VII . C.

ASSESSMENT OF
CUMULATIVE IMPACTS ON THE COLORADO RIVER
FROM WATER PROJECTS
THAT WOULD REDUCE RELEASES FROM PARKER DAM

APRIL 1991

Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada

PREFACE

This study deals with water projects that would lead to reductions in river diversions at Imperial Dam, and corresponding increases in diversions from Lake Havasu, behind Parker Dam. Generally, the projects would conserve water which would become available for use in areas other than those in which the projects are physically located. The changes in place of use would be facilitated by a variety of legal and institutional arrangements, ranging from the 1931 Seven Party Agreement in California which set priorities to the use of Colorado River water in California, to specific water transfer agreements to be made between agencies.

In the interest of brevity, the term "water transfer" has been used in this analysis when referring to the change in place of use. This term should not be construed to mean that every project involves a contractual exchange of water among agencies, or that all areas of use would acquire rights to the quantity of water made available by the project.

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PART I - SUMMARY AND CONCLUSIONS

This report deals with a reduction in river flow on the lower Colorado River below Parker Dam. More specifically, it contains an assessment of the cumulative impacts of numerous proposed water projects that would reduce releases from Parker Dam.

The assessment was prepared as part of the overall National Environmental Policy Act (NEPA) compliance process for the All-American Canal Lining Project and several other actions proposed by the Bureau of Reclamation. The projects will have a long term effect on future river flow below Parker Dam.

SUMMARY

A number of Federal and non-Federal actions are proposed under which various quantities of water, presently diverted at Imperial Dam, would be diverted from the river at Parker Dam by other water agencies. A list of 10 probable projects was compiled, which aggregate 480,000 acre feet per year. The assessment covers the effects that reducing releases from Parker Dam by that amount will have on the following resources:

1. River flow,
2. Water level of the river,
3. Riparian and backwater habitat,
4. Recreation,
5. Salinity at Imperial Dam, and
6. Hydropower generation on the Colorado River.

The Colorado River Simulation System (CRSS)[1] was used to estimate the future river discharge, salinity, and power production under two conditions--with and without the proposed projects. The "without projects" condition (the baseline condition) consists of future river operation with current projections of future diversions from the river. The "with projects" condition consists of river operation with the projects.

The assessment is confined to the river between Parker Dam and Imperial Dam, where virtually all the effects of the water projects would occur. There is one exception: hydropower generation upstream from Parker Dam would be affected, so the power analysis includes Hoover Powerplant and Davis Powerplant.

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[1] A detailed computer model of the entire Colorado River system, used regularly to project water supply conditions.

FINDINGS AND CONCLUSIONS

Reduction of the river's discharge below Parker Dam by 480,000 acre-feet per year would reduce the average monthly flow below Cibola by about 700 cubic feet per second in April and August, critical months from a biological standpoint. (Projected average flow without the projects would be about 10,000 cubic feet per second.) The reduction in flow would occur gradually over a period of more than a decade.

The results indicate that implementation of all the projects would cause, at most, a 4-inch reduction in average water surface elevations when more or less "normal" flows occur. This would occur against a background of continually fluctuating river flow and water levels, in which the minimum flow and maximum flow would remain unchanged. The river has a daily fluctuation up to a foot, and monthly and yearly fluctuations of several feet in the Imperial Division, the area of greatest biological concern.

Further upstream, the change in level would diminish to the extent that above the Palo Verde Diversion Dam, the daily fluctuation (highs and Lows) would be unaffected in magnitude. The duration of the highs would decrease slightly.

Based on the analysis, it is concluded that:

1. A 4-inch reduction in water level during normal flow would reduce the surface area of the river and the backwaters along the lower river by 30 acres at most, less than 1 percent of the total, during normal flow conditions, against a background of greater changes in area caused by fluctuations of the river.

2. Riparian and marsh vegetation would adapt to the minor shift in average bank line.

3. Fish spawning would not be impacted.

4. Recreation on the Colorado River would not be impacted.

5. The flow weighted average salinity of the Colorado River at Imperial Dam would be increased by approximately 5 mg/L by all the water projects.

6. The water projects and resulting changes in river operation would reduce hydropower generation along the river by approximately 36 million kWh per year.

PART II - PROPOSED PROJECTS

The proposed projects include Federal and non-Federal actions. The Federal actions include the All-American Canal Lining Project, the Coachella Canal Lining Project, Cliff Dam Water Replacement, Southern Arizona Water Rights Settlement Act, Colorado River Recharge in California, and the San Luis Rey Indian Water Supply.

The non-federal actions are components of the Imperial Irrigation District's (IID) Water Conservation Program, one of which is presently being implemented under a 1988 cooperative agreement between IID and the Metropolitan Water District (MWD).

Table 1 lists the water projects used in the analysis. Some of the projects are presently being implemented, and others are still in a preliminary planning stage. Some are uncertain as to implementation and amount of water involved. Questions about the probability of implementation were generally resolved in favor of including a project on the list, to have as rigorous an assessment as possible. Accordingly, this number should be regarded only as an approximation to facilitate the analysis.

Under each water project, a water agency that diverts water from the river at or near Imperial Dam would reduce its diversion, and some other agency would divert the water at Parker Dam. At Imperial Dam water is diverted into the All-American Canal and the Gila Main Canal, and water is pumped directly from the river upstream from Imperial Dam. Such diversions would decrease. At Lake Havasu, behind Parker Dam, water is diverted into MWD's Colorado River Aqueduct, and into the Central Arizona Project's Granite Reef Aqueduct. Such diversions would increase a corresponding amount.

A few potential actions were excluded from the list because their implementation or method of operation were so uncertain that it did not seem reasonable to include them. Brine Stream Replacement for the Yuma Desalting Plant is not included in the evaluation. A source has not been scoped or located geographically. The project would probably not affect the river if the source were upstream from Imperial Dam, but would decrease flow in the river if the source were in the Imperial Valley or Gila River Valley.

Colorado River augmentation is not included. No specific plans have yet been formulated. Also, it is not clear what effect augmentation would have on deliveries downstream from Parker Dam.

Changes in water use resulting from resolution of issues involving Indian claims to water for lands along the Colorado River are also not included.

Table 1
LIST OF WATER PROJECTS

Water Projects	Buildup Period (Years)	Annual Reduction Parker - Imperial (1,000 AF)
Non-Federal Actions		
IID Water Conservation - w/MWD	1991-1995 1/	100 2/
IID Water Conservation - Future	1993-1998	150 2/
Subtotal		250
Federal Canal Lining Projects		
All-American Canal Lining	1993-1997	68
Coachella Canal Lining	1993-1997	22
Subtotal		90
Other Federal Actions		
Cliff Dam Water Replacement	2000	14
Southern Arizona Water Rights	2000	28
Salt River Pima-Maricopa W.R.	1992	22
Colorado River Recharge	1995-2000	50 3/
Lower Colorado River Water Supply	1991-2000 1/	10
San Luis Rey Water Supply	1992	16 4/
Subtotal		140
TOTAL		480

Footnotes to Table 1:
1/ Implementation of this exchange is in progress.
2/ Conservation projects that would result in reduced diversions at Imperial Dam. Water from other conservation projects would be kept in Imperial Valley to meet local needs.
3/ Approximation; project is still in conceptual stage and not yet sized. Surplus water would be recharged into the East Mesa aquifer when available (2 to 4 years out of 10), and withdrawn when Colorado River Basin runoff is low (2 to 4 years out of 10). Releases from Parker Dam would be reduced only when the water is withdrawn from storage.
4/ Part or all of this water may ultimately be included in other actions listed.

PART III - HYDROLOGIC ANALYSIS

This par. presents future river flow and water level changes without and with the project water transfers.

ANNUAL RIVER DISCHARGE IN ACRE FEET

The Colorado River Simulation System (CRSS)[2] was used to estimate future river discharge. Two CRSS runs were made[3]--the base line condition without the water transfers, and the condition with the proposed water transfers. They were 62-year runs, 1989 through 2050. Each run contains 15 separate river operation simulations, called "traces", in order to smooth out fluctuations in river flow to some extent[4].

Figure 1 contains plots of the future average annual discharge of the river at Cibola, at a point just downstream from the Palo Verde Irrigation District Main Outfall Drain, about 38 river miles upstream from Imperial Dam. The difference between the two plots is 480,000 acre-feet, the amount of the water transfers.

Cibola was selected as the point at which to portray annual and monthly flows because it is the CRSS computational point[5] at backwater areas of interest in this assessment.

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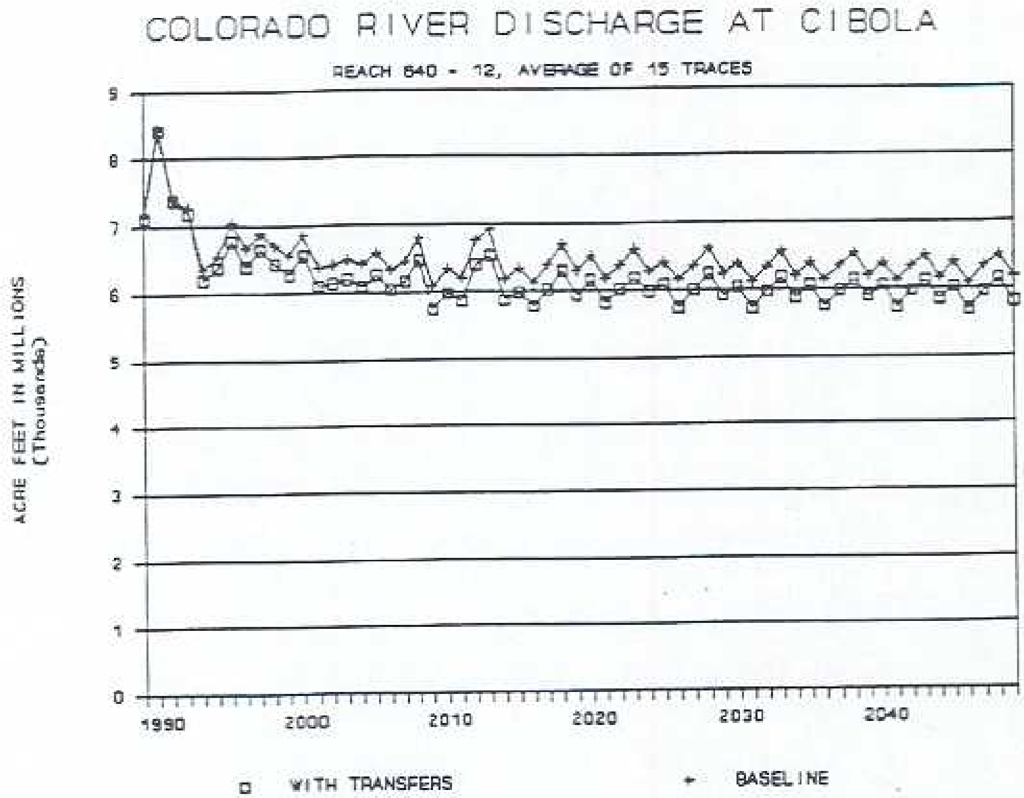
[2] The CRSS consists of the Colorado River Simulation Model (CRSM) plus various subsidiary programs and data bases which together cover runoff, reservoir storage, future diversions, power generation, and dissolved mineral content of the river. The CRSS runs on a monthly time step.

[3] June 14 and 22, 1989, respectively, at Boulder City, using Natural Flow Hydrologic Data Base of September 19, 1986, and USBR Schedule Official Demand File of October 1, 1988 (modified in the "with transfer" run).

[4] Trace 1 is a simulation of future operation from 1989 through 2050, using the historic natural runoff in the Colorado River basin from 1906 through 1957 in consecutive order, repeated as needed to make 62 years. The other traces cover the same future period, with the historic natural runoff staggered at 5-year intervals. For example in Trace 1, runoff in 1906 is used for 1989; in Trace 2, runoff in 1911 is used for 1989; and so forth. The CRSS presents monthly values for each of the 15 traces, plus the average of all 15 traces.

[5] Designated Reach 940, Node 12, in the computational framework of CRSS.

Figure 1



In Figure 1 the annual acre feet at Cibola decline for the first several decades, and then form a uniform range as Colorado River water becomes fully used. The data base in the model includes projections of increased diversions by Upper Basin states, and by Arizona and Nevada, and projections of decreases in diversion to southern California. The plotted values have somewhat of a cyclical fluctuation, reflecting the way that the historic runoff data is staggered in the 15 traces. Fifteen traces are not enough to completely smooth out the projection to the "average" projection, which lies between the cyclical highs and lows.

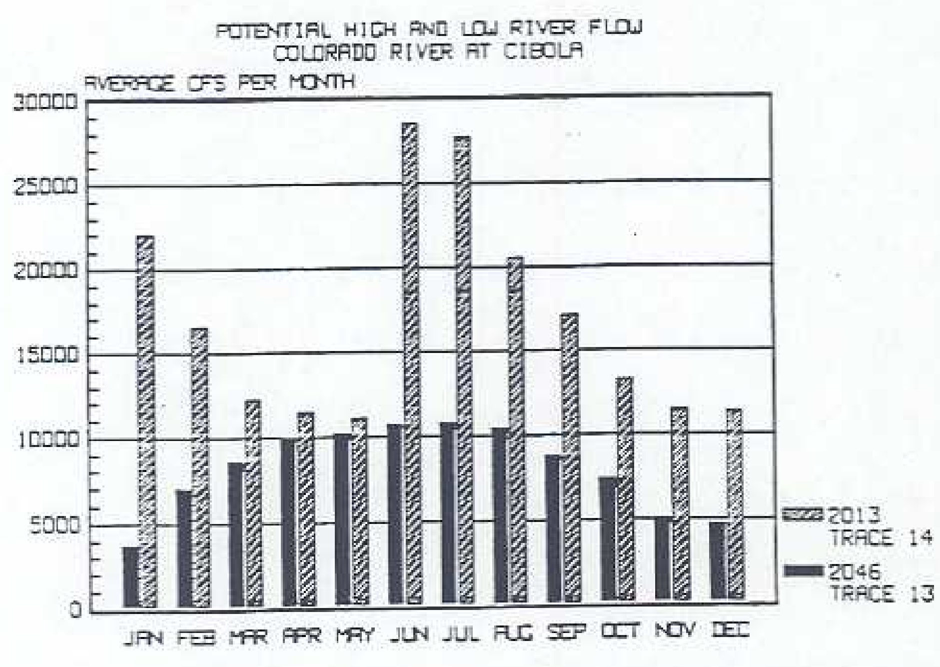
Releases from Parker Dam corresponding to the discharges at Cibola are in Attachment G.

POTENTIAL EXTREMES IN MONTHLY RIVER DISCHARGE

In the future, as in the past, river flow downstream from Parker Dam will vary with the natural runoff in the Colorado River basin. The plot in Figure 1 hints at this, but because each point is the average of 15 traces, the full effect is muted. To illustrate the range of flows that could occur at Cibola under base line conditions, the highest trace of a high year (Trace 14 of Year 2013) and the lowest trace of a low year (trace 13 of Year 2046), are shown on Figure 2.

Each bar on Figure 2 represents the average monthly flow in cubic feet per second (cfs)--the flow that would occur if the monthly acre feet of water passing Cibola flowed uniformly all month[6].

Figure 2



The plotted "low flow" values (Year 2046) are approximately the future normal flow conditions, under which basin runoff is fully used or stored, and releases from Parker Dam are limited to downstream entitlements. These values would occur about 80 percent of the time.

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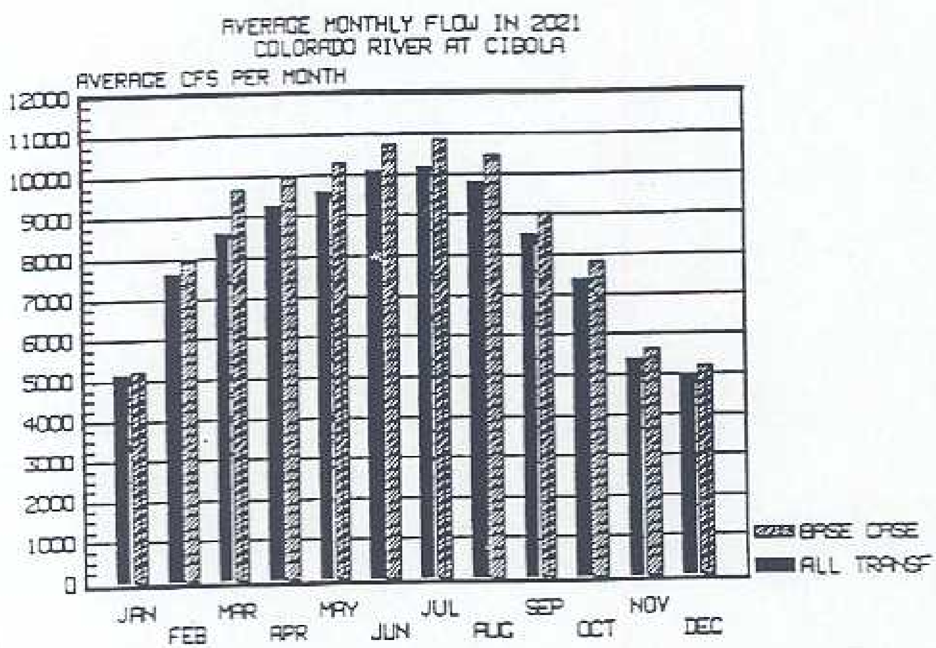
[6] One cfs flowing for a month is equivalent to approximately 60.3 acre feet on the average, ignoring variations in number of days per month.

MONTHLY VARIATION IN RIVER DISCHARGE

The concerns which prompted this assessment are whether the water transfers will reduce river flow enough to cause problems. To analyze this, an appropriate year seemed to be one in the future when river operation has stabilized, and one on the low side of range in Figure 1. Year 2021 was selected. Considering that the range on Figure 1 is relatively narrow, year 2021 is quite representative of a typical year.

Figure 3 shows the future monthly flow at Cibola Lake in Year 2021, for both cases. From April through September the with-transfers flows are all 93% to 94% of the base case.

Figure 3



The "with transfers" changes in diversions were applied to CRSS as follows. Diversions at Imperial Dam were reduced the same amount each month. The seepage loss from the All-American and Coachella Canal is relatively uniform. And the yield from the IID water conservation measures would also be relatively uniform. Some of the minor transfers may not be uniform, but this is not expected to affect the analysis.

The increase in diversions from Lake Havasu was distributed by month in the same proportion as the base case diversions to California and Arizona.

FLOW IN CRITICAL MONTHS

River flow is controlled by releases from Parker Dam. The daily amount of water is based on downstream requirements, while the hourly variation in flow is based on power generation needs.

Selection of Critical Months.

Although December and January have the lowest river flow, they are not the most active months from a wildlife and recreation standpoint, compared to months in the remaining three seasons. Moreover, Figure 3 indicates that the change in flow would be at a minimum in December and January. April was selected as a critical month for analysis because it is the nesting season for many species. August was selected as the other critical month because juveniles of many species are present and feeding independently. April and August flows are representative of summer flows, of interest for recreation.

April Average Flow

The April 2021 flows shown above on Figure 3 are the averages for the 15 traces. The values are 9,967 cfs for the base case and 9,270 cfs with the transfers (difference of 697 cfs). To illustrate the range of values making up the April 2021 average in CRSS, the April 2021 flows in each of the 15 traces are shown on Figure 4.

Figure 4 shows that the monthly flow in April would be relatively consistent in the face of variations in basin water supply conditions. It is influenced mainly by the downstream requirement, which was the same for each of the 15 traces run.

August Average Flow

The August 2021 flows shown on Figure 3 above are the average of the 15 traces. The values are 10,498 cfs for the base case and ,801 cfs with the transfers (difference of 697 cfs). Figure 5 ows the flows in each of the 15 traces that make up the averages shown on Figure 3.

Up to this point, we have been dealing with river flows in terms average monthly cfs, which are useful for comparison but do not represent actual conditions well. Next we consider the daily fluctuations in river flow.

Daily Flow In April

Normally, the flow in the river fluctuates in a daily cycle. The cycle is generated by power releases from Parker Dam, which are high in the daytime and low at night.

Figure 4

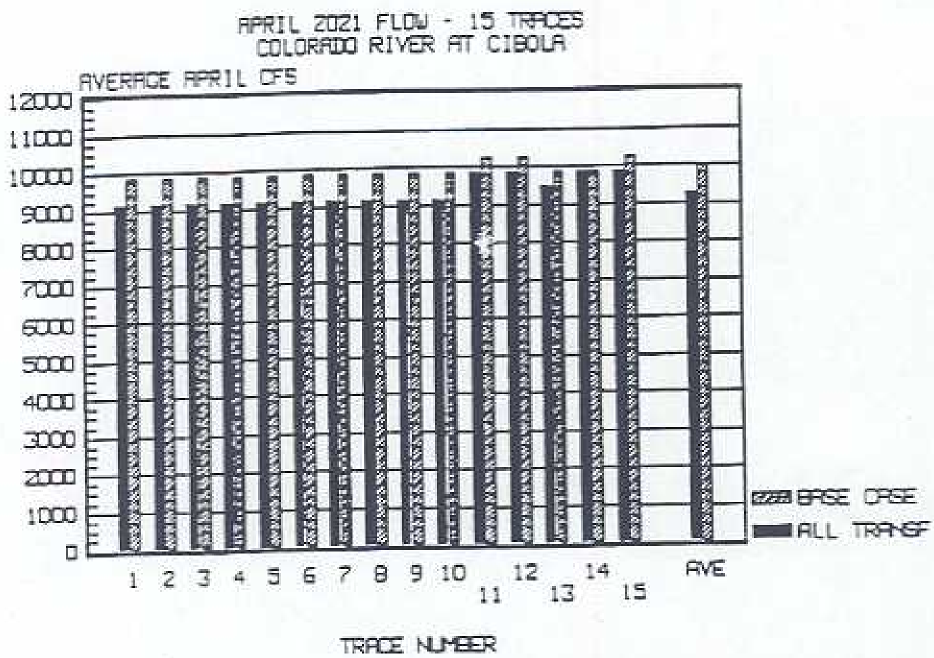
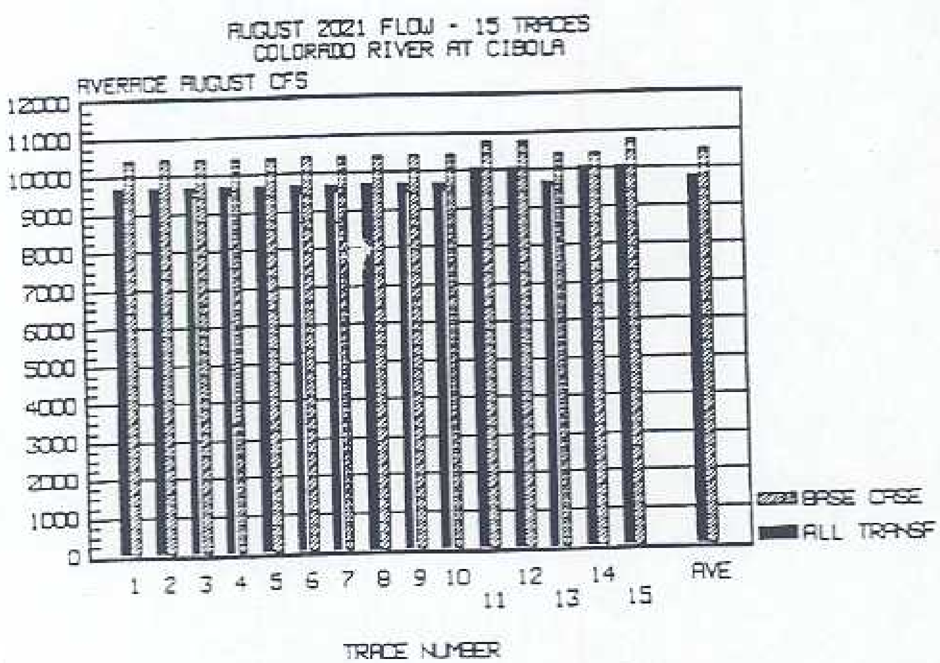


Figure 5



Parker Dam Release Pattern. Figure 6 shows a representative pattern of releases for the month of April, patterned after actual releases for the month of April 1988.

Hourly releases are arranged so as to produce the most economic pattern of electrical power generation possible with required downstream water requirements. Constraints are the minimum flow of 2,000 cfs, and the mechanical operating criteria for the generators at Parker Dam. Typically, one of the five available generators operates overnight at either half gate or full gate discharge. Additional generators are brought on line in the morning and run during the day, then shut down at night.

With all the water transfers, the releases from Parker Dam would be 94 percent of the Base Case releases in year 2021. Under such a change, the powerplant would be operated with the same peaks and lows shown on Figure 6. However, the length of time that the additional generators would be operating each day would decrease such that the vertical columns on Figure 6 representing releases would become 8 to 10 percent slimmer.

Attenuation of Parker Dam Release Patterns. The daily fluctuations are gradually attenuated as the river proceeds downstream. Diversion dams, off channel backwaters, irrigation diversions, and drainage inflows all tend to reduce the fluctuations as the river proceeds downstream. Attachment A contains a series of plots (from U.S. Bureau of Reclamation, 1985) showing observed water level fluctuations at various points along the river. Two conditions are shown--"most likely summer" (March through September) and "most likely winter" (October through February).

Two things happen to the fluctuation as the river flows downstream. First, the daily high and the daily low get closer together. For example, the difference between the Sunday low flow and the Sunday High flow at Parker Dam is about 5-1/2 feet. By the time the flow reaches Water Wheel, 42 river miles downstream, the difference has declined to about 4-1/4 feet. By the time it has reached Taylor Ferry, 86 river miles downstream from Parker Dam, the difference is about 2-1/2 feet. While this is happening, the flow rate during the peaks is decreasing and the flow rate during the lows is increasing. The high and low rates approach one another as the river nears Imperial Dam.

PARKER DAM RELEASES

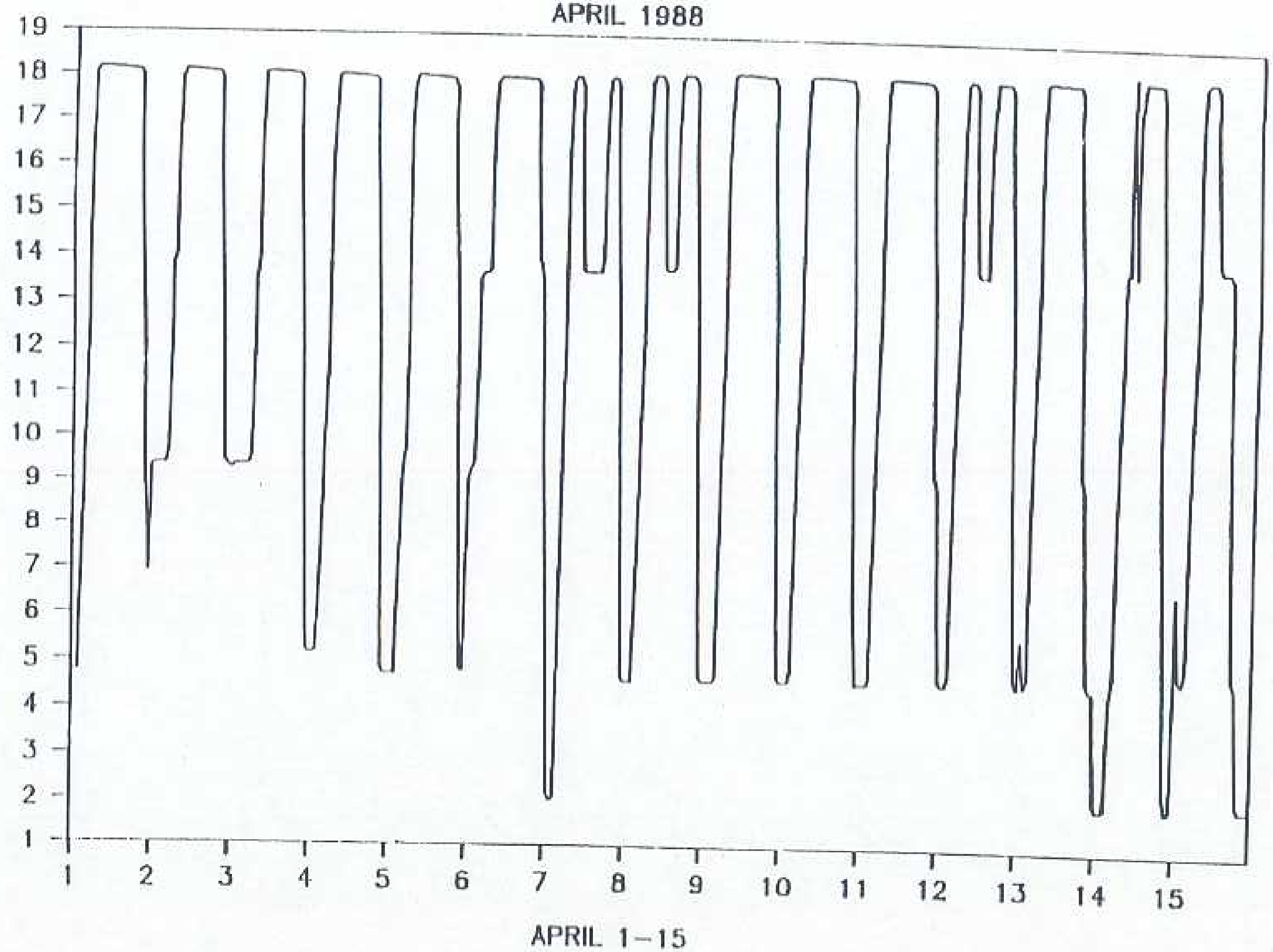


FIGURE 6

Secondly, it takes time for a high or low release from Parker Dam to reach a downstream point. For example the low flow early Sunday morning at Parker Dam takes until about midday on Sunday to reach Water Wheel, 42 river miles downstream. Then it takes until Monday forenoon to reach Taylor Ferry, 86 river miles downstream from Parker Dam.

The plots are based on Parker Dam release patterns of over a decade ago, and not the future releases being evaluated in this analysis. However, the patterns shown are representative of future conditions.

Daily Flow In August.

Flow conditions in August would be similar to those in April. Figure 3 shows that the base flow in August is slightly higher, but close to that in April. And by coincidence, the difference between the base case and the with transfers case is the same in August as in April.

Minimum Flow Conditions

Normal Operation. Under normal operating conditions, the minimum flow in the river between Parker Dam and Imperial Dam at any hour is governed by the need to maintain marshes, to enable minor pumpers to continue to divert water, and to keep the river flowing for recreation purposes. Past experience has shown that 2,000 cfs is a workable minimum flow that accomplishes these objectives. To attain this minimum flow, minimum releases from Parker Dam are generally set at 2,000 cfs plus diversion requirements at Headgate Rock Dam and Palo Verde Diversion Dam.

The 2,000 cfs minimum release is predicated on the ability of downstream requirements plus storage capacity of Senator Wash Reservoir to absorb the flow. When this can not be done, the flow is occasionally reduced below 2,000 cfs for short periods.

This minimum flow operation has been used for a number of years, and is projected to continue. The water transfers contemplated are not expected to have a significant effect on the minimum flows.

Colorado River Shortage Conditions. As shown earlier in this presentation, the normal amount of water to be released from Parker Dam on a weekly, monthly, or seasonal basis is relatively consistent, being governed by downstream water orders. (Figures 4 and 5). However, a series of low runoff years in the river basin, coupled with low upstream reservoir levels, could trigger a Secretarial declaration of shortage conditions in the river. In that case some reductions in deliveries could occur at Imperial Dam, reducing the flows shown in figures 4 and 5.

It is difficult to predict the effect that such shortage conditions would have. A compensating effect lies in the agreements under which one of the largest of the exchanges is being arranged.[7] Water transfer during a shortage condition would be curtailed, minimizing the flow reduction in the river. Other large transfer agreements will probably contain a similar provision. It is not yet known whether similar provisions will be involved in other transfers.

During shortage conditions, the minimum release would still be practiced. However, daily high release may be less than shown for the with-transfer conditions, reducing fluctuations in the Cibola area. This would be a temporary departure from the average.

WATER LEVEL ANALYSIS

This section describes how water level changes were estimated from river flow changes.

General Approach

The approach in this analysis was to estimate changes in water level at six places of concern along the river. Water levels were estimated by means of surveyed river cross sections, computer flow calculations, historic water level observations, and interpolations based on engineering judgement.

On Understanding the River System. Knowing the "discharge" in acre-feet per month calculated by the CRSS, of primary importance to water managers, is a long way from knowing the water level at the entrance to a backwater. Intermediate steps are the release pattern from Parker Dam, and the way flow pattern changes as the river proceeds downstream, as illustrated in Attachment A. This involves the science of river mechanics, which combines the shape of the river bed, power release patterns, diversions and return flows along the river, and the size of backwaters, which tend to even out flow variations as the river proceeds downstream.

It is a routine matter to estimate water levels at selected points along the river using a flow model and river bed cross section at the desired points--if the flow is steady. But variations in flow combined with the irregular shape of the river require either (1) an extremely detailed model that accurately portrays the river system, or (2) a very detailed set of water level observations at points along the river, that can be correlated to the various release patterns from Parker Dam, rates of irrigation diversions along the river, etc., for use in a simpler model.

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[7] Water Conservation Agreement between MWD and IID, 1988.

Neither of these were available for this assessment, so it was necessary to draw upon available observations of the "cause and effect" relationships between Parker Dam releases and downstream flow conditions (Attachment A, for example), and calculated hydraulic relationships at cross sections along the river. The well established release procedures at Parker Dam, based on numerous mechanical, hydraulic, and power constraints provide a good basis for making estimates.

Water Surface Profiles. The water level rises as the flow increases. This relationship is shown on drawings of water surface profiles, appended as Attachment B. They portray the surface of the river as it proceeds downstream.

On each drawing, the lowest plot is the elevation of the "thalweg", or the lowest point in the river bed. The next lowest plot is the average elevation of the bottom, the average of the ups and downs of the bottom from one side of the river to the other.[8]

The water surface profiles merge as the river enters the storage pools behind Palo Verde Diversion Dam and Imperial Dam.

River Sections Selected for Analysis. The river between Parker Dam and Imperial Dam is divided into 4 operating divisions, the Parker Division, Palo Verde Division, Cibola Division, and Imperial Division. Their locations are shown on Figure 7.

Six locations on the river between Parker Dam and Imperial Dam were selected for examination because of their proximity to backwater areas or recreation areas on the river.

River Division	Location Selected
Parker Division	Horse Island
Palo Verde Division	Interstate 10
Palo Verde Division	Goose Flats
Cibola Division	Cibola Lake
Imperial Division	Picacho State Rec. Area
Imperial Division	Martinez Lake

[8] The average bottom shown on Attachment B was calculated at the flow rate of 15,000 cfs. The elevation of the average bottom rises or lowers slightly as the water level rises or lowers.

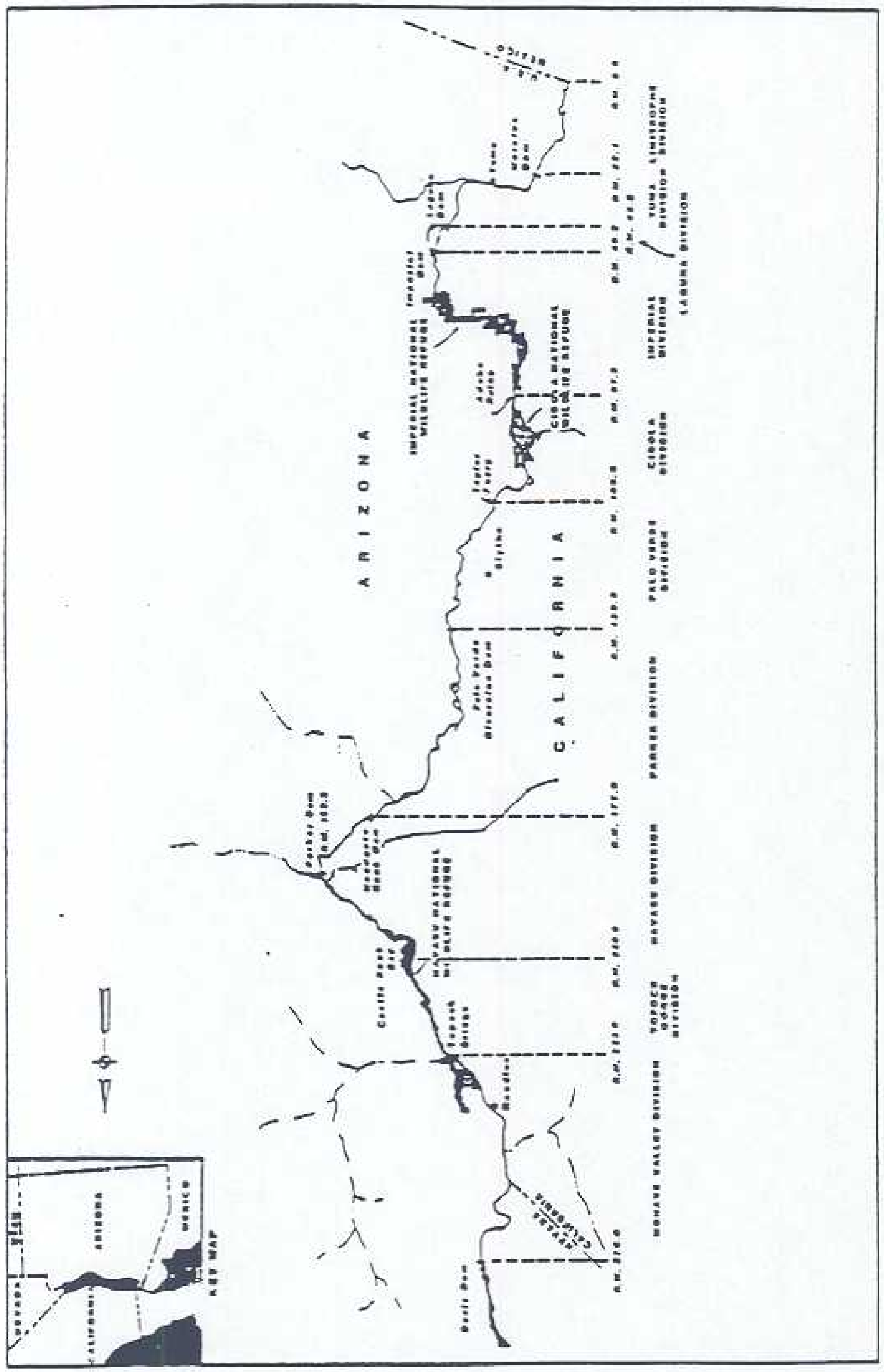

Figure 7. Colorado River Operat.ng Divisions
[From Bio/West Inc., 1986]

River Stage-Discharge Curves. River cross section measurements at each location selected were used to produce a "stage-discharge" curve for the river at each section, which shows the water level (river stage) produced by any flow rate (River discharge). The curves are in Attachment C.

The water levels shown for various rates of flow in cfs are the same as those shown on the water surface profiles on Attachment B, at the corresponding river mile.

Horse Island

Horse Island is located at River Mile 145, about 47 river miles downstream from Parker Dam. At this point on the river the flow variations originating at Parker Dam (Figure 6) would still be directly reflected, but somewhat less in magnitude. This is indicated by a comparison of Plates 4 and 6 of Attachment A. Conditions at Horse island would resemble Plate 6, but the fluctuations would be somewhat lower because the river is wider.

Considering that the maximum and minimum releases at Parker Dam would not change, it is estimated that there would be no significant change in water level fluctuation in this area with the water transfers. The duration of high flows will decrease by about 8 to 10 percent as and the duration of low flows will tend to increase a corresponding amount.

Interstate 10

The Interstate Highway is located at River Mile 121, at the City of Blythe. At this point the river has flowed past two diversion dams. The fluctuations in the base case would decrease to less than half of those below Parker Dam. Plate 7 in Attachment A provides a good indication of the type of level variation to be expected, but the fluctuation would be somewhat greater because Interstate 10 is about 15 miles upstream from the location depicted on Plate 7.

It is estimated that the water levels and their daily fluctuation at Interstate 10 would not change significantly. However, it is possible that with the transfers, the maximum flow would be attenuated somewhat more than would be the case without the transfers. It is postulated that a 300 cfs reduction would occur.

This is rationalized as follows. The average monthly discharge in April and August is reduced approximately 700 cfs[9] by the water transfers. This will not reduce the maximum or minimum releases from Parker Dam, so the daily high and low flow

[9] From section entitled FLOW IN CRITICAL MONTHS.

immediately downstream from Parker Dam would be essentially unaffected.

But by the time the river has reached Martinez Lake, near Imperial Dam, the fluctuation in flow is attenuated so much that the river approaches a steady flow condition. Under steady flow, the 700 cfs reduction would show up as a lower water level round the clock. Actually, the river does not attain steady flow at Martinez Lake; there is still a daily water level fluctuation of about half a foot. However, the approximation is used that a uniform round the clock flow reduction of 700 cfs occurs.

Thus, the water transfers reduce the daily high flow from zero at Parker Dam to 700 cfs at Martinez Lake. Interstate 10 is about halfway between Parker Dam and Martinez Lake. Thus it is postulated that the maximum flow at Interstate 10 would be reduced by about 300 cfs.

Applying the same rationale to the daily low flow produces a reduction of 300 cfs at Interstate 10.

The rating curve drawn for Mile 121.3 indicates that a 1000 cfs change in flow would change the water level by about half a foot. Thus the effect of a 300 cfs flow reduction would be to lower the range of water levels at that point by about two inches.

The duration of the higher water levels would tend to be reduced slightly, and the duration of the low water levels increased slightly.

These relationships would apply during normal river operation to meet irrigation diversions at Imperial Dam and deliveries to Mexico. However, the extremes would not be affected. Sporadic low flows of 2,000 cfs would still occur when diversions are curtailed, and steady high flows would still occur during periods of high natural runoff.

Goose Flats

Located at River Mile 118, about 3 river miles downstream from Interstate 10, this place is also designated the C-5 Backwater. Figure 8 shows a map of the area[10], and Figure 9 shows an aerial photo of the area. The fluctuations in the base case would decrease to less than half of those below Parker Dam. Plate 7 in Attachment A provides a good indication of the type of level variation to be expected.

The rating curve drawn for Mile 118.4 indicates that 1000 cfs change in flow would change the water level by about half a foot.

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[10] From Map 423-306-1190.

Thus it is predicted that the change here would be the same as at Interstate 10, or about 2 inches.

Figure 8. Map of Goose Flats Area.

FIGURE 9
GOOSE FLATS AREA
P423-300-02142

Cibola Lake

Cibola Lake is a backwater lake connected to the river at two points so as to provide flow through the backwater. The outlet is located at River Mile 88, about 38 river miles upstream from Imperial Dam. Figure 10 shows a map of Cibola Lake[11]. The aerial photo on Figure 11 (looking north) shows Cibola Lake on the right.

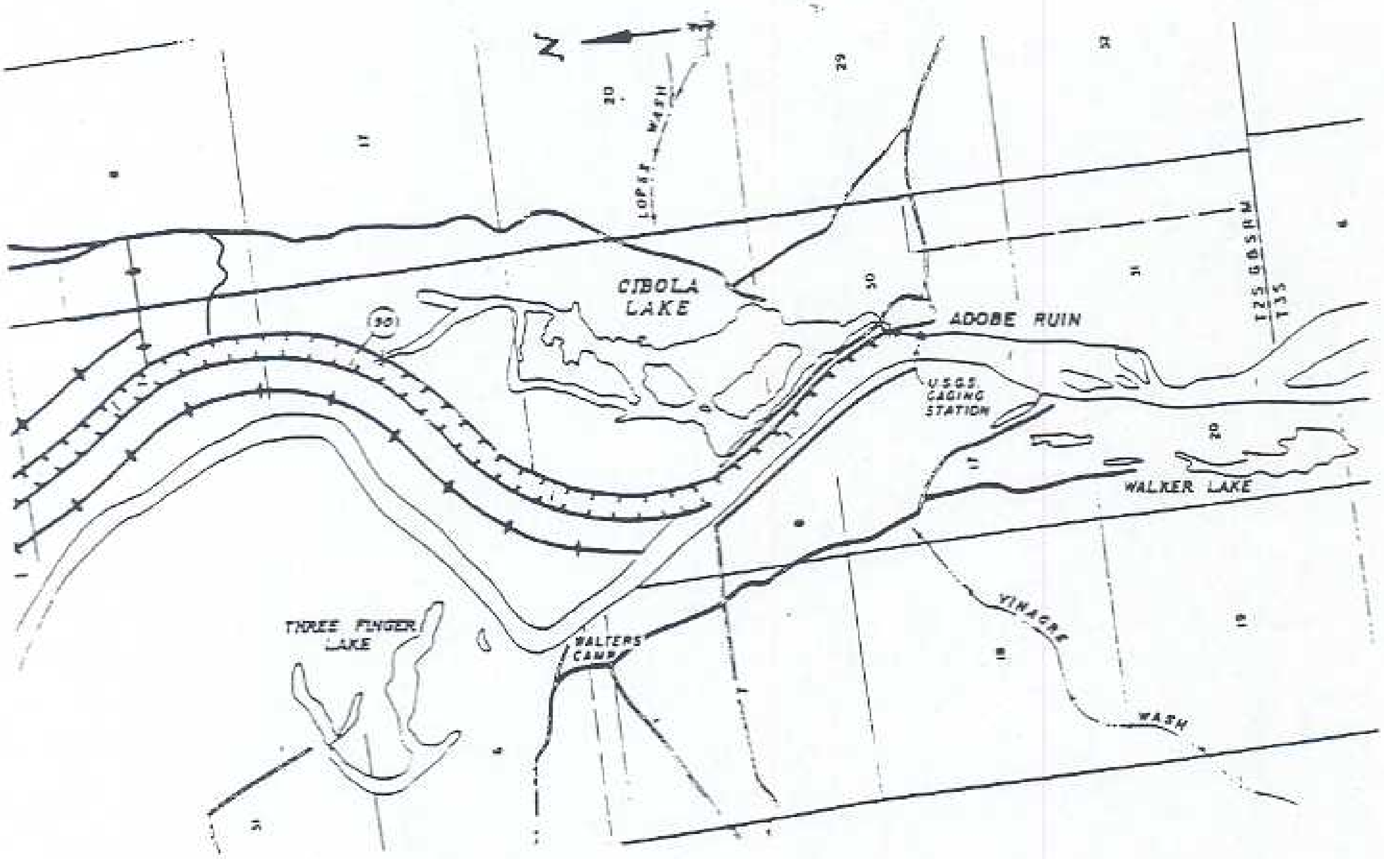

Figure 10. COLORADO RIVER AT CIBOLA LAKE

Cibola Lake lies about halfway between Interstate 10, discussed above, and Martinez Lake, discussed below. River flow conditions at Cibola Lake lie approximately halfway between conditions at those two points. The reduction in average water level at Interstate 10 is estimated to be 2 inches, and at Martinez Lake, 4 inches. Thus a reduction of 3 inches is projected for the average water level at Cibola Lake.

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11 From Bureau Map 423-306-1191.

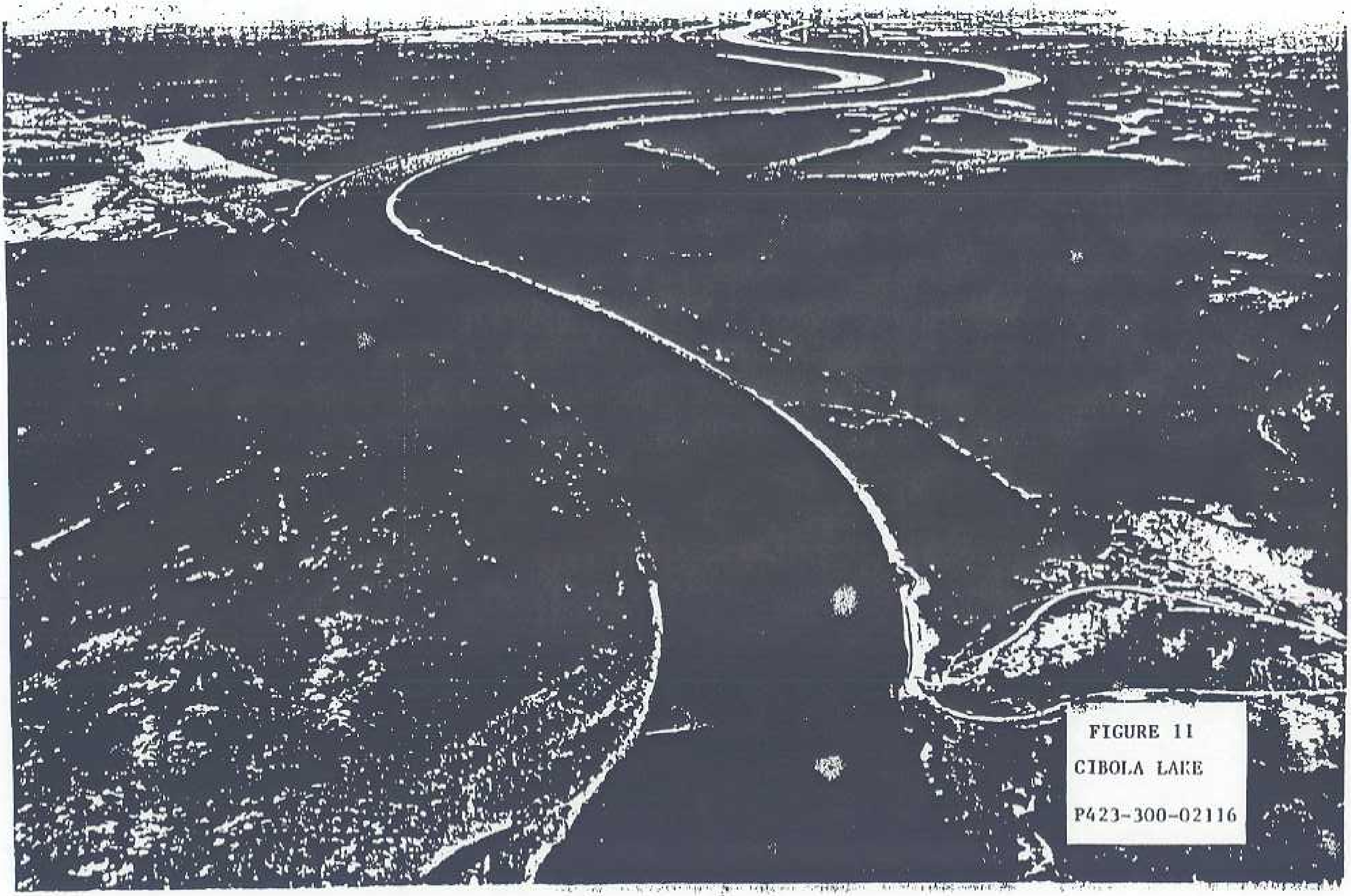

FIGURE 11
CIBOLA LAKE
P423-300-02116

Picacho State Recreation Area

This area is located at River Mile 74, about 25 river miles upstream from Imperial Dam. Figure 12 shows a map of the area[12].

It is predicted that the change in water level at Picacho State Recreation Area would be a reduction of 4 inches, the same as at Martinez Lake discussed below. The State Park is about 17 miles upstream from Martinez Lake, and the river rating curve for the State Park is similar to that at Martinez Lake. (The rating curve drawn for Mile 74.4 indicates that 1000 cfs change in flow would change the water level by about 5 inches).

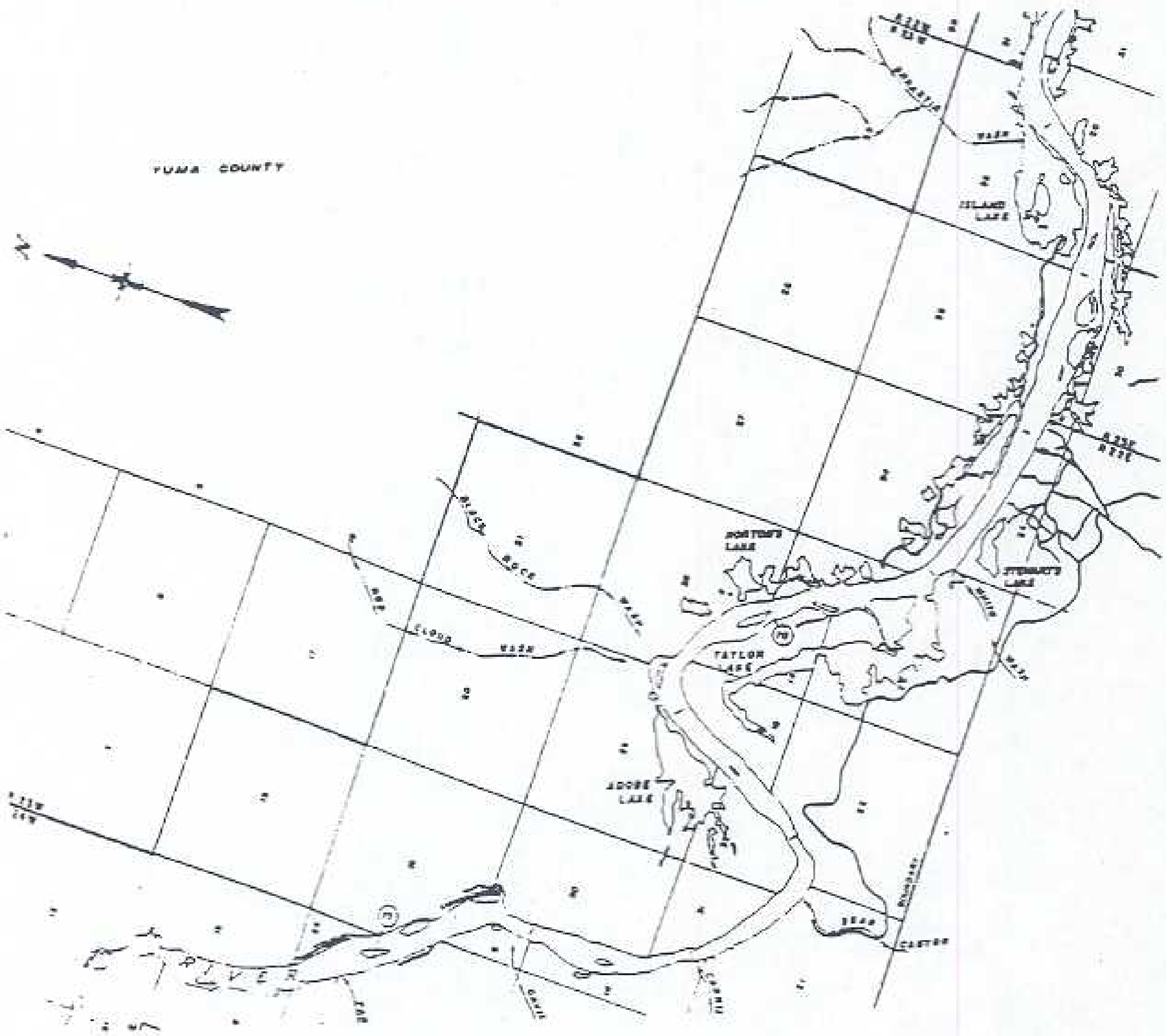

Figure 12. Map of Picacho Area

12 From Map 423-306-1192.

Martinez Lake

Martinez Lake is a backwater lake connected to the river at River Mile 57, about 7 river miles upstream from Imperial Dam. Figure 13 shows a map of Martinez Lake[13]. Figure 14 shows an aerial photo.

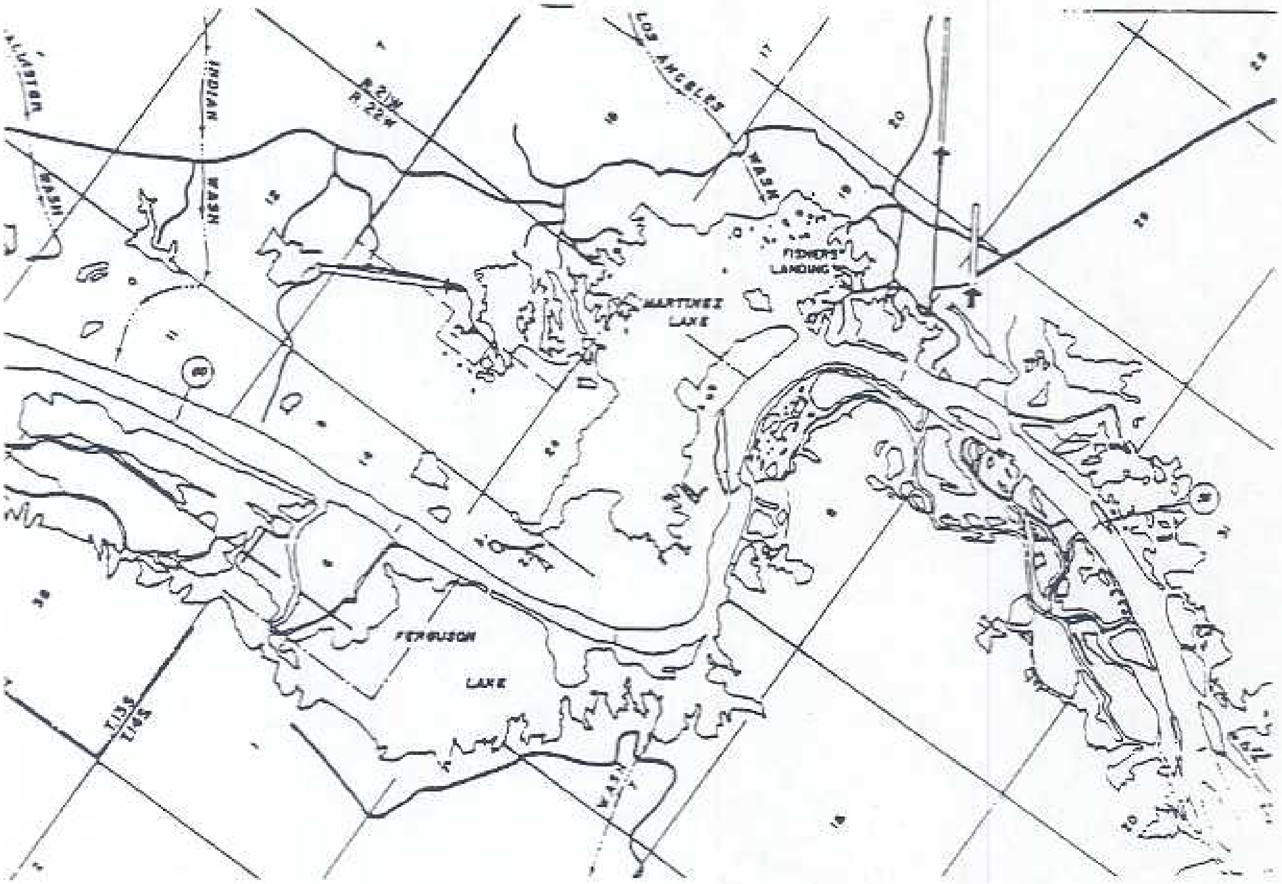

Figure 13. MAP OF COLORADO RIVER AT MARTINEZ LAKE

At Martinez Lake, the flow of the river has been attenuated to a relatively steady flow, with about half a foot of daily fluctuation. A round the clock flow reduction of 700 cfs would occur, as described above under the heading Interstate 10. The rating curve drawn for Mile 58 indicates that a 700 cfs change in flow would change the water level by about 4 inches.

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[13] From Bureau Map 423-306-1193.

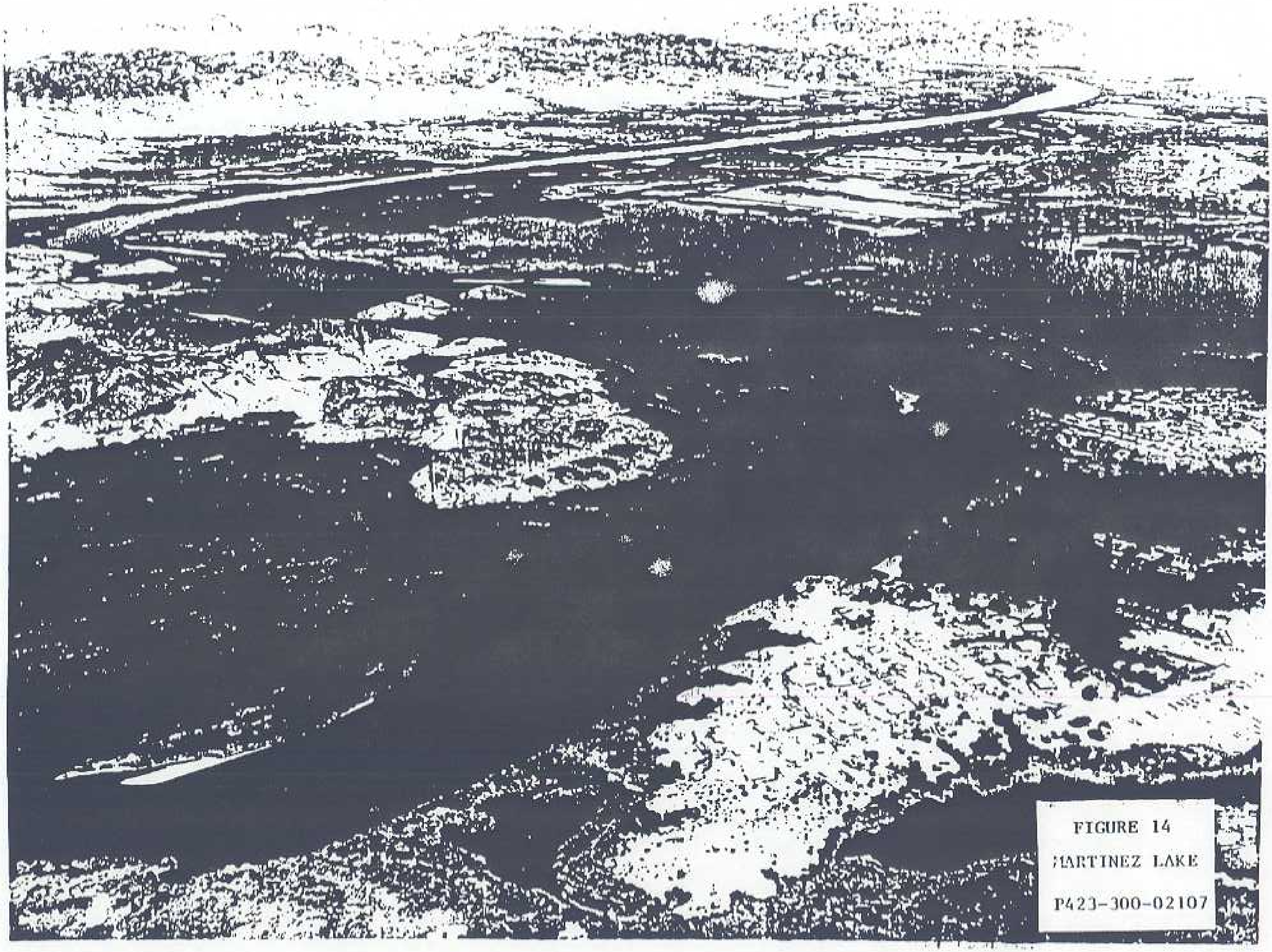


FIGURE 14
MARTINEZ LAKE
P423-300-02107

RIVER CONDITIONS DOWNSTREAM FROM IMPERIAL DAM

The proposed water transfers are wholly within the United States and would not reduce the flow in the river downstream from Imperial Dam. The proposed water transfers would not alter the timing and amount of water deliveries to Mexico under the Mexican Water Treaty of 1944. The proposed transfers would not affect the amount of water routed through Pilot Knob Power Plant.

EFFECTS OF INDIVIDUAL PROJECTS

If it is necessary to determine the impact of an individual water transfer, or if it is necessary to distribute the cumulative effect among all proposed transfers, the recommended method is--distribute the cumulative effects to individual projects in the same proportion as the proportion which the individual transfer amount bears to the cumulative estimate of 480,000 acre feet.

At the outset of this analysis, consideration was given to assessment of the impacts of individual water projects. An initial premise was that the effect per acre foot of water transferred might not be constant, but might increase gradually as successive projects were implemented. Ideally, this could be handled accurately by making CRSS runs for each incremental project, in the order of implementation. But this would not be practical because the amount of computer work and analysis would be prohibitive. So consideration was given to dividing the 480,000 acre feet into four groups of projects, grouped in order of implementation.

However, after beginning the analysis, it was concluded that this would not be a satisfactory approach, for several reasons. The dates for implementation of many of the transfers are not established well enough fix order of precedence. Some of the transfers are concurrent, or overlap. Some may not be implemented. And virtually all of the water quantities are subject to change. Finally, it was discovered that erratic changes in river operation occur as water transfers are incremented. This was shown in an initial analysis for the Federal canal lining projects in which three CRSS runs were made, incrementing from the base case through the projects. The erratic changes, which apparently reflect shifts in flood control operation, are minor in relation to the changes caused by the cumulative transfers.

It appears that there is no better way to apportion effects among the various projects than in proportion to the annual quantity of water each involves.

PART IV - BIOLOGICAL ANALYSIS

This part will address the potential impacts of flow reduction on vegetation and fish spawning. The concern is whether the 480,000 acre-feet of annual flow reduction below the dam would significantly impact the riparian and wetland vegetation along the Colorado River. And since these vegetation types are important to wildlife, whether there would be a significant impact to wildlife. In addition, there is a concern whether lower water levels would impact fish spawning.

RIPARIAN HABITAT

Existing Vegetation

The vegetation along the river varies among the four river operating divisions that would be affected by the change in flow. These divisions, the Parker Division, Palo Verde Division, Cibola Division, and Imperial Division, are shown on Figure 7.

The first three divisions have had fairly extensive modifications to the channels and banklines. These include riprapping of the banklines and a substantial number of access roads for maintaining the bankline work. The Imperial Division, on the other hand, has had no bankline work or access roads construction.

The vegetation found along the banklines within the first 3 divisions varies, but the normal complement consists of small clumps of cottonwoods & willows and substantial stands of salt cedar with screwbean and honey mesquite interspersed. There are also areas of cattail, bulrush, and phragmites scattered along the main channel. These vegetative types may be very prominent in the backwaters scattered through the three divisions; however, there are not a large number of backwaters. All three of these division: have a substantial number of acres under cultivation. The Imperial Division runs between two sets of mountains. For this reason, there has been no bankline work along the channel, and there is not an extensive maintenance road network as there is in the other three divisions.

Imperial dam has had a significant influence on the character of this section of the Colorado River. The dam reduces the velocity of the river, and therefore lowers the sediment transport capacity of the river. This results in a substantial sediment accumulation which has influenced the natural characteristics of this section of the river.

The vegetation found in the Imperial Division varies substantially. Fairly large stands of cottonwoods and willows are scattered throughout the division. There are also substantial areas of salt cedar with screwbean and honey mesquite. However, the dominant vegetation consists of phragmites, cattails and reeds. (See Bio/West 1986 and Ponder 1975.) These create a substantial band of vegetation around the numerous backwaters present in the Imperial Division. (See Figure 13.)

Assessment of Effect on Vegetation

Summary of River Changes. Flow in the Colorado River below Parker Dam can vary substantially from hour to hour, day to day and season to season. These variations are caused by a number of factors such as power demands, irrigation requirements, flood releases, and others, as discussed in Part III - Hydrologic Assessment.

As shown in Attachment A, regular fluctuations in river flow are a normal operational characteristic of the river downstream from Parker Dam. As discussed in Part III - Hydrologic Assessment, and as illustrated in Attachment A, the fluctuations in flow are attenuated as the river flows downstream.

The transfer of 480,000 acre-feet of water from Imperial Dam to Parker Dam would decrease the fluctuating water level by a maximum of 4 inches, as described in Part III. The following impact assessment will evaluate only the changes caused by the proposed water transfer because the larger fluctuations would occur with or without the proposal.

Effect on Riparian Vegetation. In most places, from Parker to Imperial Division, the Colorado River acts as a drain. What this means is that water from the adjacent flood plain flows towards the Colorado River. The river causes an effect similar to that of a well in ground water--it creates what is known as a cone of depression. This means the water level at the well is lower than out away from the well. The shape of an element of the cone, or drawdown curve, is logarithmic; the ground-water drawdown caused by the well diminishes rapidly with distance from the well. So it is with a flood plain water table when subjected to a drop in river level.

For example, it has been shown (U.S. Bureau of Reclamation 1977) that a well, under ideal conditions, with a 4 foot draw down has a cone of depression that extends to 1,500 feet. At this point, all influence from the draw down ceases, but most of the slope in the cone occurs within the first 300 or 400 feet. The hydraulic analysis shows that diverting 480,000 acre feet at Lake Havasu would lower the water elevations by a maximum of 4 inches. But this 4 inch drop would be right at the river's edge; just as there would be a cone of depression at a well, there would be a cone of depression of 4 inches at the river's edge which would slope upwards from this point. Of course, the area of impact would vary, but it would be likely that within a hundred feet the change in ground water elevation would be immeasurable. Further, irrigation that occurs along the Colorado River would reduce the effect on ground water even further since it would be recharging the water table.

In the Parker, Palo Verde, and Cibola Divisions, there should be little or no measurable impact to the riparian vegetation found along the river. The above discussion shows that the reduction to the groundwater table would be immeasurable within the first hundred feet. The riparian vegetation should be able to follow the 4 inch decline in the water table. Further, most of the bankline vegetation in these divisions has already been impacted by an extensive maintenance road system. Since the riparian vegetation would not be impacted, there would not be any significant impact upon the wildlife in these areas.

In the Imperial Division, the riparian species would also be able to adapt to a gradual reduction of 4 inches in the water table.

Effect on Marsh Vegetation (Wetlands). In the Parker, Palo Verde, and Cibola Divisions, there should be no net loss of this habitat. The vegetation most likely to be impacted would be cattails. This species usually occurs in dense, monospecific stands from marshes to any seasonally damp area (Boyd & Hess 1970, Bernard & Fitz 1979, and McNaughton 1966). As the water level declines, cattails would move down with the water level. It has been found (Grace & Wetzel 1988) that this species can maintain itself nearly 6 inches above the water table. Consequently, since there would only be a 2- to 4-inch drop in the water level, the existing cattails should not be significantly affected; above the 6 inches, salt cedar would likely replace the cattails.

Here again there should not be any significant loss of habitat, and, therefore, there should not be any significant loss of wildlife species.

The Imperial Division would have a 4 inch drop in the water level. The impact of the 4-inch drop in water level on the wetland vegetation would be similar to that which would occur in the other three divisions. The cattails, and phragmites would follow the water line as it decreased. The existing wetland vegetation should not change significantly since at least the cattails and likely phragmites can sustain themselves by at least 6 inches above the water level. And in those places where there is some thinning of wetland plants, salt cedar would likely invade those areas. Consequently, there should be no net change in wetland vegetation. As for the riparian species, these plants would likely be able to adapt to a gradual reduction of 4 inches in the water table.

FISH

Open Water Area

The Imperial Division has a relatively low gradient, and has a substantial number of backwaters. The area of the backwaters is estimated to be 3,300 acres, and the area of the river, 1,300 acres. The decrease in water level of 4 inches would reduce the total water surface area in the river proper and the backwaters by approximately 30 acres, as a worst case.

The estimate was made by planimetering the areas of the river and the backwaters, and assuming that the shores of the river and backwaters have a slope of 3 inches horizontal to 1 inch vertical. This assumption is probably conservative because the main river channel has rather steep sides. In addition, 25% was added to the final figure.

Fish Species Present

Because of the varied nature of the Imperial Division, a large main channel with off-stream backwaters, the fishery is also quite varied and extensive. Two studies (Ponder 1975 and Bio/West 1986) have surveyed this division. The Ponder study was not as extensive as the Bio/West study; nevertheless, Ponder did find most of the same major fish species. Table 2 displays the species found by these two studies in the Imperial Division.

Table 2
SPECIES OF FISH IN THE COLORADO RIVER IMPERIAL DIVISION

Species	Present
Carp	X
Goldfish	X
Tilapia	X
Largemouth Bass	X
Striped Bass	X
Bluegill Sunfish	X
Green Sunfish	X
Redear Sunfish	X
Black Crappie	X
Warmouth	X
Threadfin Shad	X
Channel Catfish	X
Mosquito Fish	X
Total Species	13

Effect on Fish Spawning

A drop in water level can have an adverse impact on fish spawning. This is especially true for those species that spawn in shallow water. Table 3 displays the spawning depths for most species present in the Imperial Division.

Table 3
SPAWNING DEPTH OF COLORADO RIVER FISH SPECIES[14]

Species	Data Source	Spawning Water Depth
Largemouth Bass	[1]	1'to 18'
Green Sunfish	[2]	> 15"
Bluegill Sunfish	[2]	2" to 6"
Red-ear Sunfish	[2]	> 6'
Warmouth	[2]	> 5'
Black Crappie	[2]	3' to 8'
Channel Catfish	[2]	Hole or open water
Carp	[2]	Broadcast
Threadfin Shad	[2]	Broadcast

Where are the endangered fish?

Data sources:
[1] Morgensen,S.A.& C.O. Padilla.1982. The status of the Black Bass Fishery in Lake Mead and A Program Toward Restoration and Enhancement. Final Report to: Bur. of Recl. Contract Number: 7-07-30-X0028.p-24.

[2] Calhoun, A.(ed.). 1966. Inland Fisheries Management. Calf. of Fish & Game.

Of the major species, only the bluegill sunfish could be impacted from a drop in water level of several inches. This fish spawns in 2 to 6 inches of water. However, it takes less than 2 days for these fish to hatch (Calhoun 1966), and the water level changes caused by the water transfers would occur slowly from year to year. Thus the water transfers would not impact the fish. The daily water level fluctuation with the water transfers would be similar to that at present.

[14] Taken from BIO/WEST, 1986, pp. 115.

PART V - RECREATION ANALYSIS

Any loss of recreation should be minimal for all four divisions.

In the upstream divisions, the minor changes in magnitude and duration of flow fluctuations are not expected to have an impact on recreation. Any changes would occur gradually over a period of about two decades, which would probably render them unnoticeable against the background of changes caused by other causes.

In the downstream divisions, the 3 to 4 inch drop in elevation would result in a decrease in water depth. This would have little or no impact on the river channel because of its steep banks. It may have a slight impact on the backwaters, but since there the banks are sloped, there should no significant changes to their appearance. The drop in elevation will reduce the average water surface of the backwaters by less than 1 percent.

Since the high flows of 1983, sand bars in the lower part of the Imperial division have occasionally been a nuisance to boaters at low river flows, particularly at entrances to back waters used as launching areas. Problems of this sort are corrected on a case by case basis. In the context of the periodic fluctuation of the sandy river bed, the variability of the river flow, and the continuing maintenance of the lower river, no significant impact is expected to occur to recreational boating.

Overall, there should be no discernable change in recreational resources along the river.

PART VI - SALINITY OF COLORADO RIVER AT IMPERIAL DAM

An analysis was made to determine the amount of increase in the salinity of the river at Imperial Dam, using projections for the Year 2021. Monthly salinity and the average annual salinity were examined.

Long Term Salinity Projection

The flow-weighted average salinity of the Colorado River at Imperial Dam was 655 mg/L in 1988. The salinity will increase in the future as upstream diversions increase. The amount of increase has not been definitely predicted, and will depend on many factors including the effectiveness of future salinity control projects under the Colorado River Water Quality Improvement Program (CRWQIP). Moreover, the salinity will tend to fluctuate annually with variations in basin runoff. Figure 15 shows a scatter plot of projected salinity by future year, which was produced by a CRSS run with 15 traces (from U.S. Department of the Interior, 1989). This projection does not include the salinity reducing effects of future CRWQIP projects. The salinity standard of 879 mg/L at Imperial Dam is shown by a dashed line.

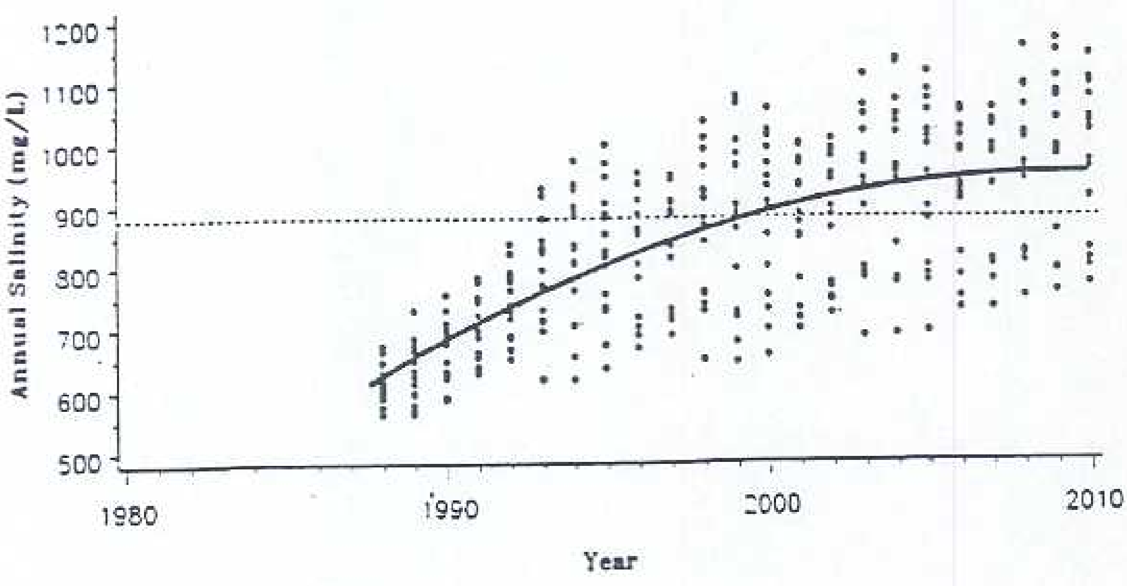
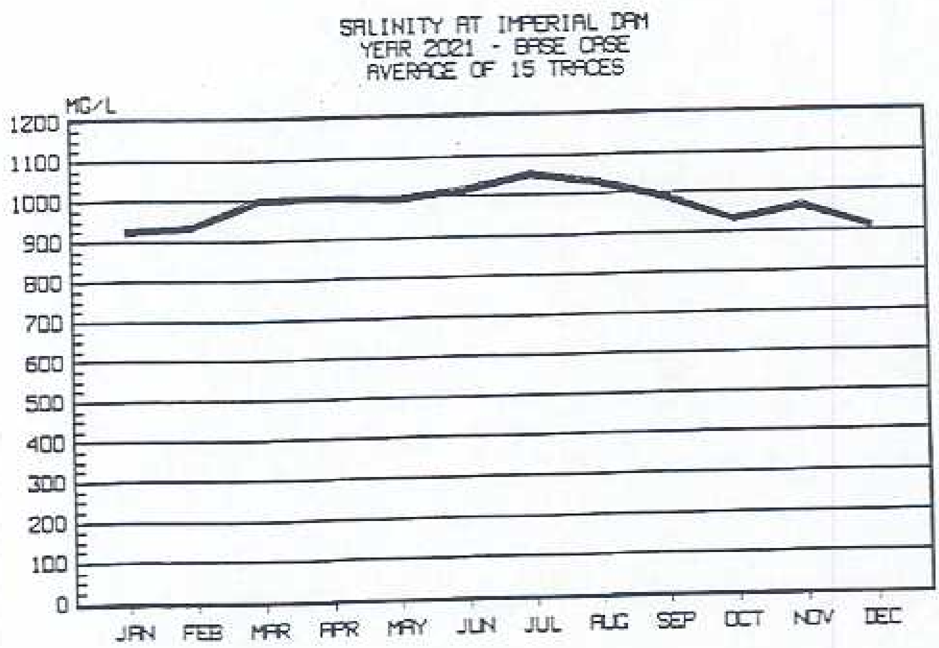


Figure 14. RANGE OF FUTURE SALINITY AT IMPERIAL DAM WITHOUT ADDITIONAL SALINITY CONTROL

Monthly Variation in Salinity

The salinity of the river at Imperial Dam varies from month to month as the proportions of river flow and agricultural drainage vary. Figure 16 shows the projected monthly variation of salinity in year 2021, computed in the CRSS run for the base case. The projected salinity is roughly 150 mg/L higher in July than in December. The projected values do not include the potential effects of future salinity control projects under the CRWQIP.

Figure 16



Effect of Water Transfers

The flow-weighted average salinity of the river at Imperial Dam would increase by 5 mg/L as the result of the water transfers. This was calculated using the monthly salinity and flow values produced by CRSS for Imperial Dam. The computations are tabulated on Attachment D.

The monthly increase caused by the water transfers would vary from zero in January to 8 mg/L in July.

PART VII - POWER GENERATION AT DAMS ALONG RIVER

The CRSS was used to estimate the average annual reduction in generation with the combined water transfers. The two CRSS runs provided with- and without-transfer projections of power generation. The results indicate that the water transfers will cause a direct reduction in power generation at Parker Dam. In addition, they will cause changes in power generation at Hoover Dam and Davis Dam. Table 4 presents the power generation under base case and with-transfer conditions.

Table 4
EFFECT ON POWER GENERATION
Million Kilowatt-Hours per Year

Powerplant	Base Case	With Transfers	Difference
Hoover Powerplant	4,463	4,450	-13
Davis Powerplant	1,061	1,063	+ 2
Parker Powerplant	412	387	-25
Total	5,936	5,900	-36

The "With Transfers" values above represent conditions with all the transfers, amounting to 480,000 acre-feet. The total difference breaks down to a reduction of 75 kWh per acre-foot of water transferred (36,000,000 kWh / 480,000 AF = 75 kWh/AF).

The decrease in generation at Hoover Dam is probably the result of a decrease in contents of Lake Mead, and consequently, of generating head at the powerplant. This is apparently caused by complex changes in the flood control operation of Lake Mead from a reduction in the capacity of MWD and CAP to divert surplus flows in the river.

Details of the power generation analysis at Parker Dam, Davis Dam, and Hoover Dam are in the following attachments:

Attachment E - Tables of monthly energy generated.
Attachment F - Plots of average annual generation.
Attachment G - Plots of average annual flow.

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