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Regional Office No.

UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DRAFT

ENVIRONMENTAL ASSESSMENT FOR GLEN CANYON POWERPLANT UPRATING

January 1982

Upper Colorado Regional Office
Salt Lake City, Utah

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I. Need for Action

A. Introduction

The purpose of this environmental assessment is to evaluate the environmental impacts that would occur with the uprating of the generating capacity of Glen Canyon Powerplant. The assessment is prepared in accordance with the National Environmental Policy Act (NEPA) and current Department of the Interior and Bureau of Reclamation guidelines.

B. Background

On April 11, 1956, the Colorado River Storage Project (CRSP) and participating projects were authorized by Public Law 84-485. The purpose of the project, among others, was to enable the comprehensive development of the water resources of the Upper Colorado River Basin, for regulating the flow of the Colorado River, for storing water for beneficial consumptive use making it possible for the States of the Upper Basin to utilize consistently; with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact, and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power. In order to maximize the use of the water and to obtain revenues to assist in the repayment of the irrigation developments, power generating plants were installed at some of the principle storage reservoirs. Generating plants are included on other participating projects where such developments are found to be feasible.

Lake Powell, a principle storage feature of the CRSP, forms behind Glen Canyon Dam and provides nearly 20.9 million acre-feet (MAF) of the 26.2 MAF of storage space above minimum power pool in the reservoir. This space in the reservoir is utilized to store and release water in order to deliver the quantity of water at Lees Ferry, Arizona, required by the Colorado River Compact and to Mexico required by the Mexican Treaty in the manner provided for in the "Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs." The annual scheduled release at Glen Canyon Dam is either the minimum objective release of 8.23 MAF or, if the projected storage in Upper Basin Reservoirs is sufficient to assure delivery of Compact and Treaty requirements at Lees Ferry without impairment of annual consumption uses in the Upper Basin, such greater amount as may be required to maintain the active storage in Lake Powell equal to the active storage in Lake Mead. Within these annual releases and as determined by the Long-Range Operating Criteria, monthly and daily releases are scheduled to meet contractual obligations to firm power customers provided such daily releases are sufficient to assure minimum flows for recreation and fish and wildlife.

In 1975, the Bureau of Reclamation initiated a study to identify, among other items, those existing hydroelectric facilities with potential for increasing power production of existing generators and thereby assist in meeting the Nation's increasing needs for energy. Uprating the generators at the Glen Canyon Powerplant and providing additional capacity were rated very high.

C. Setting

Glen Canyon Dam with Lake Powell is a key feature of the CRSP. It is located 17 miles upstream from Lees Ferry and is near Page, Arizona. The dam has two separate spillways--one on each side of the dam having a combined capacity that approaches 276,000 ft^3/s. The river outlet works near the left abutment of the dam consists of four 96-inch diameter pipes with a combined capacity of 15,000 ft^3/s. At the toe of the dam is Glen Canyon Powerplant consisting of eight generators having a combined capacity of 1,150 megawatts (MW). The turbines provide the driving force to the generators and have an output expressed in electrical units of about 148 MW at the design head of 510 feet and 170 MW when the reservoir is full; however, the generators as installed did not match the turbine capability and were only rated up to 143.75 MW. Maximum water discharge capability through each turbine is about 4,200 ft^3/s; but because of generator limitations, the present maximum discharge is approximately 3,940 ft^3/s. With eight generating units, the maximum plant discharge capability of the turbines would be about 33,600 ft^3/s; however, with generator limitations, the maximum power discharge is 31,500 ft^3/s.

Water releases to the Colorado River below Glen Canyon are normally through the powerplant; however, releases are made as necessary through the outlet tubes and spillways. While bypass of the powerplant is infrequent, a maximum power and bypass release of 55,735 ft^3/s occurred in 1965. In 1980, there was a maximum release of 48,998 ft^3/s.

Water releases at Glen Canyon would be dependent upon a number of factors, including operation for flood control, storage, downstream water demands, power generation, and commitments to recreation, fish, and wildlife. While the powerplant was designed for peaking power operations, a minimum release of 3,000 ft^3/s has been provided during the recreation season, April to September, with 1,000 ft^3/s minimum during the remaining months of a year.

II. Alternatives

A. Introduction

The uprating of the generators at Glen Canyon Powerplant would be primarily taking advantage of a low cost opportunity to provide additional capacity at an existing facility and provide opportunity for increased flexibility in the operation and maintenance of Glen Canyon power facilities.

If the Bureau elects not to proceed with uprating, the following actions could not be accomplished:

1. Correct deficiency in matching the generators' output to the turbines' output.

2. Provide additional capacity for reserves during power system emergencies.

3. Provide additional capacity and energy when power production is reduced while units are out of service for repair or maintenance.

4. Provide an opportunity to correct field pole heating problems and to replace the existing ampledyne voltage regulators.

5. Enable better river regulation to avoid and control spills.

B. Preferred Plan

Since the original turbines at Glen Canyon have capacity that is not presently usable at high-lake elevations, we have analyzed what might be done to utilize the turbine output more fully. The power equipment, other than the generators, has capability in excess of 167 MW. Since the turbines have a maximum capability only slightly greater than 167 MW, it appears the most logical level of uprate is 167 MW per unit. Modification or replacement of equipment that would enable operation beyond present equipment capacity is referred to as an uprating.

Uprating the generators from 143.75 MW to about 167 MW will likely include replacing or reinsulating the field windings, strengthening the rotor arms, and making other minor mechanical modifications, such as changing the fan assembly to increase airflow cooling as shown on Drawing No. 1. The work associated with uprating is planned to coincide with the remaining rewind activity and will probably extend into 1986. The uprating would provide an additional 186 MW and increase plant capacity from 1,150 MW to 1,336 MW. However, since the generator output in megawatts is a function of the turbine output in horsepower, and the turbine output is dependent on head or reservoir elevation, utilization of the increased capacity begins when the reservoir elevation is approximately 3641 feet and above. Figure 1 illustrates the effect reservoir elevation has on turbine output with the corresponding amount of powerplant generation and the rate at which water is discharged from the turbines.

At reservoir elevation 3641 feet, plant generation and turbine discharge presently reach a maximum of 1,150 MW and 31,500 ft^3/s, respectively. As the reservoir elevation rises above 3641 feet, the turbine gates are closed somewhat to limit power output to 1,150 MW. This limiting of the gate openings also reduces the amount of water passing through the turbines. Although the turbines have capacity above elevation 3641 feet, their output is limited to that of the generators.

Uprating the generators from 1,150 MW to 1,336 MW will utilize existing turbine capacity that exists above elevation 3641 feet. At reservoir elevation 3693 feet, plant generation and turbine discharge would increase to 1,336 MW and 33,100 ft^3/s for an increase of 186 MW and 1,600 ft^3/s, respectively, above the existing maximums. It can be seen that below elevation 3641, the uprating will have no effect. Above elevation 3641, the effect of the uprating at various reservoir elevations in ft^3/s is the difference between the 31,500 ft^3/s line and the turbine capability line as represented by the shaded area.

Drawing No. 2 is a cross sectional representation of Glen Canyon Dam and shows the various reservoir elevations and their respective relationships.

The opportunity to operate at higher reservoir levels is not always available and depends on inflow and the amount of carryover storage

Drawing No. I

HYDROELECTRIC GENERATOR

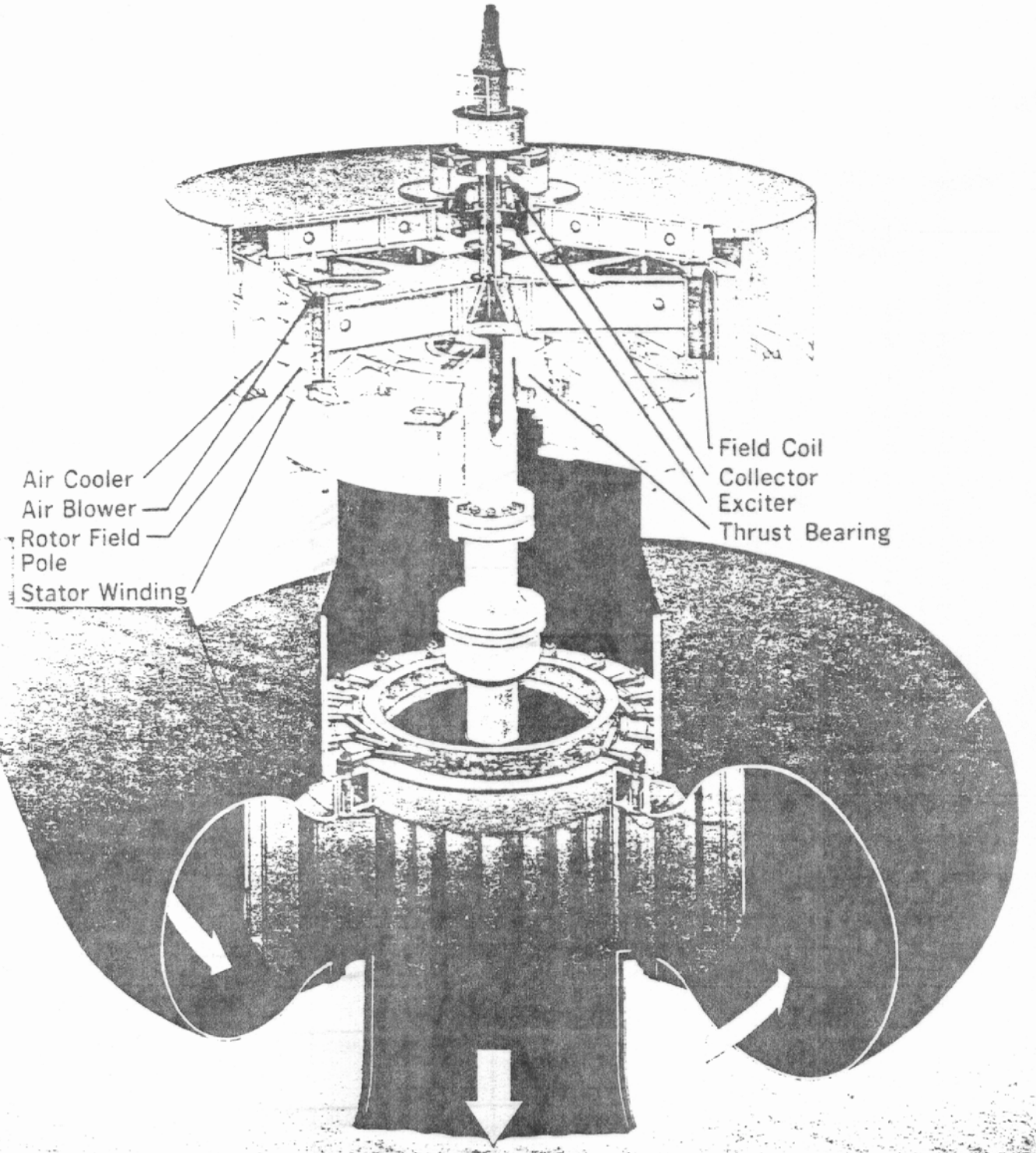
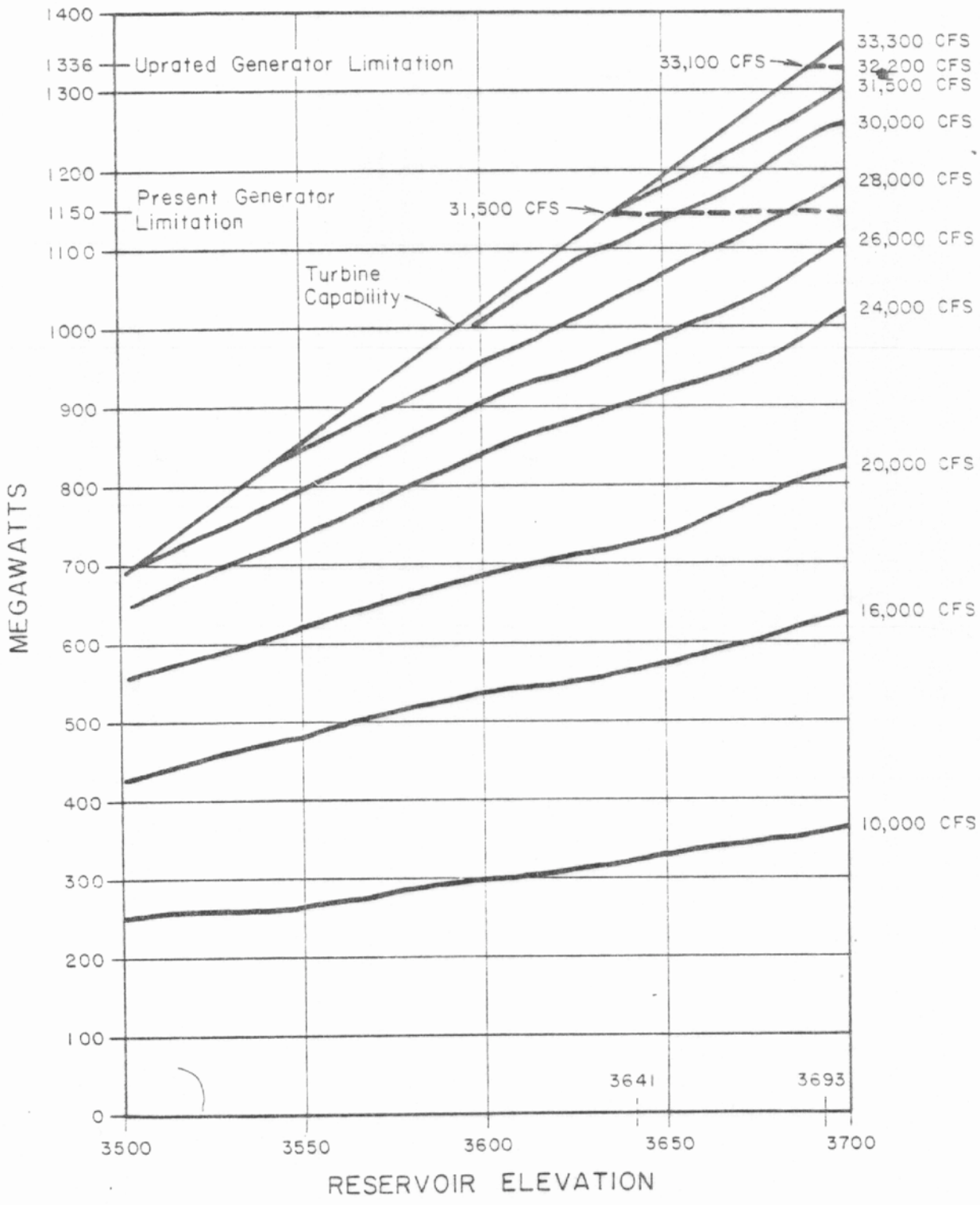


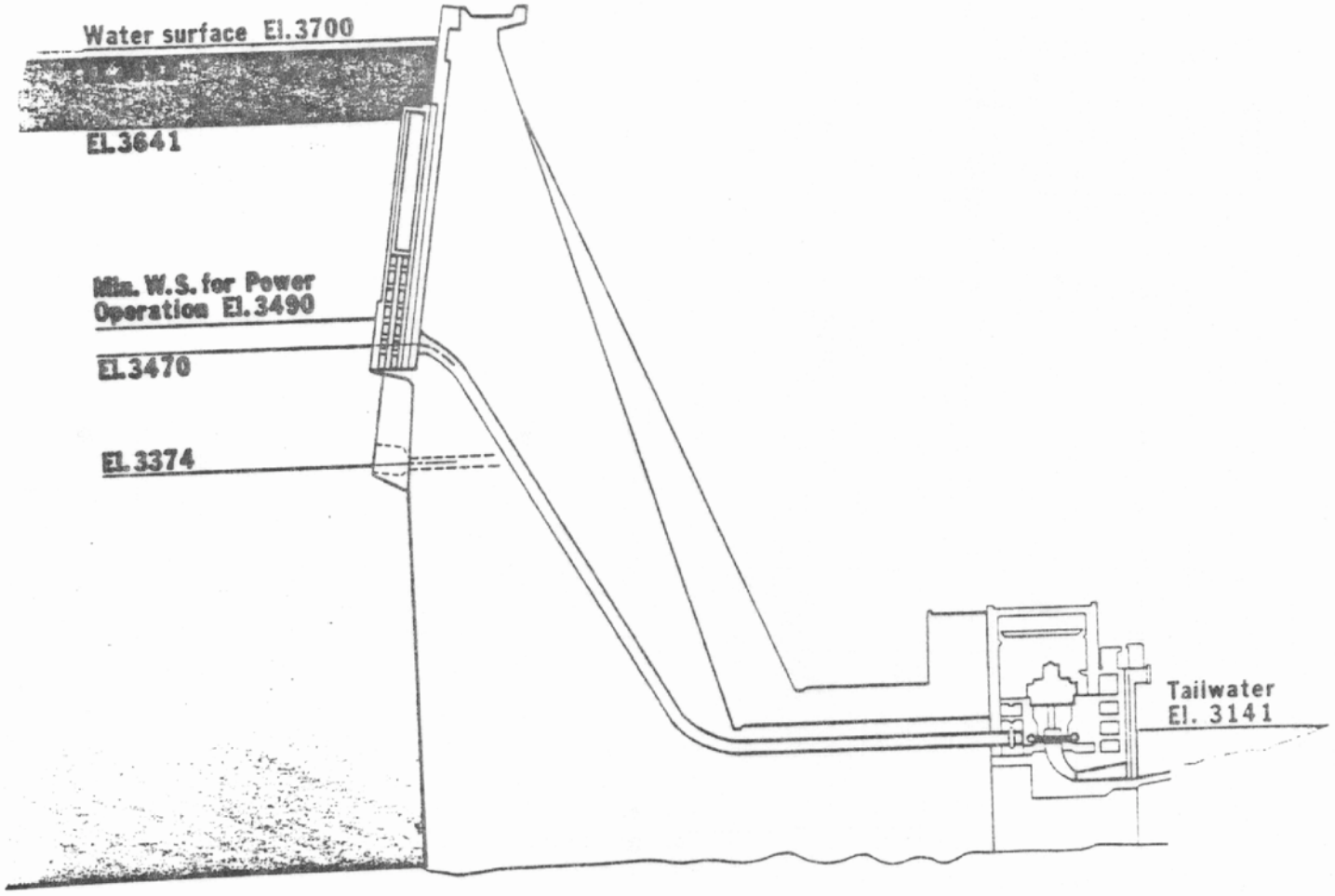
FIGURE 1

GLEN CANYON DAM
POWERPLANT GENERATION AND DISCHARGE



Drawing No. 2

GLEN CANYON DAM AND POWERPLANT
CRSP



from the previous years. Several hydrologic sequences were developed for use in a computer model of the Colorado River System to determine future probabilities of Lake Powell water surface elevations. The results of these studies have been plotted and are shown on Figure 2. The lines of probability show the percent chance of being equal to or less than the indicated elevation at certain years in the future. The declining trend of the probability lines is due to anticipated future development of water resources projects on the Colorado River and the resulting depletion.

The proposed generator upratings would allow higher maximum discharges through the turbines only above elevation 3641. It can by seen from Figure 2 that the future probability of Lake Powell being at or above elevation 3641 feet is more than 95 percent in 1985. By the year 2000, the probability of Lake Powell being at or above elevation 3641 is about 85 percent, and by 2040 it is 60 percent. In other words, there is a significant probability that Lake Powell water surface elevations will be high enough to permit utilization of some portion of the proposed additional capacity at least until the year 2040. At the same time, the frequency of maximum releases occurring at the dam is reduced.

Because of fluctuating lake elevations, utilization of the uprate capacity will not always be possible; however, after taking this into consideration, the benefit-to-cost ratio is estimated to be about 10 to 1.0. The economic advantages of the uprate are also readily apparent when the additional capacity can be developed for $32.00 per kW as compared to $300.00 per kW for the most likely alternative source of capacity, a combustion turbine plant. In addition to the obvious economic advantages and the assistance provided in meeting the Nation's energy needs, the uprating provides additional capacity for reserve during emergency situations and when power production is reduced while generating units are out of service for repair or maintenance. Also, the additional capacity enhances oil savings by exchange of energy with other utilities.

C. Operation

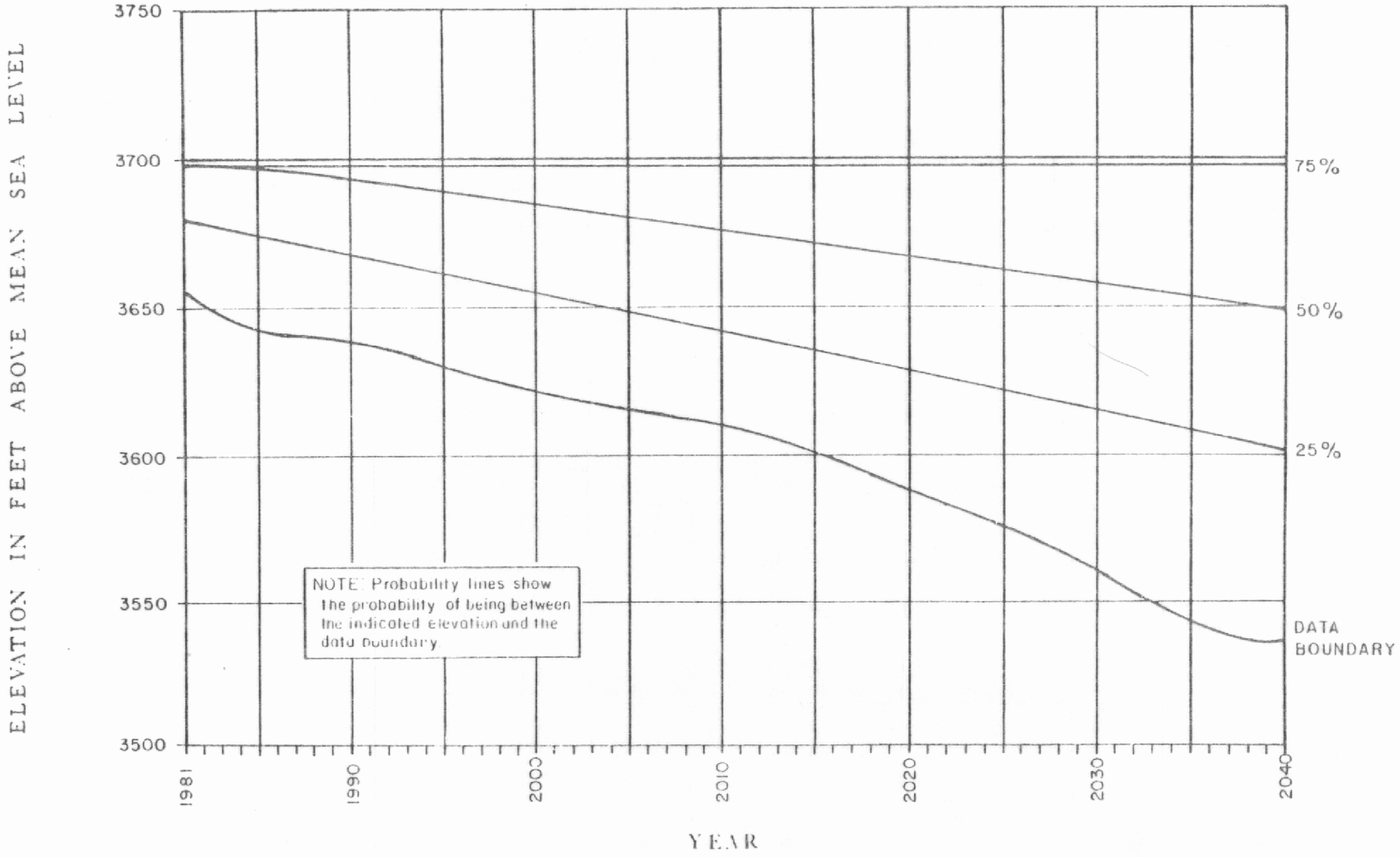
1. Present Operation

The CRSP powerplants are operated as a unit to satisfy power contract obligations. All of the powerplants are included in the dispatch program which develops the best operational pattern for each of the powerplants within the hydrological and power system operational constraints. Hydrological constraints include, but are not limited to, water laws, water rights, compacts, flood control, release criteria for recreation, fish and wildlife, available water supply, and forecast ability of future reservoir inflow. Power system operation constraints include facilities capability, powerplant unit maintenance or emergencies, transmission limits, inadvertent power flow due to adjacent power system operations (or loop flows), power system load, or demand. Power systems reserve requirements (including powerpool requirements) and transmission line outages for maintenance or emergencies including the total interconnected power system, etc.

These hydrological and operational constraints impact where and what generation resources are available, while the amount of generating capacity needed to satisfy power sale contract obligations is affected by

FIGURE 2

PROBABILITIES OF FUTURE LAKE POWELL ELEVATIONS



JUNE 9, 1981

the diversity between the various customer loads as well as climatalogical conditions throughout the five State area (Arizona, New Mexico, Utah, Colorado, and Wyoming). Inadvertent or loop flow has a major effect on the generation patterns at each powerplant because of transmission system power flow loadings. It may be necessary to increase or decrease generation at Glen Canyon or other plants to avoid area blackouts due to overloaded transmission system facilities as a result of loop flow or loss of generating unit or transmission facilities. In the operation of the power system to assure continuity of electric service, capacity is set aside for use in the event a generating unit is lost to the system. To minimize the amount of capacity needed for reserve, power pools are formed among utilities. The CRSP is a member of Inland Power Pool. This pool requires reserve in an aggregate amount by all members of the greater of:

a. Seven percent of the combined electric system load supplied by thermal generation, or 5 percent of the combined electric system load supplied by hydrogeneration for the current clock hour, or

b. The largest single synchronized generating unit, or single transmission circuit on or serving the combined electric power system, plus 1 percent.

The CRSP hourly reserve capacity obligation is in proportion to 25 percent of the total load plus 100 percent of the thermal generation, 71 percent of the hydrogeneration, and varies from hour to hour. Although the reserve requirement is a variable, past performance indicates the reserve is about 70 MW. The operational constraints with and without the Glen Canyon Unit uprates will remain the same.

Except during emergency situations that may occur during drought years, such as 1977, minimum releases will be maintained as in the past during both the recreation and nonrecreation season. Minimum releases during the recreation season, Easter to Labor Day, will normally be maintained at or above 3,000 ft^3/s. These minimum releases will occur mainly on weekends, or on weekdays between the first 8 hours of each day (midnight to 8 a.m. Colorado time). Average weekday releases from 8 a.m. to 12 midnight have been maintained at or above 8,000 ft^3/s. During the nonrecreation season, releases have been maintained at or above 1,000 ft^3/s. The minimum flow criteria will not be changed as a result of uprating the generators.

The annual, monthly, daily, and hourly patterns of power system loads and water releases for generation are the result of the essentially random combinations of the hydrological, climatalogical, and operational factors.

The effects of these factors on the releases from Glen Canyon are illustrated in Table No. 1. The releases are shown in units of thousand (1,000) acre-feet. We would expect similar release patterns to occur in the future as have occurred historically.

TABLE 1

*HISTORICAL RELEASES - GLEN CANYON DAM

WATER YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEPT.	WATER YEAR TOTAL
1970	630	706	814	706	445	486	942	900	800	769	773	701	8,672
1971	498	449	671	492	416	640	1,011	926	894	942	876	776	8,591
1972	675	786	994	840	471	364	793	912	890	871	996	948	9,540
1973	631	671	1,017	1,207	764	1,095	1,678	648	751	656	567	425	10,110
1974	510	412	333	846	299	388	494	804	914	1,226	1,213	826	8,265
1975	602	710	564	768	556	508	459	892	987	1,221	1,022	966	9,255
1976	637	425	520	692	742	676	660	1,046	756	766	720	842	8,482
1977	792	898	810	994	471	458	164	206	466	847	1,178	977	8,261
1978	379	390	823	948	601	579	492	648	758	702	1,065	969	8,354
1979	702	684	913	1,055	767	228	370	540	625	871	1,079	683	8,517
1980	614	807	652	612	626	605	841	831	1,558	1,599	1,266	942	10,953
1981	777	936	765	745	640	463	473	553	527	846	903	667	8,295
1970 1981 Average	621	656	740	825	566	541	698	742	827	943	972	810	8,941
1977 1981 Average	653	743	793	871	621	466	468	555	787	973	1,098	848	8,876

*Units of 1,000 acre-feet.

1982 608 584 838 903 → Projected 750 400 450 500 600 1000 1,100 715 8,400

D. Marketing

All electrical output of the Glen Canyon Powerplant is marketed by the Western Area Power Administration in conjunction with other Colorado River Storage and participating project electrical resources to municipals and the Rural Electrification Administration in the States of Colorado, Wyoming, Utah, New Mexico, Arizona, and part of Nevada. General Power Marketing Criteria for all Colorado River storage and participating projects' electrical resources are presented in Attachment A.

In developing the amount of capacity and energy available to be marketed, compliance with the following "laws of the river" is required:

1. All applicable Federal legislation

2. Inter-State compacts

3. International Treaties

4. Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs

These documents, viewed in combination, comprise the governing authority for storage and release of water from reservoirs in the Colorado River Basin which produce power.

Depending on anticipated future hydrological conditions, the output of all hydro resource is placed under short or long-term contract in accordance with Article 4 of these criteria. Peaking Power (capacity without energy), as would be produced from Glen Canyon Unit uprates, will normally be offered for sale on a season-by-season or monthly basis. Hydrological conditions, however, may support sale over several years. Peaking capacity is offered to and placed under contract with potential customers under the following terms and conditions:

1. Capacity is available with energy up to 50 percent monthly plant factor.

2. All energy delivered with peaking capacity must be returned on or before September 30 each year unless mutually agreed otherwise.

3. Return of energy shall be at rate and amount as agreed between the customer and the United States.

4. The capacity charge is the same rate as set forth in the firm power schedule of $1.655 per kilowatt month.

5. Delivery conditions are set forth in the General Power Marketing Criteria (Attachment A).

Peaking capacity is marketed up to the full rated capacity less the required reserves. Load diversity among CRSP customers more than offset all capacity losses associated with transmission and delivery.

E. Operation with Uprates

Uprating the generators does not provide opportunity to significantly alter the operation of the Glen Canyon Powerplant. Water discharge through the turbines would be the same as historically except for periods when the lake elevation is above elevation 3641. At lake elevation 3641 and above, the turbine discharge, as previously discussed, could be greater than previous peak turbine discharge and reaches maximum at lake elevation 3693 feet for an increase of about 5 percent.

The operational and marketing criteria would be applied the same as in the past.

To illustrate the effects of the power system operation on releases below Glen Canyon, a flow duration curve was prepared as shown in Figure 3. Hourly releases at Glen Canyon Dam were ranked from highest to lowest and then plotted against the percentage of time when that release was equalled or exceeded during an entire water year. This plot is represented by the solid line and uses water year 1979 data. Water year 1979 was selected because the annual release of 8.5 MAF would be representative of a minimum 8.23 MAF water year and, in addition, the lake elevations were such that a maximum release of 31,500 ft^3/s could occur through the turbines. The graph shows that during water year 1979 a release of about 24,000 ft^3/s was equalled or exceeded 10 percent of the time; 10,000 ft^3/s was equalled or exceeded 50 percent of the time; and 2,500 ft^3/s was equalled or exceeded 90 percent of the time. The highest hourly release recorded during the year was 31,570 ft^3/s which occurred on January 29, 1979. The daily hydrograph for this day is shown on Figure 4.

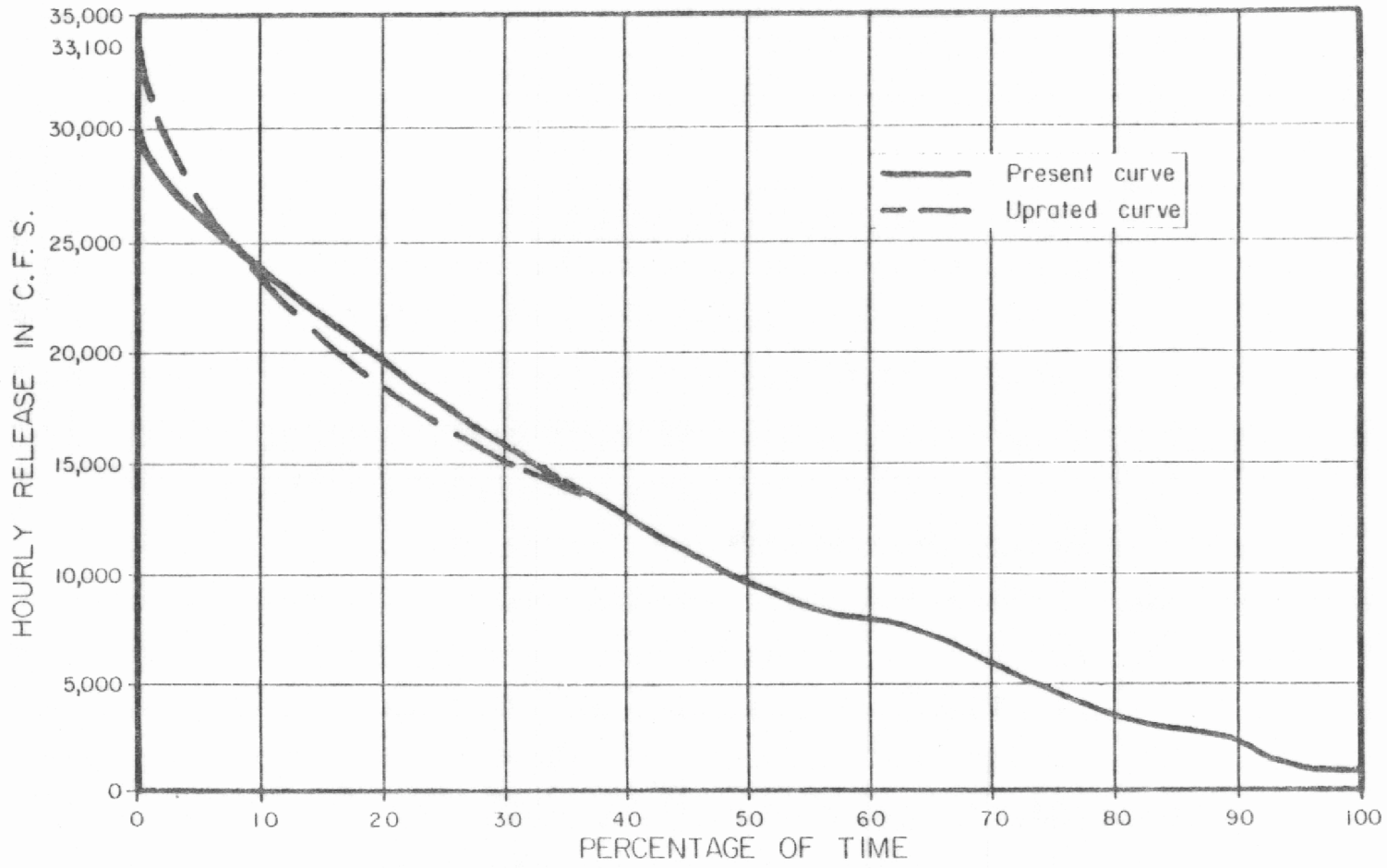
The shape and magnitude of this daily hydrograph is primarily influenced by the customers' firm power load.

As discussed previously, the proposed uprating of the generators at Glen Canyon Powerplant would develop an additional 186 MW of capacity. This capacity would be marketed in accordance with the Western Area Power Administration's (Western) marketing policies as described in the marketing section of this assessment.

The dashed line shown on Figure 3 represents the change in the flow duration curve as a result of the proposed uprating. It was assumed that lake elevations were such that the maximum possible release of 33,100 ft^3/s from uprating the generators could be reached. It can be seen that peak flows would be higher less than 10 percent of the time; that flows less than about 14,000 ft^3/s would not be affected. The assumption made in deriving the curve was that all energy is returned to the system during on-peak hours of off-peak months. This, of course, is an oversimplification because, inevitably, some customers will need to return energy to the system during off-peak hours and thus incur any penalty as imposed by the marketing criteria. This would occur in a very random sequence; however, if flows were at a minimum and the rest of the system could not absorb the return, the exchange would not be permitted as a result of minimum flow or daily average criteria.

FIGURE 3

GLEN CANYON DAM HOURLY RELEASES
DATA FROM WATER YEAR 1979
FLOW DURATION CURVE



III. Environmental Consequences

A. Impacts of Uprating

As a result of the uprating, the flows below the dam could be increased by 1,600 ft^3/s from the present day maximum of 31,500 ft^3/s to a new maximum of 33,100 ft^3/s.

Attachment B displays historic peak releases from Glen Canyon Dam at or above 28,000 ft^3/s. As can be seen on Figures 4 and 5 and Table 2, the peaks have diminished somewhat by the time they reach Lees Ferry. This is due to the daily fluctuation in flow and the physical characteristics of the channel.

Table 2
Comparison of Maximum Flows Recorded at Lees Ferry with Maximum Powerplant Discharges Recorded that same day at Glen Canyon Dam (1975-1980)

Year	Date	Lees Ferry in ft^3/s	Glen Canyon Dam in ft^3/s
1975	May 7	28,400	28,845
1976	May 19	27,100	29,042
1977	Sept. 6	29,000	30,933
	Sept. 7	29,000	30,523
	Sept. 8	29,000	30,387
1978	Jan. 23	28,400	30,879
1979	Jan. 29	28,600	31,571
1980	June 24	44,800	1/48,998

1/ Spillway test.

Higher releases travel faster than lower releases, so they tend to overtake lower flows which result in a dampening of peak releases. The duration of higher releases also influences the amount of dampening effect. As the duration of steady high discharge increases, flow characteristics will approach a steady state. This results in less dampening associated with lengthier peak releases.

The difference between the dam releases and the flow being recorded at Lees Ferry is the reduction in the peak flow. The new releases from the dam would cause an increase in flow at Lees Ferry. This corresponds to a vertical rise in the river of .2 of a foot or approximately 2 inches. Downstream from Lees Ferry, the difference would diminish to zero.

B. Terrestrial

Since 1963, when Glen Canyon Dam diversion gates were closed, significant changes have occurred in the canyons below the dam.

Vegetation resources, along with the dependent fauna, have colonized the previously uninhabitable riparian zone. Significant development of the flora and fauna are continuously occurring.

Figure 4

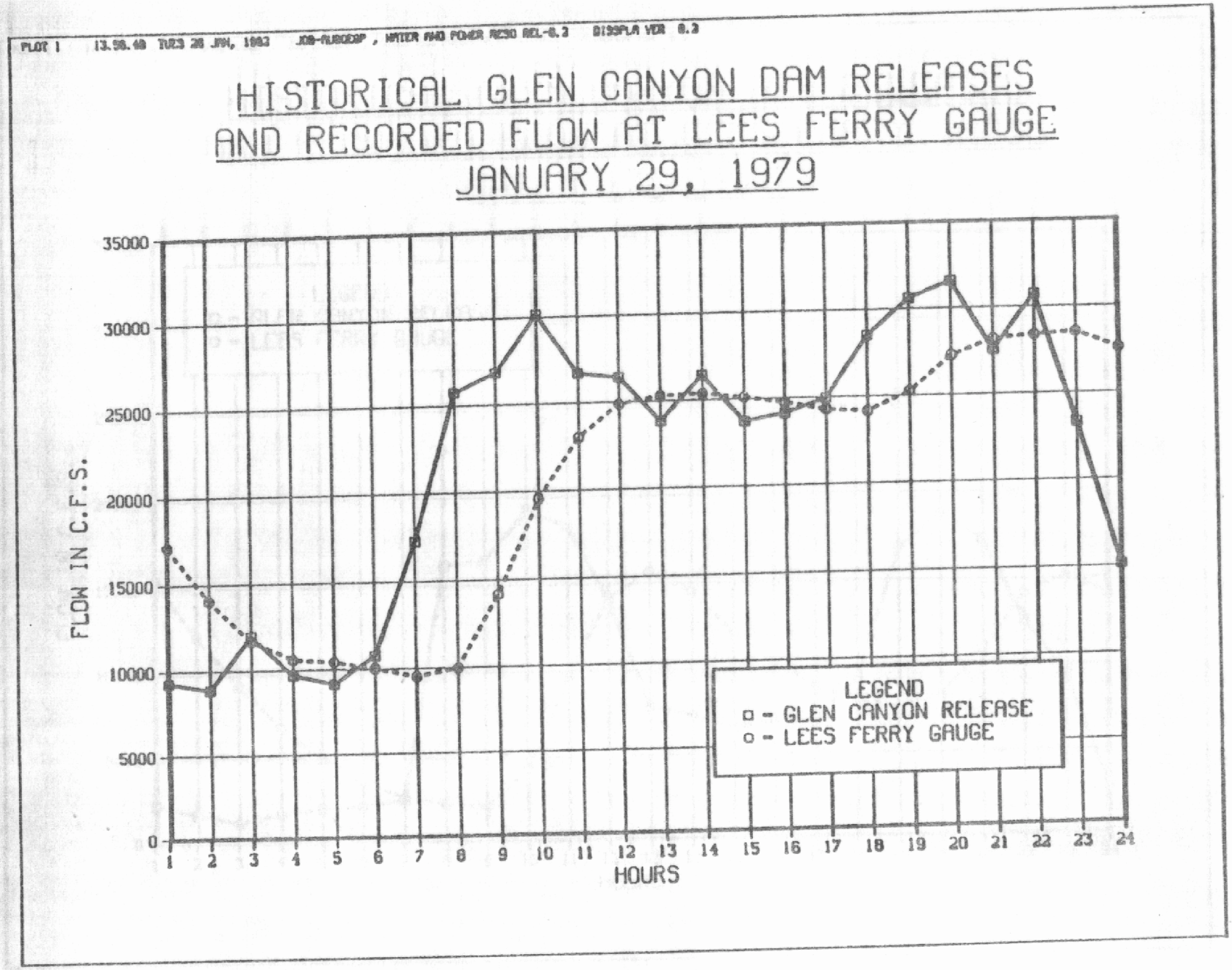
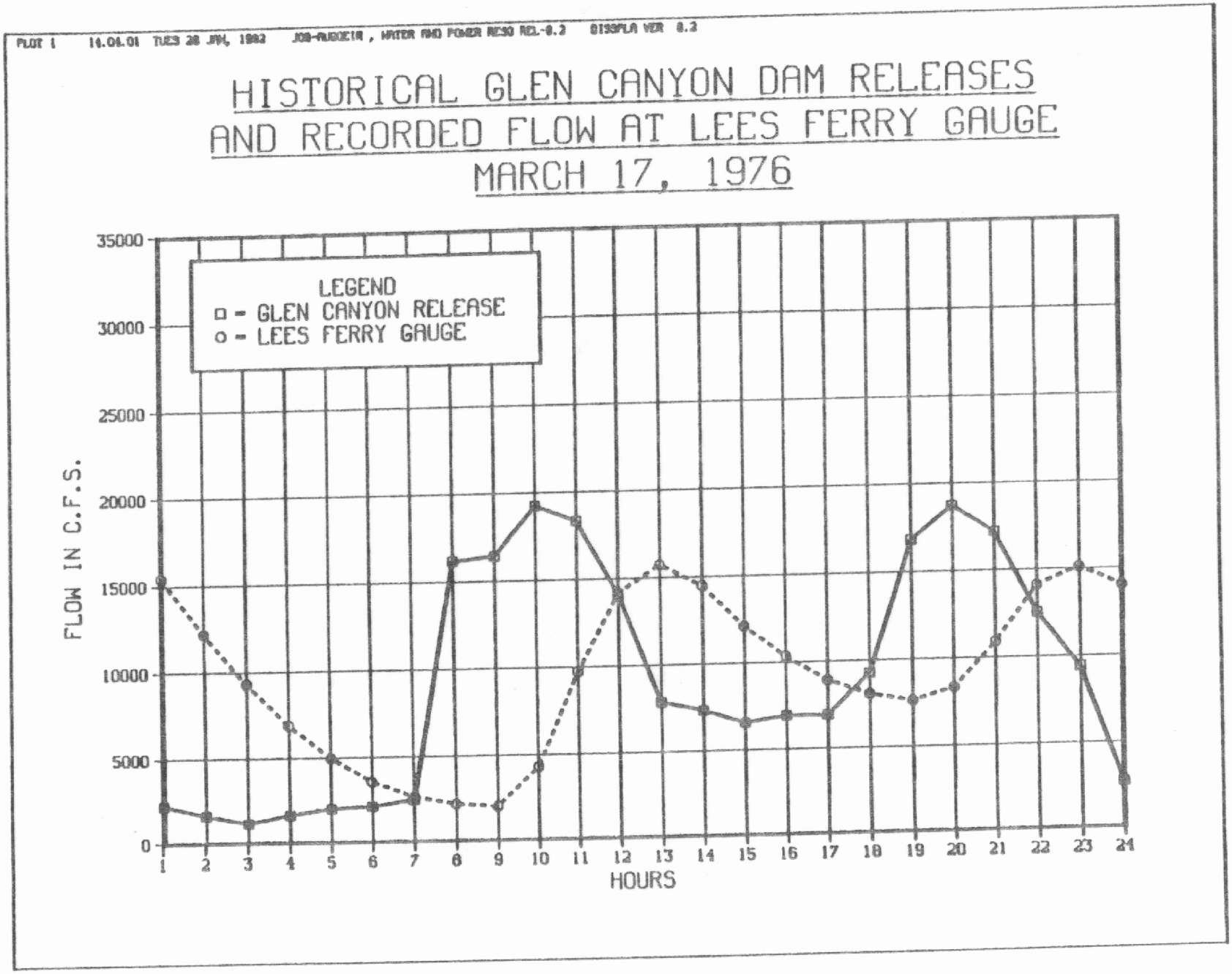

PLOT 1 13.58.48 TUES 26 JUN, 1983 JOB-RUBOOSP , WATER AND POWER RESO REL-8.3 DISSPLA VER 8.3
HISTORICAL GLEN CANYON DAM RELEASES
AND RECORDED FLOW AT LEES FERRY GAUGE
JANUARY 29, 1979
FLOW IN C.F.S.
35000
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOURS
LEGEND
□ - GLEN CANYON RELEASE
○ - LEES FERRY GAUGE

Figure 5


PLOT 1 14.04.01 TUES 28 JAN, 1982 JOB-AUDIENCE , WATER AND POWER RESO REL-8.2 DISSPLA VER 8.2
HISTORICAL GLEN CANYON DAM RELEASES
AND RECORDED FLOW AT LEES FERRY GAUGE
MARCH 17, 1976
LEGEND
□ - GLEN CANYON RELEASE
○ - LEES FERRY GAUGE
FLOW IN C.F.S.
35000
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOURS

The decreased magnitude of the original river characteristics are responsible for these changes; however, even though the river does not resemble its historical character, several features of its power as an erosionary force are evident.

Erosion is presently occurring in Glen Canyon where vertical walls of alluvial deposits from the predam era are periodically sloughed off into the river. Vegetation supported on these deposits follow the sediments into the river and are lost.

Inundation of some vegetative communities, such as bulrush and cattails (Scirpus sp. and Typha sp.), respectively, and in other areas coyote willow (Salix exigua), occurs with the highest releases from the dam.

These conditions are normal features of the dynamics of the Colorado River as it is presently managed.

Wildlife species, including wintering waterfowl, summer resident breeding birds, and the year-long resident populations of small mammals, reptiles, and amphibians, have adapted to these harsh environmental conditions. Their population levels have steadily increased.

Two examples of how a particular species have responded to these conditions are discussed below.

Beaver (Castor canadensis) were restricted to side canyon tributary streams prior to 1963. The spring runoff peak flows of close to 180,000 ft^3/s were too damaging to the shoreline habitats to allow permanant habitation by the species. Following closure of the dam, vertical river fluctuations were sufficiently stabilized to allow a perennial vegetation community to become established and thus supplied a food base. Coyote willow is the major diet component for the beaver in the canyon. In addition to the food base, the spring floods were moderated sufficiently to allow for the colonization of the main river channel.

Bell's vireo (Vireo bellii), a species that is presently under consideration by the U.S. Fish and Wildlife Service for listing on the Threatened and Endangered Species list, now thrives in the riparian community of the Grand Canyon. Habitat for this species, along with seven other species of birds, has been improved by the enhancement of the riparian flora since 1963 when the river flows were moderated. This group of birds makes up 14 percent of the Grand Canyon's breeding bird population (National Park Service FES 79-30).

The proposed increase in maximum release capabilities would result in only minor increase in wetted area downstream (see Figures 6-9). These figures represent the relationship between flow and wetted perimeter (channel width) at selected locations between Lees Ferry and Glen Canyon Dam. Figure 10 describes the location of each cross-section. Since absolute maximum releases are projected to occur for short durations, the effects of this higher flow would rapidly diminish downstream. On the average, approximately 2 feet horizontally of additional terrestrial environment would be inundated; therefore, no significant impact would occur to terrestrial species or their habitat. Similarly, no impact would

Figure 6

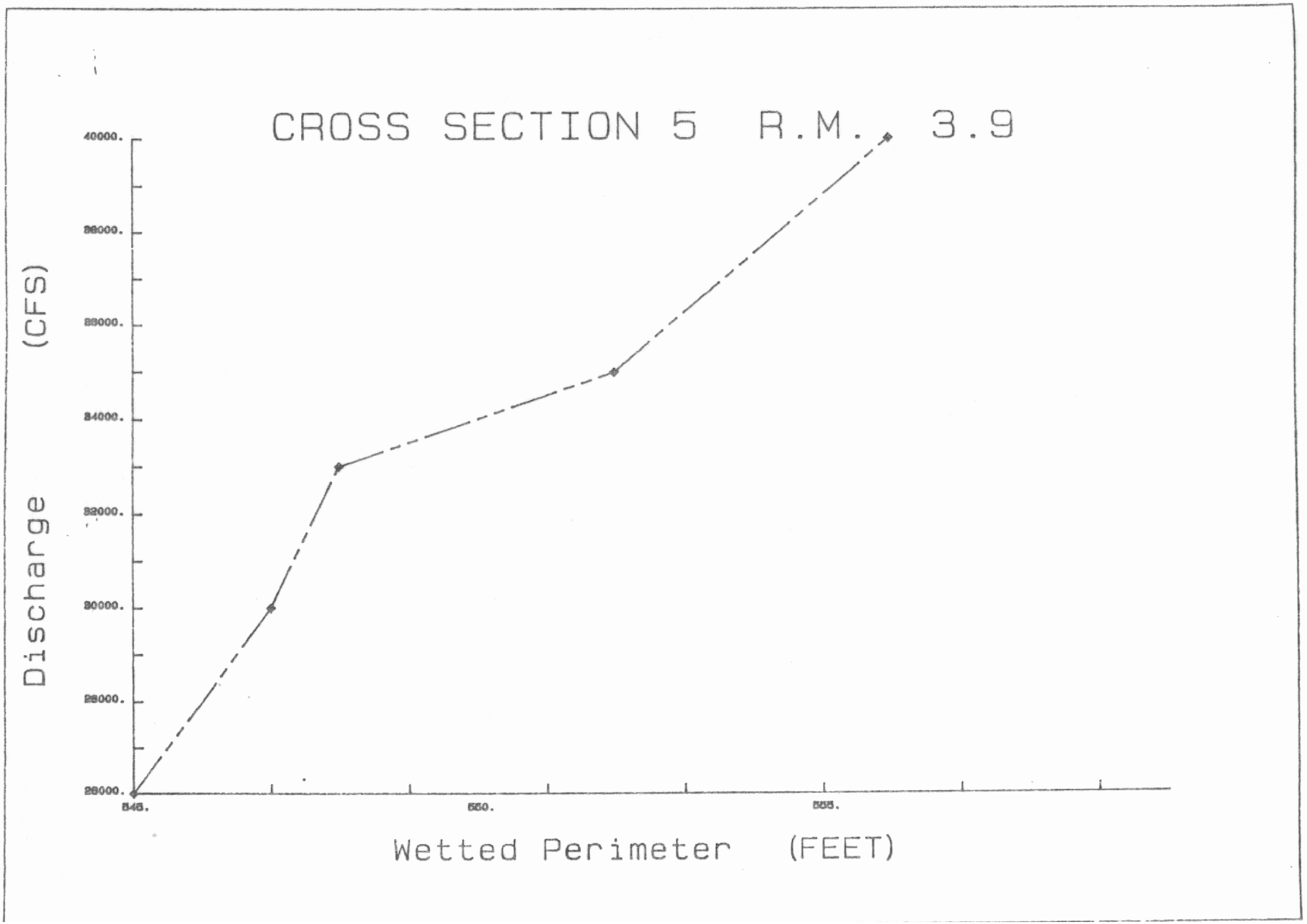

CROSS SECTION 5 R.M., 3.9
Discharge (CFS)
40000.
36000.
32000.
28000.
24000.
545.
550.
555.
Wetted Perimeter (FEET)

Figure 7

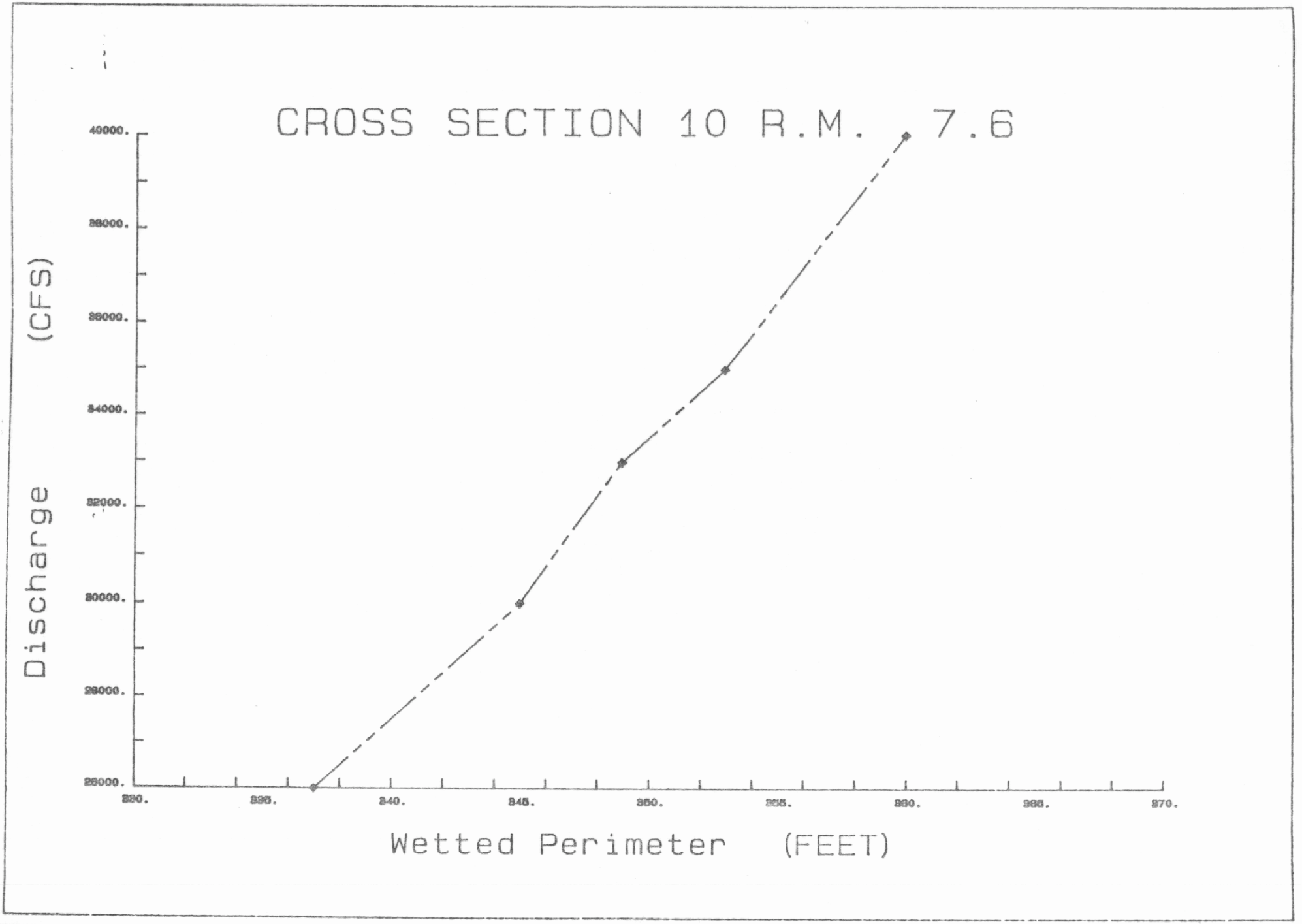

CROSS SECTION 10 R.M. 7.6
Discharge (CFS)
40000.
36000.
32000.
28000.
24000.
20000.
16000.
330.
335.
340.
345.
350.
355.
360.
365.
370.
Wetted Perimeter (FEET)

Figure 8

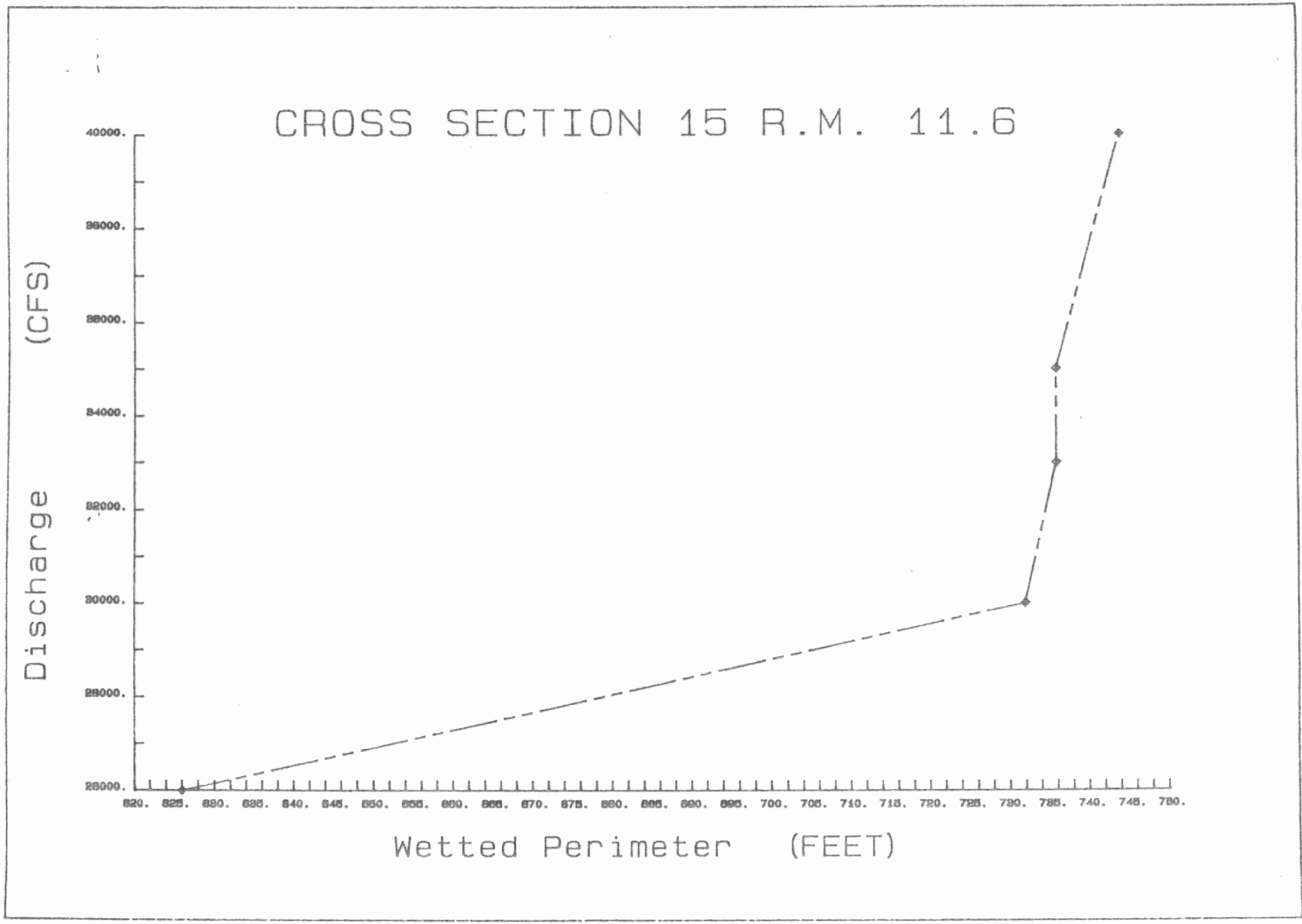
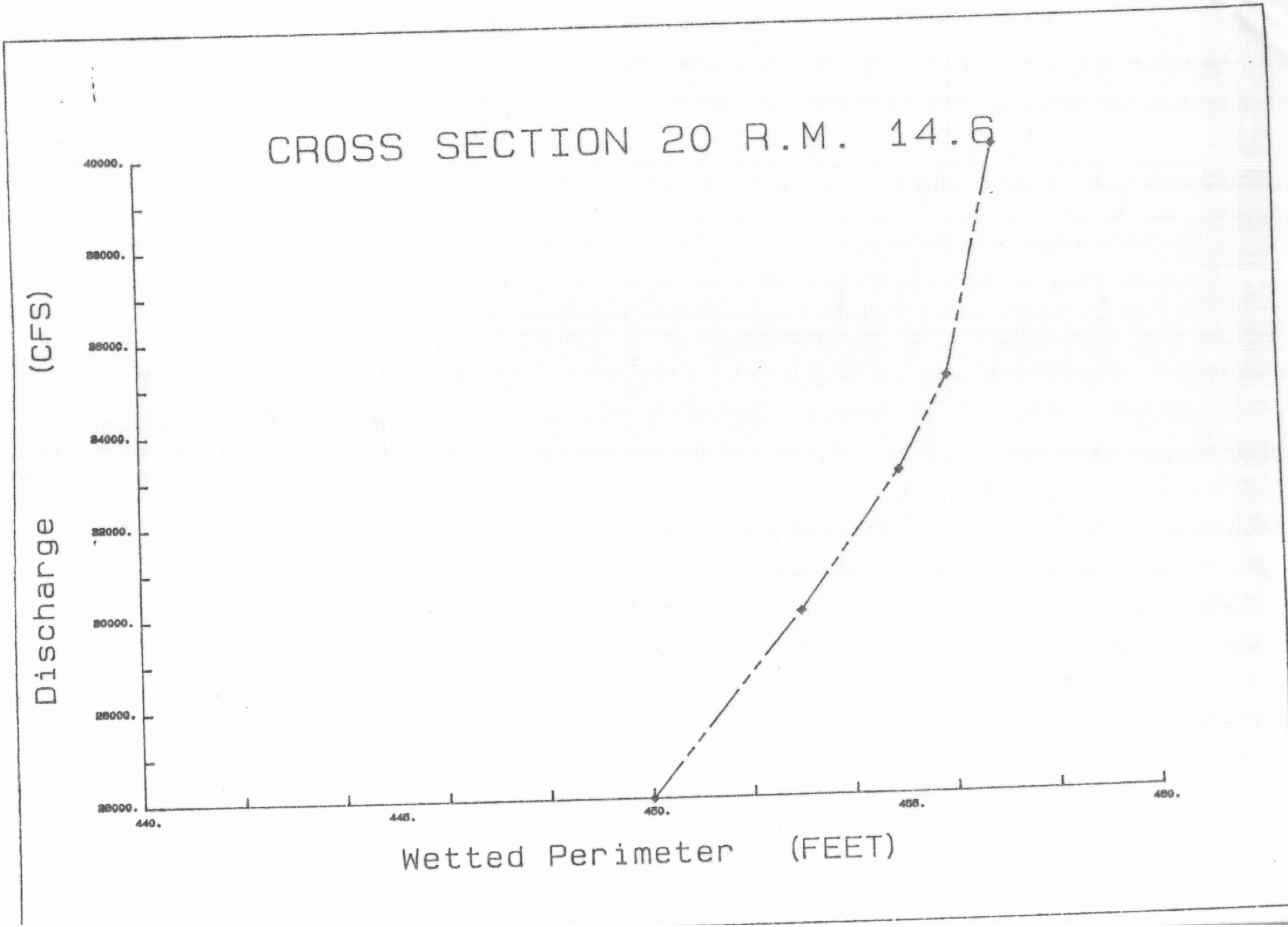
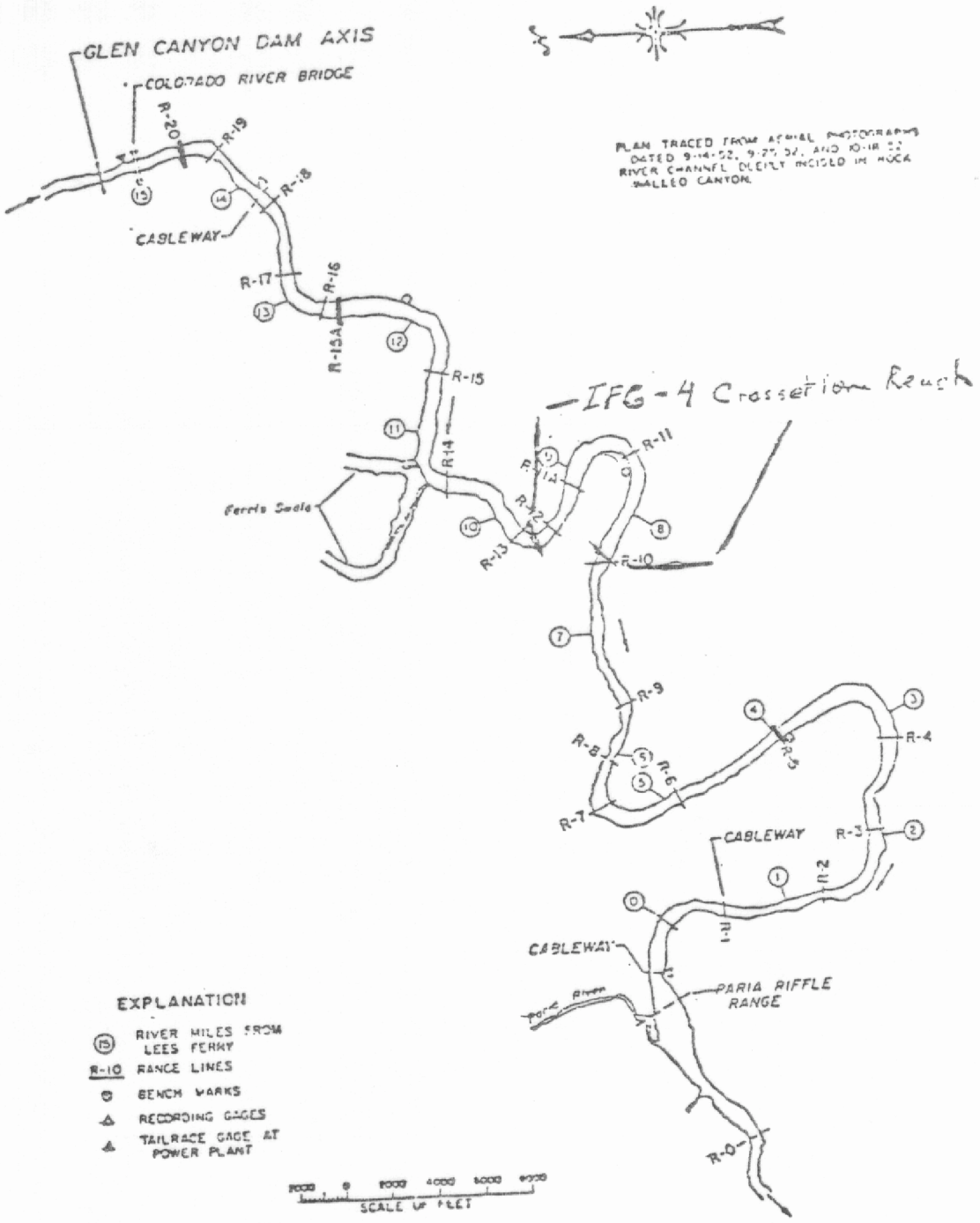

CROSS SECTION 15 R.M. 11.6
Discharge (CFS)
40000.
36000.
32000.
28000.
24000.
820. 825. 830. 835. 840. 845. 850. 855. 860. 865. 870. 875. 880. 885. 890. 895. 700. 705. 710. 715. 720. 725. 730. 735. 740. 745. 750.
Wetted Perimeter (FEET)

Figure 9


CROSS SECTION 20 R.M. 14.6
Discharge (CFS)
40000.
38000.
36000.
34000.
32000.
30000.
28000.
26000.
440.
445.
450.
455.
460.
Wetted Perimeter (FEET)



COLORADO RIVER – ARIZONA
LEES FERRY TO GLEN CANYON DAM AXIS
LOCATION MAP

occur to historical or archaeological resources which are known to occur well away from the area of impact.

C. Aquatic

Aquatic conditions and associated species' habitat have been in a state of continual change since the closure of Glen Canyon Dam in 1963. More specifically, these changes are best reflected in the development of the dam's tailwaters into one of the Southwest's best trout fisheries. Commencing in 1963, the Arizona Game and Fish Department (AGFD) initiated a fish management program for the area by liberally stocking the river with catchable size rainbow trout. Because of limited access for both the AGFD and fishermen, only the first 15 miles of the Colorado River could be effectively managed or fished. Due to the minimal spawning success of the trout, the State continues to stock in order to maintain the fishery.

Initial studies revealed trout growth was limited due to lack of forage. Over the years, clear cold hypolimnectic releases scoured the river channel free from finer sediments. This armoring process stabilized the bottom strata allowing for the attachment and year-round growth of aquatic plants. In an effort to improve trout production, the AGFD experimented with a variety of invertebrate "plants" in an effort to establish a self-sustaining food base. Many of these introductions failed because of their inability to adapt to fluctuating flows. Most notably, two species of invertebrates became established and eventually proved to be extremely important items in trout diets. These two species, a snail (Physa) and a scud (Gamarus lacustris), along with the naturally occurring midge (Chironomidae), are presently the most common occurring trout dietary items. Aquatic plants, mostly the common occurring algae (Cladophora), are also eaten by trout, but are probably taken incidentally.

The development of the fishery to its present-day designation as a "trophy trout fishery" is a direct result of the habitat changes created by the construction and operation of Glen Canyon Dam. Basically, over the last 18 years, three major changes can be identified as having occurred to the fishery. First, catchable rainbow trout plants have been replaced by plants of fingerling trout species. Second, trout growth rates are now far superior to what occurred during the early years of the fishery. Third, although the average weight of the trout now creeled is much larger (Table 3), the catch rate is considerably lower while fishermen pressure has increased. In 1981, the fisherman-day use was about 19,000.

Although some losses to the downstream environment can be associated with the fluctuation flows, such as the stranding mortality of some trout trapped on spawning redds during periods of low flow, trout growth has actually increased during the last several years. The ability of the aquatic habitat to withstand severe flow fluctuations can be attributed to the overall depth of the river. The Colorado River through the Grand Canyon is a series of deep pools, long runs, and short rapids. Some sections of the river are over 100 feet deep. A deep river such as this cuts through a restricted channel and provides protection to the aquatic biota in a number of ways. Deep pools provide refuge for fish species during times of both extreme low and high flows. Sustained low flows at

Table 3

Development of the Lees Ferry Fishery, 1968-1978[1/]

Year	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972	1977-1978
Angler hours	9,766	15,732	11,424	18,952	22,829	11,717	17,563	13,620	16,595	45,878
Angler days	2,477	4,161	2,681	4,430	4,161	3,337	3,808	3,290	3,581	10,395
Trout caught	10,654	13,512	7,757	7,899	6,597	4,082	8,016	8,421	4,372	7,854
Other species	98	985	138	695	2,638	945	57	24	44	
Fish/hour	1.05	.99	.68	.40	.39	.43	.44	.53	.26	.17
Average weight	.31	.72	.54	.70	.68	.58	.65	.61	1.30	1.70
Trout stocked:	125,800	33,500	26,000	22,100	33,800	47,495	38,536	24,725	4,760	97,880
Catchables	115,800	23,500	7,000	7,100	3,800	7,495	4,550	4,725	4,760	
Subcatchables	110,200				10,000	40,000	33,986			
Fingerlings		10,000	19,000	15,000				20,000		97,880

1/ From Arizona Game and Fish records.

or below 4,000 ft^3/s are most harmful to the benthic community, as shown by Figure 11. These low flows expose large portions of river bottom to the air. If exposed for several hours' duration, the periphyton, macrophytes, and associated invertebrates are lost to dessication. These losses to the primary producers and consumers correspondingly have an adverse effect on tertiary consumers (i.e., trout). This loss would be demonstrated as a loss in production such as a reduction in growth rate.

The increased capacity of the uprating would allow for an increase in flow of 1,600 ft^3/s. This increase would come from the high end of the flow pattern as described earlier and would not affect the minimum flows. The water from the reservoir would be coming from the same penstocks that are now drawing water; therefore, there would be no change in the temperature or the chemistry of the water. The habitat simulation models ran on the existing conditions, and the projected increases would result in essentially no change in usable area for fish (See Figure 11). Based upon this information, no significant impact or change is expected to occur to the quality of fishery resources below the dam as a result of the proposed uprate.

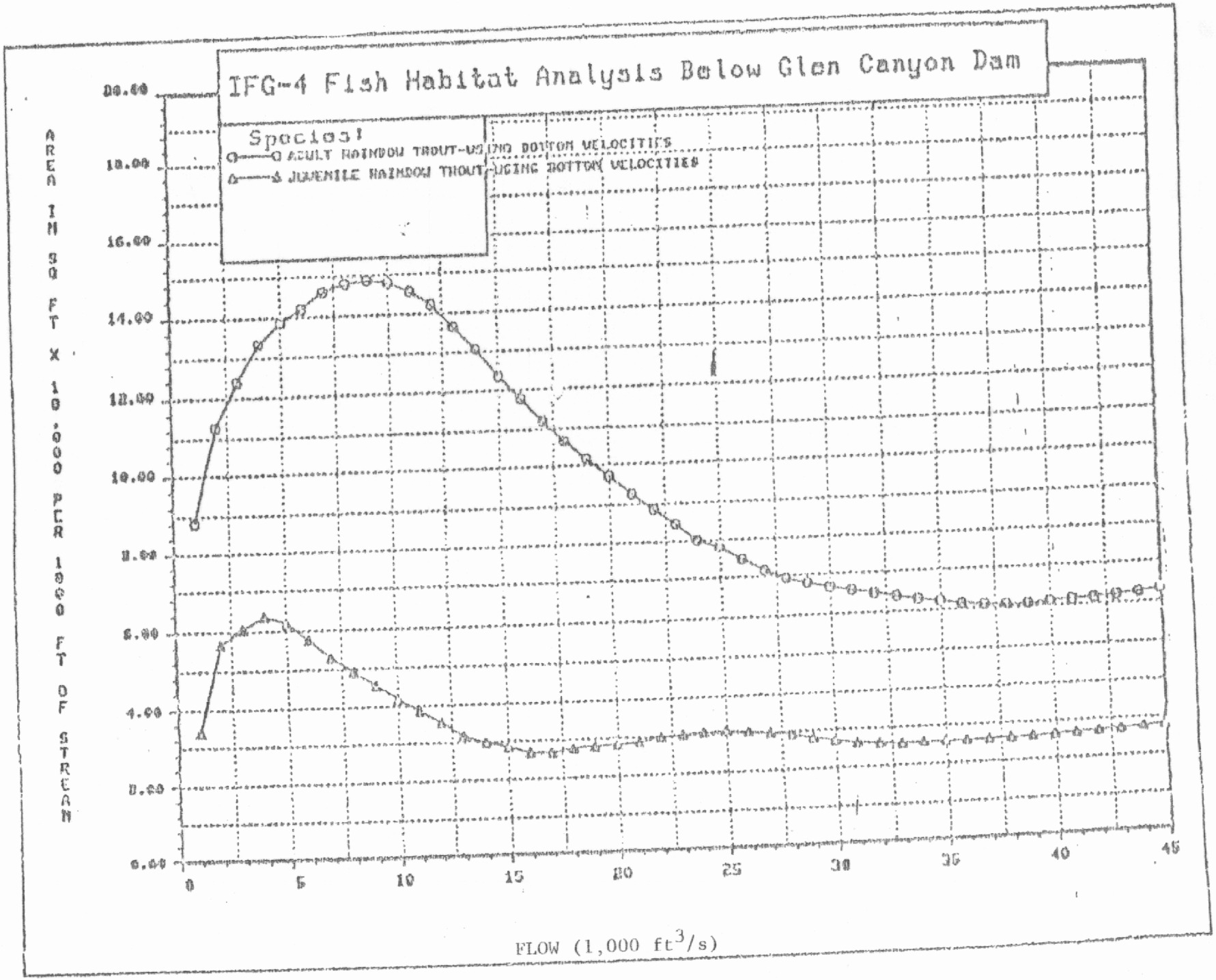
D. Recreation

The area within Glen Canyon National Recreation Area encompasses the Colorado River corridor between Glen Canyon Dam and Lees Ferry--a distance of approximately 15 miles. Trophy trout fishing, boating, camping, hiking, and sightseeing, in addition to a commercially operated 1-day float trip (Fort Lee Day Trips), are the major attractions of the area. River oriented recreation within this area accounted for approximately 24,000 visitor days in 1980 with more than 5,000 of these days occupied by the 1-day commercial float trip. Although the Park Service does not currently limit use within the area, studies are being conducted to determine the relationship between the degree of human use and environmental impact.

The area within Grand Canyon National Park encompasses the Colorado River Corridor between Lees Ferry and the backwaters of Lake Mead--a distance of approximately 240 miles--offering the longest stretch of recreational whitewater in the world. Directly related activities, such as camping, hiking, and sightseeing, also take place on the river within the park. The 1960's and 1970's saw dramatic increases in the participation of recreational rafting within the park. River use for 1972 alone exceeded the 100-year period from 1870 to 1969. The Colorado River Management Plan (CRMP) developed in 1979 currently limits annual rafting use within the Park to 169,950 user days, 115,500 commercial user days, and 54,450 noncommercial user days, which are further proportioned for the summer (May-September) and winter (October-April) seasons. Other use restrictions, such as maximum group sizes, trip lengths, and boat capacities, are fully described in the plan (CRMP, 1981).

The rafters now experience fluctuations in the river that cause several problems, such as scheduling and overnight mooring. There is also a minimum flow of 3,000 ft^3/s from April to September which is maintained by an agreement with the rafting industry.

Figure 11


IFG-4 Fish Habitat Analysis Below Glen Canyon Dam
Species!
ADULT RAINBOW TROUT-USING BOTTOM VELOCITIES
JUVENILE RAINBOW TROUT-USING BOTTOM VELOCITIES
AREA IN SQ FT X 10,000 PER 1000 FT OF STREAM
FLOW (1,000 ft3/s)

The data indicate an average increase in velocity of .16 feet per second at the higher releases. This, coupled with the fact that there would be little change in wetted perimeter as discussed earlier and no change in low flows, means recreation use of the river would not be affected.

E. Endangered Species

Two Federally listed endangered species are presently known to occur downstream of Glen Canyon Dam. These are: the peregrine falcon (Falco peregrinus) and the humpback chub (Gila cypha). Peregrine falcons would not be impacted by the proposed increase in maximum flow. Humpback chubs are known to occur in the Colorado River, but in relatively small numbers. To date, only the Little Colorado River (77 miles downstream of Glen Canyon) provides suitable habitat for the humpback chub to complete its life cycle successfully. Persistent cold water temperatures in the Colorado River inhibit and probably prevent gonadal maturation by humpback chubs. The chubs that exist in the Colorado River are probably immigrants from the Little Colorado River. Aside from the apparent inability of these fish to reproduce successfully, these main river fish have adapted well to this new environment. There is no evidence that these main river fish return to the Little Colorado River once "lost" to the Colorado.

The confluence area between the Little Colorado and Colorado Rivers would be the only area of possible impact related to fluctuating flow. Although some impact to incubating spawn and young-of-the-year fish may presently occur, it is thought not to be significant in terms of adversely affecting the chub population as a whole. Successful natural reproduction by humpback chubs has been confirmed for the first 8 miles upstream from the confluence. Also, chubs have been found to be one of the most common occurring fish species in the Little Colorado River. Comparative aerial photographs of main river flows of approximately 27,000 and 57,000 ft^3/s show essentially no difference in the extent of inundation by the Colorado River; therefore, possible slight increases in maximum flow would not further jeopardize the continued existence of the humpback chub.

F. Floodplain and Wetlands

No floodplain or wetlands encroachment would result from the uprating of the generating capacity of the Glen Canyon Powerplant; therefore, no action under Executive Order 11988 (Floodplain Management) or Executive Order 11990 (Protection of Wetlands) is necessary.

IV. Agencies and Persons Consulted

U.S. Fish and Wildlife Service

National Park Service

Arizona Game and Fish Department