Table 7. Description of Vegetation Structural Types.

Type I	Mature stand with distinctive overstory greater than 15 feet in height, intermediate class from 2-15 feet tall, and understory from 0-2 feet tall.
Type II	Overstory is greater than 15 feet tall and constitutes greater than 50% of the trees with little or no intermediate class present.
Type III	Largest proportion of trees are between 10-20 feet in height with few trees above 20 feet or below 5 feet in height.
Type IV	Few trees above 15 feet present. 50% of the vegetation is 5-15 feet tall with the other 50% between 1-2 feet in height.
Type V	60-70% of the vegetation present is between 0-2 feet tall, with the remainder in the 5-15 foot class.
Type VI	75-100% of the vegetation from 0-2 feet in height.

approximately 80 percent of the previous efforts (John Carlson and David Salas, USBR, pers. comm.). This discrepancy is especially important for community and structural types prevalent at the extreme outer portions of the floodplain. Interpreter bias and differences in minimum mapping unit size also led to potential discrepancies between mapping efforts.

Numerous disturbances have altered the plant community composition along the lower Colorado River since 1976. Two major flood events have occurred since these surveys began. First, high flows were recorded along the mainstem of the Colorado River from 1983 to 1987. Next, the Gila River flooded in 1993. Both flood events, as well as numerous small-scale disturbances such as wildfires, clearings, channel modifications, and restoration projects have changed species composition along the lower Colorado River. The change in community and structure types are documented in Table 8.

As of 1997, the lower Colorado River floodplain supported approximately 109,018 acres of riparian, marsh, and desert vegetation between the United States-Mexico border and Davis Dam. This includes 55,437 acres of saltcedar; 5,044 acres of cottonwood-willow; 3,258 acres of honey mesquite; 8,966 acres of screwbean mesquite; 18,065 acres of saltcedar and honey mesquite association; 4,145 acres of arrowweed; 798 acres of quailbush; 11,842 acres of marsh vegetation; and 1,463 acres of creosote scrub (CH2MHill, 1999).

The most abundant community/structural types observed in 1997 (CH2MHill,1999) were, by far, saltcedar type IV (33,175 acres) and saltcedar type V (14,528 acres). Saltcedar-honey mesquite type IV consisted of 10,470 acres, saltcedar-screwbean mesquite type IV consisted of 6,280 acres, saltcedar type VI consisted of 6,479 acres, and arrowweed type VI consisted of 4,145 acres. A complete description of the 1997 community and structural type acreages found along the lower river (per River Division) is shown in Table 9.

The 1997 aerial photography identifies a change in the acreage and structure of certain riparian plant communities (CH2MHill, 1999). Data indicate a trend in several plant communities since 1976. Saltcedar has steadily increased in abundance since vegetation type mapping began in 1976, with a total of 55,000 acres being classified as monotypic saltcedar and an additional 27,000 acres classified as mixed saltcedar-mesquite types in 1997. Monotypic honey mesquite acreage trends show a steady decrease to 3,258 acres in 1997. Screwbean mesquite acreage has also shown a decline since the 1983 Colorado River flood event.

Cottonwood-willow community types, along the lower Colorado River below Davis Dam, declined over 28% after the 1983 Colorado River flood event. The 1994 survey indicated that this trend was continuing, with only 3,398 acres being typed as cottonwood-willow during this effort. However, the 1997 survey typed over 5,000 acres of cottonwood-willow, a loss of only 700 acres from 1986. Some of the increase in cottonwood-willow acreage may be attributable to the 1993 Gila River flood event as the

Table 8. Acreage Delineated for Each Vegetation Community Type During Aerial Surveys Conducted Since 1976.

Community Type	1976	1981	1986	1994[1]	1997
SC I	106	330	310	290	366
SC II	188	101	9	87	40
SC III	334	425	11	267	849
SC IV	25,090	22,510	22,381	24,092	33,175
SC V	6,867	10,438	17,560	13,096	14,528
SC VI	2,876	5,057	4,766	7,011	6,479
SC TOTAL	35,461	38861	45,037	44,843	55,437
CW I	383	0	0	68	430
CW II	94	163	225	151	64
CW III	464	592	502	1,833	2,774
CW IV	4,396	4,581	1,733	938	1,129
CW V	2,417	1,700	2,867	152	376
CW VI	534	939	427	266	271
CW TOTAL	8,288	7,975	5,754	3,398	5,044
HM III	1,814	1,228	1,089	41	402
HM IV	10,430	9,051	8,889	149	2,309
HM V	3,963	2,156	1,583	193	483
HM VI	0	35	20	24	64
HM TOTAL	16,207	12,470	11,581	407	3,258
SM I	0	0	0	3	10
SM II	272	99	0	15	0
SM III	1,858	768	360	508	672
SM IV	13,734	12,067	7,825	8,771	6,280
SM V	4,561	5,238	7,067	3,679	1,386
SM VI	358	3,208	240	1,565	618
SM TOTAL	20,783	21,380	15,492	14,541	8,966
SH III	175	204	28	67	546
SH IV	5,268	7,149	5,966	1,115	10,470
SH V	2,503	2,735	1,879	1,027	6,128
SH VI	0	130	7	131	921

Community Type	1976	1981	1986	1994[1]	1997
SH TOTAL	7,946	10,218	7,880	2,340	10,065
AW TOTAL	3,944	4,253	7,478	5,197	4,145
ATX TOTAL		597	1,231	714	798
CR TOTAL			426	749	1,463
MA 1		3,975	5,657	4,216	4,248
MA 2		1,382	729	533	651
MA 3		1,241	1,857	1,913	2,892
MA 4		573	369	2,523	2,078
MA 5		1,093	443	314	823
MA 6		636	1,757	592	639
MA 7		1,255	1,757	931	511
MA TOTAL	5,834	10,155	12,549	11,022	11,842
TOTAL	98,463	105,909	107,428	83,211	109,018

[1]1994 aerial survey did not cover the entire floodplain

Table 9. 1997 Acreages of Lower Colorado River floodplain vegetation community types per river maintenance division.

	MOHAVE	TOPOCK GORGE	HAVASU	PARKER	PALO VERDE	CIBOLA	IMPERIAL	LAGUNA	YUMA	LIMITROPHE	Total
SC-I	284	0	7	0	0	14	15	32	6	3	361
SC-II	0	1	2	1	0	0	0	0	35	0	38
SC-III	31	22	38	35	341	196	65	39	65	15	849
SC-IV	6,815	135	1,067	3,997	6,792	7,377	2,514	2,071	605	1,104	32,478
SC-V	3,449	10	522	4,180	1,459	992	622	491	575	1,682	13,982
SC-VI	583	0	157	2,565	469	369	137	681	236	979	6,176
CW-I	0	7	19	4	39	67	32	163	58	40	430
CW-II	12	0	18	8	14	2	0	7	1	0	63
CW-III	551	55	343	32	193	465	227	445	328	91	2,731
CW-IV	54	7	0	184	105	18	132	292	269	69	1,129
CW-V	29	0	18	13	0	2	12	63	143	83	364
CW-VI	0	0	72	3	0	16	0	79	37	37	245
HM-III	5	0	2	328	54	0	12	0	1	0	402
HM-IV	1	0	32	1,699	299	241	15	5	3	0	2,296
HM-V	0	0	58	275	16	53	0	0	0	0	402
HM-VI	0	0	0	64	0	0	0	0	0	0	64
SM-I	0	0	10	0	0	0	0	0	0	0	10
SM-III	32	0	0	331	0	3	22	0	48	0	436
SM-IV	556	19	545	1,677	849	640	118	644	75	0	5,122
SM-V	108	0	76	408	187	71	13	15	0	0	878
SM-VI	55	0	184	7	18	0	21	0	0	0	285
SH-III	35	31	3	24	51	41	9	10	13	0	218
SH-IV	309	103	381	5,583	1,887	993	269	116	0	0	9,641
SH-V	602	4	176	2,596	1,416	407	57	47	0	0	5,305
SH-VI	0	0	62	398	102	4	0	1	0	0	566
AW	193	2	325	2,178	192	70	433	280	171	5	3,849
ATX	0	0	115	328	64	0	36	87	120	29	780
MA-1	1,335	490	325	58	139	841	667	288	0	6	4,150
MA-2	64	135	21	37	27	242	90	6	5	0	627
MA-3	108	31	225	311	49	678	1,046	312	68	3	2,830
MA-4	594	377	85	258	94	396	204	21	19	0	2,048
MA-5	358	112	14	17	23	30	248	9	0	0	810
MA-6	99	0	13	16	0	158	160	93	93	7	639
MA-7	45	9	11	81	9	15	13	98	38	132	450
CR	24	352	8	6	0	213	311	517	29	0	1,460
Total	21,355	4,924	22,405	32,509	17,415	18,565	10,168	8,110	3,554	4,365	143,370

Table 9. 1997 Acreages of Lower Colorado River Floodplain Vegetation Community Types Per River Maintenance Division.

1994 aerial photography may have been flown too soon after the flood event to adequately show the amount of cottonwood-willow regenerated. Another possible explanation is the ambiguity associated with this method of vegetation classification, especially when typing cottonwood-willow communities. To be classified as a cottonwood-willow type under the present system, cottonwoods or willows need only comprise 10% or more of the total number of trees present within the stand.

One trend does appear within the cottonwood-willow communities since the 1983 Colorado River flood, however. There has been a steady increase in the number of acres classified as CW I and CW III below Davis Dam. This trend signifies the maturity of stands regenerated during the 1983 Colorado River and 1993 Gila River flood events. It is interesting to note that CW II has never appeared in any significant amount in any of the surveys conducted as the shade-intolerant cottonwood and willow rarely grows to maturity as a dense overstory without gaps being created which enables other species, especially saltcedar, to become established within the stand.

Prior to 1997, aerial survey efforts were restricted to the portion of the Colorado River floodplain that stretched from Davis Dam to the southerly international boundary with Mexico. However, increased emphasis has been placed on the riparian habitats associated with Lake Mead. Following the Colorado River flood of 1983-87, an extended dry hydrologic cycle occurred which exposed sediments at the Lake Mead delta, Virgin River delta, Muddy River delta, and the lower Grand Canyon. Exposure of saturated soils coincided with natural seedfall producing large tracts of riparian habitat, especially in the lower Grand Canyon and Lake Mead delta, near Pierce Ferry, Arizona (Figure 8). An estimated 1,400 acres of cottonwood-willow habitat became established at the Lake Mead delta at this time (USBR, 1996). By 1995, lake levels had increased enough to inundate the majority of the Lake Mead delta resulting in the loss of this habitat by 1999. A similar scenario occurred at the Virgin River and Muddy River deltas, albeit at a much smaller scale. It is estimated that approximately 20 acres of occupied southwestern willow flycatcher breeding habitat was lost at the Virgin River delta due to rising lake levels (McKernan and Braden, 1999).

Since Grinnell's 1910 survey of the lower Colorado River, numerous additional surveys and investigations concerning the biotic attributes of the lower river system have been conducted. Probably one of the most recent and comprehensive terrestrial descriptions can be found in the Reclamation-funded *Wildlife Use and Densities Report of Birds and Mammals in the Lower Colorado River Valley* (Anderson and Ohmart, 1977). This report describes the average densities and diversities of birds and mammals as associated with the 26 vegetative community and structural types mentioned above. The information given in this report was obtained from data collected over a 4-year period, and involved continuous year-round surveys in each of the habitat types from Davis Dam to the Mexican border, near Yuma, Arizona. Over 250 species of birds and approximately 15 species of mammals were observed during this survey. Generally, the survey showed the highest bird and mammal densities and diversities in cottonwood-willow with mesquite, mesquite-saltcedar (mix) and saltcedar communities, respectively lower. Structural types I and II had the greatest species richness while the least diverse structure types V and VI had the lowest richness. More recent studies indicate that the 1977 survey underestimated the use of saltcedar communities, especially by neo-tropical migrant birds (Lynn and Averill, 1996; McKernan and Braden, 1999).

b. Marsh

Present-day marshes along the lower Colorado River are of two kinds. The first kind includes backwater marshes, which are defined as marsh areas adjacent to the river and which are either directly connected to the river or are connected by seepage. The second kind, which is more extensive, includes those marshes formed by impoundments such as the marshes in Mittry Lake, Imperial Reservoir, Lake Havasu, Topock Marsh, and other similar impounded areas.

The construction of river control features, such as training structures, along the lower Colorado River has resulted in the formation of more permanent and expansive backwater marshes. There are over 400 backwater marshes along the lower Colorado River today from Davis Dam to Laguna Dam. Some of these marshes were created and are maintained specifically for mitigation for channel improvement projects. Reclamation actively pursues maintenance and restoration of backwater marshes not tied to mitigation on a cost shared basis. These backwater marsh habitats are subject to successional factors as

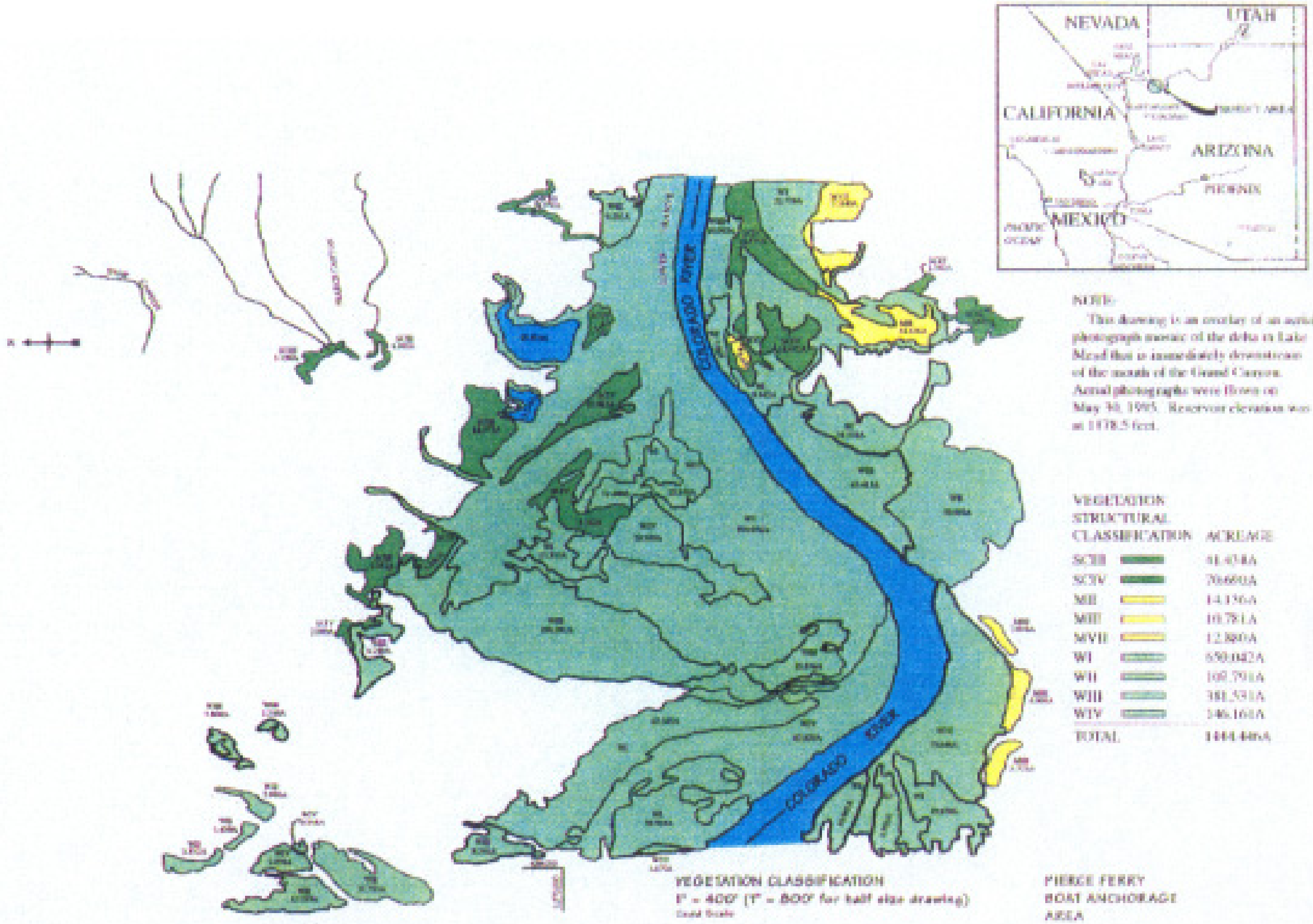

Figure 8. 1995 Colorado River Delta at Lake Mead Vegetation Classification.

were the historic marshes along the river. Under normal operating conditions, this succession is greatly slowed because current river conditions and operating criteria result in less scouring and associated sediment movement. Bankline stabilization has reduced erosion and associated sediment accrual to the river. When exceptional conditions are encountered, such as the high flow releases which occurred in 1983-1985, channel scouring occurs with associated sediment deposition in those backwater areas. These exceptional conditions would be expected to promote accelerated succession to upland conditions which are dominated by saltcedar (Tamarix sp.).

The majority of the banklines of the flowing river have been stabilized. This does not allow for natural marsh formation resulting from the river channel moving laterally, which would occur during high flows. Additionally, current river operating criteria reduce the opportunity for high flows (floods) which would also reduce natural marsh formation during those type of flows. A portion of the backwater marshes, which exist along the river today, are isolated from the main river channel, reducing the opportunity for flushing flows through them. However, it was observed during the high flows experienced on the river during 1983 through 1985, the isolated backwater marshes did not fill in with deposited sediment. Impacts which occurred to those isolated backwater marshes were a result of the main river channel scouring and the resulting drop in water table. In any case the marsh communities formed, as a result of the impoundments and training structures, are much greater in extent and permanence than those which occurred historically. As stated above, some of these marshes are specifically maintained for fish and wildlife purposes.

Vegetation mapping completed in 1997 shows the lower Colorado River floodplain supporting over 11,000 acres of marsh habitat. Of this amount, 4,248 acres were classified as Type 1, which meets the criteria of being nearly 100 percent cattail/bulrush with small amounts of common cane and open water.

Reclamation funded a 1986 report describing the development of a fish and wildlife classification system for backwaters found along the lower Colorado River from Davis Dam to Laguna Dam (Holden et al., 1986). The 2½ year study effort resulted in over 400 backwater areas being identified and classified. The backwaters were characterized by State, distance from the SIB, river division, how formed (natural or man-made), quality of associated riparian vegetation, how accessible, size, how connected to the river, shape, permanence and actual acreage of open water.

After classifying the backwaters, seasonal field studies were then undertaken to sample fish and wildlife distribution, abundance, and preferences. Eighteen individual backwaters were sampled. These efforts included sampling water quality, zooplankton, benthic macro invertebrates, and fish in nine fishery study backwaters. Wildlife studies on the 18 backwaters also included morning bird censuses, night spotlighting, small mammal trapping, and aerial waterfowl surveys. Over 100 avian species, 25 mammal species and 15 fish species were observed, quantified, and associated with classified backwaters.

This report and mapping effort was updated in 2000 with some modifications to meet present data needs (USBR, unpub. data). The backwaters for this update were defined as open water with the associated emergent vegetation (primarily cattail/bulrush). The report results still show over 400 backwaters existing on the lower Colorado River between Davis Dam and Laguna Dam. The open water areas show 7,911 acres, an increase of slightly over 1,300 acres since 1986. This differential may be due to improved sampling techniques, however. The emergent vegetation associated with the open water of the backwaters was also mapped. The total emergent vegetation acreage was slightly over 9,200 acres.

c. Aquatic

The present aquatic ecosystem of the lower Colorado River is tremendously different than found historically. Changes began in the late 1800s. The human populations of the Colorado River Basin States grew rapidly during the mid-to-late 1800s as people immigrated from the eastern United States and from other countries. The Colorado River basin, with its endemic fish community isolated for thousands of years, was invaded and swamped with new species in a very short period of time. The growing human population also set out to tame and harness the Colorado River, building flood control dams, storage reservoirs, and agricultural diversions. A chronology of the introduction of non-native fishes and dam building, are described above in the history and in the *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment*

(USBR, 1996).

Today, the lower Colorado River downstream of Grand Canyon is a tremendously diverse aquatic ecosystem with over 240,000 surface-acres of open water (Table 10). There are over 27 fish species occupying habitats ranging from deep, clear reservoirs to turbid, flowing river, to warm shallow marshes. While the system on an overall basis is diverse, meaning one reach of river does not look like the next, individual reaches do not change much from season to season. The annual changes in the system are missing. Historically the river environment was extreme. The river annually went from hot to cold, and from raging flood to gentle tranquility. Today, reservoirs are clear and deep all year long. For example, over two-thirds the volume of Lake Mead remains at 55 degrees 12 months of the year, resulting in a constant, cool discharge at Hoover Dam. Even in the lower reaches of the Colorado River between Blythe, California, and Yuma, Arizona, where the river is turbid and shifting sand beds still occupy the river bottom, annual fluctuations in discharge and sediment load are almost immeasurable when put on a scale with the historical ranges of these parameters. Even the daily water level changes, which occur below almost every dam, are constant and rhythmic. Unlike conditions described by Grinnell (1914), whereby rapid changes in water levels trapped fish in shallow pools and side channels (to the benefit of herons), stranding of fishes under the current operational release patterns are extremely rare and virtually non-existent.

Table 10. Surface acreage of open water along the lower Colorado River from Pierce Ferry to the U.S./Mexico International Boundary by river maintenance division (Water Classification).

DIVISION	FLOWING RIVER (acres)	RESERVOIR (acres)	BACKWATER (acres)	TOTAL (acres)
Lakes Mead & Mohave	0	191,500	20	191,520
Mohave	3,554	0	3,767	7,321
Topock Gorge	1,183	0	239	1,422
Havasu	515	20,510	740	21,765
Parker	3,748	0	1,364	5,112
Palo Verde	2,350	0	160	2,510
Cibola	1,971	0	505	2,476
Imperial	3,154	560	2,608	6,322
Laguna	436	25	585	1,046
Yuma	1,782	0	82	1,864
Limitrophe	0	0	146	146
TOTALS	**18,693**	**212,595**	**10,216**	**241,504**

The native fishes were adapted to the system of extremes. They spawned early, before the peak runoff, and their developing young moved into off-channel areas along with the rising flood waters to feed and grow. Migrations up or downstream were possible due to their body forms, and their long life allowed them to persist when reproductive failure occurred for successive years due to drought or other calamities. While top carnivores where included in the community, species such as the razorback sucker hid during the day and grew quickly to sizes less vulnerable to predation. The introduced fishes such as carp and catfish quickly invaded the off-channel habitats as witnessed by Grinnell (1914) who found them abundant in backwaters along with bonytail and razorback sucker. As discussed by Dill (1944), the physical extremes of the river system prior to dam construction must have been equally hard on native and nonnative fishes alike, and although these exotic fishes were present, their numbers were not great.

Dill (1944) reported that the populations of native fishes had declined prior to 1930. He proposed that native fishes were at a low point in their respective populations just prior to the period of dam building and that nonnative fish populations rapidly expanded with the taming of the river and prevented the rebuilding of native stocks. In his own words:

"...it seems probable that the native fish populations have undergone alternate periods of

> rise and fall. But each period of destruction was followed by a period during which the population could rehabilitate itself.... Because of the unfavorable water conditions around the early thirties it seems possible that the population of native fishes sank to one of its low points and that the coincidental advent of clear water following Boulder Dam brought about a heavy production of bass and other alien fishes which preyed upon the already reduced natives."

Dill (1944) argued that the native fishes had a high biotic potential which had allowed them to bounce back from previous catastrophes and had it not been for the presence of exotic fishes, they would have done so.

Minckley (1979) similarly argues that dam construction alone was not sufficient to destroy the native fish communities of the lower Colorado River:

> "Destruction of the native fauna of the lower Colorado River has been attributed to physical modifications of the environment, such as channelization and construction of dams.... Considering the great age of the Colorado River, and correspondingly great ages of at least some of the genera of fishes inhabiting it..., sufficient time has been available for them to have experienced far more change than has recently been effected by man.
>
> Excluding special cases..., almost all declines in native fish populations are directly attributable to predation by small adults or juveniles of introduced kinds upon early life-history stages of indigenous forms. Shoreline and backwater habitats once exclusively available to non-piscivorous juveniles of suckers and minnows now are inhabited by mosquitofish and young centrachids, and cropping by those animals destroys the native fauna."

Clearly, destruction of the native fauna was not a onetime event. It took some time, and in the case of razorback sucker and possibly bonytail, it is still going on today. In Lakes Mead, Mohave, and Havasu native fish expanded their populations along with the expanding aquatic habitat as the water bodies filled. Jonez and Sumner (1954) described the spawning of both bonytail and razorback sucker in Lake Mohave and of razorback sucker in Lake Mead. LaRivers (1962) details spawning of razorback sucker in Lake Havasu in 1950.

One of the few observations made of large numbers of juvenile razorback sucker this century was made in Lake Mohave in 1950, and it serves here to demonstrate how these fish populated new reservoirs during initial filling. In describing the habitat used by razorback sucker, Sigler and Miller (1963) state the following:

> "This large sucker is an inhabitant of large rivers and has adjusted well to the impoundments of the lower Colorado River Basin.... The young occur in shallows at the river or reservoir margins where individuals approximately an inch long travel in schools numbering thousands. Over 6,000 specimens were taken in two hauls of a minnow seine at the margin of the Colorado River in Nevada on June 15, 1950. Here the temperature was 71-76 degrees F, whereas the adjacent river was only 58 degrees."

Davis Dam closed and began storage in January 1950. According to statements by Minckley et al. (1991), the above cited capture of juvenile razorback sucker occurred at Cottonwood Landing, which is approximately 21 miles upstream of Davis Dam. The quoted information suggests that the reservoir had backed up to that point, because the differences stated in water temperature between the riverine and ponded areas is similar to what is found today at the inflow of the Colorado River to the lake some 20 more miles upstream.

It seems apparent that as the new water bodies filled, native and nonnative fish were initially successful in recruiting young into adulthood. As time went on, the nonnative populations were able to prey on the eggs and young of native fishes and recruitment into adulthood all but ceased for the native fishes. Adults continued to survive until they succumbed to natural causes, which in the case of razorback sucker took upwards of 50 years.

Further data supporting the hypothesis that the native fishes were initially successful in recruitment were presented by McCarthy and Minckley (1987). They analyzed otoliths of seventy Lake Mohave adult razorback suckers killed between 1981 and 1983. Roughly 88 percent hatched prior to or coincident with construction and filling of Lake Mohave (1942-1954).

Ongoing work in the upper Colorado River basin, regarding the role of flooded bottom lands in the ecology of razorback suckers, provides just as striking information on how quickly the nonnative fishes can overshadow such recruitment. In attempts to increase natural recruitment of native fishes, FWS personnel flooded a bottom land parcel with water from the Green River, near Vernal, Utah, during the spring of 1995. At the end of the summer, they drained the wetland and found 28 young razorback suckers. These were the first young razorback suckers of this size observed in that age group since 1965. However, they only represented a very small portion of the fish in the wetland. Of the 11 tons of fish measured, 95 percent were non-natives. Carp dominated the catch by weight, and fathead minnows (Pimephales promelas) were numerically the most abundant fish species (FWS, 1995).

In the lower Colorado River of today, physical and chemical conditions do not favor the nonnative fishes over the native fishes, except for possibly lack of turbidity. Adequate water quality exists in the form of water volume, water temperature, dissolved oxygen, pH, specific conductance, hardness, etc. for reproduction, nursery, rearing/growth, and resting for native and nonnative fishes. Spawning habitat in the form of clean hard substrates are excessively abundant in both lentic and lotic reaches (relative to pre-Hoover Dam period). Primary production is adequate to sustain tons of fish production. Chlorophyl levels range from 1.0 to 5.0 mg/l (Paulson and Baker, 1984), which is remarkably normal for fresh waters in the temperate zone world wide (Taylor et al., 1980). Zooplankton levels in mainstem reservoirs are on the order of 10 to 50 individual organisms per liter, a level typically found in temperate lakes across North America. Benthic invertebrates in riverine reaches are probably one or two orders of magnitude greater than that which occurred in the main channel Colorado River prior to Hoover Dam. Macrophytes abound in many reaches of the lower river, adding to the already high autotrophic production. So why do the native fish not survive?

The main problem is the sheer number of new species, all with reproductive potentials as great or greater than the native fishes. Taking the three most common native fish, (historically) razorback sucker has roughly 100,000 eggs per female, Colorado squawfish produce about 100,000 eggs per female, and bonytail produce roughly 50,000 eggs per female (Hammond, pers. comm.). One of each species would yield 250,000 eggs per spawning season. Female carp average 500,000 eggs (Carlander, 1969), striped bass in the lower Colorado River have over 500,000 eggs (Edwards, 1974), one channel catfish produces 10,000 eggs (Carlander, 1969), largemouth bass average 40,000 (Carlander, 1977), one bluegill sunfish yield 25,000 eggs (Carlander, 1977), one green sunfish produces 25,000 eggs (Carlander, 1977), black crappie average 50,000 eggs (Carlander, 1977), and even one four inch threadfin shad yields 10,000 eggs per year (Carlander, 1969). One of each would total over one million for one year. Multiply these numbers by the factor of differential survival (e.g. catfish and sunfish guard their young in nests while the three native fish are broadcast spawners) and the picture becomes clearer. The nonnative fish quickly out produce the native fish. And while not all of these immature fish survive, the greatest number of each species present are the young fish (young of year and yearlings) which are the primary predators on young native fishes.

Marsh and Pacey (1998) conducted an extensive literature search on the habitat and resource use of the native and non-native fish in the lower Colorado River. They concluded the native and non-native fishes in the river over lap broadly in their physical habitat and resource use. They stated:

> "No attribute of physical habitat or resource use can be identified that markedly or marginally favors one group of fishes over another, and we cannot envision habitat manipulations or features that could be made to accomplish such a goal. Rather, the evidence supports an hypothesis that presence of non-native fishes alone precludes successful life-cycle completion by components of the native fauna. This array of non-native fishes now present has feeding, behavioral, and reproductive attributes that allow it to displace, replace, or exclude native kinds."

In Lake Mohave, Jonez and Sumner (1954) observed razorback sucker and bonytail (separate observations) spawning in large groups and the adults did not protect their eggs and larvae. In each observation, carp were observed feeding on the eggs, and young bass and/or sunfish were observed with the larvae.

Juvenile native fishes also succumb to predation. Marsh and Brooks (1989) report on the stocking of juvenile razorback suckers into the Gila River in Arizona between 1984 and 1986. They released 35,475 fish in three separate stockings. They concluded that channel catfish and flathead catfish within the first 40 kilometers of river downstream from the release sites were able to remove the entire population of planted fish.

One possible explanation for this high incidence of catfish predation was provided by the NFWG on Lake Mohave. Its work showed the juvenile razorback sucker to be nocturnal in habit, seeking protective cover during daylight hours. These observations suggest that juvenile suckers attempted to hide in the same cavities occupied by catfish, inadvertently seeking out the predator (USBR file data).

In summary, the aquatic ecosystem that exists in the lower Colorado River today, and forms the aquatic baseline for this BA, is highly modified and is physically, chemically, and biologically different than that which existed historically. Native fishes are mostly extirpated or in danger of becoming so. Physical modifications by dam construction and reservoir formation have homogenized the river system, effectively removing the "extremes" to which only the native fishes were adapted. Without such extremes the native fishes have no advantage over nonnative fishes and both groups are able to express their reproductive potential in regard to the release of gametes. Differential mortality on native fishes due to predation on early life stages by nonnative fishes sufficiently suppresses the recruitment of native fish to the adult life stage and in a matter of only a few generations, extirpation is achieved. The primary limiting factor for recruitment of native fishes in the lower Colorado River basin today is nonnative fish predation on young life stages. This has been conclusively proven by the myriad of studies and experiments in which native fishes have been successfully reared in habitats from which nonnative fishes have been removed and excluded.

Recognizing this fact, a number of current conservation and recovery actions are being taken in the lower Colorado River basin by Reclamation and other agencies to raise native fish in protected, predator-free environments until they are big enough to avoid most predators occurring in the lower Colorado River. Similarly, fishery biologists in the upper Colorado River basin now recognize the problems caused by the invasion of nonnative fishes made possible because of dams and diversions and other developments along the Green and Colorado Rivers and their tributaries and are developing strategic plans to control nonnative fishes. Recent actions in the upper basin also include offsite rearing of native fishes and stocking of juveniles back into the river system.

B. Previous and On-Going Section 7 Consultations

A complete list of previous Section 7 Consultations is contained in the *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment* (USBR, 1996). Reclamation completed that consultation and is in the process of implementing the Reasonable and Prudent Alternatives and Measures contained in the Biological Opinion (USFWS, 1997).

An on-going Section 7 Consultation involves development of the Lower Colorado River Multi-Species Conservation Program (MSCP). The LCR MSCP is proposed to serve as a coordinated, comprehensive conservation approach for the lower Colorado River basin for a period of 50 years.

The purpose of the LCR MSCP is to: 1) conserve habitat and work toward the recovery of threatened and endangered species and to reduce the likelihood of additional species listings under the Endangered Species Act; 2) accommodate current water diversions and power production and optimize opportunities for future water and power development; and 3) provide the basis for Federal ESA and California ESA compliance via incidental take authorizations resulting from the implementation of the first two purposes.

The program is a partnership of Federal agencies; State and local agencies in Arizona, California, and Nevada; Native American tribes; and other non-Federal participants responding to the need to balance the legal use of lower Colorado River water resources and the conservation of threatened and endangered species and their habitats in compliance with the ESA.

The program area covers the mainstem of the lower Colorado River from Separation Canyon in the Grand Canyon to the SIB with Mexico, and includes the100-year flood plain and reservoirs to full-pool elevations. Potential conservation measures will focus on the lower Colorado River from Lake Mead to the international boundary, but the partnership may consider cooperative conservation efforts developed by the Grand Canyon management effort.

A single environmental compliance document will be prepared to fulfill requirements of the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), Federal Endangered Species Act (ESA), and California ESA for the LCR MSCP. This document will have the working title of LCR MSCP Environmental Impact Statement/Environmental Impact Report/Biological Assessment (EIS/EIR/BA). The Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (Service) are the joint Federal lead agencies under NEPA, and the Metropolitan Water District of Southern California (Metropolitan) is the designated CEQA lead agency for the EIR.

The EIS/EIR/BA will contain the following elements:

1. Proposed Action and Habitat Conservation Plan for an ESA Section 10 permit application
2. Alternatives
3. No Action Alternative
4. Reclamation's Biological Assessment for ongoing and future actions within its legal authority.

The EIS/EIR/BA will provide a basis for a number of actions. It will document the basis for effecting ESA compliance for Federal actions through section 7 consultation and for non-Federal actions through incidental take authorization approval under a section 10 permit. The environmental documentation will also provide a basis for the issuance of a biological opinion to Reclamation and other participating Federal agencies. Finally, the environmental documentation will provide the basis for complying with the California ESA and the Natural Communities Conservation Planning Act.

C. Indirect and Cumulative Actions

1. Indirect Effects

Any indirect effects from implementation of the ISC or the SIAs will be covered under either project specific or area specific HCPs and/or Section 7 analysis.

a. Interim Surplus Criteria: No indirect effects to listed species or their habitat are expected to occur in any of the Lower Division States because of implementation of ISC. Any indirect effects of surplus criteria in Nevada will be covered under the Clark County Multi-Species Habitat Conservation Plan (HCP). This plan provides for incidental take because of growth that might result within the HCP area. Any indirect effects that may occur because of surplus water flowing into central Arizona under ISC have previously been addressed and covered under more than 40 specific consultations for the Central Arizona

Project (CAP). The CAP provides for movement and use of some of Arizona's Colorado River water including that derived from surplus through the CAP.

No indirect effects are expected in California because of implementation of the ISC. For many years, the Colorado River Aqueduct (CRA) has transported its full capacity of about 1.3 maf of water diverted from Lake Havasu to the southern coastal plain area of California. The ultimate result of implementing ISC and the actions under the SIAs discussed below will be a decrease in reliance and use by California on Colorado River water above its basic apportionment of 4.4 maf. When fully implemented this will result in as much as 800 kaf/year of Colorado River water being left in the mainstem system for other uses. The effect of ISC for California will be to provide greater predictability about the availability of surplus through 2015 on a year to year basis. The only real change will be that in years surplus is available to California, it may make up a greater share of the 1.3 maf of Colorado River water in the aqueduct. Because of this there will be no change from historic deliveries of Colorado River water into the southern coastal plain area of California and no growth inducement. Several HCP's are currently being developed in the San Diego County area.

b. Secretarial Implementation Agreements: The implementation of the SIA(s) would allow for a change in point of delivery for up to 400 kaf of Colorado River Water from Imperial Dam up stream to Parker Dam. The availability of this water would result from conservation activities associated with the lining of portions of the All-American (AAC) and Coachella Canals (CC) and from on-farm or delivery system conservation actions in the Imperial Irrigation District (IID) service area associated with the IID/SDCWA Project. The conserved water would be transferred through Metropolitan Water District's (MWD) Colorado River Aqueduct for subsequent use in the coastal plain area of Southern California.

Any indirect effects of the SIAs in California are being evaluated and addressed as effects of project specific evaluations and preparation of HCPs. The IID is preparing a HCP that will address potential effects of the IID/SDCWA Conservation & Transfer Project to endangered species within the IID and the Salton Sea area. The primary effects under evaluation relate to potential effects on listed and other sensitive species because of changes in water quantity and/or quality in agricultural drains and in flows into the Salton Sea. The IID HCP will include conservation measures for incidental take for any of these effects. Any indirect effects associated with movement of water into the Southern California area including the LA basin and San Diego County will also be covered through HCPs in place or being developed in those areas.

Potential effects to endangered species from the lining of the AAC and CC have or are being addressed under project specific ESA compliance for the lining activities. The AAC environmental compliance was completed in 1994 through filing of a FEIS and ROD. This information was reviewed for adequacy in 1999 including evaluation for the southwestern willow flycatcher. No effects were identified during this review. The CC lining DEIS will be filed in September 2000 and will include an evaluation of potential effects to listed species in the project area.

Reclamation's analysis indicates that the water transfers resulting from the canal linings and conservation activities on IID would not result in any growth inducement in the Coastal Plain area of Southern California because no additional Colorado River water will be transported through the CRA because of these actions. Historically, the CRA has transported approximately 1.3 maf of Colorado River water each year into southern California. Implementation of these actions will not change this. The only change is in the source from which the Colorado River water is derived. Historically, the water in the CRA has consisted of some combination of MWD's basic apportionment, water from a conservation agreement with IID, any unused higher priority agricultural water within California, unused apportionment from the States of Arizona or Nevada and surplus water. Under the transfer and lining actions the CRA will continue to transport the same amount of Colorado River water each year, with a greater proportion of that water likely coming from conservation and lining each year that the actions are implemented.

The environmental baseline also includes State, local, and other human activities that are contemporaneous with the consultation in process, while cumulative actions involve future State or private activities, not involving Federal activities, that are reasonably certain to occur in the action area. The various categories of these non-Federal activities are summarized below. A detailed accounting of lower Colorado River water diversions, returns, and consumptive use is provided in the "Calendar Year 1999 Compilation of Records in Accordance with Article V of the Decree of the Supreme Court of the United States in *Arizona v. California* Dated March 9, 1964" (USBR file data, 1999). It is anticipated that these contemporaneous non-Federal actions will continue in the future, and the potential effects of such actions are referenced for each ESA-protected species in Section VI. Additionally, these cumulative actions will be addressed in the MSCP process.

Many non-Federal activities listed, dealing with the direct use of mainstem water and resulting from the diversion of water from the mainstem, have affected or may affect the natural resources of the lower Colorado River and its extended environs. These can be classified as impacts occurring 1) on the mainstem river or its reservoirs, 2) on the river's floodplain, or 3) away from the river and its floodplain primarily due to the long-distance conveyance and use of Colorado River water.

The following is a list of activities that affect or may affect the resources of the lower Colorado River and its extended environs.

Affecting the mainstem river and its reservoirs

- diversion of state entitlement waters

- potential decrease in water quality by:
  - municipal effluent discharge
  - storm water runoff
  - agricultural drainage
  - recreational waste
  - other non-point discharges

- trash accumulation

- increased recreational use:
  - fishing
  - hunting
  - boating
  - swimming

Affecting the river's adjacent floodplain

- agricultural development:
  - land conversion
  - pesticide applications
  - soil erosion/minimum tillage
  - cropping patterns that benefit certain species
  - land fallowing

- municipal and industrial development:
  - land conversion
  - air pollution (dust, automotive and industrial emissions)
  - natural area management

- trash accumulation:
  - solid waste disposal (landfills)

- increased wildfire frequency
  - reduced native riparian habitat/saltcedar expansion

- increased recreational use:
  - hunting
  - camping
  - hiking
  - off-road vehicles

<u>Affecting areas away from the lower Colorado River and its floodplain</u>

- agricultural development:
  - land conversion
  - pesticide applications
  - water pollution (of ground or surface waters)
  - soil erosion/minimum tillage
  - land fallowing
  - air pollution (dust and smoke from burning field residues)
  - cropping patterns benefitting some species
  - water conservation and reuse

- municipal and industrial development:
  - land conversion
  - air pollution (automotive and industrial emissions)
  - water pollution (of ground or surface waters)
  - solid waste disposal (landfills)
  - water conservation and reuse

- increased recreation:
  - resource impacts (off-road vehicles, trampling)
  - management plans
  - developed recreational sites