000 acre-foot per year. Thus it would appear that the modeled rate for the East Shore was 13,938 acre-feet. As discussed in item 25 above, however, the subsurface discharge to the Salton Sea from the East Shore should be approximately zero.

b) The precipitation and evaporation values appear to be based on the stage of the Salton Sea which was assumed to be -227.75 feet, and average precipitation and evaporation rates as published in "USGS 486-C" (listed as Hely *et al.*, 1966, in the attached list of references). With respect to the stage, the reference noted was a November 1997 draft document by Merlin B. Tostrud of the Colorado River Board of California entitled, *The Salton Sea 1906-1996 Computed and Measured Salinities and Water Levels*. Tostrud provides measured Salton Sea elevation values in column (1) of Table B-2 contained in Appendix B of that study. Tostrud does not identify the source of these values, but they match the values contained on page 64 of Imperial Irrigation District, 1990. These values are based on measurements at Fig Tree John, the datum from which is 0.911 feet higher than the U.S. Geological Survey's National Geodetic Vertical Datum of 1929, or "NGVD" (U.S. Geological Survey, July 1998). Thus a stage of -227.75 feet measured at Fig Tree John is actually -228.661 feet from the NGVD. At this elevation, the surface area of the Salton Sea is 230,567 acres (Reclamation, May 1997). Therefore precipitation into the Salton Sea at a rate of 0.22 feet per year and evaporation from the Salton Sea at a rate of 5.78 feet per year (Hely *et al.*, 1966) results in a total annual precipitation and evaporation of 50,725 acre-feet and 1,332,677 acre-feet, respectively. These values are significantly different from the modeled values of 31,500 acre-feet and 1,426,442 acre-feet, respectively.

76. The larger differences in the observed and modeled groundwater contours as depicted on Figure 6-13 of the Seepage Study report occur along the East Highline Canal. This is significant as the East Highline Canal could potentially be acting as control point for groundwater flow and it overlies the interface between the relatively permeable geology of the East Mesa and the relatively impermeable geology of the central Imperial Valley. The Seepage Study report does not acknowledge this. In fact, the last sentence of the second paragraph on page 6-36 of the Seepage Study report reads, "In general, the model errors also appear to be randomly distributed throughout the domain."

77. The first sentence of Section 6.2.4 on page 6-43 of the Seepage Study report reads, "A transient simulation was conducted for the period from 1979, following the lining of the first 49 miles, to 2006." As discussed above, the first 49-miles of the original earthen Coachella Canal was taken out of service in November of 1980. The next sentence reads, "Observed data generally extend to 1988 for flow…" The Seepage Study report does not discuss why it did not incorporate post 1988 published flow data that are on file with the Imperial Irrigation District and the Coachella Valley Water District.

78. The seventh and eighth sentences of Section 6.2.4 on page 6-43 of the Seepage Study report reads, "However, several hydrographs on Figures 6-17 and 6-18 show a slight rise in observed water levels starting in the early 1990s (e.g., 6926 and 7611.08). This rise is not simulated by the model because the CHD heads at La Mesa Drain are prescribed to trend towards the 1979-to-1993 average values after 1993." Thus the Seepage Study report acknowledges that the transient calibration procedure for the model included the use of a prescribed groundwater elevation along the model's boundary at the Mexicali Valley that did not reflect observed groundwater elevations. Note that the rise in observed elevation at these two wells begins in 1993, the same year in which there was over 3.69 million acre-feet of Colorado River water delivered to Mexico in excess of its scheduled deliveries. As discussed in item 13 above, the Seepage Study report failed to recognize this and other variable factors that has a significant effect on recharge to the regional aquifer.

79. The last three sentences of the last paragraph on page 6-43 of the Seepage Study report reads, "The hydrograph on Figure A-2 (15S14E18C) shows simulated heads consistently higher than observed heads by approximately 7 feet. This well is in the IID area where constant heads 6 feet below land surface are simulated in the model. The uncertainty in the land surface elevation is about 10 to 15 feet, and is thus greater than the difference between the simulated and observed heads on Figure A-2." It is not clear how the Seepage Study report concludes that the uncertainty in the land surface elevation in the central Imperial Valley is about 10 to 15 feet. Page K6 of Loeltz *et al.*, 1975, states that the gradient in this area is 1.7 feet per mile. As model cells are one-half mile by one-half mile, it would seem that the uncertainty is closer to plus or minus one foot. The Seepage Study report fails to consider that it may have incorrectly assumed that groundwater is uniformly 6 feet beneath the surface of the irrigated area of the Imperial Valley. Page K28 of Loeltz *et al.*, 1975, states that groundwater levels in this area have been stabilized at depths between 5 and 20 feet below land surface.

80. Figures 6-16, 6-17, and 6-18 depict observed groundwater elevations and elevations simulated in the 1979 to 2006 transient run. Of the eleven wells shown, eight of them show a divergence in the observed elevation versus the simulated elevations from 1979 to 1999, the last year in which observed data is available. Differences in the latest observed value and the simulated value are as follows:

	Values in feet from NGVD		
Well No.	Observed Value	Simulated Value	Difference
16S/21E-33E	147	122	25
5816.5	86	72	14
6926	107	100	7
6814	92	86	6
7703.05	81	68	13
7611.08	37	31	6
5614.4	16	5	11
3635.5	10	-3	13

Despite these differences, the first sentence on page 6-44 of the Seepage Study report reads, "The total drop in heads from the pre-lining to 1990 post-lining conditions are nearly identical to the measured values."

For well no. 7703.05, Figure 6-17 includes a note that reads, "10 foot correction for well 7703.05 on canal." This correction is discussed on page 6-32 of the Seepage Study report in which the last sentence of the second full paragraph reads, "The following mathematical method that has been proposed to correct the grid block heads to heads measured in pumping wells (Andersson and Woessner 1992; Reeves *et al.*, 1986)." Following presentation of the proposed mathematical method, the Seepage Study report reads, "A similar correction methodology for a line rather than point source would be applicable to canals, but to our knowledge methods are not currently available for estimating this correction for a canal." Then, without providing an analysis on the appropriateness of using the proposed mathematical method for a canal, the Seepage Study report reads, "Applying the well relation to the above canal, the correction factor would be 15 feet…This correction factor is of the same order observed for observation wells immediately next to the AAC and CB canals." This general discussion is not supplemented with calculations for each specific well.

81. Table 6-3 of the Seepage Study report is entitled "Observed and Calibrated Model 1993 Water Balance". However, many of the modeled rates shown in this table are indicated to be the average of the 1979 to 1993 simulated rates. Thus the reader has no way of knowing what the actual 1993 modeled rates are for those features. Notwithstanding this limitation, the following are observations with respect to the values contained in Table 6-3:

a) The observed and modeled seepage from the first 49-miles of the concrete-lined Coachella Canal are 4,800 acre-feet and 4,690 acre-feet. However, according to Coachella Valley Water District, May 1991, the observed annual seepage declined from 5,454 acre-feet in 1982 to zero seepage in years 1989 and 1990.

b) With respect to "EHC, drain seepage" and "EHC, canal seepage", see item 74 above for observations on these feature types. Note that the table does not include observed and modeled seepage from the portions of the Central Main Canal and Westside Main Canal.

c) With respect to groundwater discharge into the New River and Alamo River see item 74 above for observations on the feature type.

d) With respect to "Discharge to Salton Sea" see item 74 above for observations on the feature type.

e) With respect to evapotranspiration along the "Coachella Branch" see item 74 above for observations on the feature type.

f) It appears that evapotranspiration from phreatophytes along the East Highline Canal was not incorporated into the model.

g) With respect to "Mountain Front Stream and Geothermal Recharge" see item 74 above for observations on the feature type.

h) With respect to underflow between the Cargo Muchacho and Chocolate mountains, see item 74 above.

i) The observed and modeled rate of pumpage from East Mesa production wells is 18,500 acre-feet per year. As noted in item 20 above, the assumed amount of pumping should be 2,000 acre-feet per year.

j) With respect to the observed and modeled amount of precipitation recharge, see item 74 above for observations on the feature type.

k) With respect to "irrigation recharge", see item 74 above for observations on the feature type.

82. The following are observations with respect to the values contained in Table 6-4:

a) The observed and modeled values for "Inflow from Groundwater Discharge" are 25,674 acre-feet and 31,902 acre-feet, respectively. The four components of this feature, East Shore, Imperial Valley, Coachella Valley, and West Shore, are listed in Table 6-3. Table 6-3 indicates the modeled rate for the Coachella Valley and West Shore to be 5,674 acre-feet and 10,000 acre-feet, respectively. However, for the East Shore and Imperial Valley the modeled rate values were left blank in Table 6-3. By not providing the individual amounts in Table 6-3 and providing the total only in Table 6-4, the Seepage Study report masked what the modeled rates were for the East Shore and Imperial Valley. In order for the total discharge to the Salton Sea to equal 31,902 acre-feet, the sum of the modeled values for the East Shore and Imperial Valley must be 16,228 acre-feet. With respect to the Imperial Valley, the 2,000 acre-foot per year observed rate of discharge from this area is documented by Loeltz *et al.*, 1975. The Seepage Study report does not provide any arguments nor does it suggest that the modeled rate should vary from 2,000 acre-feet per year. Thus it would appear that the modeled rate for the East Shore was 14,228 acre-feet. As discussed in item 25 above, however, the subsurface discharge to the Salton Sea from the East Shore should be approximately zero.

b) The precipitation and evaporation values appear to be based on the stage of the Salton Sea which was assumed to be -226.78 feet, and average precipitation and evaporation rates as published in "USGS 486-C" (listed as Hely *et al.*, 1966, in the attached list of references). With respect to the stage, the reference noted was a November 1997 draft document by Merlin B. Tostrud of the Colorado River Board of California entitled, *The Salton Sea 1906-1996 Computed and Measured Salinities and Water Levels*. However, according to records from U.S. Geological Survey gaging station no. 10254005, the stage on December 31, 1993 was -227.90 feet. At this elevation, the surface area of the Salton Sea is 232,185 acres (Reclamation, May 1997). Therefore precipitation into the Salton Sea at a rate of 0.22 feet per year and evaporation from the Salton Sea at a rate of 5.78 feet per year (Hely *et al.*, 1966) results in a total annual precipitation and evaporation of 51,081 acre-feet and 1,342,029 acre-feet, respectively. These values are significantly different from the modeled values of 31,500 acre-feet and 1,428,067 acre-feet, respectively.

83. Section 6.3 of the Seepage Study report discusses the sensitivity analysis of the model. Although such analyses are critical in evaluating the viability of a model, the Seepage Study report dedicates only 23 lines for discussion of its sensitivity analysis. The scope of the sensitivity analysis is described generally at the bottom of page 6-44 as follows:

- Global increase/decrease of hydraulic conductivity throughout the entire model to define sensitivity to entire model hydraulic conductivity;

- Global increase/decrease of specific yield and storativity throughout the entire model to define sensitivity to entire model storage coefficients; and

- Changes in regional boundary conditions to define their impact on the model.

The only other information that describes the nature of the sensitivity analysis is contained in the headings of Table 6-6. These headings were entitled "Base Case", "2-zone Reduced Conductivity", "2-zone Increased Conductivity", "3-zone Reduced Storage", "3-zone Increased Storage", "25 ft Reduced Specified Head", and "25 ft Increased Specified Head". The meaning of each heading is not described. The magnitude of the increase/decrease in hydraulic conductivity or the increase/decrease in storage is not identified. The area in which the specified head was increased/decreased is not identified.

Notwithstanding the unclear meaning of "2-zone", based on the general descriptions of the sensitivity analysis, it appears that hydraulic conductivity was increased or decreased globally. The utility of this approach is not clear as movement of groundwater is significantly influenced by relative differences in regional hydraulic conductivities. For example, it would have been helpful to observe the result of reducing the hydraulic conductivity within the irrigated area of the Imperial Valley while keeping the conductivities elsewhere the same. Such an exercise would have provided useful insight into the movement of groundwater from the relatively permeable geology of the East Mesa towards and into the relatively impermeable geology of the central Imperial Valley.

The first paragraph on page 6-54 of the Seepage Study report indicates that sensitivity statistics were based on a comparison of simulated heads and the actual heads measured from wells. It also indicates that water budget statistics were not computed for the sensitivity runs. Thus there was no evaluation of the sensitivity of modeled inflows and outflows. Note that as stated on page 1-1 of the Seepage Study report, the purpose of the study is to "determine the nature of subsurface and drainage canal water movements from the unlined canals to the Salton Sea and to existing adjacent wetlands, and shall quantify the amount of water that may be lost to the Salton Sea and to those wetlands due to the canal lining projects." Given the stated purpose of the Seepage Study report, its is not clear why the sensitivity of the modeled outflows to the Salton Sea and other groundwater flows were not evaluated.

There is an apparent contradiction in the Seepage Study report in that the primary calibration objective was to achieve close agreement with the conceptual water budget, however, in performing the sensitivity analysis the resulting effect on the modeled water budget features was not considered.

84. Figure 6-19 of the Seepage Study report depicts simulated and observed Salton Sea stages. The measured stage appears to be based on data from the Imperial Irrigation District. As noted in item 75 above, these elevations are 0.911 feet higher than the actual elevation from the NGVD. Furthermore, rather than to mimic the observed elevations, the simulated stage appears to be based on minimization of the sum of the departures from the observed data. The combined result of these two factors is that the stage determined by the simulated curve is higher than the observed stage. The departure in simulated stage from observed stage ranges from 1 foot to 1.7 feet.

85. The error analysis of the sensitivity runs is contained in Table 6-6 on page 6-59 of the Seepage Study report. The terms used in this table are not defined. The significance of the error analysis as presented in Table 6-6 is not clearly evident nor is it satisfactorily explained.

86. The estimated seepage from the proposed concrete-lined All American Canal as stated in Table 7-1 on page 7-1 of the Seepage Study report, 15,800 acre-feet per year, appears to be based on the existing All American Canal earthen prism. Page II-5 of Reclamation, March 1994b, depicts the proposed concrete-lined prism which is deeper and narrower than the existing prism. Metropolitan envisions a similar canal prism having the following dimensions:

Dimension	Station 1250+00 to Drop 1	Drop 1 to Drop 2	Drop 2 to Drop 3
side slope horizontal to vertical ratio	1.5:1	1.5:1	1.5:1
bottom width	60 feet	60 feet	60 feet
water depth*	21.51 feet	18.32 feet	17.85 feet

*Based on original All American Canal maximum design flow rates.

Assuming these dimensions and a rate of seepage through concrete lining at 0.07 cubic feet per square foot per day, the projected seepage through lining should be:

Lined Reach	Reach Seepage (acre-feet per year)
1 mile west of Pilot Knob	5,290
Drop 1 to Drop 2	2,965
Drop 2 to Drop 3	3,047
Total	11,302

87. The second sentence of Section 7.2.1 on page 7-2 of the Seepage Study report reads, "Groundwater conditions in the Mexicali Valley are stable in the long-term with short-term fluctuations due to pumping in Mexicali and excess Colorado River flows." As discussed in item 13 above, groundwater elevations in the Mexicali Valley are not stable in the long term.

88. The first sentence of the last paragraph on page 7-2 of the Seepage Study report cites "Bureau of Reclamation 1984, 1987". These references are not listed in the Seepage Study report's bibliography.

89. Section 7.2.1 of the Seepage Study report discusses its use of a 1984 Bureau of Reclamation model to determine the elevation of groundwater for the southern boundary of the Seepage Study report model. Unfortunately the 1984 model's documentation is not listed in the Seepage Study report's bibliography and the Seepage Study report provides only general information on the makeup of the model. It is not clear if the Seepage Study's execution of the model incorporated the factors discussed in item 13 above.

The initial groundwater elevations and the adjustments made to these elevations from the results of the Seepage Study's use of the 1984 Bureau of Reclamation model are shown in Figure 7-1 of the Seepage Study report. For row 184, column 78, the "Head without USBR Drawdown" is indicated to be 103 feet. However, the Mexicali Valley Groundwater Level Contour Map for 1993 contained in Appendix E of the Seepage Study report indicates that the 1993 groundwater elevation in this area was approximately 26 meters, or 85 feet. Based on Figure 3 contained in Attachment D of Reclamation, March 1994b, it would appear that maximum groundwater elevations in the Mexicali Valley were experienced in 1985 and 1986. This maximum coincided with flows in the Colorado River above Morelos Dam in excess of Mexico's scheduled delivery (see item 13 above) and sustained flows in the Colorado River below Morelos Dam. It would appear that the Mexicali Valley Groundwater Level Contour Map for 1985 contained in Appendix E of the Seepage Study report would represent the maximum groundwater elevations that can be expected. This map indicates the 1985 groundwater elevation in this area was approximately 30 meters, or 98 feet. Therefore, depending on the amount of excess deliveries to Mexico and flows below Morelos Dam from the present to 2006, one would expect groundwater elevation in the vicinity of row 184, column 78 of the model to be 98 feet or less. Similarly for row 173, column 60 of the model, one would expect groundwater elevation in this area to be approximately 26 meters (85 feet) or less. Figure 7-1 indicates 92 feet. It is interesting to note that for row 164, column 37, and row 166, column 18, the 1984 Bureau of Reclamation model projected little or no drawdown after lining the All American Canal. This would be consistent with the discussion contained on page 42 of Reclamation, March 1994b (see item 29 above).

90. The last paragraph of Section 7.2.1 on page 7-6 of the Seepage Study report indicates that projected withdrawals from the Lower Colorado Water Supply Project wellfield are not incorporated into the model. Therefore the interrelationship of withdrawals from this wellfield and lining of the All American and Coachella canals on reductions in flows to the Salton Sea, if any, cannot be evaluated. Note that this wellfield, located in the Sand Hills adjacent to the All American Canal, currently has the capacity to withdraw 5,000 acre-feet per year. Withdrawal capacity may be increased to as much as 10,000 acre-feet per year as authorized by Congress in Public Law 99-655.

91. The following are observations with respect to the values contained in Table 7-3:

a) With respect to the value for "AAC, 1 mile west of Pilot Knob to Drop 2", as discussed in item 86 above, this seepage amount should be 8,255 acre-feet.

b) With respect to seepage from the first 49-miles of the concrete-lined Coachella Canal, see item 74 above for observations on this feature type.

c) The observed and modeled rate of seepage from the lined section of the Coachella Canal from Siphon 7 to Siphon 32 is 1,604 acre-feet. However, Table 7-2 on page 7-1 of the Seepage Study report indicates this loss would be 1,490 acre-feet which is consistent with Reclamation, December 1993a. The Seepage Study report does not discuss why it revised the value for the model simulation.

d) With respect to "EHC, drain seepage" the Seepage Study report indicates that groundwater discharge into these drains is expected to decrease after lining the All American Canal. The model not only projected a decrease from the observed rate of 10,413 acre-feet, it projected a reversal of flow direction. The modeled rate is indicated to be 2,760 acre-feet from the drain into the aquifer. The Seepage Study report does not specifically discuss this reversal in flow. This result is erroneous as the function of the drain is to collect water from the surrounding high water table. If the water table drops such that water present in the drain flows into the aquifer, the drain would go dry.

   Notwithstanding the erroneous projected reversal of flow, and assuming the Seepage Study report is referring to All American Canal Drain 2 and Drain 2A, an evaluation of the observed effect on amounts recovered in these drains following the November 1980 replacement of the first 49-miles of the original earthen Coachella Canal with a concrete-lined canal could provide some insight. Figure 4 attached to these observations indicates that in the decade following 1980 the amount of water recovered in All American Canal Drain 2 and Drain 2A were equal to or greater than the amounts recovered before 1980. Furthermore, page III-6 of Reclamation, March 1994a, concludes that lining the All American Canal from Pilot Knob to Drop 4 "would not lower the water table below the canal bottom downstream of Drop 4." Note that the proposal is to line only down to Drop 3, which is 9.29 miles upstream of the location of All American Canal Drain 2 and Drain 2A.

   It appears unlikely that the Seepage Study report was referring to the seepage recovery drains located along the East Highline Canal as they are not recognized in the Seepage Study report.

Nevertheless, Figure 4 attached to these observations indicates that there was a reduction in the amounts recovered following the replacement of the first 49 miles of the original earthen Coachella Canal with a concrete-lined canal. A reduction of no more than approximately 3,000 acre-feet per year is indicated. Note that most of the seepage from the unlined Coachella Canal, estimated at 141,000 acre-feet per year, entered the East Mesa. As indicated in item 34 above, page III-10 of Reclamation, March 1994a, states that less than 5 percent of the annual seepage from the canal upstream from Drop 3 flows northward under the East Mesa, which amounts to approximately 4,225 acre-feet. Therefore, after lining the All American Canal from Station 1250+00 to Drop 3, it would seem that the reduction in the amount of water recovered in the East Highline Canal seepage recovery drains would be significantly less than 3,000 acre-feet per year.

e) With respect to "EHC, canal seepage", see item 74 above for observations on this feature type. Note that the table does not include observed and modeled seepage from the portions of the Central Main Canal and Westside Main Canal.

f) With respect to groundwater discharge into the New River and Alamo River see item 74 above for observations on this feature type.

g) With respect to "Discharge to Salton Sea" see item 74 above for observations on this feature type.

h) With respect to the evapotranspiration feature type, it appears that phreatophytes along the East Highline Canal were not incorporated into the model.

i) With respect to "Mountain Front Stream and Geothermal Recharge" see item 74 above for observations on this feature type.

j) With respect to underflow between the Cargo Muchacho and Chocolate mountains, see item 74 above for observations on this feature type.

k) "Pumpage" from East Mesa production wells is projected to be 18,500 acre-feet per year. Item 20 above suggests this value should be less than 2,000 acre-feet per year.

l) With respect to the observed and modeled amount of precipitation recharge, see item 74 above for observations on this feature type.

m) With respect to "irrigation recharge", see item 74 above for observations on this feature type.

92. The following are observations with respect to the values contained in Table 7-4:

a) The observed and modeled values for "Inflow from Groundwater Discharge" is 13,517 acre-feet and 22,605 acre-feet, respectively. The four components of this feature, East Shore, Imperial Valley, Coachella Valley, and West Shore, are listed in Table 7-3. Table 7-3 indicates the modeled rate to be 6,483 acre-feet from the Salton Sea into the aquifer beneath the Coachella Valley and 10,000 acre-feet from the West Shore aquifer into the Salton Sea.

However, for the East Shore and Imperial Valley the modeled rate values were left blank in Table 7-3. By not providing the individual amounts in Table 7-3 and providing the total only in Table 7-4, the Seepage Study report masked what the modeled rates were for the East Shore and Imperial Valley. In order for the total discharge to the Salton Sea to equal 22,605 acre-feet, the sum of the modeled values for the East Shore and Imperial Valley must be 19,088 acre-feet. With respect to the Imperial Valley, the model projected reduced groundwater discharges into the New and Alamo Rivers and seepage recovery drains, therefore, it follows that the model could not have projected an increase in subsurface inflow to the Salton Sea from the Imperial Valley. Thus the modeled rate for the East Shore appears to be more than 17,000 acre-feet which is more than double the current rate of 8,000 acre-feet assumed by the Seepage Study. As discussed in item 25 above the subsurface discharge to the Salton Sea from the East Shore should be approximately zero.

Figure 7-5 of the Seepage Study report provides additional information on the modeled subsurface inflow to the Salton Sea. It indicates that the steady state post canal lining subsurface discharge to the Salton Sea would be approximately 14,425 acre-feet. Following the same logic as above, the subsurface inflow from the east shore would necessarily be approximately 8,900 acre-feet which is an increase from the Seepage Study report's assumed current rate of 8,000 acre-feet per year. Figure 7-5 also indicates that the 2026 discharge without canal lining would be approximately 24,425 acre-feet. A similar calculation suggests that the modeled rate from the East Shore was approximately 18,000 acre-feet, or 10,000 acre-feet more than the assumed current rate.

With respect to surface inflow to the Salton Sea, the Seepage Study report does not consider reductions that would be likely as a result of reduced drainage from the Imperial Irrigation District. In the future, when there are insufficient supplies of surplus Colorado River water and/or Colorado River water apportioned to another State but unused, the sum of the net diversions of Colorado River water by the Imperial Irrigation District could likely be reduced. In years declared "Normal" by the Secretary of the Interior, reductions in net diversions by the Imperial Irrigation District from levels of certain past years would be necessary such that the sum of the net diversions under the first three priorities described in the Imperial Irrigation District's water delivery contract would not exceed 3.85 million acre-feet less water conserved under the Imperial-Metropolitan Water Conservation Program. In addition, reductions in inflow would also occur under implementation of the proposed Imperial-San Diego County Water Authority transfer. The Seepage Study model does not consider these likely reductions in inflow to the Salton Sea and the resulting impact on the model's projections.

b) The precipitation and evaporation values appear to be based on the stage of the Salton Sea which was assumed to be -227.18 feet, and average precipitation and evaporation rates as published in "USGS 486-C" (listed as Hely *et al.*, 1966, in list of references attached to these observations). At the indicated stage, the surface area of the Salton Sea would be 233,725 acres (Reclamation, May 1997). Therefore precipitation into the Salton Sea at a rate of 0.22 feet per year and evaporation from the Salton Sea at a rate of 5.78 feet per year (Hely *et al.*, 1966) results in a total annual precipitation and evaporation of 51,420 acre-feet and 1,350,931 acre-feet, respectively. These values are significantly different from the modeled

values of 31,500 acre-feet and 1,426,442 acre-feet, respectively.

If there is a reduction in drainage from the Imperial Valley as discussed under 92a above, the 2026 stage of the Salton Sea would likely be several feet or more lower than that indicated in Table 7-4. The Seepage Study report does not consider this possibility. Considering the uncertainty of the future elevations of the Salton Sea, the Seepage Study report should have included varying Salton Sea elevations in its sensitivity analysis.

93. The first full paragraph on page 7-8 discusses Figure 7-2 of the Seepage Study report which shows the predicted long term and steady-state evapotranspiration rates along the All American and Coachella canals. However, instead of using the term "evapotranspiration", the discussion uses the term "seepage rates". It appears the discussion should have used the former term.

The discussion notes that the time required for the evapotranspiration rates to decline in response to lining the All American and Coachella canals from the projected 2005 level to a steady state level is dependent on the specific yield of the aquifer. The fourth sentence of this paragraph reads, "The steady-state seepage rate could be reached before 2026, if the actual specific yield value is significantly less than the modeled value of 0.25." However the Seepage Study report does not identify the value of specific yield that would result in the steady state evapo-transpiration to occur before 2026. Nor does it discuss the reasonableness of specific yield values that are less than the modeled value. These observations also apply to the curves shown in Figure 7-5 of the Seepage Study report for projected reductions in subsurface inflow to the Salton Sea and projected reductions in discharge of groundwater to Imperial Irrigation District drains.

94. With respect to projected elevations of the Salton Sea, the Seepage Study report dedicates only two sentences to this subject which are found on page 7-8. This discussion reads, "Figure 7-4 shows predicted stage of the Salton Sea for the period 2006 through 2026. The Salton Sea stage may drop by a range of less than 1 inch to 1.7 feet by the end of the simulation." The Seepage Study report does not describe the procedure followed to calculate resulting Salton Sea stage. As demonstrated in the above observations for Tables 6-2, 6-4, and 7-4, the Seepage Study report's calculated outflow by evapotranspiration and inflow by precipitation does not appear to be based on the Salton Sea area-capacity table found in Reclamation, May 1997.

95. The first two sentences of the first paragraph on page 7-17 of the Seepage Study report reads, "Net discharge into the East Highline Canal southern segment ceases by 2026. Recharge due to increased seepage along the entire East Highline Canal may increase by a range of 746 acre-feet per year to 11,521 acre-feet per year by 2026." This passage is the extent of the Seepage Study report's discussion of its assumed seepage from the East Highline Canal. The Seepage Study report does not describe what is meant by "East Highline Canal southern segment". Note that Reclamation, August 1989, concluded that there is a gross annual seepage of 105,800 acre-feet from the first 29.29 miles of the East Highline Canal from Check No. 1 to Nectarine Check. This conclusion sharply disagrees with the Seepage Study report's assumption of a net gain prior to 2026. Reclamation, August 1989, quantified the amount of water collected in the East Highline seepage recovery drains located within this reach at approximately 20,100

acre-feet per year. Thus the net annual seepage from the first 29.29 miles of the East Highline Canal from Check No. 1 to Nectarine Check was 85,700 acre-feet. Note that the incorrect canal invert and stage data entered into the model for the East Highline Canal, as discussed in item 69 above, may have led to erroneous results.

96. Pages 7-18 through 7-20 of the Seepage Study report discusses mitigation measures proposed to coincide with the lining of the Coachella Canal. The second and third paragraph on page 7-19 quantifies the current acreage of wetlands within the "Salt Creek ACEC" area and the projected post-canal lining wetland acreage with implementation of mitigation measures. The values are consistent with the riparian vegetation acreage within Hydrologic Unit D of the Coachella Canal as documented in Table III-5 of Reclamation, December 1993a. However, the Seepage Study report neglected to include (i) existing riparian vegetation acreage that would be degraded after lining but not lost and (ii) marsh acreage as shown in Table III-6 of Reclamation, December 1993a. The Seepage Study report does not discuss wetlands that would remain intact or remain in a degraded state in the other four hydrologic units of the Coachella Canal. These values for pre-and post-canal lining are found in Tables III-5 and III-6 of Reclamation, December 1993a, and are summarized as follows:

	Present Acreage	Projected Post Lining Acreage
Existing Riparian Vegetation	6,933	1,413
Degraded Riparian Vegetation	----	1,339
Marsh	479	367
Riparian Revegetation	----	1,276
Marsh Impact Avoidance/Creation	----	112
Total	7,412	4,507

The Seepage Study report quantifies the projected post-canal lining riparian vegetation acreage that would exist within Hydrologic Unit D at 1,943 acres. With respect to this acreage, the first sentence of the last paragraph on page 7-19 reads, "For modeling purposes, the post-lining CB mitigation measures will be simulated by setting overall evapotranspiration target of 14,200 af/yr in the ACEC wetlands complex…" Assuming 1,943 acres as stated in the Seepage Study report, this target annual evapotranspiration rate amounts to 7.3 acre-feet per acre. However, the last sentence of the discussion at the top of page 7-20 indicates the target evapotranspiration rate was related to 2,695 acres of wetlands, which would result in an annual unit rate of 5.3 acre-feet per acre. Note that the Seepage Study report assumed 5 acre-feet per acre for its conceptual water budget. The Seepage Study report does not acknowledge this departure nor does it discuss it.

Notwithstanding the apparent inconsistency in evapotranspiration rates, the Seepage Study's assumed wetland acreage under post-lining conditions with implementation of mitigation measures does not agree with Reclamation, December 1993a. As proposed in Reclamation, December 1993a, total wetlands along the Coachella Canal from Siphon 7 to Siphon 32 would be 4,507 acres of which 2,568 acres would be within Hydrologic Unit D. At an annual rate of five acre-feet per acre, the evapotranspiration from these areas would be 22,535 acre-feet and 12,840 acre-feet, respectively.

97. Table 8-1 on page 8-1 of the Seepage Study report documents the model's concluded current and post-canal lining evapotranspiration from wetlands along the All American and Coachella canals. With respect to current evapotranspiration along the Coachella Canal, see item 43 above for a discussion of discrepancies between the Seepage Study report and Reclamation, December 1993a. With respect to projected post-canal lining evapotranspiration along the Coachella Canal with implementation of proposed mitigation, the values do not comport with the projected wetland areas. The following is a comparison of the values contained in Table 8-1 of the Seepage Study report and the projected wetland areas along the Coachella Canal as documented in Reclamation, December 1993a:

Hydrologic	Projected Post-Lining Wetlands (acres)			Evapotranspiration (acre-feet)	
Unit	Riparian	Marsh	Total Wetlands	Projected*	Seepage Study Report
A	527	0	527	2,635	1,930
B	433	15	448	2,240	82
C	857	47	904	4,520	0
D	2,151	417	2,568	12,840	14,181
E	60	0	60	300	57
Total	4,028	479	4,507	22,535	16,250

*Annual evapotranspiration at five acre-feet per acre of Total Wetlands.

There is significant disagreement between the post-canal lining wetlands as proposed in Reclamation, December 1993a, and the conclusions of the Seepage Study model. This disagreement is not acknowledged nor is it discussed by the Seepage Study report.

98. Tables 8-3 and 8-4 of the Seepage Study report contain the results of the Seepage Study model with respect to evapotranspiration by wetlands along the All American and Coachella canals and the discharge of water to the Salton Sea. As noted in Chapter 7 of the Seepage Study report, the high and low values reflect the modeled values at year 2026 and the long term steady-state values as predicted by the model. The time required to reach steady state beyond 2026 was not identified. An error analysis was not performed. Therefore, the discussion of Section 8.4.2 in the Seepage Study report, entitled "Uncertainty in Estimates", does not identify the confidence level of the model's results.

The values under the "Unlined Water Use" column from Table 8-3 and "Unlined Groundwater Discharge" column from Table 8-4 appear to represent the modeled values for the year 2026 without lining the All American and Coachella canals. The Seepage Study report does not discuss this model simulation nor does it identify the resulting water budget. Similarly, the values under the "Low" columns from tables 8-3 and 8-4 appear to represent the modeled values for the long-term steady-state condition after lining the All American and Coachella canals. The Seepage Study report does not discuss this model simulation nor does it identify the resulting water budget.

The Seepage Study report's concluded reductions in discharge to the Salton Sea from lining the All American and Coachella canals are principally embedded in the "IID Drains" and "Salton

Sea (SS): Direct discharge" features. With respect to "Salton Sea (SS): Direct discharge", as discussed in item 92 above, the modeled flows stated in Table 7-3 and Table 7-4 of the Seepage Study report do not appear to reconcile. With respect to "IID Drains", as discussed in items 37 61 above, it appears that the Seepage Study report overestimated the amount of groundwater from outside the central Imperial Valley that migrates to the Imperial Irrigation District drains and the New and Alamo rivers.

99. The first line on page C-1 of the Seepage Study report reads, "Many conceptual model water balance calculations are given in the AAC and CB EIR reports,…" It is not clear as to what documents "AAC and CB EIR reports" reference.

In the description of the calculation of "Disconnected Canal Seepage Rates" on page C-1, the first line states that total seepage from Pilot Knob to Drop 1 is 59,187 acre-feet and the second line states that the length of this reach is 73,392 feet (13.9 miles). However, item 26 above shows that the stated amount of seepage is from Rock Section 2 to Drop 1 which does not include seepage from the 1.41 mile reach of the All American Canal from the Pilot Knob Check Gates through Rock Section 2.

The meaning of "Canal width+height" in the third line is not clear as the design canal width (130 feet) plus the design normal water depth (16.59 feet) is 146.59 feet. This amount is less than the 205 feet stated. Note that the design wetted perimeter for the All American Canal from Rock Section 2 to Drop 1 is 204.2 square feet per foot. Between Drop 2 and Drop 3 the design wetted perimeter is 180.8 square feet per foot. Page C-1 indicates this value to be 185 feet. Similarly for the Coachella Canal in Hydrologic Unit B (Siphon 14 to Siphon 18) and Hydrologic Unit C (Siphon 18 to Siphon 23) the design wetted perimeter is 86.6 square feet per foot. Page C-2 indicates this value to be 70 feet. Note that these values are for design conditions at design maximum flow. Actual flow in these canals are typically less than design, therefore, actual wetted perimeters are less than the design values stated herein.

100. Appendix D to the Seepage Study report contains a June 12, 1999 letter from the Seepage Study report's Peer Review Panel to Mr. Thomas F. Field of Tetra Tech. Appendix D also includes a four page paper entitled "Tetra Tech's Response to Peer Review Panel Report" (Tetra Tech's Response). The final Seepage Study report is dated July 9, 1999. Thus only 26 days, including weekends, were allocated to responding to the comments received from the peer review panel and for making any revisions to the Seepage Study report and the model that may have been necessary to fully respond to the comments. Coordination of the responses to those comments with the Peer Review Panel was not documented. It appears that insufficient time and effort was allocated toward the peer review process. As stated in the items below, several of the Peer Review Panel's comments were not addressed.

101. The second paragraph on page 2 of the Peer Review Panel letter reads,

> "The conceptual model generally describes flows associated with surface features based on existing data, but does not include an error budget. Thus the numbers presented probably appear more certain than they really are. *Ground water flow calculations are less well described. Inadequate descriptions are noted relating to the ground water flow calculations.*" (italics added)

Tetra Tech's Response did not address the first two sentences of this comment. The Seepage Study report does not present an error budget. In response to the italicized comment, Tetra Tech's Response reads, "Most of these calculations were given in the AAC and CB EIR reports. Additional documentation will be added to this report in Appendix C on key items such as the canal seepage rates. More detailed cross-references to the AAC and CB EIR reports will also be added to Appendix C." However, Appendix C is limited to four calculations; unit seepage rate from the All American Canal from Pilot Knob to Drop 1, unit seepage rate from the All American Canal from Drop 2 to Drop 3, unit seepage rate from the Coachella Canal Hydrologic Unit C, and unit seepage rate from the Coachella Canal Hydrologic Unit B. See item 99 above for observations of these calculations. It appears that no other additional groundwater flow calculations were provided in response to the Peer Review Panel's comment.

102. The last four sentences on page 2 of the Peer Review Panel letter reads,

> "The geology of the northeast shore of the Salton sea precludes any significant subsurface flow to the Salton Sea. The low-permeability lake clays preclude subsurface flow and restrict infiltration of surface water. Other than the active and formerly active channels of Salt Creek, little subsurface flow could be reasonably expected. As a result, the major portion of available water supply is consumed by native vegetation with little or no subsurface flow to the Salton Sea."

Tetra Tech's Response did not address this comment. As discussed in several observations above, the Seepage Study report assumed as much as 8,000 acre-feet and more reaches the Salton Sea by subsurface flow along the east shore. The Peer Review Panel's comment is consistent with the findings contained in Reclamation, December 1993b, and Hely, *et al.*, 1966. The Seepage Study report does not acknowledge its departure from these reports or the Peer Review Panel.

103. The last sentence of the first paragraph on page 3 of the Peer Review Panel letter reads,

> "Thus, the effects of head changes caused by lining the canals is restricted to a small part of the area modeled."

Tetra Tech's Response reads,

"The effects of head changes caused by lining the canal may be restricted to a small part of the area modeled, but the effects of flux changes caused by lining the canal, which is the primary focus of this study, is not restricted to a small part of the area modeled. Note that after canal lining, changes in flux are observed within the IID area drains as well as in the East Highline Canal."

As stated in the first paragraph on page 6-54 of the Seepage Study report, however, the sensitivity analysis was limited to a comparison of simulated heads and the actual heads measured from wells. Water budget statistics were not computed for the sensitivity simulations, thus there was no evaluation of the sensitivity of the flux changes caused by lining the canals.

104. The third paragraph on page 3 of the Peer Review Panel letter reads,

> "A related problem with the conceptual model of the groundwater balance is that it does not attempt to identify the current contribution of the seepage mound to flow rates in the [Imperial Irrigation District] drains. Although this is discussed to some extent elsewhere in the text, it is also relevant here."

Tetra Tech's Response did not address this comment. The Seepage Study report failed to provide an analysis that accounts for all inflows to and outflows from the groundwater system beneath the irrigated area of the Imperial Valley. Given the scope of the Seepage Study report and considering that (i) the central Imperial Valley lies between the Salton Sea and the All American Canal and the first 49-miles of the Coachella Canal, and (ii) water management practices of the Imperial Irrigation District and its farmers are a major factor in the behavior of the groundwater system being modeled, this lack of attention casts significant doubt on the reliability of the model's results.

105. The last sentence on page 3 of the Peer Review Panel letter reads,

> "The appendix should include a short discussion of the assumption used in the mathematical model, including features of the model, assumptions about lateral anisotropy, boundary conditions, mesh size, time steps, which items change during time steps and which are constant, and other assumptions and generalizations used."

The Seepage Study report includes a discussion for all but two of the features listed in the comment. The Seepage Study report failed to disclose any information on lateral anisotropy. Also, from the "Seepage without Canal Lining" curve on Figure 7-5 of the Seepage Study report, it appears that something other than the decreased flow from the Coachella Valley, as tabulated in Table 6-5 of the Seepage Study report, is causing total subsurface flow to the Salton Sea to gradually decrease. The Seepage Study report did not acknowledge this gradual decrease nor did it identify the factor that would cause it.

106. The first two full paragraphs on page 4 of the Peer Review Panel letter reads,

> "This model did not involve generating any new data, instead, existing sources were relied on for all data used. Many of the water budget items have considerable uncertainty, and many of the largest items may have uncertainties of 20 percent or more. Items notorious for wide ranges in uncertainty include evapotranspiration, underflow, and rising water. *The quality of data and the range of uncertainty for each item should be tabulated.* The results of mathematical computer models may appear more certain than they really are. This problem is most apparent in the excessive significant digits carried by the model.
>
> "The magnitude of the seepage into the Salton Sea, around 7,000 acre-feet per year, is well within the uncertainty of many of the large water balance items. Therefore, any item with an uncertainty of this magnitude could affect the range of the seepage estimate. The results of a sensitivity analyses for larger flow items should be included." (italics added)

Tetra Tech's Response addresses the italicized text only, and reads,

"The water budget tables will be modified to indicate the range of uncertainty for each item. Note, however, that it may not be possible to define the exact level of uncertainty in all water budget items due to the varied sources referenced for the water budget. The scope of this study called for building upon the work of previous investigations to construct the SSA seepage model, and it was not possible within this study to independently verify all water budget components.

Tetra Tech did, however, review all previous investigations and found that the data appeared reasonable and were from reliable sources such as the USGS.

"In order to address the Peer Review Panel's concerns, Tetra Tech has modified the water budget table by adding a category with the relative level of uncertainty in each item. The level of uncertainty for each item will be established by a qualitative assessment of the type of data, the manner in which the data were estimated, and the degree to which independent investigations agree or disagree on each item."

Thus Tetra Tech admitted that it did not verify all water budget components. Tetra Tech also claimed that all data came from reliable sources such as the U.S. Geological Survey. However, the Seepage Study makes use of the model documented in Montgomery Watson; December 1995, and the model described in the bibliography as "Fogg, Graham E., 1989, *Modeling the Effects of Seepage on the Coachella Canal, Salton Sea Area*." The Seepage Study report does not provide an analysis of the accuracy of these models. It is not clear if these models were peer reviewed. With respect to the Seepage Study report's assumed subsurface inflow to the Salton Sea from the Coachella Valley, the third paragraph on page 6-44 of the Seepage Study report reads, "Table 6-5 shows a summary of prescribed groundwater flux from Coachella Valley to the Salton Sea, with a reversal in gradient observed in 1998 due to pumping in Coachella Valley." However, no supporting documentation is provided nor referenced in the Seepage Study report's bibliography for the values presented in Table 6-5.

Even when relatively reliable sources are used, the Seepage Study appears to have misinterpreted the content of these sources. For example, as discussed in item 24 above, the Seepage Study assumed that subsurface inflow to the Salton Sea along the shore that parallels the Coachella Canal was 8,000 acre-feet per year and referenced U.S. Geological Survey Professional Paper 486-C as the source. However, this report (Hely *et al,*. 1966, in the list of references attached to these observations) identified this amount as surface flow. Also, as discussed in item 96 above, the Seepage Study report misinterpreted the impact to wetlands along the Coachella Canal as documented in Reclamation, December 1993a.

As indicated in its response, Tetra Tech did provide an indication of uncertainty of the individual model feature types presented in Table 3-1 of the Seepage Study report. However, Table 3-1 did not include all feature types presented in Tables 6-1, 6-3, and 7-3. The latter tables did not include an indication of uncertainty. The values from some of the feature types stated in Table 3-1, such as discharge to the New River, discharge to the Alamo River, and subsurface inflow to the Salton Sea from the Coachella Valley, did not agree with the observed values presented in Tables 6-1, 6-3, and 7-3. The Seepage Study report provided no explanation as to why these values were revised. Although Tetra Tech indicated that "the level of uncertainty for each item will be established by a qualitative assessment of the type of data, the manner in which the data were estimated, and the degree to which independent investigations agree or disagree on each item", the Seepage Study report does not include a discussion that describes how the relative uncertainties stated in Table 3-1 were reached.

Lastly, Tetra Tech failed to conduct a sensitivity analysis for the larger flow items of the model as suggested by the Peer Review Panel. Indeed, as stated in the first paragraph on page 6-54 of

the Seepage Study report, the sensitivity analysis was limited to a comparison of simulated heads and the actual heads measured from wells. Water budget statistics were not computed for the sensitivity simulations, thus there was no evaluation of the sensitivity of the modeled inflows and outflows.

107. The third full paragraph on page 4 of the Peer Review Panel letter reads,

> "One effect tabulated but not discussed is the effect of mound collapse on leakage out of the East Highline Canal."

Tetra Tech's Response was that text will be added regarding the change in leakage out of the East Highline Canal. The added text appears to be on page 7-17 of the Seepage Study report which reads, "Net discharge into the East Highline Canal southern segment ceases by 2026. Recharge due to increased seepage along the entire East Highline Canal may increase by a range of 746 acre-feet per year to 11,521 acre-feet per year by 2026." This passage is the extent of the Seepage Study report's discussion of assumed seepage from the East Highline Canal. See item 95 above for observations related to this matter.

108. The last paragraph on page 4 of the Peer Review Panel letter reads,

> "Evapotranspiration (EVT), as noted above, is a significant portion of the balance, yet has been calculated using a single value of a number that has a minimum 20% uncertainty. In addition, actual EVT may vary in years that are cooler or warmer or wetter or drier than normal. Because both canal seepage and EVT are calculated, but their sum is constrained, any error in one makes an equal and opposite error in the other. *In any flow-based model such as this one, the largest and most sensitive flows should receive the most effort to reduce uncertainty.*" (italics added)

In its response to the italicized text, Tetra Tech declared that, "Tetra Tech agrees in general with this statement, noting that for this very reason significant effort was devoted to matching the metered canal seepage looses [sic]." The use of the term "significant effort" is questionable. Seepage rates from the All American and Coachella canals were obtained directly from Reclamation, March 1994a, and Reclamation, December 1993a, respectively. There was no apparent attempt to further verify these values. Despite uncertainty disclosed in Reclamation, December 1993a, the Seepage Study report failed to include an analysis of the eight years of flow records that have accumulated since the last estimate was made. With respect to annual seepage from the first 49-miles of the original earthen Coachella Canal, the Seepage Study report assumed this amount was 130,500 acre-feet. However, Reclamation, March 1984, states that this annual loss was 141,000 acre-feet. The Seepage Study report failed to acknowledge this discrepancy. Similarly, the Seepage Study report fails to acknowledge differences in its estimated seepage from the East Highline Canal from that documented in Reclamation, August 1989. Lastly, the Seepage Study report provides no information on the estimated seepage from the All American Canal downstream of the East Highline Canal turnout and the portions of the Central Main Canal and the Westside Main Canal that lie within the active area of the model.

109. The first full paragraph on page 5 of the Peer Review Panel letter reads,

> "However, it should be recognized that each item of the inflow and outflow is subject to a range of potential error. These errors can result in variations in the predictions of the water that may be lost to the

> Salton Sea and adjacent wetlands from the lining of the AAC and CB. For example, the combined estimated boundary underflow and drain flow of the La Mesa Drain is several times the predicted amount of water lost to the Salton Sea due to canal lining."

Tetra Tech did not respond to this comment.

110. The last two paragraphs on page 5 of the Peer Review Panel letter reads,

> "Although the mathematical model seems to be providing reasonable results, more sensitivity runs and error budget analysis seems warranted in the future, since the magnitude of the effects being sought are small in relation to the size of the input uncertainties.
>
> "It would be helpful to develop a table similar to Table 6-1 which could present an estimated error budget for each of the named features in the table."

Tetra Tech's Response to this comment reads,

"Note that an error budget was given in Section 8 and the executive summary relating the overall model error to the model predictions. While additional analysis of uncertainty in the model predictions may be justified on technical grounds, Tetra Tech feels that it would require a level of effort well beyond the scope of this study. First, uncertainties in each of the principal components of the observed water budget would have to be quantified. We are prepared to perform only qualitative evaluations of this "input" uncertainty within our scope … Second, a multi-variate statistical analysis using an uncertainty technique such a [sic] Monte Carlo simulation would be necessary in order to truly define the relationship between the uncertainty in the model input parameters and uncertainty in the model output. This procedure would require hundreds of model runs and significant post-processing steps."

Thus, Tetra Tech acknowledges that the scope of the Seepage Study did not allow for an error analysis. Note that the "error budget" provided in Section 8 and the executive summary of the Seepage Study report actually consists of the differences in the results of the model's transient simulation to the year 2026 and the results of the model's steady-state simulation. Input data for both of these simulations were identical.

Figure 1.

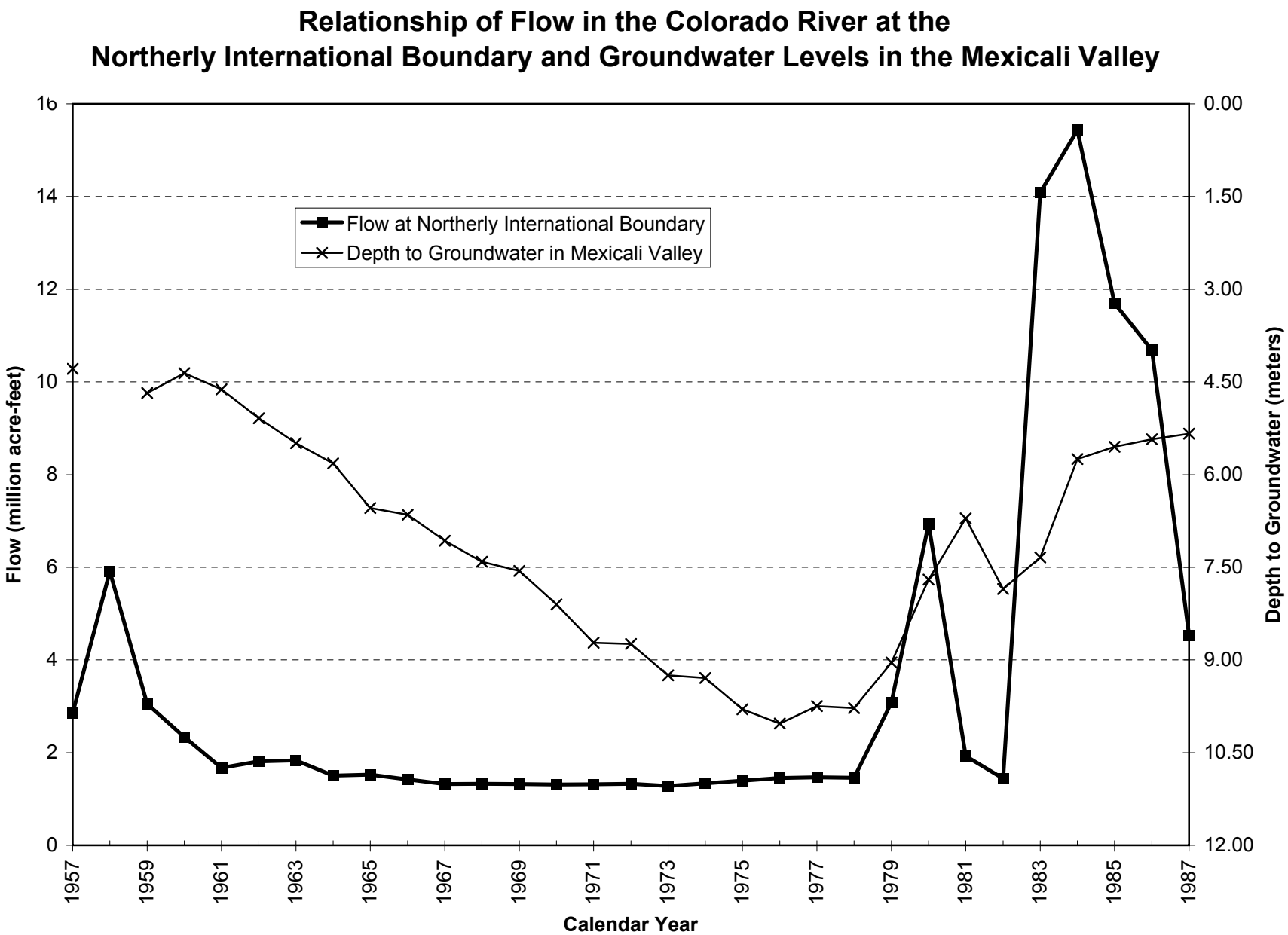

Relationship of Flow in the Colorado River at the
Northerly International Boundary and Groundwater Levels in the Mexicali Valley
Flow at Northerly International Boundary
Depth to Groundwater in Mexicali Valley
Flow (million acre-feet)
Depth to Groundwater (meters)
Calendar Year
0
2
4
6
8
10
12
14
16
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987

Figure 2.

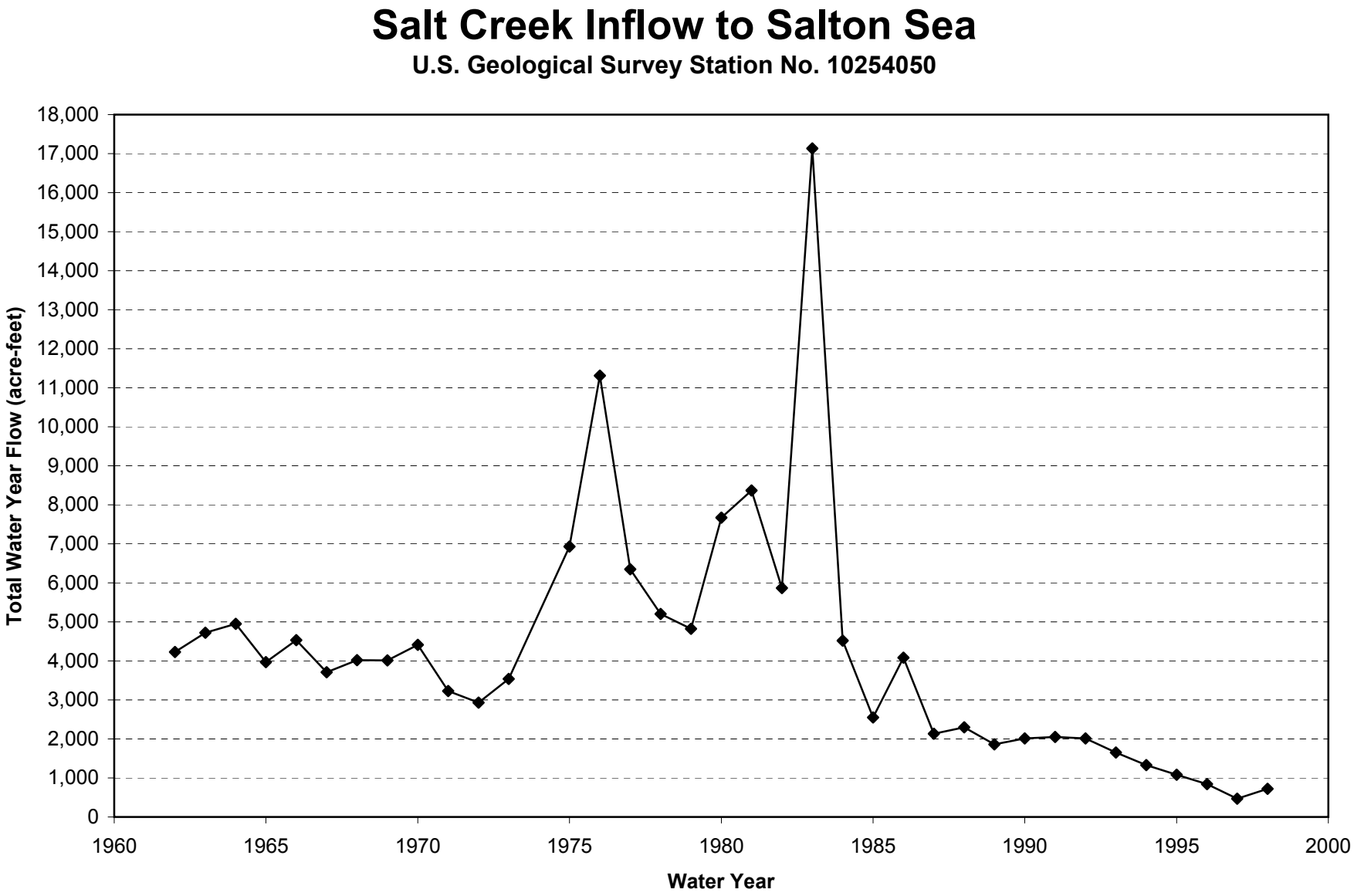

Salt Creek Inflow to Salton Sea
U.S. Geological Survey Station No. 10254050
Total Water Year Flow (acre-feet)
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
Water Year

Figure 3.

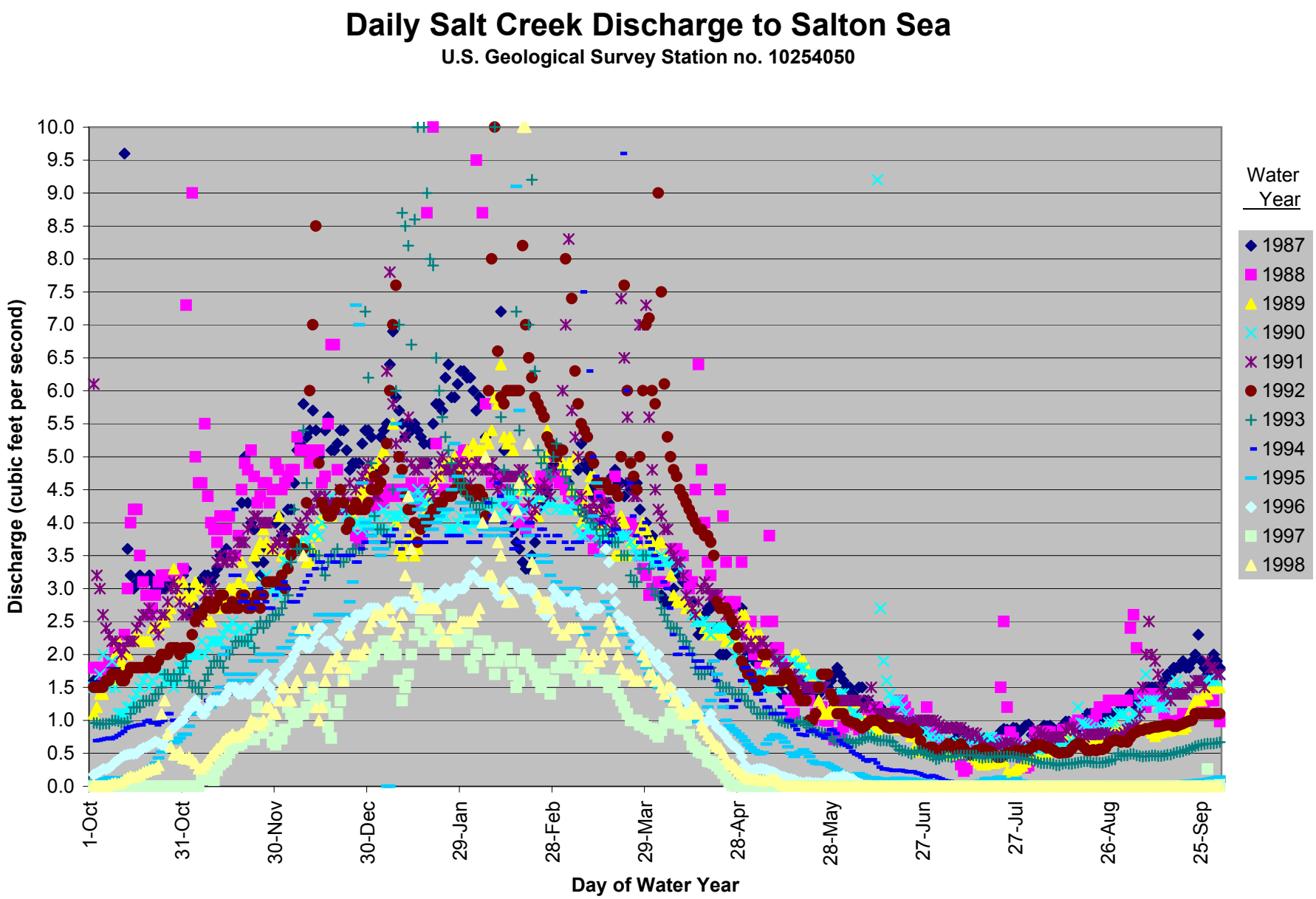
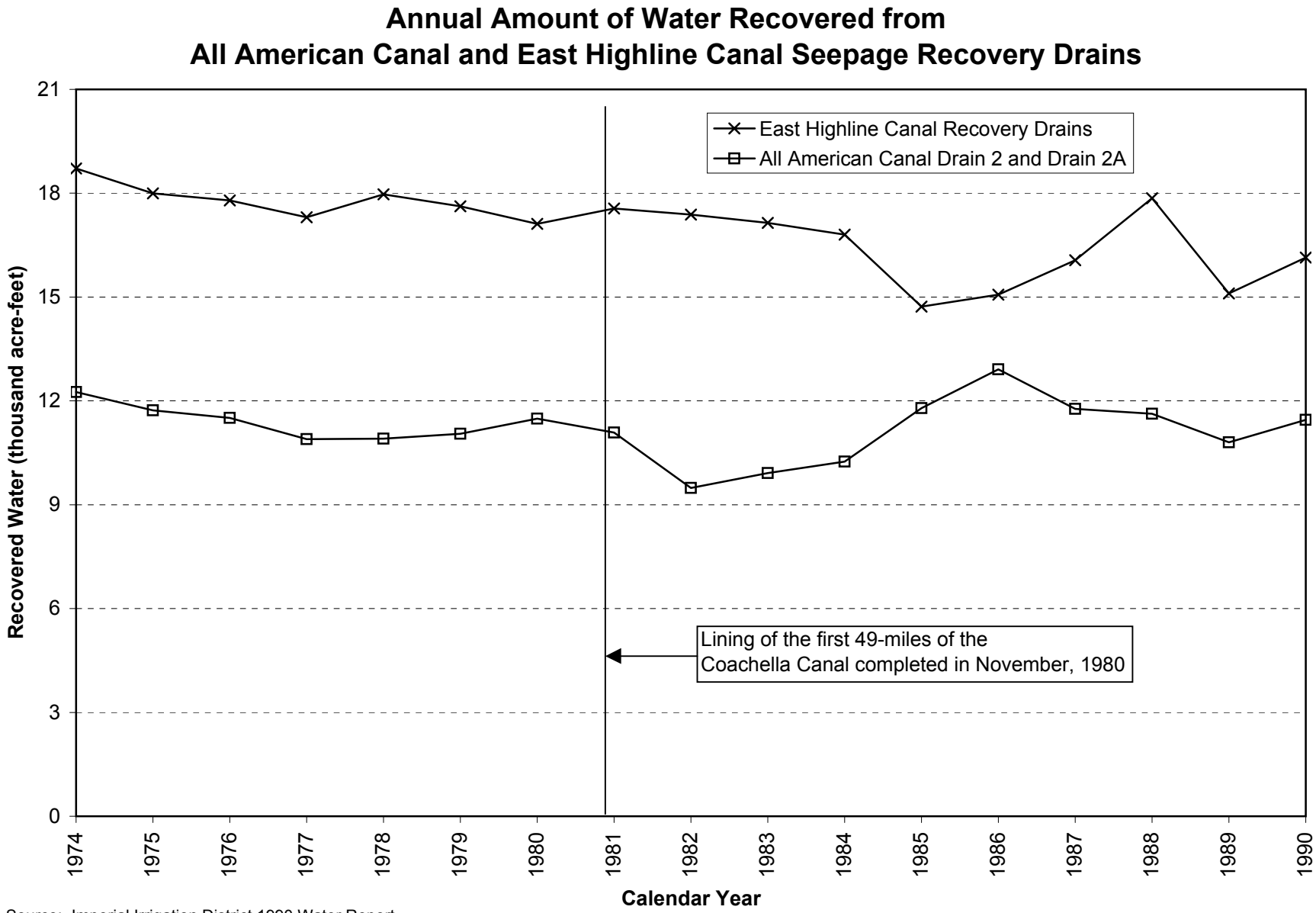

Daily Salt Creek Discharge to Salton Sea
U.S. Geological Survey Station no. 10254050
Discharge (cubic feet per second)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1-Oct
31-Oct
30-Nov
30-Dec
29-Jan
28-Feb
29-Mar
28-Apr
28-May
27-Jun
27-Jul
26-Aug
25-Sep
Day of Water Year
Water Year
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

Figure 4.



Source: Imperial Irrigation District 1990 Water Report

List of References

Boyle Engineering Corporation; August 1993; *On-Farm Efficiency: Special Technical Report for Imperial Irrigation District*.

Bureau of Reclamation; August 20, 1999 Press Release; Subject: "Extra Water to be Released from Lake Mead in September"

Bureau of Land Management; November 1997; *Imperial Project, Imperial County, California: Environmental Impact Statement/Environmental Impact Report*

Bureau of Reclamation; May 1997; Salton Sea: *1995 Hydrographic GPS Survey*
(revisions to these area/capacity curves as documented in Attachment B to Bureau of Reclamation; January 2000; *Salton Sea Restoration Project Draft Alternatives Appraisal Report*; incorporated in these observations)

Bureau of Land Management; June 1995; *Environmental Impact Statement & Environmental Impact Report for the Proposed Mesquite Regional Landfill*

Bureau of Reclamation; March 1994a; *Final Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project*

Bureau of Reclamation; March 1994b; *Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project: Geohydrology Appendix*

Bureau of Reclamation; December 1993a; *Draft Environmental Impact Statement/Environmental Impact Report for the Coachella Canal Lining Project*

Bureau of Reclamation; December 1993b; *Draft Environmental Impact Statement/Environmental Impact Report for the Coachella Canal Lining Project: Geohydrology Appendix*

Bureau of Reclamation; August 1989; *East Highline Canal Seepage and System Improvement Study: Imperial Irrigation District, California*

Bureau of Reclamation; 1988; *Colorado River Water Underground Storage and Recovery Study, Imperial County, California*

Bureau of Reclamation; March, 1987; *All-American Canal Relocation Study, California: Hydrology Appendix*

Bureau of Reclamation; March 1984; *Colorado River Basin Salinity Control Project: Coachella Canal Unit, Title I Division*; four page pamphlet

Bureau of Reclamation; 1981; *Project Data*
(published under the name "U.S. Department of the Interior, Water and Power Resources Service")

Bureau of Reclamation; April 1976 (revised July 1977); Colorado River Basin Salinity Control Project, Title I Division, Desalting Complex Unit Location Map; Map No. 1292-300-41

Bureau of Reclamation; June 18, 1975; *Final Environmental Impact Statement: Colorado River Basin Salinity Control Project Title I*

Coachella Valley Water District; May 10, 1991; Letter and enclosures from the General Manager-Chief Engineer to Martin Einert of the Bureau of Reclamation

Hallenbeck, E.M.; October 1987; Regional Director, Lower Colorado Region, U.S. Bureau of Reclamation; October 16(?), 1987 letter to the Executive Director, Colorado River Board of California

Hardt, William F., French, James J.; July 1976; Selected Data on Water Wells, Geothermal Wells, And Oil Tests in Imperial Valley, California; U.S. Geological Survey Open File Report 76-891

Hely, A.G.; Hughes, G.H.; Irelan, B; 1966; *Hydrologic Regimen of Salton Sea, California*; U.S. Geological Survey Professional Paper 486-C

Hydrosphere; 1999; *Climatedata: NCDC Summary of the Day-West I, Volume 10*; CD Rom

Imperial Irrigation District; March 26, 1999; *Imperial Irrigation District: All American Canal in Acre Feet*; single page list accounting for the diversion of water into the All American Canal and conveyance to the Imperial Valley

Imperial Irrigation District; undated; two page paper entitled "Imperial Irrigation District Annual Inventory of Areas Receiving Water: Years 1998, 1997, 1996"

Imperial Irrigation District; December 6, 1991; *All American Canal Profile Check 48+50 to West Side Main*, Drawing No. AC-3351

Imperial Irrigation District; 1990; *Water Report*

Imperial Irrigation District; 1922; drawing entitled Imperial Irrigation District Water Distribution System, 1922; drawing no. 8383 as found in Exhibit No. 125 in the Case of Arizona v. California (373 U.S. 546)

International Boundary and Water Commission, United States and Mexico; Western Water Bulletin 1996: *Flow of the Colorado River and other Western Boundary Streams and Related Data*

Loeltz, O.J.; Burdge, Irelan; Robinson, J.H.; Olmsted, F.H.; 1975; *Geohydrologic Reconnaissance of the Imperial Valley, California*; U.S. Geological Survey Professional Paper 486-K

Michel, M.L., Schroeder, R.A.; 1994; "Use of long-term tritium records from the Colorado River to determine timescales for hydrologic processes associated with irrigation in the Imperial Valley", California; *Applied Geochemistry*, Vol. 9, pages 387-401

Montgomery Watson; December 1995; *Imperial County Groundwater Study: Final Report*

Olmsted, F.H.; Loeltz, O.J.; Burdge, Irelan; 1973; *Geohydrology of the Yuma Area, Arizona and California*; U.S. Geological Survey Professional Paper 486-H

Pucherelli, Michael J., Clark, Richard; September 22, 1989; United States Government Memorandum to Head, Remote Sensing Section; Subject: Coachella Canal Mapping Study: Marsh and Riparian Wetland Delineations of 1988 Study; Applied Sciences Referral Memorandum No. 89-4-8

Pucherelli, Michael J., Van Loh, James D., Halls, Joanne N.; September 2, 1988; United States Government Memorandum to Head, Remote Sensing Section; Subject: Coachella Canal Mapping Study: A Comparison of 1949 and 1988 Aerial Photography; Applied Sciences Referral Memorandum No. 88-4-6

Schroeder, R.A., Setmire, J.G., Densmore, J.N.; July 1991; *Use of Stable Isotopes, Tritium, Soluble Salts, and Redox-Sensitive Elements to Distinguish Ground Water from Irrigation Water in the Salton Sea Basin*; Proceedings of the 1991 National Conference sponsored by the Irrigation and Drainage Division of the American Society of Civil Engineers and the Hawaii Section, ASCE

Setmire, J.G., Schroeder, R.A., Densmore, J.N., Goodbred, S.L., Audet, D.J., and Radke, W.R.; 1993; *Detailed Study Of Water Quality, Bottom Sediment, And Biota Associated With Irrigation Drainage In The Salton Sea Area, California, 1986-87*; U.S. Geological Survey Water Resources Investigation Report 93-4014

U.S. Geological Survey; July 24, 1998; *Description of Gaging Station on 10254005 Salton Sea near Westmoreland, CA*; paper prepared by K.L. Stumpf of the U.S. Geological Survey's Water Resources Division

U.S. Geological Survey; 1969; *Salton Sea, California; Arizona*; 1:250,000 scale topographic map

Vogl, R.A., personal communication on July 29, 1999 in relation to Vogl, R.A., Beadle, S.C., Ryan, H.N., Lipton, D.S.; July 2, 1999; *Environmental Reconnaissance of the Salton Sea: Sediment Contaminants, Riverside and Imperial Counties, California*; published by Levine-Fricke for the Salton Sea Authority

Attachment A

Discrepancy in the Seepage Study Model's Canal Stage and Invert Data From That as Constructed and as Currently Operated

All American Canal:
(units in feet from sea level)

Station	Seepage Study Model[1] stage	Seepage Study Model[1] invert	As Constructed[2] stage	As Constructed[2] invert	Operational Data[3] stage	Operational Data[3] invert
1250+00	161.52	138.52	164.99	148.4	161.5	148.8
1650+00	158.52	135.52	161.99	145.4	161	147
Upstream of Drop 1	158.00	135	160.09	143.5	158	147
Downstream of Drop 1	145.76	122.76	148.43	133.7	145.7	134.5
Upstream of Drop 2	145.00	122.00	146.33	131.6	146	134
Downstream of Drop 2	120.72	97.72	121.78	107.3	120.7	109.5
Upstream of Drop 3	119.04	96.04	119.48	105.0	119	105
Downstream of Drop 3	93.96	70.96	95.14	80.9	93.9	83
Upstream of Drop 4	92.01	69.01	92.94	78.7	92	80
Downstream of Drop 4	42.00	19.00	43.2	29.2	43	33
Upstream of East Highline Canal Check	41.08	18.08	41.4	27.4	41	33
Downstream of East Highline Canal Check	39.00	16.00	41.18	28.5	39	31
Alamo River Crossing	12.51	-10.49	38.82	25.97	37.5	27
Upstream of Drop 5	10.31	-12.69	37.86	24.61	37	26.5
Downstream of Drop 5	9.57	-13.43	14.99	2.68	14	4
Upstream of Central Main Canal Check	7.37	-15.63	13.0	0.69	13	2
Downstream of Highway 98 Siphon	6.66	-16.34	7.50	-3.76	3.5	-2
Upstream of Highway 111 Siphon	6.07	-16.93	6.57	-4.69	3.25	-3.5

1. Values from Seepage Study report model files Run1qT.riv, Run1nT.riv, Runtoss.riv, and Run1pT.riv. Stage and invert data from these files are identical.
2. For Station 1250+00 to the East Highline Canal Check, invert values from profile drawings contained in Attachment 4 to the U.S. Bureau of Reclamation's *Draft Environmental Impact Statement/Environmental Impact Report for the All American Canal Lining Project: Geohydrology Appendix* dated March 1994b. All other values taken from Imperial Irrigation District Drawing No. AC-3351 entitled *All American Canal Profile Check 48+50 to West Side Main* and dated December 6, 1991.
3. From Imperial Irrigation District Drawing No. AC-3351 entitled *All American Canal Profile Check 48+50 to West Side Main* and dated December 6, 1991.