VII - WATER CONTROL PLAN

7-01. General Objectives. The total project plan of improvement consists of two multipurpose reservoirs with downstream channel improvements on both rivers and a diversion channel from the Portugues River to the Bucana River. This total project plan will provide essentially standard project flood protection, a dependable surface water supply for Ponce and surrounding area, and recreation facilities for full public use of the reservoirs. In addition, the project reservoirs will be operated to assist in helping improve downstream sanitary conditions by periodic release of impounded water to provide flow in the Portugues and Bucana downstream river beds. Such flows will curtail mosquito breeding in stagnant pools during the dry season. A description of the Cerrillos Dam and Reservoir is included in Exhibit A.

7-02. Major Constraints. The major limiting factors considered in developing the regulatory release plan include the channel capacity of 2,500 cfs from immediately downstream of dam to the debris basin, downstream channel capacities in the major flood damage centers, local downstream inflow hydrograph lag times, and hydrograph combining effects.

The bankfull capacity of the channel from immediately downstream of the dam to the debris basin is estimated to be 2,500 cfs. The bankfull channel capacity downstream of the dam was verified through controlled releases and monitoring that was conducted 21 March 1997. Depending on estimates of local inflow between the damsite and the debris basin, releases through the regulating outlets will be limited to a maximum of 2,500 cfs except for emergency conditions prescribed in the Emergency Action Plan.

Another constraint concerning dam operation involves discharges and the Vayas low flow crossing which impacts families living on the east side of the river downstream of Cerrillos Dam. During large flows the crossing becomes a channel obstruction forcing a portion of the flow out of natural streambed and down an alternate access road. Community residents should be notified of impending reservoir releases.

The channel capacity monitoring that was conducted 21 March 1997 under controlled conditions confirmed that with flows over 100 cfs the crossing becomes inundated. Additionally, when flows of 500-1000 cfs occur the alternate access road is cut off because the access road elevation is very close to streambed elevation in this area. Also, large flows for several hours will cause the riverbed to shift and cover culverts of the low flow crossing which will require maintenance to uncover the culverts and restore the flows under the crossing.

7-03. Overall Plan for Water Control. The current plan of operation for the Cerrillos Reservoir provides for maintaining a normal pool elevation of 573.0 feet, NGVD. Water stored above elevation 573.0 feet, NGVD encroaches upon the flood control pool. Therefore any water above elevation 573.0 will be released as soon as practicable. Flood control storage space is reserved between elevations 573.0 (top of conservation pool) and 611.3 feet, NGVD (top of flood control pool) with surcharge storage provided above the crest of the uncontrolled emergency spillway (elevation 611.3 feet, NGVD). Releases for flood control are outlined in detail in Section 7-05. Conservation storage between elevations 451.0 and 573.0 feet, NGVD is reserved for water supply and low-flow water quality releases. The project design for water supply allows a continuous maximum withdrawal of 33.9 cfs (21.9 MGD) with a 95 percent dependable yield level. The overall plan for water control will require amendments in the event a hydropower plant is added in the future.

7-04. Standing Operating Instructions to the Damtender. A summary of procedures for the damtender during normal and abnormal operating conditions is found in Exhibit E - "Standing Operating Instructions to Damtender". A minimum regulating outlet gate opening of 6 inches is required to prevent low pressure problems around gate seals. Similarly, a minimum low-flow withdrawal gate opening of 4 inch is required to prevent low pressure problems around the gate seals. All gate openings should follow this minimum requirement. The water supply system may draw from one wetwell at a time, but not both simultaneously. The low-flow system may draw from one wetwell or both simultaneously. Any combination of the water supply and low-flow discharges are permitted within the limits of a maximum flow of 70.0 cfs per wetwell (Source: Design Memorandum No. 11, Feature Design Memorandum - Cerrillos Dam Outlet Works - Volume No. 1 Report - February 1983, Paragraph 2.4.3, Page 2-3).

7-05. Flood Control. The primary objective of the project is to prevent flood damages downstream of the Cerrillos Dam and in the municipality of Ponce. Flood control storage of 15,975 acre-feet between elevations 573.0 and 611.3 feet, NGVD is reserved exclusively for the temporary detention storage of floodwaters. Post flood evacuation of floodwater stored above elevation 573.0 feet, NGVD is to be accomplished as soon as possible by releasing flows that produce non-damaging stages in the downstream reaches of the river.

In the event the flood control storage is exceeded, an additional 12,500 acre-feet of surcharge storage exists above the uncontrolled emergency spillway between elevations 611.3 and 629.4 feet, NGVD.

The objective of flood releases is to provide storage for future control of subsequent floods. In order to avoid the risk of a series of floods whose combined volume could exceed the flood

control storage capacity, it is desirable to release water and evacuate the flood control space as quickly as possible, consistent with downstream runoff conditions and channel capacity. The bankfull capacity of the channel from immediately downstream of the dam to the debris basin is 2,500 cfs. Depending on estimates of local inflow between the damsite and the debris basin, releases through the regulating outlets will be limited to a maximum of 2,500 cfs except for emergency conditions prescribed in the Emergency Action Plan.

Because of the distance from the dam to Ponce and the amount of uncontrolled drainage area between Ponce and the dam, releases from the Cerrillos Dam will sometimes be terminated at the beginning of a storm to prevent discharges from contributing to uncontrolled floodwaters downstream. Therefore, releases should be halted whenever flood control storage is available (elevation is below 611.3 feet, NGVD) and it is forecast that storm runoff may cause damaging flows downstream.

Operational criteria for various flood situations are outlined as follows.

a. Reservoir Elevation below 573.0 feet, NGVD. When the reservoir is below elevation 573.0 feet, NGVD, no flood control releases are required. Discharges could be made for water supply or environmental purposes through the water supply and low-flow withdrawal system. Occasionally, releases may be made through the outlet works to flush the downstream channels to enhance the water quality in the city of Ponce.

b. Reservoir Elevation between 573.0 and 611.3 feet, NGVD. Flood control releases will normally occur when the pool level is above elevation 573.0 feet, NGVD. Post flood evacuation of floodwater stored above elevation 573.0 feet, NGVD is to be accomplished as soon as possible by releasing flows that produce non-damaging stages in the downstream reaches of the river.

c. Reservoir Elevation between Spillway Crest 611.3 and 629.4 feet, NGVD. Whenever the reservoir elevation is between 611.3 (spillway crest) and 613.2 feet, NGVD the uncontrolled spillway will release floodwaters equal to or less than 2,500 cfs (see Emergency Spillway Discharge Rating Curve, Plate A-3). Under these conditions the outlet works may be utilized to augment spillway flows to evacuate flood control space as long as the combined releases will produce non-damaging stages in the downstream reaches of the river.

When the reservoir elevation begins to exceed 613.2 feet, NGVD the outlet works gates shall be closed. The outlet works gates shall remain closed until releases to evacuate the flood control space can be made with non-damaging stages in the downstream reaches of the river.

d. Reservoir Elevation Above 629.4 feet, NGVD. If the reservoir level is expected to exceed elevation 629.4 feet, the outlet works will be fully opened to pass maximum discharge regardless of downstream flow conditions. The gates shall remain completely open until the reservoir has receded below elevation 611.3 feet, NGVD, at which point the regulating outlet shall be operated according to criteria in paragraph 7-05.b., Reservoir Elevation between 573.0 and 611.3 feet, NGVD. See the Operations and Maintenance Manual for operating equipment limitations concerning gate hydraulic pressure system and special instructions.

e. Regulation Assistance. In the event that unusual conditions arise during duty hours, contact can be made by telephone to the Water Management and Meteorology Section, Jacksonville District Office (AC (904) 232-2142 or 232-2914). During non-duty hours, regulation assistance can be achieved by contacting the persons listed at the front of this manual. If contact is not possible, the required release from the reservoir will be made by the damtender in accordance with the flood control operations described above, or if conditions warrant, the "Cerrillos Dam and Reservoir - Emergency Action Plan" published under separate cover. In accordance with the general procedures for computing the emergency drawdown as presented in ER 1110-2-50 dated 22 August 1975, the regulating outlet works would require a drawdown period of 9 days which is well within the limiting period of 4 months.

7-06. Water Supply. Fifty-three percent of the storage capacity behind the dam has been allocated for water supply. The project design for water supply allows a continuous maximum withdrawal of 33.9 cfs (21.9 MGD) with a 95 percent dependable yield level. Water supply releases are made from the dual wetwell, multilevel, low-flow withdrawal system. The system consists of four selective intake gates as shown on Plate 2-4. The water supply system may draw from one wetwell at a time, but not both simultaneously. During a critical dry period, the conservation pool may become completely depleted of water storage. In some situations it may be possible to allocate water in the sediment storage space for water supply. Releases made for environmental purposes downstream will be subtracted from Ponce’s water supply allocation. Drought operations are described in detail in the Drought Contingency Plan included as Exhibit B.

7-07. Water Quality.

a. Reservoir. The annual temperature pattern in the reservoir is expected to vary between moderately to weakly stratified. Temperature stratification in the reservoir will be the dominant factor controlling water quality at the project.

The reservoir is expected to exhibit only rare periods of complete vertical mixing throughout the water column because of

its moderate surface area and great depth. Since most of the intake levels are located near the mid-depth and bottom depth, the upper portion of the reservoir will have a tendency to become isolated and develop multiple thermoclines. These layers will probably have a high organic content contributed by the inflow from August and September rains. With high nutrients and sufficient light, photosynthesis by algae will probably cause algal blooms and drastic dissolved oxygen fluctuations. It is possible that the outflow from the reservoir will become anoxic, especially from May through August. Since the flow in the upper portion of the Cerrillos pool will tend to be isolated, the actual retention time could be greater than the estimated average of 210 days. At high temperatures, the oxygen consumption rate will also be high. Depletion of oxygen in the shaded portion of the epilimnion will cause these layers to become chemically distinct. They could even exhibit a tendency toward becoming anoxic. The oxygen consumption rate in the lower zone of the reservoir (hypolimnion) will also be high because of the warm water temperature and the oxygen demands from both the organic material in the water column and the sediment. Better water quality conditions in the hypolimnion will probably occur from November through February. Transitional water quality would occur in March/April and September/October. However, a Thermal Stratification Study determined that blending of water through the low-flow withdrawal system is not required. Occasionally, releases may be made through the outlet works to flush the downstream channels to enhance the water quality in the city of Ponce.

b. Downstream. There is no water quality storage in the reservoir. However the capability to provide small releases for flushing downstream channels was considered in the design to enhance downstream water quality. The Environmental Impact Statement (EIS) recommended a flow of 5 cfs from the reservoir to eliminate stagnant pools, mosquito larvae, and the resultant health hazard downstream of the dam. The EIS recommended flow is meet by reservoir seepage measured in the toe drain system which has exceeded 5 cfs during the initial filling process. Downstream water quality releases from regulating outlets as well as the low-flow selective withdrawal outlets, made for environmental purposes, will be subtracted from PRASA’s water supply yield.

c. Disease Control. Mosquito-borne diseases should not be a problem in a reservoir stocked with fish. Normal flood control operation, resulting in major pool fluctuations will affect mosquito breeding. However, as flood waters are stored above the clearing line for periods in excess of 2 weeks, an increase in malaria-mosquito production may be expected. At such times, extensive larviciding of inundated wooded areas adjacent to populated areas should be conducted by the Puerto Rico Department of Health. The drawdown to the normal pool elevation following flood events will tend to lessen the mosquito-breeding potential.

During periods when the mosquito population is abnormally large, cyclical fluctuation of the reservoir may be considered to decrease mosquito breeding. This would involve a lake fluctuation of about 1 foot on a weekly or 10-day interval, provided that inflow conditions permit. The drawdown required would have to be fairly rapid, thus stranding the mosquito larvae with restoration of the level occurring gradually, which exposes the larvae to predation. The Puerto Rico Department of Health has found no evidence of Schistosoma mansoni in the Ponce watershed and no cases of Schistosomiasis that originated in the watershed. The following recommendations have been made for the control of Schistosomiasis:

1. The Department of Health of Puerto Rico should initiate a surveillance program and continue to monitor the shore and side slopes of the reservoir, including the surrounding water and land areas for possible infestation.

2. The Department of Natural and Environmental Resources should maintain clean shorelines, devoid of vegetation below the waterline, to the maximum extent possible, and assure periodic fluctuations of the water level.

3. Upon the first indication of the B. glabrata snail, the lake should immediately be stocked with Marisa cornuarieties. This predator eats the eggs, larvae, and adults of the vector snail. It is very inexpensive and should be applied in quantities recommended by the Department of Health. Schistosoma control methods described above will adversely affect sport fisheries. The use of this method should be reevaluated after the lake becomes operational if the lake is not used for recreational swimming.

7-08. Recreation. If Schistosomiasis can be controlled adequately to permit public use of the water, recreational swimming, boating, and fishing will be some of the recreational opportunities in the reservoir. In addition, a 2000 meter long rowing course has been built by the Commonwealth in the Reservoir. This course is used by rowing clubs, the public, and for international rowing competitions. However, no specific operations for recreation are included in the operating plan for the reservoir.

7-09. Fish and Wildlife. The reservoir could produce significant sport and subsistence fishery benefits, although several factors will limit their productivity and use. Because of the reservoirs steep slopes, the eutrophic zone will be a narrow band around the lakes margins and the oxygenated epilimnion may be shallow. The lake levels are expected to fluctuate rapidly over a wide range; therefore, the more commonly known species of noxious aquatic vegetation should not develop into a major problem. The effects on harvestable wildlife from inundation of the project lands will be insignificant since

rabbits, rodents, etc., are the major animal species of wildlife in the project area. Since the Portugues and Bucana Rivers and their tributaries do not support game fish and food fish populations, the reservoir will have to be stocked. No specific reservoir operations are included for the support and enhancement of fish and wildlife.

7-10. Hydropower. Hydropower is not an authorized project purpose. However, a report titled "Cerrillos Dam Hydropower Study at Ponce, Puerto Rico, Reconnaissance Level Study", was completed in May 1980. The report indicated that a small hydroelectric unit of about 500 kilowatts is feasible. The unit would be located in the water supply conduit somewhere downstream of the dam. The contemplated unit would be remotely operated on the water supply discharge and be compatible with the water supply function. The unit would be housed in a small powerhouse at the foot of the dam. The development of hydropower from the Cerrillos Reservoir is the responsibility of the Commonwealth of Puerto Rico and they have elected to defer the construction of the hydropower facilities until a later time. The overall plan for water control will require amendments in the event a hydropower plant is added in the future.

7-11. Deviation From Normal Regulation. The Jacksonville District Engineer is occasionally requested to approve deviations from the normal regulation of the reservoir. Except as discussed below any deviation from the normal flood control procedures must be approved in advance. Deviation requests from DNER shall be submitted to the Jacksonville District Engineer. The deviation request will then be forwarded for approval to the South Atlantic Division. Deviation requests usually fall into the following categories:

a. Emergencies. Some deviations that can arise from emergency conditions include drowning and other accidents, equipment or livestock in downstream channels, failure of critical operation facilities, and flushing of unexpected pollutants. Necessary action under emergency conditions is taken immediately unless such action would create equal or worse conditions. The Jacksonville District Office (SAJ) shall be informed as soon as practicable. A written conformation showing the deviation and conditions will be furnished to SAJ after the incident. SAJ will report these deviations to the South Atlantic Division Office (SAD).

b. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviation from normal regulation of the reservoir, although they are not considered emergencies. Construction accounts for the major portion of the incidents. Change in releases are sometimes necessary for maintenance and inspection. Requests for changes of release rates are generally for a few hours or a few days.

Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes, and possible alternative measures. In the interest of maintaining good public relations, the requests are complied with, providing there are no adverse effects on the overall regulation of the project for the authorized purposes. Approval for these minor deviations will normally be obtained from the Chief, Water Management and Meteorology Section (or his designee), Jacksonville District, by telephone, who in turn will seek approval from SAD. A written confirmation showing the deviation will be furnished to SAD by SAJ after the deviation is complete.

c. Planned Deviations. Each deviation request will be analyzed on its own merits. Sufficient data on flood potential, watershed conditions, reservoir, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be presented by letter, telephone, or facsimile to the Chief, Water Management and Meteorology Section, Jacksonville District, along with recommendations for review and approval. Approval will be obtained from SAD.

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The total project plan of improvement consists of two multipurpose reservoirs with downstream channel improvements on both rivers and a diversion channel from the Portugues River to the Bucana River. This total project plan will provide essentially standard project flood protection, a dependable surface water supply for Ponce and surrounding area, fish and wildlife enhancement, and recreation facilities for full public use of the reservoirs. In addition, the project reservoirs will be operated to assist in helping improve downstream sanitary conditions by periodic release of impounded water to provide flow in the Portugues and Bucana downstream river beds. Such flows will curtail mosquito breeding in stagnant pools during the dry season.

8-02. Flood Control. The primary objective of the project is to prevent flood damages downstream of the Cerrillos Dam and in the municipality of Ponce. Flood control storage of 15,975 acre-feet between elevations 573.0 and 611.3 feet, NGVD is reserved exclusively for the temporary detention storage of floodwaters. Post flood evacuation of floodwater stored above elevation 573.0 feet, NGVD is to be accomplished as soon as possible by releasing flows that produce non-damaging stages in the downstream reaches of the river.

In the event the flood control storage is exceeded, an additional 12,500 acre-feet of surcharge storage exists above the uncontrolled emergency spillway between elevations 611.3 and 629.4 feet, NGVD.

The objective of flood releases is to provide storage for future control of subsequent floods. In order to avoid the risk of a series of floods whose combined volume could exceed the flood control storage capacity, it is desirable to release water and evacuate the flood control space as quickly as possible, consistent with downstream runoff conditions and channel capacity. The bankfull capacity of the channel from immediately downstream of the dam to the debris basin is 2,500 cfs. Depending on estimates of local inflow between the damsite and the debris basin, releases through the regulating outlets will be limited to a maximum of 2,500 cfs except for emergency conditions prescribed in the Emergency Action Plan.

Because of the distance from the dam to Ponce and the amount of uncontrolled drainage area between Ponce and the dam, releases from the Cerrillos Dam will sometimes be terminated at the beginning of a storm to prevent discharges from contributing to uncontrolled floodwaters downstream. Therefore, releases should be halted whenever flood control storage is available (elevation is below 611.3 feet, NGVD) and it is forecast that storm runoff may cause damaging flows downstream.

a. Spillway Design Flood (SDF). Spillway design data is found on Table 8-1. The Spillway Design Flood (SDF) hydrograph for flows into the full flood control pool as shown in Table 8-2 was used in conjunction with the stage-storage curve shown on Plate A-4 and the emergency spillway discharge rating curve shown on Plate A-3, in routings for determining the maximum reservoir level and discharge. The SDF was routed using the following assumptions: (1) reservoir level at the beginning of the flood would be at the top of a full flood control pool, elevation at 611.3 feet, NGVD (emergency spillway crest elevation); (2) outlet works would be inoperative during the flood; and (3) that the spillway would consist of a 394-foot wide uncontrolled emergency spillway with a crest elevation of 611.3 feet, NGVD. The routed maximum reservoir level is at elevation 629.4 feet, NGVD. This elevation plus 5.3 ft of freeboard for wave runup requires a top-of-dam elevation at 634.7 feet, NGVD. The results of the routings are included in Table 8-2. A summary of water surface profiles for the emergency spillway for SDF conditions is shown in Table 8-3.

Table 8-1

Emergency Spillway Pertinent Data

	Elevation (feet, NGVD)
Crest	611.3
SDF water surface in reservoir	629.4
SDF water surface at crest	621.6
Chute dimension (ft.)	
Width	394
Length	338
Chute side slopes	1 on 1
Chute floor slope (percent)	2
Coefficient of roughness (Manning's n)	0.030
Design discharge SDF (cfs)	75,280
Design discharge SPF (cfs)	15,190

Source: Design Memorandum No. 17, Feature Design Memorandum - Cerrillos Dam and Spillway - Volume 1 Report - June 1983, Table 7, Page T-8

b. Standard Project Flood (SPF). Table 8-2 shows the Standard Project Flood (SPF) hydrographs for flows into a full conservation pool and natural flows at the damsite (flows that would have occurred without the dam). These relate to conditions before and after construction of the dam is complete. The SPF hydrograph for flows into the full conservation pool was used in conjunction with the stage-storage curve shown on Plate A-4, and the emergency spillway discharge rating curve shown on Plate A-3, in routings for determining the peak SPF reservoir level and discharge. The SPF was routed using the following assumptions: (1) reservoir level at the beginning of the flood would be at the

top of the conservation pool, elevation 573.0 feet, NGVD; (2) outlet works would be inoperative during the flood; and (3) that the spillway would consist of a 394-foot wide uncontrolled emergency spillway with a crest elevation of 611.3 feet, NGVD. The SPF routed maximum reservoir level is at elevation 617.6 feet, NGVD. It is noted that the SPF design discharge for the spillway is 15,190 cfs so that this flow, combined with local inflows downstream, would not exceed the SPF capacity of the Ponce channels (21,739 cfs). A summary of water surface profiles for the emergency spillway for SPF conditions is shown in Table 8-4.

The frequency of use of the spillway is estimated to have a 0.48 percent chance of exceedence in any year or about a 200-year return period. (Source: Design Memorandum No. 17, Feature Design Memorandum - Cerrillos Dam and Spillway - Volume 1 Report - June 1983, Paragraph 4.5.3, Page 4-4)

c. Other Floods. The regulating outlet works would discharge up to the downstream bankfull capacity of 2,500 cfs during flood events which would raise the reservoir level above the top of the conservation pool elevation of 573.0 feet, NGVD. During the Probable Maximum Flood (PMF), which in this case is the same as the Spillway Design Flood (SDF), the event begins with a full flood control pool (elevation 611.3 feet, NGVD) and the reservoir level rises while discharges are made through the emergency spillway. A peak reservoir level at elevation 629.4 feet, NGVD, would be reached before the pool would begin to recede. A period of about 25 hours would be required for the pool to fall from elevation 629.4 ft. to the spillway crest elevation of 611.3 feet, NGVD and the regulating outlet, discharging at 2,500 cfs with an inflow of 36 cfs (average inflow for period of record), would require 80 hours to draw the pool down from the crest to the top of the conservation pool. Respective time frames for the SPF would be 13 hours for lowering the reservoir level from the peak pool elevation of 617.6 feet, NGVD to the crest; as for the PMF, about 80 hours would be required to draw the pool down from the crest to the top of the conservation pool. Except for flood events that would require discharges to be made through the emergency spillway, releases through the outlet works at Cerrillos Reservoir will be limited to the downstream bankfull capacity of 2,500 cfs.

Table 8-5 shows the 10, 50, and 100-year flow events into a full conservation pool (starting elevation 573.0 feet, NGVD). Natural flow unit hydrographs at the dam site for various storm frequencies were calculated and are included in Table 8-6.

Table 8-2

Standard Project and Spillway Design Flood Hydrographs

Time in 1-hour Periods	Standard Project Flood: Flow into Full Conservation Pool (cfs)	Standard Project Flood: Natural Flow at Damsite (cfs)	Spillway Design Flood: Flow into Full Flood Control Pool (cfs)	Spillway Design Flood: Natural Flow at Damsite (cfs)
1	119	0	507	1
2	608	2	3,305	283
3	2,124	443	9,189	2,656
4	3,492	1,708	13,983	7,599
5	4,366	3,035	21,416	12,435
6	5,061	4,024	35,332	19,375
7	5,467	4,789	62,565	31,613
8	5,784	5,284	90,868	55,540
9	6,378	5,649	78,062	81,641
10	7,310	6,196	51,316	78,306
11	8,567	7,027	35,079	57,913
12	11,339	8,200	24,804	40,741
13	15,530	10,607	18,859	28,751
14	20,484	14,339	16,316	21,294
15	33,062	19,047	14,970	17,524
16	47,390	29,924	13,361	15,559
17	40,282	42,810	12,145	13,870
18	24,361	40,544	11,014	12,546
19	13,526	28,250	9,701	11,362
20	9,010	17,203	8,753	10,090
21	6,774	11,067	8,123	9,068
22	4,490	7,783	7,632	8,340
23	3,376	5,269	7,185	7,792
24	2,961	3,826	6,634	7,314
25	2,182	3,153	4,920	6,781
26	803	2,390	1,802	5,316
27	183	1,191	409	2,668
28	37	437	83	981
29	9	138	20	310
30	4	40	9	91
31	1	12	3	26
32	0	3	0	7
33	0	1	0	2
(cfs)	285,080	284,391	568,365	567,795
(AF)	23,560	23,503	46,972	46,925

Source: Design Memorandum No. 1, Cerrillos Dam Reservoir and Bucana Channel Debris Basin Sedimentation Study and Hydrologic Update - Supplement No. 1 - June 1980, Table 8, Page 9

Table 8-3

Emergency Spillway
Water Surface Profile Data for SDF Discharge

Distance From Crest (ft.)	Floor Elev. (ft., NGVD)	Energy Gradient Elevation (ft., NGVD)	Depth (ft.)	Water Surface Elevation (ft., NGVD)	Average Velocity (fps)
0.0	611.3	626.7	10.3	621.6	18.1
8.0	611.1	626.6	9.8	620.9	19.0
18.0	610.9	626.4	9.5	620.4	19.7
38.0	610.5	626.2	9.1	619.6	20.6
58.0	610.1	626.0	8.8	618.9	21.3
78.0	609.7	625.7	8.6	618.3	21.8
98.0	609.3	625.4	8.4	617.8	22.2
118.0	608.9	625.2	8.3	617.2	22.6
138.0	608.5	624.9	8.2	616.7	22.9
158.0	608.1	624.6	8.1	616.2	23.2
178.0	607.7	624.3	8.0	615.7	23.4
198.0	607.3	624.0	7.9	615.3	23.6
218.0	606.9	623.6	7.9	614.8	23.8
258.0	606.1	623.0	7.8	613.9	24.2
298.0	605.3	622.3	7.7	613.0	24.4
338.0	604.5	621.6	7.6	612.1	24.7

Table 8-4

Emergency Spillway
Water Surface Profile Data for SPF Discharge

Distance From Crest (ft.)	Floor Elev. (ft., NGVD)	Energy Gradient Elevation (ft., NGVD)	Depth (ft.)	Water Surface Elevation (ft., NGVD)	Average Velocity (fps)
0.0	611.3	616.7	3.6	614.9	10.7
8.0	611.1	616.5	3.3	614.4	11.7
18.0	610.9	616.4	3.1	614.1	12.2
38.0	610.5	616.1	3.0	613.5	12.8
58.0	610.1	615.7	2.9	613.1	13.1
78.0	609.7	615.4	2.9	612.6	13.3
98.0	609.3	615.0	2.8	612.2	13.5
118.0	608.9	614.6	2.8	611.8	13.6
138.0	608.5	614.2	2.8	611.4	13.6
338.0	604.5	610.3	2.8	607.3	13.7

Source: Design Memorandum No. 17, Feature Design Memorandum - Cerrillos Dam and Spillway - Volume 1 Report - June 1983, Table 7, Page T-8 through T-9.

Table 8-5

Cerrillos Dam
10-, 50- and 100-Year Flow into Full Conservation Pool

Time in 1-hour Periods		10-Year Flood (cfs)	50-Year Flood (cfs)	100-Year Flood (cfs)
1		36	48	58
2		39	48	58
3		42	48	111
4		42	52	430
5		42	52	991
6		42	58	1,278
7		61	265	1,579
8		71	871	2,119
9		74	1,435	2,480
10		160	1,929	2,924
11		475	2,563	3,559
12		927	3,255	4,351
13		1,629	4,630	5,577
14		2,871	6,736	7,496
15		4,622	8,825	10,598
16		13,130	19,563	22,759
17		22,223	31,122	35,155
18		13,054	18,959	22,149
19		5,501	8,402	11,062
20		1,669	3,199	4,857
21		405	1,458	2,558
22		137	1,029	1,811
23		76	804	1,577
24		45	664	1,510
25		2	454	1,152
26		0	166	427
27		0	38	97
28		0	8	19
29		0	2	5
30		0	1	2
31		0	0	1
32		0	0	0
	(cfs)	67,375	116,684	148,750
		or	or	or
	(AF)	5,568	9,643	12,293

Source: Design Memorandum No. 1, Cerrillos Dam Reservoir and Bucana Channel Debris Basin Sedimentation Study and Hydrologic Update - Supplement No. 1 - June 1980, Table 7, Page 8

Table 8-6

Cerrillos Dam Inflows - Natural Flood Hydrographs

Time in 1-hour Periods	2-Year Flood (cfs)	5-Year Flood (cfs)	10-Year Flood (cfs)	50-Year Flood (cfs)	100-Year Flood (cfs)	Standard Project Flood (cfs)
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	443
4	0	0	0	0	49	1,708
5	0	0	0	0	330	3,035
6	0	0	0	0	812	4,024
7	0	0	0	1	1,144	4,789
8	0	0	0	173	1,464	5,284
9	0	0	0	674	1,943	5,649
10	0	0	0	1,216	2,333	6,196
11	0	0	76	1,729	2,770	7,027
12	0	0	334	2,331	3,353	8,200
13	0	0	738	3,008	4,103	10,607
14	0	0	1,375	4,230	5,213	14,339
15	0	55	2,474	6,102	6,957	19,047
16	11	560	4,088	8,176	9,751	29,924
17	2,390	5,975	11,157	17,113	19,946	42,810
18	5,507	12,353	19,101	27,195	30,906	40,544
19	3,627	8,484	14,378	20,787	24,123	28,250
20	1,457	3,575	7,658	11,440	14,264	17,203
21	477	363	3,147	5,257	7,219	11,067
22	142	106	1,064	2,395	3,721	7,783
23	41	31	326	1,325	2,259	5,269
24	12	9	96	889	1,719	3,826
25	4	0	28	686	1,542	3,153
26	0	0	5	502	1,228	2,390
27	0	0	1	248	623	1,191
28	0	0	0	91	230	437
29				28	73	138
30				8	21	40
31				2	6	12
32				1	2	3
33				0	0	1
(cfs)	13,668	32,713	66,046	115,607	148,104	284,391
(AF)	1,130	2,704	5,458	9,554	12,240	23,500

Source: Design Memorandum No. 17, Feature Design Memorandum - Cerrillos Dam and Spillway, Volume 1 Report - June 1983, Table 2, Page T-3

8-03. Recreation. Since provision of recreational opportunities is one of the project purposes, the Corps of Engineers has taken precautions to preserve recreational areas from overclearing of desirable vegetative cover. Upon completion of initial filling, the recreational facilities will be developed in accordance with the Cerrillos Lake Master Plan for Recreation. If Schistosomiasis can be controlled adequately to permit public use of the water, recreational swimming, boating, and fishing will be some of the recreational opportunities in the reservoir. There are five recreation sites which will be developed around the reservoir. However, no specific operations for recreation are included in the operating plan for the reservoir.

8-04. Water Quality.

a. Reservoir. The annual temperature pattern in the reservoir is expected to vary between moderately to weakly stratified. Temperature stratification in the reservoir will be the dominant factor controlling water quality at the project. The reservoir is expected to exhibit only rare periods of complete vertical mixing throughout the water column because of its moderate surface area and great depth. Since most of the intake levels are located near the mid-depth and bottom depth, the upper portion of the reservoir will have a tendency to become isolated and develop multiple thermoclines. These layers will probably have a high organic content contributed by the inflow from August and September rains. With high nutrients and sufficient light, photosynthesis by algae will probably cause algal blooms and drastic dissolved oxygen fluctuations. It is possible that the outflow from the reservoir will become anoxic, especially from May through August. Since the flow in the upper portion of the Cerrillos pool will tend to be isolated, the actual retention time could be greater than the estimated average of 210 days. At high temperatures, the oxygen consumption rate will also be high. Depletion of oxygen in the shaded portion of the epilimnion will cause these layers to become chemically distinct. They could even exhibit a tendency toward becoming anoxic. The oxygen consumption rate in the lower zone of the reservoir (hypolimnion) will also be high because of the warm water temperature and the oxygen demands from both the organic material in the water column and the sediment. Better water quality conditions in the hypolimnion will probably occur from November through February. Transitional water quality would occur in March/April and September/October. A Thermal Stratification Study determined that the selective withdrawal system was shown to be effective in meeting release temperature objectives. However, the only area that would be affected by temperatures different than existing flows is a reach of the Cerrillos River extending from the dam to the debris basin. This reach is undeveloped and contains no fisheries, etc., that require temperature control for closely matching the temperature of existing flows. Therefore it was determined that temperature control (mixing water) for low-flow releases from the reservoir

are not required. The chemical and biological aspects of water quality were not considered in this thermal simulation study.

b. Downstream. There is no water quality storage in the reservoir. However the capability to provide small releases for flushing downstream channels was considered in the design to enhance downstream water quality. The Environmental Impact Statement (EIS) recommended a flow of 5 cfs from the reservoir to eliminate stagnant pools, mosquito larvae, and the resultant health hazard downstream of the dam. The EIS recommended flow is meet by reservoir seepage measured in the toe drain system which has exceeded 5 cfs during the initial filling process. Downstream water quality releases from regulating outlets as well as the low-flow selective withdrawal outlets, made for environmental purposes, will be subtracted from PRASA's water supply yield.

Water quality data collected by the USGS at a station just below the Cerrillos dam site has shown extreme variations in total and fecal coliform counts. For example, during a one-year period in 1981, fecal coliforms counts at this station ranged from 120 coliforms per 100 milliliters to 18,000 coliforms per 100 ml. The mean yearly average at this station for fecal coliforms is 1,486 coliforms per 100 ml, which is well above the maximum level 400 coliforms per 100 ml recommended by the 1976 Environmental Protection Agency criteria for recreational fresh waters. These data are considered to reflect ambient or existing conditions in the watershed prior to dam construction. Land acquisition for project purposes and relocation of residences, commercial and industrial operations and the accompanying infrastructure have removed significant percentage of pollution point sources and should result in positive effects on water quality in the Cerrillos Reservoir and river.

8-05. Fish and Wildlife. Lake Cerrillos is in the subtropical moist forest zone of Puerto Rico and the surrounding hillsides are heavily forested. More accessible land in the project area has been cleared for pasturage and planting. Wildlife is not abundant, limited to some small non-native mammals, a few species of snakes, and a variety of birds. The upper reaches of the Cerrillos River support limited fish populations. Prior to initial filling about 700 acres at the dam and reservoir site were cleared of vegetation in accordance with the methods and specifications contained in Design Memorandum 18, Cerrillos Reservoir, Portuguese and Bucana Project. The clearing and initial filling will result in no important losses of terrestrial vegetation and only temporary and minimal disturbance to wildlife. No critical habitat will be affected. Because of the reservoir's steep slopes, the eutrophic zone will be a narrow band around the lake's margin and the oxygenated epilimnion may be shallow. The expected rapid fluctuation of the lake levels should prevent the development of noxious aquatic vegetation.

The main impact of the initial filling on project area flora and fauna will be to convert about 700 acres of terrestrial habitat to aquatic habitat suitable for use and colonization by a variety of waterfowl and shore birds, as well as fish and other aquatic species. Since the Cerrillos River and its tributaries support a limited fishery, the Puerto Rico Department of Agriculture is considering stocking the lake with a variety of game fish after completion of the initial filling.

Storage of 700 acre-feet has been allocated to insure water for aquatic life during drought periods.

8-06. Water Supply. The Cerrillos Reservoir will give the city of Ponce a dependable supply of water. Fifty-three percent of the storage capacity behind the dam has been allocated for water supply. The project design for water supply allows a continuous maximum withdrawal of 33.9 cfs (21.9 MGD) with a 95 percent dependable yield level. These releases will be made from the dual wetwell, multilevel, low-flow withdrawal system. Releases made for environmental purposes downstream will be subtracted from Ponce's water supply allocation.

The Cerrillos Reservoir has a conservation pool located between elevations 451.0 and 573.0 feet, NGVD, with a storage of approximately 25,200 acre-feet. During project design ten years of recorded data provided the statistical characteristics required by HEC-4, "Monthly Streamflow Simulation", to generate five 100-year routing periods. HEC-4 analyzes monthly streamflows to determine their statistical characteristics and generates a sequence of hypothetical streamflows of any desired length having those characteristics. The average of these five 100-year routing periods was used to determine water supply yield. The water supply yield was determined using HEC-5 "Simulation of Flood Control and Conservation Systems". HEC-5 simulates the sequential operation of a reservoir for short interval historical or synthetic floods or for long duration non-flood periods or for combinations of the two. The program was used to evaluate the operational criteria for both flood control and conservation (water supply) for the reservoir. For design purposes, a 95-percent dependable yield was selected which produced 33.9 cfs (21.9 million gallons per day (mgd)).

For the seepage analysis study the models have been updated using 21 years of recorded data to generate five 100-year routing periods. Table 8-7 contains the results of new model runs using constant seepage rates of 4 cfs and 7 cfs.

Table 8-7

Cerrillos Reservoir
Projected Water Supply Yield
(cfs/MGD)

Seepage Loss (cfs)	Dependable Yield in Percent 99	98	95	90
1	31.4 (20.3)	32.3 (20.8)	33.9 (21.9)	35.9 (23.2)
4	29.1 (18.8)	29.9 (19.3)	31.7 (20.5)	33.7 (21.8)
7	26.2 (16.9)	27.2 (17.6)	29.0 (18.7)	31.2 (20.2)

Source: Under Seepage and Outlet Works Leakage Investigation - Cerrillos Dam - 30 July 1993, Table A-5, Page A-11

8-07. Hydroelectric Power. In May 1980, the Corps of Engineers studied the potential of installing hydroelectric generators at the Cerrillos Dam. Based on the findings of the study, a single 515 kW generating unit located at the dam could utilize the nearly constant water supply releases and develop about 4,080,000 kWh annually. The unit would be located in the water supply conduit somewhere downstream of the dam. The contemplated unit would be remotely operated on the water supply discharge and be compatible with the water supply function. The unit would be housed in a small powerhouse at the foot of the dam. It should be noted that hydropower is not listed as one of the original authorized functions of the project. The cost of the development of hydropower from the Cerrillos Dam is the responsibility of the Commonwealth of Puerto Rico and they have elected to defer the construction of the hydropower facilities until a later time.

8-08. Navigation The reservoir may be used for recreational boating. However, no provisions have been made for boats to pass into other navigable waterways. There are local laws limiting the use of power boats on lakes. DNER should be the point of contact concerning the current regulations on power boating.

8-09. Frequencies.

a. Peak Inflow Probability. A peak inflow frequency curve will not be available until at least 10 years of actual operation have passed. In the interim, the natural frequency curve at the Cerrillos Dam multiplied by about 25 percent should be representative of peak inflow to the project (see Plate 8-1).

b. Pool Elevation Duration and Frequency. An estimated Pool Stage Frequency Curve is included as Plate 8-2.

c. Unit Hydrograph. A Synthetic 1-Hour Unit Hydrograph is included as Plate 8-3.

d. Key Control Points. The routings performed for the dam design did not indicate any key control points. However, as the reservoir is put into operation, downstream gages will be monitored to see if there is any correlation between releases made at the dam and problems that develop downstream.

8-10. Other Studies. Seepage collected and measured in the toe-drain system has been greater than projected in the design process. An analysis done during the design of the dam predicted a seepage rate of approximately 1 cfs. Upon initial filling of the reservoir seepage measured in the toe drain system has exceeded 5 cfs. A "Cerrillos Dam Seepage Investigation Task Force" was formed to determine the cause of the increased seepage and any associated problems that may be caused. The Task Force determined that the increased seepage does not affect the integrity of the dam, nor affect its function or meeting its project purposes. Although the exact source of the seepage is not known, it is believed to be coming through rock fractures in the left abutment.

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Department of Natural and Environmental Resources (DNER). As the local sponsor of the project, DNER has responsibility of operating and maintaining the project works in accordance with the regulations prescribed by the Secretary of the Army and the approved water control plan. These regulations are contained in section 208.10 and 208.11, Title 33 of the Code of Federal Regulations. A copy of these regulations is found in Exhibit D of this manual. These regulations are supplemented by approved water control plans and manuals. Day-to-day operations of the project will be performed by DNER staff located at the Cerrillos project.

b. Corps of Engineers. The Corps of Engineers could serve in an advisory capacity to the DNER on the operation and regulation of the reservoirs and water management. All contact relating to project operations and water control decisions should be with the Chief, Water Management and Meteorology Section, Hydrology and Hydraulic Branch, Engineering Division. A list of Corps of Engineers key water control personnel are found in Table 9-1. The role of the Corps is to provide and ensure that the DNER follows these regulations and that the project is operated to meet the prescribed project purposes.

c. Other Federal Agencies. No other federal agency is directly involved in the management of the Cerrillos project. However, the U.S. Geological Survey (USGS) operates and maintains gaging stations used for hydrometeorological monitoring.

9-02. Interagency Coordination.

a. Department of Natural and Environmental Resources (DNER). As owner and operator of the project, DNER has responsibility of coordinating with federal, state, and local governments.

b. Local Press and Corps Bulletins. The Public Affairs Office within the Jacksonville District is responsible for releasing information to the media concerning special events of project operation including emergency flood flows, dam break, etc.

c. National Weather Service. The NWS provides daily forecasts for the weather in the Caribbean and specifically Puerto Rico. The NWS also provides long range forecasts for the basin for weather and precipitation. The meteorological data collected is published in bulletins such as "Monthly Seasonal Weather Outlook".

d. U.S. Geological Survey. The U.S. Geological Survey has constructed and operates and maintains hydrometeorological gaging stations within the P&B project area. In the past, the Corps of Engineers contracted with USGS for the operation and maintenance of each gaging station applicable to the Cerrillos project.

e. Others. Any unusual conditions affecting water releases from the dam will be coordinated with the City of Ponce Civil Defense and other appropriate Commonwealth Agencies.

9-03. Interagency Agreements. Storage space of approximately 25,200 acre-feet or 53 percent of the conservation pool has been included in the project for municipal water supply. A contract was entered into between the United States of America and the Commonwealth obligating the total allocated water supply storage space within the project to the City of Ponce. A water supply withdrawal system has been provided for the release of this water. Interagency agreements are included in Exhibit C in this manual.

9-04. Reports. The project owner shall monitor current reservoir and hydrometeorological conditions in and adjacent to the watershed and downstream of the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the damtender or other means requested by the Corps of Engineers. In addition, the damtender shall keep accurate operation logs of gate openings and times, pool elevations, and rainfall at the damsite.

Table 9-1

Key Personnel in Water Management

Engineering Division

Name	Position	Phone Numbers
Keith Jones	Water Mgt Sect	(W) 904-232-2914
Jim Vearil	Chief, Water Mgt Sect	(W) 904-232-2142
Ed Middleton	Chief, Eng Division	(W) 904-232-2252

Construction-Operations Division

Name	Position	Phone Numbers
Jose Rosado	Resident Engineer	(W) 809-841-3181
Pablo Vazquez	Civil Engineer	(W) 809-841-3182
Pedro Davila	Civil Engineer	(W) 809-841-3181

Antilles Office

Name	Position	Phone Numbers
Yamil Castillo	Supervisor, Civil Eng	(W) 787-729-6833