Attachment I—IIDSS Model Overview

Commenters have requested a clear description of the IIDSS model to assist them in understanding how the model was used in development of the Draft EIR/EIS and in understanding how model output was used in analyses of the Proposed Project and Alternatives. This response is designed to be a brief overview of the model's structure and use. Additional information on IIDSS is included in Appendix E of the Draft EIR/EIS.

I.1 Background

IID's irrigation system diverts water from the Colorado River to over 5,000 tenants distributed throughout the 1,000 square miles of the district. As shown on Figure I-1, water

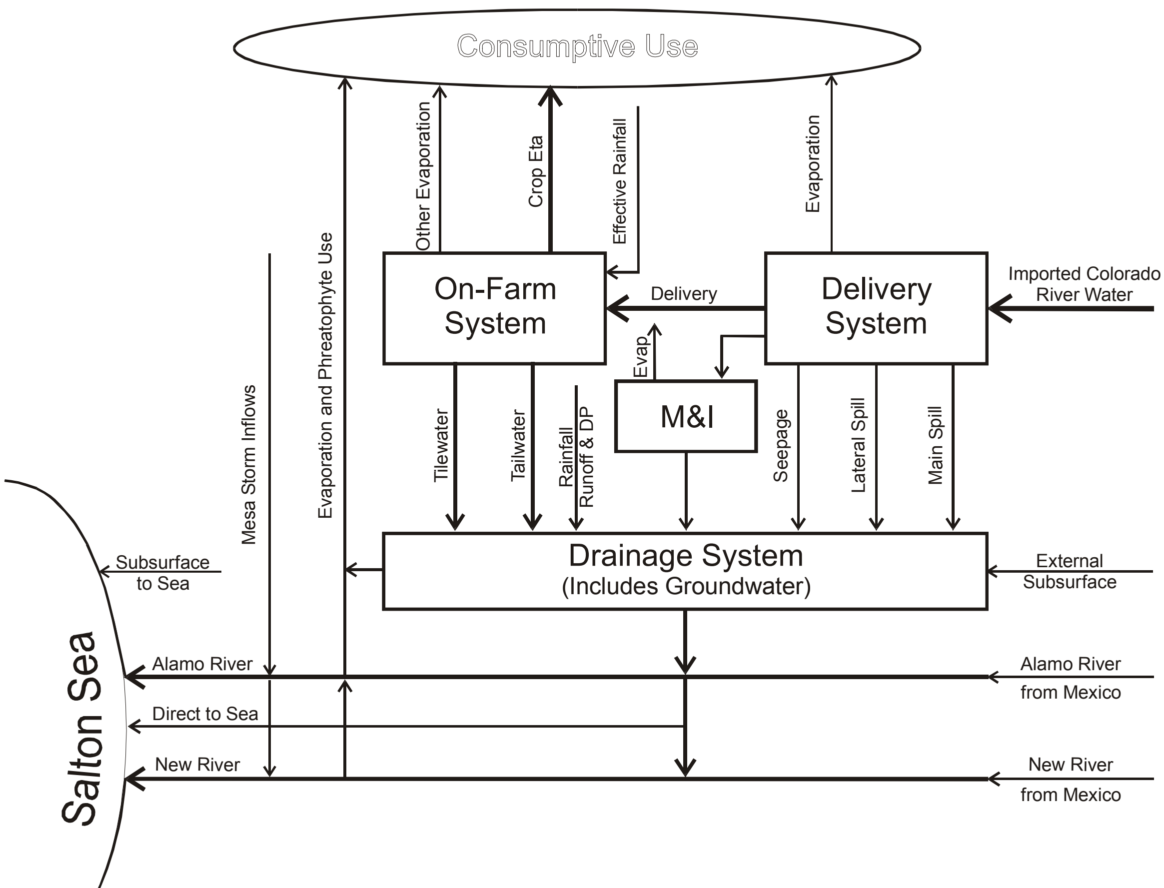

Figure I-1
Conceptual View of Water Flow Paths within IID

for irrigation is diverted from the Colorado River and distributed to farms, municipal and industrial (M&I) customers, and other users via the IID delivery system. The IID drainage system collects the return flows from these users and discharges these flows to the Alamo and New Rivers and the Salton Sea. Figure I-1 provides a conceptual overview of all the external and internal water flow paths within the IID water service area described in this response.

Rectangular boxes on Figure I-1 represent the delivery, on-farm, M&I, and drainage systems that define water demands, canal and drain flows, and water quality throughout the delivery canals and drains. The oval at the top of the figure, labeled consumptive use, represents the discharge of water to the atmosphere via evapotranspiration (ET) from farm fields, evaporation from water surfaces, and transpiration by plants growing along canals, drains, and rivers.

Approximately two-thirds of the water diverted from the Colorado River to the IID water service area is consumed by irrigated crops. The remaining third drains to the Salton Sea, which is represented by the open oval on the left-hand side of Figure I-1. Arrows connecting the system boxes and discharge ovals represent the modeled water flow paths throughout IID.

The weight of the arrows on Figure I-1 indicates the relative volume of flow along the associated flow paths. Table I-1 gives the measured and simulated mean annual flows for these flow paths for the 12-year (1987 to 1998) calibration and validation period. This table shows that IID's average annual demand for Colorado River water that is computed by the model is 99.7 percent of the observed average annual flow.

TABLE I-1
Measured and Simulated Mean (1987 to 1998) Annual Flows AF along Major Flow Paths within IID

Description	Recorded	Modeled
Imported Colorado River Water	2,865,700[1]	2,857,000
Canal and Reservoir Evaporation		20,800
Canal Seepage		122,700
Main Canal Spills		6,700
Lateral Spills		116,900
Sum of Delivery System Losses	271,600[2]	267,100
Delivery to Farms	2,489,600	2,489,700
CROP ET		1,806,200
Effective Rainfall		100,700
Tailwater		390,000
Tilewater		394,200
Delivery to M&I + Stock + Misc.	104,500[3]	104,500
Consumptive Use from M&I + Stock + Misc.		76,300
Return Flow from M&I + Stock + Misc.		28,200
Recovered Return Flow from Mesa Lateral 5		4,400
Rainfall Runoff and Deep Percolation		36,800
Evaporation and Phreatophyte Use		125,100
Mesa Storm Inflows		7,900
Subsurface Inflow (Estimated)	20,000	20,000
Alamo River from Mexico	1,700	1,700
New River from Mexico	164,700	164,700
Alamo River to the Salton Sea	604,500	605,100
New River to the Salton Sea	453,500	453,000

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TABLE I-1
Measured and Simulated Mean (1987 to 1998) Annual Flows AF along Major Flow Paths within IID

Description	Recorded	Modeled
Direct to Sea	100,200	101,200
Subsurface to Sea (Estimated)	1,000	1,000

[1] All American Canal at Mesa Lateral 5 by water balance from recapitulation data.
[2] Sum of delivery-system losses is calculated from the difference in recorded diversions less deliveries.
[3] Includes estimates of deliveries to rural pipes and community greens.

A water balance is kept for each system (rectangle) shown on Figure I-1, so that the sum of the inflows is equal to the sum of the outflows plus the change in storage within each system. The storage capacity within IID's delivery system is very small relative to the annual flow.

The soil moisture capacity of IID's farm fields and the drainable, shallow groundwater storage are relatively large. However, over the course of several years the change in stored water within the on-farm and drainage systems is small and assumed to be zero. This is to say that the volume of water stored in IID's soils and drains at the end of the 12-year modeling period was assumed to be the same as it was at the beginning of the period. Thus, the data in Table I-1 show that the sum of mean annual flows into each system is exactly equal to the sum of the flows out of each system. Likewise, a water balance can be computed for the IID water service area as a whole showing that the sum of inflows equals the sum of outflows.

The IIDSS modeling is based on the concept that the total volume of water entering the IID water service area can be accounted for by an equal volume of water leaving the IID water service area.

I.1.1 Delivery System

Using the 12-year modeled mean values presented in Table I-1, IID imports 2,857,000 acre feet per year (AFY) from the Colorado River via the All American Canal.[1] From this, 2,489,700 AFY are delivered to IID farms and 104,500 AF are delivered to M&I users, stock, rural pipes, and community greens, leaving a net delivery system loss of 267,100 AFY. Of this net delivery system loss, approximately 8 percent is canal and reservoir evaporation, 46 percent is canal seepage, 2 percent is main canal spills, and 44 percent is lateral spills.

I.1.2 On-farm System

Water from the delivery system is delivered to agricultural and other users through approximately 5,300 turnouts. Of the total number of turnouts, roughly 35 percent are solely for agricultural irrigation, 3 percent are for other uses, and the remaining 62 percent serve a combination of agricultural and other uses. Agricultural irrigation accounts for 96 percent of the total water use within the IID water service area.[2]

[1] The upstream boundary of the study area is the All American Canal at Mesa Lateral 5, which is just upstream of the East Highline Canal Heading.

[2] Other uses comprise mainly M&I demands, but also include stock, rural pipe deliveries, and water for irrigating community greens (e.g., parks, school grounds).

Water delivered through these turnouts to farm fields is either consumed by crop uptake, evaporated, or discharged to the drainage system as surface runoff (tailwater) or subsurface drainage (tilewater). This partitioning of water delivered to farm fields into consumptive use and tailwater and tilewater flows to drains is carried out within the on-farm system.

Using the 12-year modeled mean values presented in Table I-1, the average annual deliveries to IID farms are 2,489,700 AF. Of this, approximately 390,000 AF returns to the drainage system as tailwater and 394,200 AF as tilewater. The balance, 1,705,500 AF, makes up the volume of irrigation deliveries consumed by crops or evaporated from fields.

In addition to irrigation water, another source of water reaching fields is rainfall. During the 12-year calibration period, the estimated average volume of precipitation consumed by crops is estimated to be 100,700 AF while approximately 36,800 AF flows into the drainage system.

I.1.3 Drainage System

The third major component of the overall IID system is the drainage system, that consists of approximately 1,500 miles of surface drains. The drains collect tilewater and tailwater flows from the farms and pass them either directly to the Salton Sea or discharge them to the New or Alamo Rivers.

Using the values presented in Table I-1 the average annual discharge to the Salton Sea is 1,160,300 AF (605,100 AF via the Alamo River, 453,000 AF via the New River, 101,200 AF via drains discharging directly to the Salton Sea, and an estimated 1,000 AF of subsurface flow). Of this total drainage system discharge to the Salton Sea, 186,400 AFY on average comes from Mexico (1,700 AF via the Alamo River, 164,700 AF via the New River, and an estimated 20,000 AF via subsurface inflows) and an estimated 44,700 AF comes from rainfall runoff and deep percolation and mesa storm inflows (36,800 AF and 7,900 AF, respectively).

An estimated 125,100 AF is lost from the drainage system through evaporation from the water surface or through uptake by plants drawing water from the drains and rivers.

I.2 Data Review

The IIDSS determines the effectiveness of water conservation measures and the associated impacts to water quality and quantity in the drains. The basis for these determinations are water balances constructed in the model according to the framework described above. These balances track the flow of water through IID as shown Figure I-1. Large amounts of data were assembled and checked to construct each of these balances. The following section of this response briefly describes the process of collecting and reviewing data incorporated in the model.

I.2.1 Data Collection and Analysis

Data on historical deliveries to each turnout were compiled from IID's computer files. These data describe the measured amounts of water that were delivered to each of the 5,287 turnouts during the 12-year span from 1987 to 1998. This 12-year period from 1987 through 1998 was selected for model development since this was the only period of full monthly water deliveries and cropping information available in electronic form.[3] Because the amount of data was large, a special database was used to store this information.

I.2.2 Delivery System Modeling

Using the historical record of deliveries, a water balance was constructed to determine system losses in the All American Canal downstream of the Mesa Lateral 5 Heading and to account for all system deliveries. This water balance identified the sum of evaporation and seepage loss volumes plus spill volumes. Because main canal spillage was the only recorded delivery system loss, equations describing canal seepage and evaporation and lateral spillage were developed to estimate these losses in each section of canal based on flows in that section.

The model is also able to compute how historical and future system improvements, such as canal lining and construction of lateral interceptors, would alter seepage and spillage in sections of the system where these improvements were constructed.

I.2.3 On-farm Modeling

On-farm data included information on crop acreage, crop type, and irrigation method, soil type, and name of delivery turnout. Crop water consumption was estimated by applying established estimation methods to crops recorded at each parcel receiving water deliveries. Evaporation at each parcel was also estimated using established practices based on the soil texture, method, and frequency of irrigation recorded at each parcel. Water not consumed by crops or evaporated from fields was partitioned between tailwater and tilewater at each field based on soil texture, crop, irrigation method, and volume of water delivered in excess of crop demand.

I.2.4 Drainage System Modeling

Tailwater and tilewater from irrigated fields, spillage, M&I discharges, canal seepage, and precipitation enter the drainage system and flow to the Salton Sea. Approximately 52 percent of drainage system flow is in the Alamo River basin, approximately 39 percent in the New River subbasin and approximately 9 percent is in drains that discharge directly to the Salton Sea. The drainage network is simulated by approximately 1,500 points throughout the IID water service area that represent locations where water may enter IID drains or rivers. These points are linked to depict the flow paths that water entering the drainage system would take as it is conveyed to the Sea. In the case of both the Alamo and the New Rivers, flows crossing the international boundary from Mexico also contribute to the flows modeled within the IID water service area.

I.2.5 Water Quality Modeling

Water quality data were obtained and reviewed for nine constituents of concern: salinity, sediment, boron, nitrogen, phosphorus, selenium, organochlorine insecticides (DDT, also

[3] Electronic data on IID water orders, deliveries, and charges began May 1986 and, at the time of IIDSS model development, ran until mid-November 1999. Coincident with executing and logging water deliveries the zanjeros (ditch riders) also noted crops and planting and harvest dates. These crop history data were also stored in an electronic database covering the same time period as the delivery history database.

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used to represent its metabolites, and toxaphene), and organophosphorus insecticides (diazinon and chlorpyrifos).

Water quality data were compiled from various sources to describe concentrations and flows in the Colorado River, the All American Canal, IID drains, and the Alamo and New Rivers at the international border and their outlets to Salton Sea. Individual measurements were averaged into monthly values for the period from 1970 to 1999, and a subset of these monthly values for the 1987 to 1998 model calibration period was used in the model runs.

In general, salinity, boron, and selenium are imported into the system from the Colorado River with the irrigation water. Small amounts of nitrogen, phosphorus, and sediment are also introduced through the irrigation water, but the primary source of these constituents is irrigated fields. In addition, pesticides come exclusively from farm runoff and pass through the drain system. Once in the drainage system, TDS and boron behave as conservative constituents, and selenium, nitrogen, and phosphorus appear to be influenced by chemical and biological activity. The coarse sediment largely settles in the drains while fine sediment particles tend to remain in suspension and conveyed through the rivers to the Sea. The measured concentrations for the constituents in the irrigation water, drains, and rivers to the Salton Sea are summarized in Table I-2.

TABLE I-2
Mean Flows and Concentrations for Water Quality Parameters

Parameter	Irrigation Delivery	New River			Alamo River		
		Border	Drains	Outlet	Border	Drains	Outlet
Total dissolved solids (TDS) (mg/L)	771	3,894	2,116	2,997	3,191	2,375	2,458
Total suspended solids TSS (mg/L)	86	117	193	313	360	318	479
Selenium (Se) (μg/L)	2.5	3.0	7.4	3.9	5.9	7.9	7.7
Nitrate (NO_3) (mg/L)	0.28	0.84	7.49	4.37	1.87	8.14	7.81
Total phosphorus (mg/L)	0.05	1.42	0.78	0.81	0.47	0.84	0.63
DDT (μg/L)	0.001	0.088	0.013	0.016	0.011	0.020	0.016
Diazinon (μg/L)			0.025				0.025
Chlorpyrifos (μg/L)			0.025				0.025
Boron (μg/L)	170	1,600	804	1,172	1,798	683	695

I.3 MODSIM Simulations

The water balance structure described above was implemented in MODSIM, a well accepted hydrology model that is one of the few models capable of processing the large amount of input data needed to describe the complete IID system. MODSIM was used to simulate the monthly operation of the IID system for 12- and 75-year time periods for modeling of each of the alternatives. For each model run, MODSIM began by routing water through the delivery system to delivery points throughout the IID water service area and computed the overall water demand in the All American Canal at Mesa Lateral 5. Water flows were governed by constraints including maximum canal and drain flows, system spills, maximum and minimum reservoir capacities, and conveyance losses.

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Delivered water that was not consumed by crops or evaporated from fields was then routed through the IID drainage network together with canal seepage, spillage, M&I discharges, and rainfall runoff to the discharge point of the individual drains. In some instances, these drains discharge directly to the Salton Sea, but in most cases drains discharge to either the New River or the Alamo River where they mix with water conveyed in the river from the International Boundary, and the commingled flows are routed to the Salton Sea.

As well as routing flow, MODSIM routes water quality constituent loads associated with each of the flow paths described in the water balance. While mass balance is maintained with water (the volume of water entering the system equals the volume of water leaving the system) some water quality constituents undergo physical, chemical, or biological transformations within the IID system so that the mass of constituent observed to leave the system is different from the mass computed to have entered the system. For this reason, MODSIM includes loss functions that simulate physical, chemical, or biological decay or losses of constituents in the drainage/river system. From the MODSIM output of flows and loads, concentrations can be calculated at any drain or river node throughout the drainage/river network. The constituent concentrations measured at the outlets of the New River and of the Alamo River to the Salton Sea were used for calibration of the water quality equations.

I.4 Key Findings

IIDSS simulation runs were made to produce the reasonable estimates of changes in flow and water quality in the IID drains and rivers likely to result under the Proposed Project and each of the Alternatives.

I.4.1 IID Hydrology

Simulated water balance data from IIDSS are shown in Table I-3. Historical data, IIDSS calibration data, and Baseline information are shown for reference. Table I- 3 shows a water balance for four conservation programs. Slight differences between target and actual conservation (Baseline diversion less program diversion) are noted. This difference is attributed to two things. First, actual acreage needed for on-farm or fallowed conservation is slightly exceeded (the last randomly selected participatory farm will create a conservation volume in excess of the target), and, second, an additional 4 percent conservation above on-farm and fallowing transfer volumes is associated with reduced system losses because of lower delivery volumes.

I.4.2 Water Quality in the IID Drainage System

Water quality changes are computed at the ends of all IID drains and along the Alamo and New Rivers at drain intersections for all IIDSS simulations. Figure I-2 demonstrates that reductions in drainage flow are almost linear to the reductions in IID diversions that result from conservation. Figure I-3 illustrates that the reduction in salinity loading in the IID drainage system is also a linear function of diversion salt loading. For a salinity concentration of 879 mg/L, this simply means that a 1 AF reduction in diversion reduces salt loading in the IID drainage system by 1.1954 tons.

Table I-4 presents a general overview of water quality changes for three constituents (TDS, selenium, and TSS) at key locations within the IID water service area for a 300 KAFY transfer program that includes 200 KAFY of on-farm conservation and 100 KAFY of water delivery system conservation. The percentages shown are for the predicted change from Baseline conditions. Table I-5 demonstrates changes in water quality for 300 KAFY of transfer developed by fallowing. For all water quality parameters, there is a slight improvement in water quality using fallowing to achieve the water transfer.

- The data shown in Tables I-4 and I-5 are average annual concentrations for the 12-year simulations. Output from the IIDSS is monthly and shows all water quality constituent concentrations varying on a monthly basis. General observations are that selenium and TDS concentrations increase for all conservation alternatives and that the percentage change for each alternative is nearly identical for both constituents. Because New River inflows from Mexico buffer changes resulting from implementation of conservation, greater changes in concentration tend to be observed in the Alamo River than in the New River.
- TSS concentrations are reduced. This is directly related to on-farm conservation and a resulting decrease in tailwater discharge.
- TSS concentrations are decreased only slightly in the direct-to-sea drains. This is related to farming methods and cropping patterns, as well as soil types. Most of the soils are very sandy along these drains.
- Fallowing results in minor reductions in salinity and selenium concentrations in the IID drains and rivers.

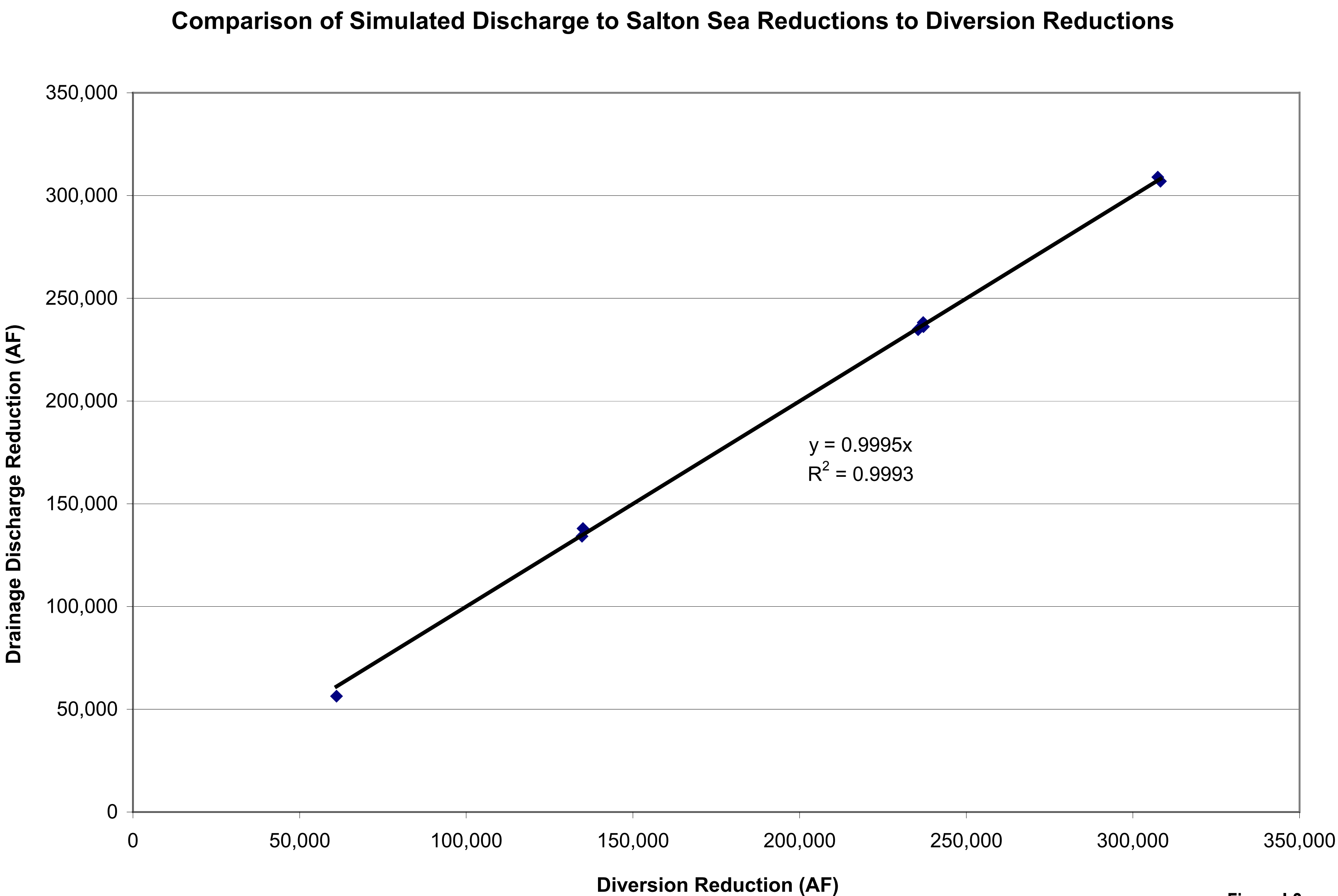

Figure I-2
Diversion and Drainage Flow Relationships

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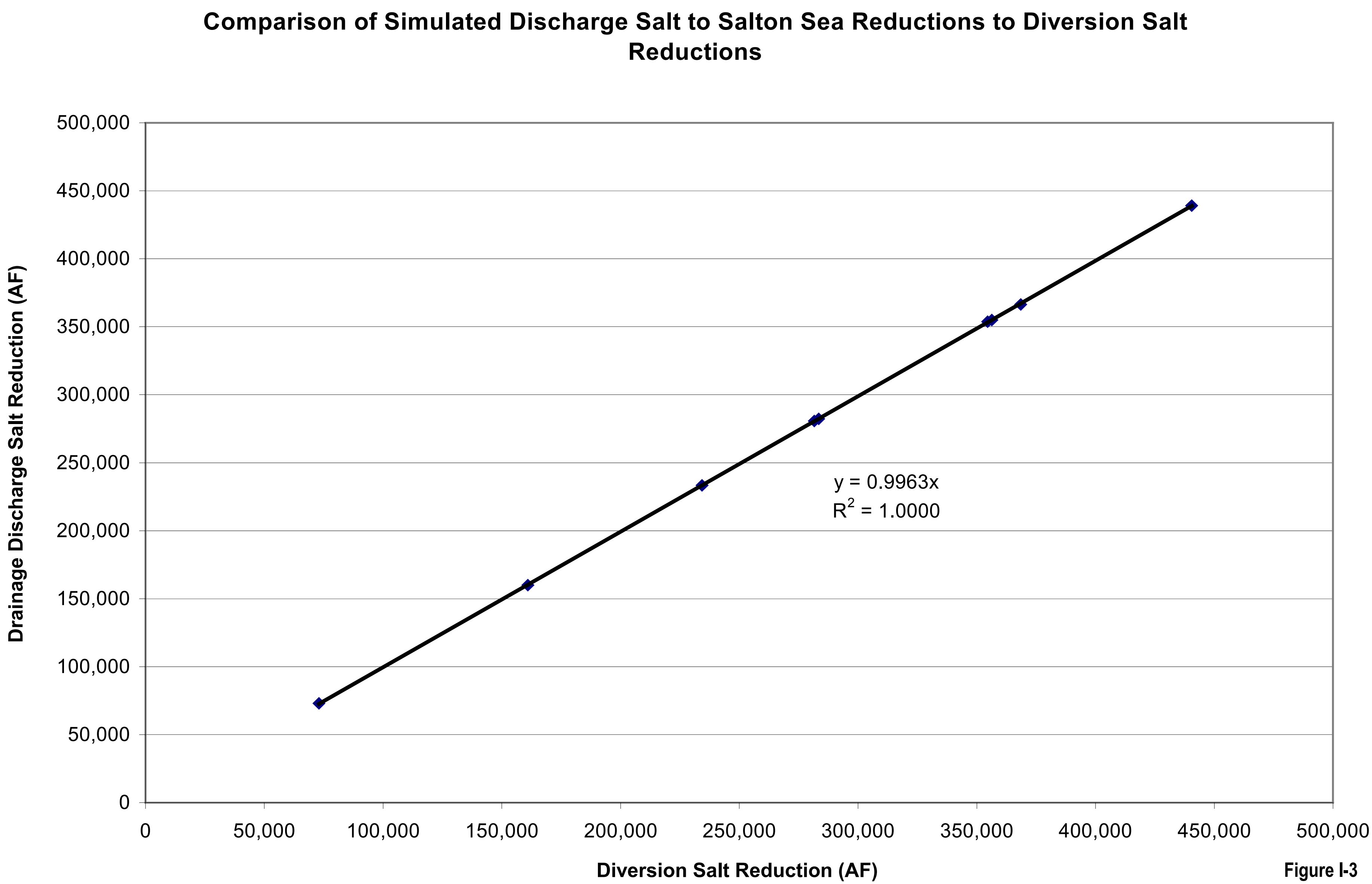

Figure I-3
Relationship of IID Salinity Diversions to Salinity and Discharge to Drainage

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TABLE I-3
IIDSS Simulated Water Balance

Description	Recorded	Calibration	Baseline	200 KAFY On-farm plus 100 KAFY System	230 KAFY On-farm	130 KAFY On-farm	300 KAFY Fallowing
Imported Colorado River Water [1]	2,866,000	2,857,000	2,803,000	2,495,000	2,566,000	2,668,000	2,490,000
Canal and Reservoir Evaporation	-	21,000	19,000	17,000	17,000	18,000	17,000
Canal Seepage	-	123,000	111,000	89,000	104,000	107,000	100,000
Main Canal Spills	-	7,000	-	-	-	-	-
Lateral Spills	-	117,000	99,000	15,000	99,000	99,000	99,000
Sum of Delivery System Losses [2]	272,000	268,000	229,000	121,000	220,000	224,000	216,000
Delivery to Farms	2,490,000	2,490,000	2,458,000	2,258,000	2,229,000	2,328,000	2,158,000
Crop ET	-	1,807,000	1,807,000	1,806,000	1,806,000	1,806,000	1,593,000
Effective Rainfall	-	101,000	101,000	101,000	101,000	101,000	101,000
Tailwater	-	390,000	344,000	197,000	178,000	252,000	305,000
Tilewater	-	394,000	408,000	356,000	346,000	371,000	361,000
Delivery to M&I + Stock + Misc [3]	105,000	105,000	120,000	120,000	120,000	120,000	120,000
Consumptive Use from M&I + Stock + Misc	-	76,000	86,000	86,000	86,000	86,000	86,000
Return Flow from M&I + Stock + Misc	-	29,000	34,000	34,000	34,000	34,000	34,000
Recovered return flow from Mesa Lateral 5	-	4,000	4,000	4,000	3,000	4,000	4,000
Rainfall Runoff and Deep Percolation	-	34,000	38,000	36,000	37,000	37,000	38,000
Evaporation and Phreatophyte Use	-	125,000	125,000	125,000	125,000	125,000	125,000
Mesa Storm Inflows	-	8,000	8,000	8,000	8,000	8,000	8,000
Subsurface Inflow (Estimated)	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Alamo River from Mexico	2,000	2,000	2,000	2,000	2,000	2,000	2,000
New River from Mexico	165,000	165,000	165,000	165,000	165,000	165,000	165,000
Alamo River to the Salton Sea	604,000	605,000	576,000	401,000	448,000	503,000	517,000
New River to the Salton Sea	454,000	453,000	431,000	335,000	346,000	382,000	399,000
Direct to Sea	100,000	101,000	92,000	56,000	70,000	80,000	86,000
Subsurface to Sea (Estimated)	1,000	1,000	1,000	1,000	1,000	1,000	1,000

[1] AAC at Mesa Lateral 5 by water balance from recapitulation data.

[2] Sum of delivery system losses is calculated from the difference in recorded diversions less deliveries.

[3] Includes estimates of deliveries to rural pipes and community greens.

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TABLE I-4
IIDSS Simulations of Water Quality—General Overview
On-farm Conservation = 200,000 AF and System Conservation = 100,000 AF

	New River Basin						Alamo River Basin					
	Baseline			Proposed Project			Baseline		Proposed Project		Direct to Sea Drains	
Parameter	Mexico Inflows	Surface Drains	River at Sea	Mexico Inflows	Surface Drains	River at Sea	Surface Drains	River at Sea	Surface Drains	River at Sea	Baseline	Proposed Project
TDS (mg/L)	2,719	2,585	2,617	2,719	3,294 (+27.4 percent)	3,075 (+17.5 percent)	2,492	2,465	3,559 (+42.8 percent)	3,101 (+25.8 percent)	1,892	2,637 (+39.4 percent)
Se (µg/L)	2.25	6.51	3.30	2.25	8.30 (+27.5 percent)	3.77 (+14.2 percent)	6.32	6.25	9.03 (+42.8 percent)	7.86 (+25.8 percent)	4.80	6.69 (+39.4 percent)
TSS (mg/L)	50	294	238	50	232 (-21.2 percent)	175 (-26.7 percent)	252	264	193 (-23.4 percent)	209 (-20.8 percent)	136	132 (-3.0 percent)

TABLE I-5
IIDSS Simulations of Water Quality—General Overview
Fallowing for 300,000 AF per year

	New River Basin						Alamo River Basin					
	Baseline			Proposed Project			Baseline		Proposed Project		Direct to Sea Drains	
Parameter	Mexico Inflows	Surface Drains	River at Sea	Mexico Inflows	Surface Drains	River at Sea	Surface Drains	River at Sea	Surface Drains	River at Sea	Baseline	Proposed Project
TDS (mg/L)	2,719	2,585	2,617	2,719	2,585 (0 percent)	2,606 (-0.4 percent)	2,492	2,465	2,403 (-3.6 percent)	2,418 (-1.9 percent)	1,892	1,815 (-4.1 percent)
Se (µg/L)	2.25	6.51	3.30	2.25	6.51 (0 percent)	3.18 (-3.6 percent)	6.32	6.25	6.10 (-3.5 percent)	6.13 (-1.3 percent)	4.80	4.61 (-4.0 percent)
TSS (mg/L)	50	294	238	50	285 (-3.1 percent)	226 (-5.0 percent)	252	264	247 (-2.0 percent)	259 (-1.9 percent)	136	136 (0.0 percent)

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