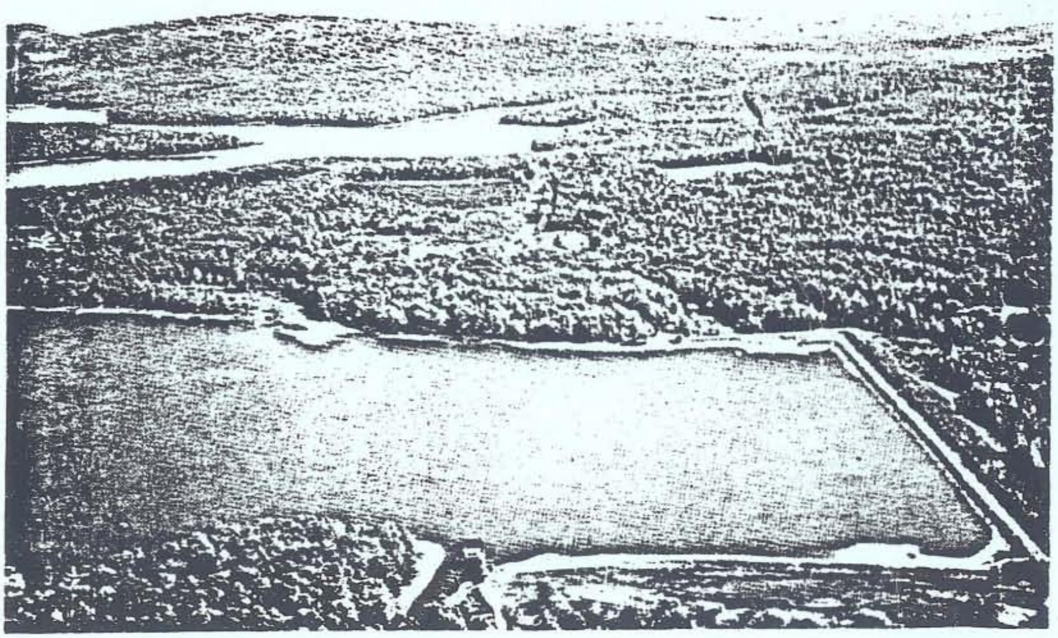
DEEP CREEK STATION

SUPPORT DOCUMENT FOR PERMIT APPLICATION TO APPROPRIATE AND USE WATERS OF THE STATE

AUGUST 1993

With Revised TOC, Section 4.0, and Appendix D April 1994 - Merged into original document by MDE on 25-Feb-2013



PENNSYLVANIA ELECTRIC COMPANY

DEEP CREEK STATION

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FOR
PERMIT APPLICATION TO
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REVISED SECTION 4.0

APRIL 1994

PENNSYLVANIA ELECTRIC COMPANY

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EXECUTIVE SUMMARY

The Deep Creek Station hydroelectric project has been in continuous operation since 1925. While designed and operated as a peaking power plant, Penelec has operated the plant to enhance lake and downstream recreation, whenever possible. The plant operation is regulated by a license issued by the Federal Power Commission, predecessor to the Federal Energy Regulatory Commission (FERC), in 1968. The license expires December 31, 1993.

On September 26, 1991, the FERC determined that the Deep Creek Project is non-jurisdictional and Penelec is not required to obtain a new license for the project. Penelec elected not to seek a new FERC license and subsequently submitted an Application for A Permit To Appropriate And Use Waters Of The State on June 3, 1992 (Permit Application). As part of the Permit Application, Penelec has prepared this Support Document which provides additional specific information on project plans and specifications, project operation, and project environmental resources as required by Code of Maryland Regulations (COMAR 08.05.02.04A).

In preparing the Permit Application and this Support Document, Penelec has consulted extensively with the Maryland Department of Natural Resources (MDNR) including technical and environmental studies, data compilation and interpretation; and developing the proposed operating rules for balancing conflicting needs for project waters.

Historical and existing conditions of the resources of the project area are described to provide background information (Sections 1 to 3). The data forms the basis for historical operation of the Deep Creek Station, as well as, the proposed changes to the plant operation.

The proposed operating rules, described in Section 4, have been designed to provide minimum flows in the Youghiogheny River, maintain River water temperatures at or below 25°C for fisheries enhancement, and support lake and river recreation, while maintaining the plant's power generation capabilities. Extensive analyses were performed to assess alternative reservoir operations to meet the various objectives. The proposed operation balances the following objectives with the need for reliable power generation:

- Minimum Flow Releases: The proposed operation will endeavor to maintain a minimum of 40 cfs in the Youghiogheny River downstream of the plant tailrace at all times. The minimum flow will include natural river flows, leakage flows from the plant as well as specific flow maintenance releases. This will enhance the river fisheries by assuring a minimum amount of aquatic habitat not presently available on a continuous basis.

- Releases for Temperature Control: Penelec proposes to operate the plant in an attempt to maintain river water temperatures between the project tailrace and Sang Run at or below 25°C during critical periods from June through August. This will enhance the brown and rainbow trout fisheries in the river.

- Lake Recreation: Penelec proposes to operate the plant in an attempt to maintain high lake levels suitable for boating during the summer recreation season and restrict monthly drawdown to 1.25 feet or less. Penelec will curtail generation in March and April, if necessary, to raise the lake levels for the summer.

- River Recreation: Penelec proposes to provide releases for whitewater boating on all Fridays and one designated Saturday every month during the period May-September and will attempt to schedule energy generation to further enhance whitewater boating opportunities during April through October.

Due to complex and conflicting interaction of these requirements with energy generation, Penelec has developed monthly operating rules to assist plant operators to balance the various needs (Section 4).

Penelec proposes to construct two facilities as part of the proposed operations:

- A flow bypass system to provide the minimum flow releases when the project is not operating.

- A W-shaped weir in the project tailrace to enhance the dissolved oxygen (DO) concentration of project discharges to comply with the State water quality requirements.

Historical operation of the Deep Creek project is not known to adversely affect any Federally listed or State-listed endangered, threatened, and rare species in the project area. Proposed operation of the project is not expected to have any adverse effects on such species. The provision for DO enhancement and the minimum flow would be beneficial to the hellbender and mudpuppy populations in the river.

Discussions between the State Historic Preservation Officer (SHPO) and Penelec have indicated no concerns or objections to the proposed project operation.

Penelec will monitor a number of parameters such as lake levels, plant and river flows, river water temperature at Sang Run, dissolved oxygen concentration in the plant discharges and record specific releases for whitewater boating, water temperature control, etc., in order to evaluate project performance and to refine or revise operations, if necessary, to meet the intended objectives. The data will be submitted to MDNR at regular intervals.

Penelec believes that the proposed operation of the Deep Creek Station will provide a reasonable and balanced use of available resources among competing requirements. Penelec has endeavored to develop an operating rule that will benefit all competing resources (Section 5). Penelec will continue to work with MDNR and others to refine and revise operation details, to meet the recreation, fisheries and power objectives.

1.0 INTRODUCTION

The Deep Creek Station hydroelectric project was placed in service in 1925 by a predecessor company of Pennsylvania Electric Company (Penelec). In 1968, the Federal Energy Regulatory Commission (FERC) issued Penelec a license for the project (FERC Project No. 2370-MD). The FERC license expires December 31, 1993.

On September 26, 1991, the FERC determined that (1) the Deep Creek Project is non-jurisdictional, (2) Penelec is not required to obtain a new license for the project after the original license expires, and (3) Penelec will remain under Federal jurisdiction until the existing license expires. Penelec subsequently informed the FERC that it has elected not to seek a new license. Accordingly, Penelec submitted an Application For A Permit To Appropriate And Use Waters Of The State on June 3, 1992 (Permit Application). As part of the Permit Application, State regulations require applicants to provide additional specific information on project plans and specifications, project operation, flows, water quality and water use, aquatic habitat, terrestrial resources, threatened and endangered species, and archeological resources (COMAR 08.05.02.04A).

This Application Support Document provides the required information as well as information on recreational and aesthetic resources that are affected by project operation. It provides Penelec's balancing of development and non-development resources and Penelec's proposed project operating rules. These operating rules were developed in consultation with the Maryland Department of Natural Resources (MDNR). The Application Support Document describes changes proposed by Penelec to ensure compliance with State laws, particularly water quality standards and to enhance the resources.

Section 2 of this document provides a description of the project and current project operations. It includes a description of measures to ensure safe operation. Descriptions of resources in the vicinity of Deep Creek Lake and along the Youghiogheny River are presented in Section 3. Proposed physical and operational changes to the project are described in Section 4. Section 5 explains why the proposed operation is in the best public interest.

2.0 PROJECT DESCRIPTION

2.1 PROJECT FACILITIES AND EQUIPMENT

The Deep Creek Project is a conventional hydroelectric development located on Deep Creek, a tributary of the Youghiogheny River in Garrett County, Maryland. The nearest principal city is Oakland, Maryland, which is located 8 miles south of the dam. The project structures comprise: an earth and rockfill dam across Deep Creek approximately 1.75 miles upstream from its confluence with the Youghiogheny River at river mile 120.5; Deep Creek reservoir (also known as Deep Creek Lake) which stores the water impounded by the dam; a power intake structure in the lake; a concrete-lined rock tunnel, surge chamber and steel penstocks which convey waters from the lake to a powerhouse located on the bank of the Youghiogheny River near Hoyes Run at river mile 119; a brick powerhouse with two Francis type turbines; a switchyard; and an excavated tailrace which directs powerhouse discharges to the river.

2.1.1 Project Structures

Principal structures of the project are described in greater detail in the following sections. Table 2-1 provides salient project data. Figure 2-1 shows the project location. The general arrangement and detailed drawings of the existing facilities and adjoining lands are presented in Figures 2-2 through 2-5.

2.1.1.1 Dam and Spillway

The project dam is an earth and rockfill structure constructed around a concrete core wall. The embankment contains approximately 750,000 cubic yards of fill material and is 86 ft. high at its maximum section. The total length of the embankment is 1300 ft. The concrete core wall, 78 ft. high at its maximum section, has a thickness varying from 16 inches at the top to 28 inches at the base. The overall slope of the embankment is about 2(H) to 1(V) on

Table 2-1 Project Structures

Location	Garrett County, Maryland
Nearest Town	Oakland, Maryland
<u>Dam</u>	
Water Course	Deep Creek, a tributary to the Youghiogheny River
Drainage Area	64.7 sq. miles
Type	Earth/rockfill with concrete core
Height	86 ft. (maximum fill section) 78 ft. (concrete core wall)
Length	1,300 ft.
Top width	12 ft. (embankment), 16 in. (core wall)
<u>Impoundment</u>	
Surface Area	3,900 acres at El 2,462 ft. mean sea level (MSL)
Length	11.6 miles
Gross Storage	106,000 acre-ft
Usable Storage	93,000 acre-ft
Avg. Annual Drawdown	7-8 ft.
<u>Spillway</u>	
Type	Ogee shaped, concrete
Height	6 to 14 ft.
Length	720 ft.
Crest	El. 2,462 ft. MSL
PMF level	El. 2,472.8 ft. MSL
Capacity	90,000 cfs at PMF
<u>Diversion Tunnel</u>	
Location	Beneath embankment
Size, Shape	10 ft. diameter, horseshoe shaped
Status	Upstream half has been permanently plugged since project completion.
<u>Power Intake</u>	
Type	Concrete structure with trash racks, trash rake, gates and gate hoists

Table 2-1 Project Structures (Continued)

Power Tunnel	
Type	Rock tunnel, concrete and steel lined
Diameter, Shape	9 ft., horseshoe shaped
Elevation	El. 2,415 ft. MSL at centerline at intake
Slope	0.8 percent downstream
Length	6,652 ft. to surge chamber plus 46 feet beyond (concrete lined), 393 ft. to bifurcation (steel lined)
Penstocks	
Number	2 - circular steel penstocks
Diameter	6 ft. 3 in. - upper portion, 6 ft. 0 in. - lower portion
Length	757 ft.
Surge Chamber	
Type	Partially above ground, steel/concrete cylinder
Diameter	30 ft.
Height	145 ft. (total) 52 ft. above ground
Powerhouse	
Location	On the right bank of Youghiogheny River
Type	Brick and concrete, four story structure
Size	106 ft. wide, 43 ft. long and 100 ft. high
Tailrace	
Type	Excavated trapezoidal channel
Size	40 ft. base width, 1(V): 2(h) side slopes
Length	435 ft.
Important Elevations	(ft. MSL)
Dam Crest	2475.0
PMF Level	2472.8
Top of the Core Wall	2466.5
Spillway Crest	2462.0
Normal Max. Pool	2462.0
Intake Tunel	2415.0 (center line)
Generator Floor	2046.5
Turbine Distributor	2034.0 (center line)
Normal Tailwater	2024.0

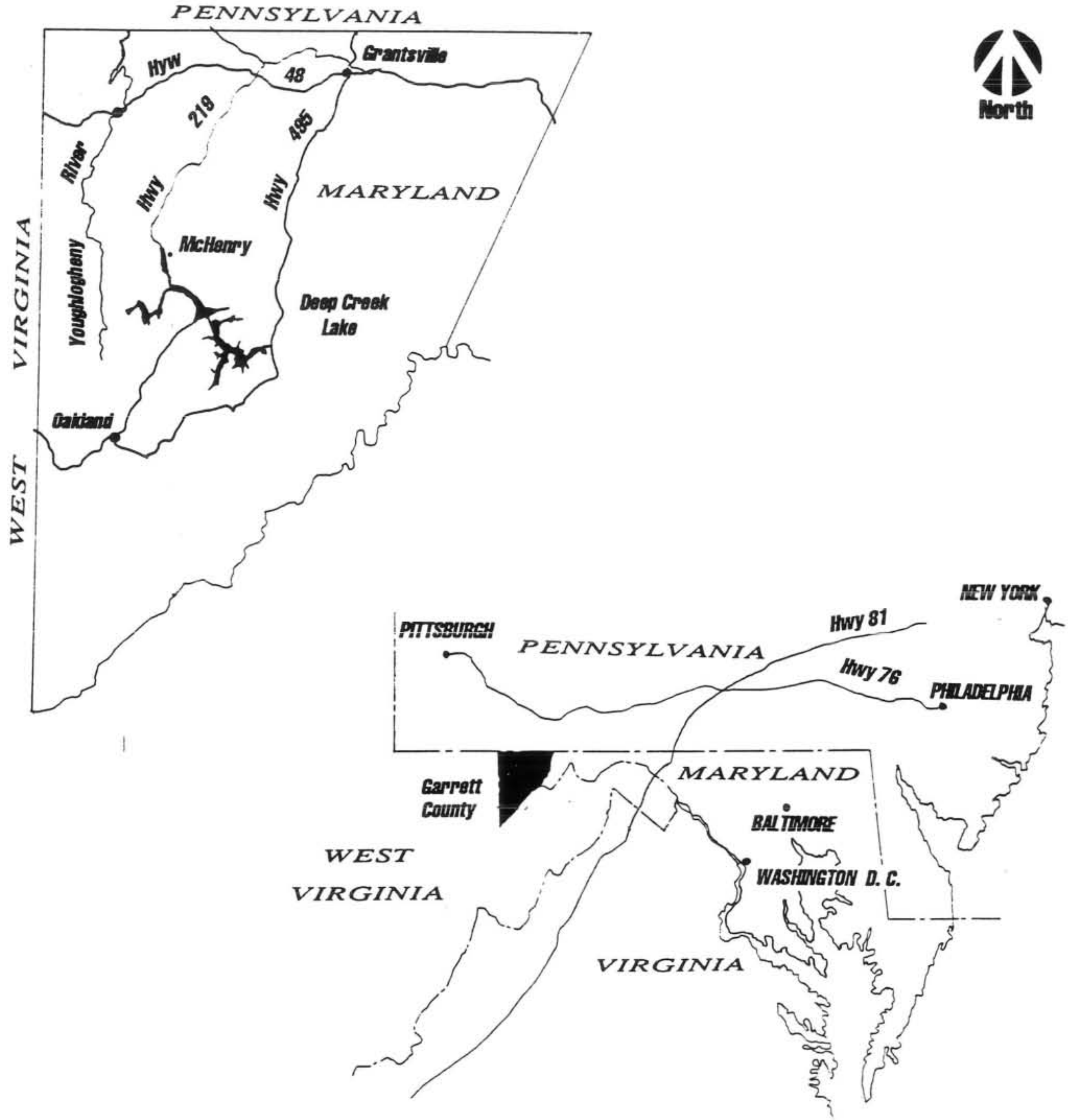

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Figure 2-1
GENERAL LOCATION MAP
Sheet 1 of 2

EBASCO ENVIRONMENTAL

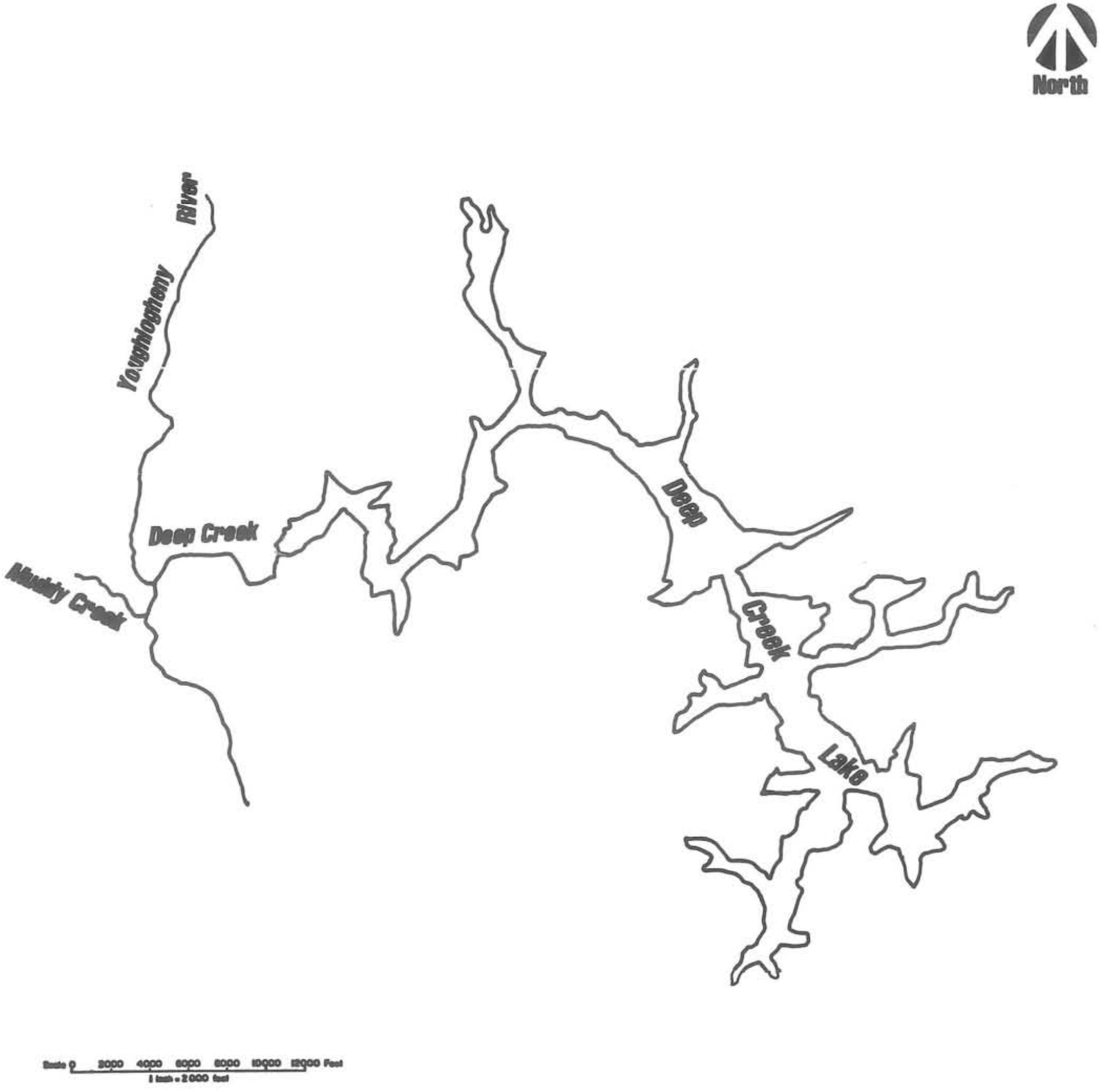

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Figure 2-1
GENERAL LOCATION MAP
Sheet 2 of 2

EBASCO ENVIRONMENTAL

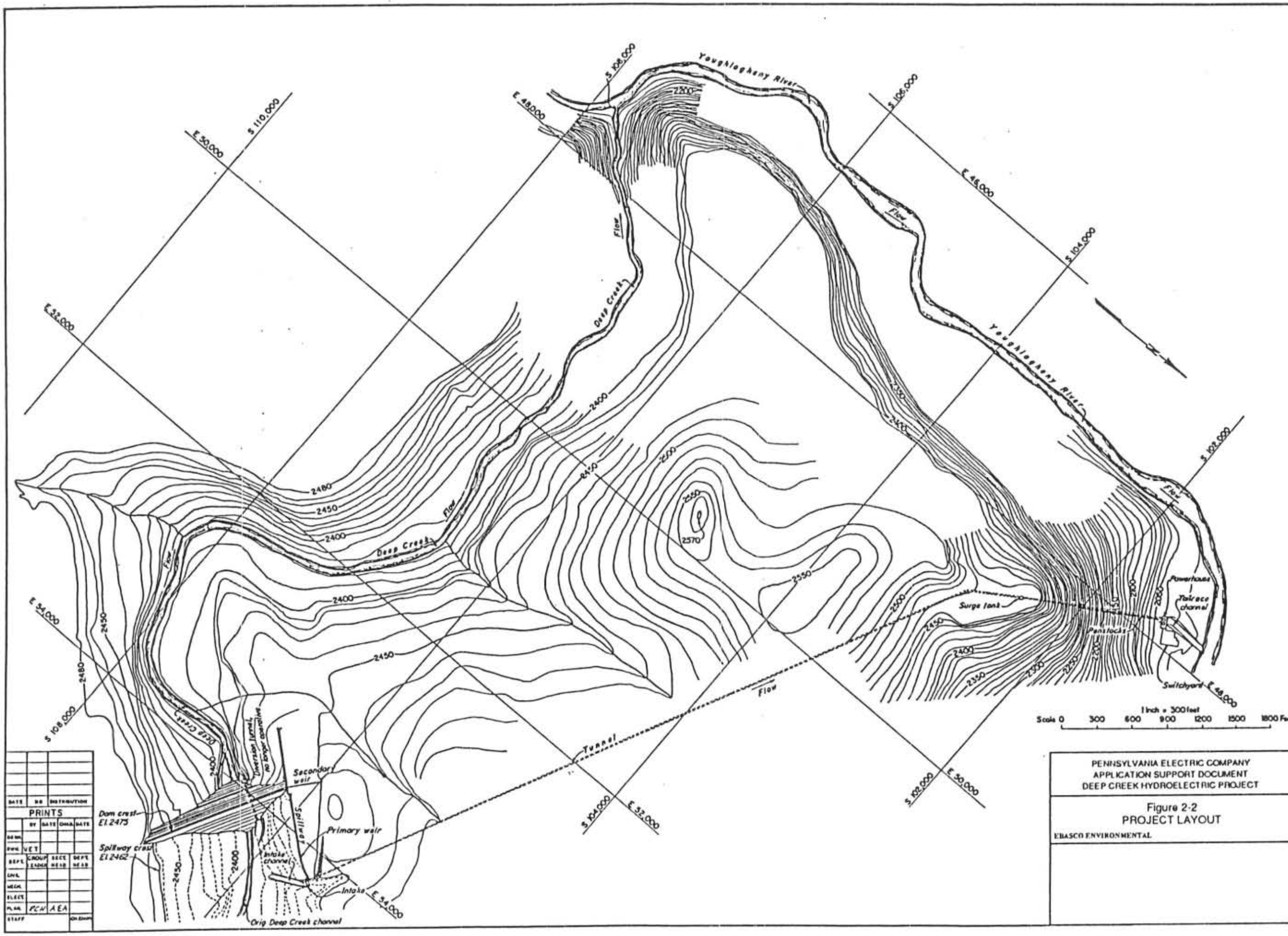

Figure 2-2
PROJECT LAYOUT

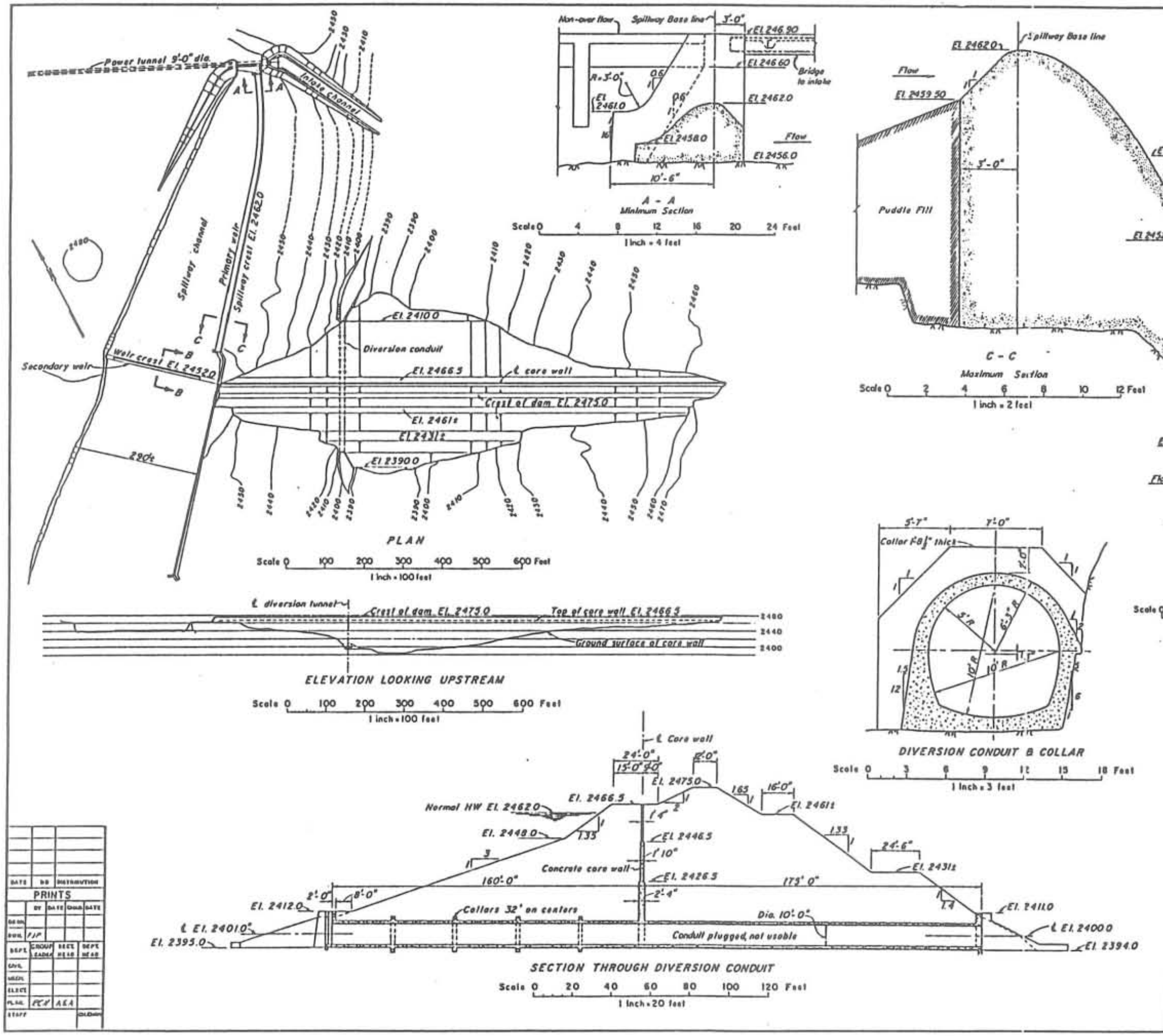

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Figure 2-3
DAM AND SPILLWAY

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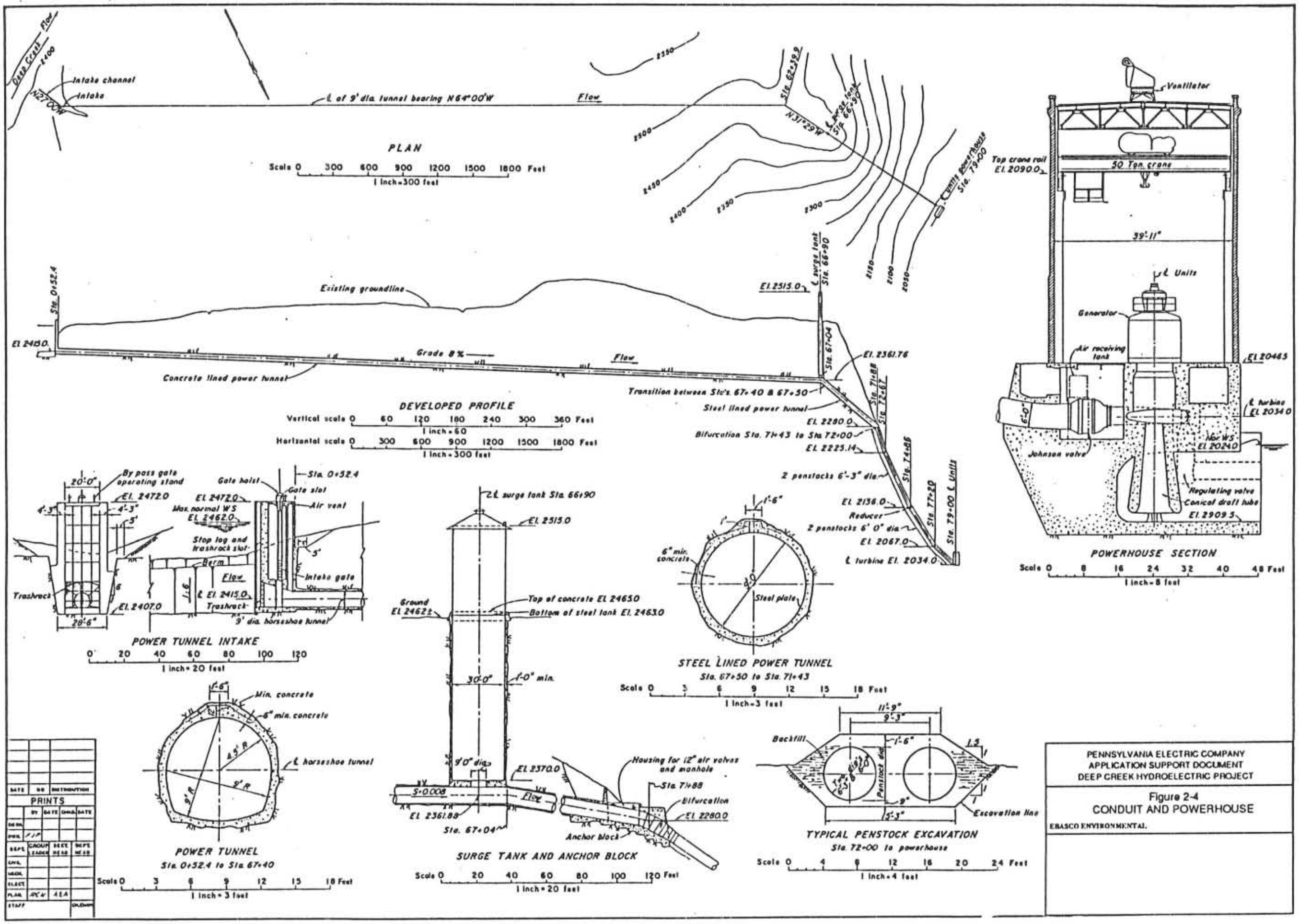

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Figure 2-4
CONDUIT AND POWERHOUSE

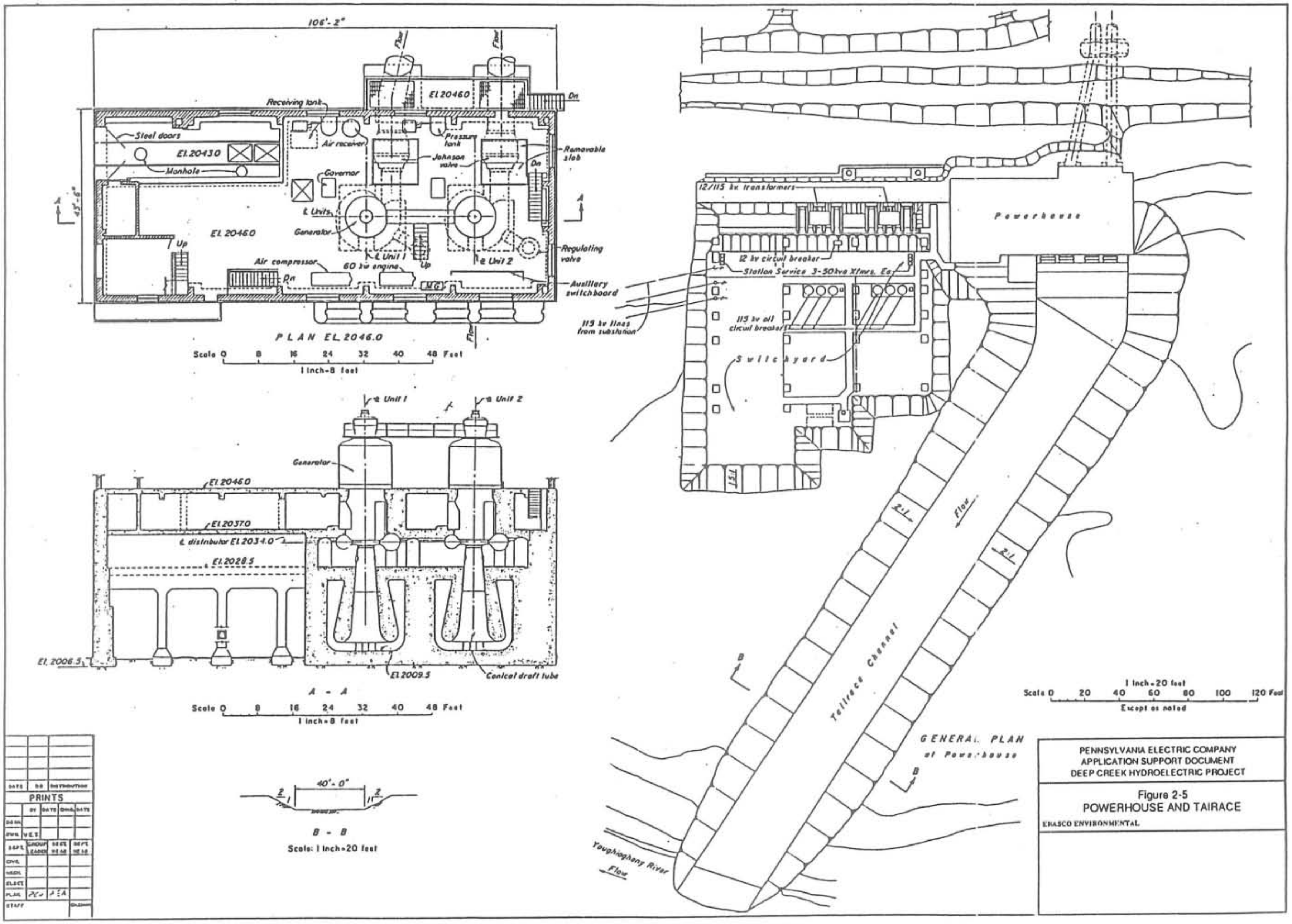

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Figure 2-5
POWERHOUSE AND TAIRACE

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the downstream and 3(H) to 1(V) on the upstream sides. The crest of the dam is at elevation 2475 ft. MSL.

A concrete spillway, 720 ft. long, is located to the north-west of the embankment. It is an ogee shaped, gravity retaining structure and is 14 ft. high at its maximum section. A concrete training wall located south of the spillway, protects the right embankment of the dam during spillway releases. Penelec believes that the reservoir has spilled only on three occasions in its sixty eight year history.

A diversion tunnel used during the construction of the project is located under the embankment. It is horse-shoe shaped and is 10 ft. in diameter. The tunnel has been plugged permanently with concrete since completion of project construction.

2.1.1.2 Water Conveyance Structures

A concrete intake structure is located upstream of the spillway on the western shore of the lake to direct water into the power tunnel. The intake structure is equipped with trash racks, trash rake, control gates and gate hoists.

The power tunnel is 9 ft. in diameter, horse-shoe shaped and is concrete lined throughout its 6652 ft. length from the intake to the surge chamber. The tunnel has a gradient of 0.8 percent in this section. Forty six feet downstream from the surge chamber, the tunnel is lined with steel for approximately 393 ft. where it then bifurcates over a transition length of 57 feet into two 700 foot-long steel penstocks. The diameter of the penstocks varies from 6 ft. 3 in. to 6 ft. 0 in. The penstocks feed the two turbines in the powerhouse, which in turn, discharge into the Youghiogheny River through a 435 foot-long excavated tailrace.

The surge chamber is of concrete and steel construction. It is 30 ft. in diameter and 145 ft. high and extends approximately 52 ft. above ground level.

2.1.1.3 Powerhouse

The powerhouse is a four-story concrete and brick structure and houses two, vertical Francis type turbines each rated at 12,000 horsepower at 400 ft. head. Each turbine is directly connected to a generator rated at 12,000 kVA, 9,600 Kw at 0.8 power factor. Two Johnson valves are located within the powerhouse at the downstream end of the penstocks. The powerhouse also accommodates all the mechanical and electrical control and ancillary equipment for plant operation. A 50 ton overhead crane in the powerhouse is available for repairs and maintenance of the powerhouse facilities.

2.1.2 The Impoundment

The dam impounds a lake approximately 3,900 acres in surface area and a storage volume of approximately 106,000 acre-ft at the original design pool elevation of El 2462.0 ft. MSL. The usable storage volume above elevation 2,425 ft. is approximately 93,000 acre-ft. The contributing drainage area is 64.7 sq. miles. The lake has 65 miles of shoreline.

The project is operated to provide suitable water levels for lake recreation. Historically, the average annual drawdown has been about 9 ft. but more recently, the drawdown has been about 7-8 feet.

2.1.3 Hydraulic Turbines and Generators

The existing generating equipment is identified in Table 2-2. Scheduled and preventive maintenance and regular replacements and repairs of turbine runners, governors, hydraulic control systems and generators have been carried out as needed. The plant has been operated at its design capacity historically with a high reliability and availability.

Table 2-2 Generating Equipment and Controls

Turbines	
Number, Type	2-Vertical shaft Francis
Rated output	12,000 hp
Rated net head	400 ft.
Discharge	320 CFS
Speed	514 rpm
Manufacturer	Allis Chalmers
Year Installed	1925
Runners Replaced	
Unit 1	1972
Unit 2	1973
Governors	
Type	Actuator
Controls	Hydraulic
Manufacturer	Allis Chalmers
Valves	
Number, type	2 - Johnson type needle valves
Size	6 ft. 3 in.
Generators	
Number, Type	2 - vertical shaft synchronous, 3 phase, 60 cycles, with direct connected exciter
Speed	514 rpm
Rated output	12,000 kVA, 9,600KW at 0.9 power factor
Manufacturer	Allis Chalmers
Exciter	
Number, Type	2 - Unit 1 - No. 119113, Unit 2 - No. 119190
No load	250 volts
Full load	250 volts
Amps	1,000
Speed	514 rpm
Manufacturer	Allis Chalmers

Table 2-2 Generating Equipment and Controls (Continued)

Main Transformers	
Number, Type	2 - 115 - 11.5 kV
Manufacturer	Westinghouse Electric Corporation
Circuit Breakers	
Number, Type	2 - 115 kV Transformer Oil Circuit breakers
Manufacturer	Allis Chalmers
Number, Type	1 - 12 kV generator OCB (Unit 2), oil blast circuit breaker, type FK-144-250-2, 4,400 volts, 600 amps, 60 cycles, interrupter current at rate voltage - 10,000 amps, impulse with stand - 110 kV maximum design 15,500
Manufacturer	General Electric
Station Service Transformers	
Number, Type	6 - 25 kVA, 12,000 volts, 120/240, class OA, single phase, 60 hertz
Manufacturer	McGraw Edison
Number, Type	1 - for electric heat - 500 kVA, 3 phase, class OA, 12,000 volts, 480Y/277, 60 cycles
Manufacturer	RTE Corporation

2.1.4 Ancillary Equipment

The project is remotely operated from Penelec's Johnstown, PA System Operations Center. Electrical and mechanical equipment and devices required for the operation, control and dispatch of the project power are located in the powerhouse and at the Johnstown System Operations Center. Table 2-3 lists the ancillary equipment at the existing project.

2.2 EXISTING PROJECT OPERATIONS

The project is primarily operated to provide peaking capacity to the Penelec/GPU system. Operation of the power plant is automatically controlled from Penelec's System Operations Center in Johnstown, PA. The annual plant factor is approximately 18 percent, based upon the summer net capacity rating of 18 MW.

The large volume of storage in the project reservoir and the large plant discharge capacity relative to the runoff from the drainage area of Deep Creek Lake permit virtually a total regulation of inflow. Penelec has operated the project to provide for the needs of recreation in the lake to the extent possible. Since the early 1980's, Penelec has generally maintained a water level of 2,458 ft. or higher during the months of June, July, and August. Figure 2-6 shows the minimum, maximum, and mean monthly reservoir levels maintained during the period 1970-1990.

2.2.1 Energy Generation

The average energy production of the plant over the 65-year operating period is 28,300,000 kWh per year.

Figure 2-7 shows the project power capability as a function of available head at the plant.

Table 2-3 Existing Ancillary Equipment

SAFETY EQUIPMENT AND ALARMS	
Each generator is equipped with it's own ANSUL 1501 Clean Agent Fire Control System which is discharged at a specified temperature in the generator. When this system discharges, it rings a bell at Deep Creek Station, shuts the generator down and sends a fire alarm to the Johnstown System Operations Center. The following alarms exist on Penelec's lake level monitoring system:	
Lake Level Rate of Change	0.05 ft. per hour based on three consecutive readings and only if the lake level is 2,461 feet or greater.
Master Weir High Flow - High Alarm	Flow of 2.5 cfs or greater
Master Weir High Flow - High-High Alarm	Flow of 3.0 cfs or greater
Master Weir Flow - Rate of Change	Rate of change equal to 200 gpm in any 1 hour time period
High Lake Level	Lake level elevation equal to or greater than 2,461.5 feet
Power/Communication	Loss of power to the DCP or
Problem	loss of communication to the CPU
The station is equipped with smoke detectors which alarm the Johnstown System Operations Center. Since Deep Creek Station is fully automated and only manned Monday through Friday, 7 a.m. to 3:30 p.m., all of Penelec's alarms are transmitted to the Johnstown System Operations Center. Most alarms are in the form of targets and flashing lights. Examples of flashing lights would include the lights on the Bentley Nevada Turbine Monitoring Equipment and the generator status temperature alarms. The protective relaying for both the generators and transformers provides an example of a target. Also all the protective relaying on the 115 kV line has targets. These targets drop when any of these relays operate.	

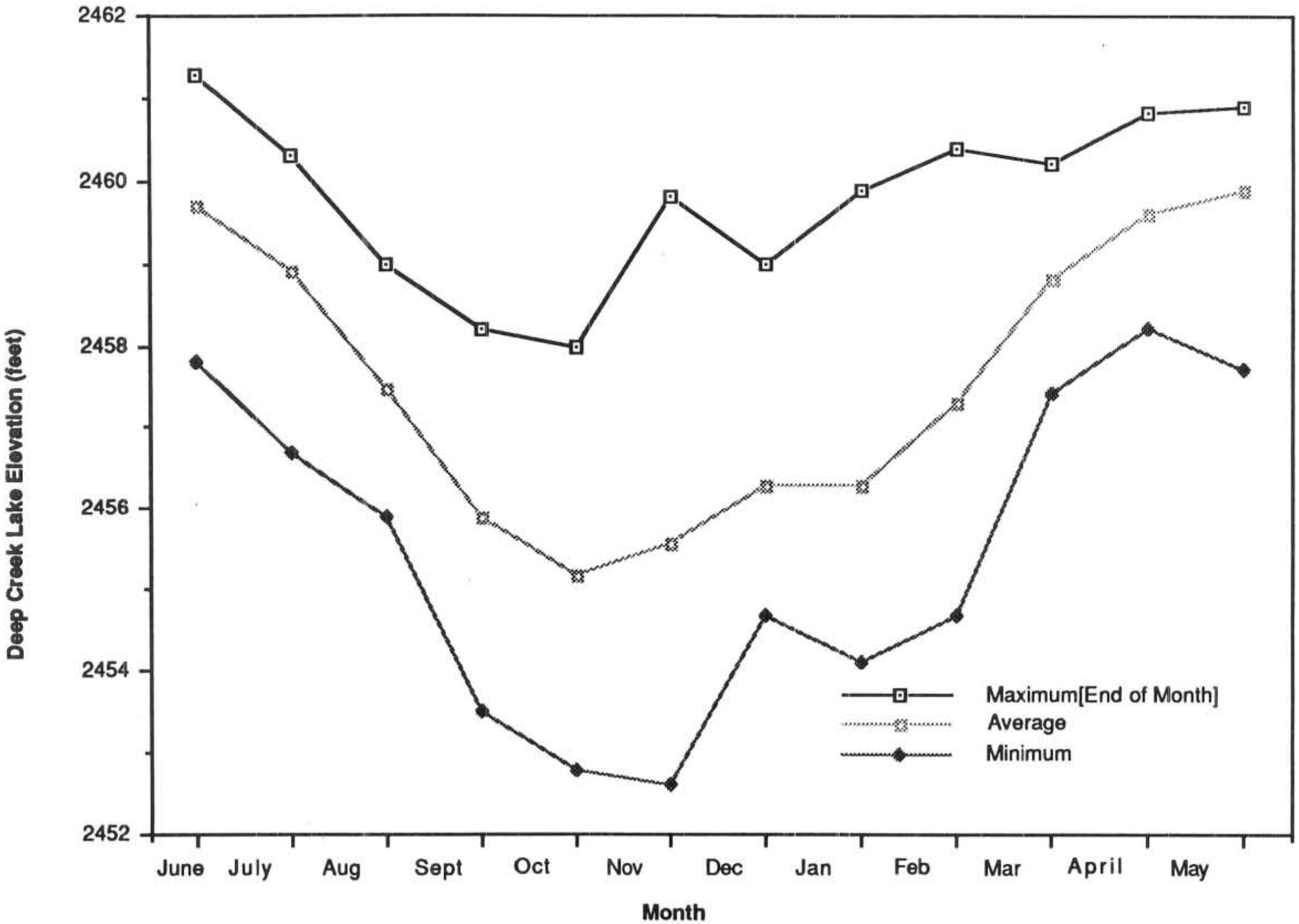
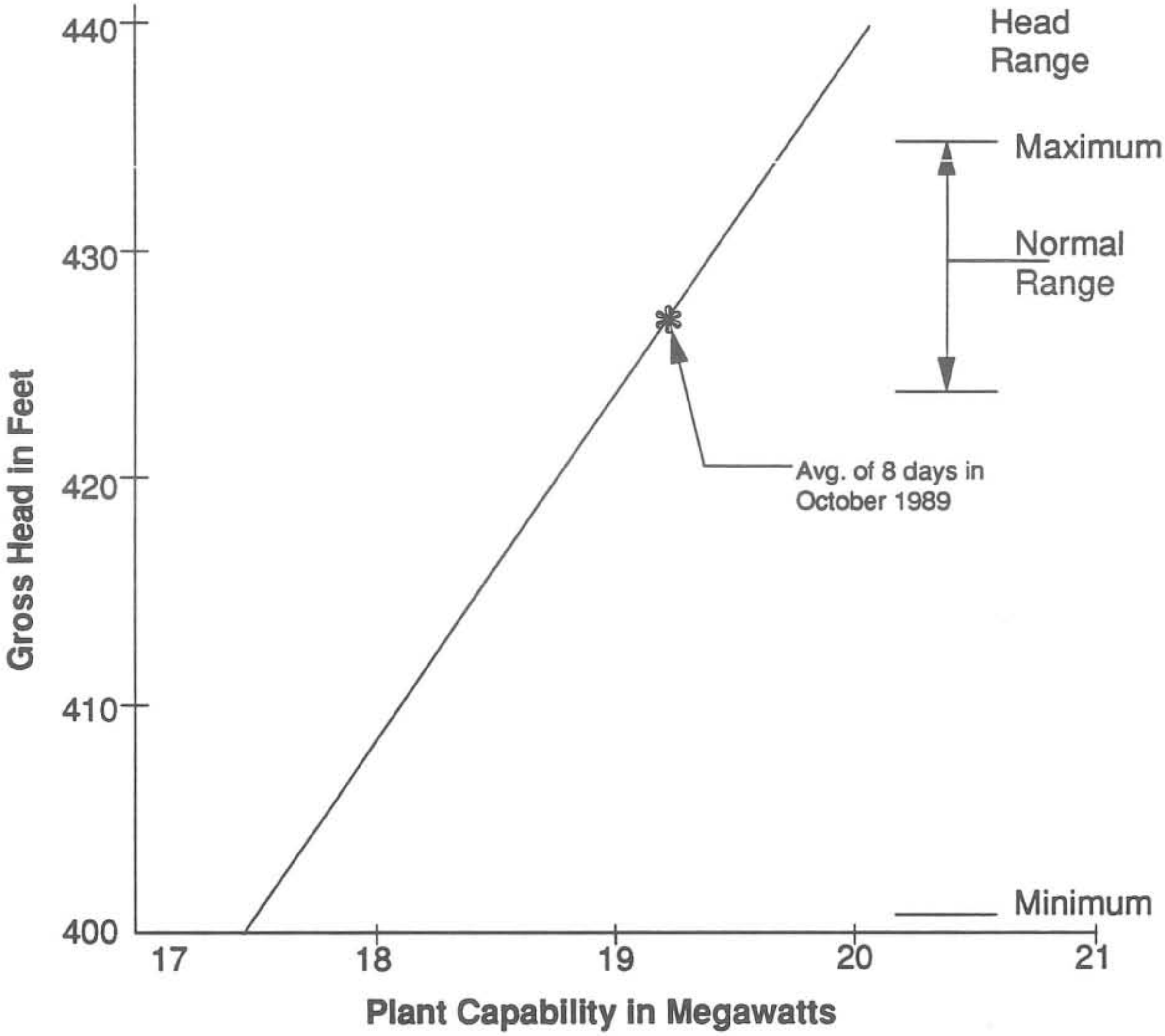


Figure 2-6. Monthly historic Deep Creek Lake water levels 1970-1990.



NOTE: Outside of the normal head range, the plant capability is uncertain. The depicted curve was derived from known capability at a head of approximately 436 feet and extended in accordance with Figure 9 – "Typical Francis turbine performance – constant speed and full gate," Monograph No. 20, Bureau of Reclamation.

Figure 2-7. Deep Creek station capability vs. gross head.

2.2.2 Impoundment Storage and Operation

The impoundment created by the project dam extends over 11.6 miles upstream. The surface area at El. 2,462 ft. MSL is 3,900 acres. An area-capacity-elevation curve is shown in Figure 2-8.

The capacity of the reservoir and the turbine discharge capabilities are adequate to ensure no spill from the reservoir except during unusual floods. Snow pack depth measurements are taken regularly by Penelec. The power plant operation regulates most of the floods in the catchment and provides incidental flood control benefits downstream.

2.2.3 Hydraulic Capacity of the Project

The two Francis turbines in the powerhouse have a total hydraulic capacity of around 640 cfs. Based on index testing of the units in 1992, Penelec normally operates the turbines for maximum efficiency. At maximum efficiency, flow through the turbines is about 560 cfs.

2.2.4 Tailwater Relationship

The tailwater elevations at the powerhouse are influenced by the backwater effect of flow in the main stem Youghiogheny River for all flows in the latter. Therefore, a one-to-one relationship between project flows and tailwater levels does not exist. Normal tailwater level when both units are operating is at or near El. 2,024 ft. Variation of tailwater level from elevation 2,024 feet is less than ½ percent of the total head on the plant.

2.2.5 Power/Resource Utilization

The existing capacity of the project completely develops the potential of Deep Creek at the site. The reservoir almost completely regulates the catchment. The project is operated to maximize multi-user demand for the project waters. The power

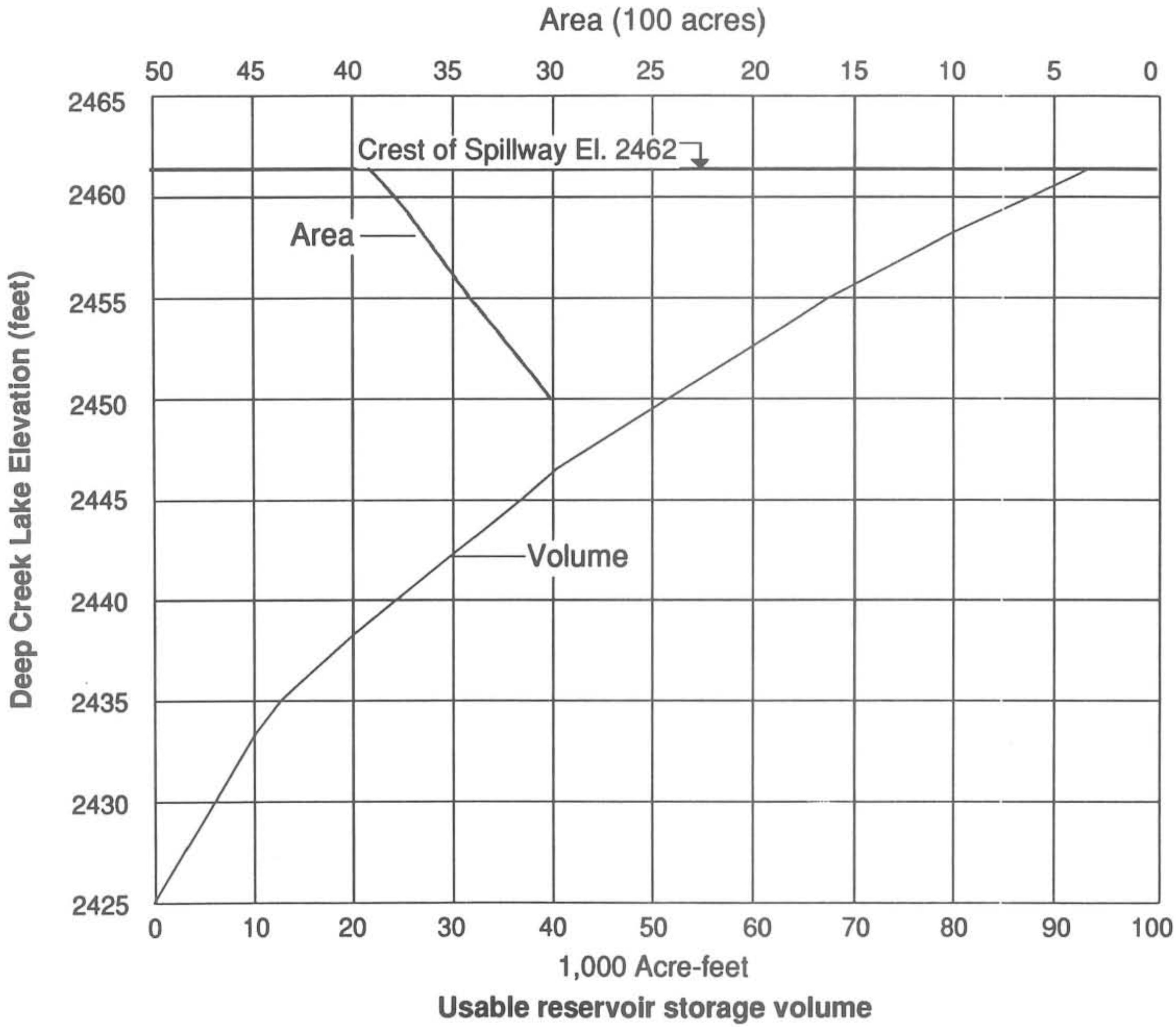


Figure 2-8. Area - capacity - elevation curve.

generated by the plant is fully utilized within the Penelec/GPU system.

2.3 ANNUAL VALUE OF PROJECT POWER

In 1992, the project generated 22,690 MWh. The value of this energy and capacity to Penelec is estimated to be $560,000 and $1,240,000 respectively, based on Penelec's avoided cost.

3.0 AFFECTED ENVIRONMENT

3.1 YOUGHIOGHENY RIVER AND DEEP CREEK WATERSHED FEATURES

3.1.1 Drainage Characterization

The Youghiogheny River above Friendsville, Maryland drains approximately 295 square miles. This entire drainage area lies within the Allegheny Plateau Province. From Oakland, Maryland, the size of the drainage area approximately doubles, with more than 35 small tributaries contributing to the increase. The largest increase in drainage is from the Deep Creek subbasin with a drainage area of 64.7 square miles; the next largest increases are from Muddy Creek, Herrington Creek, and White Rock Run (Figure 3-1).

The elevation of the entire river basin ranges from 1550 feet (472 m) to 3360 feet (1024 m) above sea level. Backbone, Meadow, and Negro Mountains, and Winding Ridge are four major ridges in the basin that interrupt an otherwise rolling upland area. Stream valleys in the basin tend to be cut deeply and flow in a northeasterly direction between ridges.

There are a number of impoundments on tributaries to the Youghiogheny River, including the 3900-acre Deep Creek Lake, the largest lake in Maryland. Except for Deep Creek Lake, releases from these small (<100 acre) impoundments are primarily on a run-of-river basis and do not have a substantial impact on the hydrology of the river.

In contrast, flows from Deep Creek Lake are highly regulated by the Deep Creek Station hydroelectric facility which operates in a peaking mode. In general, releases for power generation are only made during the daytime period of peak electrical demand and the duration and frequency of releases is highly limited by reservoir inflows. Since the construction of the dam at Deep Creek Lake in 1925, the flow from the Deep Creek subbasin upstream of the dam has

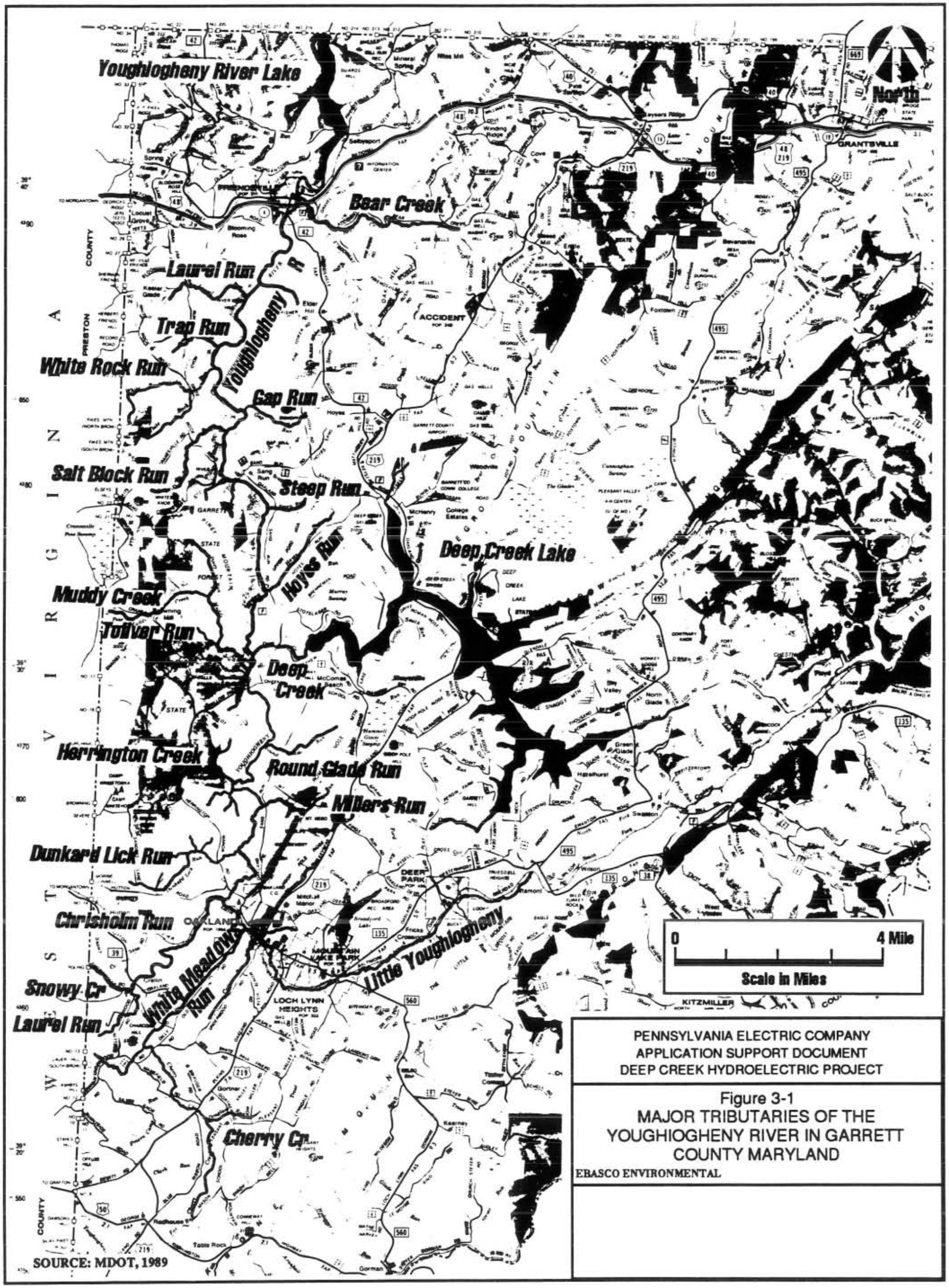


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Figure 3-1
MAJOR TRIBUTARIES OF THE YOUGHIOGHENY RIVER IN GARRETT COUNTY MARYLAND

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been diverted to the hydro project and is released from a tailrace located approximately one mile (1.6 km) downstream of the original Deep Creek channel.

The Youghiogheny River corridor is defined in this document to include the reach of river from Millers Run, which is about 3 miles north of Oakland, to Friendsville. This 20-mile long reach was designated as "Wild" by the state of Maryland in 1976. The following sections focus on the lower half of the corridor from the Deep Creek Station tailrace to Friendsville, since it is this reach that is most affected by the project.

The Youghiogheny River area in the vicinity of the Deep Creek tailrace can be characterized as a steep, narrow river canyon. From the river, slopes as steep as 50 percent lead to the canyon rim. The river itself is steeply sloping with falls both upstream and downstream of the tailrace confluence. The average gradient between Oakland and upstream of Swallow Falls (which is upstream of the confluence with Deep Creek), is 12 ft. per mile. Between Swallow Falls and Friendsville, the average gradient is 50 ft. per mile.

3.1.2 Climate

Climate within the watershed is heavily influenced by its relatively high elevation. Mean annual temperature is 47°F (8°C), several degrees colder than in neighboring basins such as the Savage River basin. Precipitation averages 47 inches (120 cm), and mean annual snowfall is 61 inches (155 cm).

3.1.3 Geology

Minerals found within the Deep Creek drainage area are all associated with the area's sedimentary rock. They include deposits of limestone, shale, siltstone, commercially valuable clays, high silica sandstone, coal, and sand and gravel deposits. One gravel quarry, now abandoned, is located along the river at Sang Run.

Of the commercially valuable minerals found in the area, mining operations are most extensive for coal. The Upper Youghiogheny and Lower Youghiogheny coal basins, both of which are located within Garrett County, have a combined recoverable reserve of approximately 316 million tons, most of which has a high sulphur content (>1%). Of the total coal reserve, less than 3% lies within the Youghiogheny River Corridor.

Within the Deep Creek Lake Basin, a number of abandoned deep coal mines exist. Many of these mines have subsequently been reclaimed, but a number of active and abandoned mines are located in the Cherry Creek watershed which drains into Deep Creek Lake.

Soils along the Youghiogheny River are of predominantly four types: Dekalb-Gilpin-Cookport, Gilpin-Cookport-Dekalb, Dekalb-Calvin-Gilpin, and Gilpin-Wharton-Dekalb (U.S. Department of the Interior 1978). Limitations associated with these soil types include severe slopes, stoniness, and a high degree of wetness. These unfavorable conditions have discouraged agriculture and other development, especially in areas near the mainstem Youghiogheny and the lower portions of tributaries.

3.1.4 <u>Hydrology</u>

3.1.4.1 Youghiogheny River

The Youghiogheny River just below the Deep Creek Project tailrace drains a watershed area of 249 square miles. Discharge records for the Youghiogheny River in the project area are available from two U.S. Geological Survey gaging stations. The first station is located 10.0 miles upstream from the project tailrace at Oakland, Maryland and gages discharge for a 134 square mile drainage area. The second station is located 12.8 miles downstream from the project tailrace at Friendsville, Maryland and gages discharge for a 295 square mile drainage area. The Friendsville gage is affected by water releases from Deep Creek Lake.

Natural river discharge records were synthesized for the Youghiogheny River at Deep Creek Station using a regression method that employs data from both the Oakland and Friendsville gages. Using daily discharge data for days when Deep Creek Station was not operating, the following relationship between discharge at Oakland and Friendsville was established:

$$QF = 2.275 * Q^{0.964} \quad (\text{R-Square} = 0.99)$$

where QF = Discharge at Friendsville (cfs)
Q = Discharge at Oakland (cfs)

This equation was then used to provide an estimate of natural daily discharge (effect of Deep Creek Lake releases removed) for the Youghiogheny River at Friendsville for a 30-year period of record observed at the Oakland gage. A 30-year daily discharge record for the river immediately above the Deep Creek Project tailrace was then calculated by multiplying these daily discharge values by 0.8. This constant reflects the increase in watershed area from the tailrace (184 square mi.) to the Friendsville gage (230 square mi.) along the mainstem Youghiogheny River, excluding Deep Creek catchment of 64.7 square miles.

The resulting discharge record provides a reasonable estimate of natural river inflows occurring immediately above the project tailrace. Flow exceedence values were calculated on a monthly basis to describe variation in river discharge at this location (Table 3-1). Calculated daily discharge values in the Youghiogheny River immediately above the project tailrace ranged from a low of 6 cfs to a high of 11,258 cfs over the 30-yr period of record (1960-1990).

On a seasonal basis, discharge in the Youghiogheny River is lowest in September and highest in March (Figure 3-2). High flows in the river typically occur from November to May, with highest discharges occurring during the months of February, March, and April. For median daily conditions (50 percent exceedance), discharge ranges

TABLE 3-1 Daily discharge (CFS) exceedance statistics for period of record 1960-1990. Natural discharge regime synthesized using regression (double mass) method.

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
100	17	20	64	70	70	79	103	47	22	8	8	6
95	21	43	110	86	105	171	157	92	33	18	15	10
90	34	68	141	125	156	243	228	126	54	30	22	22
75	48	124	246	206	237	410	332	194	92	59	47	32
50	80	266	436	358	416	653	552	330	167	115	84	64
25	187	488	728	652	804	1111	884	623	395	251	175	138
10	408	905	1182	1184	1529	1719	1290	1073	840	562	384	302
5	714	1219	1552	1695	2229	2200	1619	1390	1252	867	595	433
1	1638	2048	3190	2857	3762	4190	2762	2381	2286	1905	1619	1048
0	3194	11258	6788	5596	5777	10408	4774	5388	5023	6388	5933	2098

from a low of 64 cfs in September to a high of 653 cfs in March (Table 3-1). For high flow conditions (10 percent exceedance), discharges range from 302 to 1,719 cfs for these same months. For flood flow conditions (1 percent exceedance), discharges in the Youghiogheny River range from 1,048 cfs in September to 4,190 cfs in March. A seasonal low flow period typically begins in June and extends through October. Within this period, lowest river discharges occur during the months of July, August, and September. During dry conditions (90 percent exceedance), river discharge for these three months are 30, 22 and 22 cfs, respectively (Figure 3-2). During critically dry conditions (95 percent exceedance), one-day river discharges during these months drop to 18, 15, and 10 cfs, respectively.

3.1.4.2 Deep Creek Station Tailrace

Flows in the Youghiogheny River below the tailrace are augmented by water releases from Deep Creek Lake during power generation periods. During two-turbine operation, flows in the river increase by between 500 and 640 cfs. During one-turbine operation, river flows increase by between 250 and 320 cfs. The Deep Creek Project typically operates between 3 and 5 days a week. The project generated power on 70 percent of all possible days occurring from 1980 to 1990 (Figure 3-3). During this 10-year period, daily generation was most frequent during September (81 percent daily occurrence), and least frequent during November (52 percent daily occurrence). Two-turbine generation occurred far more frequently than one-turbine generation. The Deep Creek Project operated in a two-turbine mode on average from a low of 51 percent of the days in February to a high of 76 percent of the days in September. In comparison, one-turbine operation on average did not occur during the months of December, May, June, July, and August, and only reached a high of 22 percent of days during January and February.

On an annual average basis, the Deep Creek Lake watershed contributes about 100 cfs to the Youghiogheny River. Dating back

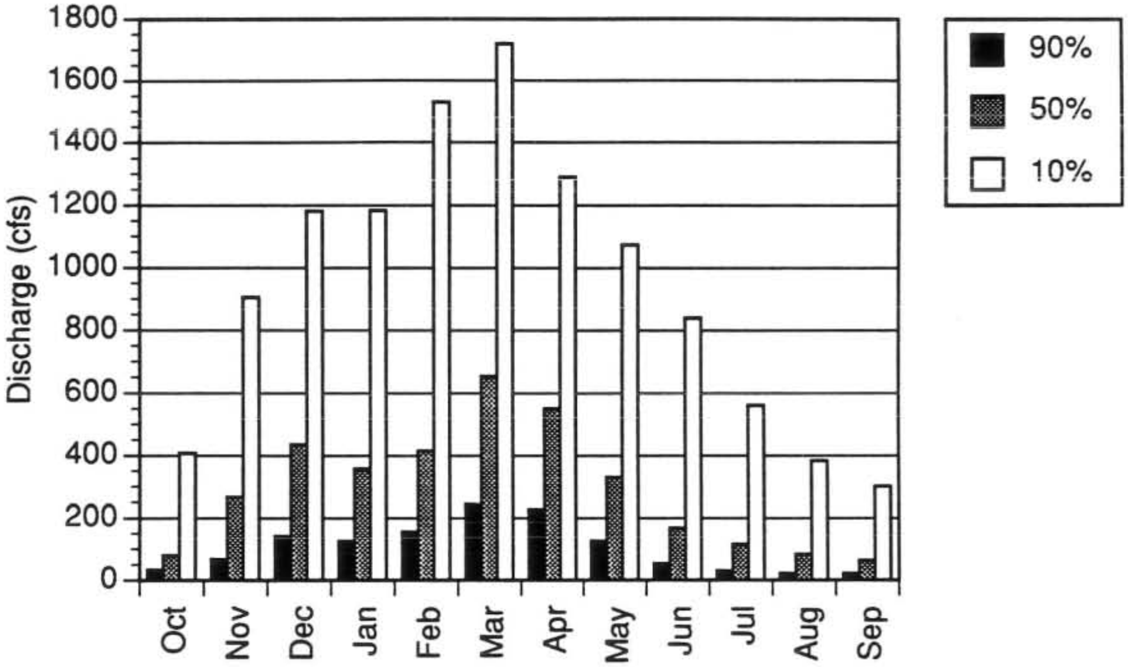


Figure 3-2. Monthly 90%, 50%, and 10% exceedance values for Youghiogheny River daily average discharges above Deep Creek tailrace, 1960 - 1990.

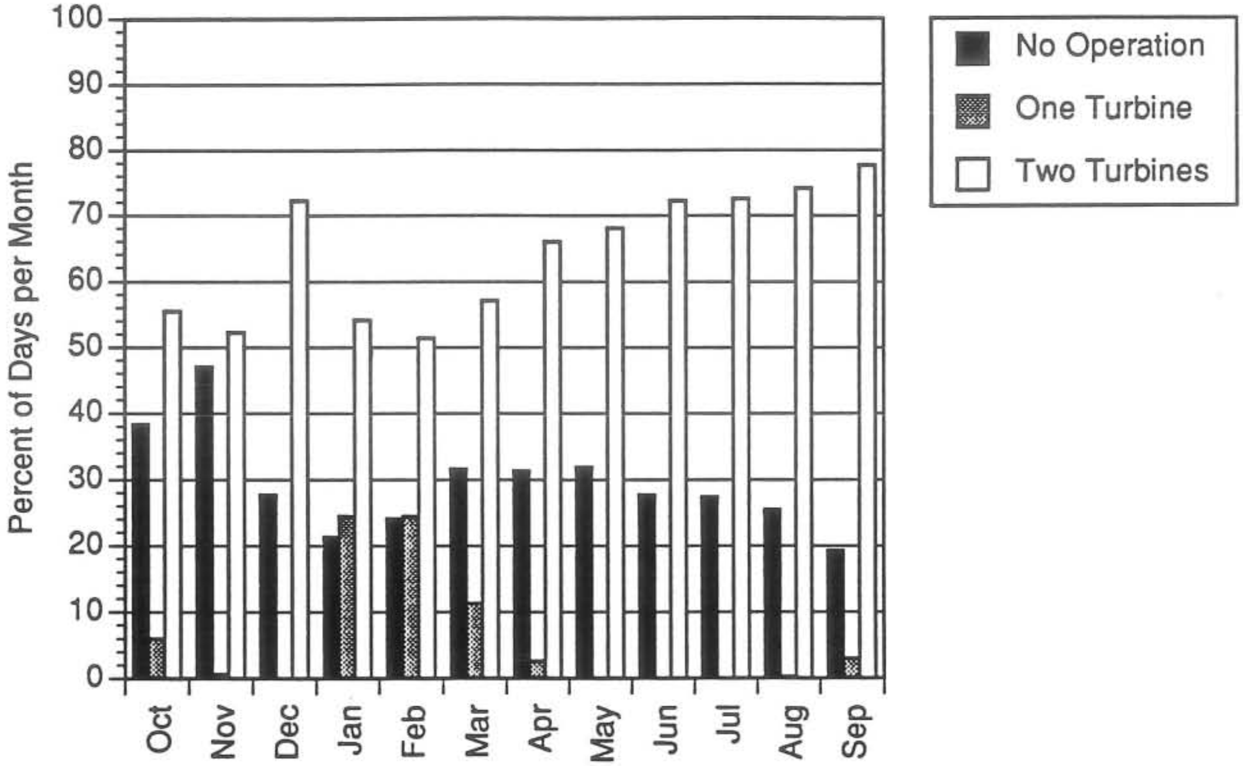


Figure 3-3. Operation record by month for Deep Creek Station, 1980 - 1990.

to 1930, average annual outflows from Deep Creek Station have varied from a low of 38 cfs in 1930-31 to a high of 151 cfs in 1985-86 (Table 3-2).

Deep Creek Station operates typically in a daily hydropeaking mode. On power generation days, water is normally released from Deep Creek Lake for 2 to 6 hours, and most frequently for 3 to 4 hours per day. However, generation may occur for up to 24 hours during periods of flooding (e.g. July of 1990), and may not occur for several weeks at a time during periods of drought (e.g. August and September of 1987). Flow over the spillway occurs very infrequently (i.e., only three times in the life of the project), as most water during high inflow periods is either stored in the reservoir or released through the powerhouse tailrace. The only spill event from 1980 to 1990 transpired during a flood in July 1990.

Deep Creek power generation substantially increases daily peak flows in the river. Median (50 percent exceedance) values for daily peak flows in the river below the tailrace range from approximately 680 cfs for August, September, and October, to 1,080 cfs for March and April (Figure 3-4). Fifty percent flow exceedance values occurring under non-generation for this same reach of the river would be approximately 80 cfs for August, September, and October, and 600 cfs for March and April (Figure 3-2). Power generation also significantly increases discharge in the river below the tailrace during higher flow conditions. Ten percent exceedance value flows for the river below the tailrace range from approximately 840 cfs in August to 2,180 cfs in February (Figure 3-4), while values for the river above the tailrace range from approximately 300 cfs in September to 1,800 cfs in March (Figure 3-2). During dry conditions, water releases from the project become infrequent. Consequently, monthly flow values for dry conditions (90 percent exceedance) in the river below the tailrace (Figure 3-4) do not change appreciably from values for the river above the tailrace (Figure 3-2).

Table 3-2. Recorded Outflows from Deep Creek Powerplant (cfs)

YEAR	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	ANNUAL
1930	9	33	56	89	97	32	46	58	11	7	6	9	38
1931	54	88	116	165	98	38	27	21	199	77	126	128	95
1932	212	180	249	222	99	5	5	7	8	3	48	124	97
1933	192	189	147	218	88	68	14	99	221	66	5	14	110
1934	83	138	80	108	144	37	44	26	32	52	143	141	86
1935	234	176	120	96	172	87	65	55	115	132	219	181	138
1936	125	148	160	144	119	33	11	7	280	212	49	64	113
1937	172	125	97	144	125	85	131	109	20	69	94	88	105
1938	153	150	193	195	126	57	4	6	5	155	143	89	106
1939	74	55	53	86	78	119	74	76	31	32	7	144	69
1940	30	113	124	114	165	143	134	183	179	107	45	8	112
1941	31	89	159	212	226	164	38	44	16	7	14	15	85
1942	36	18	99	58	54	100	197	268	276	238	135	25	125
1943	31	127	146	152	111	98	45	7	0	14	9	47	66
1944	76	142	160	153	160	154	43	136	87	113	95	92	118
1945	127	60	64	93	160	179	198	127	110	55	87	38	108
1946	66	113	111	93	89	108	39	11	68	63	41	20	69
1947	42	95	89	123	147	122	108	80	48	68	88	71	90
1948	211	171	141	118	169	133	142	165	185	64	64	56	135
1949	73	19	181	153	177	156	55	85	224	122	155	45	120
1950	132	86	83	179	200	206	209	91	69	146	28	123	129
1951	146	104	117	114	144	50	91	151	177	61	44	168	114
1952	74	82	99	145	121	90	91	59	35	92	158	117	97
1953	54	39	45	85	119	100	47	21	3	4	13	25	46
1954	14	33	67	137	173	226	234	183	71	58	71	57	110
1955	149	98	116	126	84	101	74	18	82	109	99	145	100
1956	159	95	300	170	140	134	131	182	214	105	76	36	145
1957	39	45	45	43	84	160	181	119	62	59	64	217	93
1958	71	75	96	110	70	122	104	71	86	78	55	44	82
1959	24	49	42	43	59	116	144	164	138	76	94	175	94

Table 3-2 (Cont'd). Recorded Outflows from Deep Creek Powerplant (cfs)

YEAR	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	ANNUAL
1960	113	51	149	68	77	63	49	32	34	204	226	128	100
1961	142	65	105	109	127	182	107	36	43	180	149	62	109
1962	51	71	73	60	107	143	139	50	38	186	86	68	89
1963	68	89	97	88	113	98	102	61	58	92	106	152	94
1964	84	69	69	68	65	71	103	60	99	81	123	89	82
1965	72	37	51	40	103	113	137	50	24	33	31	98	66
1966	81	73	88	63	77	88	84	43	27	64	102	265	88
1967	92	69	75	89	105	140	136	87	56	53	47	75	85
1968	174	94	82	16	89	104	114	90	61	58	50	5	78
1969	17	28	70	77	65	74	109	68	65	116	321	122	94
1970	100	115	118	96	47	46	84	112	117	334	108	56	111
1971	60	68	113	125	159	115	134	92	103	242	302	147	138
1972	99	161	151	51	0	86	282	244	78	79	297	188	143
1973	111	92	77	60	75	70	72	207	206	138	77	54	103
1974	120	169	104	102	76	68	63	121	183	209	134	146	124
1975	130	93	92	109	115	128	119	117	108	114	75	65	105
1976	68	62	38	38	86	127	123	74	100	77	93	53	78
1977	59	85	86	62	52	63	118	238	193	119	110	236	118
1978	84	148	124	75	74	72	123	164	184	346	218	87	141
1979	71	68	79	64	122	111	78	109	96	42	172	215	102
1980	207	143	160	189	34	0	23	38	58	104	114	131	100
1981	185	124	110	151	47	96	108	177	190	173	86	35	123
1982	39	80	79	101	94	64	42	39	31	54	199	204	85
1983	114	72	58	52	38	95	230	97	59	97	365	143	118
1984	46	91	188	131	112	41	64	125	109	152	75	26	97
1985	155	235	76	37	43	333	353	96	220	186	52	27	151
1986	8	113	144	186	0	0	247	174	74	24	125	70	97
1987	37	22	44	254	81	19	68	137	85	46	13	199	84
1988	42	17	37	97	81	78	86	167	188	125	50	145	93
1989	142	152	111	242	208	5	17	125	176	2	4	21	100
1990	84	346	95	87	125	115	242	212	286	40	50	91	148
1991	29	19	12	22	14	3	66	104	157	50	75	60	51
AVG.	92	96	102	109	102	96	104	98	104	99	100	95	100

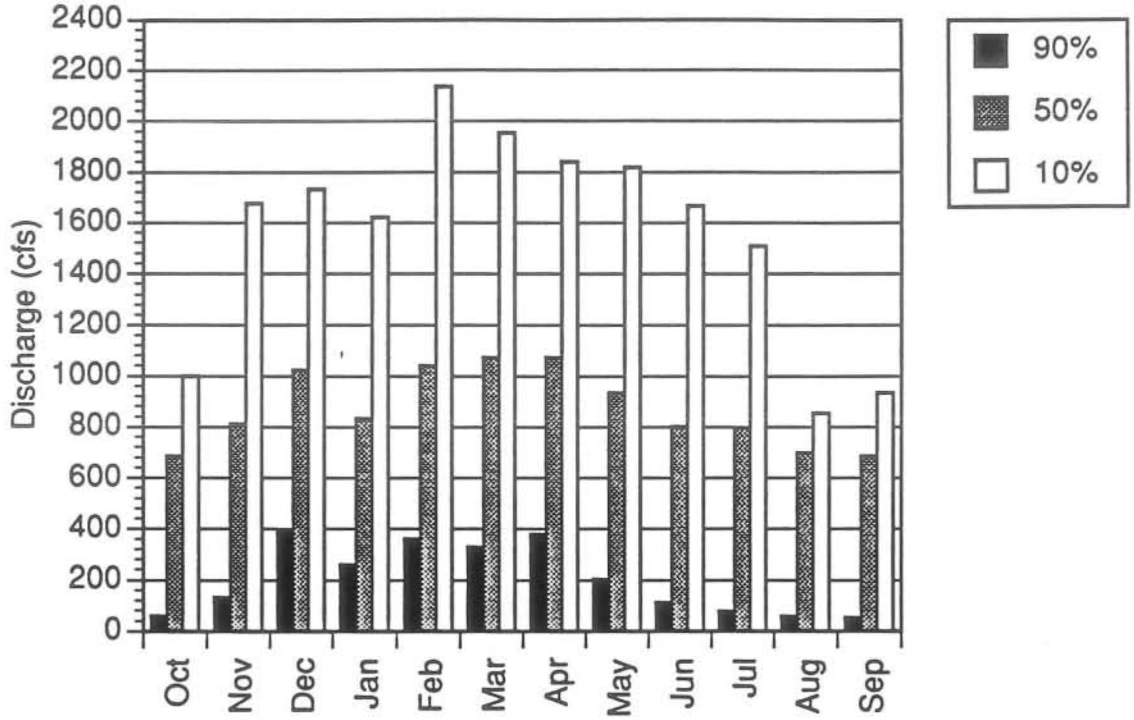


Figure 3-4. Monthly 90%, 50%, and 10% exceedance values for peak daily discharges below Deep Creek tailrace, 1980 -1990.

3.1.4.3 Deep Creek Discharge Downstream from Dam

A weir is located just downstream from the dam (see Figure 3-15) on Deep Creek. During normal operations, discharge over this weir is usually less than 1 cfs. This water originates from either groundwater or from seepage through or under the dam.

The sewage treatment plant (1/4 mile downstream from the dam) is authorized to discharge up to 600,000 gallons per day (0.9 cfs) and is currently in the process of expanding to a 1.5 million gallon per day capacity. The plant services McHenry and approximately 1/2 of the residences surrounding Deep Creek Lake, primarily along the Route 219 corridor. All other residents are on septic systems.

3.1.5 Deep Creek Lake Water Quality

Numerous studies have been conducted in the lake since 1954 (Davis 1975). Following is a summary of characteristics of Deep Creek Lake's water quality as described by Davis.

Mean pH values are typically less than 7 and mean total alkalinity (expressed as $CaCO_3$) values are usually less than 20 mg/l. Major cations and nutrient concentrations have been found to be low in both surface and bottom waters. Nitrite-N for the most part is not detectable. Nitrate-N has been found not to exceed 0.44 mg/l, and total phosphorus (PO_4-P) less than 0.04 mg/l.

Alkalinity, expressed as $CaCO_3$ ranges from 3-10 mg/l in surface waters and 4-34 mg/l in bottom waters. The highest alkalinity occurring in October and the lowest between May and July.

Surface water conductivity ranges between 50-75 mhos/cm and bottom conductivity between 54-90 mhos/cm. Conductivity values are highest between August and October and usually occur in the surface layer.

Carbon concentrations range between 1.20-10.06 mg/l for surface water and 1.20-29.16 mg/l for bottom water. Lower concentrations occur during April and July, whereas higher concentrations occur during August and October.

During most of the winter months Deep Creek Lake is ice covered. Water temperatures increase during the spring, causing turnover of surface and bottom waters at a temperature of about 8°C. By June, the water column becomes thermally stratified into three distinct layers. The upper layer, the epilimnion, typically ranges from 22 to 23°C. The mid-layer or thermocline ranges from 20-30 feet in depth and typically shows temperature fluctuations between 8°C and 25°C. The deepest layer, the hypolimnion, usually increases from a water temperature of 6°C in April to about 12°C in June. During late summer, July to October, when temperatures in the hypolimnion range between 12°C and 16°C, severe oxygen depletion (<1 ppm) occurs. According to research referenced by Davis and Flemer (1975), this can be expected during the summer months each year in Deep Creek.

3.1.6 Wetlands and Floodplains

Wetlands can have significant influence on land use. Both the State of Maryland and Garrett County have made the preservation of nontidal wetlands major components of their land preservation efforts. As a result, development near wetlands is monitored and can involve agency interaction.

Development in floodplains is also closely regulated. The Federal Emergency Management Agency (FEMA) identified areas near and including project lands that are subject to flooding. In an effort to reduce the impacts of flooding, Garrett County included guidelines for development near floodplains in its zoning ordinance for Deep Creek Lake.

3.1.6.1 Wetlands

Garrett County contains numerous wetlands locally known as "glades", "prairies", "bogs", "swamps" or "marshes". Governmental agencies such as Garrett County and the MDNR have recognized the importance wetlands play in providing wildlife habitat, controlling stormwater runoff, erosion protection, purifying water, groundwater recharge, serving as recreational resources and adding to aesthetic richness. Agencies have consequently made the preservation and enhancement of wetlands priority items.

Wetlands of Special State Concern (WSSC) have been identified by the State as being unique habitats or containing rare, threatened or endangered species (Maryland Department of Natural Resources 1989b). Nontidal WSSC wetlands throughout Maryland have been mapped by the MDNR, but because of their sensitive nature, the maps are not made available to the general public. To help protect WSSCs or other sensitive areas, any reference to them in this report will be general and specific locations and conditions will not be revealed.

A variety of wetlands are found near and within the project. The most common wetland habitat types found in the vicinity of Deep Creek Lake are lacustrine (related to lakes) wetlands and lacustrine deepwater habitats. Lacustrine wetlands are found from the edge of the shoreline to a depth in the lake of approximately six ft. (Cowardin et. al. 1979). Wetland maps produced by the MDNR indicate lacustrine wetlands along the entire margin of Deep Creek Lake. The lake bottom at depths below six ft. is considered to be lacustrine deepwater habitat.

Palustrine wetlands are nontidal wetlands dominated by trees, shrubs, lichens, emergent mosses and persistent emergents (Cowardin et. al. 1979). They are found most commonly at Deep Creek Lake near the end of coves where streams enter the lake. Isolated pockets of palustrine wetlands are also found away from the lake and streams in isolated upland wet areas. Palustrine wetlands are especially important in providing habitat for many local animals and game birds. The WSSCs adjacent to the lake are palustrine wetlands.

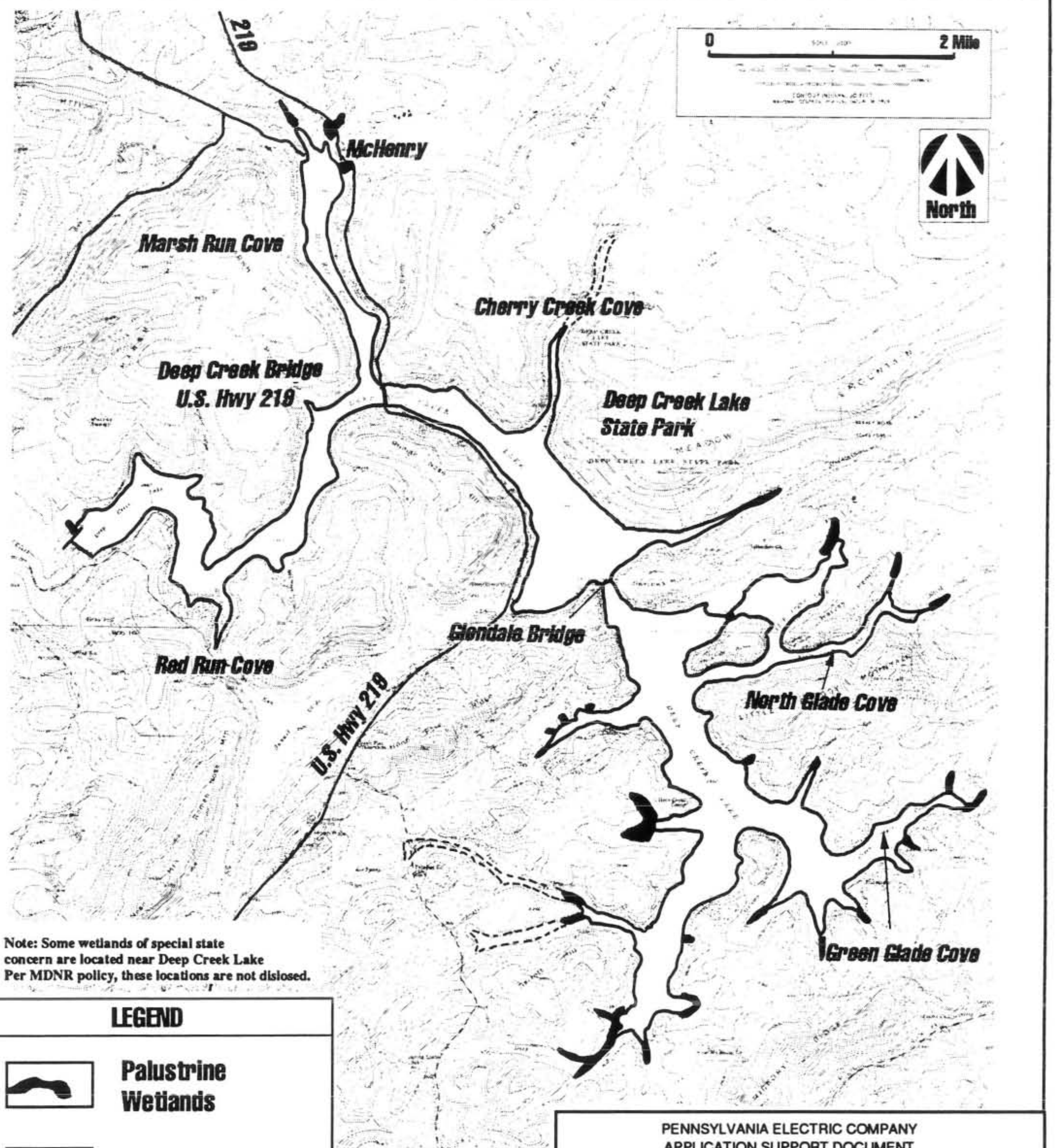
Riverine wetlands are found along the Youghiogheny river shoreline. The MDNR's Nontidal Wetlands Guidance Map series shows only one WSSC along the stretch of river between the Deep Creek/Youghiogheny River confluence and Friendsville (MDNR 1989b).

3.1.6.2 Floodplains

Most of the Deep Creek Station project land lies within a 100-year floodplain (see Figures 3-5 and 3-6). To determine the location of 100-year floodplains near the project area, Flood Insurance Rate Maps issued by the FEMA were examined. The FEMA maps locate the general areas that would be affected by a 100-year flood but do not establish base flood elevations or flood hazard factors.

Garrett County's Deep Creek Watershed Zoning Ordinance addresses floodplain issues in more detail. Through zoning ordinances, the County regulates development in floodplains by encouraging certain practices such as retaining open spaces and restricting specified land uses. The County also requires a review of proposed development that will occur within one hundred ft. of floodplains and other water sensitive areas. A major factor in the county's adherence to strict regulations in dealing with floodplain development is to ensure that the county can participate in the National Flood Insurance Program, which allows residents of qualifying jurisdictions to obtain reasonably priced insurance.

The entire shoreline of Deep Creek Lake is within FEMA's Zone A or 100 year flood area. The Zone A designation also applies to the land bordering several creeks that enter the lake, as illustrated in Figure 3-5. Zone C designates "areas of minimal flooding" and has been assigned to some low-lying land adjacent to the lake. Although the FEMA maps for Deep Creek Lake do not determine flood elevations, an approximate determination of the elevation of areas



Note: Some wetlands of special state concern are located near Deep Creek Lake Per MDNR policy, these locations are not disiosed.

LEGEND

(symbol)	**Palustrine Wetlands**
Not Shown	**Wetlands of Special State Concern**
(symbol)	**Area of 100 Yr. Flood**

SOURCE: Maryland Department of Natural Resources Non Tidal Wetlands Guidance Maps,1989 Federal Emergency Management Agency Flood Insurance Rate Map, June 5, 1985

PENNSYLVANIA ELECTRIC COMPANY
APPLICATION SUPPORT DOCUMENT
DEEP CREEK HYDROELECTRIC PROJECT

Figure 3-5
WETLANDS AND FLOODPLAINS NEAR DEEP CREEK LAKE

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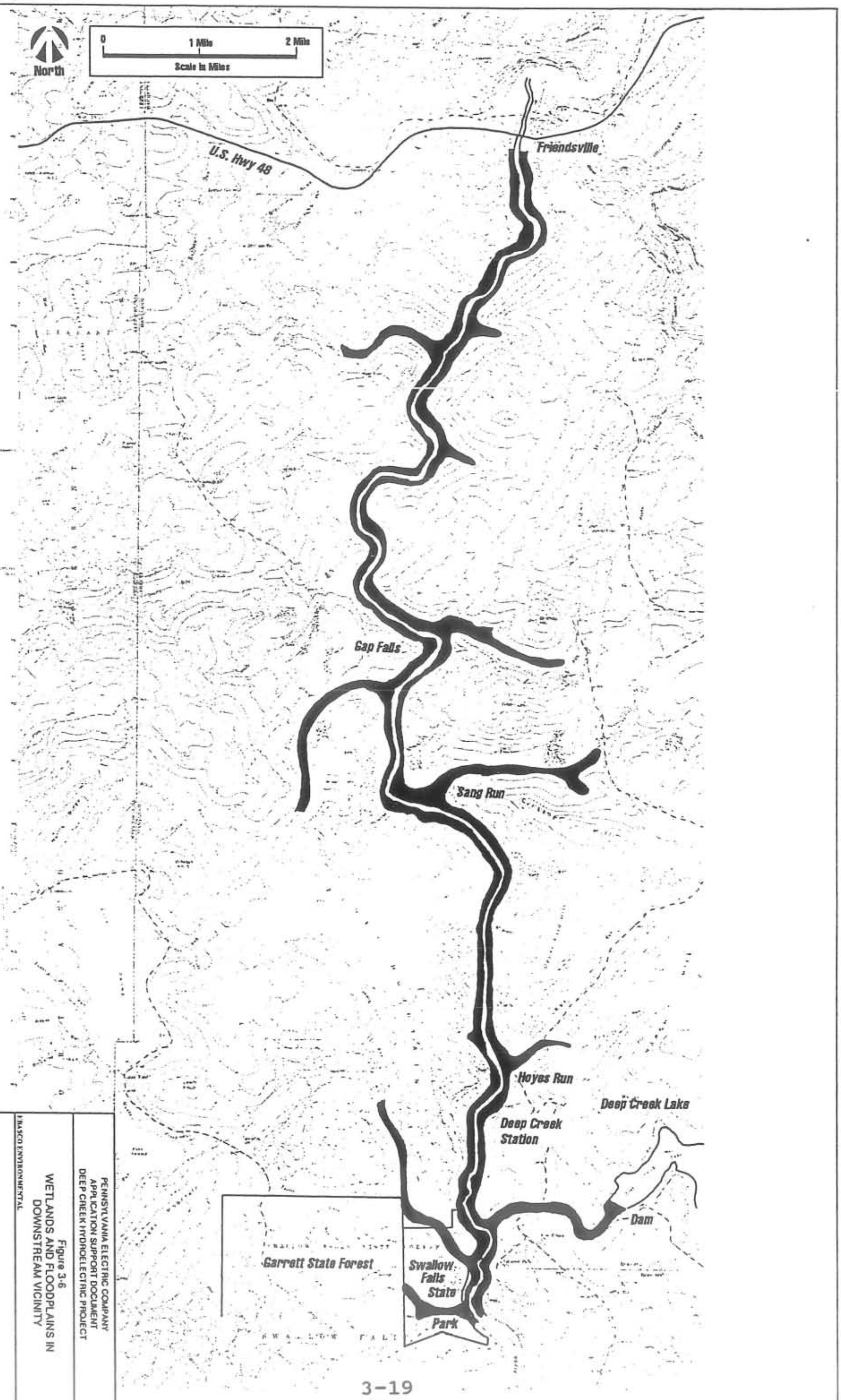

NOTE: Some wetlands of special state concern are located along the Youghiogheny River. Per MDNR policy, these locations are not disclosed.

SOURCE: Maryland Department of Natural Resources Non Tidal Wetlands Guidance Maps,1989
Federal Emergency Management Agency
Flood Insurance Rate Map, June 5, 1985

PENNSYLVANIA ELECTRIC COMPANY
APPLICATION SUPPORT DOCUMENT
DEEP CREEK HYDROELECTRIC PROJECT

Figure 3-6
WETLANDS AND FLOODPLAINS IN DOWNSTREAM VICINITY

EBASCO ENVIRONMENTAL

potentially subject to flooding can be made. All land around the lake below the spillway crest elevation of 2,462 ft. can be considered within the flood zone. In the event of a major flood that introduced enough water to overflow the spillway (this has occurred three times, in July 1949, May 1967, and July 1990), land above elevation 2,462 ft. could conceivably be inundated. Indeed, the location of the upper limit of the buffer strip at elevation 2,466 ft. (plus 25 horizontal ft.) was at least partly based on consideration of an adequate margin for maximum credible flood heights.

Much of the lower-elevation land along the Youghiogheny River shoreline is included within the 100-year floodplain. Project facilities along the river that are included within the floodplain include the powerhouse, switchyard and tailrace. Additional riverside facilities such as the white water boating put-in points near Sang Run and take-out locations near Friendsville are also within the 100-year floodplain.

Although the Deep Creek Project was not designed for flood control, it has reduced flooding to some extent along the Youghiogheny River. Because the lake impounds water at the beginning of the high flow season, the river is not normally affected by unusually high runoff (Penelec 1963).

3.1.7 Vegetative Cover

Mountains within the Youghiogheny River Basin are generally covered in thick forest. Forests within the Youghiogheny River and Deep Creek Lake area are predominantly northern hardwoods such as oak, beech, birch, maple, hickory, and ash species. White pine is also common, and eastern hemlock, great laurel, and mountain laurel are commonly observed in hollows and along stream and river valleys. Except for several virgin stands of eastern hemlock and white pine, most of the Youghiogheny River corridor area was clear-cut during the period from 1900 to 1920. More recent logging activity has included clear cutting along 2 miles (3.2 km) of the west side of the Youghiogheny opposite Hoyes Run.

In addition to northern hardwoods, numerous mountain bogs drain portions of the watershed. One of these, Cranesville Swamp near Swallow Falls, has been designated as a National Natural Landmark for its exceptional value as an illustration of North America's glacial past.

Scattered among the forested mountains and open valleys of the watershed are a number of farms. Forested, shrub scrub, and emergent wetlands occur in most of the low lying areas, including Deep Creek Lake and along the Youghiogheny River. Much of the Deep Creek Lake shoreline consists of expansive lawns associated with the single- and multi-family dwellings.

3.2 LAND USE AND ZONING

This section describes current land use, ownership patterns and locally significant wetlands and floodplains. Existing shoreline facilities and current development policies concerning project shorelines are also examined, along with relevant comprehensive and other plans and the project's consistency with those plans.

3.2.1 Existing Land Ownership and Use

Land use and ownership surrounding Deep Creek Lake and in the Youghiogheny River corridor are mixed. The vast majority of land in both areas is privately owned. Penelec has retained ownership of a significant amount of land near Deep Creek Lake, which includes a shoreline buffer strip around the lake and property along parts of the river near the Deep Creek Project powerhouse. Another major landowner in the area is the State of Maryland. The State owns large tracts of land that have been designated as state parks and forests.

3.2.1.1 Deep Creek Lake Area

Land use around Deep Creek Lake is varied with about 70 percent forest, 25 percent agricultural, and 5 percent developed. The rural character and use of lands bordering the lake and highways leading to it has changed in the past 20 years as a result of the area's popularity as a vacation and recreation destination. Development pressure has been particularly strong in recent years. More than 3000 permanent and vacation homes are clustered in the lake district, in addition to numerous hotels and condominiums. In 1984, the Deep Creek Sewage System began servicing the lake district development. The Wastewater Treatment Plant (WWTP) for the system is located on Deep Creek below the dam.

Land ownership and use patterns in the Deep Creek Lake area have been strongly influenced by the development history of the Deep Creek Project. In the mid-1920s the Youghiogheny Hydro-Electric Corporation completed the purchase of almost 7,000 acres of farm land for what was to become the Deep Creek Project. The dam was completed in 1925 and power generation started the same year. The Youghiogheny Hydro-Electric Corporation owned the project until 1942 when it was sold to Penelec. In the 1960s, Penelec sold much of the land above the lake's buffer strip to private interests. This was followed by development of the land for permanent and vacation homes.

The areas adjacent to Penelec's land and Deep Creek Project lands contain a variety of land uses. The dominant land use around Deep Creek Lake is residential. Areas of single family dwellings used as primary residences or second homes are the most common residential land use near the lake. Garrett County determined that in 1980 the lake planning area contained 560 primary housing units and 1,970 second homes. Current zoning could allow as many as 9,900 to 15,000 more housing units to be built in the Deep Creek Lake area (URDC 1988). Most of the existing single family residences are located adjacent to or very close to Penelec's buffer strip, although there are some large developments of single family residences away from the lake. Most single family residences around the lake are on parcels of at least one acre in area so the overall residential density is relatively low. Further, most parcels are clustered together where large tracts of land have been subdivided.

Higher-density residential areas, including multi-family dwellings, are found primarily in the developing "town" centers of McHenry and Thayerville. In addition to multi-family residential, the "towns" contain commercial, single family, church, restaurant, office and commercial recreational land uses. Much of the residential growth in the Deep Creek Lake area since 1987 occurred with the development of townhouses and condominiums in and near McHenry and Thayerville.

Recent development near Deep Creek Lake has resulted in considerable conversion of land to residential and commercial uses. Despite the recent rapid growth, several large parcels of undeveloped land adjacent to the lake still exist. Privately held areas of the lake that have relatively significant amounts of undeveloped shoreline and upland areas include:

- The shoreline beyond the end of Marsh Hill Road at the north end of the lake,
- The shoreline south of North Glade Cove,
- The shoreline west of Shalmar road near Holy Cross Road, in the southern section of the lake.

The largest and most significant parcel of remaining undeveloped land is Deep Creek State Park with its approximately 4,700 lineal ft. of shoreline and 1,775 upland acres. Most of the park is still in its natural state and provides a visual contrast to more developed sections of the lake. The areas of the park that are developed cater to both day and overnight users. There are 112 campsites located within the park.

3.2.1.2 Youghiogheny River Area

The downstream section of the project differs significantly from the lake area in land use and ownership. Land use is much less intensive in the river corridor and development has been limited by terrain, access and jurisdictional constraints.

The reach of the Youghiogheny River examined in this report is part of a larger reach that was designated in 1971 as a state wild river. Over 95 percent of the land in the wild river corridor was privately owned in the mid-1970s (U.S. Congress 1979). Exceptions at that time included several segments of Garrett State Forest located within a mile of the river and the river itself. The State of Maryland owns river beds, but recognizes landowners who hold title to riparian land from patents issued prior to March 3, 1862 as also having an ownership interest in the river bed. The public retains the rights to fish and navigate rivers in Maryland (U.S. Congress 1979). The State of Maryland has recently been acquiring lands from willing sellers within the designated river corridor and now owns about half the corridor acreage (Maryland Department of Natural Resources, 1991).

Despite the high percentage of privately held land, little development has occurred in the area near the river (General Accounting Office 1986). Commercial and industrial land uses are prohibited and residential development must be set back a minimum of 300 ft. from the river. Minimum lot sizes are most commonly 10 acres (although in more remote and rugged locations can be 5 acres) (General Accounting Office 1986).

According to several studies, the Youghiogheny River corridor is expected to have greater development pressure for second homes (General Accounting Office 1986, U.S. Congress 1979). The U.S.

Congress study predicted that 300 residences would exist in the wild river corridor by 1990. The study pointed out the possibility that a total of up to 1,200 residences could exist near the Youghiogheny River under 1979 zoning regulations.

Mining and logging seriously impacted the river corridor in the past, and mining was specifically prohibited in the scenic corridor when the wild river designation was made. Logging was allowed in the corridor, but only after the Maryland Department of Natural Resources (MDNR) reviewed and approved of individual operations (General Accounting Office 1986). However, unauthorized logging has occurred. In 1984 a logger sued the State to allow him to log without a MDNR permit and won. The State did not appeal and there have been reports of additional unauthorized logging in the corridor since the trial (General Accounting Office 1986).

In addition to logging operations, there have and continue to be strip mines operating in the corridor. Because of the difficulty the State had in regulating the corridor, it reduced the size of the corridor by 50 percent between 1978 and 1986 in an effort to make it more manageable. After 1984, management emphasis changed from relying on land use regulations to preserve the scenic corridor to a more aggressive policy of acquiring land and scenic easements (General Accounting Office 1986).

3.2.2 Garrett County Zoning

Planning in Garrett County is currently done on a county-wide basis and will eventually also be done for component areas of the county. The county-wide plan now in use (the Development Plan for Garrett County) was adopted in 1974.

The only area plan and zoning ordinance currently in place in Garrett County is for the Deep Creek Lake area. The current lake area plan was updated and adopted in July 1986. The plan provides the legal basis for the Deep Creek Watershed Zoning Ordinance (Garrett County Planning Commission 1986).

The Deep Creek Lake planning area is delineated by the boundaries of the Deep Creek Lake watershed and encompasses all of the watershed's 64.7 square miles. Project lands and facilities that fall within the geographic scope of the plan include the lake bottom, the buffer zone, the dam, the intake facilities, and the surge tank. Penelec's lands near the powerhouse are outside of the watershed and thus not addressed by the lake area plan.

An important role of the Deep Creek Lake plan was to establish a series of planning goal statements. The statements reflect community values and attitudes concerning future development in the watershed. Among the land development oriented goal statements that are included in the plan, several general themes emerged that are of significance to the Deep Creek Project.

Several goal statements identified conservation of the lake's scenic attributes and natural areas as being important planning objectives. Controlling development to insure compatibility with existing conditions was deemed necessary. The plan recognized the importance of recreation to the Deep Creek Lake area.

The Deep Creek Watershed Zoning Ordinance established zoning districts within the watershed area (see Figure 3-7). Lake Residential (LR) is the most pervasive zoning district and is the district under which most project lands are zoned. The LR designation limits residential development to a low average density. It also allows land-based, privately owned and operated, family-oriented recreational facilities as special exceptions.

Some of the project buffer strip lands are adjacent to areas designated as Town Residential (TR) and Town Center (TC). This occurs along the north end of Marsh Run Cove near McHenry and on the main body of the lake near Thayerville. The TR zone allows

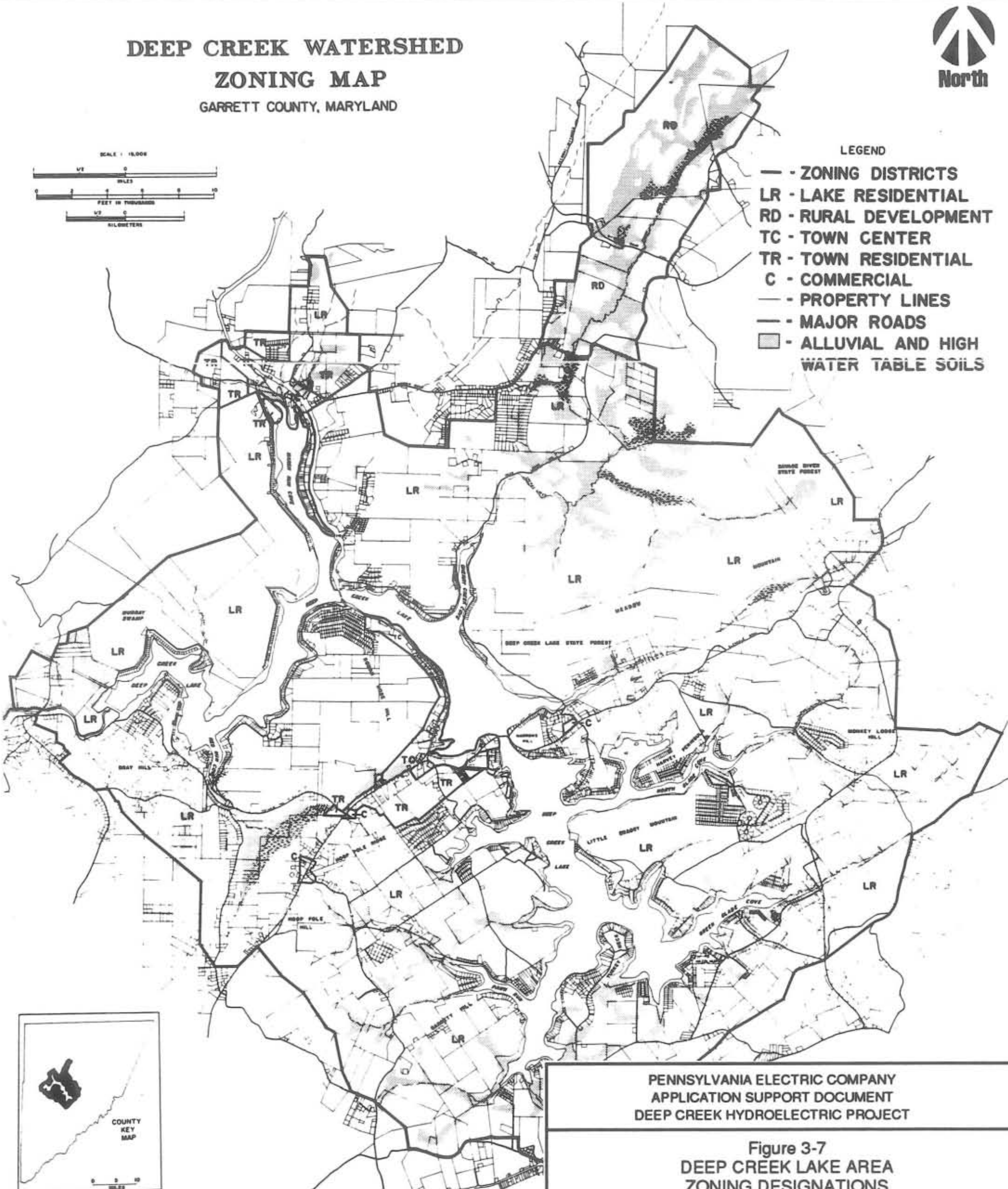

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Figure 3-7
DEEP CREEK LAKE AREA
ZONING DESIGNATIONS

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SOURCE: Garrett County Planning Commission, 1987.

higher density development where sewage facilities exist or may exist. The TC designation consists of the town or village "core" and allows a mixture of residential, commercial and public service uses.

There are several other land use designations within the Deep Creek watershed area. The Rural Development (RD) classification is the broadest and includes much of the land outside of the watershed in the rest of Garrett County. It allows almost any kind of land use except for activities prohibited by the State or County because they pose health or safety risks. Commercial Districts (C) are located outside of town and village areas in several small locations and do not allow residential use.

Two additional zoning classifications are defined in the watershed zoning ordinance, but are not used at present. The Suburban Residential district will allow suburban-type residential subdivisions of moderate density near towns, villages, and other areas where there are no central sewage treatment facilities. The other classification is the Employment Center district, in which manufacturing operations will be permitted.

3.2.3 Shoreline Buffer Strip

Penelec owns the submerged land under Deep Creek Lake and a buffer strip which encircles the lake. The buffer strip is defined to include all project land lying between the current survey boundary of the Deep Creek Lake project and the waters of the lake.

The primary purpose of the buffer strip is to protect shoreline resources and preserve use of the buffer strip for the general public. The general public is granted the right to walk along and fish from any section of the buffer strip. Uses that are not allowed (except in designated areas) on the buffer strip include camping, picnicking, swimming, beaching boats, driving vehicles or bicycles and building fires. Other uses of the buffer strip and lake are authorized by permit.

3.2.4 Consistency With Comprehensive Plan

Deep Creek Lake and the Youghiogheny River are valuable regional resources and have attracted the interests of a number of governmental agencies and organizations. Different organizations have different interests and jurisdictions in the lake and river and have formulated a variety of plans.

There is one comprehensive state plan for Maryland that is relevant to the project:

- Maryland Recreation and Open Space Plan, Report V: Strategy and Summary, 1983.

Maryland Recreation and Open Space Plan, Report V: Strategy and Summary, 1983

The 1983 recreation and open space plan was updated and renamed in 1989 (Maryland Office of Planning 1989). The new title, Maryland Land Preservation and Recreation Plan reflects the broader spectrum of issues addressed by the updated plan. In addition to the recreational and open space issues covered in the 1983 plan, the updated plan addresses land preservation issues. In view of the recent update, only the 1989 plan is discussed below.

The purpose of the plan in regards to land preservation and open space is to formulate policies and recommendations that help the State protect and improve the Chesapeake Bay, productive forest land, prime agricultural land, wildlife habitat, stream valleys and other unique and endangered biota or natural resources. The plan emphasizes the state's recreational goal of providing recreational opportunities throughout Maryland. The plan recommends and formulates policies for providing recreational land and facilities for communities. It also guides State and local programs involved in planning and acquiring outdoor recreation areas and directs State investment of funds used in acquiring those areas.

An important component of the plan is its inventory and assessment of recreational resources across the state. Each resource is examined in regards to its existing conditions. Future steps that need to be taken to preserve the resource and meet recreational needs are then presented.

The plan concludes by offering nine general policies and recommendations. The policies and recommendations are prioritized into groups of top, high and moderate priority. The general policies and recommendations that have the most applicability to the Deep Creek Project are the following:

1. Preserve land for recreation and open space (high priority),

2. Preserve natural areas, stream valleys, and fish and wildlife habitats (high priority),

3. Develop and maintain recreational facilities to satisfy growing demands (moderate priority).

The Deep Creek Project helps meet the first policy by preserving the lake buffer strip and land adjacent to the powerhouse near Deep Creek and the Youghiogheny River. The second policy would be observed by not developing facilities near sensitive areas and by considering benefits to fish and wildlife in project operations. The objectives of the third policy would be met by maintaining the buffer strip, and helping to assess and meet recreational needs in the area.

The Maryland Land Preservation and Recreation Plan contains two supporting addenda that are relevant to the project. They are:

Natural Areas Preservation - prepared by the Office of Planning. The report inventories and examines the impact of development on several state resources, including the Chesapeake Bay, forest lands, agricultural lands and natural areas. Both governmental and private preservation programs are examined and recommendations concerning various preservation measures are made. The report identified numerous natural areas and recommended 10 as having the highest priority for acquisition. A document to be released by the Maryland Scenic and Wild River Program, titled The Youghiogheny Scenic and Wild River Study and Management Plan, would contain updated information concerning sensitive areas found near the Youghiogheny (letter from Ronald D. Leonard, Maryland Department of Natural Resources, Forest, Park & Wildlife Service, Annapolis, Maryland, April 10, 1991).

State Wetlands Priority Plan - prepared by the Department of Natural Resources (1988). The report was created as a result of the Federal Emergency Wetlands Act of 1986. The Act requires states to append or revise their Statewide Comprehensive Outdoor Recreation Plans (SCORP) to address wetlands as recreational resources. An inventory of state wetlands, documentation concerning the loss of wetlands and a review of existing wetlands programs and agencies concerned with wetlands were included in the report. Recommendations intended to stem the loss and degradation of wetlands were made. The recommendation most relevant to the Deep Creek Project pointed out that, unlike tidal wetlands, nontidal wetlands are not well protected and more emphasis must be placed on protecting them. As a result of the generally unprotected status of nontidal wetlands, the state has embarked upon an acquisition program to acquire and protect more non-tidal wetlands.

Wetlands near Deep Creek Lake and the Youghiogheny River have been identified by the MDNR as wetlands of special State concern. A variety of State agencies administer development permit and review programs (e.g., water quality certification, waterway construction permit) that provide some degree of protection for wetlands.

3.3 AESTHETICS

This section presents a regional overview of aesthetic conditions and discusses aesthetic resources and conditions near Deep Creek Lake and the Youghiogheny River. Project facilities and operations have some effects on aesthetic resources, and are reviewed in Section 3.3.2.

Several techniques were used to evaluate aesthetic resources and the effect of project works and operations on those resources. To evaluate existing resources, field observations were conducted in the fall of 1989 and the summer and fall of 1990. Photographs and videotapes were taken to catalog existing conditions and views. Pertinent technical and popular literature were reviewed to identify important aesthetic resources in the region and for specific areas. User group interviews were conducted in the summer of 1990 to identify the impact of project operations on local aesthetic resources.

3.3.1 Existing Aesthetic Resources

The Deep Creek Lake area and the Youghiogheny River corridor have outstanding regional aesthetic appeal. The rural and natural setting of Deep Creek Lake make it a popular holiday destination for the Mid-Atlantic region. Garrett County realized and acknowledged the importance of the area's aesthetic qualities when it adopted A Plan for the Deep Creek Lake Area. A number of the plan's stated goals mention the importance of maintaining and protecting the area's scenic and aesthetic resources. The aesthetic qualities of the Youghiogheny River are likewise important to its value as a recreation resource. Studies of the river when it was being considered for nomination as a state and national wild and scenic river all mentioned its outstanding scenic qualities.

3.3.1.1 Regional Overview

Deep Creek Lake is located along the edge of the Allegheny Plateau region of the Appalachian physiographic province. The Alleghenies are geologically old, estimated to have been in existence from 95 to 200 million years. Years of erosion have worn away the ancient mountain tops so that now the mountain forms are gentle and rounded. Backbone Mountain is the highest mountain in the Maryland section of the Alleghenies and at an elevation of 3,360 ft. is the highest point in Maryland. It is located approximately 17 miles southwest of Deep Creek Lake.

Flowing through the Alleghenies are numerous river and stream valleys. The rivers and streams have carved some rugged gorges and ravines in the region. They are characterized by cliffs, steep slopes, and jumbled, boulder-filled stream and river beds. The mountains, along with the steep gorges and cliffs of the river valleys, are the dominant landscape features in the region.

The mountains in the project area are in most places covered in thick forest. With the exception of some clearcuts near Hoyes Run, large scale logging has not occurred in the area since the 1920s (U.S. Congress 1979). As a result, trees have had 70 or more years to mature, and many areas near the project have acquired a pristine character.

Scattered among the forested mountains and open valleys are farms, residences, small communities, roads and other landscape features influenced by human activity. The natural and man-made features form a mosaic of landscape types throughout the region. Most of the landscape surrounding Deep Creek Lake has a rural or residential character, while the predominant character of the Youghiogheny River corridor is natural and pristine.

3.3.1.2 Deep Creek Lake Area

Deep Creek Lake extends up the sinuous Deep Creek valley 9 miles from the dam. The section of lake north of the Glendale bridge is surrounded by rolling hills extending up to 350 ft. above the lake with slopes as steep as 20 percent. Most of the hillsides are covered with thick, predominantly deciduous forest. With the exception of forest clearings created for agricultural or other uses, the hillsides ringing the northern part of lake have a natural, undisturbed appearance. The shoreline of the northern part of the lake is on the other hand, generally developed. Single-and multi-family dwellings line much of the shoreline. The manicured landscaping, expansive lawns and docks create an almost suburban character in sections of the lake. The commercial area of McHenry has a small town atmosphere. Scattered between the residentially developed shoreline and commercial area of McHenry remain undeveloped parcels of property. The undeveloped areas still retain an undisturbed, natural character.

The lake south of the Glendale bridge is surrounded by gentler terrain. Coves in the southern section typically end in shallow valley bottoms. Much of the terrain in the southern section is forested with primarily deciduous forests. However, more forest has been cleared in the southern section than in the northern section for agricultural use and residential development. The sections of shoreline with the most densely developed residential areas include Beckmans Point, North Glade Cove and Green Glade Cove. These areas have a suburban character as a result of their relatively dense development and manicured landscaping.

Due to the twisting lake body and hilly topography around the lake, distant views from the lake surface are limited. From most locations on the lake, views of other parts of the lake are restricted. As a result, most views are what would be considered middle ground views of ½ to 5 miles in distance (U.S. Forest Service [USFS] 1973). Because of the relatively low topography around the lake, middle distance views are not dominated by high terrain. Instead, views are composed of four elements -- the sky, the vegetation bordering the lake, the shoreline, and the water surface (see Figure 3-8). Of the four visual elements, the fluctuating shoreline and its visual character is the element most influenced by lake management practices.

3.3.1.3 Youghiogheny River Area

The landscape character of the Youghiogheny River portion of the study area is characterized by a steep, narrow river canyon thickly covered in forest. The dominant landscape element is the 'V' shaped canyon itself. From the river, slopes as steep as 50 percent lead to the canyon rim. In some places the rim is as high as 500 ft. above the river, at elevations approaching 2600 ft. above mean sea level. The steep slopes are covered with mature, primarily deciduous trees.

The section of canyon where Deep Creek flows into the Youghiogheny River is steep and largely unmodified. Closer to Hoyes Run the canyon opens up to the east and changes in character from natural to rural due to nearby residences. Between Hoyes Run and Gap Falls the canyon narrows and again becomes predominately natural, despite passing several residences and a bridge near Sang Run. Below Gap Falls the canyon narrows even more and passes very steep slopes and bluffs. Just upriver from Friendsville the canyon opens to a ¼- to ½-mile wide alluvial plain.

The character of the river changes with location and time. As the river passes Deep Creek it drops quickly over a boulder strewn bed to just upriver of Hoyes Run. From Hoyes Run to Gap Falls the river flattens out to a relatively gentle gradient of ten ft. per mile (U.S. Congress 1979). This slowest-moving section of river

Figure 3-8. Typical lake view composition.

quickly changes in character when it reaches Gap Falls. The river between Gap Falls and Kendall Run is the steepest stretch of river in the entire state and drops as much as 100 ft. per mile (U.S. Congress 1979). Beyond Kendall Run the river becomes calmer, and by the time it enters Friendsville is relatively gentle most of the year.

The character of the river also changes during the year. In the spring, natural flows from the Youghiogheny and its tributaries create spectacular whitewater displays. During high flows, the entire river channel is filled and many whitewater features can be observed. As the summer progresses, natural flows decrease and the quality and quantity of whitewater features generally declines. Releases from the Deep Creek Project during the summer periodically increase river flow and whitewater features for short periods of time.

Potential river viewers include people using the river such as fishermen, whitewater boaters or property owners. The most accessible viewing location for people not boating the river is Sang Run. It has been selected to represent the river's visual characteristics and evaluate the effects of operations and proposed enhancement measures on the aesthetic qualities of the river.

The Sang Run bridge offers views extending approximately 3/4 mile upstream and 1/4 mile downstream. Several residences and the thick forest that lines the river banks are visible from the bridge. Modification of the natural landscape is limited to these residences, the road and bridge, several cleared fields on the valley bottom, and two small eroded areas along the right bank where whitewater boaters access the river. The predominant visual element from the bridge is the broad, relatively placid river which dominates the view. Figure 3-9 illustrates the views from the Sang Run bridge.

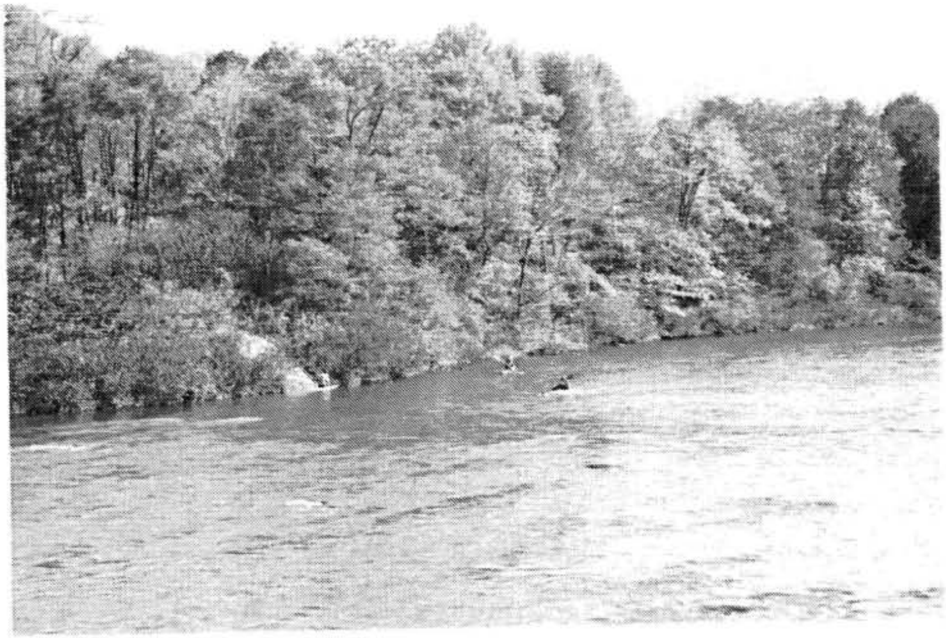

Photo 1. View southwest (upstream) from Sang Run Bridge.

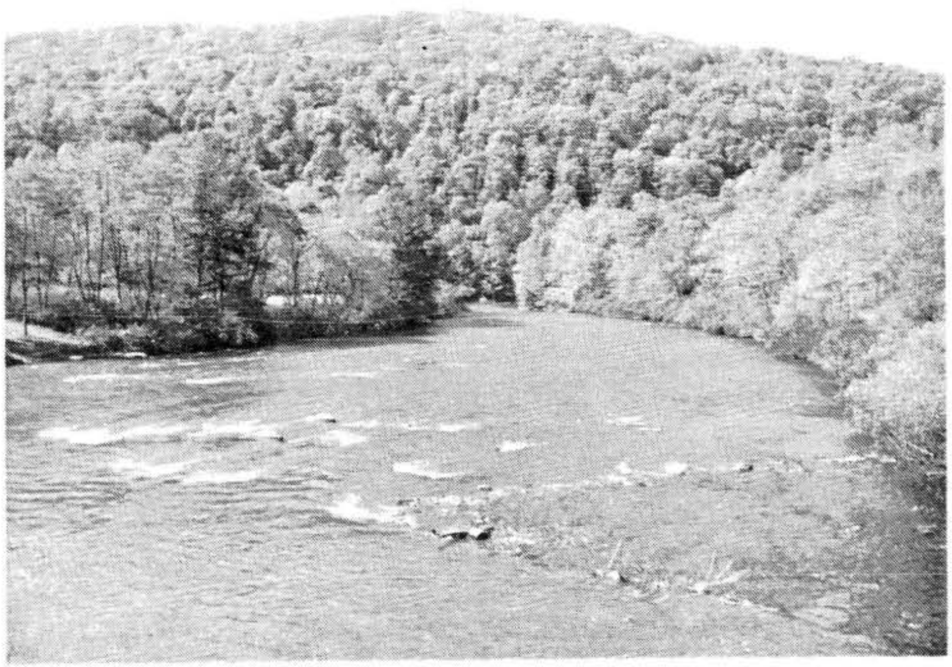

Photo 2. View northwest (downstream) from Sang Run Bridge.

Figure 3-9. Views From Sang Run Bridge.

3.3.2 Project Influence on Aesthetics

The project's influence on aesthetic resources is varied. Project works have relatively little impact on the lake or river, while operations have some effect on both. The following sections discuss the project's aesthetic influence on the lake and river in greater detail.

3.3.2.1 Visibility of Project Works

The project works that are part of the Deep Creek Project do not create a major visual impact on the surrounding area. The dam and other project facilities are located in a sharp bend of the Deep Creek valley. Because of the hilly terrain, these facilities are visually isolated from the remainder of the lake. The dam, spillway, and intake are only visible to a very small area below and adjacent to the dam (see Figure 3-10). From the lake side of the dam, project facilities are visible on the lake from approximately 1 mile away and on two local secondary roads. They are also visible between breaks in the trees that cover the hillsides above this section of lake.

The majority of the earth-filled dam is planted in grass and the shoreline is composed of riprap. The top of the dam is at an elevation of 2,475 ft., which is from 13 to 21 ft. above the lake water level depending upon the time of the year. The dam creates a long, low horizontal form above the lake surface to viewers on the water or shoreline. Although the texture of the grass and riprap is different than that of the adjacent water, it is not dissimilar at a distance from the background vegetation. The dark color of the riprap material also helps to reduce the dam's visual contrast when viewed from a distance. Water level plays an important role in the area of dam that can be viewed. Thus the visual impact of the dam on the small adjacent section of Deep Creek Lake is to an extent dependent upon lake elevation.

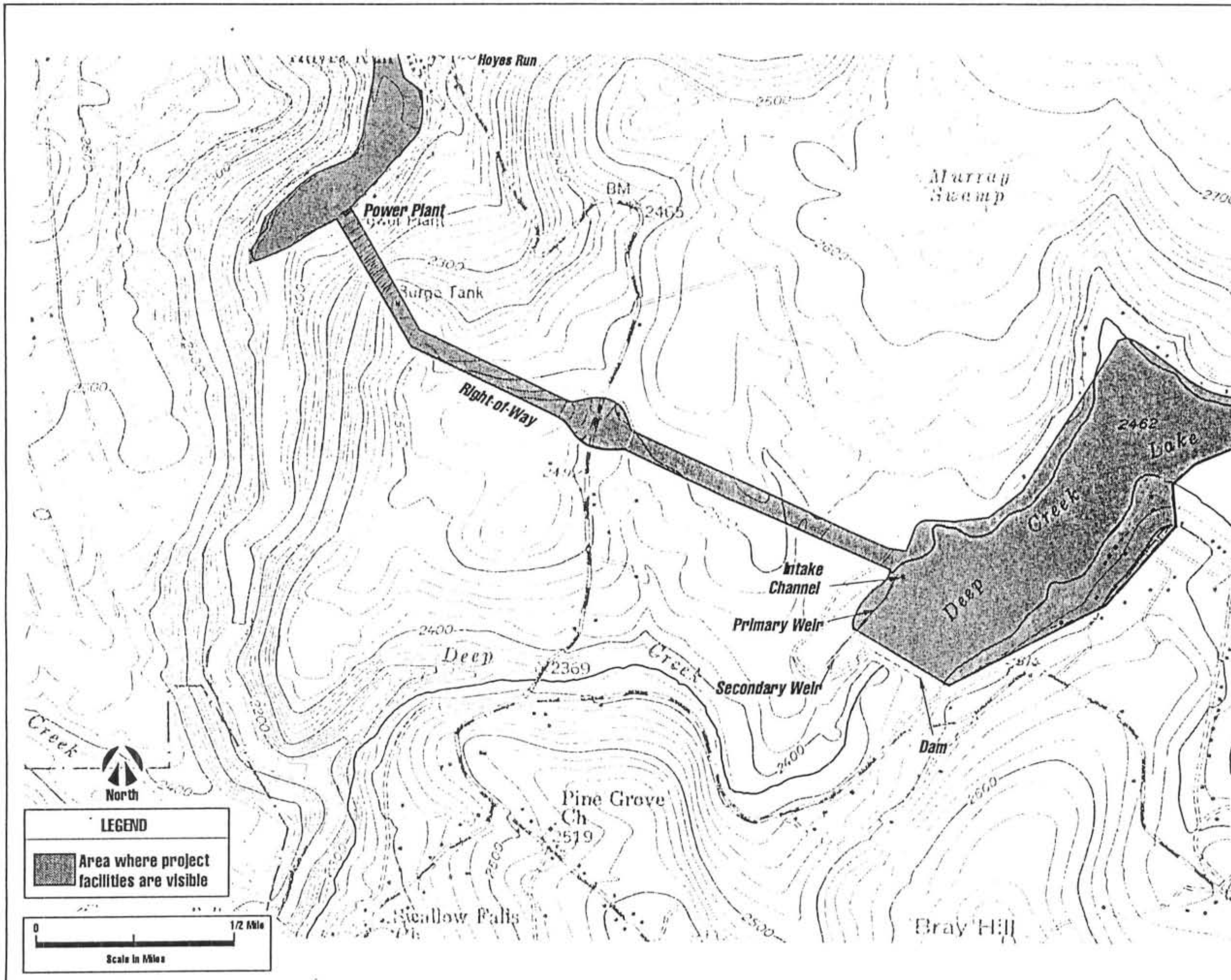

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Figure 3-10
PROJECT FACILITY VIEWSHED

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The spillway to the west of the dam is 720 ft. long and is more visually intrusive than the dam. The light color and smooth texture of the concrete used for the spillway contrasts sharply with the dark fill below it and the dark vegetation behind it. The intake structure introduces a contrasting vertical element to the strongly horizontal form of the side channel lakeshore. The blue color of the metal members of the gate structure contrast in color with the surrounding scene.

The section of the lake where the dam is located is not one of the more heavily used parts of the lake (URDC 1988). Compared to most parts of the lake, a relatively small number of users venture into the section of the lake from where the dam is visible. The downstream face of the dam is visible to an even smaller area that consists of the area immediately to the south.

Between the intake structure and the powerhouse located near the Youghiogheny River is approximately 7,900 linear ft. of pipeline right-of-way. The approximately 100 ft.-wide right-of-way has been cleared of all trees. The clearing of trees and the straight layout of the right-of-way contrasts with the surrounding natural woodlands and rolling terrain. However, locations where the right-of-way is visible to the general public are relatively few. The greatest number of viewers see the right-of-way as they pass it on the Oakland-Sang Run Road. The second area where the public can see the right-of-way is from the Youghiogheny River near Hoyes Run.

Upstream of the confluence of Hoyes Run and the Youghiogheny River is the four-story powerhouse and the associated switchyard. Neither can be clearly seen from the river and neither is visible beyond the immediate surroundings. At present, few people use the area near the powerhouse facilities.

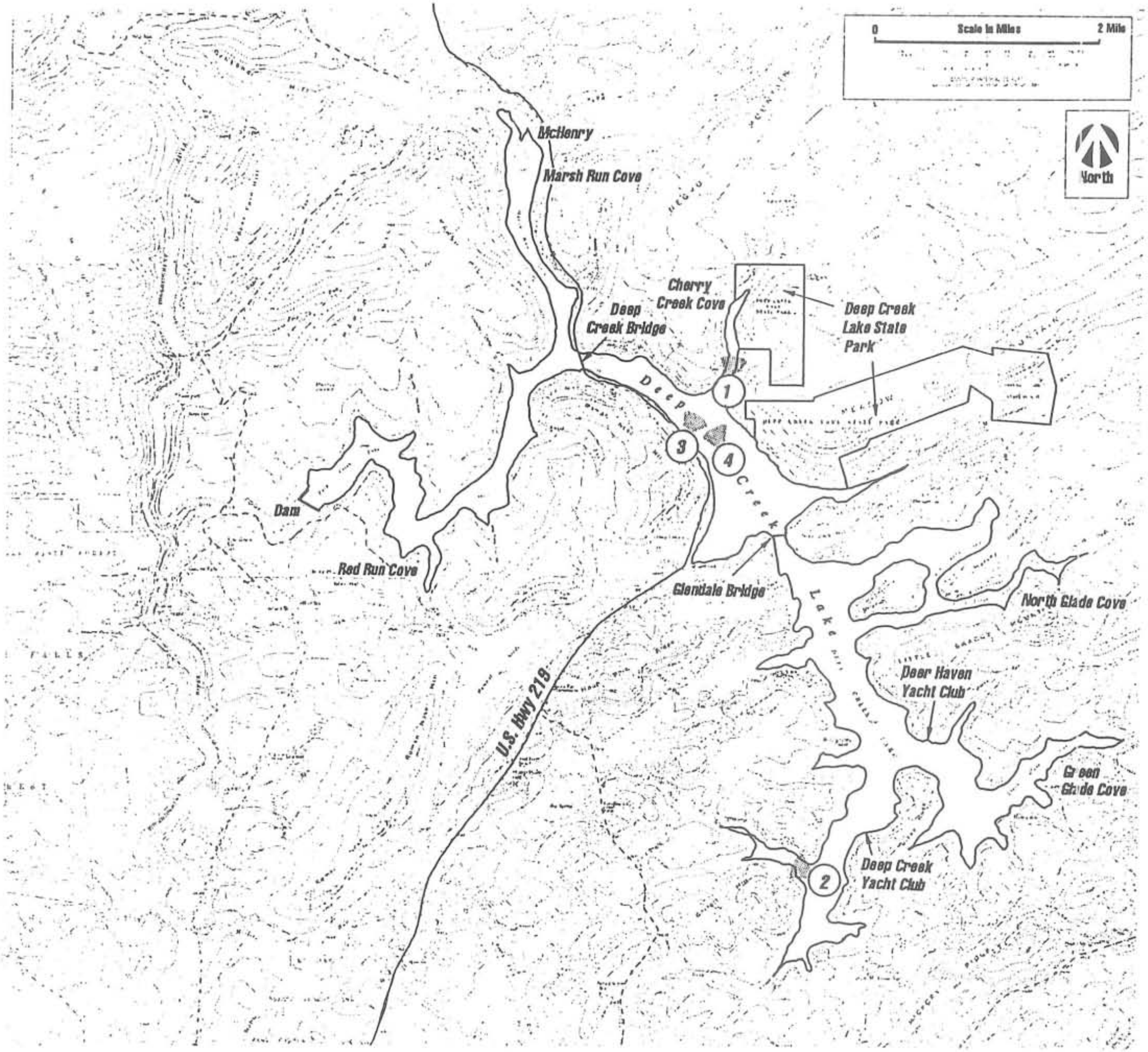
3.3.2.2 Effect of Project Operations

Deep Creek Lake

The aesthetic impact of project operations depends upon lake elevation and the location, sensitivity and number of viewers. Lake elevation is the most critical factor because it determines the amount of lake bottom exposed at various elevations. Viewer location plays an important role in that various parts of the lake are affected differently by the drawdown due to variation in lake topography. The sensitivity of viewers is significant because at various times of the year different viewers observe the lake with different expectations. Finally, the number of potential viewers varies according to season.

Over the last 20 years project operation has resulted in 10-ft. operating range in lake elevation from the maximum elevation of 2,462 ft. to a minimum elevation of 2,452 ft. Deep Creek Station has been operated to achieve a target maximum lake elevation of 2,461 ft. at the end of May. Deep Creek Lake was then gradually drawn down during the summer to an elevation of about 2,457 ft. by Labor Day. Between Labor day and October 31, the water level was further decreased to about 2,455 ft. From November 1 through the end of May the lake level fluctuated somewhat, but was generally increased so that it filled to elevation 2,461 ft. by the end of May.

The visual effect of drawdown at Deep Creek Lake is varied in different parts of the lake. In areas where the lake bottom near the shoreline is shallow, drawdown exposes more lake bottom and thus creates more extensive visual contrast. In shallow areas each foot of vertical drawdown can expose a large area of lake bottom. The ends of many coves, particularly in the southern part of the lake, are shallow and become exposed as lake levels are lowered. Therefore, Penelec examined the visual effect of drawdown at selected views of Deep Creek Lake (Figure 3-11). Figure 3-12



LEGEND

View Direction

View Number

View Number

1=Photo No. 3
2=Photo No. 4
3=Photo No. 5
4=Photo No. 6

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Figure 3-11
LOCATION OF SELECTED VIEWS OF LAKE

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Photo 3. View into Meadow Run Cove south of the main area of the state park.

Photo 4. View west into Penn Cove.

Figure 3-12. Selected views of lake.

illustrates the extent of the exposed lake bottom in Penn Cove, which is located in the extreme south end of the lake, when the lake was at an abnormally low elevation of 2,453 ft. Bathymetric data for this area indicate that at a lake elevation of 2,457 ft., approximately 400 horizontal ft. of lake bottom are exposed, as measured from the end of the cove's highwater mark of 2,462 ft. to the waters edge at 2,457 ft. At an elevation of 2,452 ft. (similar to the condition in Figure 3-12), almost 800 ft. of the end of the cove are dewatered.

The other shallow cove illustrated in Figure 3-12 is Meadow Run Cove. The photograph was taken looking towards the end of the cove when the lake was at an elevation of 2,453 ft. From the sides of the cove near where the photo was taken, 10 to 40 ft. of lake bottom are exposed at elevation 2,457 ft. At a lake elevation of 2,452 ft., up to 80 ft. of the lake bottom are revealed.

Typically, visual effects from drawdown are less for shoreline areas with steeper lake bottoms than the shallow cove areas. Figure 3-13 shows the shoreline near the entrance to Cherry Creek Cove. The shoreline area here is steep, as is the lake bottom. Because of the steep topography, less lake bottom is exposed (approximately 15 ft. at a 5-ft. drawdown and approximately 25 ft. at a 10-ft. drawdown) than for shallower areas with the same lake elevation change. Visual contrast thus is less in this location, and in other steep shoreline areas of the lake than in shallow areas. The Deep Creek Lake State Park boat ramp area (see Figure 3-13) is an example of how an area with moderately sloped terrain is affected by drawdown. The photograph was taken when the lake elevation was at 2,453 ft. and approximately horizontal 80 ft. of lake bottom were exposed.

The transition band or drawdown zone increases as the lake level is lowered, which makes the demarcation between the water and land more visually distinct. The light-hued exposed shoreline can contrast distinctly in color with the dark blue or gray of the

Photo 5. View east to Deep Creek Lake State Park boat launching ramp.

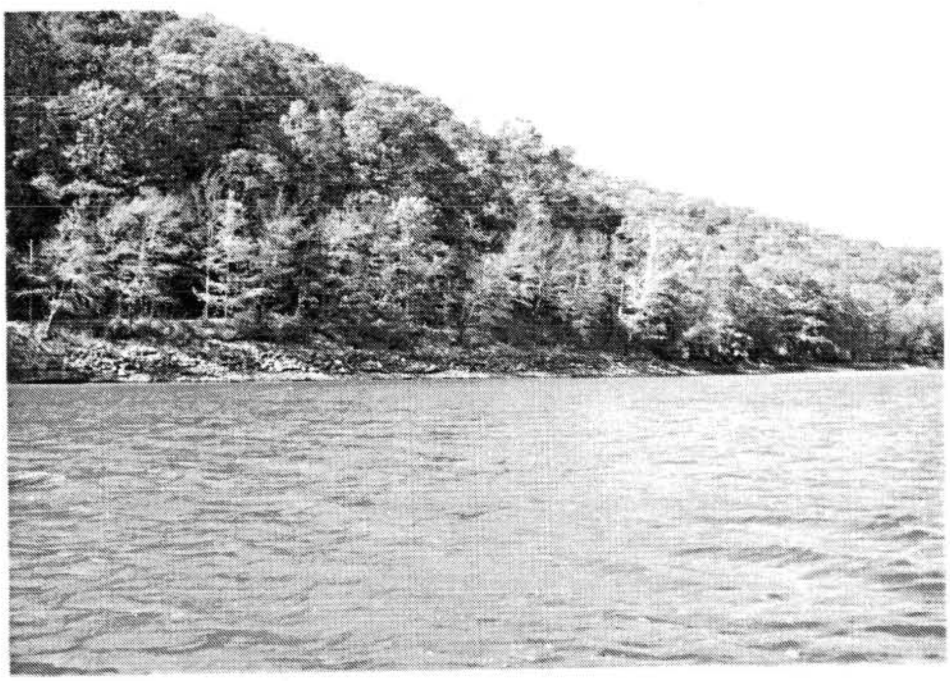


Photo 6. View northwest to Cherry Creek Cove.

Figure 3-13. Selected views of lake.

water and dark green of the lakeshore vegetation. Although the textural contrast between the exposed shore and the water and nearby vegetation is not as noticeable from a distance as the color contrast, it is evident. Exposed areas of flat lake bottom that have stones and rocks scattered on them especially draw attention as a result of the textural contrast between the stones and the flat bottom. As more lake bottom is exposed, a greater contrast is created with the nearby lake and shoreline vegetation and the visual extent of the drawdown becomes greater.

The aggregate area of exposed lake bottom at various elevations can be determined from the lake surface area data. The lake's surface area is 3,900 acres at the maximum lake elevation of 2,462 ft. At an elevation of 2,457 ft., the lake surface area has been reduced 9 percent to 3,535 acres, exposing approximately 365 acres of lake bottom. When the lake elevation reaches 2,452 ft., the exposed area increases to 724 acres.

A key factor in the effect of project operations on aesthetics is the number of people viewing the lake at different times of the year. The annual patterns of visitor levels and Deep Creek Lake elevations are shown in Figure 3-14, using attendance figures for day-use visitors at Deep Creek Lake State Park and the average end of month lake levels from 1970-1990. Visitation at Deep Creek Lake State Park picks up dramatically in June, peaks in July, and starts to decrease in August. Based on current operating practice, the lake is at its maximum elevation in early June, a month before the maximum number of day users visit the park. The lake elevation decreases after early June, and continues to decrease generally in parallel with a decrease in visitation from August through the end of November. The significance of this pattern is that most viewers are present when the lake level is relatively high, while the number of viewers (at least at Deep Creek Lake State Park) decreases as the lake level decreases and more lake bottom becomes exposed. With the exception of a mid-October festival that can attract up to 55,000 visitors, the number of people visiting the

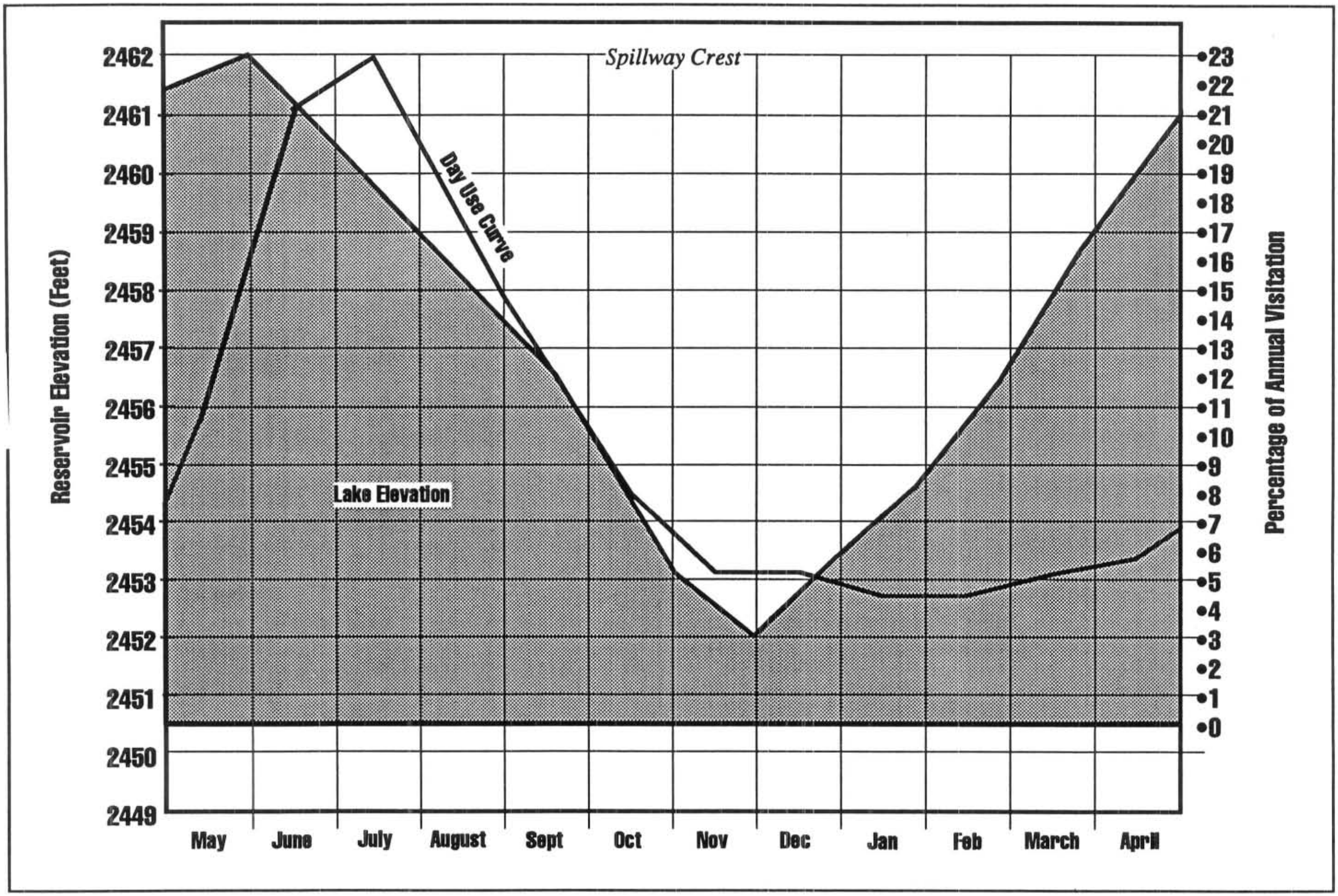


Figure 3-14. Average monthly lake elevation and day use at Deep Creek Lake State Park.

Deep Creek area is relatively small by the time the drawdown becomes more visually prominent in September or October.

Interviews with local user and interest groups confirmed that park visitors find the lake more visually appealing when it is at a higher elevation with less lake bottom exposed than when it is at a lower elevation with more lake bottom exposed. However, the majority of local groups interviewed did not seem to feel that the drawdown was a significant aesthetic concern. Some people interviewed felt the drawdown detracted from the natural beauty of the lake, but most apparently accepted the drawdown pattern as a normal occurrence. Several respondents indicated a preference that most of the drawdown take place after the October festival, so that visitors could view a relatively full lake and have assured access to boating opportunities.

Real estate interests were specifically asked if they felt that the drawdown hampered real estate marketing efforts. They reported that some customers commented on the drawdown, but adverse reactions were not common. In fact, some customers who noticed the drawdown remarked that the exposed lake bottom was surprisingly clean (primarily because it does not have large numbers of stumps, as is common at many reservoirs).

Youghiogheny River Corridor

Descriptions of the scenic qualities of the Youghiogheny River corridor mention a number of outstanding natural attributes such as steep valleys, vegetation, remoteness, and swiftly flowing water (U.S. Congress 1979). Of the physical components that together help make the corridor an outstanding visual resource, the operations of the Deep Creek Project only affect one, water flow.

The amount of water in the river has a direct effect on the visual character and variety of the river. Indirectly, water flow can affect vegetation and rate of erosion. However, Deep Creek Station typically does not have a significant effect on flood flows in the Youghigheny River and hence does not have a significant impact on vegetation and bank erosion. Other, more subtle, effects such as microclimatic effects associated with temperature changes would not likely have any significant impact on the visual character of the river corridor.

The appearance of the Youghigheny River can be considerably different at typical summer low-flow conditions, at the moderately high flows used by boaters, and during flood conditions. A representative characterization of these differences can be provided by examining the river cross-section in the Sang Run area.

The river segment from the powerhouse to approximately Gap Falls, which includes the Sang Run area, has a relatively wide, shallow channel and low gradient. The river channel is very straight, with few bends. The hydraulic character is predominantly a single long run interrupted by short riffles and shallow rapids at the few bends in the channel, and deep pools are completely absent. Bedrock is frequently exposed in the river channel and along the stream banks, but there are few large boulders in the river bed.

The average width of the wetted Youghiogheny River channel from Hoyes Run to the Sang Run bridge ranges from approximately 130 ft. at 40 cfs to about 185 ft. at 1200 cfs. The wetted width changes rapidly from 130 to 158 feet, as flows increase from 40 to 70 cfs and changes little with increasing flows once flows reach 300 cfs, which provides essentially bank-to-bank wetting of the channel. The average depth of this river section ranges from 0.7 ft. at 40 cfs to about 2.8 ft. at 1200 cfs. The average depth/discharge relationship is nearly linear. Maximum channel depths at three cross sections near Sang Run are about 1 to 2 ft. at 40 cfs, up to 3 ft. at 300 cfs, and up to nearly 4 ft. at 1200 cfs.

These width and depth measurements indicate that the visual geometric character of the Sang Run section of the river does not change drastically over the normal range of flows, or when a Deep Creek release is added to a low summer base flow. If the natural flow were at 40 cfs prior to a release, increasing the flow to 700 cfs with a release would increase the average width in the Sang Run area by only 33 percent, from 135 ft. to 180 ft. The corresponding increase in average depth would be from about 0.7 ft. to 1.8 ft., a much larger change in percentage terms but still a small absolute change. The effect of a Deep Creek release on wetted channel geometry would be even less with a higher base flow. In summary, the Sang Run section of the river appears as a relatively wide, shallow stream at both typical natural flows and during Deep Creek releases.

One physical characteristic that does change somewhat more than width and depth is water velocity. The Hoyes Run-Sang Run section is a slow-moving stream at low flows, with an average velocity of about 0.5 ft. per second (0.34 miles per hour). The average velocity increases to approximately 2.2 ft. per second (1.5 mph) at 700 cfs and 2.5 ft. per second (1.7 mph) at 1200 cfs. While considerably higher than the low-flow velocity, the latter velocities are still rather low compared to steeper downstream sections of the river.

Overall, Deep Creek Project operations have a minor effect on the aesthetic character of the Youghiogheny River in the Sang Run area. Due to the relationships of width, depth and velocity to discharge, project releases have minimal effects on these characteristics if base flows are relatively high, and modest effects at low base flows. In general, releases during low flow periods may temporarily make the river appear somewhat wider and deeper to the typical visitor, and perceptibly change the otherwise placid pace of the river. The most likely change that visitors would notice would be more rippling of the surface in general, and small patches of turbulent water where there are submerged rocks or other obstacles.

Because instream flow studies were not conducted below the Sang Run area, it is not possible to address the aesthetic character of the river in the whitewater section to the same level of detail. The river channel is generally more confined and narrower in this section, so changes in width with increasing flows should be comparatively small. The whitewater section is characterized by short falls, rapids, and deep plunge pools. Consequently, higher flows from a Deep Creek release would cause relatively small increases in pool depth but have greater effect on depth in the rapids sections. Due to the steep gradient, river velocities are relatively high even at low flows. Overall, the primary direct visual effect of project operations in this reach is probably to add measurably to the level of water activity in the rapids, and thereby increase visual variety and interest. Indirectly, the releases significantly increase the opportunities for whitewater boaters to view these features, and therefore have a positive effect on river aesthetics.

3.4 DESIGNATED USES

3.4.1 Deep Creek Lake

Deep Creek Lake has a surface area of 3900 acres (1600 hectares) at a full pool reservoir level of 2462 feet. In addition to providing storage for hydroelectric power generation, the reservoir is a popular recreational site year-round, especially during the summer.

Only minor water withdrawals are permitted from Deep Creek Lake. Penelec has agreements with Harvey Brothers Potato Farm, Bechman Farms, and the McHenry Fire Company to draw water from the lake. In addition, the contractors spraying for gypsy moths have been given permission to take water from the lake.

3.4.2 Youghiogheny River

The Youghiogheny River has become a popular rafting and kayaking river. The Maryland segment of the river provides whitewater experts with the most difficult and challenging stretches.

Due to recent improvements in water quality, trout habitat and populations in the river have also steadily increased. As a consequence, the Youghiogheny is becoming increasingly popular with sports fishermen. The improvements have been a result of river basin activities such as reforestation of mined lands, mine reclamation projects, and stricter mine regulations (Hendricks 1980).

Permits for water withdrawals from the Youghiogheny River in the region of the study area include a 1.5 million gallon per day water right held by the City of Oakland, 10 river miles upstream of the plant, and a 100,000 gallon per day water right held by the Town of Friendsville, about 12.8 river miles downstream of the plant. All residents along the river not served by these two water withdrawals depend upon wells for their water supply.

3.5 WATER QUALITY

This section presents an overview of water quality in the Youghiogheny River basin and the results of specific investigations conducted by Penelec to determine project effects on water quality. Field measurements were conducted in Deep Creek Lake, Deep Creek immediately downstream from the dam, the Deep Creek tailrace, and the Youghiogheny River downstream of the tailrace. Water quality investigations centered on the chemical characteristics of the tailrace discharge and dam seepage, and dissolved oxygen and temperature in Deep Creek Lake, the tailrace, and Youghiogheny River.

3.5.1 General

The mainstem Youghiogheny River and its tributaries, including Deep Creek Lake, are classified as Class III, Natural Trout waters by the State of Maryland. Water quality standards for Class III Waters are summarized in Table 3-3. In addition to basic uses of water contact recreation, fish, other aquatic life, wildlife, and water supply, the Class III designation provides further protection to support the existence of natural, reproducing trout populations. In waters that possess an existing water quality that is better than the water quality standards established for them, the State requires that the quality of these waters be maintained. Downgrading is discouraged by the State and only allowed under certain conditions and with notice and opportunity for public hearing.

Water quality in the Youghiogheny River basin is variable, ranging from excellent in many headwater areas to poor in certain sections such as the mainstem Youghiogheny River above Oakland (Garrison 1990). Acidic mine drainage and raw sewage inputs have substantial influence on water quality within the basin (Garrison 1988a). High bacterial levels have been observed in some areas, and during 1987 to 1989, swimming was banned in 0.5 miles of the mainstem river below Deer Park because bacterial levels exceeded allowable limits (Garrison 1990). Other documented factors influencing water quality include dissolved oxygen (DO), temperature, turbidity, and elevated nutrient levels (Garrison 1990).

Low dissolved oxygen and acidic conditions are found in the following areas. Approximately two miles (3.2 km) of Deep Creek below the hydroelectric project are affected by dissolved oxygen concentrations less than the state water quality standard of 5 mg/l. When water is discharged from the Deep Creek Project during the summer period, approximately one mile (1.6 km) of the Youghiogheny River downstream of the project is also affected by sub-standard dissolved oxygen concentrations. The lower 7.9 miles

Table 3-3 Maryland State Water Quality Standards for Class III Waters

Parameter	Criteria
Bacteriological	Pathogenic or harmful organisms are not to constitute a public health hazard. Fecal coliform should be log mean <200 per 100 ml and less than 10% of samples > 400 per 100 ml, unless the Department of the Environment discloses a no significant health hazard.
Dissolved Oxygen	$\geq$ 5 mg/liter with a minimum daily average of $\geq$ 6 mg/liter.
Temperature	not to exceed 68°F (20°C) or ambient temperature of surface waters. Thermal barrier which adversely affects aquatic life may not be established.
pH	normal values must be between 6.5 and 8.5
Turbidity	Levels may not be detrimental to aquatic life. Discharge surface waters $\leq$ 150 NTUs with a monthly average of 50 NTUs.
Total Residual Chlorine (TRC)	Wastewater discharge may not be treated with chlorine or chlorine compounds, unless certain criteria are met.

Source: Code of Maryland Regulations (26.08.02) Water Quality. Maryland Department of Environment. January 1, 1989.

(12.7 km) of the Upper Youghiogheny River and most of Cherry Creek, a tributary to Deep Creek Lake, have pH conditions that fall below the state water quality standards. The acidic conditions in these areas may result from coal, and possibly peat, mining operations that discharge acidic waters.

3.5.1.1 Recent Trends in the Youghiogheny River

In the Youghiogheny River, Garrison (1988b) reported a non-significant decreasing trend in pH at the mainstem monitoring station near Oakland (YOU1139) and a statistically significant decline in pH at the station near Friendsville (YOU0925) during the period from 1979 to 1986. Other trends in water quality include significant increases in fecal coliform bacterial counts at the Friendsville station, and a significant decrease in total suspended solids at the station near Oakland (Garrison 1988b). In the Little Youghiogheny River near Oakland (LYO0004), significant decreases in total suspended solids, total phosphorus, and fecal coliform bacteria were observed, suggesting that water quality has generally improved in that major tributary.

In spite of the improvements documented in the Little Youghiogheny River and in the mainstem above the confluence with the Little Youghiogheny, pH levels declined and fecal coliform counts increased in the designated "wild" portion of the Youghiogheny River declined during the period from 1979 to 1986. Although the observed changes in water quality may be due to abiotic factors such as precipitation, the differential results between the two upstream monitoring stations and the station near Friendsville suggest that water quality in the designated "wild" portion of the river has declined.

Data presented by Davis (1984) and Garrison (1988) indicate that Youghiogheny River waters are not well buffered, with alkalinity values ranging from 1 to 28 ppm $CaCO_3$ equivalent. Acid loading is from atmospheric deposition and acid mine drainage (Martin Marietta Environmental Systems, 1985).

Turbidity data reported by Davis (1984) from the designated "wild" portion of the Youghiogheny River during 1979 and 1980 ranged from 3 to 96 Jackson Turbidity Units (JTU), with mean values of 10 JTU. Similarly, suspended solids values ranged from 3 to 136 mg/l, with an overall mean of 21 mg/l. More recent information collected by Maryland Department of the Environment (unpublished data) for the period 1987 to 1990 shows a similar pattern of low values during non-storm periods and elevated levels of turbidity and suspended solids during or immediately after storm events.

3.5.1.2 Deep Creek Lake

Numerous studies have been conducted in Deep Creek Lake since 1954 (Davis 1975). Following is a summary of characteristics of Deep Creek Lake's water quality as described by Davis.

Mean pH values are typically less than 7 and mean total alkalinity (expressed as $CaCO_3$) values are usually less than 20 mg/l. Major cations and nutrient concentrations have been found to be low in both surface and bottom waters. Nitrite-N for the most part is not detectable. Nitrate-N has been found not to exceed 0.44 mg/l, and total phosphorus (PO_4-P) less than 0.04 mg/l.

Alkalinity, expressed as $CaCO_3$ ranges from 3-10 mg/l in surface waters and 4-34 mg/l in bottom waters. The highest alkalinity occurs in October and the lowest between May and July.

Surface water conductivity ranges between 50-75 mhos/cm and bottom conductivity between 54-90 mhos/cm. Conductivity values are highest between August and October and usually occur in the surface layer.

Carbon concentrations range between 1.20-10.06 mg/l for surface water and 1.20-29.16 mg/l for bottom water. Lower concentrations occur during April and July, whereas higher concentrations occur during August and October.

During most of the winter months Deep Creek Lake is ice covered. Water temperatures increase during the spring, causing turnover of surface and bottom waters at a temperature of about 8°C. By June, the water column becomes thermally stratified into three distinct layers. The upper layer, the epilimnion, is at a uniformly warm water temperature that typically ranges from 22 to 23°C. The mid-layer or thermocline ranges from 20-30 feet in depth and typically shows temperature fluctuations between 8°C and 25°C. The deepest layer, the hypolimnion, usually increases from a water temperature of 6°C in April to about 12°C in June. During the late June to October period, when temperatures in the hypolimnion range between 12°C and 16°C, severe oxygen depletion (1 ppm) occurs. According to research referenced by Davis and Flemer (1975), this can be expected during the summer months each year in Deep Creek Lake.

3.5.2 Chemical and Physical Characteristics of Deep Creek Station Discharge

This section summarizes water quality measurements taken in the Deep Creek Station tailrace. Water samples were collected from the tailrace to provide baseline information on the water quality in Deep Creek Lake and to verify that leaching from pressure-treated materials used for docks along the shore of Deep Creek Lake does not affect water quality. Wood for the docks has been injected with chemicals (typically chromated-copper-arsenate) that act as a preservative. The following metals and wet chemistry parameters were measured on a seasonal basis: arsenic, chromium, copper, total suspended solids, turbidity, and pH. Samples were analyzed using EPA and ASTM approved methodologies (EPA 1982; EPA 1983; APHA-AWWA-WPCF 1985).

Tables 3-4 and 3-5 summarize the water quality results. Table 3-4 also compares the results to EPA freshwater acute and chronic criteria. Concentrations of arsenic and chromium for Deep Creek Lake are well below the EPA acute and chronic freshwater criteria. This implies that if leaching of these two chemicals from dock construction materials occurs, it is not detectable in the general water quality of the lake or downstream areas at least to the levels of detection used in these analyses. Copper concentrations for the July 1990 sample were 2 $\mu g/l$ below the EPA chronic freshwater criteria of 12 $\mu g/l$. Previous samples were below the detection limits, but these limits were higher than the acute and chronic EPA freshwater criteria. Turbidity and suspended sediment data indicate that the plant discharge generally has low suspended sediment concentrations.

3.5.3 Temperature and Dissolved Oxygen

Temporal and spatial dissolved oxygen (D.O.) measurements in Deep Creek Lake, the tailrace of the Deep Creek hydroelectric facility, and in the mainstem Youghiogheny River below the tailrace were obtained during 1989 and 1990 using calibrated, remote and portable D.O. monitoring devices. Data from the lake were similar to historical data and indicate that Deep Creek Lake is dimictic, with severe hypolimnetic oxygen depletion occurring during summer stratification (July through September). Since water for hydroelectric generation is withdrawn from a single intake location in the hypolimnion, water low in D.O. content is discharged during several months each summer.

During certain conditions of warm weather, low stream flow, and relatively low generation, water temperatures in the mainstem Youghiogheny may reach critical or lethal levels to some species of important fish (e.g., brown trout). These species utilize cooler discharges from the Deep Creek Project as a "refuge" from the higher temperatures. Thermographs were placed in the river to monitor water temperature conditions and lake water temperature profiles.

Table 3-4 Analytical Water Quality Results[1]

	EPA Freshwater Criteria		Deep Creek Lake				
Chemical	Acute	Chronic	8/8/89	9/19/89	10/31/89	3/1/90	7/12/90
Arsenic[2]	360	190	<10 <1.2	<5.5	<10 <10	<10	ND[3] ND
Chromium[4] (μg/l)	1,700	210	<10	2.1	<10	<10 <10	20 50
Copper (μg/l)	18	12	<25	[5]	<25	<25 <25	10 10

[1] Samples collected at powerhouse tailrace.

[2] EPA criteria values are for trivalent arsenic. Deep Creek Lake values are for total arsenic.

[3] ND = Not Detectable.

[4] EPA criteria values are for trivalent chromium. Deep Creek Lake values are for total chromium.

[5] Sample contaminated.

Source: Hittman Ebasco Associates Inc., Analytical Report for Deep Creek Lake Site, 1989.

Table 3-5 Water Quality Results

Date	TSS (mg/l)	pH	Turbidity (NTUs)	Comments
Tailrace Discharge				
8/8/89			1.3	before startup
			1.2	5 min. after startup
			1.5	10 min. after startup
			0.8	15 min. after startup
			0.8	20 min. after startup
			0.75	25 min. after startup
8/10/89	6.0			tailrace
8/22/89		5.65		tailrace
8/23/89		5.90		tailrace
9/18/89		6-6.5	1.8	during operation
9/19/89	<1	6-6.5	1.8	during operation
10/31/89	<1	5.5-6	5.1	11 min. after startup
			1.7	37 min. after startup
3/1/90	7.0			
	<1			
7/12/90	3.6			
	0.6			
Deep Creek Lake				
8/9/89		5.91	2.0	Transect 2, Station 4[1/]
		5.67	1.25	Transect 2, Station 4[2/]
9/18/89			0.85	Transect 1, Station 1[1/]
			4.8	Transect 1, Station 1[2/]
			0.90	Transect 1, Station 2[1/]
			4.3	Transect 2, Station 2[2/]

1/ Samples taken from lake epilimnion.
2/ Samples taken from lake hypolimnion.

Sources: Penelec and Hittman Ebasco Associates Inc. Analytical Report for Deep Creek Lake Site, 1989.

Using remote, continuous recording and instantaneous temperature monitoring devices, temperature regimes of the mainstem Youghiogheny and its tributaries were relatively well documented during the period from 1987 to 1991. In the mainstem Youghiogheny River, peak water temperatures exceed 27°C in summer both above and below the Deep Creek hydroelectric tailrace (Pavol, 1988). During non-release periods, high temperatures can extend throughout the river for short periods during the day. However, numerous tributaries and an estimated 9 cfs leakage from the Deep Creek hydroelectric facility create small, localized pockets of cold water in the mainstem. Mainstem temperatures in summer are profoundly influenced by hydroelectric facility operation, with rapid temperature declines of 10 to 15°C common during typical releases in hot, dry periods of summer.

3.5.3.1 Deep Creek Lake and Tailrace

Three transects were established in Deep Creek Lake between the Deep Creek intake and the U.S. Route 219 bridge (Figure 3-15). Up to four temperature and D.O. profiles along each transect were measured using a Yellow Springs Instrument (YSI) Model 57 oxygen meter. These measurements were taken at 2 meter intervals near the surface and at depths where the water temperature changed more rapidly. Table 3-6 lists the dates and conditions under which temperature and D.O. were measured. Additional measurements were taken in the tailrace to characterize temperatures and oxygen levels. These additional measurements were also used for comparison to the lake results.

Figures 3-16 through 3-22 show the temperature and D.O. for each profile (station) by transect. Both D.O. and temperature levels were fairly similar from profile to profile and even from transect to transect. The only major differences were evident with fall turnover, which began sometime after September 18, 1989 (Figure 3-21) and was almost complete by October 9, 1989 (Figure 3-22).

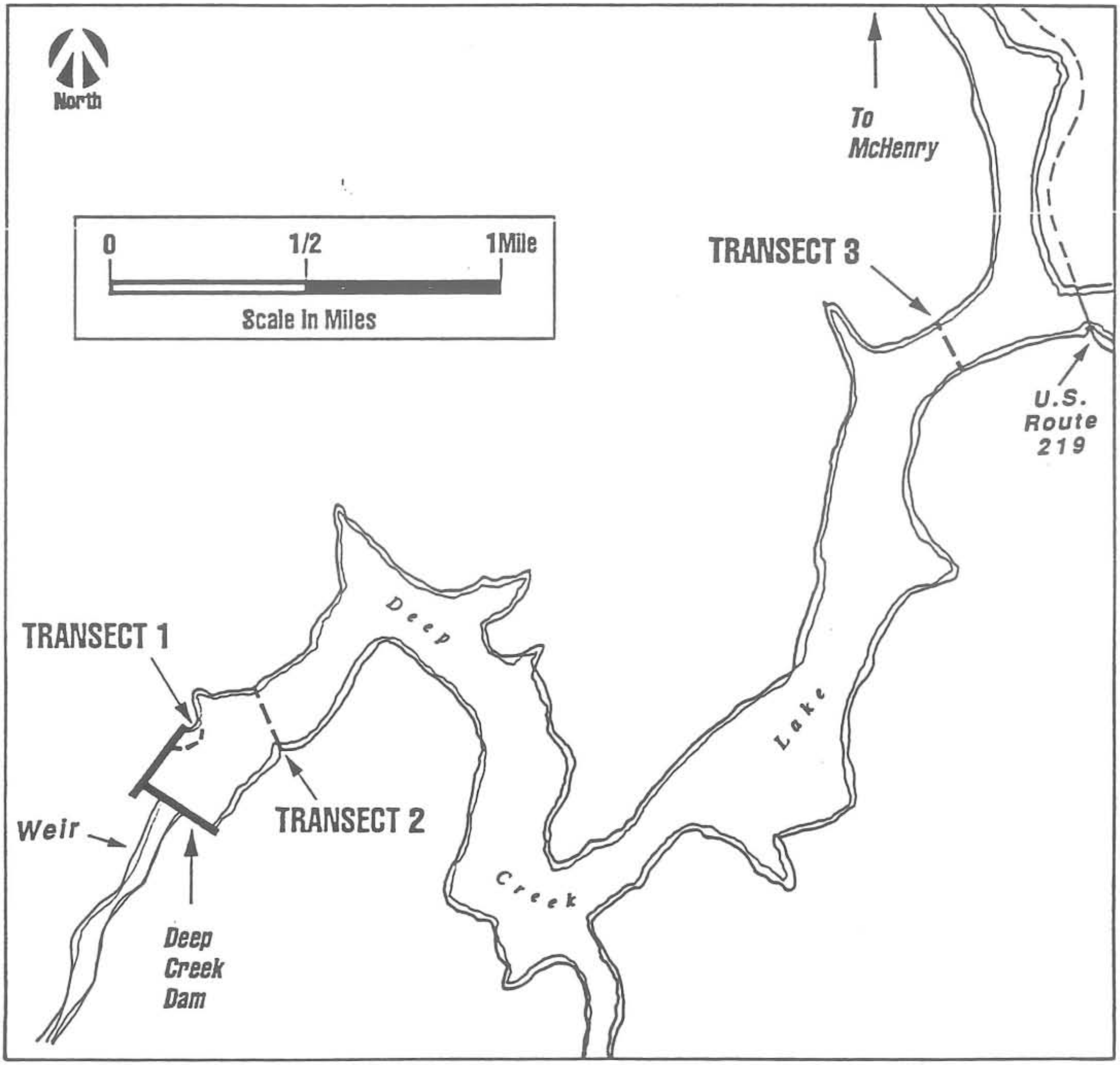


Figure 3-15. Water quality sampling sites in Deep Creek Lake.

Table 3-6 Schedule for temperature and dissolved oxygen measurements in Deep Creek Lake

Date	Project Operation	Transect	Profile
08/8/89	before operation	1	1 - 3
		2	1 - 4
		3	1 - 4
08/9/89	during operation	1	1 - 4
		2	1 - 3
08/22/89	during operation	1	1 - 4
		2	2 & 3
		3	2 & 3
08/23/89	before operation	1	1 - 4
08/30/89	during operation	2	1, 2 & 4
09/18/89	during operation	1	1 - 4
		2	2 & 3
		3	2 & 3
10/9/89	during operation	1	1 - 4
		2	1 - 3
		3	1 & 3

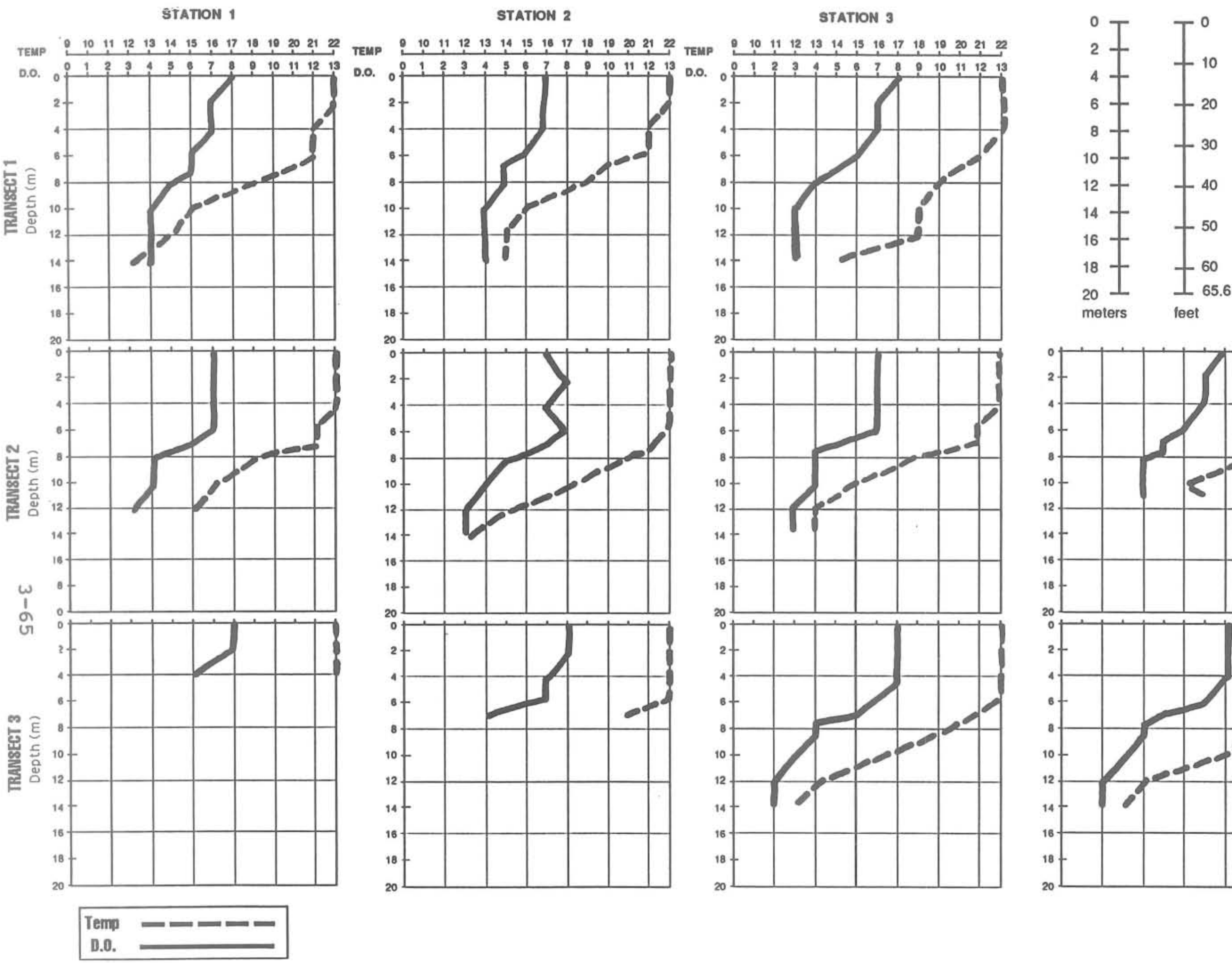


Figure 3-16. Temperature (°C) and dissolved oxygen (ppm) measurements for August 8, 1989, before operation.

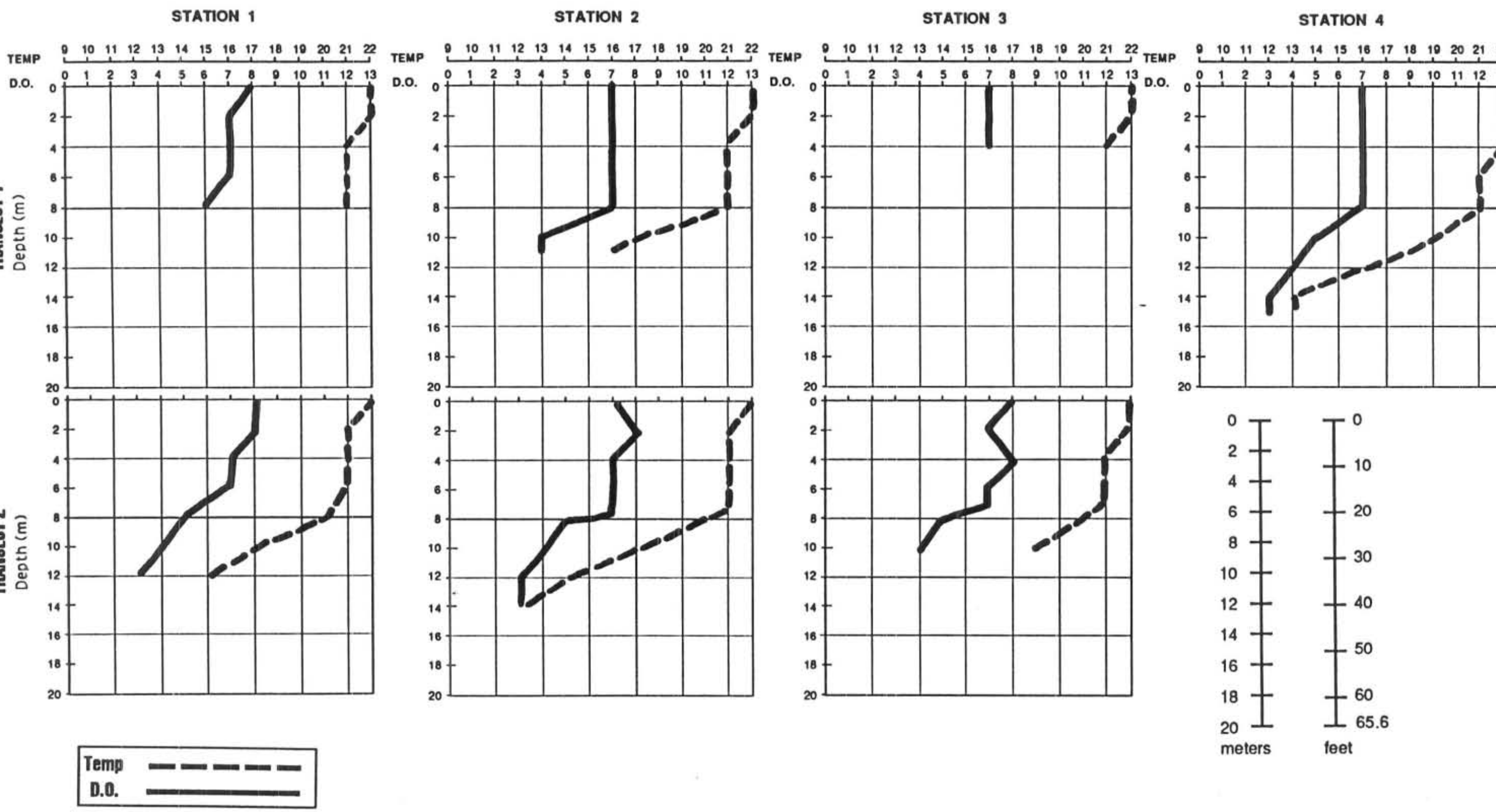


Figure 3-17. Temperature (°C) and dissolved oxygen (ppm) measurements for August 9, 1989, during operation.

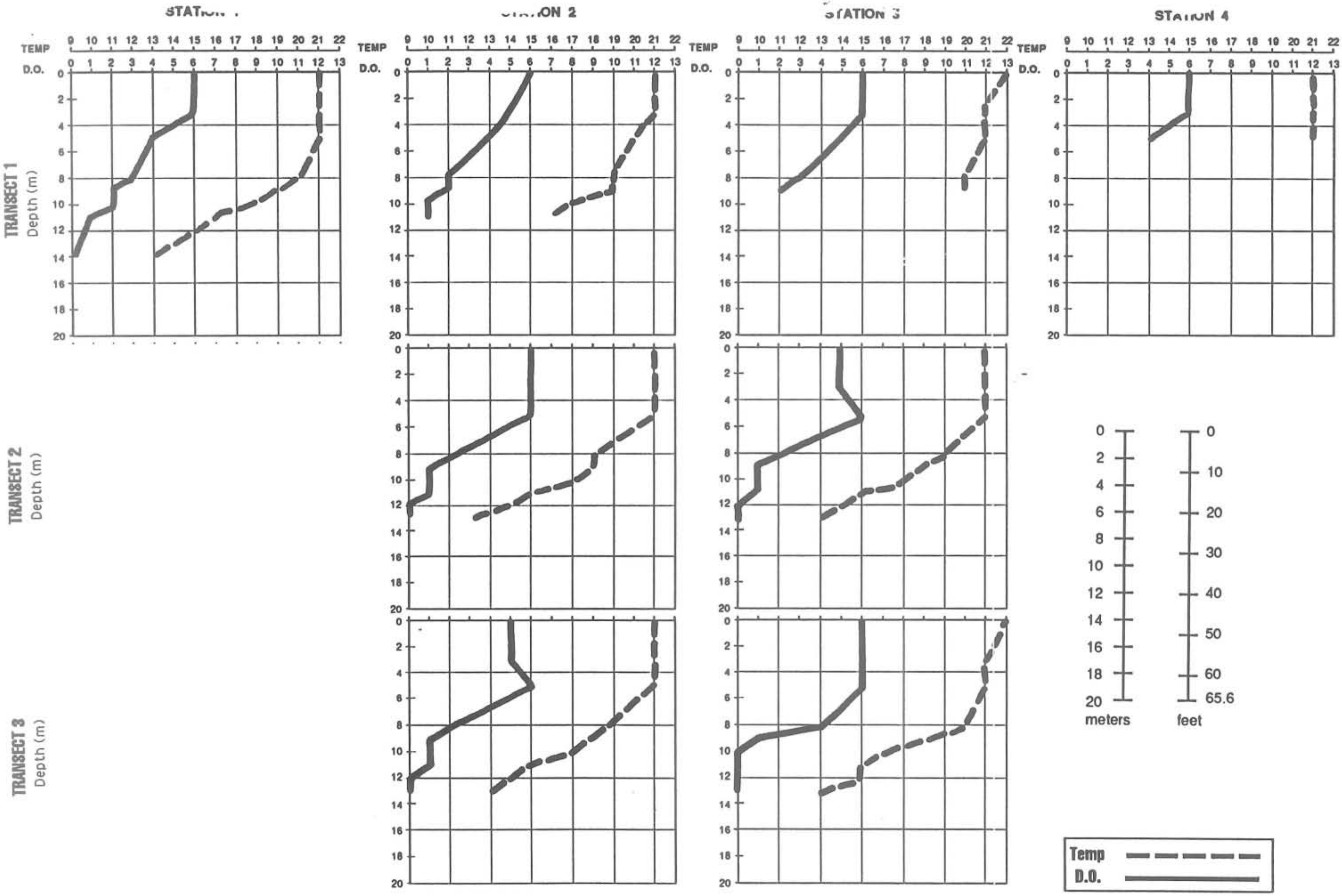


Figure 3-18. Temperature (°C) and dissolved oxygen (ppm) mmeasurements for August 22, 1989, during operation.

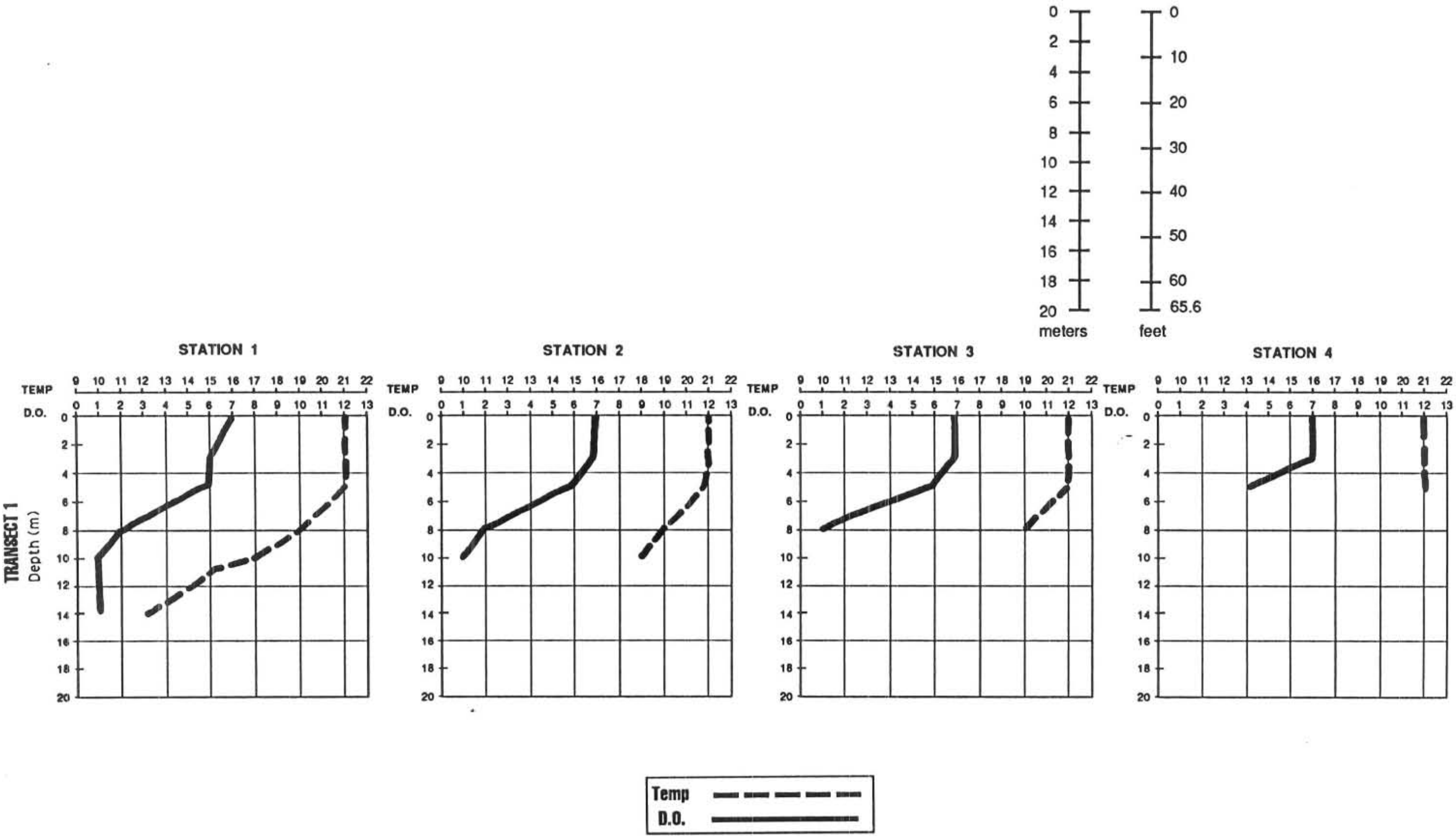


Figure 3-19. Temperature (°C) and dissolved oxygen (ppm) measurements for August 23, 1989, before operation.

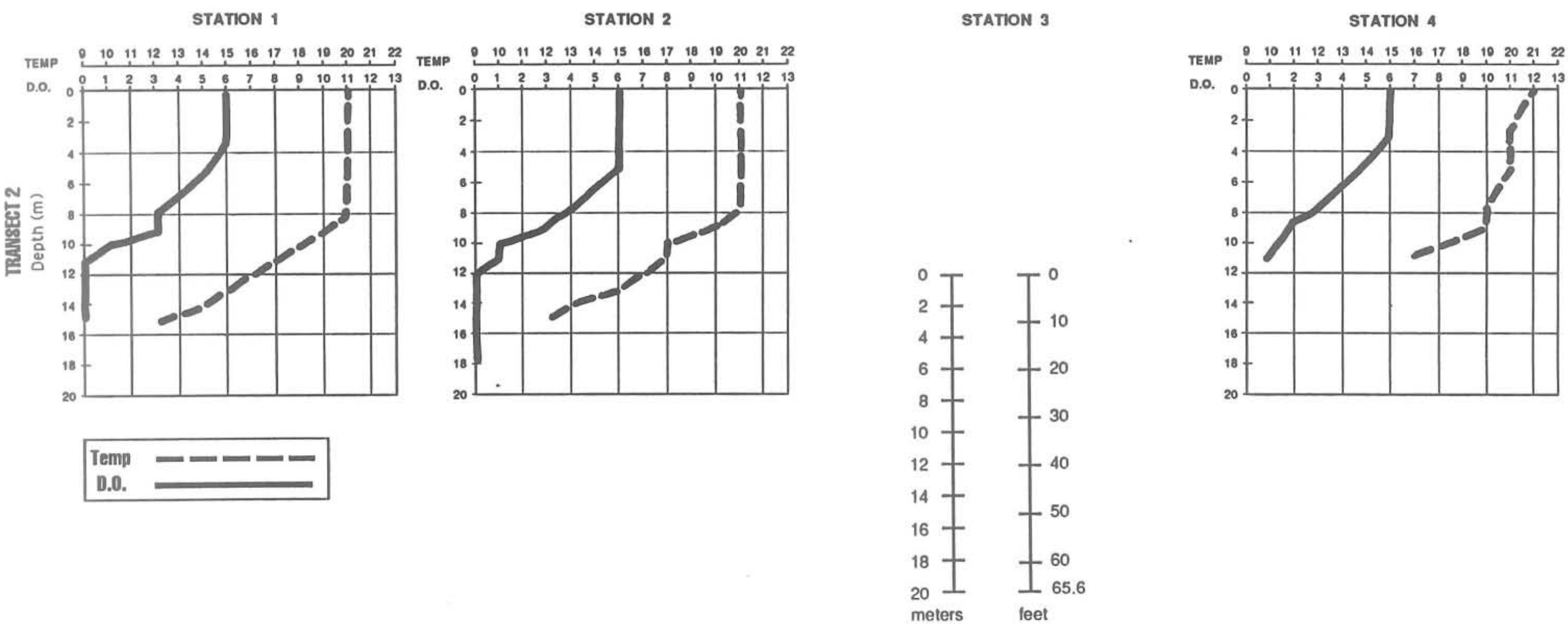


Figure 3-20. Temperature (°C) and dissolved oxygen (ppm) measurements for August 30, 1989, during operation.

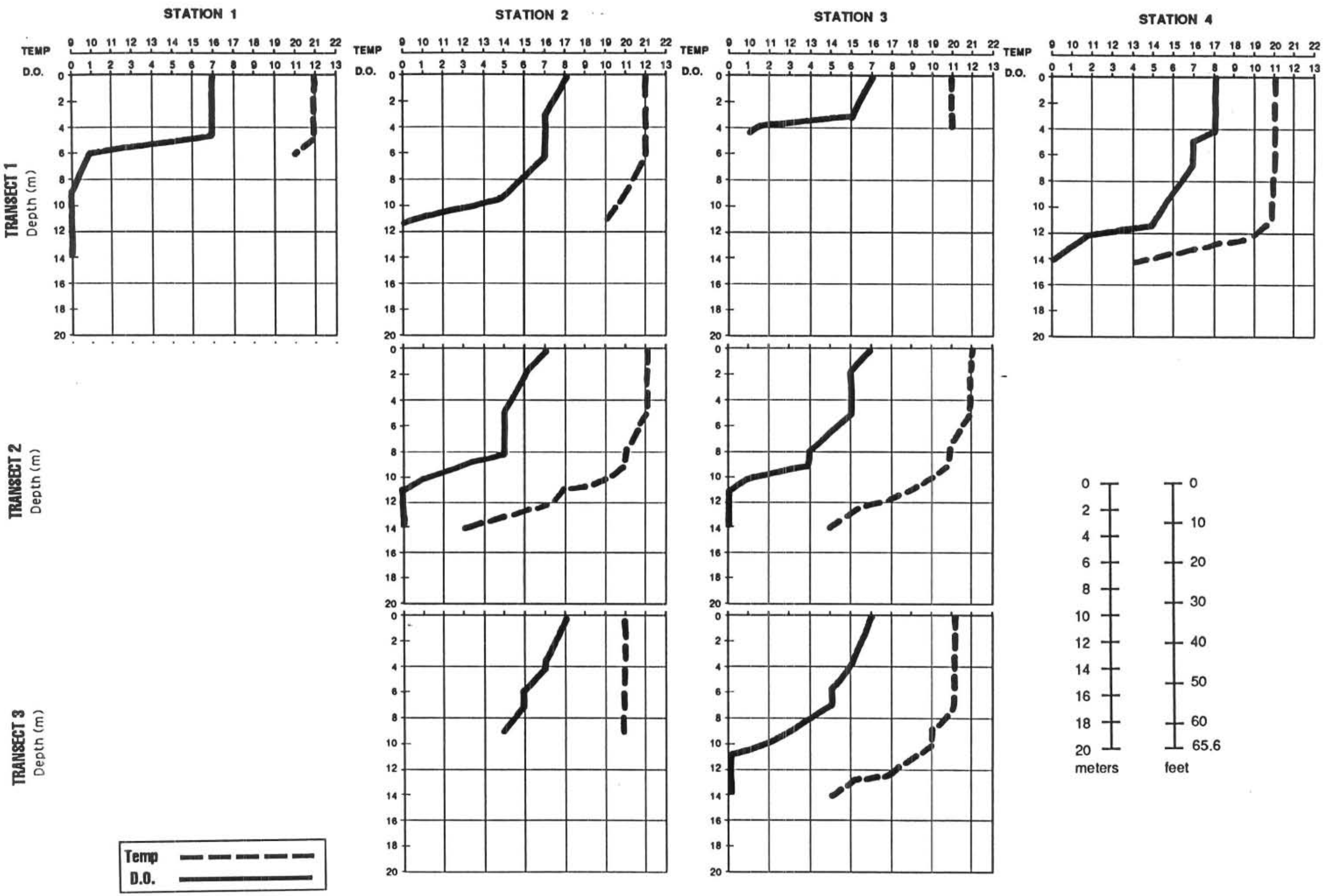


Figure 3-21. Temperature (°C) and dissolved oxygen (ppm) measurements for September 18, 1989, during operation.

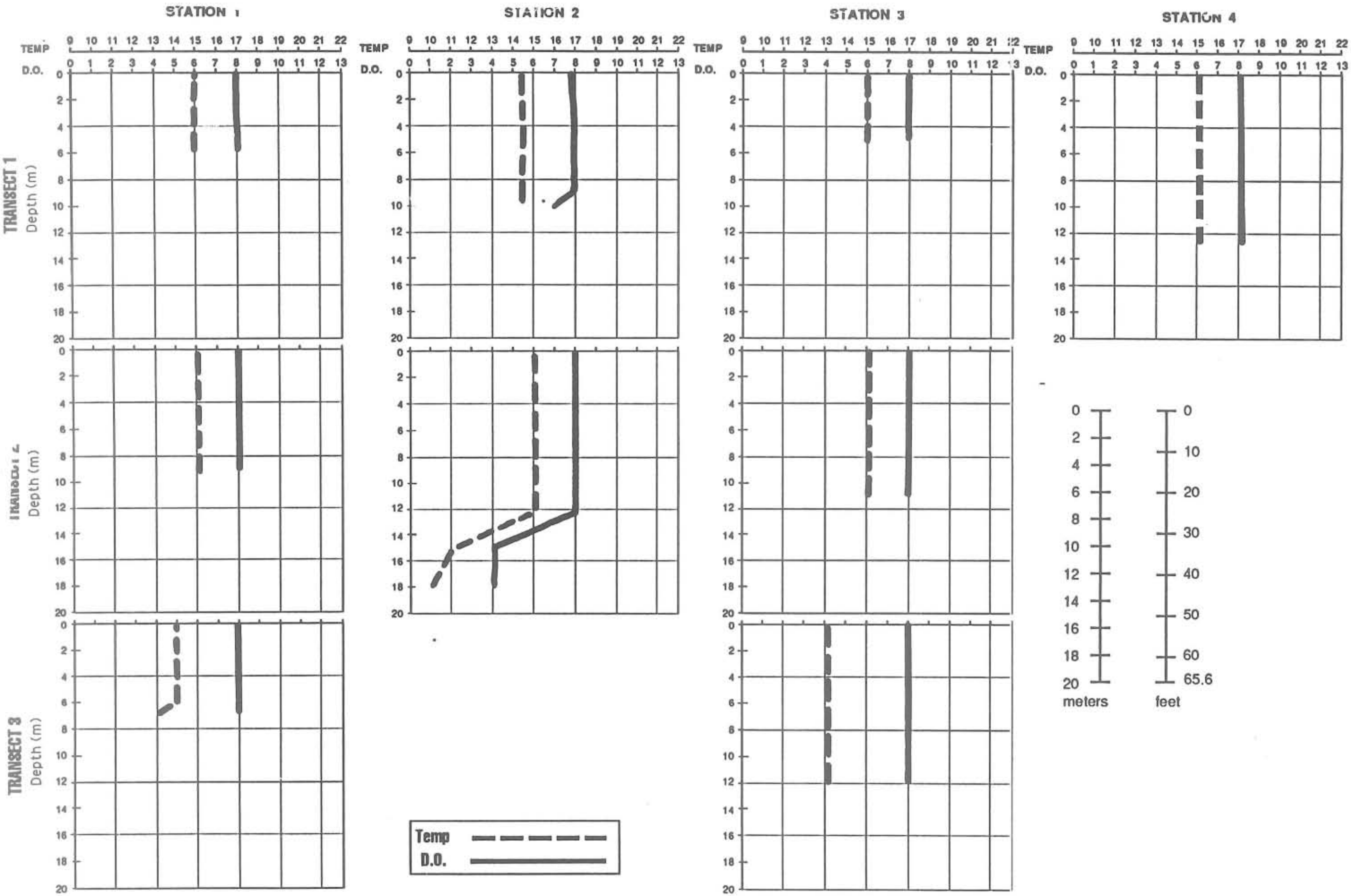


Figure 3-22. Temperature (°C) and dissolved oxygen (ppm) measurements for October 9, 1989, during operation.

Temperature

Surface (0-6 m [0-20 ft]) water temperatures ranged from a high of 22°C on August 8 and 9, 1989 (Figures 3-16 and 3-17) to a low of 13°C on October 9, 1989 (Figure 3-22). For each day sampled, temperatures varied no more than 2°C along any given transect.

Bottom (10-18 m [33-60 ft]) water temperatures ranged from a high of 18°C on August 9, 1989 (Figure 3-17) to a low of 10°C on October 9, 1989 (Figure 3-22).

Dissolved Oxygen

Surface (0 to 6 m [[0-20 ft]) concentrations of D.O. were just above the Maryland state water quality standard of > 5 mg/l. Measurements ranged from a low of 5 mg/l on August 22, 1989 (Figure 3-18) to highs of 8 mg/l throughout the August-October, 1989, sampling period.

Dissolved oxygen concentrations near the bottom of the lake were below the state water quality standard, with measurements ranging from a low of 0 mg/l on September 18, 1989 (Figure 3-21) to a high of 8 mg/l on October 9, 1989 (Figure 3-22). This stratification is, however, very characteristic of lakes or reservoirs during this period of the year.

A discharge of approximately 9 cfs is released at Deep Creek Station during periods when the project is not operating. This flow originates from leakage through the turbine wicket gates. During "shutdown" periods, the 9 cfs leakage flow enters the penstock from the deepest part of Deep Creek Lake gradually replacing the water that is in the power tunnel when generation stops. (The tunnel and penstock water is totally replaced in approximately 16 hours of shutdown.) When the next generation period begins, this replacement water is first discharged from the power tunnel and penstocks before lake water, which is entrained over a greater vertical range within Deep Creek Lake, passes through the tunnel, penstocks, and turbines and into the discharge channel. During summer, the water entrained during "shutdown" periods is lower in D.O. and cooler than the rest of the lake. Hence, the water quality of the powerhouse discharge at the start of generation resembles that of the bottom of the lake.

In summer, D.O. levels in the tailrace drop immediately after startup and remain depressed for about 15 minutes before increasing (Figure 3-23). Approximately 15 minutes is required to evacuate the water contained in the power tunnel and penstocks at the start of generation if both units are operating at full gate. After the initial startup, D.O. levels stabilize at operation levels that are higher than startup levels (i.e., at least 3 mg/l).

Temperature levels appear to mirror lake bottom temperature levels during the startup period and then increase and stabilize at higher temperatures (Figure 3-23). The higher temperatures suggest that water is drawn over a wide range of depths from the bottom to near the surface during generation. The largest fluctuations in both D.O. and temperature from the shutdown condition to the operating condition seem to occur between mid August and mid September. The most stable measurements recorded were for early August when D.O. at the lake bottom was 2-4 mg/l and October after the lake overturns.

3.5.3.2 Youghiogheny River

To monitor the frequency of critically warm water temperatures and their potential impacts on river trout populations, thermographs have been deployed annually since 1987 at a number of locations above and below the tailrace by the MDNR. The thermographs were placed in the river from June to mid-July each year, and removed from the river during the fall. Data recorded by these thermographs provides a basis to evaluate longitudinal changes in the river temperature downstream from the tailrace during periods of generation and non-generation.

A)

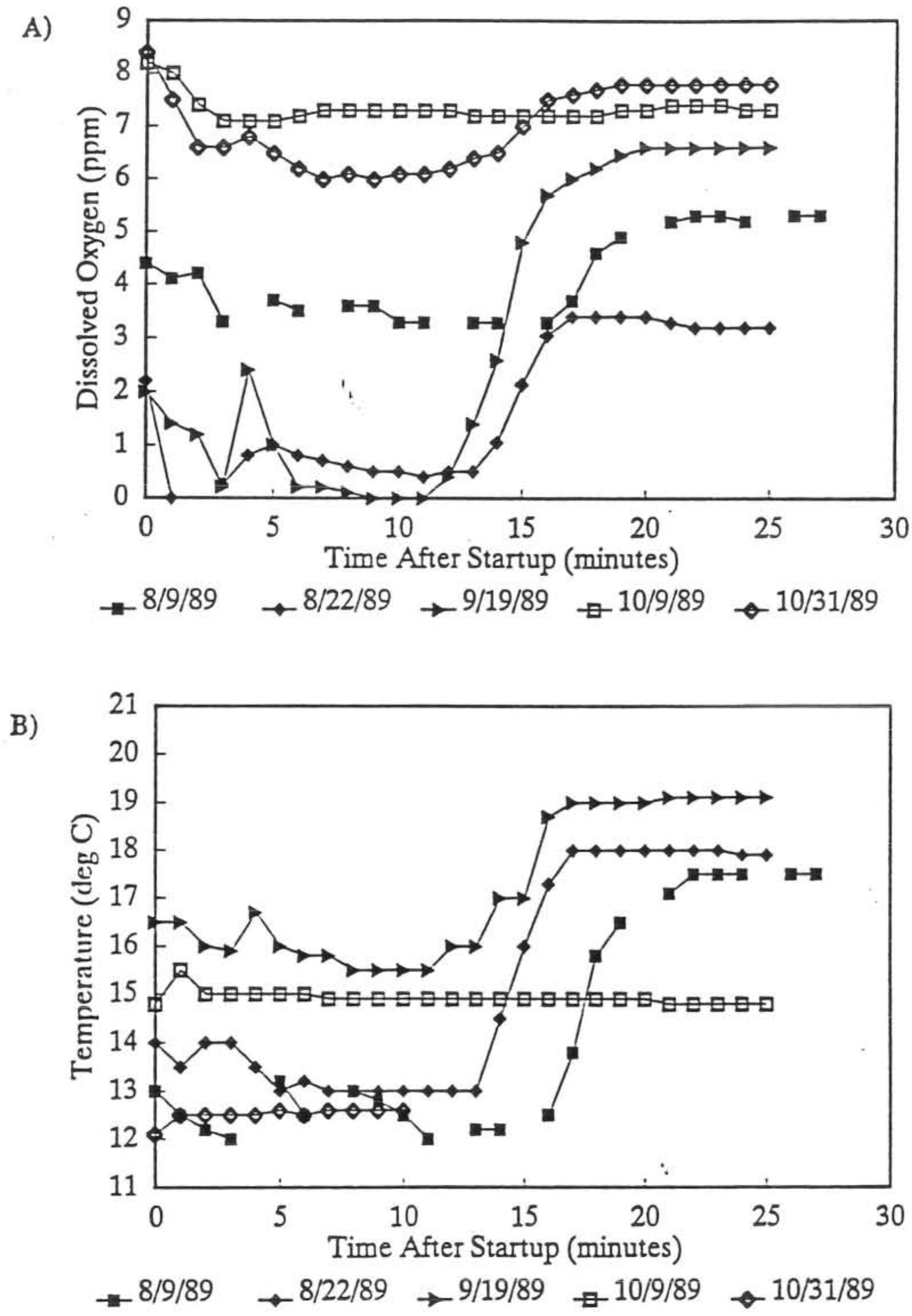


Figure 3-23. Dissolved oxygen (ppm) and temperature (^{o}C) measured in the tailrace after startup.

To supplement thermograph data, Penelec measured both water temperature and D.O. profiles across the river at a number of water quality transect locations downstream from the tailrace. These cross-sectional transects provided important information as to the proportion of the river affected by tailrace water releases from the Deep Creek Project. In addition, Penelec analyzed travel time in the river for generation and non-generation periods by conducting a dye study. The dye study was conducted using fluorescein dye and a fluorometer.

Water Temperature

Thermograph data was obtained for the Youghiogheny River upstream of the project's tailrace, and downstream from the tailrace at Hoyes Run and Sang Run. The thermograph located above the tailrace provided a record of inflow temperatures into the reach of the river below the tailrace. The thermographs at Hoyes Run and Sang Run provided temperatures in the river 0.4 miles and 3.7 miles below the tailrace, respectively. Temperature data were also obtained from a thermograph placed in the tailrace, which provided a record of temperature for water released from Deep Creek Lake during the summer and fall.

Water temperatures of the Youghiogheny River downstream from the Deep Creek tailrace are a function of discharge from the project, air temperature, and cloud cover (solar radiation). Variation in water temperatures for the period from 1987 to 1991 reflect the combined influence of climate and discharge. Relatively hot and dry weather conditions prevailed during the summers of 1987, 1988 and 1991, while cool and wet conditions prevailed during the summers of 1989 and 1990. Consequently, summer water temperatures in the Youghiogheny River were higher during 1987, 1988 and 1991, and considerably lower during 1989 and 1990.

Critical water temperatures (greater than 25°C) were encountered during the summers of the 1987, 1988 and 1991. Moreover, critical water temperatures were only observed during late May, June, July, and August. A critical temperature criteria of 25°C was developed with regard to the incipient lethal temperature for brown trout, which was identified as the species of most concern in the Youghiogheny River below the tailrace.

Youghiogheny River above Tailrace

Water temperatures during July, 1987 were the highest observed during the data collection period. Maximum daily water temperatures observed in the Youghiogheny River upstream of the Deep Creek tailrace generally exceeded 25°C during the last two weeks of July, with a peak reading of 28°C observed on July 22 (Figure 3-24). Maximum daily air temperatures for July, 1987 averaged 29.4°C, the highest observed during the data collection period (National Weather Service Records for Oakland, MD). River discharge was relatively low during this month, with a median value of 68 cfs. In August 1987, stream discharge declined to a median value 48 cfs. Maximum daily air temperature also declined to an average of 27.0°C during this month. Because of declining air temperatures, maximum daily water temperatures above the tailrace were lower than 25°C for most of August, exceeding this level for only 5 days. Maximum daily water temperature fluctuated between 18°C and 24°C for the remainder of the month.

Temperature data collected in 1988 may not be representative of the area upstream of the tailrace, possibly because the temperature monitor was placed in an area influenced by generation flows. Nonetheless, critical water temperatures were encountered in 1988 (Figure 3-25).

Maximum daily water temperatures did not reach critical conditions in either 1989 or 1990 (Figure 3-26 and Figure 3-27). Maximum daily temperatures were considerably lower in 1989 and 1990 than in 1987 and 1988 mainly for two reasons. First, air temperatures were substantially lower during these two years. The monthly average for maximum daily air temperature was 25.9°C for July 1989, 24.5°C

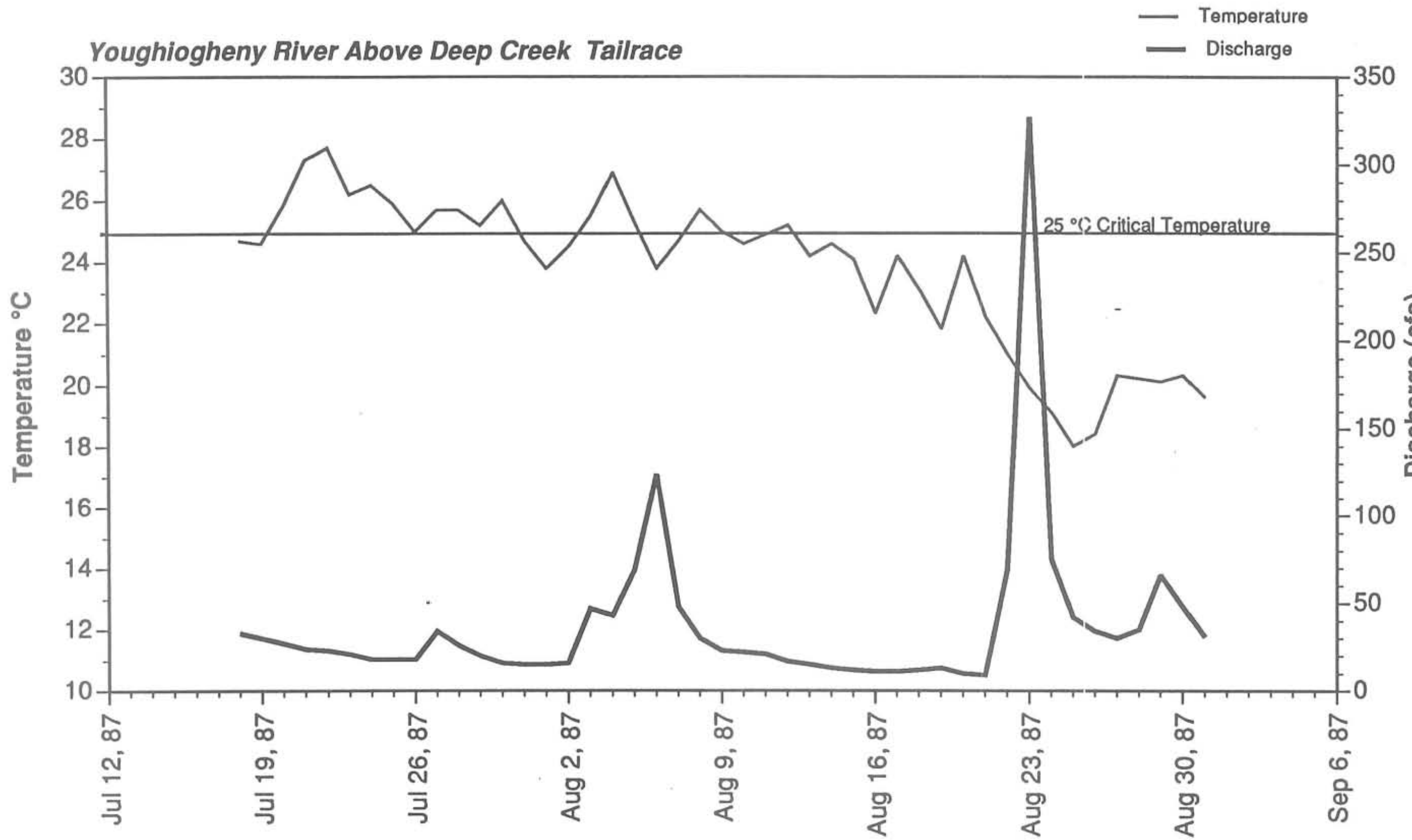


Figure 3-24. Maximum daily temperatures for Youghiogheny River above Deep Creek Project tailrace, July 18 - August 31, 1987.

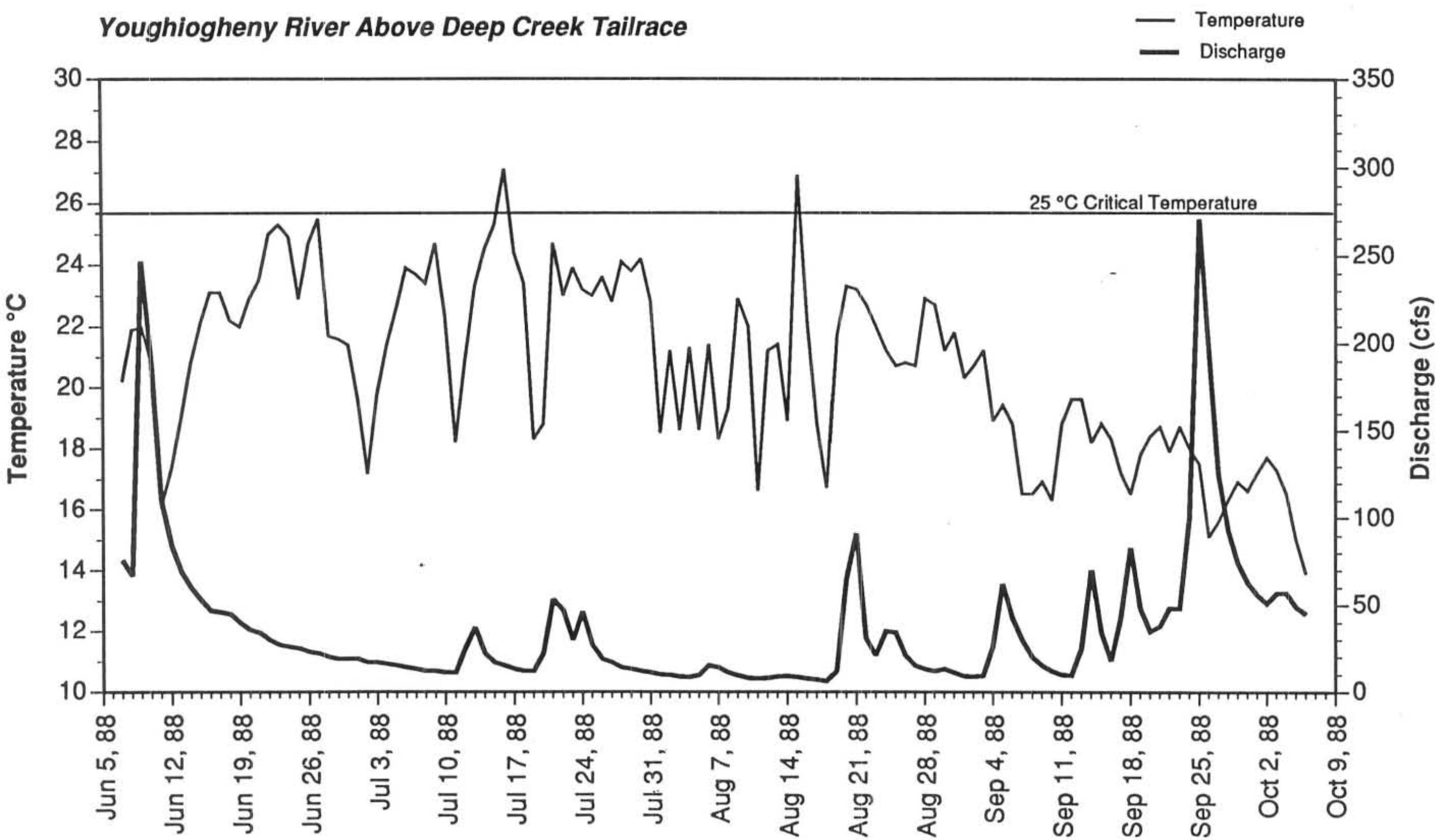


Figure 3-25. Maximum daily temperatures for Youghiogheny River above Deep Creek Project tailrace, June 7 - October 6, 1988.

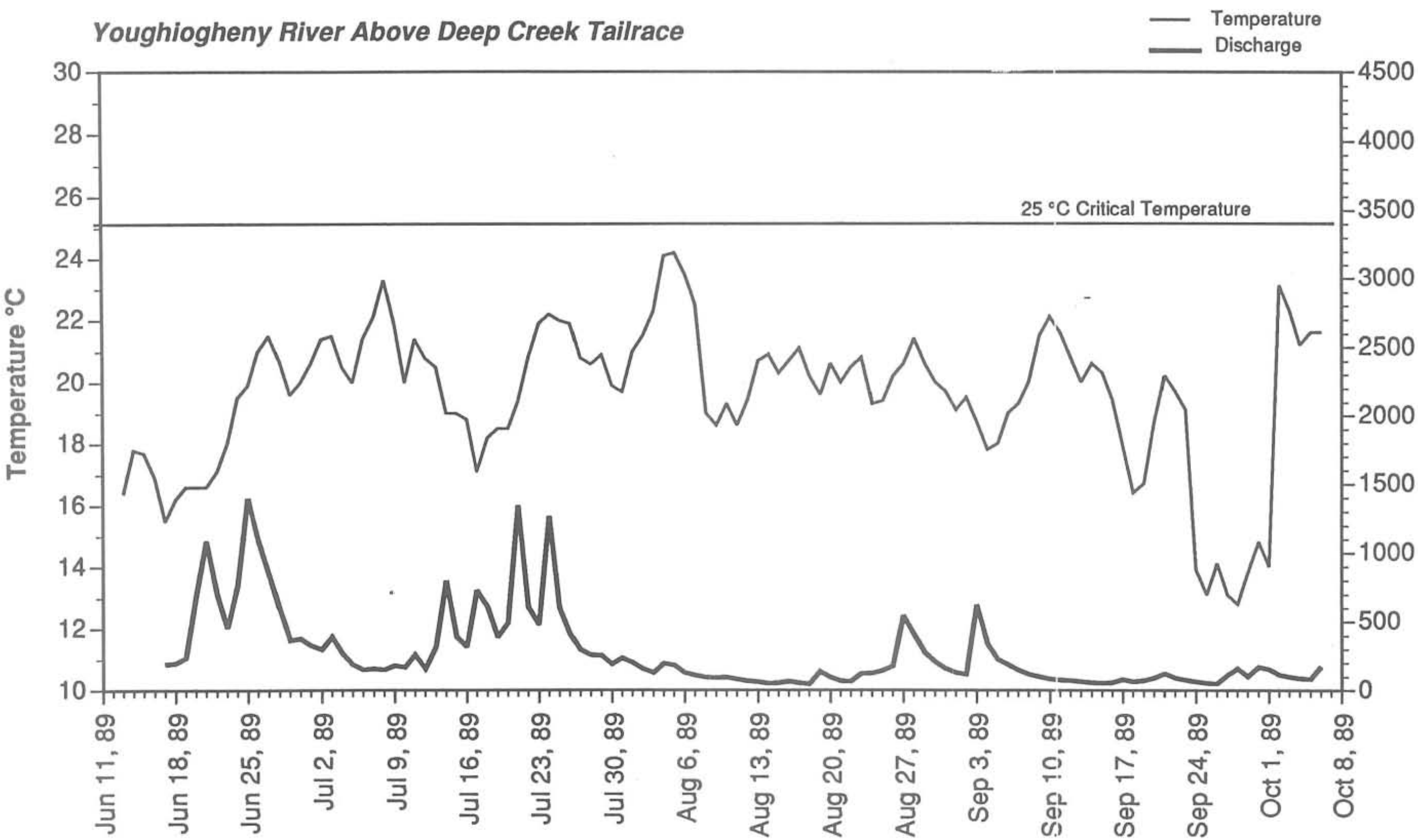


Figure 3-26. Maximum daily temperatures for Youghiogheny River above Deep Creek Project tailrace, June 13 - October 6, 1989.

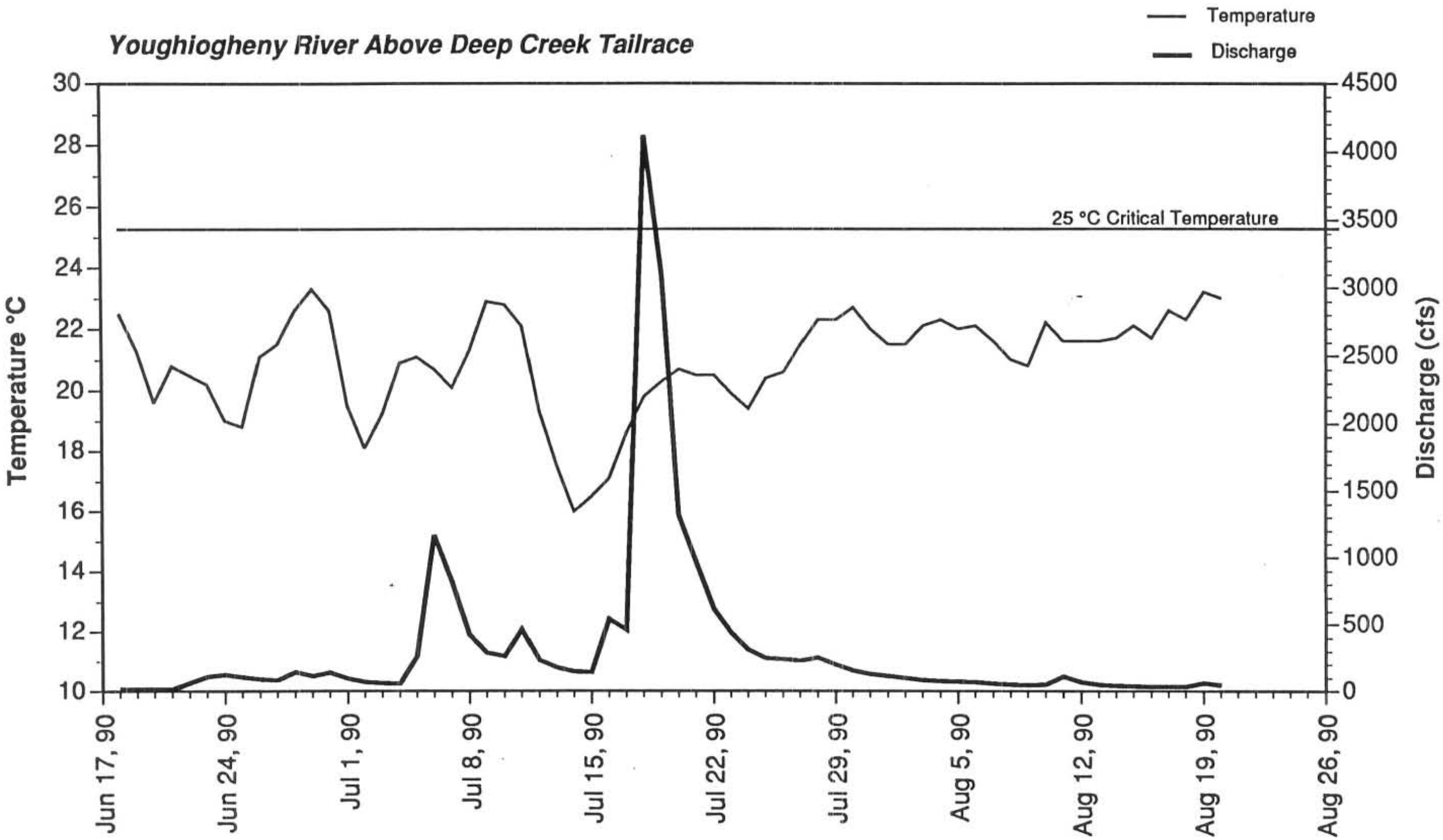


Figure 3-27. Maximum daily temperatures for Youghiogheny River above Deep Creek Project tailrace, June 18 - August 20, 1990.

for August 1989, 25.8°C for July 1990, and 24.7°C for August 1990. Secondly, the discharge was considerably higher.

From late May 1991 through August 1991, Youghiogheny River flows remained less than 100 cfs, and at times were below 20 cfs. Water temperatures upstream of the tailrace exceeded the 25° threshold on more than 20 occasions with the majority of the higher water temperature conditions occurring late May and early June, the latter half of June and July, and early August (Figure 3-28).

Youghiogheny River at Hoyes Run

Maximum daily water temperatures in the Youghiogheny River at Hoyes Run were substantially lower than those observed upstream of the tailrace in 1987 (Figure 3-29). Temperatures at the Hoyes Run location exceeded 25°C after July 19, 1987 only one occasion. Prior to July 19, no water temperature measurements were made. Water temperatures in the river at Hoyes Run were also significantly cooler than those observed above the tailrace in 1988, 1989, 1990, and 1991 (Figures 3-30 through 3-33).

The substantially cooler river water temperatures observed at Hoyes Run than upstream of the tailrace resulted from both the leakage flow through the turbines and releases of cool reservoir water from the Deep Creek Project tailrace. Leakage flows primarily cool the river along the right bank immediately below the tailrace.

During periods of power generation, the cooling effect of reservoir waters on the river below the tailrace is considerable. Maximum daily temperatures at the Hoyes Run location during the summer were typically from 2 to 5°C cooler than those observed in the river above the tailrace during generation.

Tailrace Conditions

Maximum daily water temperatures recorded in the Deep Creek Project tailrace varied between 12 and 18°C during the summer of 1987 (Figure 3-34). Lowest temperatures in the tailrace were observed

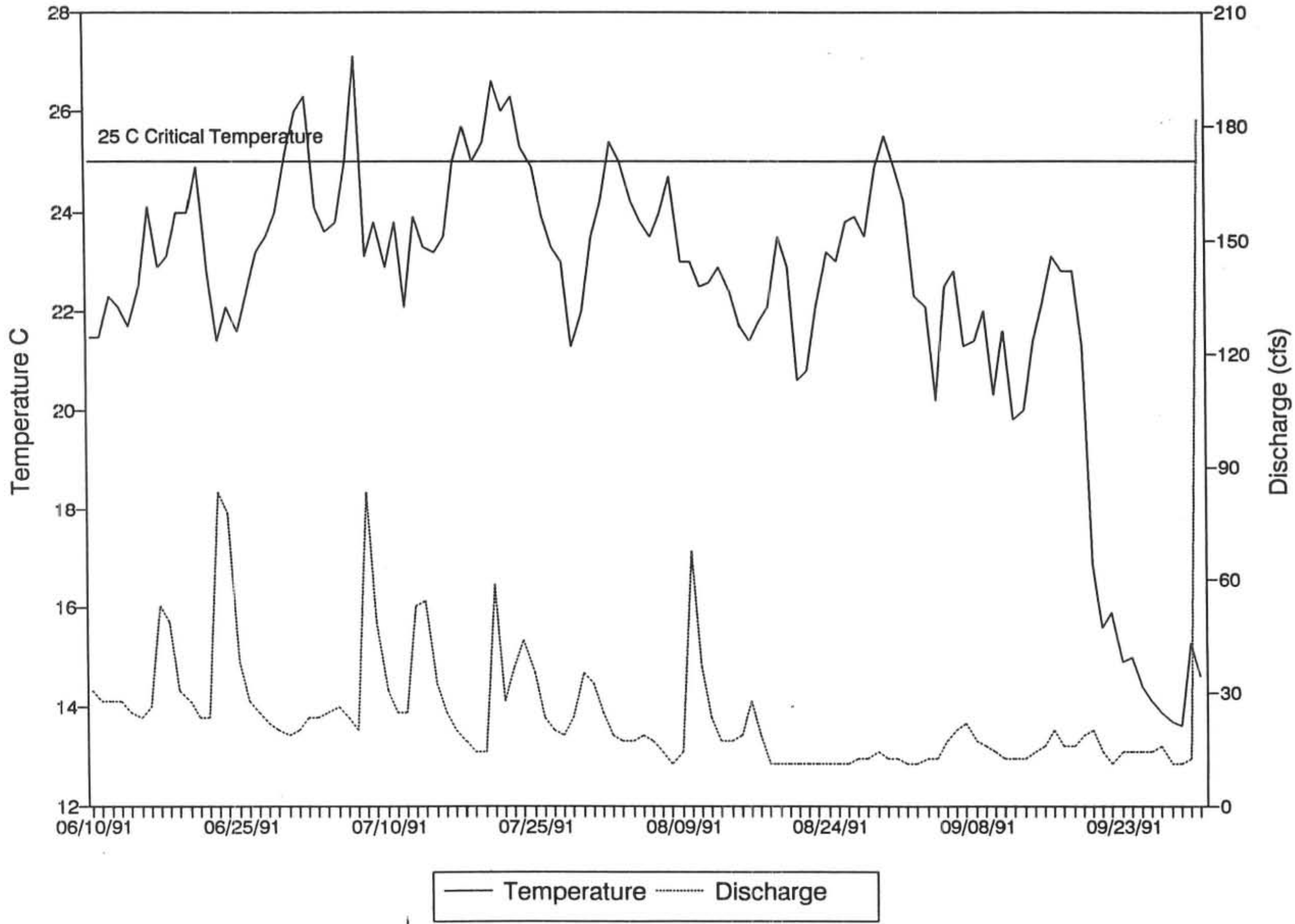


Figure 3-28. Maximum daily temperatures for Youghiogheny River above Deep Creek Project tailrace, June 10 - September 30, 1991.

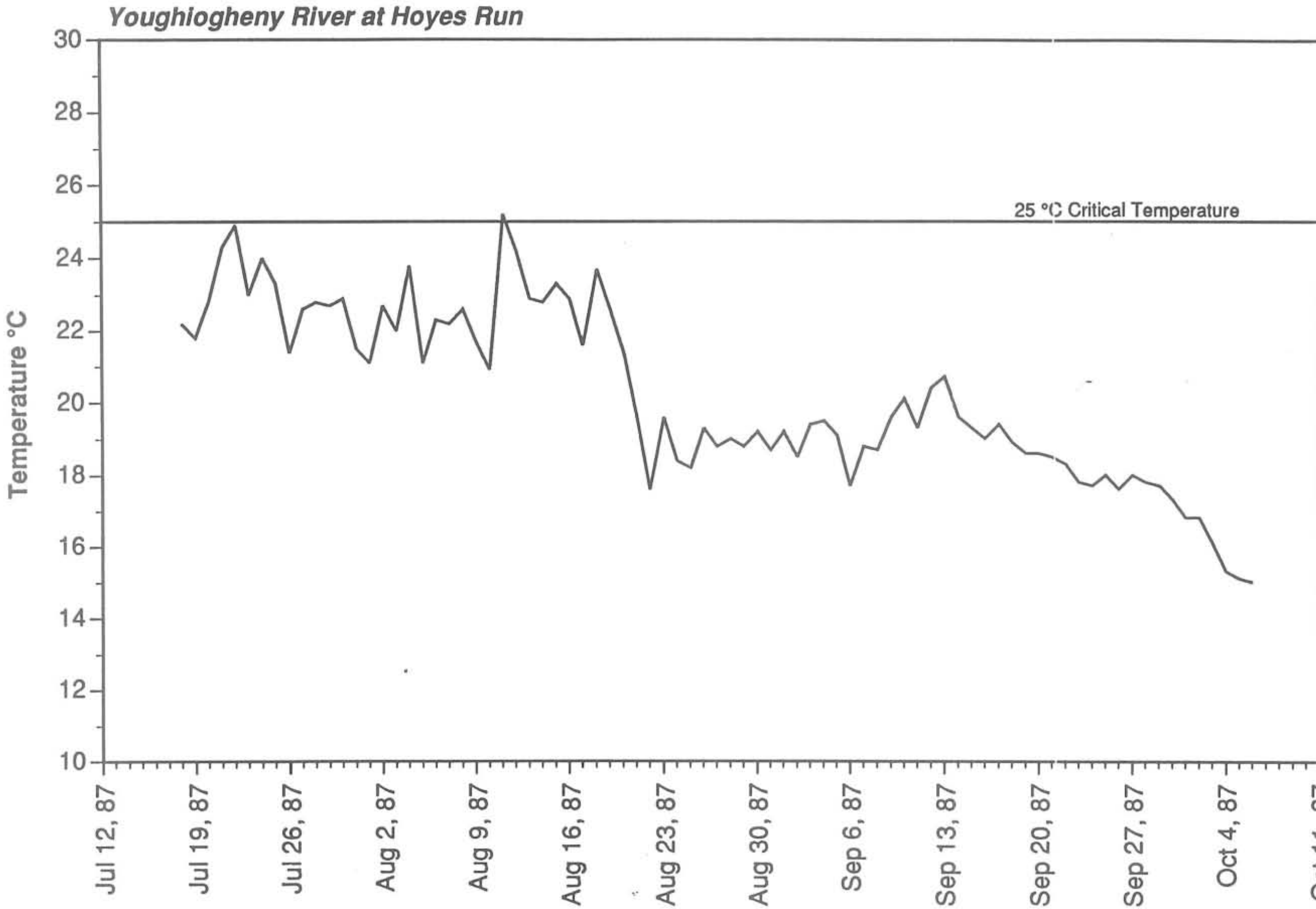


Figure 3-29. Maximum daily temperatures for Youghiogheny River at Hoyes Run, July 18 - October 6, 1987.

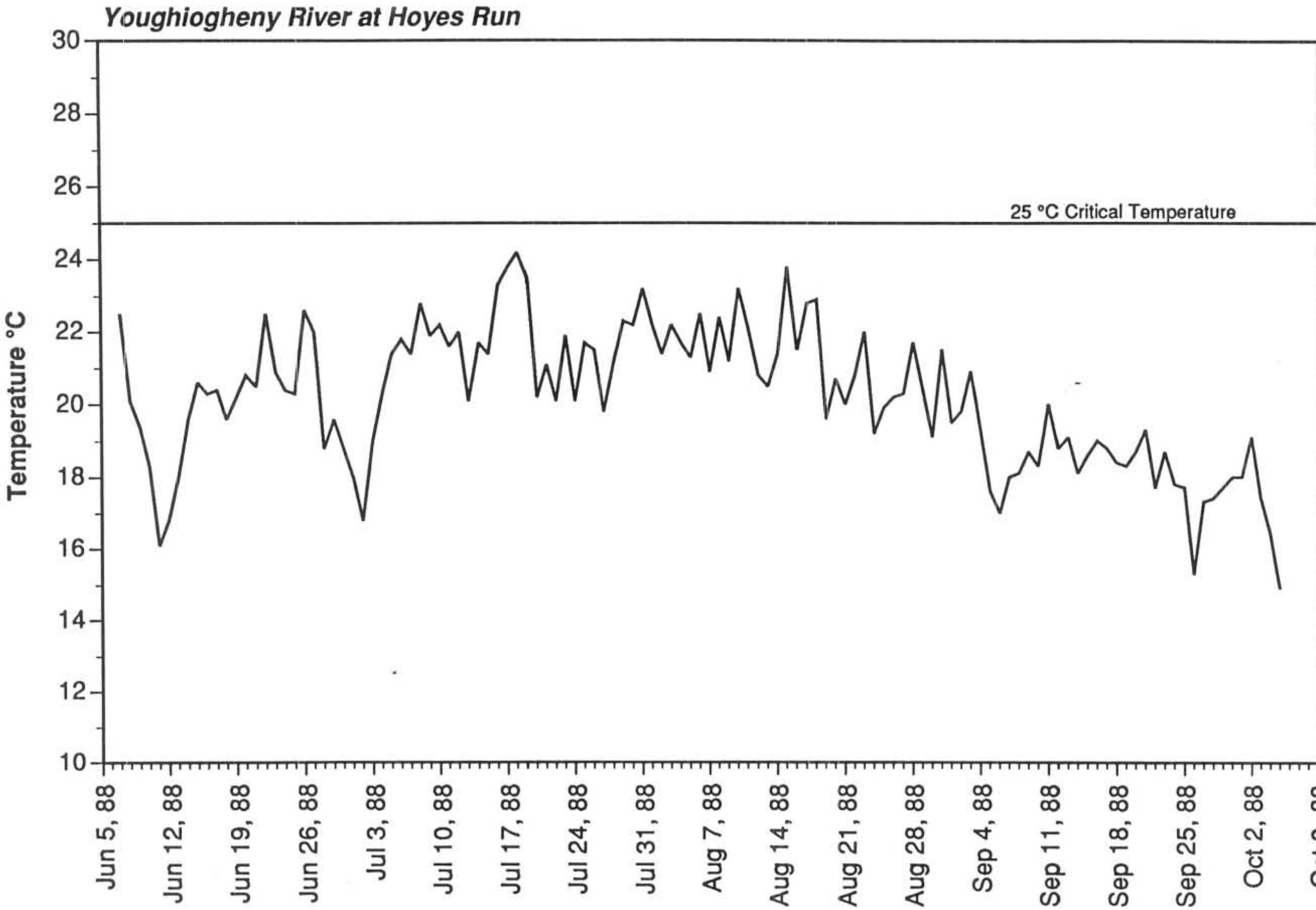


Figure 3-30. Maximum daily temperatures for Youghiogheny River at Hoyes Run, June 7 - October 5, 1988.

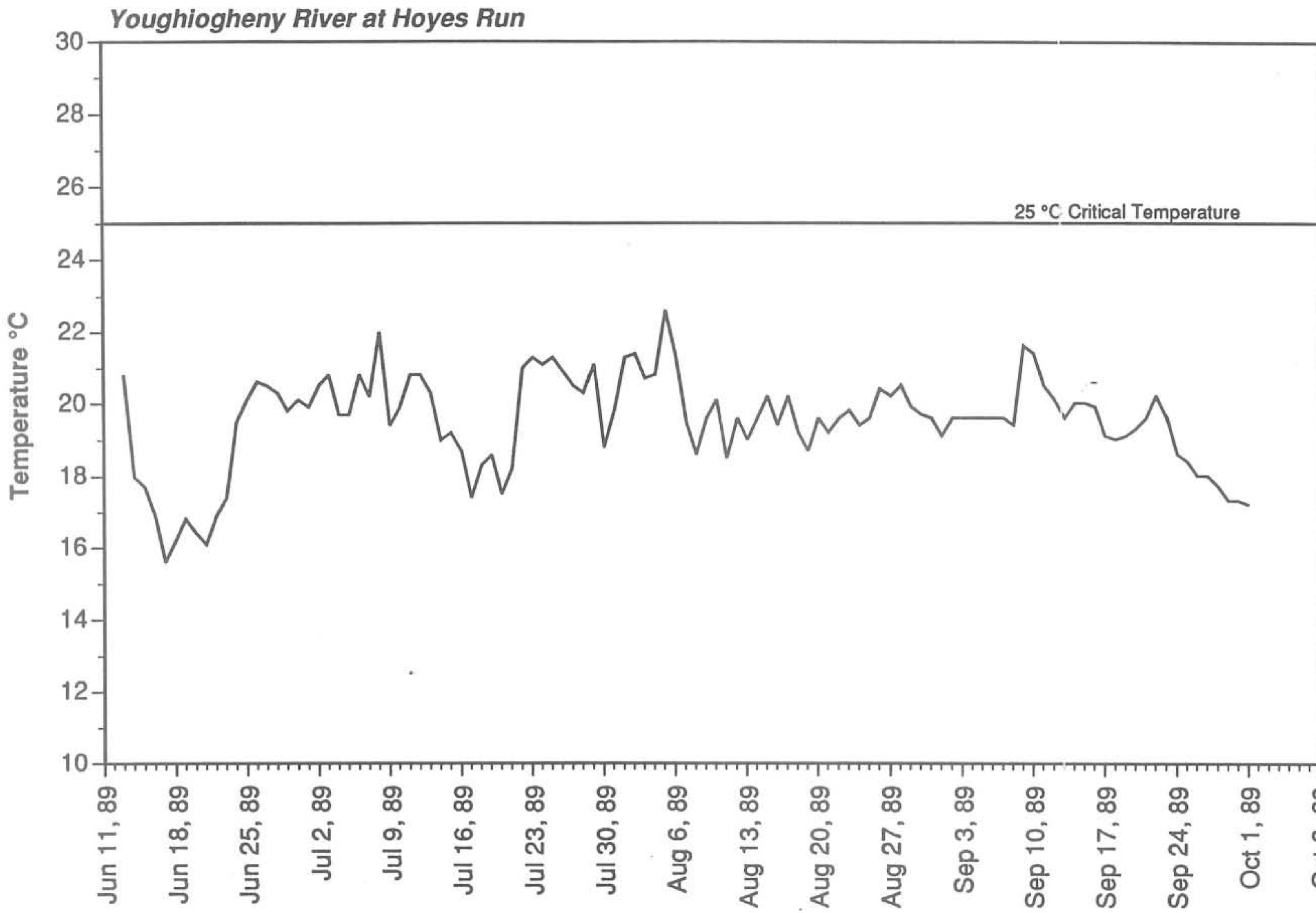


Figure 3-31. Maximum daily temperatures for Youghiogheny River at Hoyes Run, June 13 - October 10, 1989.

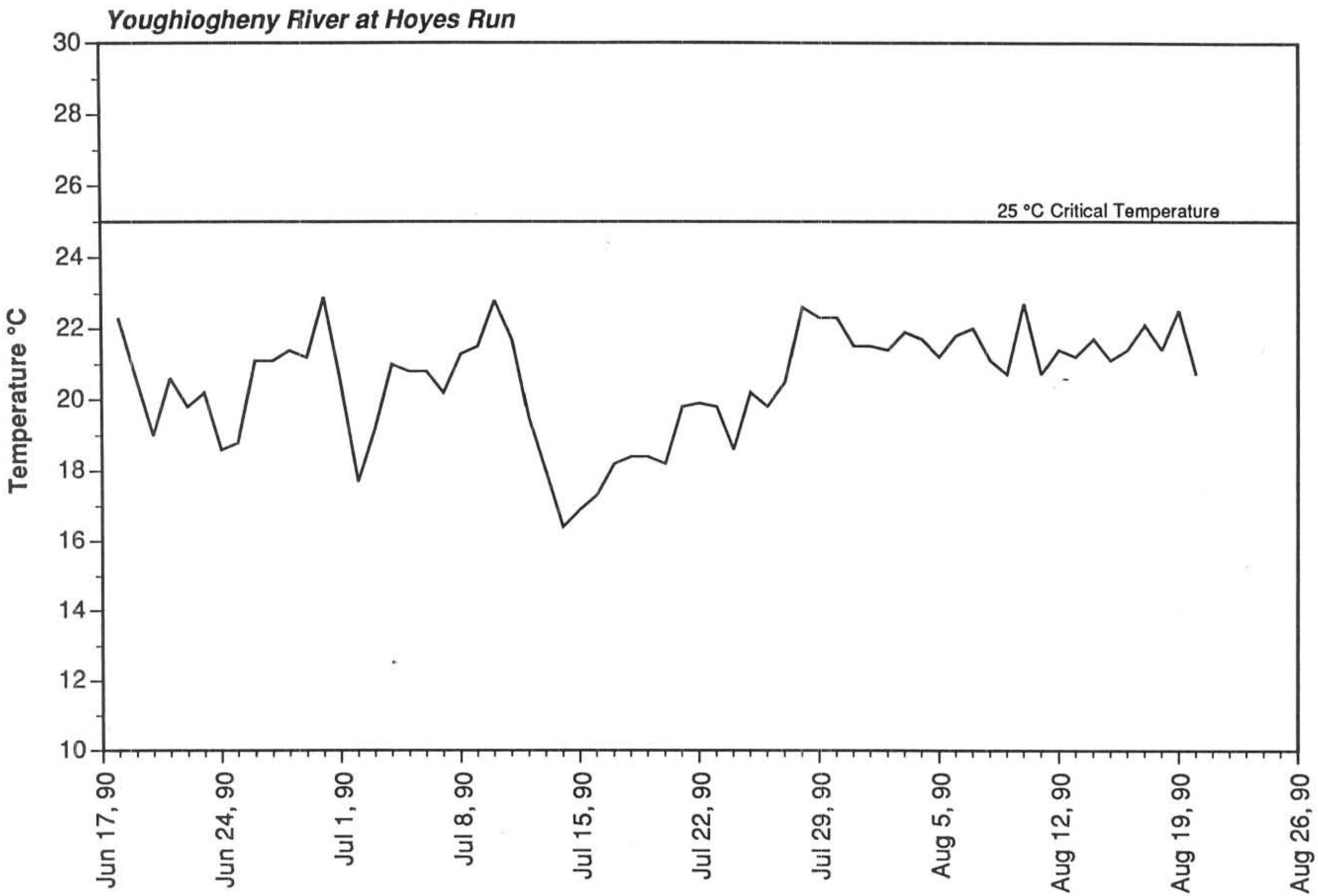


Figure 3-32. Maximum daily temperatures for Youghiogheny River at Hoyes Run, June 18 - August 20, 1990.

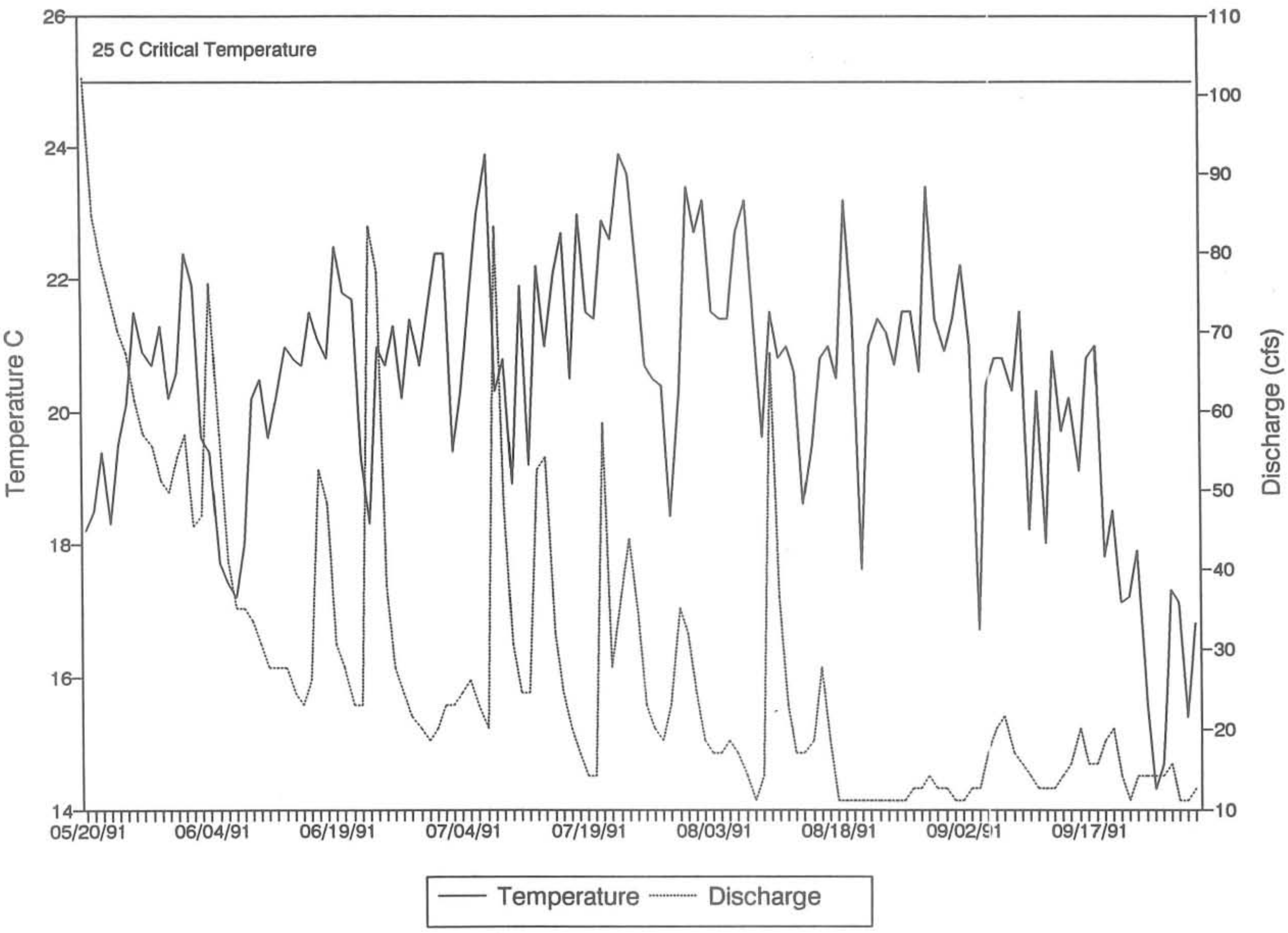


Figure 3-33. Maximum daily temperatures for Youghiogheny River at Hoyes Run, May 20 - September 30, 1991.

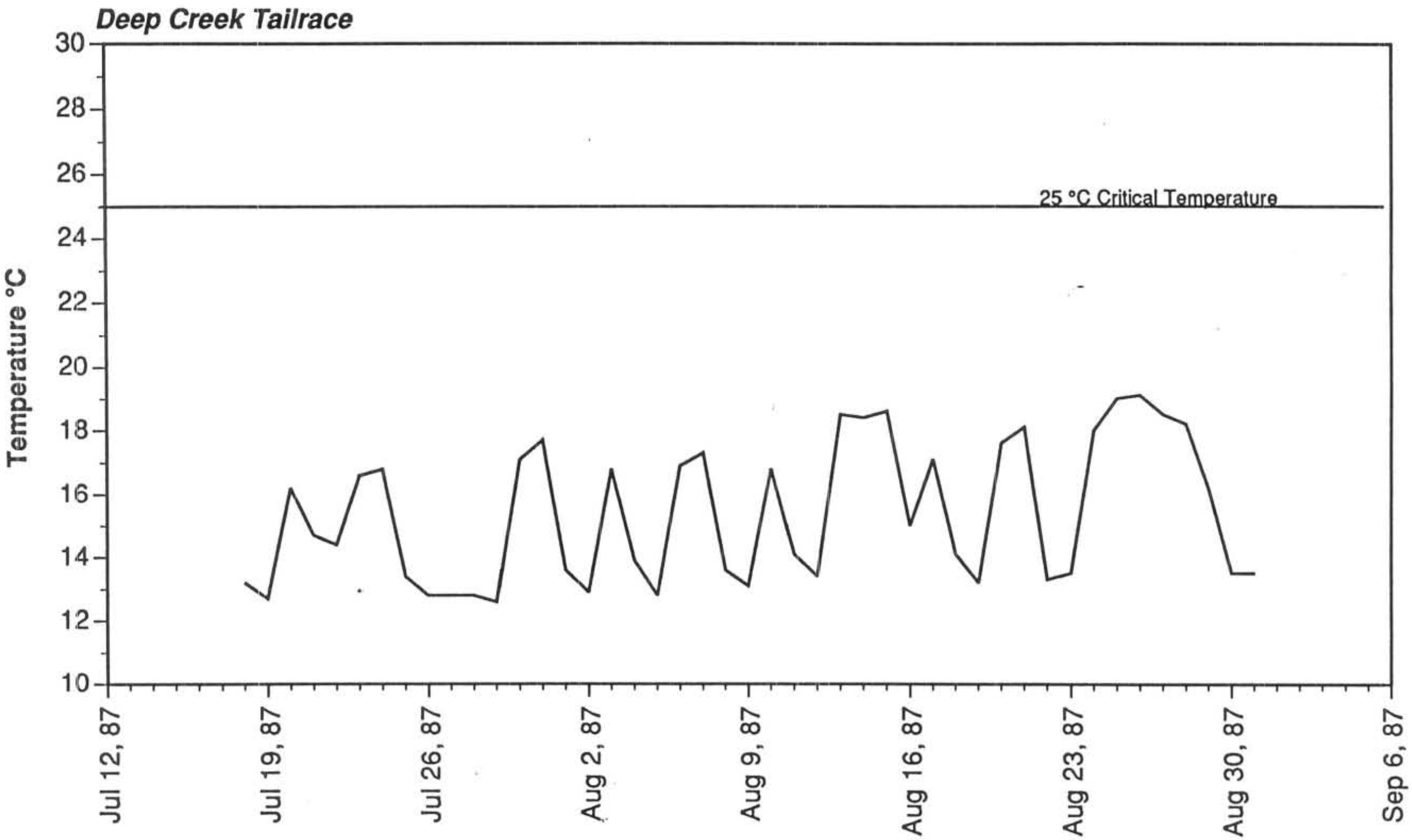


Figure 3-34. Maximum daily temperatures for Deep Creek Project tailrace, July 18 - August 31, 1987.

during non-generation periods, when temperatures were primarily affected by the 9 cfs leakage flows. The lower maximum daily tailrace temperatures observed from 1987 to 1991 coincide with days of non-generation (Figures 3-34 to 3-37). Tailrace waters are colder during periods of non-generation because most tailrace discharge originates from cooler hypolimnetic waters in Deep Creek Lake. During generation periods, maximum daily water temperatures in the tailrace are several degrees higher due to the entrainment of warmer epilimnetic lake waters into the power tunnel.

Water temperatures in the tailrace increased progressively during the summers of 1989, 1990 and 1991 until late August when they began to decrease (Figures 3-35, 3-36 and 3-37). (Temperature records in the tailrace were not available for 1988.) This trend in tailrace water temperatures was caused by a number of factors. A high daily frequency of power generation during the summer of 1989 and 1990 necessitated by storm inflows probably reduced the volume of cooler hypolimnetic lake waters, resulting in the release of warmer waters in late August and September. The severe summer storms, combined with periods of flooding (particularly in 1990), may have resulted in greater thermal mixing in the lake and further reduction of hypolimnion water. Reduction of the hypolimnion would be expected to be greatest during wet periods when the potential for lake thermal mixing is greatest, and power generation most frequent. Given that tailrace temperatures are dependent upon the depth and volume of the hypolimnion, warmer tailrace waters would be expected during wet rather than dry summers. Declining tailrace temperatures during September and October of 1989 and 1990 are explained by seasonal cooling of lake waters due to lower air temperatures.

Youghiogheny River at Sang Run

Leakage of cool waters from the tailrace was not sufficient to alleviate critically high water temperatures in the Youghiogheny River at Sang Run in 1987 and 1988 (Figures 3-38 and 3-39). Maximum daily water temperatures exceeded 25°C for a majority of days from July 17 to August 20, 1987 and from July 6 to August 20,

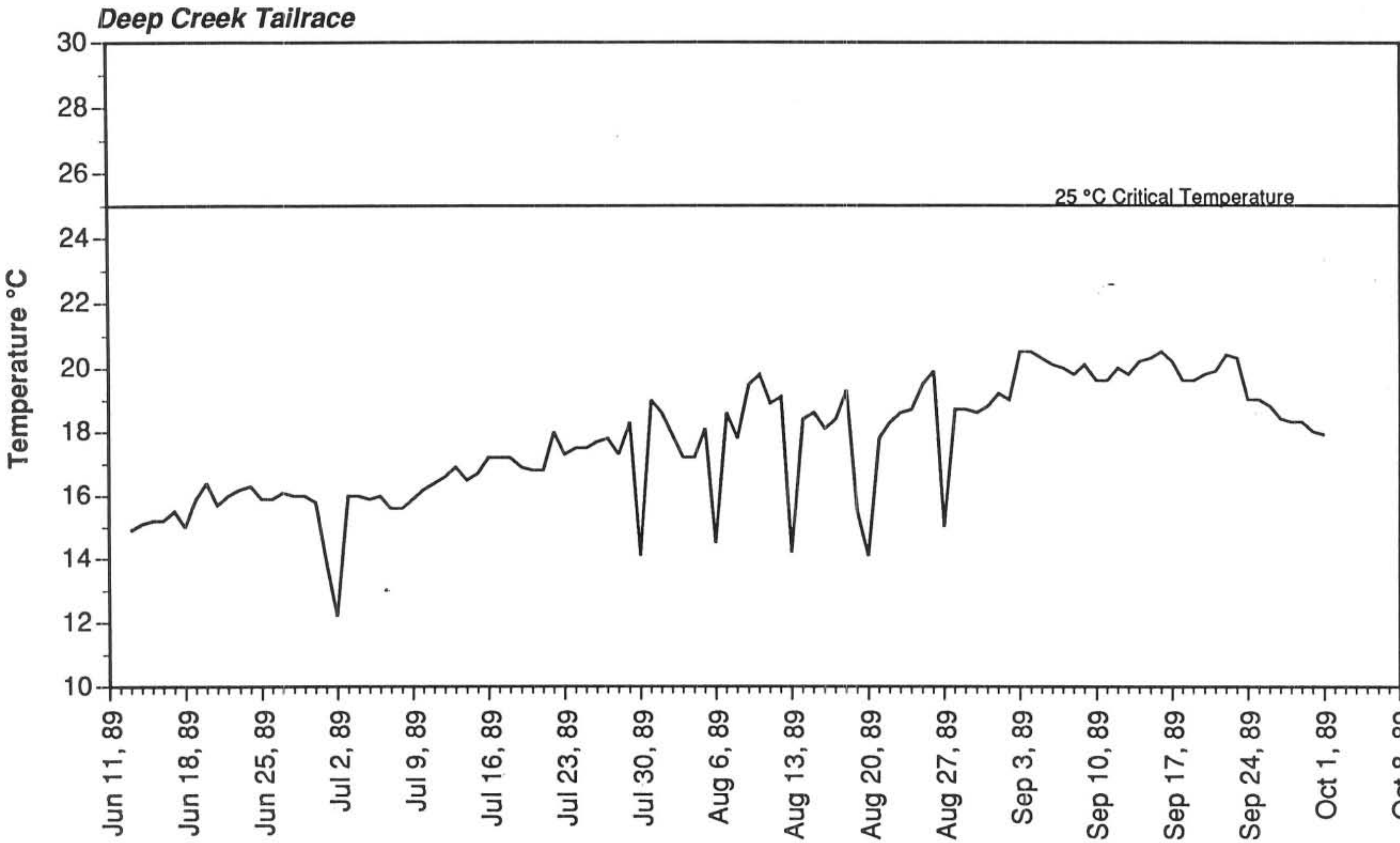


Figure 3-35. Maximum daily temperatures for Deep Creek Project tailrace, June 13 - October 1, 1989.

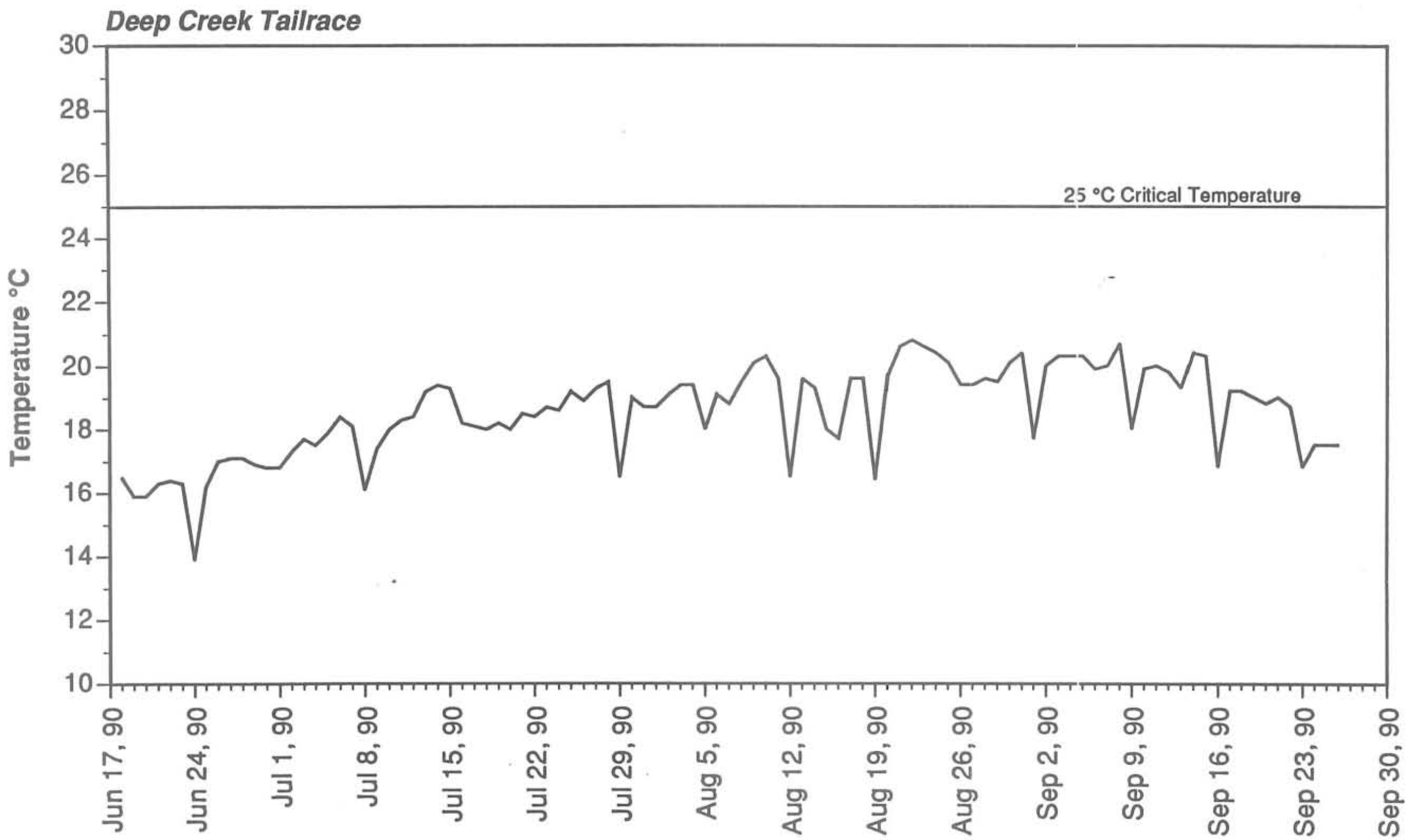


Figure 3-36. Maximum daily temperatures for Deep Creek Project tailrace, June 18 - September 26, 1990.

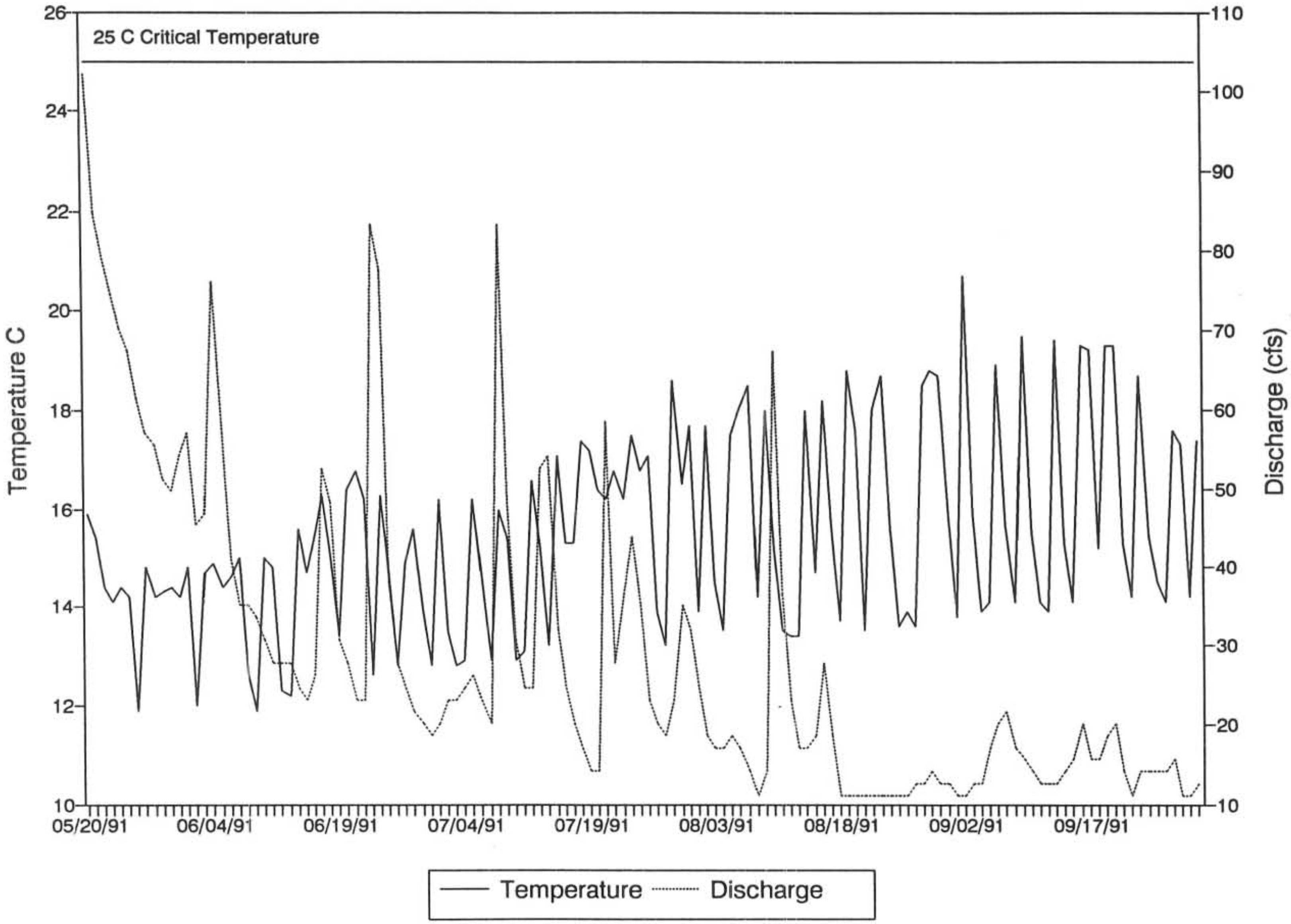


Figure 3-37. Maximum daily temperatures for Deep Creek Project tailrace, May 20 - September 30, 1991.

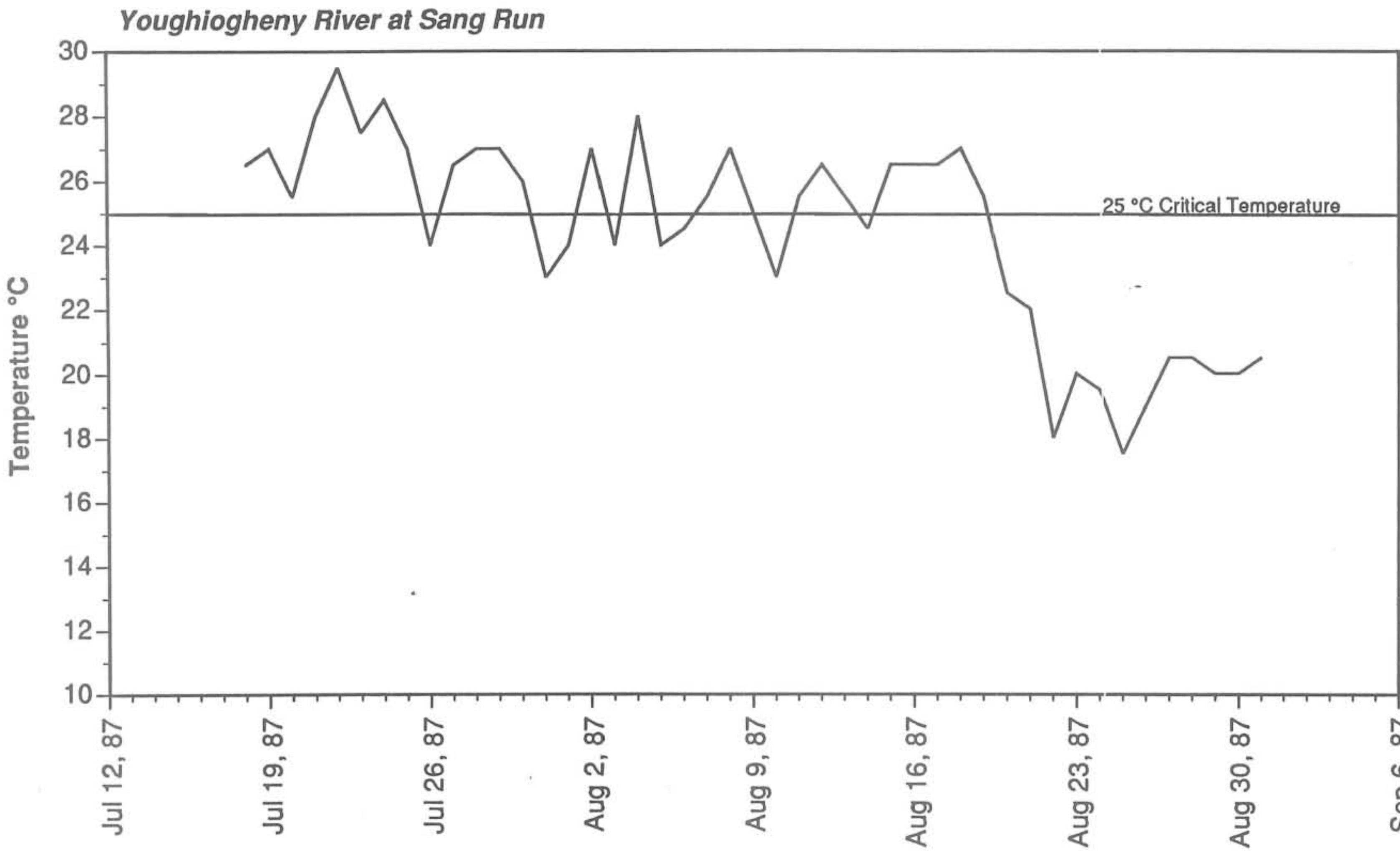


Figure 3-38. Maximum daily temperatures for Youghiogheny River at Sang Run, July 18 - August 31, 1987.

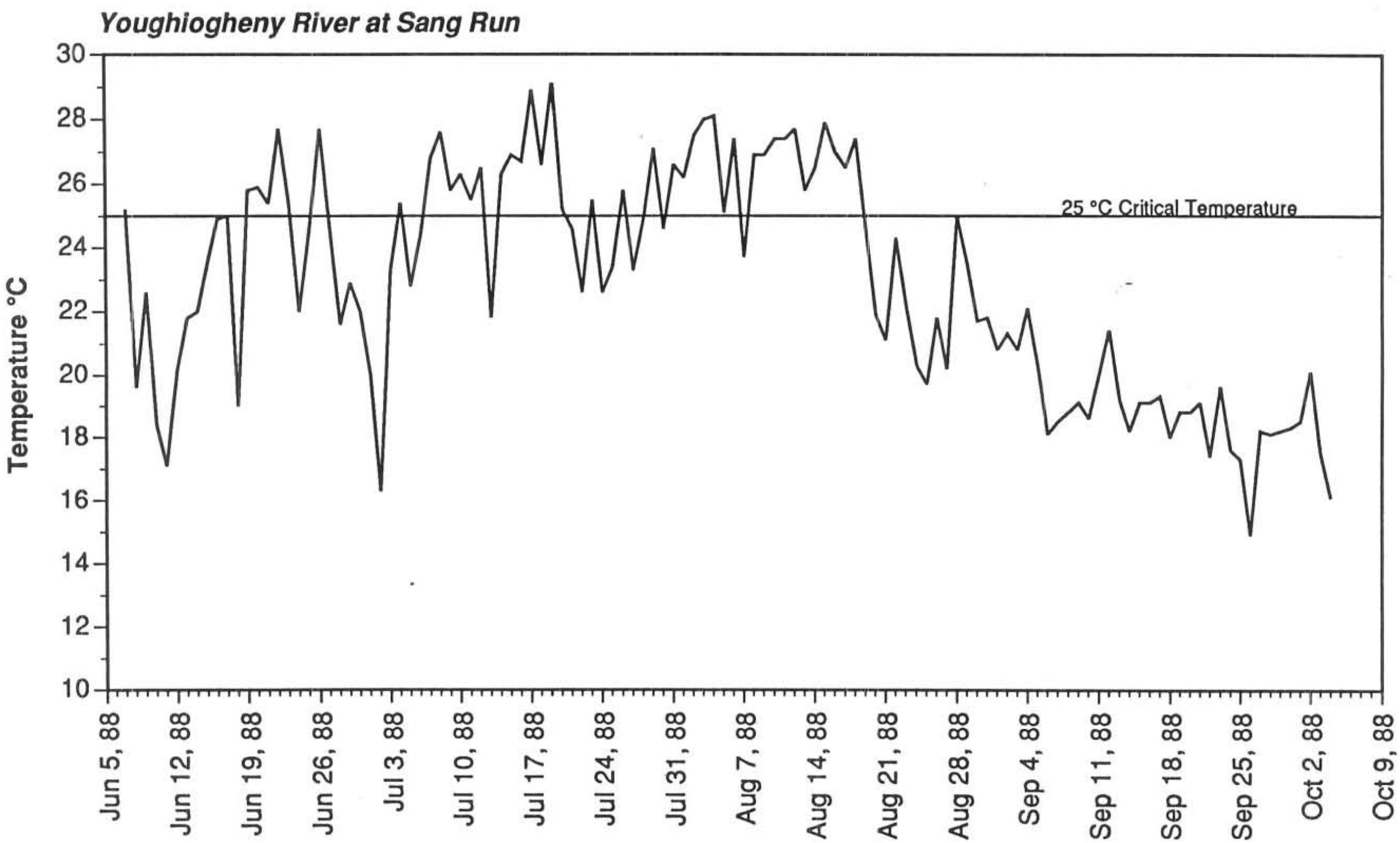


Figure 3-39. Maximum daily temperatures for Youghiogheny River at Sang Run, June 7 - October 4, 1988.

1988. The highest daily maximum temperature recorded from 1987 to 1990 at Sang Run was 29.5°C, which occurred on July 22, 1987. Temperatures of 29.0°C were recorded on July 17 and 19, 1988. The highest daily temperatures in 1987 and 1988 occurred on days when the Deep Creek Project was not generating. During the critically high water temperature periods occurring during July and August of these two years, temperatures below 25°C occurred primarily on days of power generation. Generation days can be identified on Figures 3-38 and 3-39 as apparent sudden temperature reductions in maximum daily temperature.

Like the river upstream of the tailrace, maximum daily water temperatures at the Sang Run location were considerably lower in 1989 and 1990. Temperatures exceeding 25°C only occurred once during 1989, and three times during 1990 (July 29, August 17, and August 19; Figures 3-40 and 3-41). Maximum daily water temperatures at the Sang Run location in 1989 and 1990 remained relatively low due to cooler climatic conditions, higher river flows, and from a daily generation frequency of about 90 percent.

In 1991, Sang Run water temperatures exceeded 25°C on 33 days from May 26 to August 30. The highest water temperature recorded was 29°C on July 7, 1991. Temperatures exceeded 28°C on 7 occasions (Figure 3-42).

Diel Temperature Patterns

Analysis of diel (24-hour) temperature data in the Youghiogheny River upstream of the tailrace, in the river at Sang Run, and in the tailrace, provides important information about the time of day when critical high temperature conditions occur. The highest water temperature recorded on the river upstream of the tailrace and at Sang Run occurred on July 22, 1987, which was a non-generation day. On this day, water temperatures at Sang Run declined from 25°C at midnight to a low of 21°C at 8:00 a.m. (Figure 3-43). Water temperatures increased to reach a high 29.5°C at 6:00 p.m., and then declined again to about 25°C at midnight. For the river

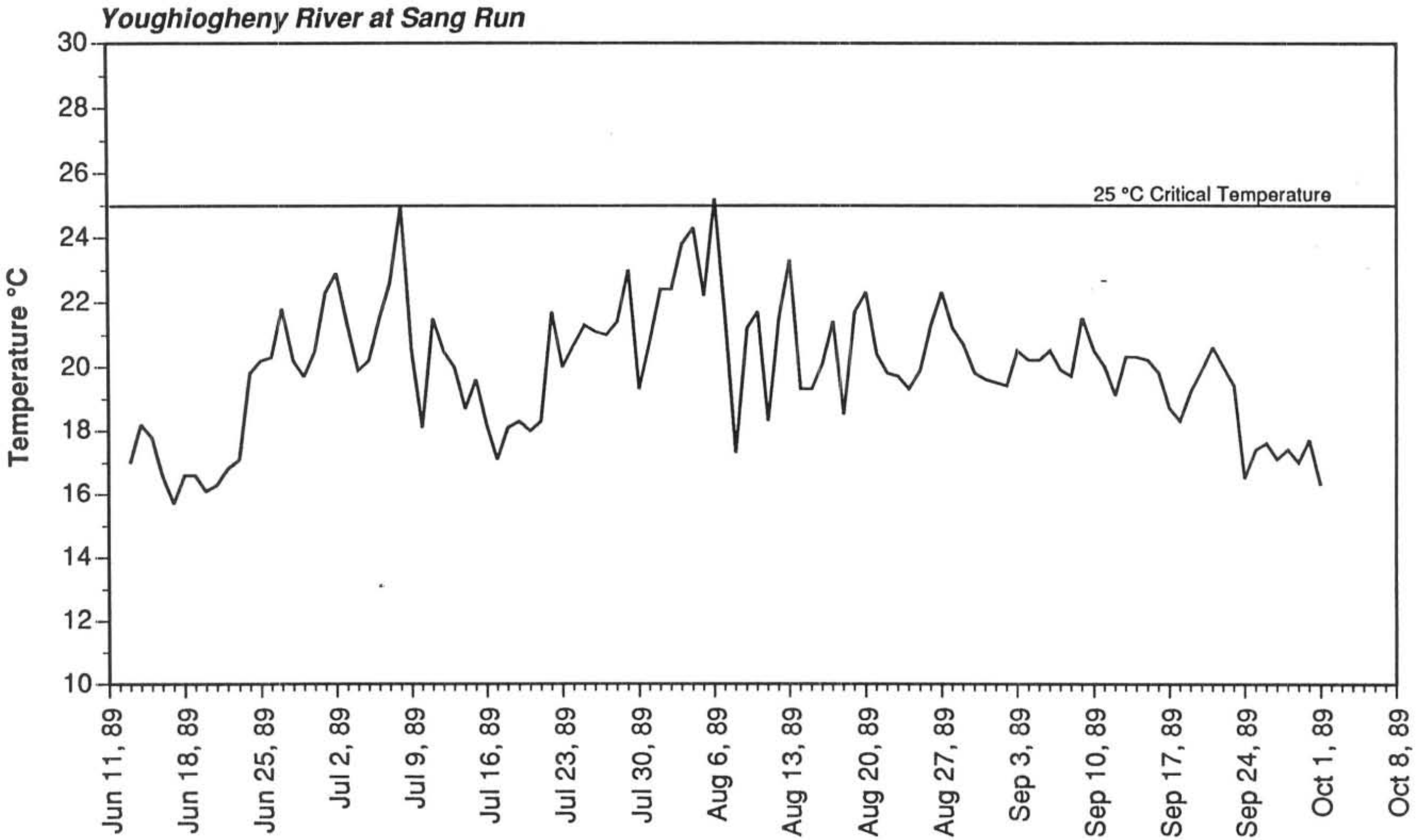


Figure 3-40. Maximum daily temperatures for Youghiogheny River at Sang Run, June 13 - October 1, 1989.

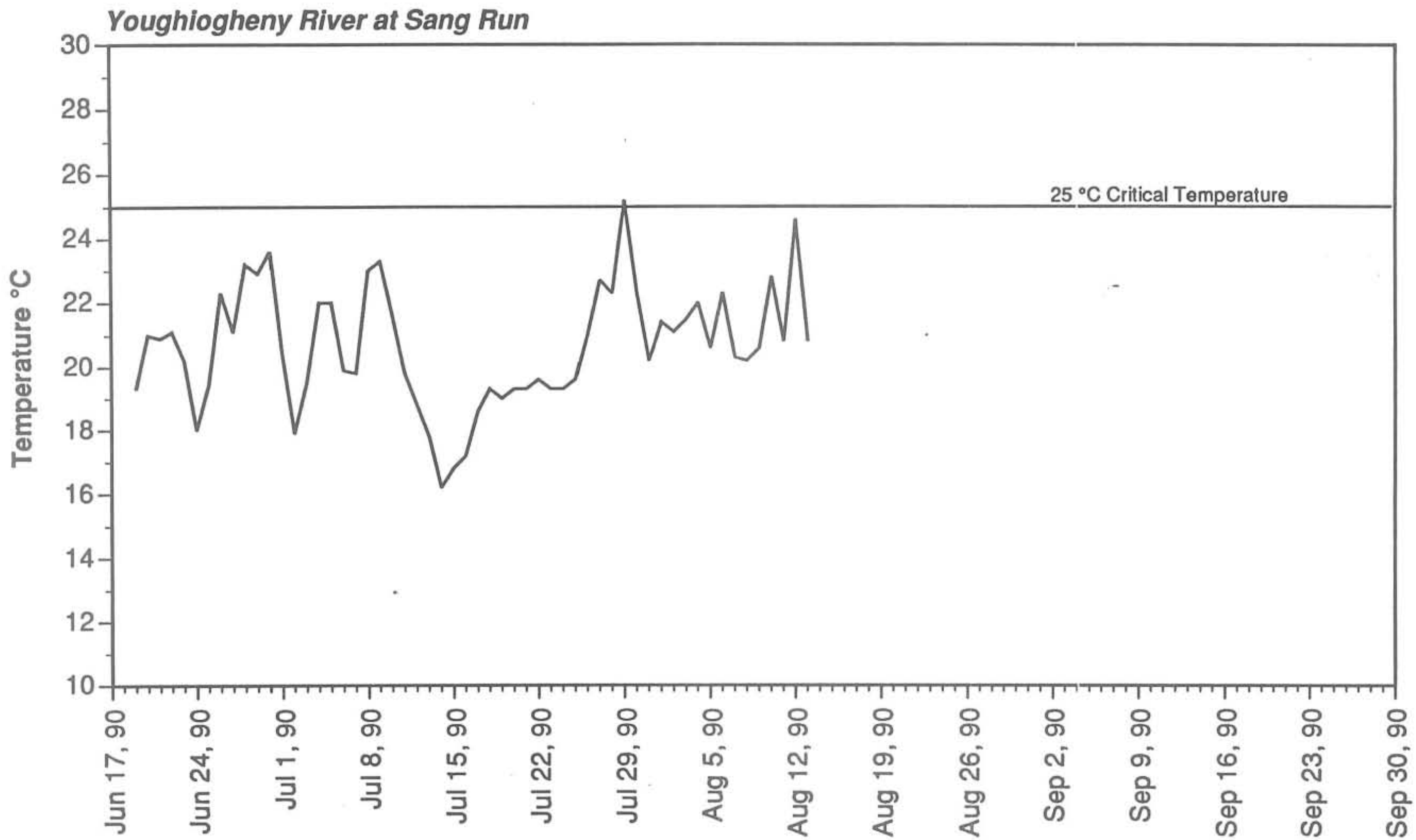


Figure 3-41. Maximum daily temperatures for Youghiogheny River at Sang Run, June 19 - August 13, 1990.

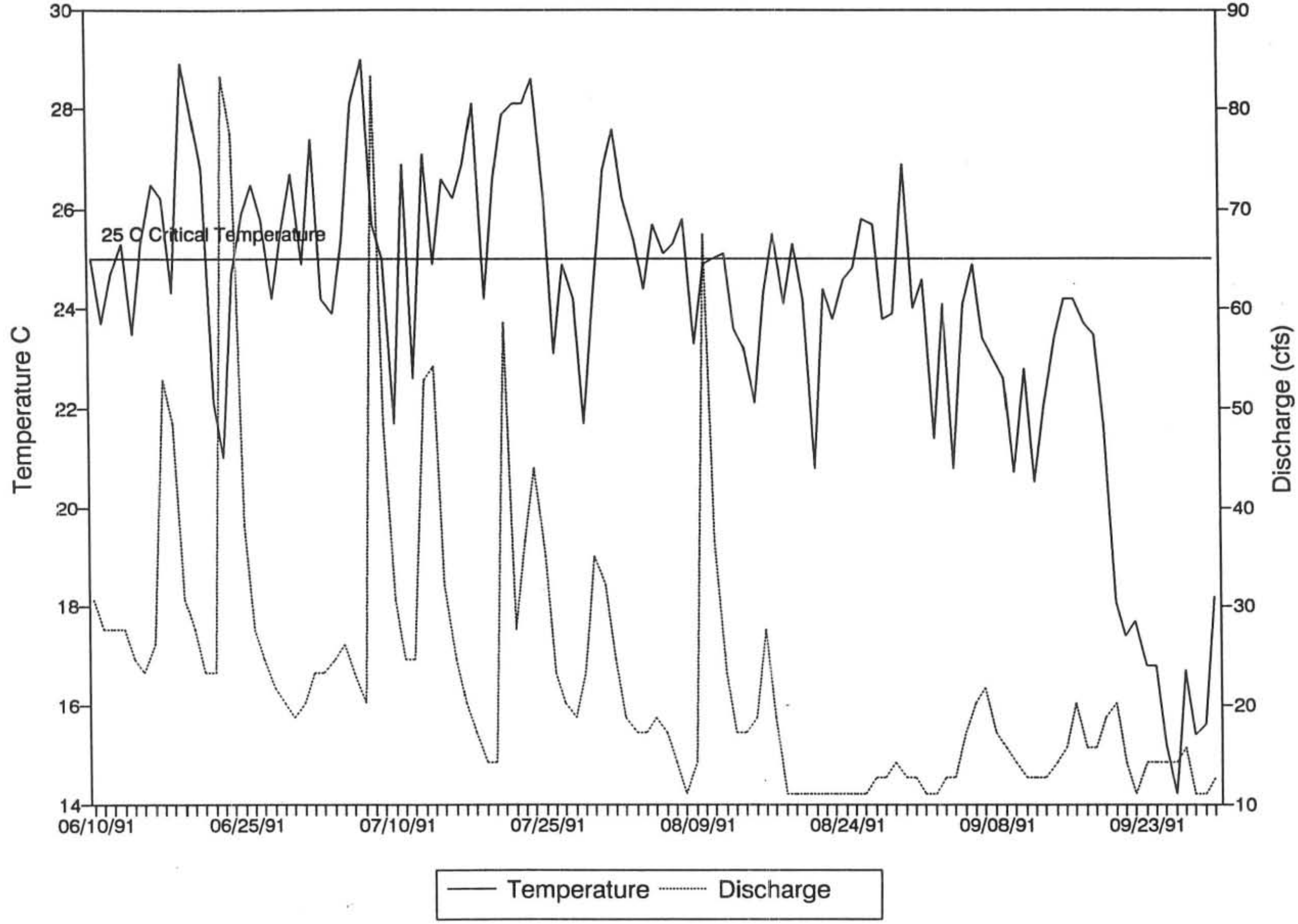
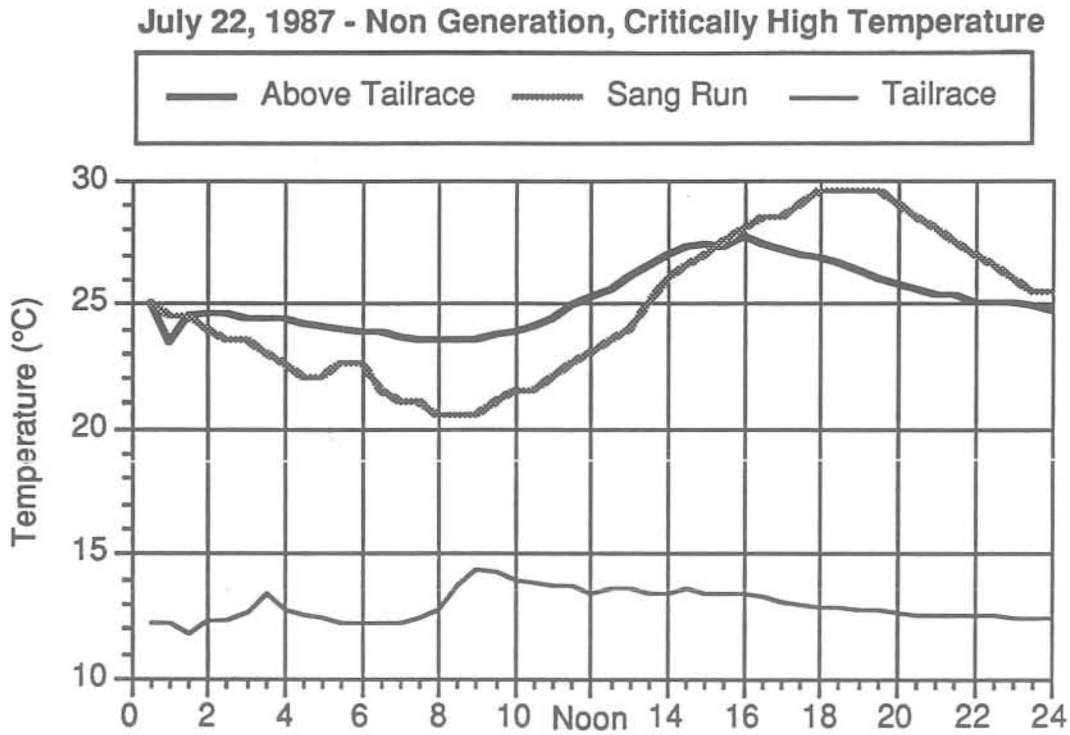
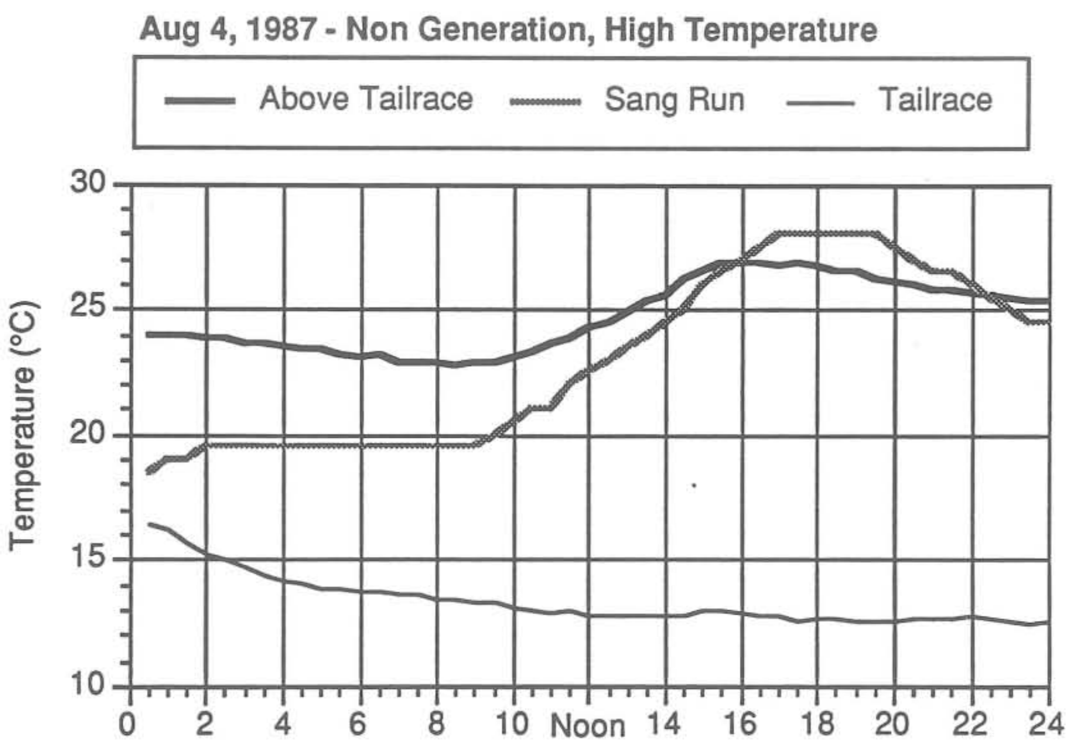


Figure 3-42. Maximum daily temperatures for Youghiogheny River at Sang Run, June 10 - September 30, 1991.



Average discharge above tailrace is 23 cfs.



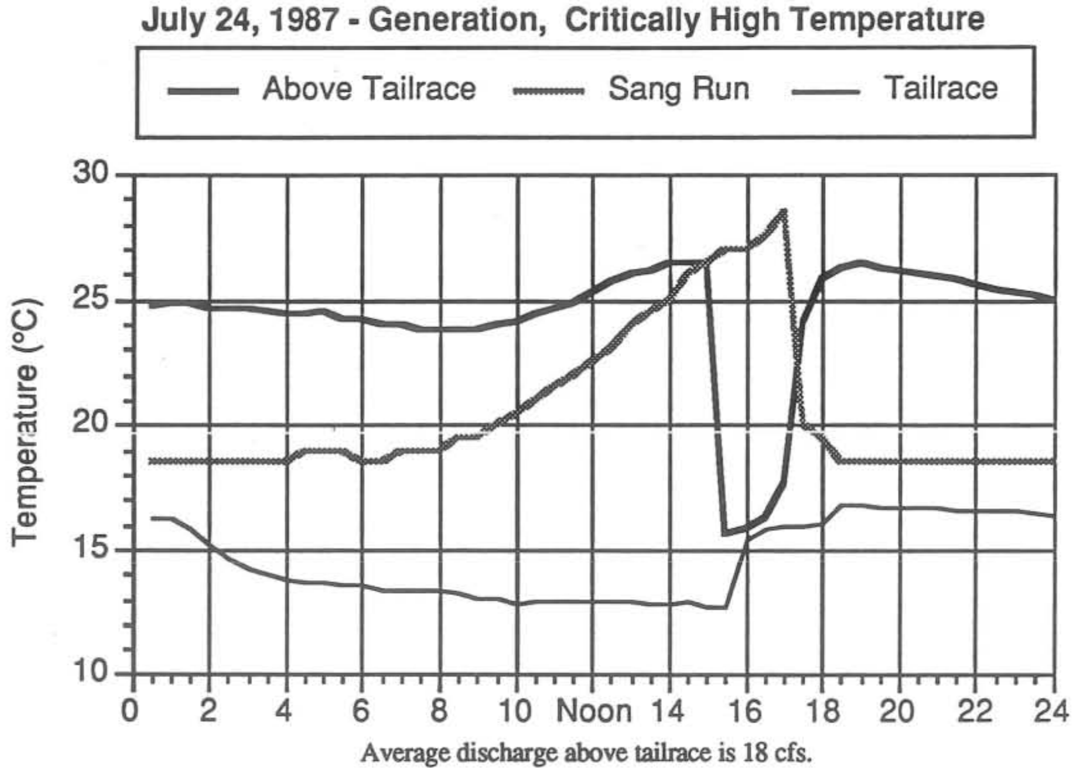
Average discharge above tailrace is 43 cfs.

Figure 3-43. Results of temperature measurements taken in the Deep Creek Project tailrace and mainstem Youghiogheny River during non-generation periods.

upstream of the tailrace, a lower peak temperature of 27.5°C was observed two hours earlier at 4:00 p.m. For both locations, critical temperatures above 25°C were exceeded for 10 hours during the day. Temperatures exceeded 25°C at noon upstream of the tailrace, and dropped below this level at 10:00 p.m. For the river at Sang Run, temperatures exceeded 25°C at approximately 2:00 p.m., and dropped below this point at midnight. Similar diel temperature patterns were observed on August 4, 1987, a non-generation day for which high temperature conditions were observed. On this day, water temperatures for the river upstream of the tailrace exceeded 25°C for 11 hours, beginning at 1:00 p.m. and ending at midnight. Water temperatures for the river at Sang Run exceeded 25°C for about 9 hours, beginning at 2:00 p.m. and ending at 11:00 p.m. Water temperatures in the tailrace varied between 12 and 14°C on July 22, and between 13 and 16°C on August 4.

Power generation results in rapid reductions in water temperatures in the river during critically high temperature conditions. This was illustrated on July 24, 1987, when Deep Creek Station operated for a 2-hour period between 3:00 p.m. and 5:00 p.m. (Figure 3-44). The thermograph located above the tailrace was obviously influenced by backwater effects from power generation, as temperatures dropped suddenly from 26°C to 16°C at 3:00 p.m. For the river at Sang Run, temperatures rapidly declined at 5:00 p.m., two hours after project operations commenced, indicating a 2-hour hydraulic travel time. At Sang Run, temperatures dropped from 28°C to 18°C. A similar pattern was observed for cooler conditions occurring on August 3, 1987 (Figure 3-44). The project also generated on this date for approximately two hours. For the river immediately upstream of the tailrace, the temperature decreased 10°C, while at Sang Run the temperature decreased 5°C. On both days, temperatures in the tailrace increased from 12°C before generation, to 16°C during and immediately following generation.

The importance of hydraulic travel time on water temperatures in the river is illustrated on both July 24, 1987 and August 3, 1987



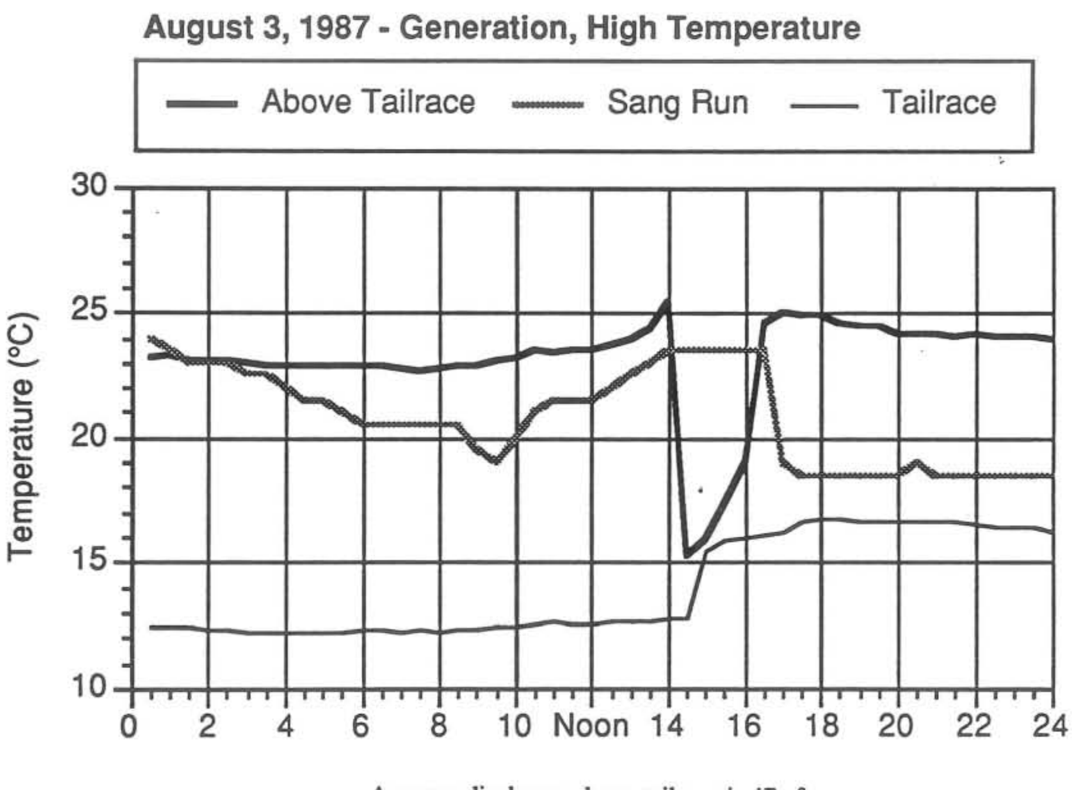


Figure 3-44. Results of temperature measurements taken in the Deep Creek Project tailrace and mainstem Youghiogheny River during generation periods.

at the Sang Run thermograph location (Figure 3-44). After water temperature dropped from 28 to 18°C on July 24, it remained at about 18°C for the remainder of the day, a period exceeding six hours. River discharge on July 24 was 640 cfs during generation, and 30 cfs after power generation ceased. A similar pattern was observed on August 3, when temperatures dropped from 23°C to 18°C and then remained at 18°C for the remainder of the day. River discharge on August 3 was 680 cfs during generation, and 74 cfs after generation ceased. Although power was generated on both days for a period of two hours, water temperatures at Sang Run continued to be moderated by cool water released from the reservoir for more than 6 hours. Deep Creek Lake water released during power generation effectively flushes the river downstream from the tailrace with cool water. When power generation ceases, this cool water remains in the river for many hours due to the longer travel time of water at baseflow conditions. Thus, generation for short periods of time affects downstream temperatures for much longer periods.

During two-turbine generation, the river between the tailrace and Sang Run is seeded with cool water in about two hours. Dye studies conducted by Penelec during non-generation indicated that the hydraulic travel time between the tailrace and Sang Run bridge for 173 cfs is about 5 hours (Figure 3-45). The travel time for this same discharge to Friendsville is about 18 hours (Figure 3-46). At lower discharges, hydraulic travel time would be considerably longer. During low flow summer conditions, the river between the tailrace and Sang Run is fully saturated by cooler Deep Creek Lake water after about two hours of generation. As a result of the increased hydraulic travel time after generation ceases, water from Deep Creek Lake present in the river between the tailrace and Sang Run immediately after shutdown continues to reduce water temperatures at Sang Run for over 5 hours. At Friendsville, the beneficial effects of cool reservoir water on river temperatures could continue for 18 hours or more, albeit substantially reduced due to natural heating processes.

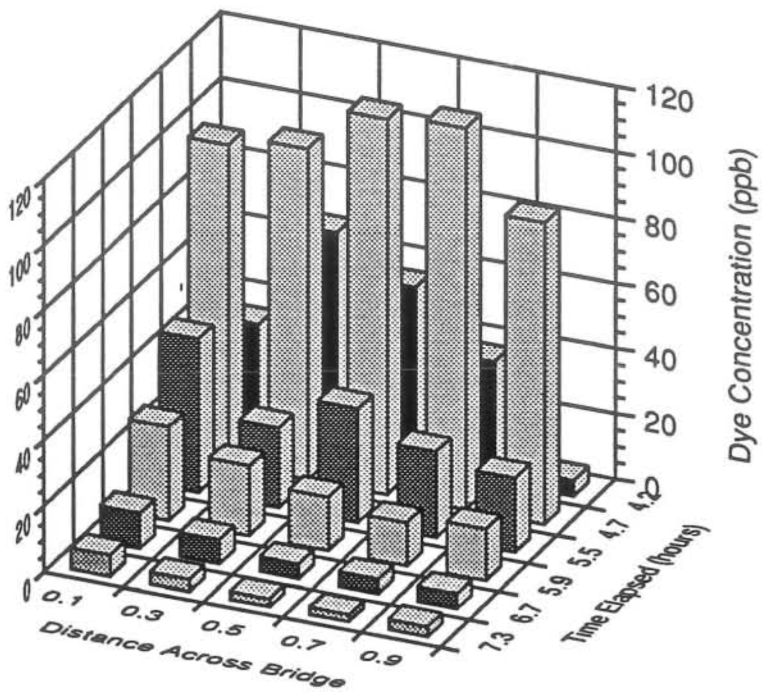


Figure 3-45. Dye concentration values at Sang Run Bridge, September 17, 1989.

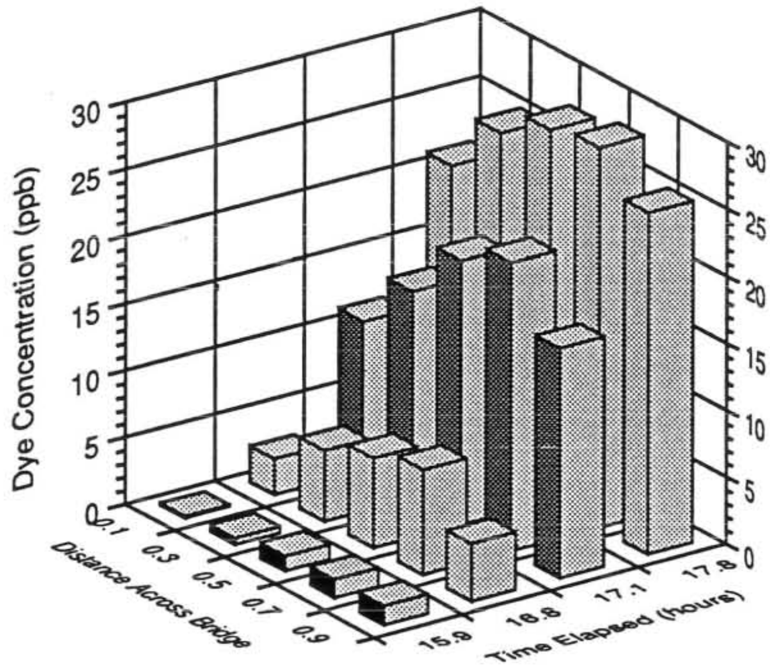


Figure 3-46. Dye concentration values at Friendsville Bridge, September 18, 1990.

Benthic conduction and heat absorption are important processes controlling daily temperature fluctuations in the reach downstream of the tailrace. These processes store heat in the river bottom on hot sunny days and return it to the water column during project releases and at night. The river bottom also conducts some of the cooler temperatures from the releases and buffers the water column from other heating processes after shutdown.

Water Temperature and Dissolved Oxygen Cross-Sectional Profile

As mentioned previously, hypolimnetic (lower layer) water from Deep Creek Lake provides benefits to the river below the tailrace during critically warm periods. However, the hypolimnetic waters can also be low in D.O. Since the tailrace is located on the right bank of the Youghiogheny River, the greatest positive influence of cooler water temperatures, and negative influence of low D.O. concentrations, occurs along the right bank for some distance downstream. To investigate the impact of tailrace temperatures and D.O. concentrations on the river downstream from the tailrace, temperature and D.O. were measured at intervals across the river at predetermined transect locations.

The influence of tailrace water releases on temperature and D.O. concentrations at any cross-section in the river depends on the flow released from the tailrace, the discharge in the river above the tailrace, and the distance downstream from the tailrace. Distance downstream from the tailrace is a major factor affecting temperatures and D.O. concentrations across the river. For a transect located 480 feet (146 m) below the tailrace on August 22, 1989, only the first 50 feet (15 m) of the river from the shore were affected by tailrace temperatures and D.O. concentrations (Figure 3-47). At this location, temperature was reduced by about 2°C, while D.O. concentration was reduced by about 2 ppm.

Downstream from this location, a much greater proportion of the river cross-section is affected by the plume of water released from

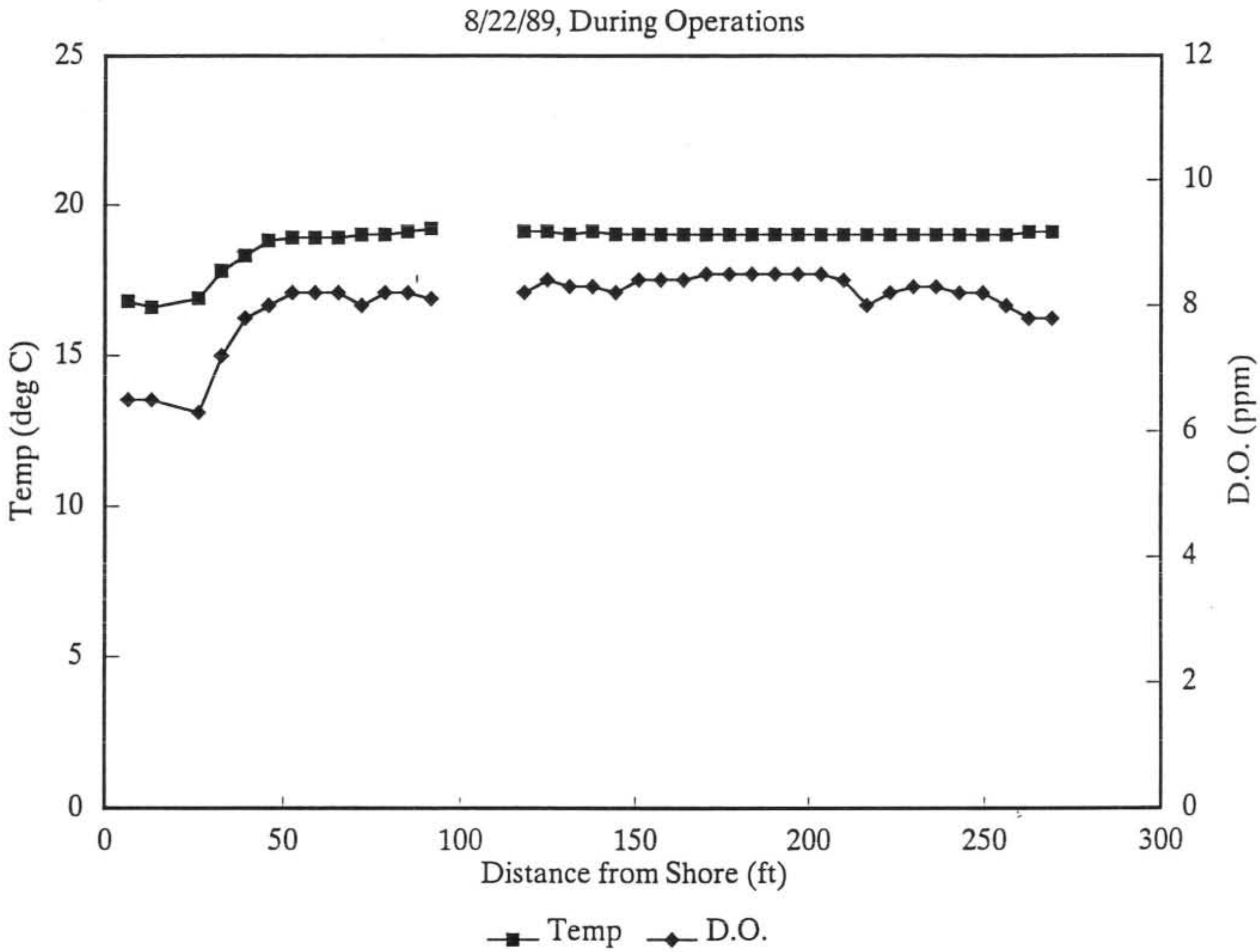


Figure 3-47. Cross-sectional profile for water temperature and dissolved oxygen (D.O.) concentrations 480 feet below Deep Creek Project tailrace, August 22, 1989.

the tailrace. At a transect measured 1000 feet (305 m) below the tailrace, both water temperature and D.O. concentrations were reduced for more than half the width of the river (Figure 3-48). Water temperatures were reduced from 20°C to 17°C, while D.O. concentrations were reduced from 8 ppm to 4 ppm because of project operations. At 2,125 ft (648 m) below the tailrace, the plume from the powerhouse discharge affects most of the width of the river (Figure 3-49). Temperatures were fairly constant across the entire river at this location, having a value of about 18°C. Relatively low D.O. concentrations of 4 ppm extended across all but the last 50 feet (15 m) from the left bank.

A transect at Sang Run confirmed that temperature and D.O. concentrations were homogeneous across the channel at distances farther downstream (Figure 3-50). Measurements at this transect demonstrated the reaeration capacity of the river below the tailrace. Dissolved oxygen concentrations at Sang Run were near saturation, having a value of about 8 ppm.

During the cooler conditions in fall and winter, water released from the project may be warmer than river waters. The effect of warmer water releases was observed on October 31, 1989 at a transect located 1000 feet (305 m) below the tailrace (Figure 3-51). Water temperatures at this transect decreased from the right bank to the left bank, ranging from 13°C along the tailrace bank to 11°C along the opposite bank. Dissolved oxygen concentrations exhibited an opposite trend, increasing farther across the transect away from the right bank. Dissolved oxygen concentrations were approximately 8 ppm along the right bank, and 10 ppm along the bank opposite the tailrace. Like the transect measured previously at 1,000 feet (305 m) downstream from the tailrace, temperature and D.O. were affected about halfway across the river channel.

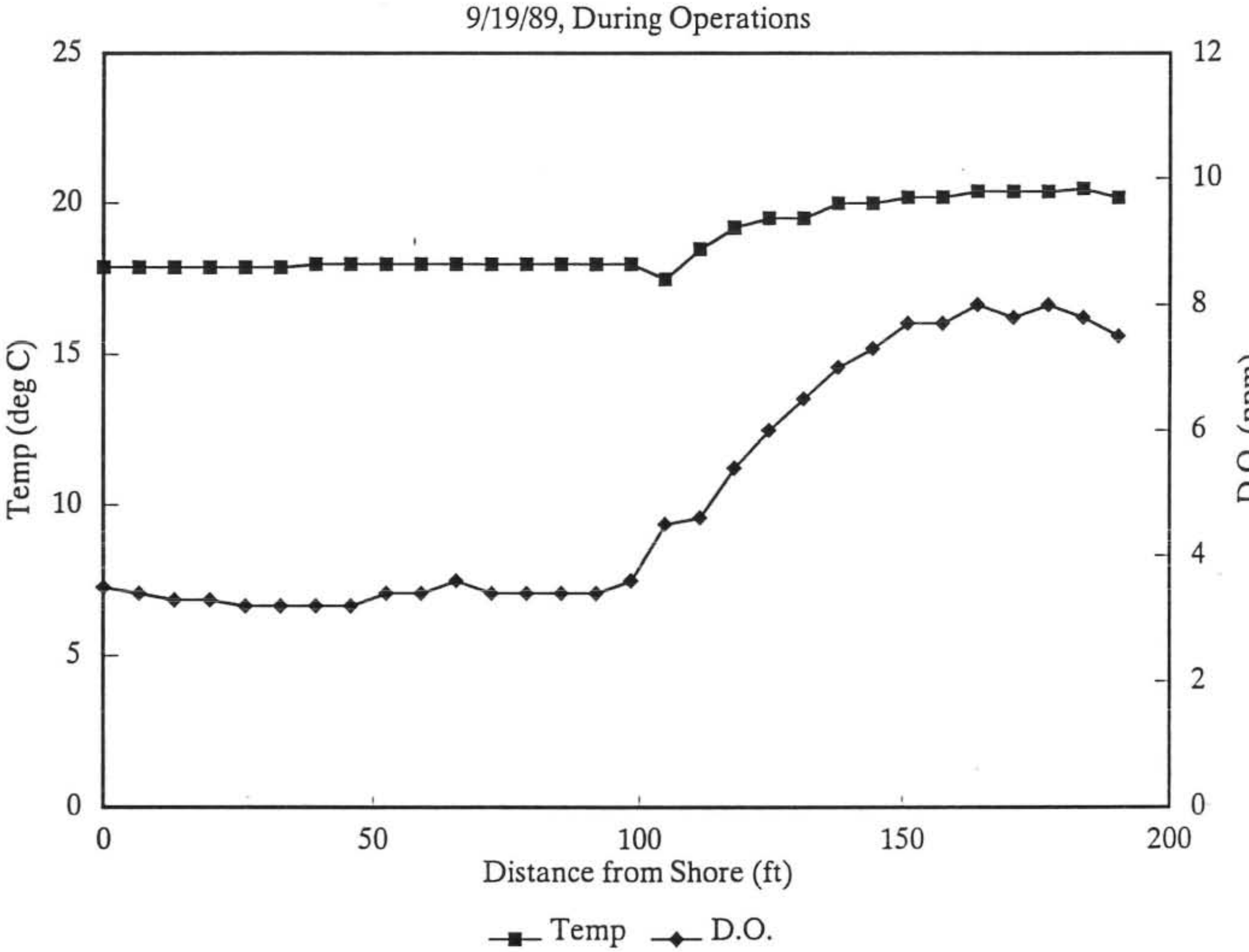


Figure 3-48. Cross-sectional profile for water temperature and dissolved oxygen (D.O.) concentrations 1000 feet below Deep Creek Project tailrace, September 19, 1989.

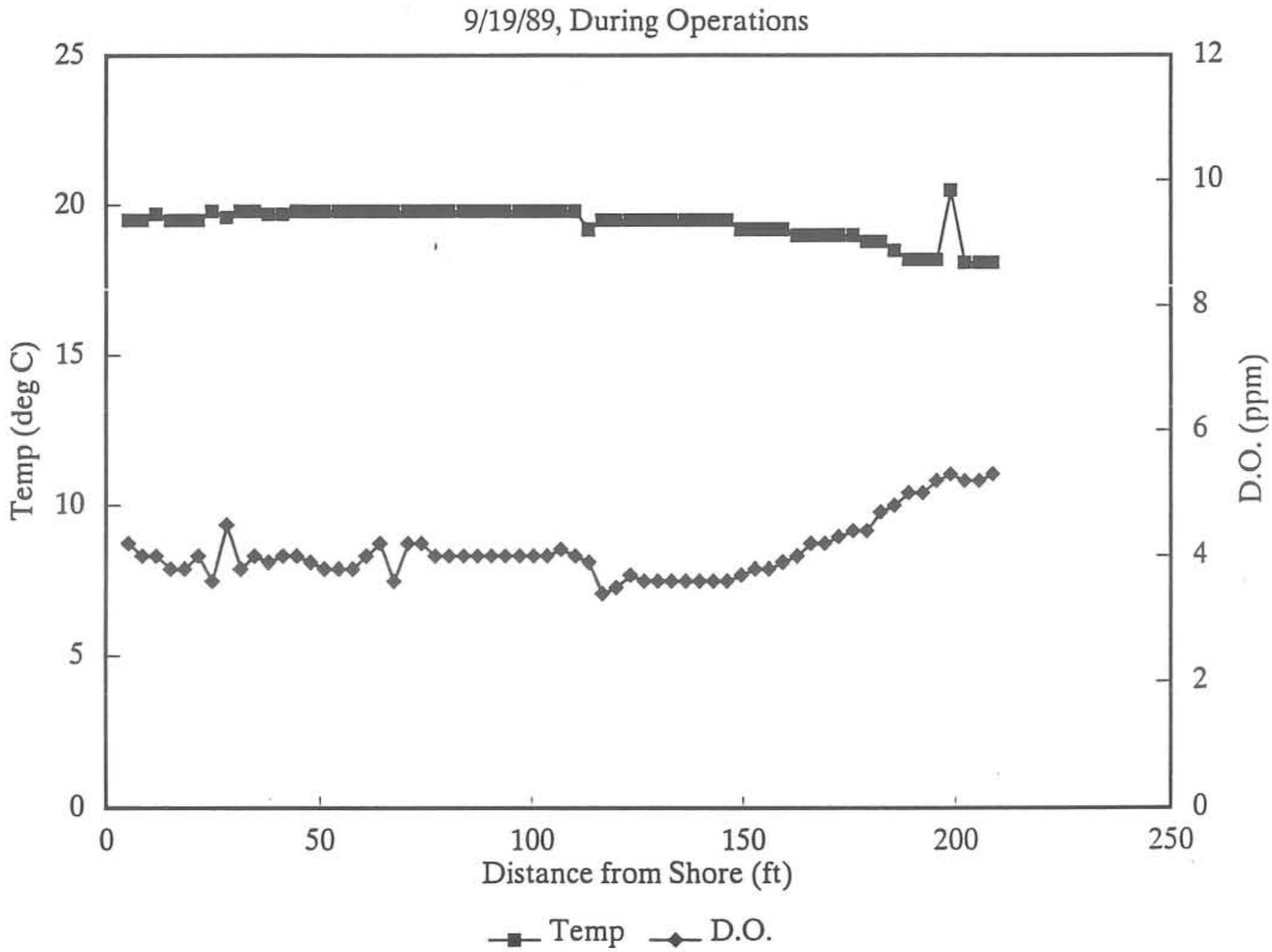


Figure 3-49. Cross-sectional profile for water temperature and dissolved oxygen (D.O.) concentrations 2125 feet below Deep Creek Project tailrace, September 19, 1989.

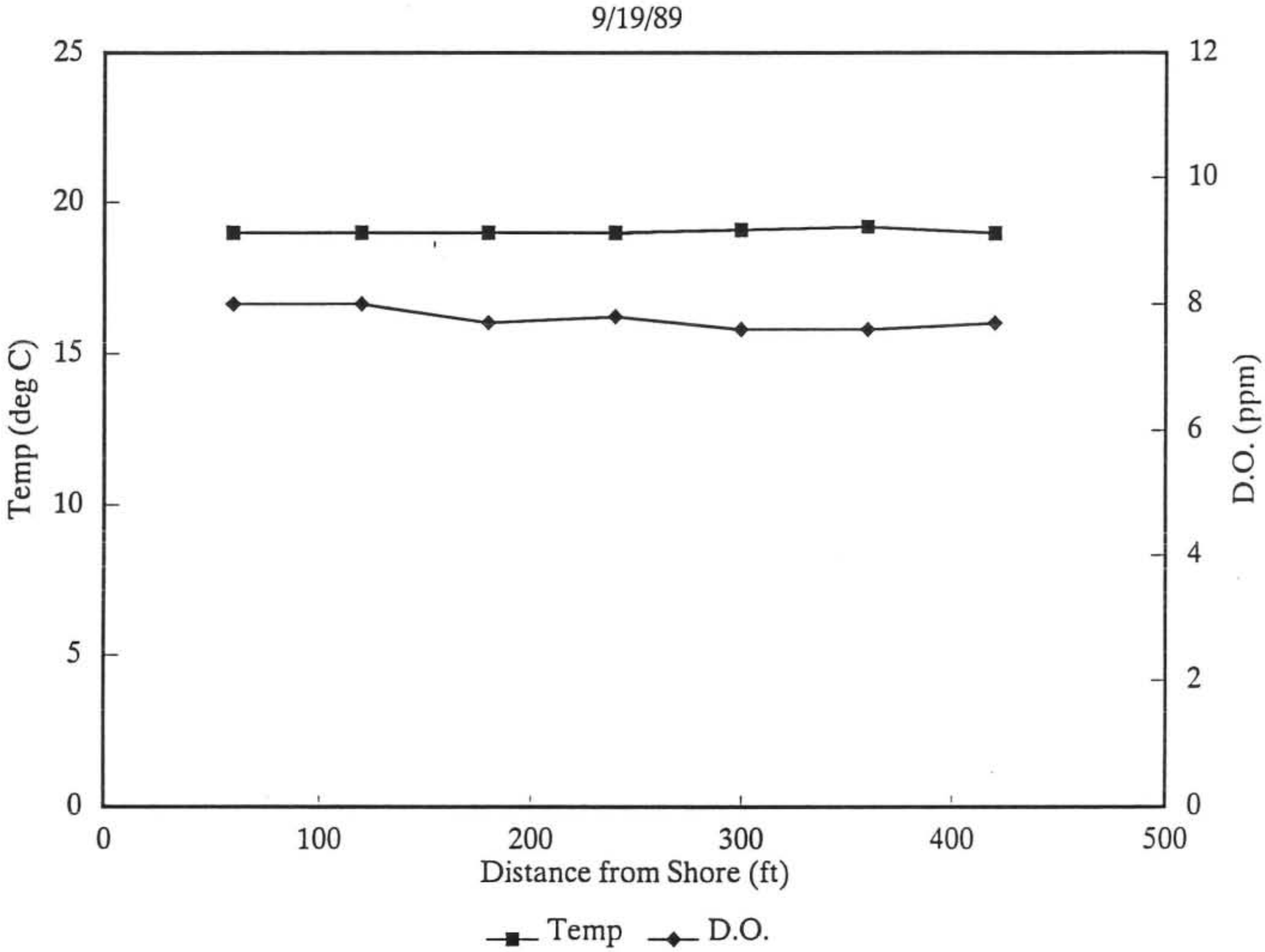


Figure 3-50. Cross-sectional profile for water temperature and dissolved oxygen (D.O.) concentrations at Sang Run, September 19, 1989.

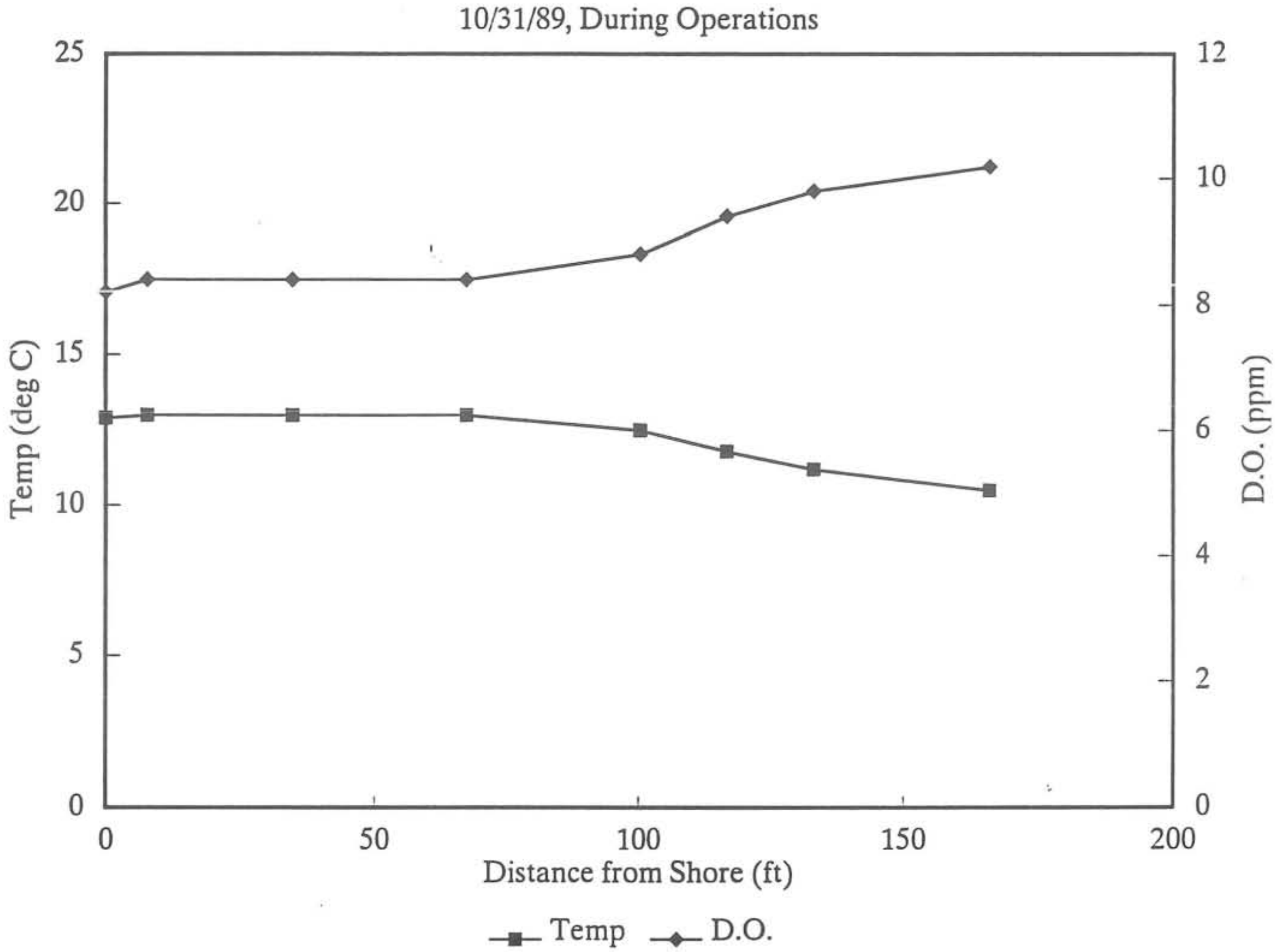


Figure 3-51. Cross-sectional profile for water temperature and dissolved oxygen (D.O.) concentrations 1000 feet below Deep Creek Project tailrace, September 19, 1989.

3.5.4 Deep Creek Bypass Channel Water Quality

Representative samples for water quality were collected at the weir downstream from the dam during the summer and early fall seasons (Table 3-7). The analyses were focused on selected parameters that were believed to be possible components of the seepage that might not meet water quality criteria in a receiving water body. These parameters included iron, manganese, aluminum, sulphide, D.O., temperature, and turbidity.

The analytical results showed that concentrations of iron and manganese did not exceed either acute or chronic levels for aquatic life. Aluminum was detected but does not have an established criteria. Sulfide concentrations were below detectable levels and therefore, are not considered significant. Dissolved oxygen concentrations exceeded the state minimum standard of 5 mg/l during the fall period. However, during the summer the concentration was below state standards. Temperature and turbidity measurements, although limited, did not show any potential problems.

Water quality data from the sewage treatment plant was obtained from monthly NPDES reports, submitted to the State of Maryland (personal communication, Dale Allen, Plant Superintendent, Deep Creek Sewage Treatment Plant, Maryland Environmental Services, Maryland, April 3, 1991). Fecal coliform counts have been <200 per 100 ml and turbidity <20 NTUs. Dissolved oxygen ranges from 8 to 10 mg/l. Values for pH range from 6.9 to 7.6.

3.6 AQUATIC RESOURCES

This section of the report addresses the fish resources of Deep Creek Lake and the Youghiogheny River, and the interaction of the project with these resources. General descriptions of the fish resources in Deep Creek Lake and the Youghiogheny River are followed by the results of specific investigations conducted by Penelec.

Table 3-7 Summary of analytical results for weir samples

Date	Aluminum (ug/l)	Iron (ug/l)	Manganese (ug/l)	Sulfide (mg/l)	pH	Dissolved Oxygen (mg/l)	Temp. °C	Turbidity (NTU)
8/10/89	218	801	343	<1	5.53	4.42		
9/19/89	172	478	250	<1	6-6.25	5.80	15.2	2.5
	129	457	250	<1	6-6.25	5.00	15.2	2.5
10/31/89	395	129	248	<1				
3/1/90	496	301	302	<1				
	487	173	231	<1				
7/12/90	500	780	360	ND[1/]				
	500	750	340	ND				

[1/] ND = Not Detected

3.6.1 Deep Creek Lake

Deep Creek Lake is characterized as a soft water, low nutrient, low plankton producing oligotrophic lake (Davis and Flemer 1975, Feller and Pinder 1990). Warm surface water conditions in the summer and a deeper cool water environment create favorable conditions for both warm and cool water fish species.

The fish community of Deep Creek Lake can be characterized as a coolwater fishery, but warmwater and coldwater species are found within the lake as well. A total of 23 fish species presently occurs in the lake (Table 3-8). Emerald shiner (*Notropis atherinoides*), a species recently introduced as a forage fish for Deep Creek Lake walleye, has apparently not established a viable population to date. Brown trout, the only coldwater species presently found in the lake, are stocked annually in the reservoir on a put and grow basis and are not known to reproduce successfully. Smallmouth bass and walleye are the most abundant piscivores in the lake, and yellow perch and sunfish (*Lepomis spp.*) are the dominant planktivores.

The major sport species include walleye, smallmouth bass, largemouth bass, northern pike, yellow perch, pumpkinseed, bluegill, rock bass and black crappie (Pavol 1985). Additionally, MDNR has stocked brown and rainbow trout and intends to continue annual stocking of brown trout (personal communication, R. Bachman, Maryland Department of Natural Resources, April 5, 1991). The major forage fish in the lake is golden shiner.

Early fishery management of Deep Creek Lake focused on stocking efforts, many of which were unsuccessful. These unsuccessful introductions included: striped bass, white bass, muskellunge, rainbow smelt, gizzard shad, and Atlantic salmon (Elser and Vandeusen 1954; Hendricks 1980). Plantings of rainbow trout produced successful runs for several years, but the species was eliminated by extensive poaching of adults during tributary spawning (Powell 1967). Other species such as northern pike, chain

Table 3-8 List of Fish Species Reported From Deep Creek Lake

Family	Species	Common Name
Salmonidae	*Oncorhynchus mykiss* *O. trutta* *Salvelinus fontainalis*	rainbow trout[a] brown trout brook trout
Esocidae	*Esox americanus* *E. lucius* *E. niger*	redfin pickerel northern pike chain pickerel
Centrarchidae	*Lepomis gibbosus* *Lepomis macrochirus* *Micropterus dolomieu* *M. Salmoides* *Pomoxis annularis* *P. nigromaculatus*	pumpkinseed bluegill smallmouth bass largemouth bass white crappie black crappie
Percidae	*Perca flavescens* *Stizostedion vitreum*	yellow perch walleye
Cyprinidae	*Cyprinus carpio* *Notemigonus crysoleucas* *Notropis chrysocephalus* *Pimephales notatus* *P. promelas*	common carp golden shiner striped shiner bluntnose minnow fathead minnow
Catostomidae	*Catostomus commersoni*	white sucker
Ictaluridae	*Amerius natalis* *A. nebulosus* *Noturus insignis*	yellow bullhead brown bullhead margined madtom[b]

(a) Historically stocked, no recent reports
(b) Specimens collected in 1955

pickerel, yellow perch, and largemouth bass were repeatedly stocked to remedy wide fluctuations in angler catches.

Historically, populations of different gamefish species in the lake have gone through a series of major population increases and declines (Elser and Vandeusen 1954, Pavol 1985). There are no recent data on relative or absolute fish abundance in the lake. A two-year study of fish abundance in bays of the lake in 1972-73 found that the estimated total biomass of fish greater than 3 in. in length was about 47 to 50 pounds per acre (Institute of Statistics 1972, 1973). This study found that the most abundant fish by total biomass and percent of total, averaged for the two years were: yellow perch (45 percent), pumpkinseed (22 percent), golden shiner (14 percent), chain pickerel (7 percent), brown bullhead (5 percent), and largemouth bass (3 percent).

Based on recent information, walleye, which were only present in trace numbers at the time of the 1972-73 study, are now much more abundant. Yellow perch are probably less abundant because they are a major food source for walleye. Based on recent harvest information, smallmouth bass are about three times more abundant lakewide than largemouth bass (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). Other changes may have occurred, but the level of change is not known. It is likely that total lake production, or fish standing stock (biomass) has not changed because a comparison of limnological studies conducted in 1975 and 1989 show little apparent change in the physical and chemical characteristics of the lake (Feller and Pinder 1990).

3.6.1.1 Fish Community

Walleye

Walleye populations in the lake are of regional importance because they offer some of the best fishing in the area and often attract fisherman from outside of the state (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). Walleye have become a highly sought gamefish at Deep Creek Lake, and a directed fishery exists for the species, especially in spring.

Beginning in 1970, walleye were introduced as a means to control chronic overpopulation of planktivores in the lake, especially yellow perch. The introduction was successful and significant natural reproduction of walleye has been documented in each year since 1982, with electrofishing catch per unit effort (CPUE) of young-of-year (YOY) ranging from 11 to 131 fish per hour (Pavol and Klotz 1989a). As a result of successful reproduction, walleye have not been stocked in the lake since 1983. Adult walleye typically avoid light. Adults will stay in the sublittoral region in the daytime. However, in the spring, they commonly move into the shallows at night. Spawning takes place in the shallows over boulder or coarse gravel substrate (Scott and Crossman 1973). Adults are commonly collected during spring spawning by electrofishing shallow shoreline areas (Maryland Department of Natural Resources 1988).

Walleye spawning activity in Deep Creek Lake probably occurs shortly after ice-out. Movement of walleye can be quite extensive, with migrations of over 100 miles recorded (Scott and Crossman 1973). Pelagic larval stages may be common where this species occurs, but were nearly absent during the sampling conducted in 1990 (see Entrainment Section 3.6.1.2), with only one specimen captured during the entire sampling period.

Prior to 1982, no significant natural spawning occurred in the lake. In 1981, however, stocking of fry resulted in successful spawning in all years since (Pavol 1988a, 1989). These particular fry originated from a stock that occurs in a Pennsylvania lake. Spawning success peaked in 1988 and has been reduced for the last two years (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991).

Growth has also slowed since 1983. The decrease in growth rate has been attributed to a reduction in the abundance of its major food source, yellow perch whose population have declined, probably as a direct result of increased walleye predation. Further declines in the walleye population may occur because the current yellow perch population may be too low to support the existing walleye population (Pavol 1988a). Length-frequency data for walleye captured by annual boat electrofishing indicate that as the walleye population has increased in number, walleye growth rates have declined such that walleye now reach legal size (35.6 cm) after their third year instead of during their second year (Pavol and Klotz 1989a).

Yellow Perch

Concurrent with the increase in walleye biomass in Deep Creek Lake, a large increase in growth rates and size of yellow perch, the primary forage species of walleye, has occurred. The relationship between predator biomass and planktivore size has been demonstrated in numerous other studies (Swingle 1956, Gabelhouse 1984, Boxrucker 1987, Mills et. al. 1988), including other lakes dominated by walleye and yellow perch. Interest in the yellow perch sportfishery is high, particularly through the ice in winter (Pavol and Klotz 1989a).

Yellow perch compose the highest biomass in Deep Creek Lake. They also are the most frequently captured sport species in the lake (Pavol 1985; personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). Yellow perch are usually found in shallow water (less than 30 ft.), but can be present at much greater depths (Scott and Crossman 1973). Most lake fishing currently occurs in depths less than 30 ft. (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). Underyearling fish (those that are less than one year of age) are typically present in shoreline areas, with older fish further offshore. Spawning typically occurs in shallow water in the spring, with most occurring in April and early May. Fry move from shoreline areas to deeper water after the first two months (Krieger et al. 1983). Larval stages are commonly found in the pelagic zone. In 1990, yellow perch were the only larval species captured in ichthyoplankton nets (with the exception of one walleye, see Entrainment Section 3.6.1.2).

Historically, the abundance of yellow perch in the lake has been high, resulting in slow growth and small fish (Pavol 1985; personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). The formerly abundant 4 to 7 in. size class is now uncommon as a result of increased predation by walleye (Pavol 1985). Currently, the yellow perch population consists of large numbers of young-of-the-year, few intermediate size fish and many quality size fish (25 cm and larger; Pavol 1988).

Largemouth and Smallmouth Bass

In addition to intense fisheries for walleye and yellow perch, Deep Creek Lake supports high quality fisheries for largemouth and smallmouth bass, including annual bass angling tournaments sponsored by Maryland B.A.S.S. Chapter State Federation, Inc. Although smallmouth bass outnumber largemouth bass in Deep Creek Lake by several-fold, both species are highly sought after by anglers who fish the lake and a directed fishery exists for both species. Prior to the early 1980's, exploitation of bass in Deep Creek Lake was low, and special angling regulations for bass in the lake were unnecessary. In 1981, consistent with increased fishing activity on the lake, age and size structure of both largemouth and smallmouth bass populations declined. As a means to reduce exploitation on larger bass during the spawning season, MDNR Fisheries Division implemented a closed season (April 1 to June 15 beginning in 1987; March 1 to June 15 beginning in 1990).

Since the closed season has been in effect, the percentage of legal (>12 inches (30.5 cm), total length) largemouth bass caught which were also greater than 15 inches (38.1 cm) approximately doubled, from 25% to 50% (Pavol and Klotz 1990). Similarly, the percentage of legal (12 inches (30.5 cm)) smallmouth bass caught which were also greater than 15 inches (38.1 cm) increased from about 10% to 20%. Catch rates of legal bass in Deep Creek Lake by tournament anglers average approximately 0.15 fish per hour (personal communication, Ken Pavol, Maryland Department of Natural Resources, 1991), above the catch rates observed in many other bass waters of the northeast (Green et. al. 1987).

Largemouth bass are probably the most sought after gamefish species in the lake (Pavol 1985). This species has good growth and adequate reproduction in the lake. Habitat for this species is considered marginal, but there is a viable self-maintaining population (Pavol 1985). Typical habitat for this species is shoreline areas, although largemouth bass will migrate into deeper water at certain times, particularly in the winter (Stuber et al. 1982). Most spawning probably takes place from mid May to mid June. Peak spawning occurs at the end of May, with most activity occurring in shallow regions of bays at the upper end of the lake (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991).

Smallmouth bass is one of the most commonly captured and desirable sport fish in the lake. The aquatic habitat in the lake is well suited for smallmouth bass and includes abundant cool, clear water with a rock and rubble bottom (Pavol 1985). Smallmouth bass stay in moderately shallow water, often utilizing rocks as cover habitat. Migrations are generally restricted to a range of less than 0.5 to 5 miles (Scott and Crossman 1973). Spawning in the lake is usually in 3 to 6 ft. of water near large boulders or docks, with spawning probably occurring during May to mid-June. Peak spawning generally occurs in mid-May (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991).

Northern Pike and Pickerel

Northern pike, although not abundant, supply a selective fishery in Deep Creek Lake for fisherman who wish to catch large fish (some greater than 20 pounds) (Pavol 1985). These fish are most common for all life stages in shallow weedy bays (less than 13 ft. deep; Inskip 1982). They typically do not make extensive migrations from these areas. The spawning periods of these species are the earliest of any in Deep Creek Lake. Spawning occasionally occurs prior to complete ice out (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991), but most probably occurs from late March into April. Spawning areas usually require submerged vegetation (Inskip 1982), which is scarce in Deep Creek Lake in the spring. Populations of northern pike have maintained a fairly constant low level of abundance in recent years (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991).

Chain and redfin pickerel in the lake are generally poorly regarded by fishermen (Pavol 1985; personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). The life histories of these two species are similar to that of northern pike. Their current abundances are not known, but the 1972-73 studies (Institute of Statistics 1972, 1973) suggested that their biomass, at least in bay areas, may have been relatively high. As predators, they can influence the abundance of other species in the lake.

Black Crappie and Other Sunfish

Although formerly a major sport species, crappie are currently a minor species in the lake due to increased predation and loss of desired cover habitat (submerged trees) (Elser and Vandeusen 1954, Pavol 1985). Other relatively abundant sunfish in the lake include pumpkinseed and bluegill. Since the successful introduction of walleye in 1981, the average size of bluegill has increased, resulting in their growing importance in the sport catch (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). The current abundance of predator fish in the lake, particularly walleye, bass, and pike, keeps the abundance of this species in check.

All sunfish species have similar habitat and timing requirements for spawning and rearing. Spawning occurs from May to July with most in June. The primary spawning habitat is shallow water, usually in or near vegetation. In general, these species typically prefer regions with cover such as vegetation, submerged trees, or large boulders (Scott and Crossman 1973).

Shiners

Golden shiners are abundant in the lake. They supply a valuable prey resource for predator species. This species is especially important in shallow water areas as prey for species like smallmouth bass. Typical habitat of golden shiners is weedy areas where the water is clear and quiet, with extensive shallows such as those found in many of the bays in the lake (Scott and Crossman 1973). Spawning occurs in aquatic vegetation from late spring to mid summer (May to August).

Attempts have been made to establish emerald shiners in the lake. They would increase pelagic and offshore prey resources for walleye. Stockings of these fish were made in 1987 and 1988, but have yet to show any natural spawning success. Attempts to establish this species have been hampered by inadequate supplies of fish for stocking (Pavol 1988). This species differs from golden shiner in that it is pelagic in nature and utilizes zooplankton resources present in the pelagic zone. It differs from all other major species in the lake by having pelagic midwater spawning in late spring to early summer (Scott and Crossman 1973).

Trout

Trout were one of the earliest gamefish resources in the lake, but have never established an active self sustaining population (Pavol 1985). The lack of suitable stream spawning habitat is thought to limit their natural reproduction (Pavol 1985). Low dissolved oxygen and high lake temperatures in the summer also limit trout production. However, refuge areas in the lake may be adequate for some species (Pavol 1985; personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991).

A MDNR study of angler user patterns in the mid-1980s indicated that 10 percent of all fishing effort in the lake has been historically directed at brown trout. This is primarily attributed to the stocking of catchable trout since attempts to stock fry or fingerling trout directly into the lake have resulted in few ever reaching catchable size. Beginning in 1990, 18,000 catchable size rainbow and brown trout (9 to 11 in.) were stocked with apparent good results for the fishery (Pavol 1985; personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). The catch ratio of rainbow to brown trout was approximately 1:1. During the fall and winter, brown trout were caught in the lake, which indicates summer survival and good growth. There are plans to continue this program, with stocking to occur from late March through May and possibly again in the fall. The exact distribution of trout in the lake is not known, but they have been observed near some creek mouths in the fall and, at times, near the area of the turbine intake (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991). Distribution in the lake is apparently somewhat dependent on locations where the fish were stocked.

3.6.1.2 Entrainment and Abundance Studies in 1990

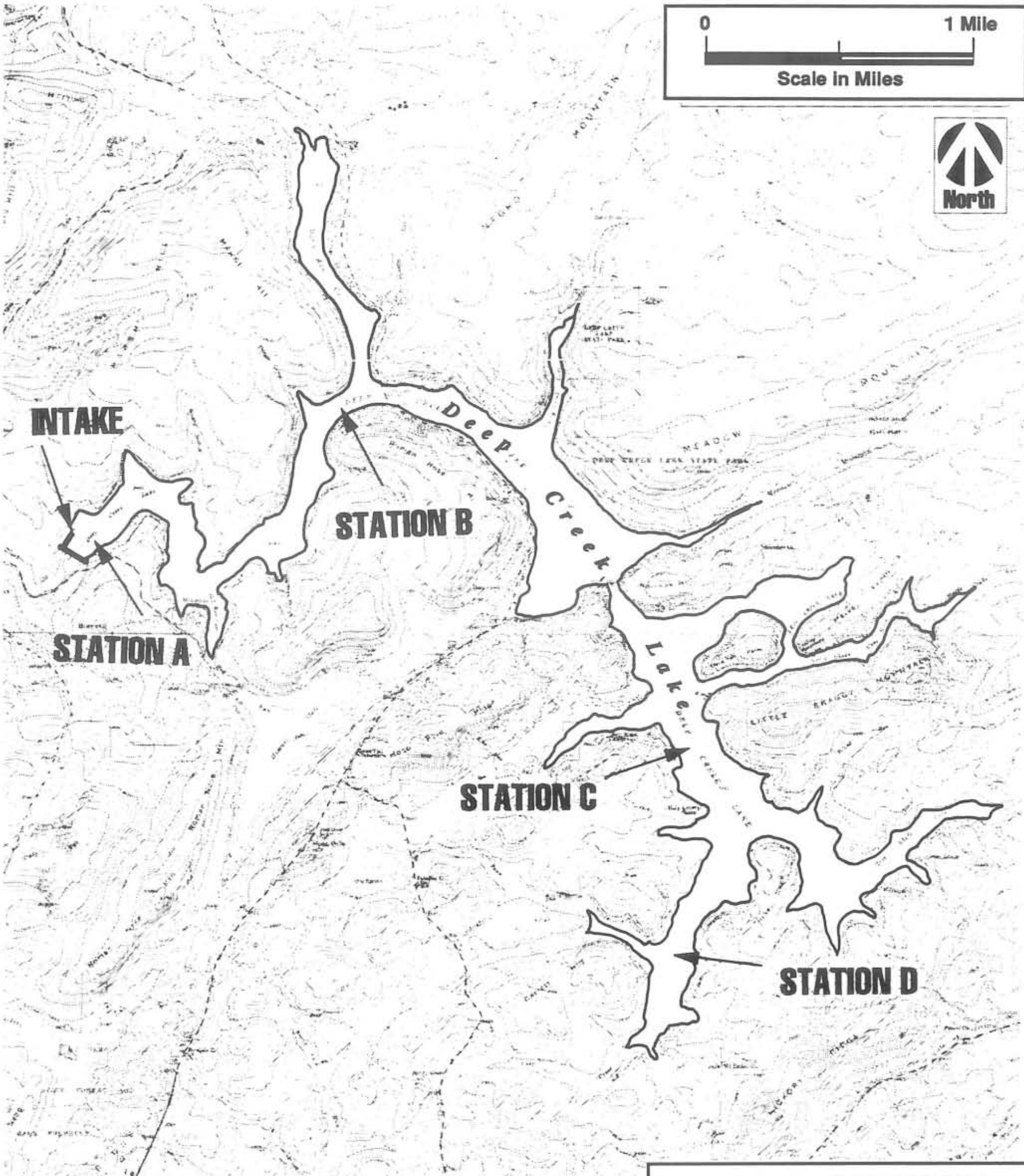
Penelec conducted two studies during 1990 to augment available fisheries information and to determine the effect of entrainment on lake fish resources. These studies were designed to help define the current fisheries resources of the lake and the potential effects that project operation has on lake fish resources. The first study evaluated the distribution, abundance and entrainment rate of larval fish and focused on walleye and yellow perch. The second study evaluated the rate of entrainment of resident juvenile and adult fish from the lake into the power tunnel.

Methods

The larval fish study entailed sampling the lake at four stations in midlake areas (Figure 3-52) and the tailrace during periods of expected peak juvenile and larval walleye and yellow perch abundance. Sampling included use of a high-speed Miller sampler with a 9.4 cm opening and 0.505 mm mesh net. Three depths (1, 3, and 6 m) were usually sampled at each station, except at Station B which was too shallow for the 6 m (20 ft.) sample. The net was towed horizontally behind a motor-powered boat at 1.3 meters per second for a five minute period at each station and depth (i.e. approximately 1,300 feet).

The tailrace was sampled within one day of lake sampling, except for two periods when the turbines were not operating or equipment failure prevented sample collection. At least two samples were collected on each sample date, with sampling times ranging from 5 to 62 minutes for each sample.

The volume of water sampled in both the lake and tailrace was determined by a General Oceanics, Inc. flow meter mounted near the opening of the net. Average velocities in the lake and tailrace samples were 1.3 and 1.1 meters/second (4.3 and 3.6 fps.), respectively. Sampling began on April 5 and continued for seven sampling periods through June 14, at which time, no further larvae were collected. The contents of each net sample were preserved in formaldehyde immediately after collection. These samples where shipped to Tim Simon at Large Rivers Larval Research Station,



PENNSYLVANIA ELECTRIC COMPANY
APPLICATION SUPPORT DOCUMENT
DEEP CREEK HYDROELECTRIC PROJECT

Figure 3-52
DEEP CREEK LAKE LARVAL FISH
SAMPLING STATIONS

EBASCO ENVIRONMENTAL

Indiana, for identification (to species), enumeration, and measurement (length) of the larvae. All data on larvae were converted to density in terms of numbers per unit volume.

Juvenile and adult fish that passed through the penstock and the powerhouse were collected with nets placed in the trash rack slots at the outlet of the turbines (Figure 3-53). Nets were placed in two of the four slots. Each net was designed to sample the total water flow through the slot (about 7 ft. high by 8 ft. wide). The nets were 20 ft. long with 1/4-in. stretch mesh in the first five ft. of the net and 3/16-in. stretch mesh in the remainder to insure collection of most fish sizes. During each generation cycle, nets were lowered into the slot about 10 minutes after generation began and were removed just as generation stopped. The net was closed by tightening a rope which passed through net rings in the forward end of the net. This closing was done just prior to project shutdown to ensure no escape of trapped fish.

Sampling in the tailrace occurred during typical daytime operation. The only exception was one night sampling period which was taken to determine if entrainment varied with time of day. A total of five periods were sampled (May, July, August, October, and November) to characterize entrainment at different seasons. Typically, three dates or intervals were sampled each period. This was not done in some periods due to lack of turbine operation, equipment failure, or high flow conditions. Each sampling period typically encompassed a single one to three hour generation cycle.

After collection, resident fish from the river that had become trapped in the net were released as quickly as possible to minimize stress. Entrained fish were identified, counted, and measured.

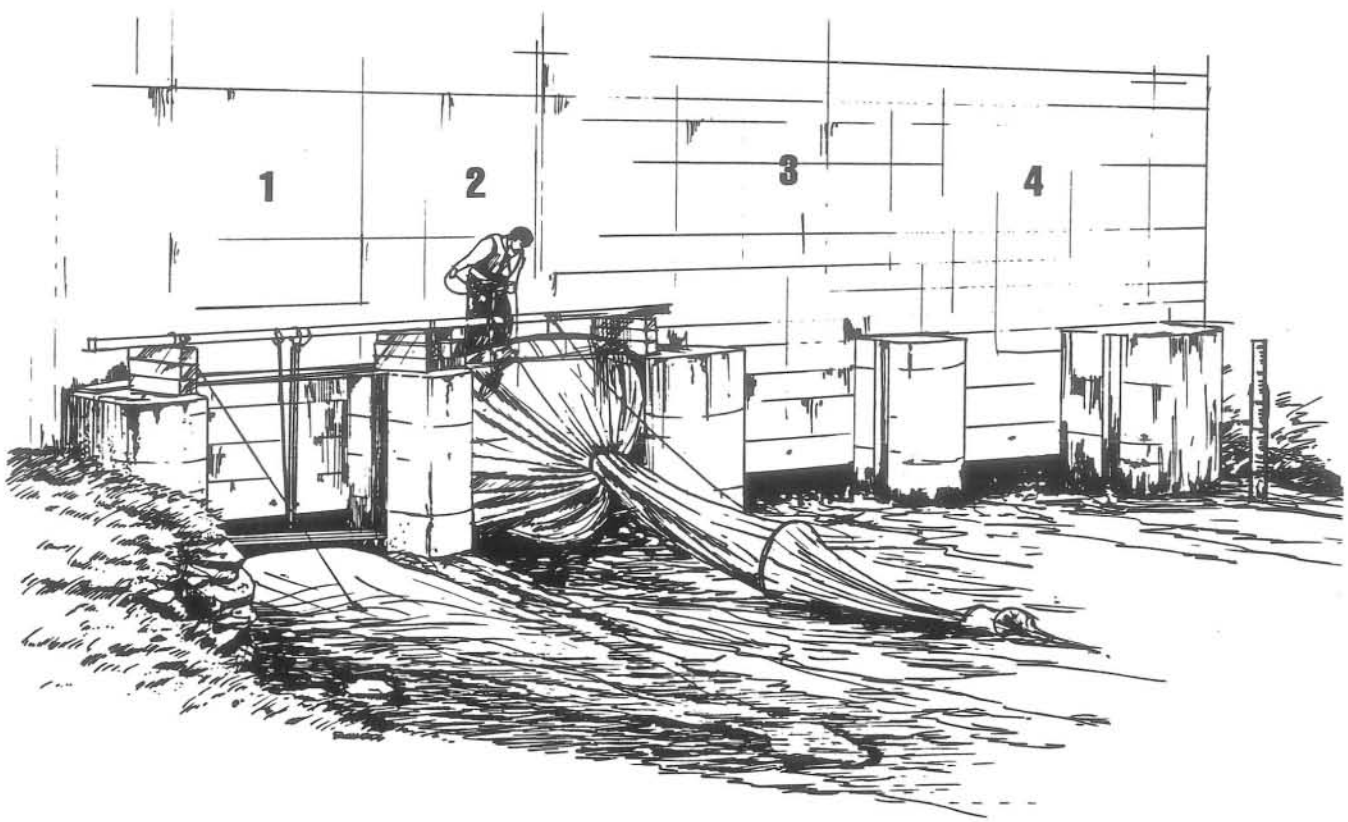


Figure 3-53. Adult and juvenile fish net sampling design at Deep Creek Lake Tailrace. (Numbers indicate the four turbine discharge openings.)

Results

<u>Larval Fish</u>

Only yellow perch larvae (except for one larval walleye) were collected in Deep Creek Lake. Larvae were present in the lake from April 19 to May 31, but abundant only during May (Figure 3-54, Appendix A Fish Entrainment Studies). Peak average lake density occurred May 2 at 46.7 larvae/10 m^3 (353 $ft.^3$), with a general reduction in abundance from early to late May. Highest densities typically occurred at Stations B and C with the lowest at Station A, near the intake (Figure 3-55). Average densities for April 19 through June 14, excluding the 6 meter (20 ft.) samples, were 4.5, 24.6, 16.7, and 7.8 larvae/10 m^3 for Stations A, B, C and D, respectively. Densities of larvae were highest in the upper 1 and 3 meter depth strata (Figure 3-56) for most of the season. Seasonal average densities for April 19 through June 14 in 1, 3, and 6 meters were 12.3, 15.1, and 3.4 larvae/10 m^3, respectively.

Only yellow perch larvae were captured in the tailrace. The pattern of larval abundance was similar to that of the lake, with the highest densities occurring in May (Figure 3-57, Appendix A Fish Entrainment Studies). Average density estimates were typically higher than those for comparable periods in the lake. A peak density of 33.0 larvae/10 m^3 occurred on May 11. Densities were consistently higher in the first sample collected (Figure 3-58).

During May, when most larvae were collected, densities averaged 21.6 and 8.9 larvae/10 m^3 in the first and second sample, respectively. On June 1, five samples were collected in succession. Samples taken after the first hour had lower densities, with no apparent further decreases after the first hour (Appendix A Fish Entrainment Studies). This difference in abundance with sample period suggests that densities decrease in the water after, at most, the first hour of discharge.

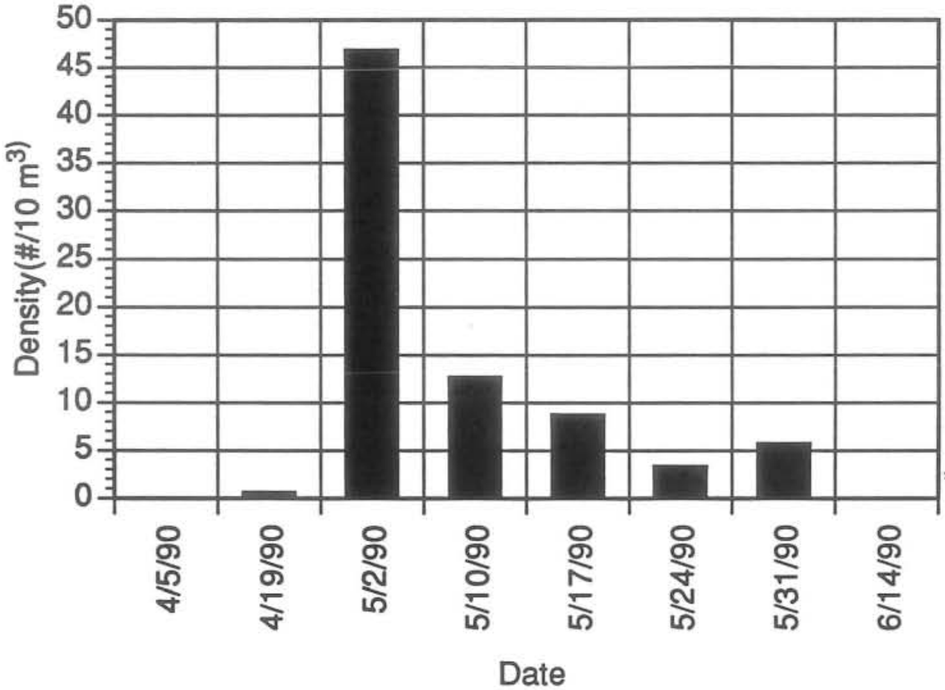


Figure 3-54. Average density of yellow perch larvae by date for Deep Creek Lake.

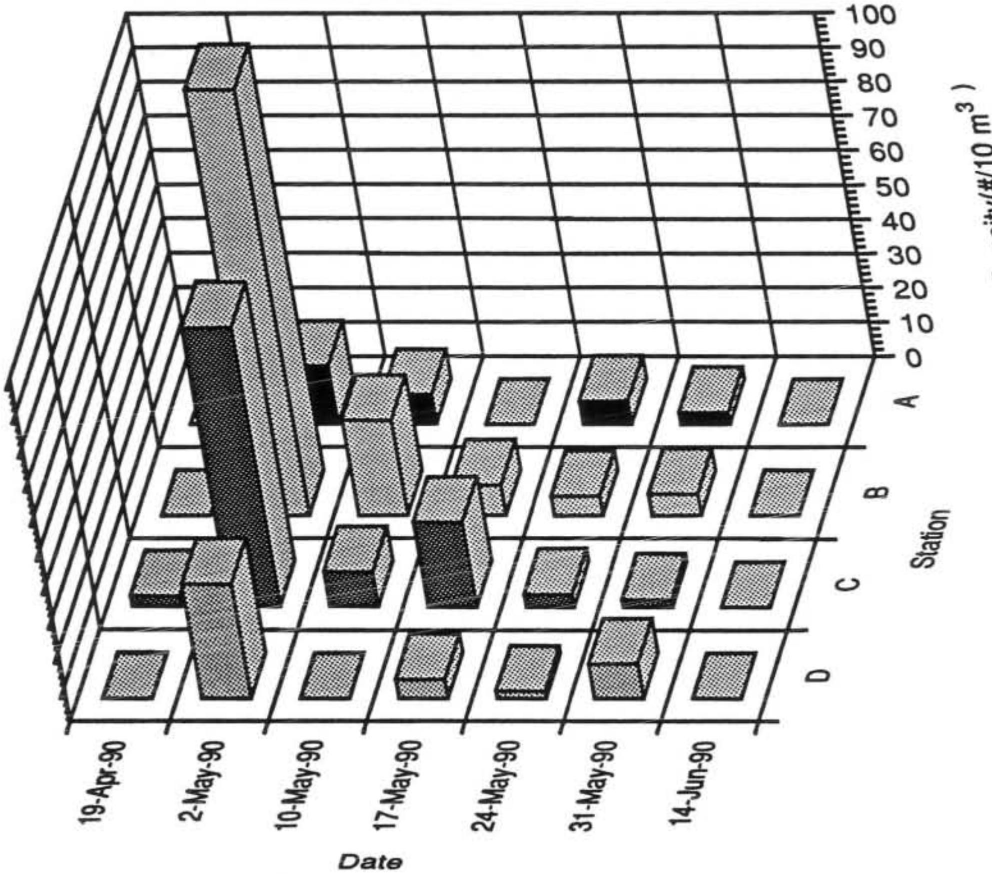


Figure 3-55. Average density for yellow perch larvae by date and station for combined 1- and 3-meter depth samples in Deep Creek Lake.

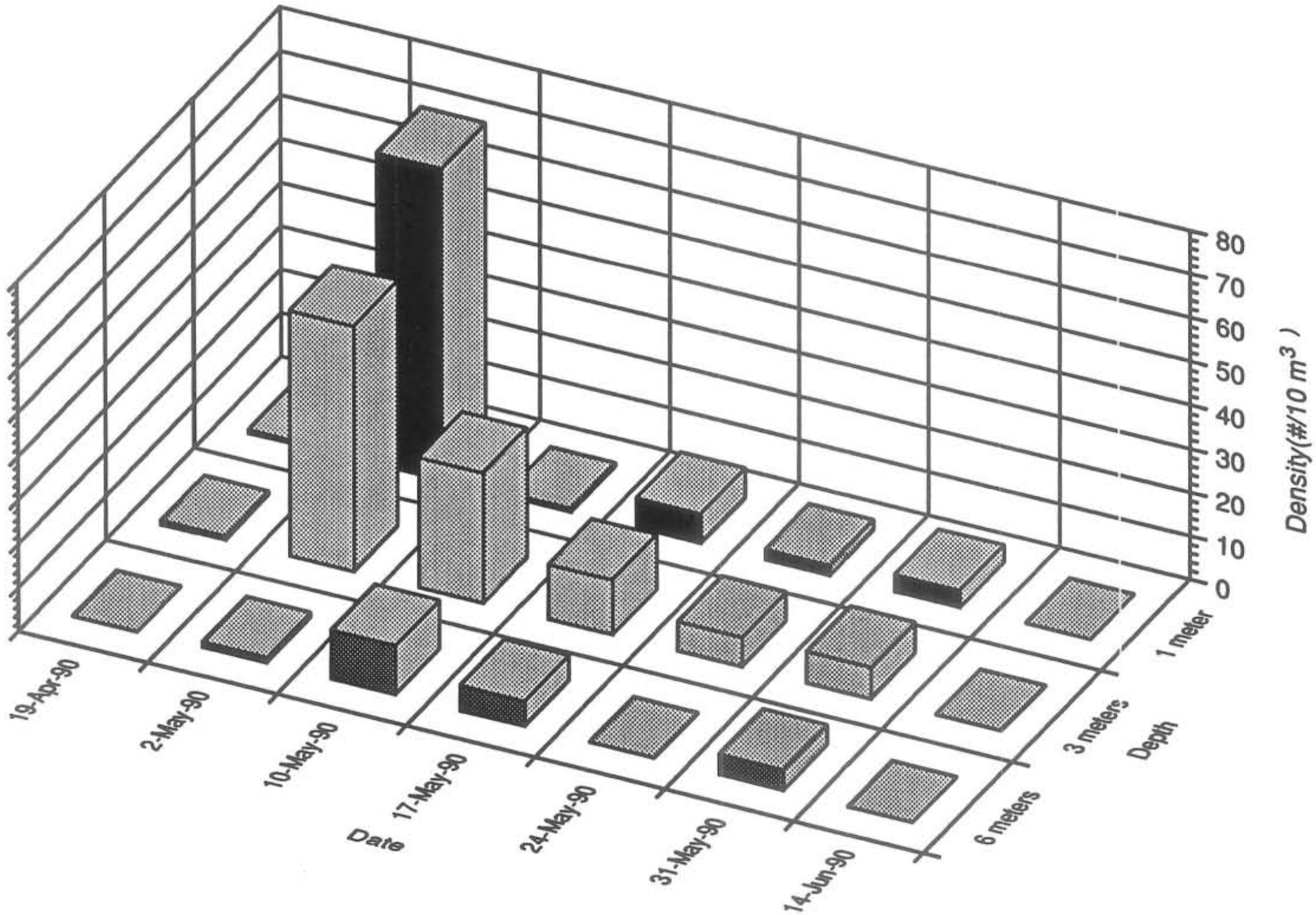
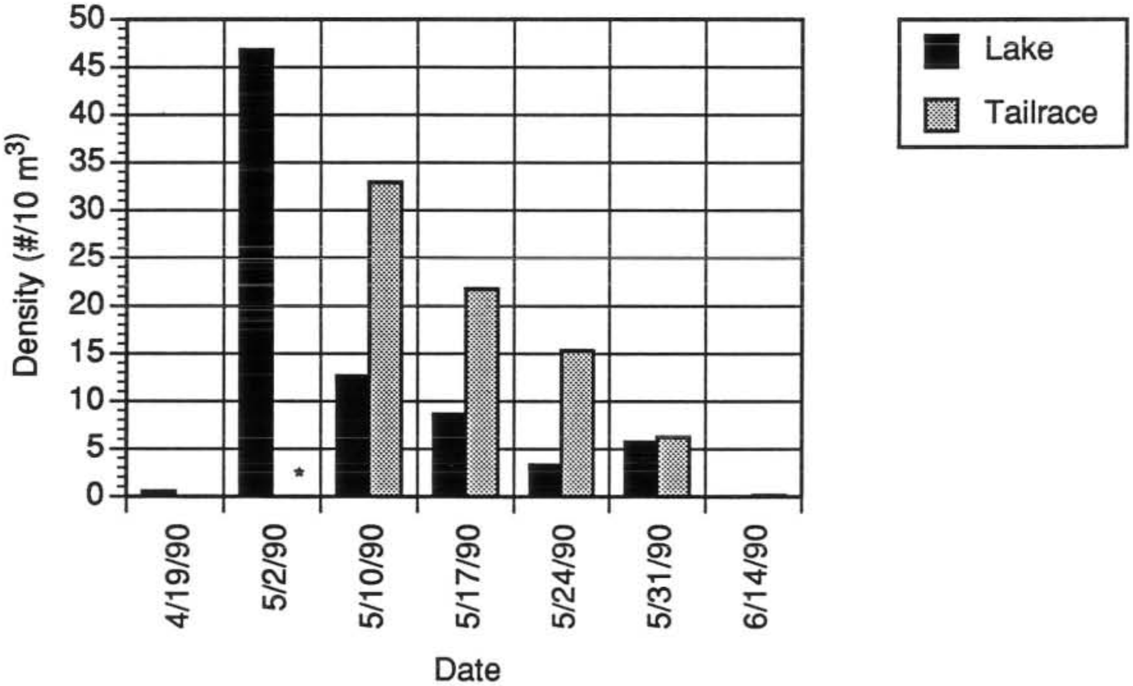


Figure 3-56. Average density of yellow perch larvae by depth and date in Deep Creek Lake.



* Indicates tailrace not sampled.

Figure 3-57. Average density of yellow perch larvae by date for the tailrace and Deep Creek Lake.

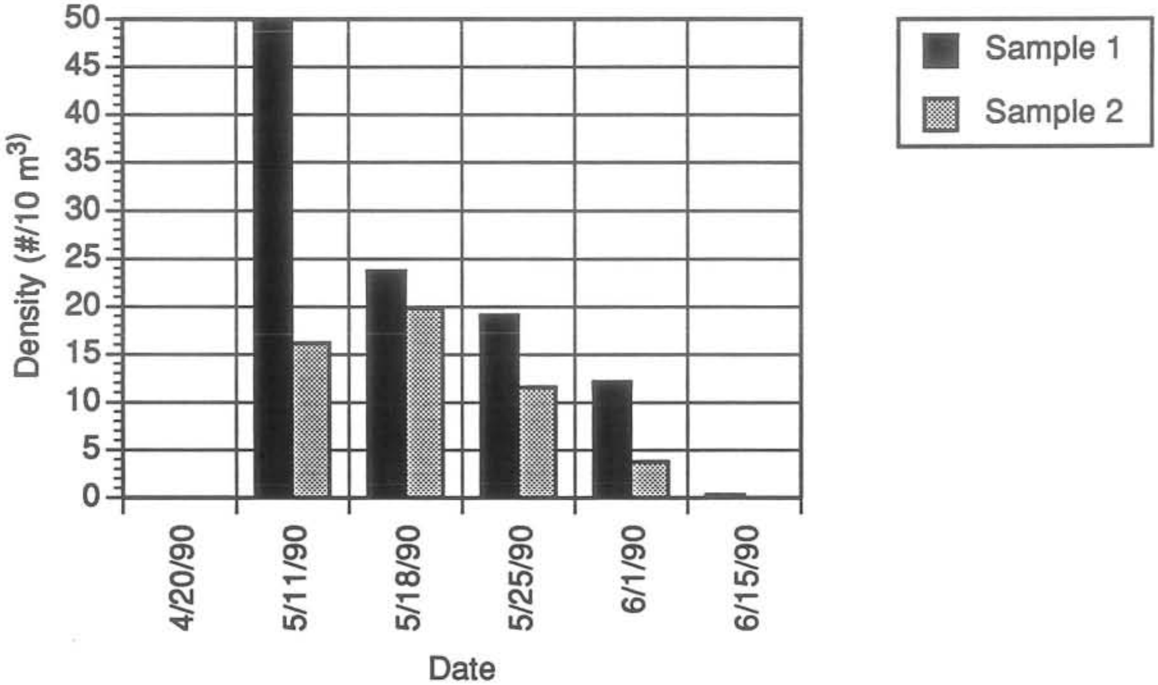


Figure 3-58. Average density of yellow perch larvae by date for tailrace samples 1 and 2.

Juvenile and Adult Fish Entrainment

A total of 244 entrained fish were captured in 66 hours of net sampling in the tailrace (Table 3-9). Underyearling and yearling yellow perch accounted for 95 percent of all fish captured. No more than four fish of any other species were captured, with only one adult walleye among all sampling. The majority of fish were collected during May and July. Most entrained fish other than yearlings and underyearlings had signs of injury due to contact with the turbine blades. Many of the smaller fish also had signs of damage from passage. A significant number of fish, such as trout, bluegill and pickerel, that were assumed to have originated from downstream of the turbine discharge because of their condition, were captured in the nets. Apparently these fish entered the turbine discharge openings during operation, and were captured while holding in the net opening or being swept into the net. Most of these fish were in good condition and released unharmed.

Although tailrace sampling did not result in the capture of brown trout originating in Deep Creek Lake, brown trout carcasses were incidentally observed in the tailrace and Youghiogheny River, indicating that these trout had been entrained.

Tests to determine the sampling efficiency of the nets were conducted on August 31 by placing 100 each yellow- and red-marked dead minnows (60 to 100 mm [2-4 in.] total length) into the surge tank during operation. A total of 22.5 percent of the marked fish, counting only marked whole fish and heads, were recovered. Assuming each of the two nets sampled 25 percent of the total discharge, average efficiency was estimated to be 45 percent (i.e., 36 percent for the net in the turbine discharge opening No. 1 and 54 percent in opening No. 2).

For several reasons, this estimate of net efficiency is believed to be much lower than what actually occurred, particularly for larger fish. First, it was observed that many of the marked fish

Table 3-9 Number of juvenile and adult fish captured in the Deep Creek Project tailrace nets.

SPECIES	CATCH BY SAMPLE PERIOD 5/11,18, 25/90	7/10, 11/90	8/31/90	10/10, 11/90	11/27, 28/90	TOTAL CATCH
Yellow Perch (underyearling)		78	1			79
Yellow Perch (yearling)	153					153
Walleye (adult)	1					1
Largemouth Bass (underyearling)				3		3
Largemouth Bass (adult)		1				1
Pumpkinseed (juvenile)	1					1
Black Crappie (juvenile)					1	1
Sunfish (juvenile)			2			2
Rainbow Trout	2					2
Fathead Minnow	1					1
TOTAL CATCH	158	81	1	4	1	244
Net hours sampled[1/]	12.0	14.5	12.8	10.8	16.0	66.1

[1/] Total hours sampled by both nets (i.e., one hour sampled with both nets in the water is two net hours).

continued to float in the surge tank and did not enter the power tunnel. Although attempts were made to submerse these fish, Penelec suspects that many may not have entered the power tunnel during the generation cycle.

Following passage through the turbine, a high proportion of the fish were in pieces and many of these did not have heads. Because these were small fish, it is possible that some heads may not have been captured by the net. Also, only a small percentage of the flow through each turbine discharge opening could bypass the net allowing little area for fish to bypass the net. Penelec estimates that the maximum cross sectional flow area not sampled by each net (i.e., corners and bottom) was less than 5 percent of the total area and therefore, there is reason to believe that most fish were collected in each of the two openings sampled. As a result of some of the sampling limitations associated with these results, Penelec believes that the sampling efficiency of the nets to be closer to 100 percent than the 45 percent average measured.

Overall, there were low catches of most fish species in the sampling of the turbine openings. Therefore, any estimates of the total number of fish entrained for any one species was considered questionable. However, a "rough" estimate was made for yellow perch underyearlings and yearlings because they were the most abundant and frequently captured species. The actual catch was expanded by the formula:

$NE = AAD * (\Sigma_i(C_i/SD_i * 1/EFF))/N$ where

NE = Estimated number entrained during a sample period

$_i$ = Net sample number during a period

N = Number of net samples during a period

C_i = Number caught in a net for a sample $_i$

SD_i = One-quarter of the total flow discharged during time for sample $_i$ (assumed equal discharge through each of four turbine discharge openings)

EFF = Net efficiency (a value of 0.45 was assumed)

AAD = Average annual discharge during a sample period (e.g., May sampling was assumed to represent mid-February to mid-June)

Based on this calculation, there was an estimated annual entrainment of 6,000 underyearling and 31,000 yearling yellow perch. As a result of the large expansion factors used in the analysis, low and infrequent capture, and limited sampling, no confidence intervals could reasonably be placed on these estimates. Also, because a calculated efficiency factor of 45 percent was used instead of 100 percent, the estimates for yellow perch are most probably high.

Effects of Entrainment on Lake Fish Populations

The loss of fish through entrainment does not appear to significantly affect populations of fish in the lake. The only fish that appeared to be entrained in large numbers were larval and juvenile yellow perch. Walleye, one of the most important sportfish in the lake, was not noted in any larval samples and only one adult was captured in over 66 net hours of sampling. Similar low abundance in the juvenile and adult net samples was apparent for all other species, although estimates of entrainment could not be reasonably calculated because of infrequent and low catches.

Even though the density of larval perch in entrained water appeared to be relatively high, the number entrained was probably small relative to the lake population. The results of the larvae study suggested that densities of yellow perch in the entrained water were about three times higher than the average in the lake for comparable May samples (average 6.8/10 m^3 in the lake and 19.5/ 10 m^3 in the tailrace). Also, tailrace densities were about five times higher than Station A (near the tailrace) for this period (the Station A average was 3.9/10 m^3).

The higher densities of yellow perch larvae in the tailrace discharge were probably a result of a higher avoidance of capture by larvae in the lake than in the tailrace, and not a result of higher densities in the discharge water. First, it does not seem likely that the density in the tailwater discharge would be higher than that in the lake area near the discharge. The estimated density in Station A near the intake was the lowest in the lake. The highest concentrations in the lake appeared to be in the mid-lake Stations B and C. Therefore, the possibility of high concentrations of larval perch being present near the intake and available for entrainment, is unlikely. Second, the depth distribution of larval fish in the lake, with highest concentrations in the upper 3 meters (10 ft.), suggests that concentrations near the 12-meter (40 ft.) depth of the intake should be relatively low.

The most probable reasons for the higher density estimates in the tailwater is lower avoidance of the net in the tailwater than in the lake. It is known that even small larvae can show marked avoidance of nets. For example, Smith and Richardson (1977) reported that for one larval fish species, densities were 10 times higher in the same area when samples were collected with an ichthyoplankton purse seine than with a plankton net, even for larvae as small as 8 mm (1/3 in.) in length. The difference was attributed to the avoidance behavior of the larvae. Although this was a different species, these results suggest that avoidance of the plankton net by larval perch in the lake may occur.

Even though a high-speed sampler was used in the Deep Creek Lake studies to reduce avoidance, it probably was not eliminated. Noble (1970) found, using a high-speed Miller sampler (similar to the one used in the Deep Creek Lake studies), that avoidance was significantly reduced by increasing towing speed from 8 to 11 miles per hour which resulted in an average increase in the capture of larval of 85 percent. It also seems apparent that larval fish which have been entrained and passed through a turbine into the turbulent waters of a tailrace would be less able to avoid a net than would larval fish in a lake.

There may be some reason to believe that larval fish densities near the intake were higher than the samples at mid-lake stations, but this appears unlikely. The observation that the first net sample in the tailrace was consistently higher than the subsequent samples implies that some local shoreline populations may be present that are entrained when the project first starts up. Studies in a New York lake found that larval yellow perch were generally limnetic, i.e., not concentrated in the shallow nearshore habitat, during their larval stages (Houde 1969). However, as larval perch develop into early fry stages, they become more concentrated in shoreline areas, but are still in abundance offshore (Noble 1972). The fact that the densities between the tailrace and lake were large even during early larval stages (e.g., May 11), suggests that differences in distribution are not the likely reason for the higher concentrations in the tailrace discharge.

If it is conservatively assumed that densities of larval yellow perch in the discharge water are about the same as the average density for the entire lake, the typical entrainment loss for this species can be estimated. Based on the seasonal distribution of larvae in the lake, it appears that most larvae are present for about a 1.5 month period that extends from the last week in April to the first week in June. Therefore, if it is assumed that distribution is uniform in all lake waters, then loss of larval perch will be directly proportional to the percent of lake volume discharged during the 1.5 month period when pelagic larvae are present. Average discharge from the tailrace during this period (based on flow information from 1970 to 1989) is equal to about 8.3 percent of the total lake volume at full pool. Therefore, assuming direct proportionality, 8.3 percent of yellow perch larvae in the lake would be entrained. It is more probable that entrainment losses are similar to the density in the region of the lake being entrained. The density in this region is about 1/3 of the average density of larvae in the lake, resulting in an average estimated entrainment of 2.8 percent of the lake larval population.

Estimated losses of juvenile and adult yellow perch were also probably low relative to lake populations. The total loss estimated for juvenile fish was about 36,000 fish (no adults were captured in the tailrace nets). There are no comparable estimates of densities in the lake for these size groups. However, some comparisons can be drawn from other regions and from historical population studies on Deep Creek Lake.

The results from the 1972 study of Deep Creek Lake provided an estimate of 473 yellow perch per acre for fish greater than 2 in. in length. This estimate was based on rotenone applications in bays of the lake. It is common in these rotenone bay population studies to greatly underestimate the numbers of small fish in a lake for fish that were the size entrained in the Deep Creek Lake studies (Bayley and Austen 1990). Therefore, it is expected that the number of small fish in the lake would have been greatly underestimated. Assuming that the 1972 study of fish in Deep Creek bays could be extrapolated to the entire lake, then the yellow perch population at that time was about 1.8 million. The number entrained in 1990 was only about 2 percent of this number.

Another way to evaluate the relative importance of these numbers is to compare them to fish densities in other areas. For example, Banks Lake in Washington State is a large reservoir having yellow perch as the most abundant species. In studies of the lake, Stober, et al. (1976) found very high lakeshore densities of underyearling yellow perch in the summer. In one year, Stober, et al. captured over 30,000 underyearling yellow perch in 16 hauls with a 100-ft. long beach seine. This demonstrated that in yellow perch dominated lakes, the populations of small yellow perch can be very high. Although Penelec cannot precisely estimate the portion of yellow perch that are entrained, it appears that the losses are probably small relative to the total lake population.

The exact effects of entrainment of larvae and other age classes on lake yellow perch populations are not known. However, the ability of fish populations to compensate for mortality, either from natural events, harvest, or other human induced causes, is well documented (McFadden 1977). Depending on the number lost, populations can be fully compensated under natural conditions. Historical population levels of yellow perch in Deep Creek Lake, prior to the successful introduction of walleye, have been characterized as consisting of small individuals that constituted a major prey species in the lake (Pavol 1985, Pavol 1990). This suggests that any losses through entrainment are not a major factor affecting the overall population. As a result of increases in walleye populations in recent years, the age structure of yellow perch populations has changed and now consists of abundant young-of-the-year and larger (greater than 25 cm [10 in.]) individuals (Pavol 1990). This change is apparently a function of predation by walleye, not entrainment of yellow perch. Also, yellow perch are the dominant species (by total abundance) in the lake, as demonstrated by the studies of Deep Creek bays in 1972 (Institute of Statistics 1972). According to the regional biologist (personal communication, Ken Pavol, Maryland Department of Natural Resources, February 4, 1991), yellow perch are still the major species in sport catches which indicates that their overall population is not adversely affected by any entrainment of the larvae, juveniles, or adults.

Losses of other fish species, either larvae or adults, through entrainment, appear to be small and should not affect lake populations of these species. No other entrained larvae were captured even though sampling extended into mid June. It is not known if late season spawning occurred, but the lack of a pronounced effect on perch, which were entrained, suggests that other species are not likely affected significantly. Although juvenile and adult losses could not be accurately assessed for all species, the low catches during all seasons (no more than four fish of any one species captured other than yellow perch) suggests that entrainment of other fish is not a significant problem.

3.6.2 Youghiogheny River and Tributaries

3.6.2.1 Historical Fishery

The Youghiogheny River originates in Preston County, West Virginia, flows northward through Maryland into Pennsylvania, and joins the Monongahela River at McKeesport, Pennsylvania. Historically, the Youghiogheny River in Maryland supported excellent fisheries for brook trout and smallmouth bass (Mansuetti 1962; Reppert 1964, cited in Davis 1984). Rainbow trout, introduced to the Youghiogheny around 1885, also developed into an excellent fishery, with 22 to 24 inch fish historically taken by anglers (Powell 1967).

The Youghiogheny River basin has been affected by surface and deep mining since the late 1800's (Hendricks 1980). These mining operations have contributed to acid mine drainage, which Hendricks characterizes as the "most severe and limiting pollutant to aquatic organisms in the Youghiogheny".

On 19 September 1929, a massive fish kill was caused by runoff from a mining fire entering the Youghiogheny drainage. This incident, combined with acidic mine drainage from other mines, was sufficient to render the Maryland portion of the river devoid of fish until at least 1950 (Davis 1984). By about 1963, conditions in the river improved considerably (Reppert 1964, cited in Davis 1984) and fish began to repopulate the river from downstream areas, tributaries, and stocking programs.

More than 100 species of fish have been documented in the Youghiogheny River drainage or are thought to have occurred there (Hendricks 1980). Of these, nine species were unsuccessfully introduced, and nine species were extirpated because of anthropogenic impacts, such as exposure to several decades of severe acidic mine drainage inputs.

Additional effects have occurred from municipal sewage, industrial effluents, agricultural run-off, and siltation resulting from forest practices, mining, and construction (Hendricks 1980). Since the 1950's, however, the quality of fish habitat in the Youghiogheny River has improved considerably, primarily due to decreases in coal production, water quality law enforcement and mine drainage abatement programs.

Davis (1984) described the existing water quality in the Youghiogheny as good with local exceptions. These local exceptions could be related to continuing acid mine drainage and areas of high fecal coliform counts (see Section 3.5).

Due to their relative abundance, brown trout are the most important coldwater gamefish in the Youghiogheny River from the Deep Creek Station tailrace to Friendsville, MD. Optimal brown trout habitat is characterized by cool to cold water, rocky substrates providing sufficient cover, and riffle-run habitat in combination with areas of slow, deep water (Raleigh et. al. 1986). Extreme water temperatures are probably the most important limiting factor to brown trout (Raleigh et. al. 1986). The upper limiting temperature to brown trout is approximately 27°C, above which viable stream populations cannot be maintained (Needham 1969). Other sources cited by Brungs and Jones (1977) list a temperature of 26°C as the upper incident lethal temperature for adults acclimated to 20°C. Optimal water temperatures for adult brown trout are between 12 and 22°C. The incipient lethal level of dissolved oxygen for adult and juvenile brown trout is 3 mg/l or less, depending upon temperature and other water quality factors (Doudoroff and Shumway 1970).

Water temperatures in the mainstem during the summer may significantly limit habitat for coldwater species such as trout. Water temperatures in the range of 26 to 29.5°C have been recorded during periods of warm or hot air temperatures. During these periods of warm mainstem water temperatures, discharges (primarily leakage flows) from the Deep Creek powerhouse have been beneficial in providing relatively lower water temperatures in the tailrace and for some distance downstream in the mainstem. This occurs because the project withdraws water from deeper areas in the lake where water temperatures are normally cooler than river temperatures during the summer period. Pavol (1989) found that during these periods of higher mainstem temperatures, trout seek refuge in areas affected by cooler water discharges from the Deep Creek Project.

Davis (1984) has characterized the Youghiogheny River as having a variety of gradients ranging from steep areas to low gradients. Riffle areas are mostly bedrock and boulders; cobble and gravel riffles, essential for trout reproduction, are limited and not sufficient to maintain a quality trout fishery by natural reproduction. However, tributary streams do provide spawning areas for natural trout reproduction. This also provides a natural source of fish for the mainstem.

There are three major falls and two dams that form total or partial barriers to fish that would migrate upstream on the main channel of the Youghiogheny River (Davis 1984). These are Ohiopyle, Gap, and Swallow Falls, and the Connellsville and Youghiogheny Reservoir Dams.

3.6.2.2 Description of Affected River Reaches

Youghiogheny River Downstream from Project Tailrace

The 12.9-mile reach of the Youghiogheny River between Friendsville, MD and the Deep Creek powerhouse tailrace can be divided into three segments based upon channel morphology and gradient. The first segment extends from Friendsville upstream 2.7 miles to the lower end of a steep, narrow canyon (Figure 3-59). This segment is

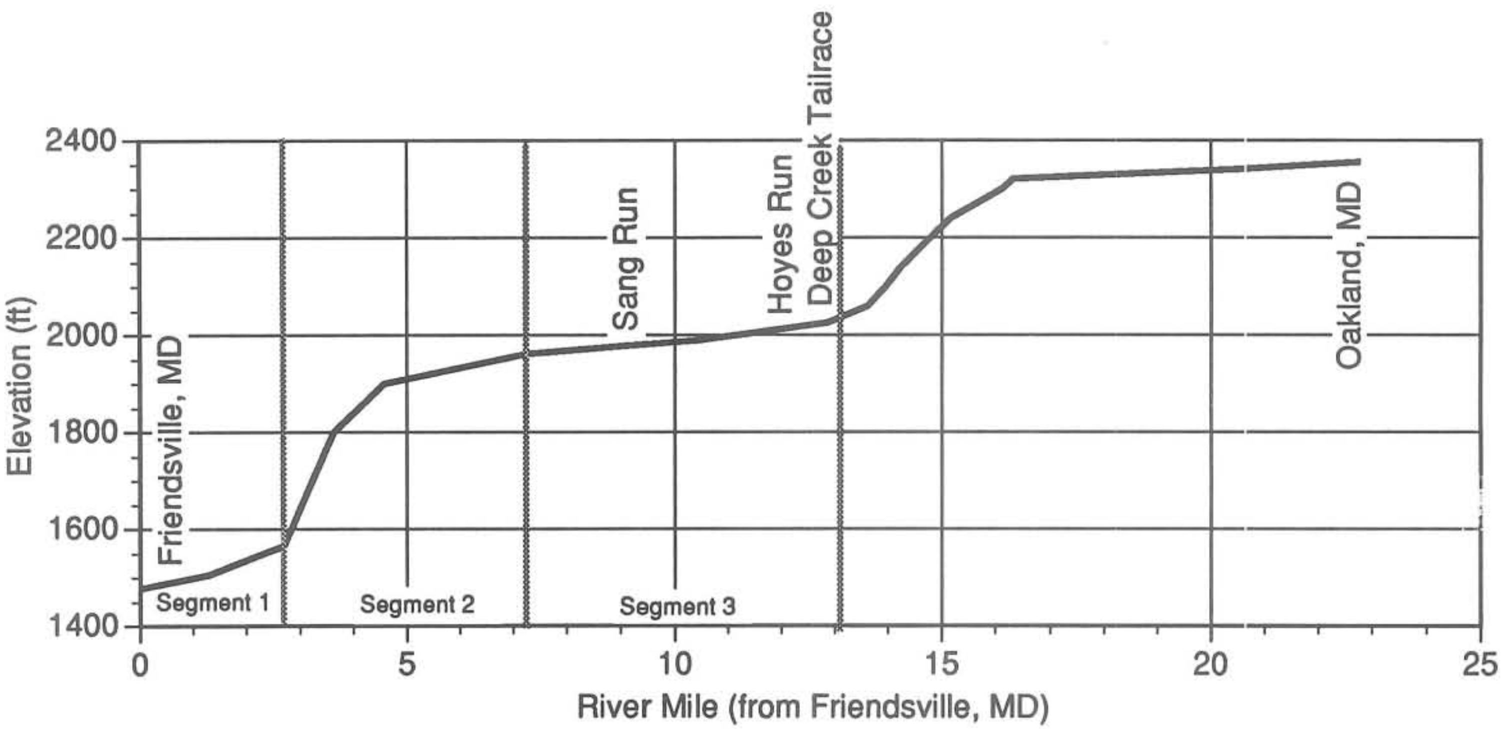


Figure 3-59. Longitudinal profile of the Youghiogheny River between Friendsville, MD, and Oakland, MD.

characterized by a low gradient, relatively wide river channel. In its lower reaches, this segment has a gradient of 0.4 percent, which increases to 0.8 percent in the upper portion of the segment. Substrate in this segment is dominated by small to large cobbles.

The second segment is a steep, narrow river canyon which has a length of 4.6 miles (Figure 3-59). This canyon has an average gradient of 1.65 percent, and is characterized by short falls, rapids, and deep plunge pools. Substrates are dominated by boulders, boulder blocks, large cobbles, and bedrock. Deep plunge pools in this segment provide good habitat for resident brown trout and rainbow trout populations. The large boulders also provide excellent cover for fish. The plunge pools are important to coldwater fish because they provide thermal refugia during critically warm periods during the summer (personal communication, Robert Bachman, Maryland Department of Natural Resources - Freshwater Fisheries, September 5, 1990). During summer low flow periods, power generation at Deep Creek Station provides a source of cooler water to this section of the river. During extreme low flow periods (e.g. summer of 1988), water releases from Deep Creek Lake, even though infrequent and short in duration, may beneficially cool this segment of the river for several days or more due to a long hydraulic residency time. Groundwater accretions and springs in this steep canyon likely provide additional cooling during critical summer periods. Like most rivers during low flows, deeper plunge pools probably undergo thermal stratification to some extent. Stratified pools, especially those influenced by groundwater and springs, provide important thermal refugia to trout during critical periods.

The third river segment extends from the head of the steep canyon (approximately 1.7 miles downstream from Sang Run) for 5.5 miles upstream to the Deep Creek powerhouse (Figure 3-59). This segment is dissimilar from the second segment, and is characterized by a relatively wide, shallow channel. It has a relatively low gradient of between 0.17 and 0.27 percent, and is steepest between the Deep Creek Project powerhouse and Hoyes Run, which is located 0.42 miles downstream from the powerhouse tailrace. Substrates are largely dominated by small to large cobbles. Bedrock frequently becomes exposed in large patches, and is also a common feature of the stream banks. Large boulders are uncommon.

The river in this segment is hydraulically very homogeneous in character, and can generally be described as a single, very long run interrupted by short riffles and shallow rapids which occur primarily at river bends. The river has a very straight channel, thus bends in the river are few. Deep pools are completely absent in this segment. Pool depth is limited by a low reach sinuosity, limited bend curvature, low gradient, and the absence of large roughness features (e.g., boulder blocks).

Habitat for coldwater fish (e.g., brown trout, rainbow trout) in this third segment is limited by a relative absence of deep water, a lack of boulders and other sources of instream cover, and high water temperatures during periods of high air temperatures. Habitat surveys conducted by Penelec indicate that cobbles are often embedded by course sand, which further limits the availability of cover in this segment. Above the Deep Creek Project powerhouse, the river becomes narrower in width and steeper in gradient.

Powerhouse Tailrace

The powerhouse is within 435 ft. of the Youghiogheny River. Discharges from the powerhouse can be as high as 640 cfs during peak operation and decrease to approximately 9 cfs during non-operation. The 9 cfs results from leakage from the project works. In general, habitat in the tailrace consists of gravel and cobble substrate.

Deep Creek Downstream from Dam

The original channel of Deep Creek immediately downstream from the dam normally receives flow only from groundwater accretions and dam seepage. Discharge in Deep Creek several hundred feet downstream of the dam, as measured at the master weir, was approximately 1 cfs. Deep Creek from the dam to the Youghiogheny River can be divided into two sections: a low gradient section located immediately downstream from the dam, and a high gradient section which extends to the confluence with the Youghiogheny River. In the upper section of this reach, the historic stream channel has filled with sediment and organic materials derived from leaf fall. Due to the accumulation of sediments and organic material following construction of the Deep Creek dam and subsequent diversion of water, the historic channel is mainly composed of hydric soils. Organic laden sediments presently form a layer over the historic channel which is from 2 to 3 ft. thick. Consequently, the upper bypass reach channel is heavily vegetated by wetland grasses, sedges, and rushes. Because of its soil and vegetation characteristics, this reach of Deep Creek has been designated as wetland habitat by the State of Maryland (COMAR 08.05.04.24). The active stream channel meanders through these thick hydric soils, and is only about 2 ft wide and about 1 ft deep. The historic stream channel, which is now wetlands, is approximately 100 ft wide.

Approximately 1/4 mile downstream of the dam, discharge is released from a wastewater treatment plant into Deep Creek. Discharge from this plant averages 600,000 gallons per day, which increases discharge in the reach. Waste discharge released from this sewage treatment plant provides a further source of organic materials to the reach. As a result of organic matter loading, sediments in the Deep Creek channel are anaerobic.

The lower section of the reach has a steeper gradient, and is characterized by boulders, cobbles, and bedrock which is embedded by sand and silt. The active stream channel in this section is approximately 10 to 20 ft. wide, and is composed of runs and cascades interspersed by shallow to moderately deep pools. This section of Deep Creek is under heavy vegetation cover, which is provided by both woody riparian vegetation and hardwoods.

3.6.2.3 Existing Fishery

Today, the Maryland portion of the Youghiogheny River supports at least 19 fish species (Table 3-10), including reproducing populations of brown trout, rainbow trout, brook trout, and smallmouth bass. Table 3-11 presents a list of fish species that have been recently identified as either known to exist or probably existing in the Youghiogheny River system. This composition has changed considerably throughout the years in response to preconditions such as acid mine drainage, introductions of non-native species, and alteration of original habitat.

Hendricks (1980) confirmed that 78 fish species have been present in the Youghiogheny. His information was developed from field collections, museum records, and stocking records. An additional 21 species were expected to occur, but no verification could be made. In comparing records between 1949 and 1977-78, Hendricks found that the number of fish species present at most stations had increased. The author suggested that this increase is due to improvements in water quality in the river that have resulted from reforestation of mined lands, mine reclamation projects, and stricter mining regulations.

Even though a large number of fish species may exist in the Youghiogheny River, recent interest has focused on trout species due to their sport value. In general, brown trout are the major trout species present. Some rainbow trout are also present. Additionally, both species, along with brook trout, are also present in major tributaries to the Youghiogheny (e.g., Sang Run and Hoyes Run). The tributaries provide a significant source of

Table 3-10 List of Fish Species Reported from the Youghiogheny River Near Deep Creek, Maryland

Family	Species	Common Name
Salmonidae	*Oncorhynchus mykiss* *O. trutta* *Salvelinus fontainalis*	rainbow trout brown trout brook trout
Esocidae	*Esox americanus* *E. niger* *E. lucius x* masquinongy	redfin pickerel chain pickerel Tiger muskellunge
Centrarchidae	*Ambloplites rupestris* *Lepomis cyanellus* *L. gibbosus* *L. macrochirus* *M. dolomieu* *Micropterus salmoides* Pomoxis migromaculatus	rock bass green sunfish bluegill pumpkinseed sunfish smallmouth bass largemouth bass black crappie
Percidae	*Etheostoma blennioides* *E. nigrum* *Perca flavescens* *Stizostedion vitreum*	greenside darter Johnny darter yellow perch walleye
Cottidae	*Cottus bairdi*	mottled sculpin
Cyprinidae	*Campostoma anomalus* *Cyprinus carpio* *Nocomis micropogon* *Notemigonus crysoleucas* *Notropis chrysocephalus* *N. spilopterus* *Pimephales notatus* P. pcomelas *Rhinichthys atratulus* *R. cataractae* *Semotilus atromaculatus*	stoneroller common carp river chub golden shiner striped shiner spotfin shiner bluntnose minnow fathead minnow blacknose dace longnose dace creek chub
Catostomidae	*Catostomus commersoni* *Hypentellum nigricans*	white sucker northern hogsucker
Ictaluridae	*Amerius nebulosus* *Noturus flavus*	brown bullhead stonecat[a]

[a] Reintroduced to the Youghiogheny River near Sang Run in 1989

Table 3-11 Fishes known from the Youghiogheny River

Common Name	Scientific Name	Status
Least brook lamprey	Lampetra aepyptera	N
Bowfin	Amia calva	I
Alewife	Alosa pseudoharengus	UI
American shad	Alosa sapidissima	UI
Gizzard shad	Dorosoma cepedianum	N
Goldeneye	Hiodon alosoides	N
Rainbow trout	Oncorhynchus mykiss	I
Atlantic salmon	Salmo salar	UI
Brown trout	Salmo trutta	I
Brook trout	Salvelinus fontinalis	N
Lake trout	Salvelinus namaycush	UI
Rainbow smelt	Osmerus mordax	UI
Redfin pickerel	Esox americanus	I
Northern pike	Esox lucius	I
Muskellunge	Esox masquinongy	N
Chain pickerel	Esox niger	I
Stoneroller	Campostoma anomalum	N
Goldfish	Carassius auratus	I
Redside dace	Clinostomus elongatus	N
Common carp	Cyprinus carpio	I
Silverjaw minnow	Ericymba buccata	N
Streamline chub	Hybopsis dissimilis	N
River chub	Nocomis micropogon	N
Golden shiner	Notemigonus crysoleucas	N

Table 3-11 (Cont'd) Fishes known from the Youghiogheny River

Common Name	Scientific Name	Status
Emerald shiner	Notropis atherinoides	N
Striped shiner	Notropis chrysocephalus	N
Silver shiner	Notropis photogenis	N
Rosyface shiner	Notropis rubellus	N
Spotfin shiner	Notropis spilopterus	N
Sand shiner	Notropis stramineus	N
Mimic shiner	Notropis volucellus	N
Bluntnose minnow	Pimephales notatus	N
Fathead minnow	Pimephales promelas	I
Blacknose dace	Rhinichthys atratulus	N
Longnose dace	Rhinichthys cataractae	N
Creek chub	Semotilus atromaculatus	N
Pearl dace	Semotilus margarita	N
Tench	Tinca tinca	UI
Quillback	Carpoides cyprinus	N
Highfin carpsucker	Carpoides velifer	N
Longnose sucker	Catostomus catostomus	N
White sucker	Catostomus commersoni	N
Northern hog sucker	Hypentelium nigricans	N
Silver redhorse	Moxostoma anisurum	N
River redhorse	Moxostoma carinatum	N
Black redhorse	Moxostoma duquesnei	N
Golden redhorse	Moxostoma erythrurum	N
Shorthead redhorse	Moxostoma macrolepidotum	N

Table 3-11 (Cont'd) Fishes known from the Youghiogheny River

Common Name	Scientific Name	Status
White catfish	Ictalurus catus	I
Yellow bullhead	Ictalurus natalis	N
Brown bullhead	Ictalurus nebulosus	N
Channel catfish	Ictalurus punctatus	N
Stonecat	Noturus flavus	N
Margined madtom	Noturus insignis	?
Flathead catfish	Pylodictus olivaris	N
Banded killifish	Fundulus diaphanus	I
Brook silverside	Labidesthes sicculus	N
White bass	Morone chrysops	UI
Striped bass	Morone saxatilis	UI
Rock bass	Ambloplites rupestris	N
Green sunfish	Lepomis cyanellus	N
Pumpkinseed	Lepomis gibbosus	N
Bluegill	Lepomis macrochirus	N
Redear sunfish	Leopomis microlophus	I
Smallmouth bass	Micropterus dolomieui	N
Largemouth bass	Micropterus salmoides	N
White crappie	Pomoxis annularis	N
Black crappie	Pomoxis nigromaculatus	N
Greenside darter	Etheostoma blennioides	N
Rainbow darter	Etheostoma caeruleum	N
Fantail darter	Etheostoma flabellare	N

Table 3-11 (Cont'd) Fishes known from the Youghiogheny River

Common Name	Scientific Name	Status
Johnny darter	*Etheostoma nigrum*	N
Yellow perch	*Perca flavescens*	?
Logperch	*Percina caprodes*	N
Longhead darter	*Percina macrocephala*	N
Walleye	*Stizostedion vitreum*	N
Freshwater drum	*Aplodinotus grunniens*	UI
Mottled sculpin	*Cottus bairdi*	N

Source: Lee 1980 and Hendricks 1980.

Status codes: N - native,
I - introduced,
UI - unsuccessfully introduced,
? - status unknown.

recruitment for trout species, particularly for brown and rainbow. Reproduction of rainbow trout has been documented only in Hoyes Run; this stream represents more than 50% of the miles of Maryland streams in which naturally reproducing populations of rainbow trout exist. Evidence of reproduction in brown trout has been observed in the following tributary streams: Sang Run, Hoyes Run, Laurel Run, Gap Run, Millers Run, Salt Block Run, and Bear Creek.

In general, trout distribution throughout the mainstem Youghiogheny River during periods of high water temperatures and low streamflow are directly related to the availability of cooler water areas or refugia (Pavol 1988b). This is believed to be a major reason for the lack of wild trout and low survival of hatchery fish at sampling stations on the mainstem upstream of the confluence with Deep Creek.

Releases of relatively cooler water through the Deep Creek powerhouse are likely a direct contributor to the higher numbers of trout observed in areas downstream of the project. For example, the MDNR has sampled fish populations at three sites (Swallow Falls - 2.5 miles upstream of the project; Hoyes Run - 0.4 miles downstream; and Sang Run - 3.7 miles downstream) for several years (1987 - 1988). Results have shown that the highest trout densities occur at the Hoyes station. It is believed that this is directly related to the cooler waters discharged from the Deep Creek Project (Pavol 1989).

Brown trout have been documented to reach 10 pounds in the vicinity of the Deep Creek hydroelectric facility (personal communication, Ken Pavol, Maryland Department of Natural Resources, 1991). Although the standing crop of trout in the mainstem between Swallow Falls and Sang Run is relatively low, angler catch rates of several fish per hour are common. On this basis, the brown trout fishery in the mainstem Youghiogheny River compares favorably with other brown trout streams in Maryland.

Brook trout are known to occur in most of the previously listed tributaries, as well as virtually all tributaries with adequate water quality and flow. Reproducing brook trout are found in 44 miles (70.8 km) of stream in the Youghiogheny basin; this represents approximately 13% of the total number of miles within the State (Stinefelt et. al. 1985).

MDNR Fisheries has concluded that natural reproduction of trout in Youghiogheny River tributaries is insufficient to maintain a quality trout fishery in the river at present. Accordingly, annual stockings of brown trout fingerlings have been made between the Deep Creek Station project tailrace and Sang Run since 1984 on a "put and grow" basis. Similarly, rainbow trout fingerlings were stocked in 1984, 1990, and 1991 on a put and grow basis in this section of river.

In addition to put and grow stockings, MDNR Fisheries also stocks approximately 2000 catchable brown and rainbow trout per year in the river upstream from Swallow Falls (Pavol 1991). These plantings support a popular spring fishery in the vicinity of Swallow Falls State Park.

Including contributions from both naturally reproduced fish and stocked fingerlings, standing crop estimates of Age 1+ and older trout in the Youghiogheny River have been on the order of 7 pounds/acre, while standing crops of the same fish in tributary streams between Oakland and Friendsville have been as high as 55 pounds/acre (Pavol and Klotz 1989b). Trout taken in the mainstem rarely exceed 12 inches in length, but individuals in excess of 20 inches were observed in 1990 and 1991.

Of the non-trout species which occur in the Youghiogheny River, a species of special concern of the State of Maryland is the stonecat (Noturus flavus). This species, which historically occurred in the Youghiogheny River in Maryland, was reintroduced in the vicinity of Sang Run in 1989.

3.6.2.4 Instream Flow Study

Effects of discharge on fish habitat were evaluated in the Youghiogheny River below the Deep Creek Project tailrace by Penelec during the late summer and fall of 1990. This instream flow study employed PHABSIM, the Physical Habitat Simulation System developed and supported by the U.S. Fish and Wildlife Service (Milhous et. al. 1984; Milhous et. al. 1989). PHABSIM, part of the Instream Flow Incremental Methodology (IFIM), is essentially a system of analytical procedures and computer programs used to conduct hydraulic and habitat simulations. The IFG4 hydraulic simulation program (Milhous et. al. 1984; Milhous et. al. 1989) was used to evaluate the effect of discharge on physical habitat variables in the river, including depth, substrate, velocity, and cover (see Appendix B). The HABTAT habitat simulation program (Milhous et. al. 1984; Milhous et. al. 1989) was then employed to determine the relationship between discharge and fish habitat in the river.

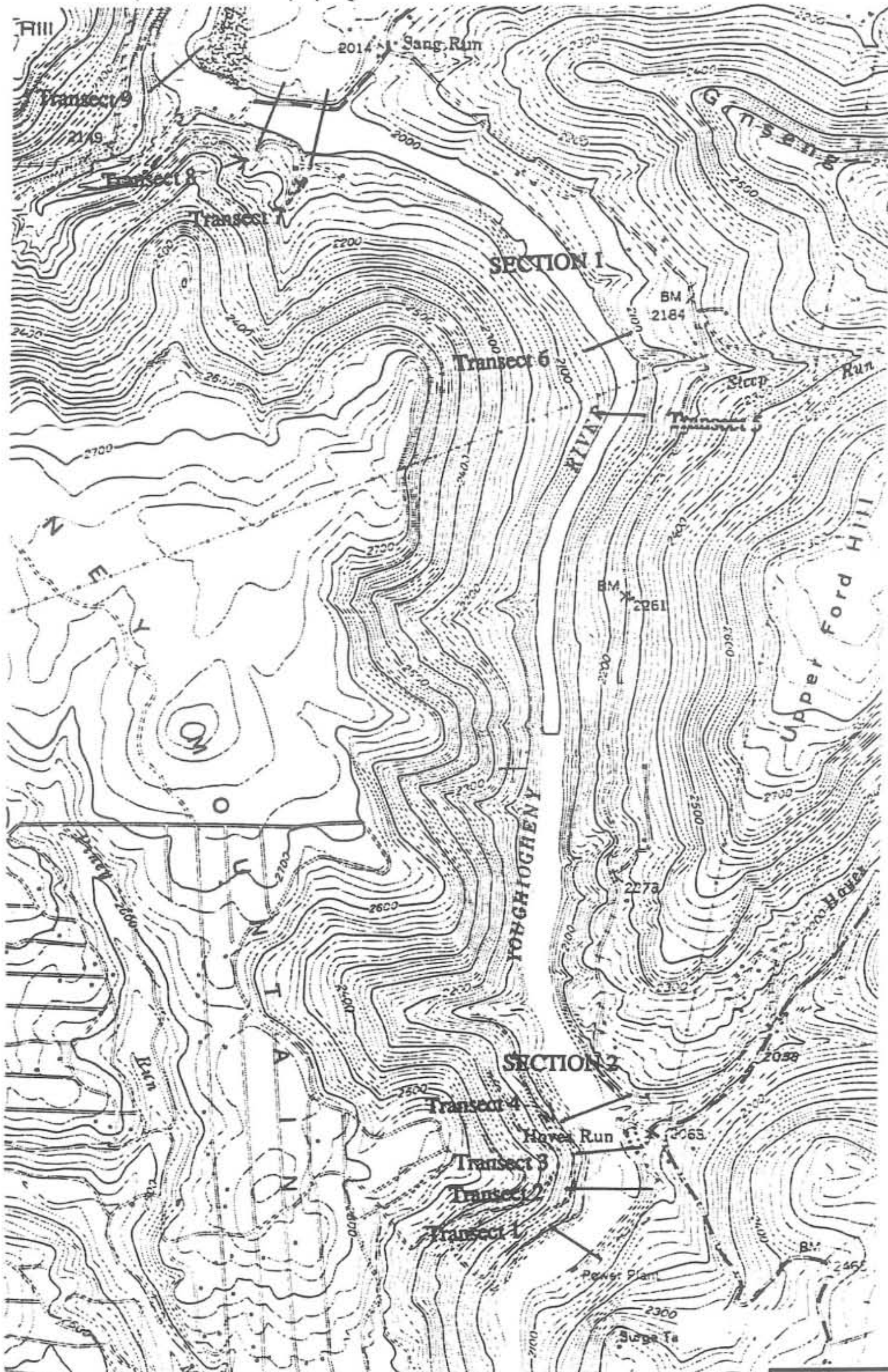
Methods

An instream flow study was conducted in the third segment of the river (Figure 3-59), a 5.5 mile long segment of the river between the Deep Creek Station tailrace and the head of the steep canyon downstream from Sang Run. This segment is most sensitive to changes in habitat quantity and quality with discharge because it is located immediately downstream from the tailrace, and because it has a relatively wide and shallow cross-sectional profile. The steep, narrow canyon reach of the river located downstream from this segment was not evaluated because it was judged to be far less susceptible to changes in habitat with respect to discharge.

Hydraulic simulations were based upon cross sectional transects placed in the river. Prior to transect placement, the southern 3.7 miles of this river segment was divided into two sections based on channel morphology and gradient. These sections were also used to account for downstream increases in discharge due to groundwater and tributary inflow. The lower of these two sections (Section 1) extended from just below Sang Run bridge upstream to Hoyes Run (Figure 3-60). This section represented a 3.3 mile length of river in the instream flow habitat simulations. In terms of fish habitat, this section was dominated by long, relatively deep runs interspersed by short sections of shallow runs. The second section (Section 2) extended from Hoyes Run upstream to the Deep Creek tailrace. This section was considerably shorter than the first section, representing only a 0.4 mile length of river. However, it encompassed more diverse habitat conditions, including wide and shallow riffles and runs, a narrow and steep rapid section, deep runs, and boulder scour pools. This section was of particular interest in instream flow simulation modeling because of a higher potential for fish stranding problems due to its proximity to the tailrace.

A total of nine transects were used in the IFIM study, with five located in Section 1, and four located in Section 2. Transects were selected to represent a full range of habitat conditions occurring with each section. In the upper section (Deep Creek tailrace to Hoyes Run), transects were placed 0.09, 0.17, 0.30, and 0.43 miles downstream from the tailrace. Transect 1 was located in a wide, shallow run just downstream from the tailrace. Transect 2 was located at a narrower, deeper run than Transect 1. Transect 3 was located at the first bend in the river below the tailrace in a relatively narrow and deep run/rapids area. Transect 4 was located at an extremely wide, shallow section of the river adjacent to Hoyes Run.

In Section 1 (Hoyes Run to Sang Run), transects were located 2.38, 2.51, 3.49, 3.61, and 3.74 miles downstream from the tailrace. Transect 5 was located just upstream from Steep Run (Figure 3-60), and was located in a deep run very characteristic of this homogeneous section of the river. Transect 6, located just downstream from Steep Run, was very similar to Transect 5 with the addition of pool habitat located along the right bank of the river. Transect 7 was located in a narrow run/rapids within a river bend.



PENNSYLVANIA ELECTRIC COMPANY
APPLICATION SUPPORT DOCUMENT
DEEP CREEK HYDROELECTRIC PROJECT

Figure 3-60
YOUGHIOGHENY RIVER INSTREAM
FLOW STUDY TRANSECT SITES

EBASCO ENVIRONMENTAL

Transect 8 was located in a wide but deeper run just upstream from the Sang Run bridge. Finally, Transect 9 was located across a shallow, steeper run located just downstream from the Sang Run bridge.

Mean column velocity, depth, substrate, and cover were measured at each transect. These measurements were acquired at a river discharge of approximately 720 cfs at the upper four transects, and 800 cfs at the lower five transects. Measurements were obtained during two-turbine power generation from August 28 to August 31, 1990. Water surface elevation measurements were obtained in conjunction with transect measurements. Additional water surface elevation measurements were taken on September 1, 1990 during a non-generation period. The measured discharge during this latter period was 73 cfs.

A hydraulic simulation model, MANSQ (Milhous et. al. 1989), was used to estimate water surface elevations at each transect for discharges of 40, 300, and 1200 cfs. This PHABSIM program employs Manning's equation to estimate water surface elevations over a range of simulation discharges from a known water surface elevation and discharge measurement (Milhous et. al. 1984). MANSQ estimates of water surface elevations for 300 and 1200 cfs discharges were based on water surface elevations measured at 720 to 800 cfs, while estimates for 40 cfs were based on water surface elevations measured at 79 cfs.

After completing hydraulic calibration following procedures recommended by the U.S. Fish and Wildlife Service Instream Flow Group (Bovee and Milhous 1978; Milhous 1984; Milhous 1985), the IFG4 hydraulic simulation program was used to simulate velocities and depths for discharges in the river ranging from 20 to 2000 cfs. Results of these hydraulic simulations were then employed by a habitat simulation program, HABTAT, to predict weighted usable habitat as a function of river discharge. This program calculates weighted usable habitat based upon habitat suitability data for a given species or life stage of fish. Habitat suitability curves for brown trout fry, juveniles, and adults were employed in habitat simulation modeling, since brown trout were identified as the most important gamefish in the Youghiogheny River below the tailrace. These curves were obtained from the U.S. Fish and Wildlife Service (Raleigh et. al. 1986).

Rapid reductions in wetted width during downramping periods below hydroelectric projects often result in stranding of fish. Potential stranding of fish in the Youghiogheny River below the Deep Creek Project tailrace was identified by MDNR as an item of concern. The potential for fish stranding would be greatest immediately following cessation of power generation, especially during summer critical low flow periods. To address this concern, a stranding potential analysis was calculated using PHABSIM. The effective habitat simulation program HABEF was used for this purpose (Milhous et. al. 1989). HABEF calculates a stranding index based on differences in weighted usable habitat values between two flows. Increasing index values indicate a higher potential for stranding. With respect to the Youghiogheny River, the stranding index calculation was based on net differences in habitat area between baseflow conditions (non-generation) and during power generation. Separate stranding index values were calculated for one-turbine operation at full gate (320 cfs) and two-turbine operation at full gate (640 cfs). Stranding index values are most sensitive to large changes in wetted channel width between two given discharges. This index only provides an indication of relative stranding; it cannot be used to predict actual stranding in a given river. The stranding potential of fish is also highly influenced by behavioral traits, age, water temperature, and time of day, among other factors. Younger age classes of fish are especially vulnerable to stranding in wide, shallow margins of the river channel. Older age classes of brown trout in particular may be not be susceptible to stranding even though a high stranding index is indicated.

Results of Instream Flow Study

The instream flow study conducted on the Youghiogheny River was used to describe the hydraulic geometry (i.e. changes in channel width, depth, and velocity with discharge) of the river, changes in weighted usable habitat with discharge, and finally stranding potential under one-turbine and two-turbine operation.

Hydraulic Geometry

Wetted width is very important with respect to fish habitat. Large increases in habitat area may result from small increases in discharge as a result of changing width. The Youghiogheny River changed proportionately more in wetted width than in depth or velocity for discharges between 0 and 300 cfs. For the section of the river between the project powerhouse and Hoyes Run, wetted width increased most rapidly between from 40 cfs to 70 cfs (Figure 3-61). Transects in this section increased in average wetted width from 140 ft at 40 cfs to 164 ft. at 70 cfs. At discharges greater than 300 cfs, wetted width changed very little with discharge and were generally a constant value of approximately 200 ft.

The wetted width of the river from Hoyes Run to Sang Run bridge also increased most rapidly from 40 cfs to 70 cfs (Figure 3-62). Transects in this section increased in average wetted width from 130 ft. at 40 cfs to 158 ft. at 70 cfs. Like the previous river study section, wetted width changed very little with discharges greater than 300 cfs, and were generally a constant value of approximately 180 ft.

Changes in wetted width were greatest for transects having both a broad lateral bar and incised inner channel (Figure 3-63). Transects having a more constant or flat cross-sectional profile changed far less in width with discharge. Transects 2,4,5, and 6 were characterized by a skewed cross-sectional profile in which the channel thalweg (deepest point of cross-section) was along either the right bank or left bank of the river. Consequently, changes in width with discharge were greatest at these transect locations.

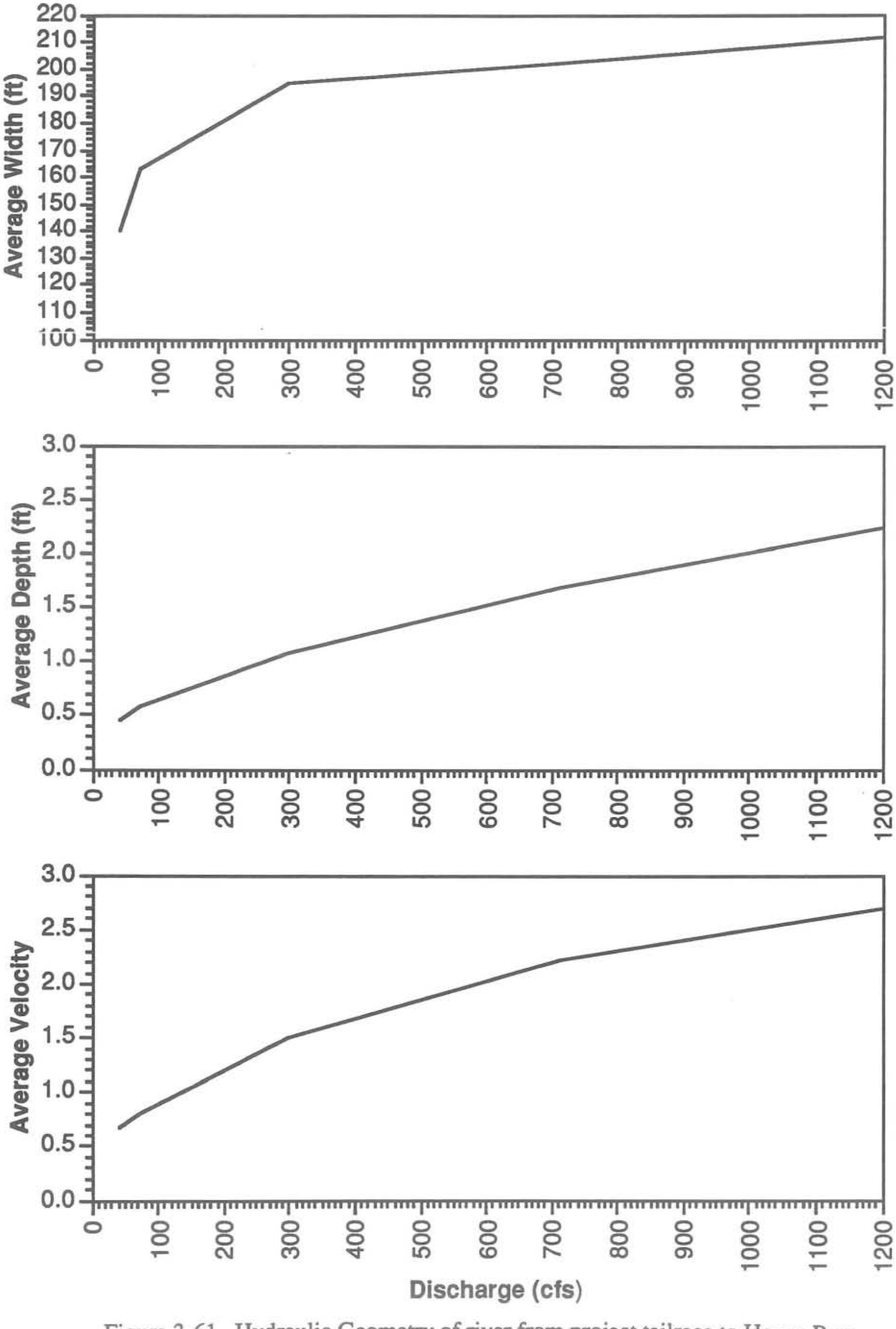


Figure 3-61. Hydraulic Geometry of river from project tailrace to Hoyes Run.

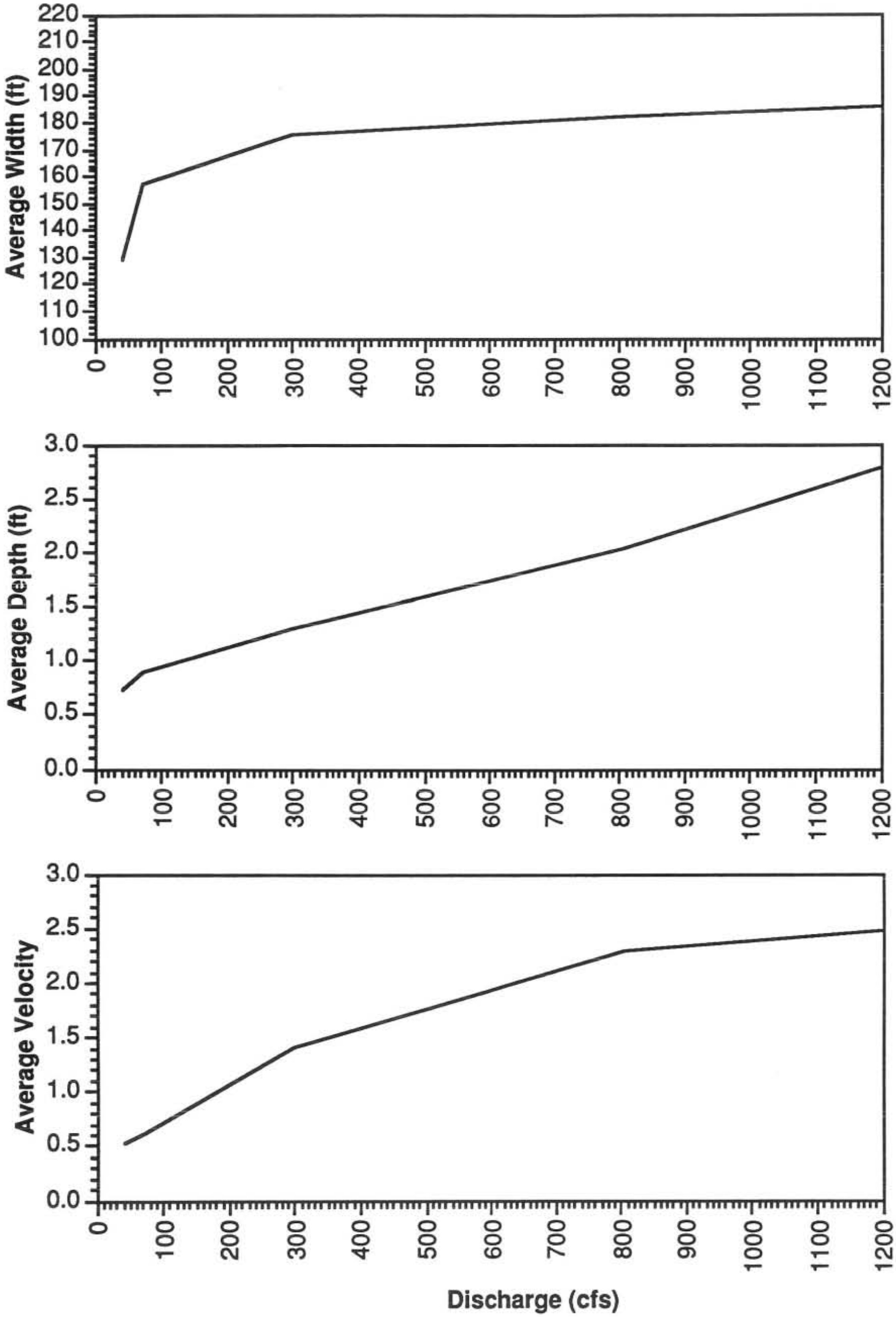


Figure 3-62. Hydraulic Geometry of river from Hoyes run to Sang Run Bridge.

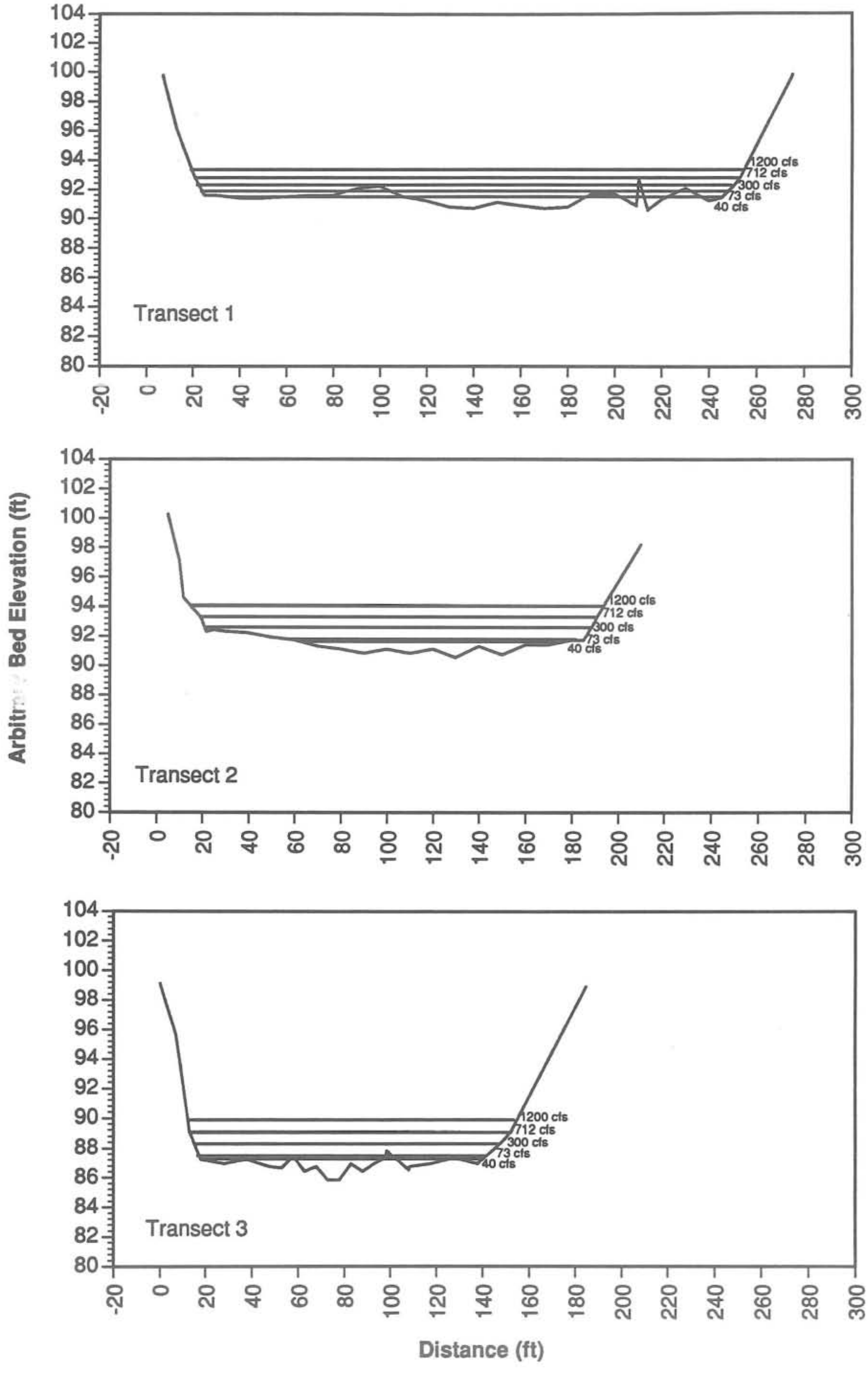


Figure 3-63. Cross-sectional profiles for instream flow study transects.

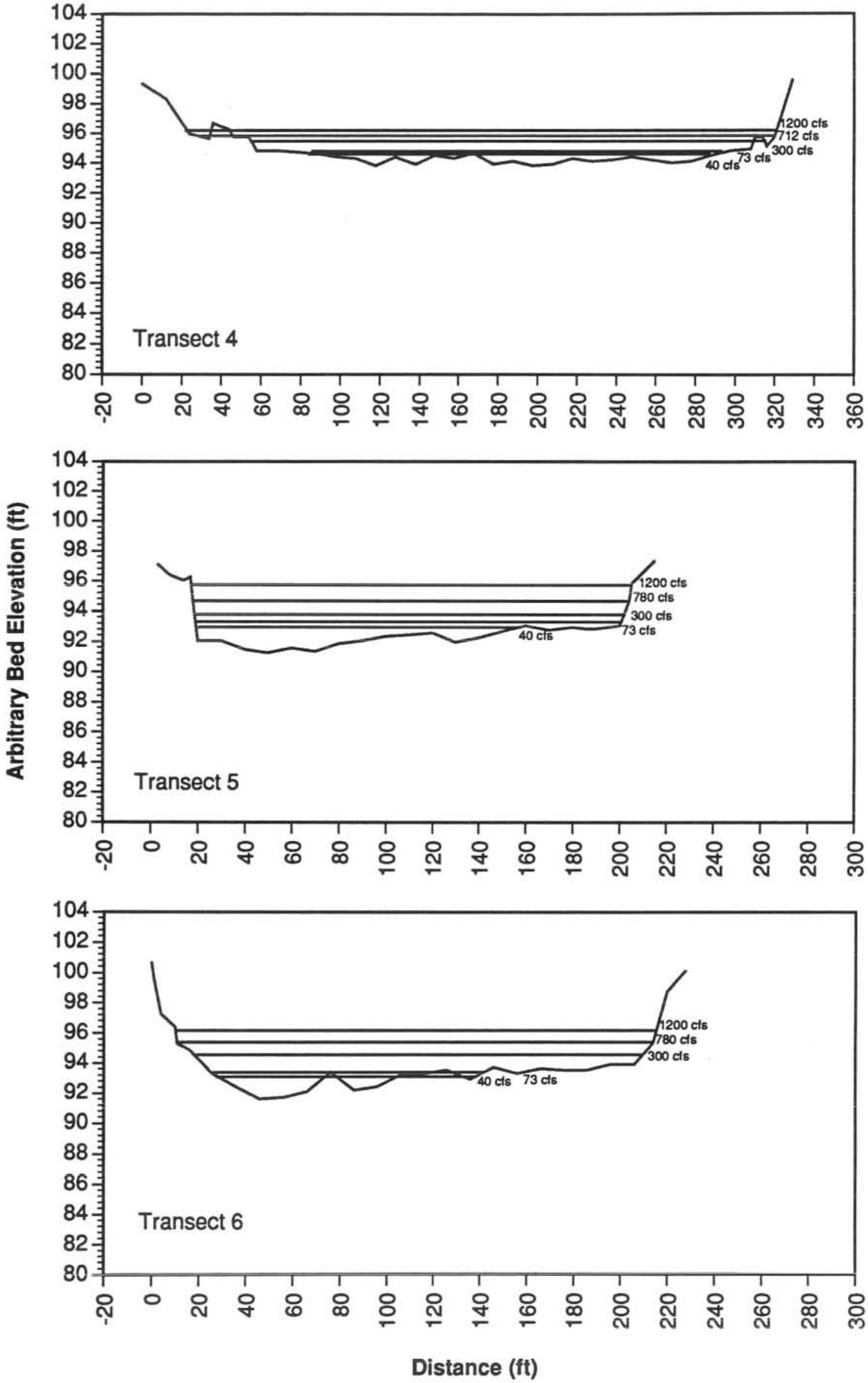


Figure 3-63 (cont.)

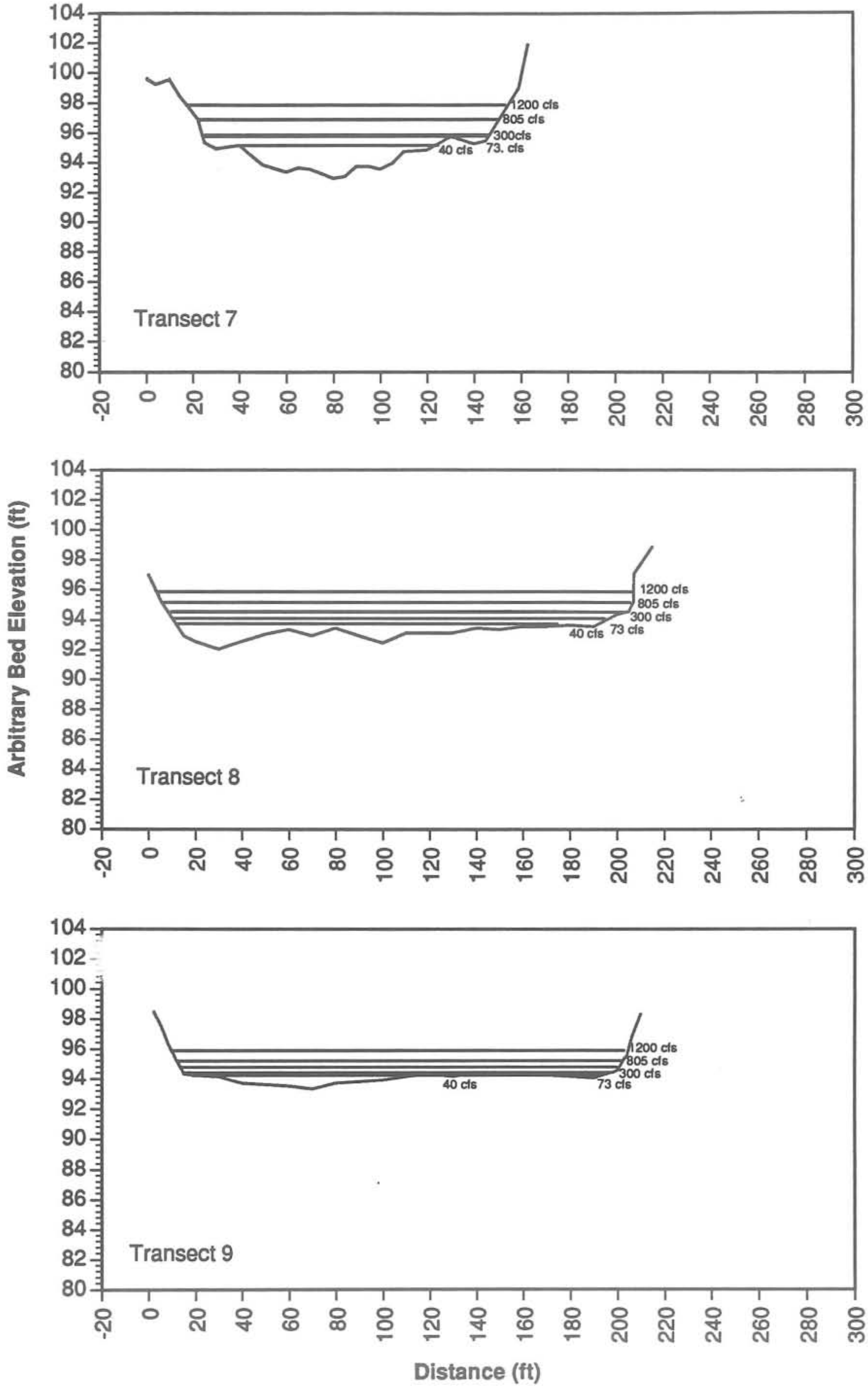


Figure 3-63 (cont.)

These transects all possessed a lateral bar composed of small to large cobbles, which was dry at lower discharges and became progressively inundated at higher flows. Transects 4 and 6 had the largest exposed lateral bars at discharges less than 300 cfs. Transects 1,3,7,8, and 9 had relatively flat cross-sectional profiles, with the thalweg located approximately near the middle of the channel. Increases in width were relatively small with respect to increasing discharges greater than 40 cfs. This latter set of transects had almost fully wetted channel cross-sections at 40 cfs. Even wide, shallow transects such as transect 1 changed relatively little in width with discharge above this baseflow level.

Unlike width, depth responded in a nearly linear relationship to discharge (Figures 3-61 and 3-62). At discharges of 40 to 70 cfs in the river between the tailrace and Hoyes Run, the average depth of transects increased by only 0.15 ft. (Figure 3-61). The average transect depth at 40 cfs was 0.45 ft., and at 70 cfs was 0.60 ft. Average depth in this section increased to 1.1 ft. at 300 cfs, 1.4 ft. at 600 cfs, and 2.1 ft. at 1200 cfs. For the river between Hoyes Run and Sang Run bridge, depth of transects increased on average by only 0.20 ft. between 40 and 70 cfs (Figure 3-63). Average transect depth was 0.7 ft. at 40 cfs, and 0.90 ft. at 70 cfs. These depths increased to 1.3 ft. at 300 cfs, 1.7 ft. at 600 cfs, and 2.7 ft. at 1200 cfs. Depth is a more important habitat requirement of adult brown and rainbow trout, which prefer relatively greater depths than fry and juvenile life stages. Depth can provide important cover habitat to larger fish, especially when cover provided by channel features such as boulders, woody debris, and banks is relatively scarce.

Velocity increased in a curvilinear relationship to discharge. In both study sections, average channel velocities increased most rapidly between 40 and 300 cfs (Figures 3-61 and 3-63). Between 40 and 300 cfs, velocities in the river between the tailrace and Hoyes Run increased from 0.6 to 1.5 feet per second (fps) (Figure 3-61). Velocities in this section increased to 1.8 fps at 600 cfs, and 2.6

fps at 1200 cfs. Between Hoyes Run and Sang Run Bridge, velocity also increased most rapidly between 40 and 300 cfs. Average channel velocities in this section ranged from 0.5 fps at 70 cfs to 1.4 fps at 300 cfs (Figure 3-62), and increased to 1.8 fps at 600 cfs and 2.5 fps at 1200 cfs. Velocity is not expected to limit brown trout populations in the river at lower discharges, since velocities are well within the range preferred by this species. Velocity becomes the most important limiting factor at higher discharges when the velocity tolerance of fish, especially fry and juveniles, is exceeded.

Weighted Usable Area vs Discharge

Habitat modeling simulations conducted with PHABSIM for the Youghiogheny River between the tailrace and Hoyes Run suggests that the optimal discharge for brown trout fry and juveniles is 275 cfs, and 350 cfs for adults (Figure 3-64). For the section of the river between Hoyes Run and Sang Run bridge, the optimal discharges for brown trout fry, juveniles, and adults is 250, 275, and 300 cfs respectively (Figure 3-65). In both sections, weighted usable area for all life stages of brown trout increases most rapidly between discharges of 0 and 100 cfs. Maximum values of weighted usable area are achieved between 200 and 350 cfs.

Wetted width exerts the greatest influence on weighted usable values at discharges between 0 and 100 cfs. In this range, small changes in discharge result in relatively high increases in wetted width and subsequently habitat area. A combination of increasing width and depth has greater importance to weighted usable area values between discharges of 100 cfs and 350 cfs. Mean channel depths increase significantly through this range of discharges, providing better cover to adult fish. Maximum weighted usable area values, which occur between 200 and 350 cfs, coincide with almost complete bank to bank wetting of the river channel. At discharges exceeding approximately 400 cfs, weighted usable area values for all life stages decline in both sections of the river (Figures 3-64 and 3-65). This decline in weighted usable area values is strongly

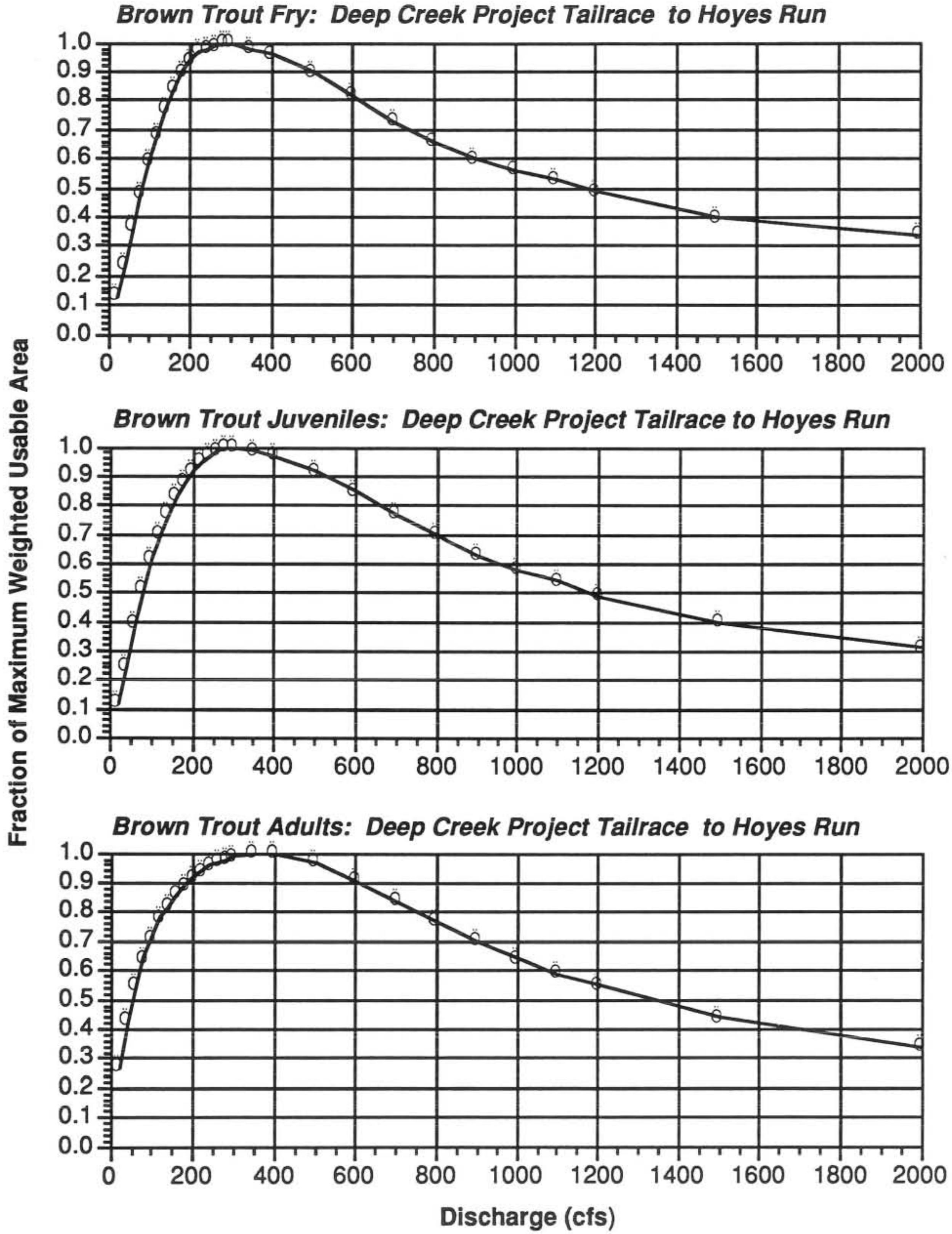


Figure 3-64. Weighted usable area vs. discharge curves for brown trout life stages; Deep Creek Project tailrace to Hoyes Run.

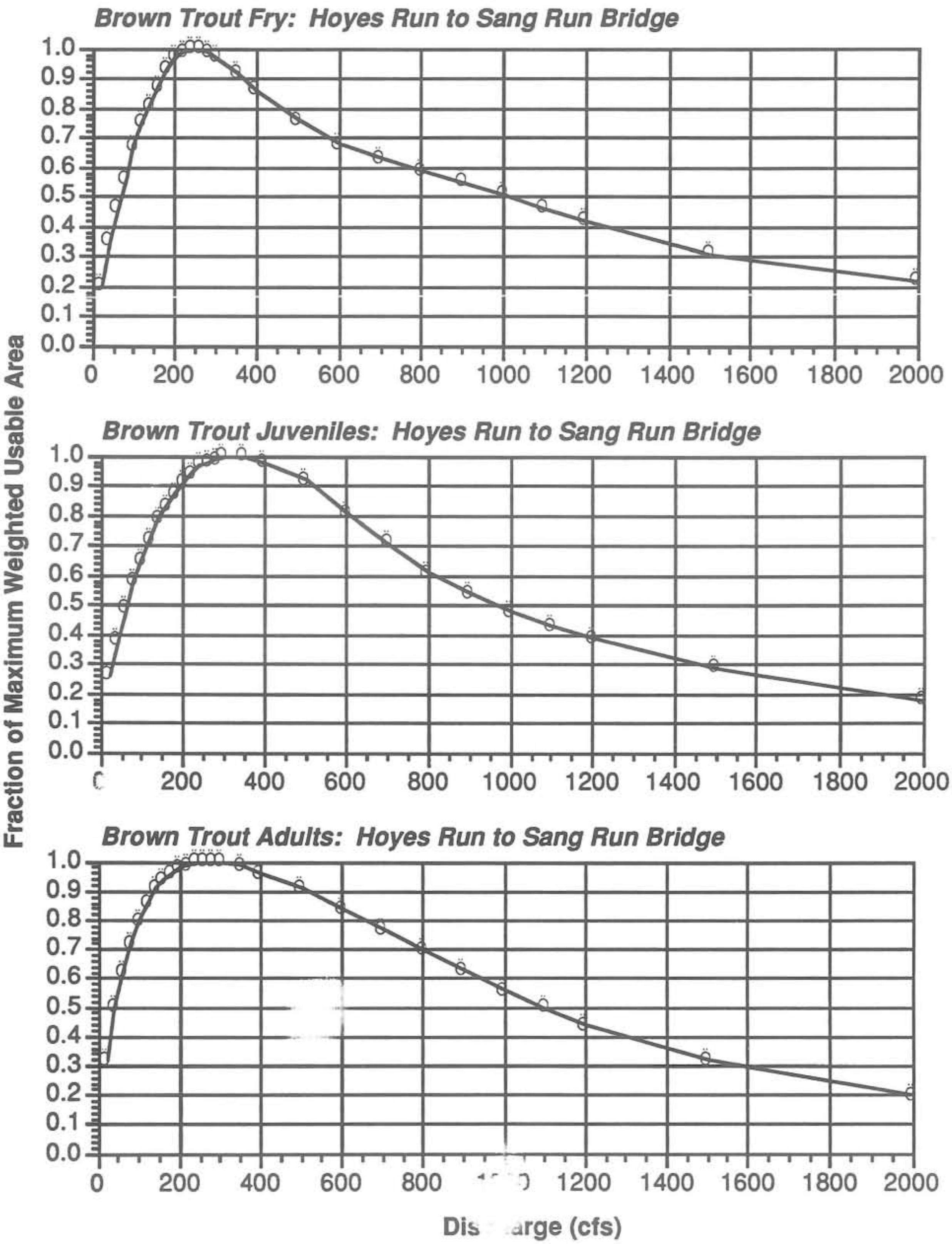


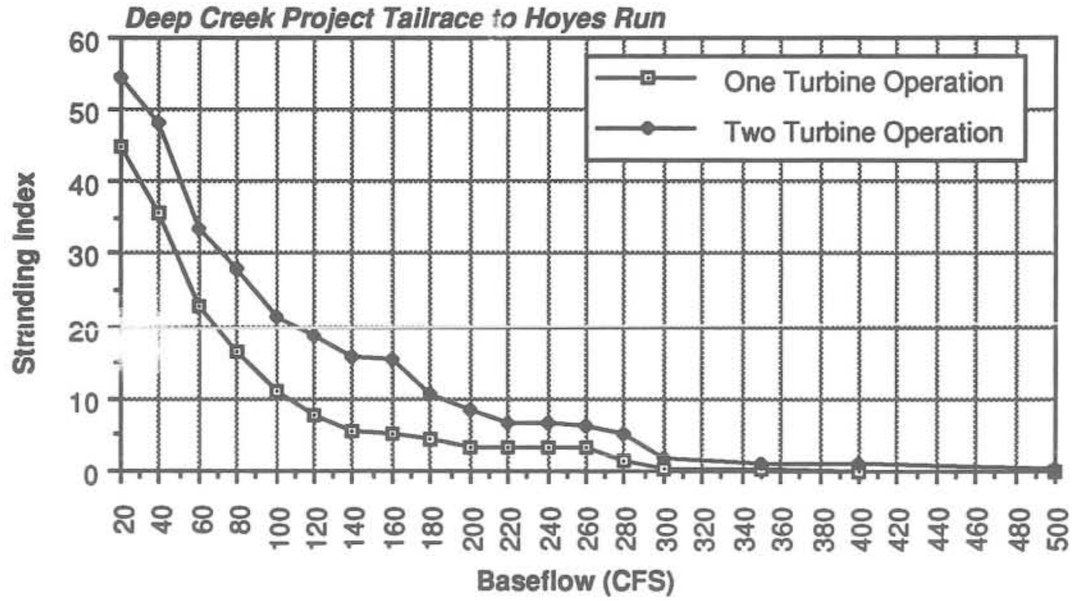
Figure 3-65. Weighted usable area vs. discharge curves for brown trout life stages; Hoyes Run to Sang Run Bridge.

influenced by relatively high velocities above 400 cfs, which become decreasingly preferred or tolerated by fish.

With two unit operation and average Youghiogheny River flow conditions (i.e., total flow about 1,000 cfs), the WUA is about 60 percent of the maximum WUA for adult brown trout. With only one unit operating the WUA increases to about 80 percent. With less than full gate operation, WUA would correspondingly increase.

Stranding Analysis

The stranding analysis conducted with PHABSIM suggests that the highest potential for stranding occurs during two-turbine operation when river baseflow discharges range from 20 to 100 cfs (Figure 3-66). For both study sections of the river, stranding values range between 10 and 45 for one-turbine operation, and between 20 and 55 for two turbine operation. These stranding index values, as mentioned previously, only indicate the relative potential for stranding between baseflow and peak flow discharges. Baseflow and peak flow discharge combinations having high stranding index values (> 10) indicate a greater potential for stranding relative to discharge combinations having low stranding index values. Both study sections would be expected to have a similar potential for stranding at baseflow discharges less than 100 cfs, since both sections have equivalent stranding index values below this baseflow discharge value. However, attenuation in flow fluctuations at increasing distances from the tailrace would result in reduced stranding of fish in the study section between Hoyes Run and Sang Run bridge. Stranding potential is higher for two-turbine operation than for one-turbine operation for baseflow discharges less than 100 cfs (Figure 3-66). Discharge in the river downstream of the tailrace decreases by 320 cfs following cessation of one-turbine operation, while it decreases by 640 cfs following cessation of two-turbine operation. Higher stranding values for two-turbine operation reflect a greater change in discharge, and thus wetted width, between peak flow and baseflow conditions.



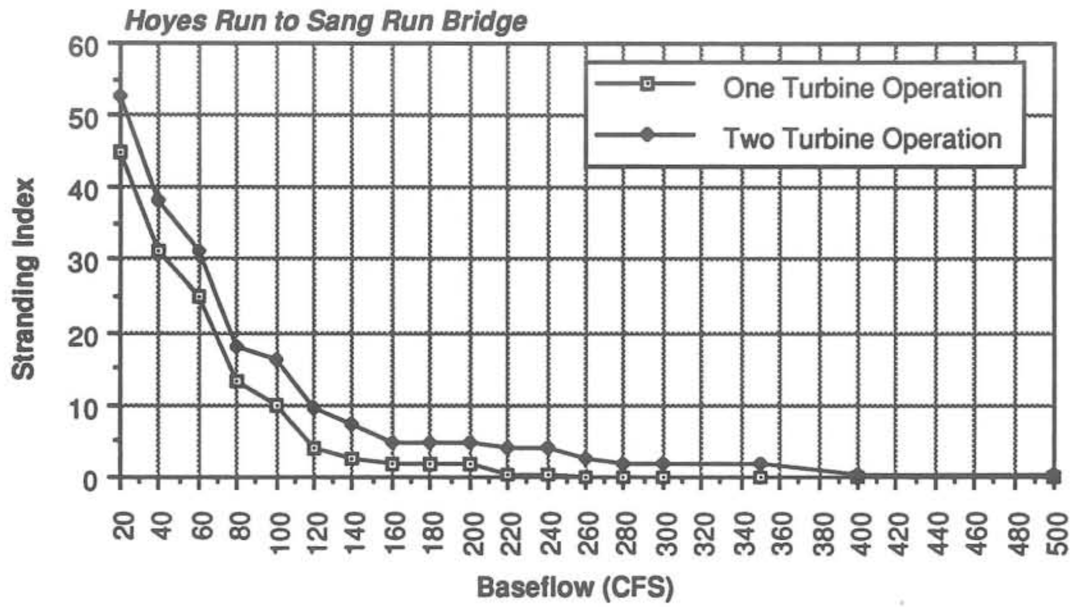


Figure 3-66. Stranding index curves for baseflow and one- and two-turbine peak flow generation, Youghiogheny River.

The potential for stranding decreases considerably when river baseflow discharges exceed 100 cfs (Figure 3-66). Stranding potential becomes minimal in the river between the tailrace and Hoyes Run for baseflow discharges greater than 300 cfs, and in the river between Hoyes Run and Sang Run bridge for baseflow discharges greater than 260 cfs. These baseflow discharge values correspond to bank to bank wetting of the river channel, a condition beyond which fish stranding becomes highly unlikely.

3.6.3 Rare, Threatened, and Endangered Fish Species

Both the Maryland Natural Heritage Program and the U.S. Fish and Wildlife Service were contacted regarding information on the presence of rare, threatened, or endangered fish species. The Natural Heritage Program indicated that two fish species in the Youghiogheny River are listed as rare or endangered. These are:

Scientific Name	Common Name
Noturus flavus	Stonecat
Rhinichthys bowersi	Cheat Minnow

Hendricks (1980), in a comprehensive review of fish species distribution in the Youghiogheny River, noted that *Noturus flavus* was primarily only present in two drainages downstream of the Youghiogheny Reservoir. He also noted that this species was recorded in 1977 at a sampling station in the Youghiogheny just downstream from the Deep Creek Project. *Rhinichthys bowersi* was not listed as being present in the Youghiogheny system by Hendricks (1980). More recent studies (e.g., Pavol 1988b, Davis 1985) do not note either of the two species. It should be noted, however, that these more recent studies were focused on management of key species such as trout, and were not targeted on the general distribution of all species throughout the Youghiogheny system.

A small number of stonecats (*Noturus flavus*) were reintroduced in the Youghiogheny River near Sang Run in 1989, and one individual was observed at Sang Run during routine electrofishing in 1990. Therefore, there is a possibility that a reproducing population may now exist in the Youghiogheny River above Friendsville (letter from Mr. Richard McLean, Maryland Department of Natural Resources, October 28, 1991).

3.7 BOTANICAL RESOURCES

The following description of botanical resources within the Deep Creek project area was developed by consulting the following information sources: the Society of American Foresters' "Forest Cover Types of the United States and Canada (Frye 1980), MDNR aerial photography of Deep Creek Lake, MDNR nontidal wetland maps, MDNR's "Field Guide to Nontidal Wetland Identification" (Tiner 1990), and by contacts with MDNR staff. The U.S. Fish and Wildlife Service and the Maryland Natural Heritage Program were contacted regarding any endangered, threatened, or rare species that could occur in the project area. The flora of the study area was examined in a pedestrian survey conducted on October 4-5, 1990.

3.7.1 Region

Deep Creek Project is located within the mixed oak forest of the Appalachian Highlands province. This forest type is characterized by an overstory of white oak (Quercus alba) throughout its range, with northern red oak (Q. rubra) occurring in moister locations, and black oak (Q. velutina) in drier locations. Other tree associations include hickories (Carya spp.), yellow poplar (Liriodendron tulipifera), black gum (Nyssa sylvatica), sugar and red maples (Acer saccharum and A. rubrum), white and green ash (Fraxinus americana and F. pennsylvanica), American and slippery elm (Ulmus americana and U. rubra), basswood (Tilia americana), cucumbertree (Magnolia acuminata), sweetgum (Liquidambar styriflua), black cherry (Prunus serotina), American beech (Fagus grandifolia), black walnut (Juglans nigra), eastern hemlock (Tsuga canadensis), and shortleaf, pitch, Virginia and loblolly pines

(Pinus echinata, P. rigida, P. virginiana and P. taeda). Understory species include flowering dogwood (Cornus florida), sassafras (Sassafras albidum), sourwood (Oxydendrum arboreum), serviceberries (Amelanchier spp.), hornbeams (Ostrya spp.), witch hazel (Hamamelis virginiana), viburnums (Viburnum spp.), vacciniums (Vaccinium spp.), spicebush (Lindera benzoin), mountain laurel (Kalmia latifolia), and rhododendrons (Rhododendron spp.) (Society of American Foresters 1980). Ground cover includes various ferns, mosses, mayapple (Podophyllum peltatum), partridgeberry (Mitchella repens), clubmosses (Lycopodium spp.), raspberry (Rubrus spp.), grapes (Vitis spp.), greenbriar (Smilax spp.), and povertygrass.

Forested, shrub scrub, and emergent wetlands occur throughout the region. Forested wetlands include hemlock-yellow birch-red maple-alder (Tsuga canadensis-Betula aleghaniensis-Acer rubrum-Alnus spp.) communities in seasonally flooded/saturated areas, and black cherry in temporarily flooded areas. Shrub scrub wetlands include alder-northern arrowwood (Alnus spp.-Viburnum recognitum) communities and meadowsweet (Spirea alba) in seasonally flooded/saturated areas. Emergent wetlands include woolgrass-rice cutgrass (Scirpus spp.-Leersia oryzoides) communities, bur-reed-rice cutgrass (Sparganium spp.-Leersia oryzoides) communities, sweet flag-jewelweed (Acorus calamus-Impatiens spp.) communities, and bluejoint (Calamagrostis canadensis) which occur in seasonally flooded/saturated areas (Tiner 1990). Extensive mountainous bogs, locally known as "glades", occur within the region.

Several large tracts of publicly owned land, including Garrett State Forest, Swallow Falls State Park, Mount Nebo Wildlife Management Area, Deep Creek State Park, Savage River State Forest, and Potomac State Forest occur within the region. Additionally, the Maryland Chapter of the Nature Conservancy is working with the landowners of several wetland areas, including Hammel Glade and Cherry Creek Glade, to register these sites for preservation.

3.7.2 Project Study Area

With respect to botanical resources, the project study area was limited to Penelec's land around Deep Creek Lake and the Youghiogheny River, and the area that could be affected by any changes in project operation or other improvement measures, such as provision of a minimum flow in Deep Creek in the reach downstream from the dam. This includes the Deep Creek Lake periphery, the 1.75-mile stretch of Deep Creek between the dam and the Youghiogheny River, and the 5-mile stretch of Youghiogheny River between Deep Creek and Sang Run.

3.7.2.1 Deep Creek Lake Periphery

Virtually all of the Deep Creek Lake periphery is developed into recreational, residential, and commercial property, with much of the shoreline maintained as residential lawns. There are only limited areas where the natural forest vegetation occurs undisturbed along the lake periphery. The natural vegetation includes predominantly oaks and hickories in steeper sloped areas, and red maples, black cherry, and pitch pine along more gradually sloping areas.

Physically, the lake can be divided into two sections that differ in terms of shoreline character. The section of the lake north of Glendale Bridge generally has steep banks and few marshy areas. Wetlands are limited to two emergent areas at McHenry, two at the dam area, and an emergent/shrub scrub wetland above the Meadow Mountain Run cove. The southern portion of the lake has a more gentle shoreline than the northern portion. Wetlands are more numerous in the southern portion, with emergent and shrub scrub wetlands occurring within the uppermost reaches of each cove. The MDNR classified one of the wetland areas at McHenry and the wetland area within the cove at Holy Cross Camp as Wetlands of Special State Concern (WSSC).

Emergent vegetation was not visible at the four wetland areas at the dam and McHenry, due to the time of the year of the field survey. Fringes of shrub scrub vegetation (alders, willows (Salix spp.), viburnum, and witch hazel) occur in these areas. The emergent vegetation in the lake coves was observed to be predominantly sedge-grass-rush communities, although other species are likely to be observable at other times of the year. These coves are fringed with shrub scrub vegetation as described above. Forested wetland areas of red maple and black cherry occur at the upper limits of many of the cove areas.

Hammel Glade is the closest glade wetland to the lake. It is located approximately 0.5 mile from the lake, and is about 200 ft. higher in elevation. Cherry Creek Glade occurs about 1.25 miles northeast of the lake, and is also about 200 ft. higher in elevation. Both of these glades are classified by MDNR as WSSC because of their diverse ecosystems. Neither of the glade wetlands are considered to be hydrologically influenced by Deep Creek Lake levels (personal communication, Ed Thompson, Maryland Department of Natural Resources, March 15, 1991).

3.7.2.2 Deep Creek Downstream from Dam

Deep Creek downstream from the dam flows for 1.75 miles to the Youghiogheny River. The channel is a wide flat spillway immediately below the dam, and becomes increasingly narrower and steeper toward the river. The spillway area supports wetland emergent and shrub scrub vegetation. The steeper area supports forest vegetation dominated by eastern hemlock and white pine (Pinus strobus), with other species such as red maple and black cherry. The State has designated Lower Deep Creek as a Wetland of Special State Concern.

3.7.2.3 Youghiogheny River

Between Deep Creek and Sang Run the Youghiogheny River flows through a steep-sided valley. The shoreline is entirely wooded with an overstory of hemlock, American beech, red maple, elms, basswood, and black cherry, and an understory of dogwood, rhododendron, laurel, and various ferns. One wetland area, classified as WSSC by the MDNR, occurs at the Sang Run confluence. This area supports primarily hemlock with red maple, black cherry, and elms.

3.7.2.4 Rare, Threatened, and Endangered Species

There are no recent reports of any federally listed threatened or endangered species occurring in the project area. A number of state-listed endangered, threatened, and rare species are reported to occur within the general Deep Creek area. Endangered species include blue monkshood (Aconitum uncinatum), a semi-aquatic plant, and smooth rose (Rosa blanda) and long-bracted orchis (Coeloglossum viride) in more upland habitats. Threatened species include large purple-fringed orchid (Platanthera grandifolia), a wetland species, and climbing fumitory (Adlumia fungosa), an upland species. Several area wetland species are on the state watchlist: thyme-leaved bluet (Houstonia serpyllifolia), Carolina tasselrue (Trautvettria caroliniensis), Carex bromoides, Goldie's fern (Dryopteris goldiana), black ash (Fraxinus nigra), smooth azalia (Rhododendron arborescens), bluejoint grass (Calamagrostic canadensis), and Loesel's twayblade (Liparis loeselii). Two more upland species on the watchlist are Carolina spring beauty (Claytonia caroliniana) and umbrella magnolia (Magnolia tripleta). Rare species include Carex nostrata and skunk current (Ribes glandulosum), both wetland species, and Appalachian blue violet (Viola appalachiensis) and northern beech fern (Thelypteris phegopteris), both upland species.

3.8 WILDLIFE RESOURCES

The following description of wildlife resources within the project area (defined in Section 3.7) was developed through consultation with the MDNR staff, conversation with Jim Wilburn, Deep Creek Lake State Park Manager and Kevin Dodge, Wildlife Specialist, Garrett County Community College, and through coordination of efforts with the U.S. Fish and Wildlife Service (FWS) and the Maryland Natural Heritage Program regarding threatened, endangered, and rare species in the area. A brief field survey of the area was performed on October 4-5, 1990 to verify habitat conditions.

3.8.1 Deep Creek Lake Periphery

As discussed in Section 3.7, the entire Deep Creek Lake periphery is fairly well developed. Wildlife habitat along the shoreline is limited to a few sections that remain undeveloped. These sections include the upland habitat at the Deep Creek Lake State Park and a few undeveloped shoreline areas in the northern portion of the lake. Lacustrine and wetland habitat in coves around the southern portion of the lake also provides the type of cover necessary for wildlife to pass freely without human disturbance. The habitat in these few undeveloped areas supports the same species common to Garrett County, including game species, such as deer (Odocoiles virginianus), wild turkey (Meleagris gallopavo), rabbit (Sylvilagus floridanus), squirrels (Sciurus spp. and Tamiasciurus hudsonicus), and non-game animals, such as fox (Vulpes fulva and Urocyon cinereoargenteus), chipmunk (Tamias striatus), groundhog (Marmota monax), mice, and shrews. Other wildlife species include beaver (Castor canadensis), otter (Lutra canadensis), and muskrat (Ondatra zibethica). Birds common to the lake shoreline include loons (Gavia spp.), grebes, herons, geese, ducks, swans (Olor columbianus), and egrets. Most of the waterfowl species are seasonal migrants, since the lake does not have sufficient habitat to maintain waterfowl year-round (personal communication, K. Dodge, Garrett County Community College, March 20, 1991). Other common bird species include owls, kingfisher (Megaceryle alcyon), woodpeckers, swallows, crows (Corvus spp.), and warblers.

3.8.2 Deep Creek Downstream from Dam and Youghiogheny River

These areas described in Section 3.7 are completely undeveloped and are contiguous with extensive forested areas. This habitat can maintain the same game and non-game mammals that are found in the Deep Creek Lake periphery. In addition, black bear and bobcat may occur in the wooded areas where human activity is limited. The bird species would also include most of the same species found in the Deep Creek Lake periphery except the waterfowl species which prefer wetland/lacustrine habitats.

3.8.3 Rare, Threatened, and Endangered Species

There are no recent reports of any federally listed threatened or endangered species occurring in the project area, although the area is in the range of the endangered bald eagle (Haliaeetus leucocephalus) and Indiana bat (Myotis sodalis). Several species that are candidates for federal listing have been reported in the project area: the state-listed endangered hellbender (Cryptobranchus alleganiensis), mudpuppy (Necturus maculosus), and Cheat minnow (Rhinichthys bowersi) which occur in the Youghiogheny River; the state-listed endangered southern water shrew (Sorex palustris), which occurs along the Deep Creek diversion; a state-listed endangered planarian (Procotyla typhlops), which occurs in the area waters; the state-listed "species in need of conservation" eastern woodrat (Neotoma floridana), which occurs in rocky outcrops, and long-tailed shrew (Sorex dispar), which occurs in moist forests.

Other state-listed endangered species occur in the project area: the mudpuppy (Necturus maculosus), which occurs in the Youghiogheny River; the mountain earth snake (Virginiana valeriae pulchra), which occurs along rocky clearings; and the northern coal skink

(Eumeces anthracinus) and green salamander (Aneides aeneus) which occur in moist woods. One state-listed threatened species, the smokey shrew (Sorex fumeus) may occur in deep forest. State "rare" species include black bear (Ursus americanus), pied-billed grebe (Podilymbus podiceps), hooded merganser (Lophodytes cucullatus), and a planarian (Planaria dactyligera). Other state species "in need of conservation" are bobcat (Lynx rufus), eastern spiney softshell turtle (Trionyx spiniferus spiniferus) and Wehrle's salamader (Plethodon wehrlei).

3.9 RECREATIONAL RESOURCES

Deep Creek Lake, the project's reservoir, is a major resource for lake-oriented recreation in western Maryland. The project's powerplant discharges to the Youghiogheny River, which also has regional significance for river recreation activities. This section describes the Deep Creek Project's relationship to these recreational resources and activities. Section 3.9.1 provides an overview of recreational resources in the study area. A regional inventory of federal, state, local and private sector opportunities is presented in Section 3.9.2. Section 3.9.3 examines in more detail recreation facilities, activities, use patterns and future conditions at Deep Creek Lake. The final section, 3.9.4, discusses downstream recreation activities and use patterns.

3.9.1 Study Area Overview

The rivers, lakes and forested mountains of Garrett County provide a variety of outdoor recreation opportunities. The primary recreation resources in the county include Deep Creek Lake and several other reservoirs; a number of major streams, including the Youghiogheny River; and large areas of publicly-owned park, forest and wildlife lands. These resources support a wide variety of recreational activities, both in undeveloped settings and at developed facilities provided by public and private sector operators.

In order to provide an appropriate regional context, Garrett County as a whole is used as the study area for this report. The inventory of existing recreational opportunities and use presented in Section 3.9.2 was conducted on a countywide basis. However, due to their direct relationship to project facilities and operations, Deep Creek Lake and the upper Youghiogheny River receive the most detailed treatment in the inventory, issues review, and enhancement sections. In addition, in some cases it is necessary to consider local relationships to comparable recreation resources located outside of Garrett County.

Deep Creek Lake is a popular weekend and vacation destination and is the most prominent focal point of recreation in Garrett County. The lake area's scenic appeal, recreational attributes and proximity to mid-Atlantic cities such as Pittsburgh, Baltimore, and Washington, D.C. attract a large number of visitors from outside the local area. Water-based recreational activities such as motorboating, waterskiing, sailing, swimming, and fishing in Deep Creek Lake are very popular. Many people visiting the area also participate in land-based recreational activities such as skiing, camping, picnicking, hiking, and golfing. Recreation and tourism in the lake area are supported by extensive developed facilities, including campgrounds, day-use areas, boat ramps, marinas, lodging establishments, golf courses, and a ski area. Much of the land adjacent to the lake has also been developed for residential use.

The section of the Youghiogheny River examined in detail in this report starts at Swallow Falls on the Youghiogheny River upstream of Deep Creek and continues downstream approximately 15.2 miles to Friendsville. In much of the study area the river travels through a narrow gorge with cliffs rising as high as 800 ft. above the river. Hugging the sides and ridges of the gorge are thick stands of second- and third-growth hardwoods. The rugged and often inaccessible terrain has helped the area retain a primitive character. Recreational facilities within the river corridor are limited, but include a popular state park and several informal access points. Boating and fishing are the primary recreational activities, although hunting and some other dispersed uses occur in upland areas.

The steep gradient and narrow, rocky channel of the Youghiogheny River provide an outstanding whitewater boating resource. One 4-mile stretch starting at Gap Falls has a series of 20 major rapids, including some rapids rated as high as Class V on the six-class International Scale of River Difficulty. The river's difficulty and beauty have given the Youghiogheny the distinction of being considered one of the premier whitewater rivers in the United States (letter from Risa Callaway, Executive Director American Whitewater Affiliation, Washington, D.C., March 21, 1988). In 1971 the Youghiogheny was designated by the State of Maryland as one of its original "Scenic and Wild Rivers."

While Deep Creek Lake and the Youghiogheny River are the most widely known recreation attractions in Garrett County, there are numerous other components of the local recreation resource base. Other water resources that are important for recreation include the Casselman, Savage and North Branch Potomac Rivers, many tributary streams, three major reservoirs, and several smaller reservoirs and lakes. Approximately 73,000 acres of land in Garrett County (17 percent of the county, by area) are publicly owned, primarily in parks, forests and wildlife areas managed by the State of Maryland. These lands provide extensive opportunities for land-based recreation, particularly for undeveloped activities in dispersed settings.

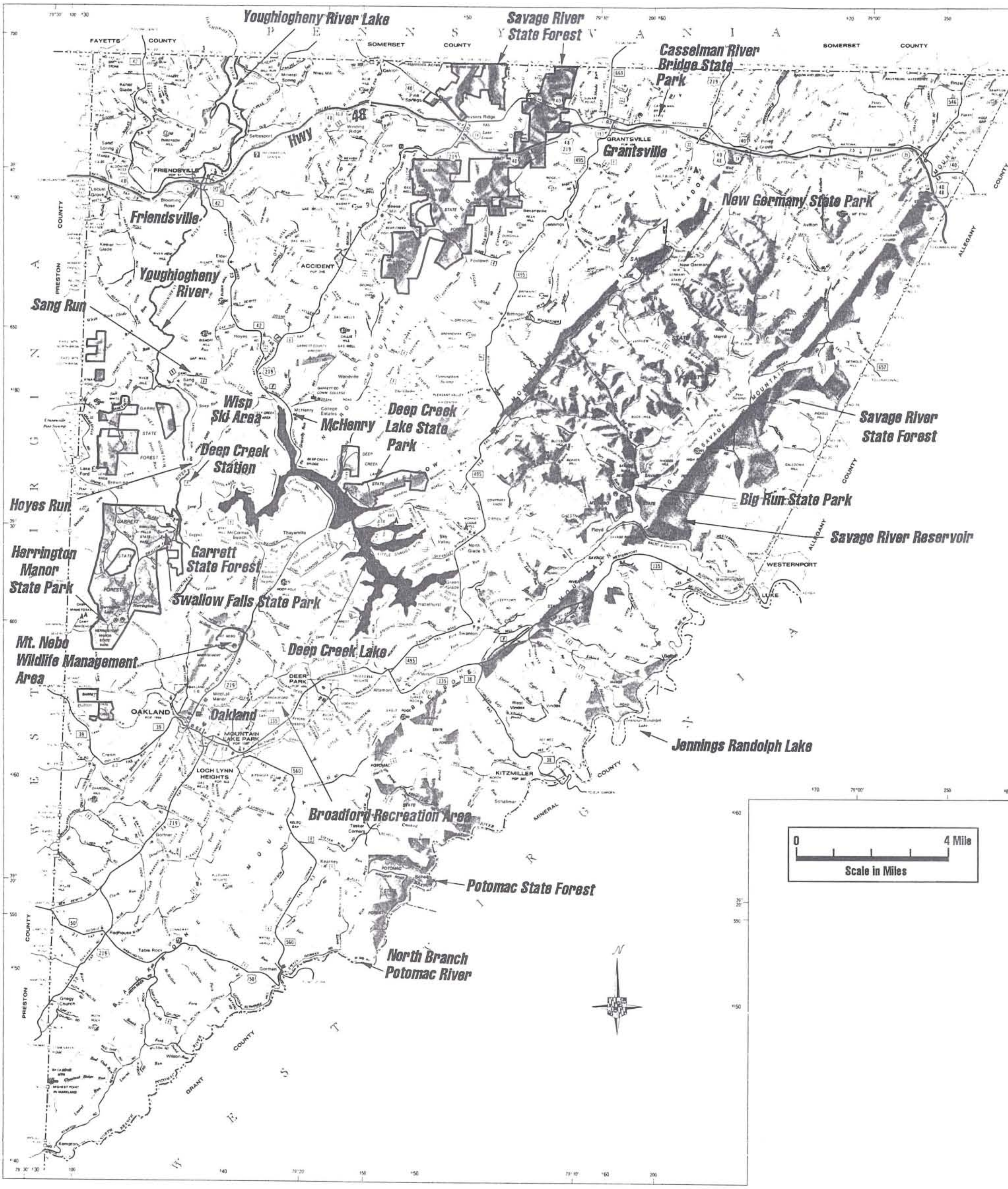
3.9.2 Regional Inventory

Garrett County provides significant recreational resources for the entire Mid-Atlantic Region. Visitors from Maryland, Pennsylvania, Washington D.C., New Jersey, Delaware, Virginia and West Virginia travel to the county to take advantage of its wide range of recreational opportunities. Federal, state, local and private interests provide developed and dispersed recreational opportunities throughout the County (Figure 3-67, Table 3-12).

3.9.2.1 Federal Resources

The federal government's share of recreation resources in Garrett County is relatively minor. Youghiogheny River Lake, which is managed by the U.S. Army Corps of Engineers (Corps), is formed by a dam located upstream of Confluence, Pennsylvania (U.S. Congress 1979). The 16-mile lake extends into Garrett County, reaching Friendsville when the reservoir is full. The project provides for flood control, low flow augmentation, and recreation. Daily water releases from the dam support trout fishing and boating on the river below Confluence. Recreational facilities include a boat launch, marina, visitor information center, picnic facilities, and campsites without hookups (personal communication, T. Kiddo, U.S. Army Corps of Engineers, Baltimore, Maryland, April 26, 1991). All or most of these developed facilities are located along the Pennsylvania portion of the reservoir.

Jennings Randolph Lake (also known as Bloomington Lake), located in southeastern Garrett County on the Maryland-West Virginia border, is also managed by the Corps. The approximately 1,000-acre lake extends 5 miles up the North Branch of the Potomac River from the dam. There are 2,700 undeveloped upland acres controlled by the Corps on the Maryland side of the reservoir. Railroad tracks parallel the reservoir shore and do not allow access to the lake from the Maryland side. The Corps hopes to eventually gain access across the tracks and establish lakeside recreation facilities. The West Virginia side of the reservoir has a boat ramp, camping facility, and picnic area. Undeveloped lands in both states offer nonstructured activities such as hiking and hunting (personal communication, T. Kiddo, U.S. Army Corps of Engineers, Baltimore, Maryland, April 26, 1991).



SOURCE: MDOT, 1989

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Figure 3-67
RECREATION RESOURCES IN
GARRETT COUNTY

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Table 3-12 Outdoor recreation resources in Garrett County

Facility Type	State	Federal	Other	Total
Park (acres)	3,199			3,199
Forest (acres)	67,776			67,776
Fish Management Area (acres)	113			113
Wildlife Management Area (acres)	1,763			1,763
Boating (acres)	474	654	352	1,480
Bicycling (miles)	867		123	990
Camping (sites)	245		808	1,053
Fishing (acres)	474	654	352	1,480
Fishing (shore miles)	31	15	7	53
Hiking (miles)	867		123	990
Hunting (acres)	73,771		1,290	75,061
Nature Trails (miles)	867		121	988
ORV Trails (miles)	867		121	988
Picnicking (# tables)	937	4	263	1,204

Source: 1979 Maryland Outdoor Recreation and Open Space Plan and July 1989 MDNR Acreage Report, as reported in Graefe et al., 1989.

3.9.2.2 State of Maryland

Garrett County contains 43 percent of all state-owned land in Maryland. State forests, parks and wildlife management areas make up 17 percent of the total land area of Garrett County, and offer a variety of year-round recreational opportunities. State lands comprise 100 percent of the public forest, and fish and wildlife management acreage in Garrett County (Table 3-12). These lands provide the majority of local opportunities for activities such as bicycling, fishing from shore, hiking, hunting, picnicking and riding off-road vehicles (ORVs).

Six state parks are located in Garrett County (Table 3-13). They range in size and use from the 4-acre, day-use oriented Casselman River Bridge State Park to the 1,775-acre Deep Creek Lake State Park, which has extensive facilities for overnight use. Recreational opportunities found in state parks in Garrett County involve both land- and water-based activities and are offered throughout the year. All six state parks offer day use facilities and four have overnight campsites. State parks reportedly account for 20 percent of the developed campsites in the county (Graefe et. al. 1989).

Water resources in the six state parks range from small streams to rivers and from ponds to large reservoirs. All offer the public access to the water to enjoy activities such as sightseeing, picnicking and fishing. Four of the parks have launching facilities for various types of boaters and four offer swimming areas. Land-based activities that take place at the parks include hiking, interpretive programs, interpretive centers, cross country skiing, and historic sightseeing (Deep Creek Lake/Garrett County Promotion Council [Promotion Council] 1990).

Three state forests lie within Garrett County. Savage River state forest is the largest in Garrett County. Of the 52,800 acres that make up the forest, 2,700 have been designated as Big Savage

Table 3-13 Maryland state park facilities located in Garrett County

Park	Acres	Number of Campsites	Picnic Units	Other Features
Deep Creek Lake	1,775	112	500 4 shelters	6 square mile lake, boat ramps and slips, 700' swimming beach, trails, cross-country skiing, hunting
New Germany	462	37	100	Boat launch, swimming, cross-country skiing
Swallow Falls	300	64 4 group	50	Trails, cross-country skiing 1 pavilion
Herrington Manor	300	0	shelters	53 acre lake, cross-country skiing, 20 cabins, trails, swimming beach, boat rentals
Big Run	300	30 unimproved 2 group	shelters	Historic structures
Casselman River Bridge	4	0	10	Historic bridge

Sources: Deep Creek Lake/Garrett County Promotion Council, 1990.
Garrett County Planning Commission, 1986.
Maryland Department of Natural Resources, undated-a.
Personal Communication, L. Baker, Maryland Department of Natural Resources, Swallow Falls/Herrington Manor State Parks, Oakland, Maryland, May 1, 1991; J. Rodgers, Maryland Department of Natural Resources, New Germany/Casselman River Bridge State Parks, Grantsville, Maryland, May 1, 1991.

Wildland (Maryland Department of Natural Resources, undated-a). The rest of the forest is managed for multiple use and acts as a watershed for the 525-acre Savage River Reservoir. Because the reservoir supplies local communities with drinking water, only canoes or boats with electric motors are allowed to use the reservoir's boat ramp. New Germany and Big Run State Parks are situated within the forest. The forest has hiking and horseback trails which connect unimproved campsites and three group camping sites.

The Potomac State Forest's 10,685 acres are used for watershed, wildlife and timber harvest purposes. Potomac State Forest does offer recreational opportunities such as hunting, hiking, primitive camping, horseback riding, and fishing. Garrett State Forest at 6,825 acres is the county's smallest. It contains pine plantations, wildlife, and opportunities for primitive camping, fishing, hunting, and cross country skiing. Swallow Falls and Herrington Manor State Parks are also located within this forest.

The Wildlife Division of the MDNR manages the 1,800-acre Mt. Nebo Wildlife Management Area, located northeast of Oakland. Recreational opportunities include hunting, fishing, viewing, wildlife, hiking, cross-country skiing, and bike riding. There are no established trails at Mt. Nebo, but there is a main access road and several abandoned logging roads that are used by recreationists. (personal communication, L. Johnson, MDNR, Mt. Nebo Wildlife Management Area, Oakland, Maryland, March 5, 1991.)

The MDNR owns property located on the Youghiogheny River that was purchased from the National Lands Trust (personal communication, K. Christianson, MDNR, Youghiogheny River Management Area, Oakland, Maryland, July 16, 1990). The property includes access to the river and a flat area for parking. A deed restriction prohibits commercial rafters from using the property to gain access to the river, but use by private boaters is permitted.

Five roadside picnic and rest areas are situated along major highways at various locations in Garrett County (Promotion Council 1990). These facilities are maintained by the Maryland Department of Transportation.

3.9.2.2 Local Government

Garrett County does not have a park department, but several of the communities in the county have small informal recreation facilities. The municipal park of most local significance is the Broadford Recreation Area. Broadford is located next to the town of Mountain Lake Park but is owned and managed by the nearby town of Oakland. A 125-acre park surrounds Broadford Lake and includes picnic pavilions and tables, boat docks, ball diamonds, concession stands, a 600-ft. swimming beach with bath house, and trails (Promotion Council 1990; personal communication, D. Reall, City of Oakland, Broadford Recreation Area Manager, Oakland, Maryland, April 26, 1991).

3.9.2.4 Private Sector

Garrett County has a number of commercial operations offering recreation opportunities. The largest number of private sector recreational opportunities are located near Deep Creek Lake and involve boating and camping facilities.

A fluctuating number of private whitewater outfitters take customers rafting on local rivers, particularly the upper Youghiogheny (see Section 3.9.4). Other warm-weather activities provided by the private sector include golf (two 18-hole courses), and camping (four private campgrounds). Maryland's only ski resort, the Wisp Ski Resort located near McHenry, is a popular winter attraction.

3.9.3 Deep Creek Lake

Deep Creek Lake is the "center of Garrett County's recreational attractions" (Promotion Council 1990). The 3,900-acre lake offers year round recreational opportunities, but is most popular during the summer months. People are drawn to Deep Creek Lake for a number of reasons and participate in water- or land-based recreation. Among the popular water-based activities are boating, fishing, swimming, waterskiing and sailing. Land-based opportunities include hiking, hunting, picnicking, photography, cross country-skiing, and snowmobiling.

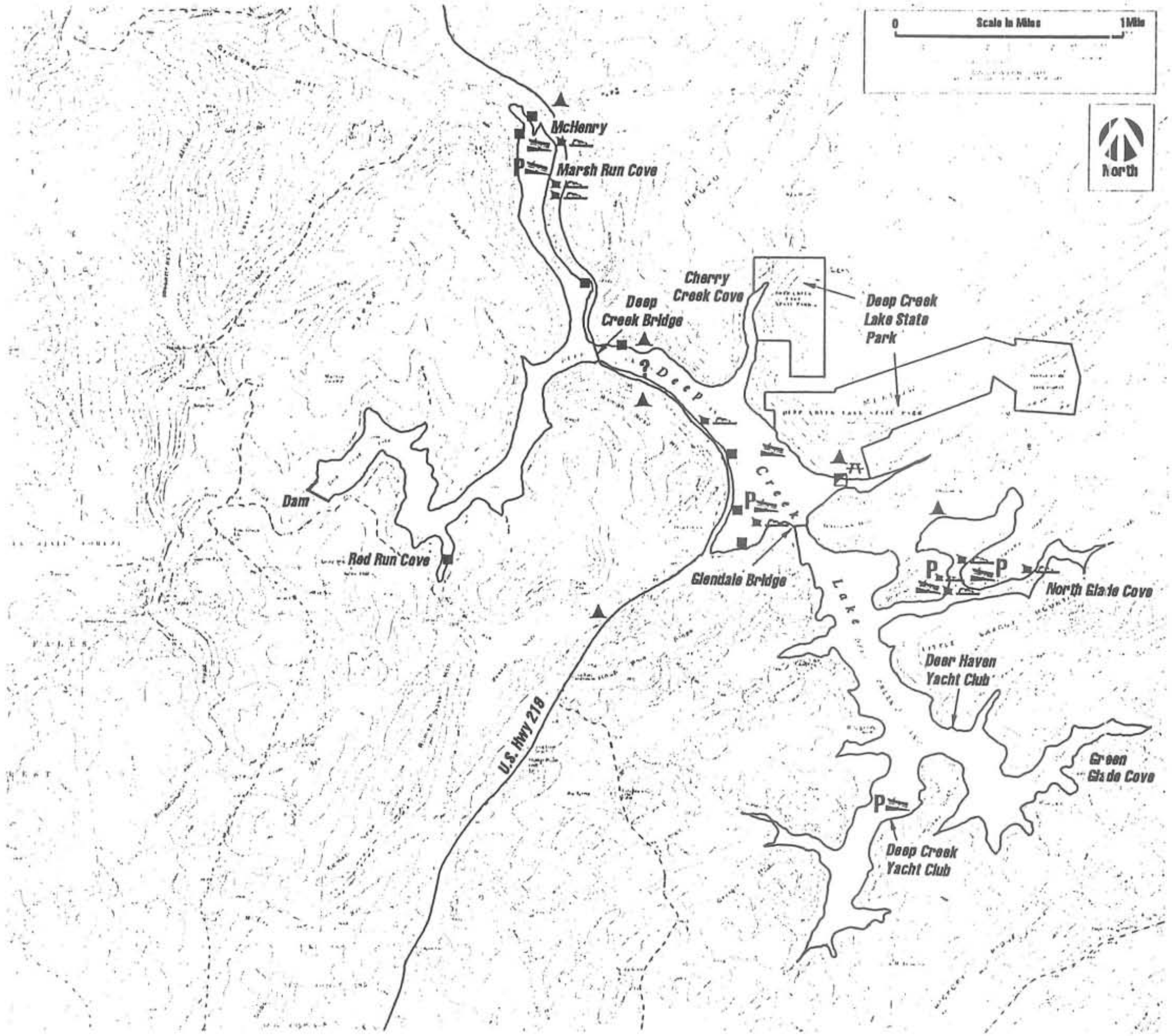
The following sections describe recreation facilities, activities, and use levels; and expected future conditions for lake recreation.

3.9.3.1 Developed Facilities

Recreational facilities at Deep Creek Lake have been developed by the State of Maryland and the private sector (Figure 3-68). The State provides public recreational facilities and access to the lake via Deep Creek State Park and an MDNR fishing access location. Private sector marinas and ramps also provide access to the lake. A number of businesses located on or near the lake provide services to boaters, anglers and other water users.

Deep Creek Lake State Park

Deep Creek Lake State Park is the single most significant recreation resource on the lake, and is the focus of lake use by the general public. Major developed facilities at the park include a day use area, boat launch facilities, a campground and a visitor contact station (Maryland Department of Natural Resources undated, 2-b). The day use area is located in a largely wooded setting along the north shore of the main body of the lake. It provides tables, fireplaces, four picnic shelters, a play area, a nearby ball field, and restrooms. Along the south edge of the day use



LEGEND

- P Boat Ramp (Private)
- Boat Ramp (Available to Public)
- Marina Facilities
- Beach (Private)
- Beach (Available to General Public)
- Campground
- Picnic Area
- ? Information Center

SOURCES: MDOT,1989; Garrett County Planning Commmission, 1986

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Figure 3-68
RESERVOIR RECREATION RESOURCES

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area is a swimming area which includes 700 lineal ft. of beach, a bathhouse/restroom building and a concession stand. North and east of the day use area is the camping area, which contains 112 improved sites, a dumping station, a play area and restroom facilities.

The boat launch is one of the most popular facilities at the park. To accommodate the numerous boat users launching from the park, 50 trailer parking stalls are located near the launch area. The launch ramp currently has two 15-ft. launch lanes. A limited number of slips are available to the public on the park's dock for overnight moorage.

MDNR Fishing Access

The MDNR administers a shoreline fishing access and parking site at the U.S. Highway 219 bridge across the lake near McHenry, known locally as the Deep Creek Bridge.

Private Facilities

A number of privately owned recreational facilities are located in the Deep Creek Lake area. Many of the facilities are adjacent to the lake and offer varying degrees of commercial lake access to the public. Private-sector operations that provide for recreation at Deep Creek Lake include public lodging facilities, marinas, yacht clubs and campgrounds.

Several waterfront lodging establishments have docks, boat ramps, and swimming areas that can be used by those staying at the facility as guests. Lakefront lodging facilities are located in several different areas of the lake, although most are concentrated along Marsh Run Cove from McHenry to the Deep Creek Bridge and in the Thayerville area on the main body of the lake.

Marinas provide a primary means of access to water activities for nonresident visitors to Deep Creek Lake. There are currently seven marina operations on the lake, including one operation with facilities at multiple locations (Appalachian Background, Inc. 1987; Promotion Council 1990). These marinas provide a varying mixture of boating facilities and services, including short- and long-term moorage, boat rentals, boat and equipment sales, fuel, boat repairs, and launching. Most of the marinas provide some, but not all, of these services or otherwise limit the services they provide. For example, most allow only moorage or boat purchase customers to use their ramps, some do not provide moorage, and some do not offer rentals. The number of marinas providing specific types of services is summarized below:

Type of Service	Number of Marinas
Moorage	5
Boat rentals	5
Sales	5
Fuel	6
Repairs	5
Boat ramps	5
Public launching	1

The combined boat rental and moorage capacities of these marina operations is not known.

Two yacht clubs are located on Deep Creek Lake. Both are private organizations comprised of sailboat users. The Deep Creek Lake Yacht Club in the Turkey Neck area is the largest organization, with 120 members, a large clubhouse facility, a boat ramp for members' use, and an extensive system of docks and mooring buoys (personal communication, W. Seilhamer, Deep Creek Lake Yacht Club, Swanton, Maryland, August 29, 1990). The Deer Haven Yacht Club in the nearby Thousand Acres section of the lake has about 50 member families and minimal permanent facilities (personal communication,

T. Redick, Deer Haven Yacht Club, Swanton, Maryland, August 24, 1990).

In addition to these commercial facilities, private sector recreational facilities on Deep Creek Lake include docks and small beach areas at the many private residences bordering the lake. While these facilities do not provide recreation for the general public, they are large in number. Some privately controlled docks are common docks built for the joint use of people living in a particular development. The majority of docks on the lake are individual docks belonging to property owners with waterfront property.

3.9.3.2 Recreational Activities and Use Patterns

Recreational use of Deep Creek Lake has grown in recent years. In response to local concerns over use pressures, space demands on the lake, and conflicts between user groups, the MDNR sponsored an extensive study of Deep Creek Lake recreation. A consulting firm, Urban Research and Development Corporation (URDC), conducted numerous surveys of lake users and local residents and businesses. The surveys were used to develop information on temporal and geographic use patterns, visitor origins, length of stay, frequency of visits, recreational experience, and satisfaction levels. URDC (1988) identified 19 summer and winter activities that take place in the Deep Creek Lake area. A description of some of the more popular activities follows.

Angling

Angling is an important recreational activity at Deep Creek Lake; unpublished MDNR recreational use data for 1987 (Graefe et al. 1989) indicate that approximately 140,000 fishing trips are taken annually. Of the total, more than 10% of the trips made are specifically for brown trout which are stocked on an annual basis in the lake. Other directed fisheries exist for largemouth and smallmouth bass, and walleye. In winter, ice fishing is popular and primarily directed at yellow perch. The contribution of each of these fisheries to the total amount of angling trips on Deep Creek Lake is unknown.

Shoreline Fishing

The most popular seasons for shoreline fishing are spring and summer. Anglers are about equally divided in fishing during the week and on weekends. The most popular times are in the early morning and early evening. Most shoreline anglers interviewed fished at the state park. Most of those not in the state park who were interviewed were fishing on Penelec's buffer strip directly in front of the building they lived in or were staying in. Shoreline anglers came from throughout the Mid-Atlantic region. Thirty percent had never fished at Deep Creek Lake before, while 40 percent had fished the lake more than 21 times. Almost half the shoreline anglers stayed in the area from three to seven days.

Boat Fishing

Boat fishing is most popular during the spring and summer, and peak use is on weekends, early evenings and early mornings. The most popular area is the main body of the lake on either side of the Glendale Bridge, although all arms of the lake are fished. Most boat fisherman stay relatively close to shore and like to fish near natural or man-made fish cover, such as snags, logs, docks, aquatic vegetation, and submerged rocks. Only 6 percent of boat anglers contacted in the survey were local residents, the rest coming from various Mid-Atlantic locations. Eighty-seven percent of the boat anglers surveyed reported that they fished "very often" and 83 percent regarded their experience as "very enjoyable," a figure consistent with the corresponding responses for other user groups.

Nonpower Boating

URDC's classification of nonpower boating includes canoeing, kayaking, rowboating and paddleboating. Nonpower boating is most popular during spring and summer on weekends. The highest concentration of nonpower boaters occurs in early to midmorning hours. These users tend to stay close to shore, away from power boaters. Nonpower boaters come to Deep Creek Lake from all over the Mid-Atlantic Region, typically stay three to seven days per visit, and have been to the lake before.

Power Boating

Spring and summer are the most popular seasons for power boating, and the weekend is the most popular part of the week. The boating season extends into mid-October until Autumn Glory weekend. Midmorning to late afternoon is the most popular time of day to use the lake. Power boating is concentrated in the main body of the lake between Deep Creek Bridge and the Glendale Bridge, and in Marsh Run Cove. Most powerboaters travel to Deep Creek Lake from various Mid-Atlantic locations. The majority of powerboaters (59 percent) have been to the lake 21 or more times.

Sailboating

Sailboating activity is most popular during the spring and summer, and peak use is on weekends. At Deep Creek Lake a lack of wind in the early morning and early evening results in most sailing activity occurring from midmorning to late afternoon. Sixty percent of all sailboaters interviewed were contacted south of the Glendale Bridge. This reflects the high activity contribution of the two yacht clubs, which are both located in the southern portion of the lake, and the fact that sailboats cannot safely pass under the Glendale Bridge. As with most other lake users, sailboaters tend to come from many different areas of the surrounding region. Two-thirds sail the lake regularly, having visited Deep Creek Lake over 21 times. Forty-one percent of the survey respondents planned to sail 25 or more days during the year.

Water Skiing

Water skiing is a late-spring through early-fall activity, with summer being the most popular season. Early morning and early evening weekend hours are the most popular times. Although most users skied in the main part of the lake between Deep Creek Bridge and the Glendale Bridge, skiers tend to stay in the calmer coves during the day. Waterskiers come from all over the Mid-Atlantic region, and over 60 percent have skied at Deep Creek Lake 21 times or more. Eighty-nine percent of the water skiers said they skied "often" or "very often".

Camping

The most popular time to camp is in the spring and summer, but there are campers at the state park from its opening in April through its closure in December. Weekends are the most popular part of the week to camp and campers travel to Deep Creek Lake from many places in the mid-Atlantic region. Over a third of the campers surveyed were camping near the lake for the first time. Twenty-one percent, on the other hand, had visited the area more than 21 times. More than half the campers interviewed stayed from three to seven days.

Hiking

Hiking is popular from spring through fall. As with most activities at Deep Creek Lake, it is most popular on weekends. The state park was the most popular place to hike among people interviewed. Hikers indicated that they come from many places, although one quarter were locals. Forty-four percent were visiting Deep Creek Lake for the first time and over half were staying in the area from three to seven days.

Picnicking

Picnicking is most popular on weekend afternoons during the pleasant weather of spring, summer and early fall. The state park is the most popular place to picnic at Deep Creek Lake. People from all over the Mid-Atlantic region participate in this activity. Over half of the interviewees had visited the lake area less than five times and almost half were picnicking at the lake as part of a day trip.

Swimming

Summer is the most popular time of year to swim at Deep Creek Lake. Peak use is on weekends from midmorning to mid-afternoon. The interviewers found areas of high swimming activity at Deep Creek Lake State Park and a lodging establishment with a large beach. Private docks were popular for swimming. As with other recreational users, swimmers came from a wide variety of places. Almost thirty percent were visiting the lake for the first time, while almost 40 percent had been to the lake more than 21 times. Over fifty percent stayed in the area from three to seven days.

Comprehensive data on use levels for all recreational activities at Deep Creek Lake are not available. This is primarily due to the diffuse nature of sources of recreational activity at the lake, and the fact that most of these sources are commercial or private facilities. However, reliable data for use levels at Deep Creek Lake State Park are available, and are summarized in Table 3-14 for the 1980-1988 period. These figures indicate that camping activity has remained rather stable during this period, while day use increased dramatically from 1980 to 1981 (presumably because of the opening of new facilities) and has remained relatively stable thereafter. Camping visits averaged approximately 26,700 per year over the 9 years. Day use visits in 1988 were about 140 percent above the 1980 level. Due to the change in day use, total state park visitation nearly doubled from 1980 to 1988. Prior to this

Table 3-14 Attendance at Deep Creek Lake State Park, 1980-1988.

Year	Overnight Camping	Day Use	Total
1980	25,683	39,823	65,506
1981	26,371	89,823	116,194
1982	28,104	76,509	104,613
1983	28,446	78,587	107,033
1984	26,865	90,689	117,514
1985	23,764	86,006	109,770
1986	27,238	90,749	117,987
1987	27,096	95,182	122,278
1988	27,083	95,273	122,356

Source: MDNR, 1990a.

period, state park visitation had decreased by 53 percent from 1970 through 1978 and had continued to decline until 1981 (Garrett County Planning Commission, 1986).

3.9.3.3 Projected Future Conditions

Existing patterns and trends in recreational use indicate that future conditions for water-based and land-based activities at Deep Creek Lake will likely continue to differ. Overall, existing use pressure for most passive types of land-based activities is low, and the buffer strip (intended for public access) is under utilized. Conversely, recreational use of Deep Creek Lake is much higher and the lake can be crowded on summer weekends. According to the URDC (1988) study, recreational use of the lake is relatively low except for summer weekends and holidays. During peak times on busy summer weekends, the lake can be quite crowded, particularly with boat oriented recreation. As a result of boating activities, there can be conflicts on the lake with other lake users.

Many of the people interviewed by URDC felt that there were times when there were too many people using the lake. URDC concluded that "continuation of this trend of heavy weekend and holiday use will soon result in a level of use which exceeds the optimum if present management policies are continued" (URDC 1988). Clearly recreational use at Deep Creek Lake is at times sufficiently intense to have made concerns about overuse and user conflicts a significant issue.

Although most of Garrett County has not experienced much population growth in recent years, the area near Deep Creek Lake is growing. There was a 43 percent increase in the number of residential unit permits taken out between 1985 and 1986 and a 69 percent increase between 1986 and 1987 (URDC 1988). The Deep Creek Lake area has become a very popular place to live, have second homes and vacation. According to URDC, with current zoning and 17,800 developable acres of land in the Deep Creek Lake watershed, between 26,000 and 39,000 people could be added to Deep Creek Lake's current population. URDC estimated the 1987 permanent and seasonal population of the area at 10,500 people. (The Garrett County Planning Commission (1986) had previously estimated the 1983 peak summer weekend population, including campers and other short-term visitors, at a minimum of 15,600 people). The increased population will result in additional pressure on recreational activities found near Deep Creek Lake (Table 3-15). URDC (1988) projected that local demand for a variety of key recreation activities in the area would increase by 30 percent from 1988 to 1993.

At the state level, the demand for activities which are possible at Deep Creek Lake is also expected to increase. In developing the most recent Statewide Comprehensive Outdoor Recreation Plan (SCORP), the MDNR found that the three most popular recreation activities for residents of Maryland were swimming at the beach, picnicking and swimming in an outdoor pool (Maryland Office of Planning 1989); the first two of these are major activities at Deep Creek Lake.

The SCORP found that "the demand for swimming seems to greatly exceed the supply; community facilities continue to remain relatively unavailable for swimming at the beach. There is an indication that people go out-of-state for this activity because opportunities to participate in their communities are lacking" (Maryland Office of Planning 1989). The study also mentioned that water-based activities like boating and swimming have been very popular over the past decade and should continue to be. The study's findings give a strong indication that the water-based recreation available at Deep Creek Lake will continue to be in demand by people throughout the state and by implication, throughout the region.

Table 3-15 Estimated recreation demand generated by the 1988 and 1993 population of the Deep Creek Lake watershed.

Activity	Occasions Demanded 1988	1993	Increase	Percent Change
Camping	30,543	39,879	9,336	30.6
Cross Country Skiing	292	381	89	30.6
Fishing	89,354	116,666	27,312	30.6
Hunting	42,230	55,138	12,908	30.6
Motorboating	77,432	101,100	23,468	30.6
Sailing	17,632	23,022	5,390	30.6
Swimming (Beach)	66,361	86,645	20,284	30.6
Waterskiing	40,007	52,236	12,232	30.6

Source: URDC, 1988.

Operations Effects

Hydroelectric generating operations that take advantage of water storage can affect reservoir-based recreation in several ways. As water stored in a reservoir is released, the elevation of the water surface is lowered unless inflow to the reservoir replaces the released water. Shoreline recreational facilities such as boat launching ramps, docks, and mooring buoys can be adversely affected by reservoir drawdowns. Depending on specific conditions, decreases in lake level can leave these types of shoreline recreational facilities dewatered, or inoperable because the water depth is too shallow to permit use of the facilities by boats. Because the water storage capacity of Deep Creek Lake is drawn down seasonally to provide power generation, these types of recreation facility effects have been identified as operational concerns.

Reservoir drawdowns reduce the surface area of a lake, potentially decreasing the amount of usable water available for recreation. Reduced water levels during drawdowns can expose features such as tree stumps and rocks or create shoal areas, thereby presenting hazards to navigation. Drawdowns also expose lake bottom area to the public eye and can detract from the aesthetics of an area. All of these concerns are present at Deep Creek Lake. The surface area and navigation hazards issues are addressed below.

Several methods were used to evaluate the impact of operations on lake recreation. Existing shoreline recreational facilities were identified primarily from MDNR records on permitted facilities. This information was supplemented with a field inventory of recreational facilities conducted during summer 1990 by Penelec. The survey investigated the number and type of docks in use, levels of dock development by area of the lake, boat ramp characteristics, and water depths near shoreline facilities.

Bathymetric data and information on lake elevation/surface area/volume relationships are key to the investigation of these lake recreation issues. These types of data were obtained from Penelec files, published maps indicating water depths by location in Deep Creek Lake, and MDNR automated mapping files. Drawdown effects on lake surface area were calculated and mapped from these sources.

Drawdown effects on shoreline recreational facilities were evaluated from review of field data and known operating characteristics, and through consultation with knowledgeable local sources. Staff from the MDNR Lake Management Office were contacted for information on the operating ranges of shoreline facilities and the location and depth of navigation hazards. Similar meetings were held with key facility operators, lake user groups, and other local interests. Representatives of seven different user groups identified as key contacts were interviewed to obtain their input on a number of operational and recreational issues. The specific organizations interviewed were:

- Deep Creek Lake Business Association,
- Deep Creek Yacht Club,
- Deep Creek Water Sports Club,
- Garrett County Board of Realtors,
- Deep Creek Lake/Garrett County Promotion Council
- Deep Creek Property Owners Association, and
  Garrett County Chapter, Bass Anglers Sportsmen's Society (BASS).

Inventory of Boat Ramps and Docks

There currently are nine operations providing boat ramps located around Deep Creek Lake, with a total of 12 launch lanes. Boat ramps are operated by Deep Creek Lake State Park, six marinas (including one with multiple ramps), one of the yacht clubs, and a lakeside cottage establishment. All but the two-lane ramp at the state park are privately owned. Three ramps are located near McHenry in Marsh Run Cove. The ramp at Deep Creek Lake State Park is the most centrally located on the lake. The small ramp at the

Deep Creek Yacht Club is the most southerly and is only available to club members to launch their sailboats. Two ramps are located near Highway 219 on the main body of the lake, and there are two in the Harvey's Cove area. There are no ramps west of Marsh Run Cove.

A permit system for the development and maintenance of docks on the lake has been instituted. Several types of dock permits are issued. The vast majority of docks and dock permits are noncommercial and intended for the use of nearby residences. One "Type A" dock is allowed per individual eligible property owner, requiring a 100 feet minimum of usable Penelec frontage on newly subdivided properties. Properties subdivided prior to 1983 are generally grandfathered in. Type A or "individual" dock permits allow a single dock structure and up to three boat slips per dock. This is the most numerous dock and permit for single private residences along the lakeshore. New community docks are permitted 1-slip per 50 feet of Penelec frontage. Commercial facilities are regulated through a special permit governing such uses as launch ramp access sites, rental slips, rental boats, gas, repairs, and other commercial activities.

As of 1990, there were 1,671 individual docks, 1,456 slips at common docks, and 321 mooring buoys permitted on the lake. The actual number of private slips installed at Type A and common docks was 2,547. Commercial lakeside facilities in 1990 included 658 commercial slips at 190 docks, plus 22 commercial buoys. The commercial dock permits were for the most part divided among 18 commercial installations that included commercial marinas, yacht clubs, and lakeside resorts and restaurants.

Unlike boat launching ramps, boat docks are dispersed throughout Deep Creek Lake. Most of the shoreline at Deep Creek Lake above the buffer strip is privately owned and many landowners have docks on the lake. Penelec's 1990 dock inventory identified a total of 1,612 docks that ring the lake. These docks are fairly evenly distributed geographically, although several areas have a larger number of docks than others. Areas with the highest concentrations of docks include Green Glade Cove, Marsh Run Cove, and the shoreline adjacent to and north of Thayerville. The sections of the lake with the least dock development include the state park and the shoreline near Turkey Neck, Holy Cross, Shingle Camp, and Cherry Creek.

All docks at Deep Creek Lake are able to be removed from the lake, rather than being permanently anchored to the lake bottom. The vast majority of docks (i.e., 1,464) are mounted on pontoons in sections that are small enough to be moved. As the lake level rises or drops, the floating sections are moved in or out from the shoreline to provide the necessary depth. A number of older docks are mounted on tracks that run from the edge of the buffer zone into the lake. As the lake level drops, the dock structure is moved on the tracks farther along the lake bottom. (New docks of this type are not currently permitted, and the old docks will be phased out as they need to be replaced.)

Boat Ramp Operating Ranges

Boat launching ramps tend to be the recreational facilities most affected by reservoir drawdowns. Boat ramps are fixed facilities, and so cannot be moved or adjusted to accommodate changing reservoir levels. Because ramps also are relatively expensive to construct, they generally are not built to operate over a wide range of elevations. Ramps are typically built at slopes of from 8 to 12 percent, requiring up to 12 ft. of ramp length for every ft. of elevation difference. To be operable over a drawdown range of 10 ft. of elevation, for example, a ramp would need to extend roughly 100 to 150 ft. horizontally from shore to provide a water depth of 2 to 3 ft. at the toe of the ramp (a depth sufficient for most trailered boats).

In addition to these factors, boat ramps tend to be critical facilities in providing boat access to lakes. Unless boats can be moored year-round at a dock or are small enough to be pulled up on shore, they require ramps in order to be able to use a body of water. Boats as well as docks are required to be removed from the water during the winter. Deep Creek Lake boaters (except those with hand-carried boats), regardless of whether they are permanent or seasonal residents, marina moorage users, or short-term visitors, are therefore dependent upon boat ramps for access to the lake. Short-term visitors require two ramp operations on every trip to the lake, while seasonal visitors and residents typically launch their boats in the spring or early summer and take their boats off the lake in late summer or early fall.

Penelec initially contacted operators of key boat ramps at Deep Creek Lake to determine the operating ranges or toe elevations of their respective ramps. However, several operators contacted could not provide these data. They were able to report useful information regarding the typical timing of their operations relative to the annual drawdown, but generally did not have as-built drawings or other precise elevation data available.

In the absence of such specific elevation information from all ramp operators, characterization and assessment of ramp operating ranges had to be based on limited field observations, file data, and anecdotal evidence. In the fall 1989, an unusually low lake drawdown was scheduled in order to restore a section of eroded shoreline along Cherry Creek Cove. The drawdown was such that many of the lake's boat ramps were rendered unusable. Visual observations were made at several of the ramps on October 12, 1989, when the lake was at elevation 2,452.9 ft. The 1989 maintenance drawdown was discussed with several operators and ramp users at that time or during later interviews. MDNR files at Deep Creek Lake State Park also provided some information on the physical characteristics of the state park ramp. The following observations concerning ramp operating ranges are based on these various sources:

The state park boat ramp was reported to be inoperable on October 12, 1989; water still covered the toe of the ramp, but apparently not at sufficient depth to permit launching. Use of this ramp at low water is hampered by the configuration of the lake bottom, which actually slopes upward somewhat just beyond the toe of the ramp (personal communication, J. Wilburn, MDNR, Forest, Park, and Wildlife Service, Deep Creek Lake State Park, Swanton, Maryland, July 12, 1990).

- At a lake level of 2,460 ft., the water depth at the end of the dock alongside the state park ramp is 11 ft. The dock extends into the lake approximately the same distance as the ramp, indicating the toe of the ramp is at about elevation 2,449 ft. Extrapolation of contours on MDNR site plans for the boat launch area also suggests a ramp toe elevation in the vicinity of 2,450 ft. This would indicate a water depth at this ramp of 3 to 4 ft. on October 12, 1989, and that elevation 2,453 is probably the limit of operation for the state park ramp.

- The ramp at Quality Marine/Blue Anchor Boat Rentals in McHenry was inoperable at the 2,453-ft. lake level on October 12, 1989, although boats and docks were still in the water at this facility. This is the only privately-operated ramp on the lake where the general public can launch boats on payment of a ramp fee. Based on visual observation, the lower operating limit for this ramp was estimated at about elevation 2,455 ft. However, the operator reported a water depth of about 7 ft. at the toe of the ramp when the lake is high (suggesting a toe elevation of 2,453 to 2,455 ft.), and indicated that launching becomes difficult when the lake reaches about 5 ft. below full pool, or 2,457 ft. (personal communication, J. Sherman, Blue Anchor Boat Rentals, McHenry, Maryland, March 21, 1991). At this level, trailers need to be hauled across soft lake bottom below the toe of the ramp. Launching at low water here is also hampered by sediment accumulation on the lake bottom associated with a culvert discharging storm runoff to the lake.

- The ramp at Bill's Marine service area in North Glade Cove (one of three ramps operated by Bill's Marine) appeared to be totally dewatered at elevation 2,453 ft., although the lake bottom below the ramp may have been firm enough to permit continued use.

- The ramp at the Patterson Boat Company is located at the tip of Harvey's Peninsula in a section of the lake where the lake bottom is steep. Because the toe of the ramp is located in deep water, the lake level has never been so low that boats could not be launched. In fact, during the unusually low 1989 maintenance drawdown, other ramp operators who were not able to use their ramps because of the low lake elevation used the Patterson ramp to remove boats for the winter (personal communication, T. Raynovich, Swanton, Maryland, March 21, 1991). Based on this report and historical lake elevation data, the Patterson ramp appears to be operable to at least elevation 2451.6 ft.

- S&H Marina, which is located in McHenry, reports having problems launching boats from its ramp when the lake falls 8 ft. below the maximum lake elevation of 2462, or to elevation 2,454 ft. (personal communication, R. Trydahl, S&H Marina, McHenry, Maryland, March 21, 1991). During the 1989 maintenance drawdown launching problems began around the third week of September, when the lake was at about elevation 2,455 ft.

- The toe of the ramp at the Deep Creek Yacht Club was several ft. above the water at elevation 2,453 ft. By visual estimate, the toe of the ramp is at elevation 2,455 ft. and the minimum operable level is about 2,458 ft.

Based on these observations, boat ramps at Deep Creek Lake begin to reach the end of their operating ranges at elevation 2,458 ft., or 4 ft. below full pool. The reservoir level at which all ramps are inoperable is unknown but is somewhere below elevation 2,452 ft., or more than 10 ft. below full pool. However, at this elevation it appears that the only operable ramp is at a private facility that only serves marina customers, including lake residents who store their boats at this facility over the winter. In some respects elevation 2,453 ft. could be considered the critical elevation for ramp use, as the state park ramp has the largest launching capacity and is open to all users. However, the marinas provide important boat launching and dock installation and removal service to many permanent and seasonal residents, and would not be physically or institutionally able to rely on the state park ramp in order to accommodate these activities late in the season. Consequently, it appears that lake drawdown begins to have a significant effect on the utility of local boat ramps at elevations below about 2,455 or 2,456 ft. At this lake level only the state park ramp is available to the general public and two or more ramps that are exclusively for private use are also inoperable.

The historic operating rule or rule curve for Deep Creek Lake indicates a relatively steady decline from elevation 2,461 ft. at the end of May to a minimum of elevation 2,451 ft. by the end of November. Actual operations often do not precisely follow the rule curve, particularly with respect to the depth and rate of the annual drawdown. Penelec has attempted to keep the lake near full through late August or Labor Day, and generally has not drawn the lake down as far as 2,451 ft. in winter.

In recent years the lake has typically remained at about elevation 2,460 ft. or above through mid-July, then has decreased at the rate of about 1.5 ft. per month through October or November. Based on historic lake elevation data, the lake level typically falls below elevation 2,458 ft. at the end of August and below elevation 2,456 ft. by early October (Table 3-16). The average October 31

Table 3-16 Deep Creek Lake elevations by date, 1970-1990[1].

Date	Minimum Elevation	Maximum Elevation	Average Elevation
May 15	2,458.3	2,461.3	2,459.8
May 31	2,457.7	2,460.9	2,459.9
June 15	2,457.7	2,461.1	2,459.8
June 30	2,457.8	2,461.3	2.459.7
July 15	2,457.2	2,462.2	2,459.7
July 31	2,456.7	2,460.1	2,458.9
August 15	2,456.5	2,460.1	2,458.3
August 31	2,455.9	2,459.0	2,457.8
September 15	2,455.3	2,458.7	2,456.8
September 30	2,453.5	2,458.5	2,456.0
October 15[1]	2,452.2	2.457.5	2,455.5
October 30[1]	2,451.6	2.458.0	2,455.2

[1] October data for 1970-1989 only.

Source: Penelec.

elevation, based on the 1970-1990 period, is 2,455 ft. Based on average conditions over the past 21 years, reservoir drawdown typically begins to have a significant effect on boat ramp utility between October 1 and October 15 of each year.

The frequency at which various lake elevations occur is also a significant measure of drawdown effects on ramp utility. During the 1970-1990 period, Deep Creek Lake has consistently been at elevation 2,456 ft. or above from late May through mid-August (Table 3-17). Using 2,456 ft. as the key indicator of boat ramp utility, project operation has not significantly impaired ramp use over this portion of the season. The lake level fell below 2,456 ft. by August 31 in 1 year out of 21 (2,455.9 ft. in 1973), and by September 30 was below this level in 10 years out of 21.

September 30 can therefore be considered the effective end of the boating season for a large portion of Deep Creek Lake boat users. However, a significant amount of boating access capacity remains usable at a lake elevation of 2,454 ft. At this lake level the state park boat ramp is still usable for the general public, as are ramps at marinas that provide rental boats and boat retrieval and storage service for local residents. All of the major segments of the boating public can still be served at elevation 2,454 ft., a lake level that has been maintained 90 percent of the time through October 15 and 80 percent of the time through October 31 since 1970. The years in which the lake level fell below 2,454 ft. in October represent years of unusually dry fall weather conditions or abnormal drawdowns for maintenance purposes.

Dock Operating Ranges

Because all docks at Deep Creek Lake are mobile, they can be moved as lake levels change. Generally, docks are placed in the lake no earlier than mid-March and are removed for the winter from Labor Day on. A small number of full time residents leave their docks in the lake as late as November. To prevent ice damage, docks must be removed by December 31st of each year.

Table 3-17 Frequency of Deep Creek Lake level at or above given elevation, 1970-1990.

Date	Percentage of Years by Elevation (Feet)			
	2,458	2,456	2,454	2,452
May 31	95	100	100	100
Jun 30	95	100	100	100
Jul 31	81	100	100	100
Aug 31	67	95	100	100
Sept 15	14	76	100	100
Sept 30	14	52	95	100
Oct 15	5	38	90	100
Oct 31	5	35	80	95

With no fixed operating range, assessment of the effects of reservoir drawdown on docks must be subjective and based largely on the perceptions of users as to the degree of inconvenience associated with periodically relocating docks. This issue was a key discussion item at meetings with user group representatives. In general, Penelec's interpretation of the user response is that the lake drawdown is an accepted fact of life on the lake and that personal schedules are adapted to changing lake levels. Dock owners typically move docks up to six to ten times over the course of a season. Moving a dock is a relatively simple procedure commonly requiring about 30 minutes. There no doubt is considerable variation among dock owners in the frequency of moving docks during the season, so some dock owners probably experience inconvenience at times from shallow water. Some of those interviewed acknowledged that the drawdown generally parallels weather and vacation patterns, usually occurring after seasonal residents and short-term visitors have left the lake, so that recreational activities are minimally disrupted. In fact, the drawdown is appreciated to some extent by many dock owners because it gives them an opportunity to make dock repairs.

The annual lake drawdown can have the effect of accelerating the rate at which docks and boats must be removed from the lake at the end of the season. Most residents of lakeside dwellings rely on marine services to remove both docks and boats. Being familiar with the drawdown pattern, the services typically recommend removal by mid- to late October, which leaves adequate time to accommodate the service demand. If the annual drawdown begins unusually early in the season or at an unusually high rate, some residents could be caught unprepared and the services might have difficulty in pulling all of the docks and boats within a compressed time period.

Penelec's overall assessment from the dock inventory information and the user group interviews is that the primary concern relative to docks is with abnormal drawdowns that occur earlier or more quickly than users expect. These abnormal drawdowns are generally associated with maintenance needs, such as the fall 1989 shoreline restoration at Cherry Creek Cove. The 1989 drawdown was a fresh and frequent topic during the 1990 interviews. It was mentioned by many group representatives contacted, and many recalled complaints from members of their respective groups.

The primary problem with abnormal drawdowns appears to be with notification and awareness. Penelec sent over 3,300 notices to property owners several months in advance of the 1989 drawdown, and distributed notices to local media outlets as well. Nevertheless, some residents were not aware of the drawdown and suffered stranded boats or damage to equipment. Some degree of missed communication is probably inevitable in a situation where the vast majority of residents are absentee owners with permanent residences in other locations, and where there is a high rate of turnover in property.

Visitation patterns also contribute to facility problems associated with lake drawdown. Some seasonal residents stay at Deep Creek Lake for much of the recreation season, but many make periodic short-term visits to the lake. If the interval between these visits is several weeks or longer, the lake level can recede by 2 ft. or more during this period. Therefore, it is possible for seasonal residents to return to the lake after several weeks' absence to find beached or damaged boats moored at docks.

Consequently, Penelec concludes that lakeside residents' greatest concern over project operations is with abnormally rapid lake drawdown. If the rate of drawdown is sufficiently gradual, there will be ample time for docks and boats to be moved and residents are not likely to be surprised by the drawdown.

<u>Lake Surface Area</u>

Reservoir drawdown gradually reduces the amount of lake surface area and increases the amount of exposed shoreline. As the drawdown continues, certain sections of the lake are more affected than others. Shorelines adjacent to deep water are affected less by drawdowns than shallow sections of the lake. (Section 3.3 discusses the visual characteristics of the drawdown in various areas of the lake.)

In general, the ends of the shallowest coves are most affected by drawdown. Noticeable portions of some coves and shallow shoreline areas of the lake become dewatered at drawdowns of 5 to 7 ft., and the submerged areas adjacent to them are frequently too shallow to navigate. Figure 3-69 illustrates how the drawdown would reduce the surface area in one of the lake's shallower coves, Green Glade Cove at the southeast end of the lake. The lake shoreline location is shown for elevation 2,457 ft. and the minimum rule curve elevation of 2,451 ft. At elevation 2,457 ft., a band of exposed shoreline ranging from 0 to about 300 ft. is created. The upper 1,900 ft. (1/3 mile) of the cove are dewatered at the minimum rule curve elevation, and the band of exposed shoreline along the side of the cove ranges up to about 900 ft. and averages 200 to 300 ft. Other relatively shallow areas of the lake that are most reduced in area by normal drawdowns are listed as follows (Maryland Department of Natural Resources undated c; personal communication, P. Durham, Maryland Department of Natural Resources Deep Creek Lake Manager, Swanton, Maryland, October 12, 1989):

- both ends of Marsh Run Cove (McHenry Cove)
- north end of Cherry Creek Cove
- State Park Cove (Meadow Run Cove)
- East shore of main lake between Narrows Hill and Beckman's Peninsula
- Harvey's Cove
- ends of North Glade Cove
- end of Poland Run Cove
- head of lake at Deep Creek inlet
- ends of Pawn Run Cove
- Thayerville Cove on west shore of main lake
- end of Red Run Cove
- small bay at Brushy Hollow

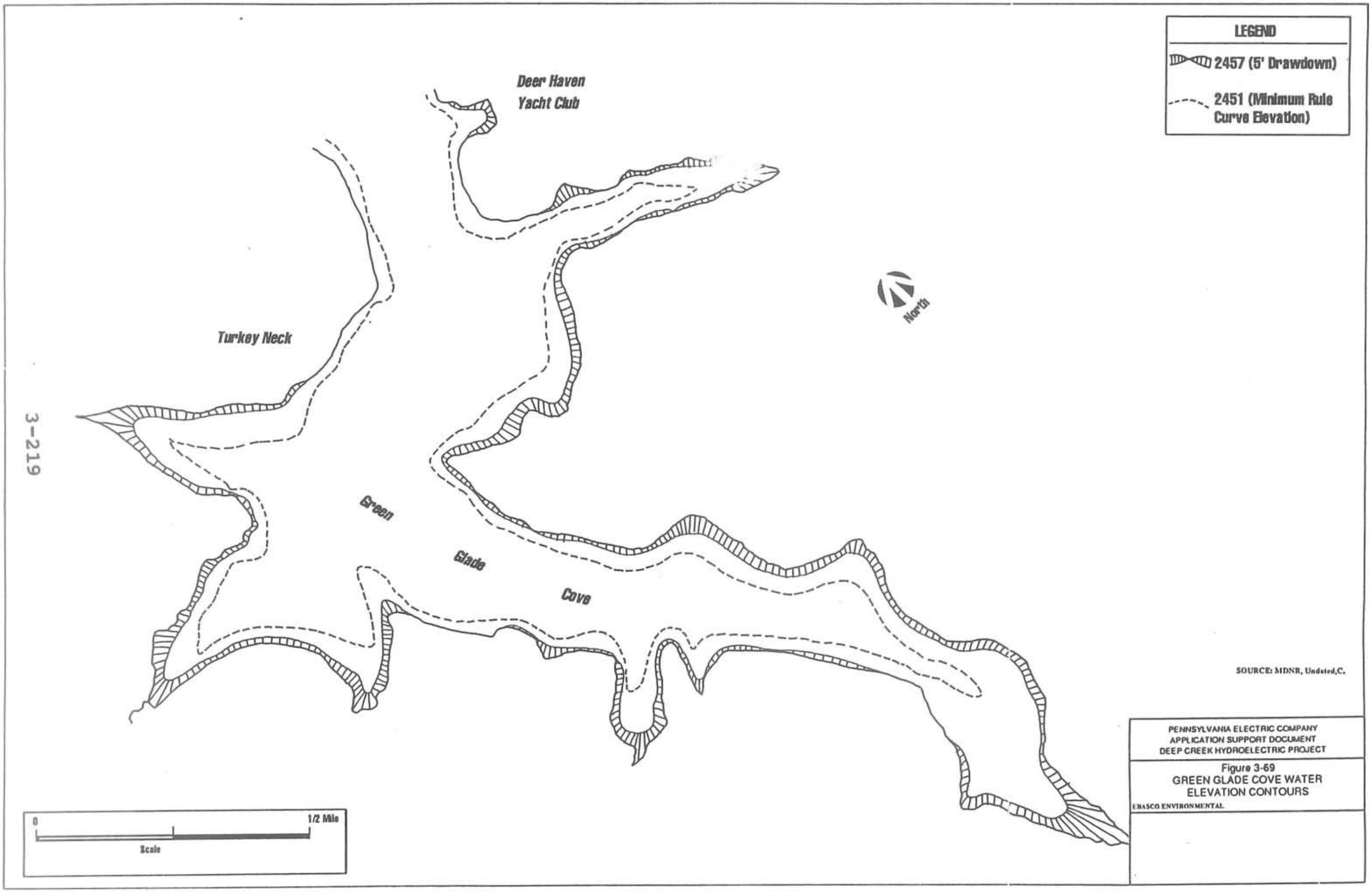

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Figure 3-69
GREEN GLADE COVE WATER ELEVATION CONTOURS

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While there are significant shallow areas of Deep Creek Lake that are exposed during a normal drawdown, much of the lake has a more steeply sloping bottom and is less affected by drawdown. If Figure 3-69 were expanded to cover the entire lake, it would have to be at a very large scale to be able to show much distinction between the 2,457-ft. and the 2,451-ft. contours over most of the lake. Because these lake bottom elevation contours are so closely spaced along most of the lake shoreline, they have not been mapped and the lake surface area at the various elevations within the drawdown range has not been measured. However, additional discussion of the drawdown and exposed shoreline is provided in Section 3.3.

Table 3-18 indicates the surface area of the lake in acres at different lake elevations. At the lake's maximum elevation of 2462 ft., the lake has a surface area of 3,900 acres. As the drawdown reduces the lake elevation, the amount of surface area is reduced at a variable rate. At elevation 2,457 ft., the surface area has been reduced to about 3,535 acres, a reduction of approximately 9 percent from the surface area at the 2,462 elevation. At the minimum rule curve elevation of 2,451 ft., the lake's surface area is reduced to approximately 3,100 acres, which is approximately 22 percent less than the maximum surface area.

The significance of these decreases in lake surface area is subject to interpretation and subjective judgment. During Penelec's contacts with lake users and other local interests, responses to specific questions did not indicate that reduction in lake area was a significant concern. While use pressure and crowding on Deep Creek Lake have been much publicized and debated, it is generally acknowledged that heavy use is limited to weekends and holidays during the peak summer recreation season. Except in unusually dry years, this season has already passed, by the time that drawdown has begun to significantly affect the area available for water recreation. The 3,000-plus acres of lake remaining through a typical September and early October should be more than adequate to

Table 3-18 Deep Creek Lake surface area by reservoir elevation.

Elevation (ft. msl)	Surface Area (acres)[1/]	Percent Reduction from Full-Pool Area
2,462	3,900	--
2,461	3,719	4.6
2,460	3,696	5.2
2,459	3,661	6.1
2,458	3,604	7.6
2,457	3,535	9.4
2,456	3,467	11.1
2,455	3,397	12.9
2,454	3,328	14.7
2,453	3,248	16.7
2,452	3,179	18.5
2,451	3,099	20.5
2,450	3,030	22.3

[1/] Calculation to determine surface area at each elevation based upon trapezoidal model relating volume, area, and elevation.

accommodate the reduced water recreation demands at this time of year.

The most significant possible effect of the surface area reduction potentially could involve fishing on the reservoir. A number of the shallow coves listed above are restricted areas where no-wake zones have been created, primarily to benefit anglers. Dewatering these coves during drawdown would presumably eliminate some of the preferred fall fishing opportunities. However, published information on fishing at Deep Creek Lake identifies some of these same areas (e.g., McHenry Point, Harvey's Cove, Poland Run and Hoop Pole Cove) as good for fishing all year or specifically good during the fall (Maryland Department of Natural Resources undated, c). Further, many of the other preferred locations identified have deeper water and are not affected by drawdown. Consequently, it does not appear that drawdown substantially diminishes fishing opportunity in the fall.

Navigation Hazards

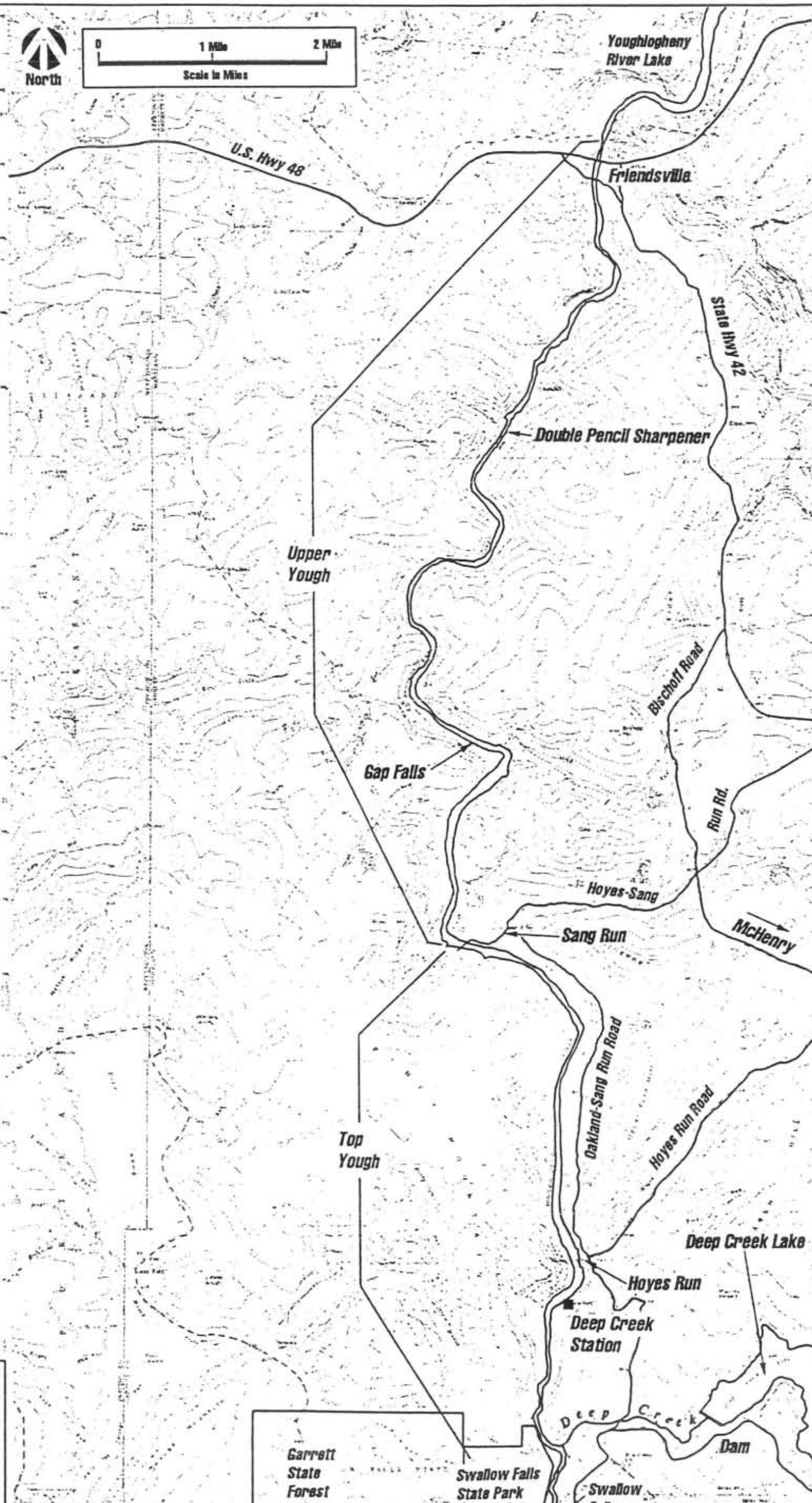
As the lake level is lowered during drawdown, some areas of the lake become quite shallow (in addition to those described above). Submerged tree stumps in some parts of the lake are brought closer to the surface as the lake level drops. Shoals, stumps and other submerged obstacles can be hazardous to navigation, particularly for boaters who are unfamiliar with local conditions or who are accustomed to higher water levels.

The location, extent and significance of these potential navigation hazards were investigated through contacts with local groups. The substance of these discussions indicated that physical hazards were not a significant problem at either normal or low water levels. The group representatives participating in these meetings typically mentioned the same specific locations, primarily Green Glade Cove, Red Run, Stump Point, Glen Acres and Hazelhurst. The prevailing opinion appeared to be that shallow coves, stumps and other potentially hazardous areas are generally well known to users and well marked with buoys.

Most of the discussions of navigation hazards focused on non-physical hazards or on physical factors unrelated to project operation. The representative of one user group noted that sedimentation from runoff was filling in the lake bottom in some areas and creating shoals that affected boating. Another group pointed out that some mooring buoys are anchored 60 to 80 ft. offshore, creating a hazard for people using the lake at night. (Current MDNR regulations generally permit the placement of mooring bouys to a distance of 100 feet from shore, unless otherwise specified by special permit.) Overall, a common opinion was that the most significant navigation hazards occurred as the result of unsafe activity by other lake users rather than from the effects of project operations.

3.9.4 Youghiogheny River

As mentioned previously in this section, the Youghiogheny River is an exceptional whitewater recreation resource. The river draws a wide variety of people from the Mid-Atlantic region. Users inexperienced with rivers take advantage of the many rafting outfitters who take customers down the river. More experienced users run the river in their own watercraft. While whitewater boating is probably the most well-known activity, the Youghiogheny River is also popular for fishing and supports several land-based activities within the river corridor. The following sections characterize the various activities and users on the Youghiogheny River within the study area. Key features within the downstream recreation study area are indicated in Figure 3-70.



SOURCE: MDOT, 1989
MDNR, 1987; USGS, 1974, 1981

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Figure 3-70
DOWNSTREAM RECREATIONAL RESOURCES

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3.9.4.1 Whitewater Boating

Three distinct sections of the Youghiogheny are used by boaters, beginning at Swallow Falls upstream of Deep Creek. The first section, known to whitewater boaters as the "Top Yough," is generally considered to be the 6.4 miles of river from Swallow Falls to Sang Run. Some boaters travel only the first 2.7 miles to Hoyes Run, as the lower section to Sang Run is all flatwater (Grove, et. al. 1987). The first 2 miles of the Top Yough run are steady whitewater rated as Class IV and V on the six-class international scale of river difficulty (on which Class VI is considered nearly impossible to navigate).

The key section of the Youghiogheny with respect to the Deep Creek Project is the 9.2 miles from Sang Run to Friendsville, which is commonly termed the "Upper Yough" (Grove, et. al. 1987; Gedekoh 1988). This reach is one of the most exceptional whitewater runs in the United States. Boaters put in at one of four informal access points at or just upstream of the Sang Run bridge, about 5 miles west of McHenry (Graefe et. al. 1989). Three locations in Friendsville serve as take-out points. The initial 1.8 miles of river below Sang Run are relatively calm, as are the last 2.7 miles into Friendsville. The middle 4.6 miles, however, is continuous whitewater that contains 20 named rapids rated as Class IV and V. Upper Yough floats are day trips generally taking from 3 to 6 hours, although expert kayakers can run this section in much less time.

The Lower Youghiogheny in Pennsylvania is the third whitewater section of the river. This run begins at Confluence, downstream of Youghiogheny River Lake, and continues through Ohiopyle State Park. The "Lower Yough" is the easiest of the three runs, rated as Class III+, but is the most popular (Gedekoh 1988). In fact, the Lower Yough is the most heavily used run in the nation, receiving approximately 100,000 whitewater visits in a typical year (General Accounting Office 1986).

The Deep Creek Project affects Youghiogheny River flows from Hoyes Run to Friendsville. The primary whitewater section of the Top Yough is located above the project discharge at Hoyes Run, while flows on the Lower Yough in Pennsylvania are influenced by releases from the Corps of Engineers' Youghiogheny River Dam. Consequently, all of the following material on whitewater boating (as well as other downstream recreational uses) pertains only to the Upper Yough.

River Regulations

The State of Maryland designated the entire Youghiogheny River within the state as one of the first components of the Maryland Rivers Program in 1971, and in 1975 amended the state rivers law to designate the 20-mile segment from Millers Run (3 miles north of Oakland) to Friendsville as a state wild river (Heritage Conservation and Recreation Service 1978). Land use regulations to protect the river corridor were initially adopted in 1975, and were revised in 1978 (General Accounting Office 1986). Since 1984, the MDNR has been assisting the Youghiogheny Scenic and Wild River Local Advisory Board in developing a Youghiogheny River management plan. The local board is a citizen advisory group comprised of riparian landowners, county residents and a representative of local government, all appointed by the Maryland Scenic and Wild River Review Board. Additional regulations addressing whitewater boating use by outfitters were adopted in 1989 (Graefe et. al. 1989). These regulations limited outfitters to a combined total of 72 customers per day, and a maximum of 12 customers per day for any one company. The capacity limits have subsequently been revised. Currently, one company is allocated eight rafts per day (24 customers) on a two hour release. For releases of three hours or more, or where there is sufficient natural flow (1.9 feet on Sang Run gauge), the allocation is increased by 50 percent (i.e., 12 rafts).

Outfitter Boating

Whitewater boating on the Upper Yough via outfitter trips is a relatively new activity. According to MDNR records, 1980 was the first year of outfitter rafting on the Upper Yough (Graefe et. al. 1989). By 1988, the number of outfitters using the Upper Yough grew from 2 to 10. (Two additional companies are permitted to make one run per season [personal communication, K. Christensen, Maryland Department of Natural Resources, Youghiogheny River Management Area, Oakland, Maryland, October 13, 1989]). Although the MDNR regulations limit any company to a maximum of 8 or 12 rafts per day (depending on flow), trading of allocated slots among the companies is permitted. Consequently, outfitter boating use is dominated by four to six companies that specialize to varying degrees in Upper Yough trips.

Whitewater customers on the Upper Yough are all transported in inflatable rafts. Due to the complex and highly technical nature of the rapids on the Upper Yough, the outfitters operate smaller rafts than are typical on other rivers (personal communication, P. Coleman, Precision Rafting, Friendsville, Maryland, July 13, 1990). Upper Yough trips are made in four-person rafts carrying one guide and up to three passengers per raft. All of the outfitters operate single-day trips on the Upper Yough. Some combine day trips on the Upper Yough and the Cheat River or another nearby stream into a weekend package.

Private Boating

Much of the whitewater boating use on the Upper Yough is by private individuals. Private boaters use rafts, hardshell kayaks, inflatable kayaks (called "duckies") and canoes. (Virtually all canoes used on the Upper Yough are decked rather than open.) Based on field observations from late summer and early fall 1988, Graefe et. al. (1989) estimated that private boaters account for approximately 46 percent of annual whitewater use. This figure includes estimated use shares of 10 percent for private rafts, 33 percent for kayaks, and 3 percent for duckies and canoes. There are no limits on the number of private boaters allowed to run the Upper Yough.

As indicated above, kayakers comprised one-third of the whitewater boaters on the Upper Yough in 1988 (Graefe et. al. 1989). Because kayaks generally carry only one person, kayaks accounted for 60 percent of all boats observed in 1988. The Upper Yough is a very popular and challenging river for kayakers and they are drawn from throughout the Mid-Atlantic region. There are numerous kayak clubs in the region, and club members often organize group outings. Kayak interests have also organized an annual race on the Upper Yough that was first run in 1981.

Use Level and Distribution

Whitewater boating on the Upper Yough has increased dramatically in recent years. Use was minimal in 1980, when there were no outfitters and MDNR field observations operating on the Upper Yough. MDNR data on outfitter use of the Upper Yough from 1981 through 1989, based on reports from the outfitters, are presented in Table 3-19. The reported number of annual customers increased from 46 in 1981 to 3,186 in 1988. While Table 3-19 indicates a decrease in use after 1988, these figures are only partial totals reflecting MDNR field observations. Subsequent outfitter reports for aggregate customer use in 1989 and 1990 (which do not show the monthly distribution) totaled 3,325 customers for 1989 and 3,519 for 1990. After a large initial increase from 1981 to 1983, use held relatively steady through 1985. Dramatic annual increases then occurred again in 1986, 1987, and 1988. The annual average over the entire period, including the higher outfitter reports for 1989 and 1990 was approximately 1,600 customers. The average for 1986 through 1990 was over 2,700 customers, while the 1988-1990

TABLE 3-19 Outfitter Rafting Use on the Upper Youghiogheny River, 1981-1990

	NUMBER OF CUSTOMERS										
	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Total
1981	--	--	--	13	9	10	14	11	--	--	46
1982	--	--	7	24	38	63	51	41	11	--	224
1983	--	--	22	40	111	184	176	80	39	--	652
1984	--	--	57	134	159	103	130	41	17	--	641
1985	--	3	73	212	84	147	65	39	40	--	663
1986	--	8	148	358	235	175	252	167	--	--	1,343
1987	--	2	191	524	559	438	324	202	71	--	2,311
1988	--	9	358	753	558	396	481	512	117	2	3,186
1989[1/]	25	22	81	32	160	412	512	330	150	--	1,724
1990[1,2/]	--	10	190	370	450	470					
Total 1981-1989	25	44	937	2,090	1,913	1,928	2,005	1,423	445	2	10,790
Annual Average[3/]	3	5	104	232	213	214	223	158	49		1,190
Percent of Total	0.3	0.4	8.7	19.3	17.8	17.8	18.6	13.2	4.1	0	100

[1/] 1989 and 1990 figures are based on MDNR field observations rather than outfitter reports, and understate actual use. Outfitters reported 3,325 total customers in 1989 and 3,519 in 1990.

[2/] 1990 figures after July were not inclduded in the source.

[3/] Annual average including higher outfitter reports for 1989 and 1990 (see footnote 1) would be 1,591 customers.

Source: MDNR 1990b.

average of over 3,300 may be more representative of the current typical annual use level.

The recent Penn State study of the Upper Yough (Graefe et. al. 1989) reported outfitter customer numbers that were considerably higher than shown in Table 3-19. The Penn State team reported an outfitter customer total of 4,225 for 1988, or 1,039 more customers than the MDNR files. The discrepancy with MDNR files is possibly due to the fact that the figures reported to the Penn State team actually reflected total people, including both customers and guides, while the MDNR figures are just for customers.) Based on a series of ratios among the various types of users developed from field observations, the Penn State team expanded the 1988 customer figure to a total use level of 10,002 people for 1988. This total was distributed by user type as follows:

Outfitter customers	4,225
Outfitter guides	1,538
Private rafters	638
Other private boaters (primarily kayakers)	3,601
Total People	10,002

The Penn State team found from their field observations in 1988 that the total number of boats on a given day during the sample time (August 15 to October 14) ranged up to 117, with as many as 191 people per day observed (Graefe et. al. 1989). The average number of boats in 1988 was 49 and the average number of people was 90 per day.

The outfitter customer data presented in Table 3-19 also illustrate the monthly distribution of rafting use within the year. Over the 9 years covered, no outfitter use occurred in December and January and minimal use was reported for February, March, and November. Customer numbers were very evenly distributed across the four months of May through August, which collectively accounted for 73.5 percent of all outfitter use. September was also a relatively high-use month. Similar customer numbers developed by the Penn State team for 1985 through 1988 are shown graphically in Figure 3-71. This graph clearly depicts use rising rapidly to a peak in May and remaining relatively high through September. However, it also indicates that the monthly pattern can vary considerably from year to year, probably due to varying hydrologic and weather conditions. At current levels of use, the number of boaters is well below limits specified by MDNR regulations on most days (Graefe et. al., 1989).

The monthly distribution of use for private boaters has not been tracked as well as outfitter use. However, because private rafters can be expected to have generally the same flow preferences as outfitters, private rafting should follow the seasonal pattern shown in Table 3-19 and Figure 3-71. The Penn State researchers observed proportionately lower kayak, duckie, and canoe use from April through early August 1989 compared to mid-August through mid-October 1988. This may indicate that activity on the Upper Yough by these types of users is concentrated later in the season. If so, this would be consistent with outfitter observations that private boaters tend to paddle rivers that are closer to their homes (primarily the Potomac for Washington D.C. - area residents and the Lower Yough for boaters from the Pittsburgh area) when those rivers have suitable flows, and come to the Upper Yough primarily for the dependable late-season flows (personal communication, P. Coleman, Precision Rafting, Friendsville, Maryland, July 13, 1990). Limited spot checks of river use by the MDNR river manager also suggest a late-season peak for private boating. The highest number of private boaters observed in 1989 occurred in September, while partial data for 1990 indicated use in July was three times the May level (Maryland Department of Natural Resources 1990b).

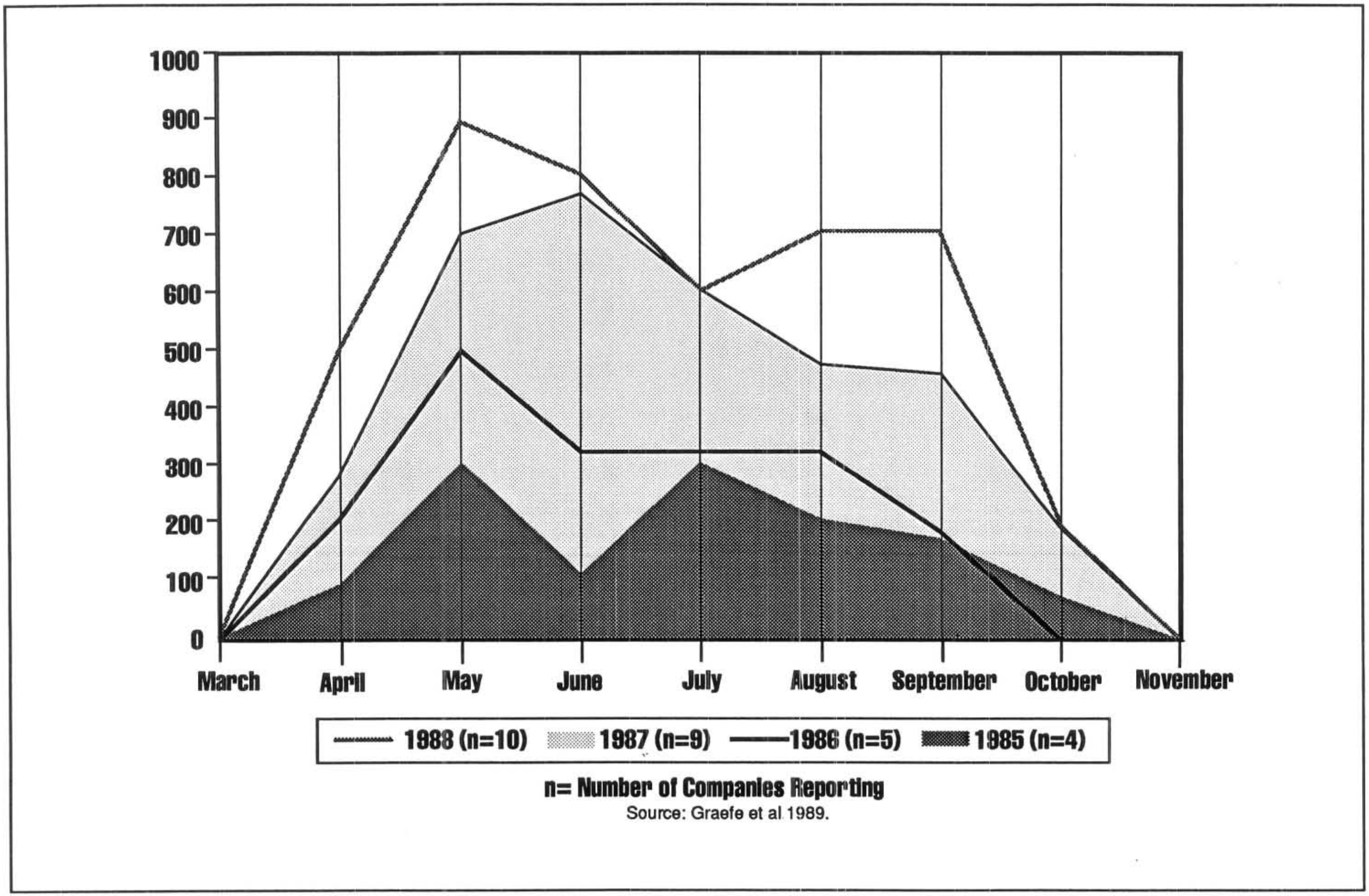


Figure 3-71. Number of outfitter customers reported by month.

Economic Impact

Whitewater boaters have a substantial impact on the economy of the State of Maryland and Garrett County. As mentioned previously, the vast majority of whitewater boaters using the Upper Yough are not residents of Garrett County. In fact, 89 percent of the kayakers and 93 percent of the rafters surveyed during 1988 were from outside of Maryland (Graefe et. al. 1989). All of the commercial outfitters running the Upper Yough are located in the general region. Three Maryland companies are all based in Garrett County (Friendsville). Four outfitters are located in West Virginia and five are based in Pennsylvania at either Ohiopyle or Confluence. Based on figures provided by all outfitters the three Garrett County outfitters accounted for 42 percent of the rafting customers during the survey period.

Whitewater boating contributes to the local economy through both the expenditures of outfitter companies and their customers. Outfitters pay local taxes, hire local labor and buy food supplies and services locally. The Penn State team estimated that all rafting companies combined spent nearly $193,000 in Maryland, including $177,500 within Garrett County in 1988 (Graefe et. al. 1989).

The money spent in Garrett County by rafting customers and noncommercial boaters was even more significant. Rafters surveyed by the Penn State team in 1988 reported an average expenditure per trip, including raft and guide services, of nearly $264 per person (Graefe et. al. 1989). The corresponding figure for kayakers was over $146 per person per trip. Overall, total expenditures in Maryland from raft and guide services in 1988 were approximately $544,000. Rafter and kayaker expenses other than fees paid to outfitters were even greater. Nonfee dollars were spent on items such as lodging, food and beverage purchases, restaurants, supplies, night clubs, souvenirs, and auto expenses. These whitewater boater expenditures in 1988, were estimated at nearly $1,004,000 within Maryland, including over $798,000 on nonfee items in Garrett County.

The total direct and indirect economic impact in Maryland from out-of-state whitewater boaters in 1988 was estimated at nearly $1,443,000 (Graefe et. al. 1989). The total impact in Garrett County from nonlocal boaters was estimated at over $1,227,000. These figures include the multiplier effect from recirculation of the direct boater expenditures within the state or local economy, but exclude expenditures for raft and guide service. As indicated previously, approximately 90 percent of the whitewater boaters surveyed came to Garrett County primarily to boat the Upper Yough. Therefore, virtually all of the total direct and indirect figures cited above represent net new income to Maryland and Garrett County that would not have occurred without the Upper Yough whitewater resource.

Operations Effects on Whitewater Boating

The generation of power at Deep Creek station generally has a direct positive impact on whitewater boating on the upper Youghiogheny River. Releases from the lake often allow whitewater boating to be conducted during times of the year when the natural flow is too low for whitewater boating. On the other hand, during high flow conditions such as occur in the spring, generation releases can make the river hazardous to navigate.

Input from the whitewater boating community indicated that river users understand and acknowledge the value of the project in supporting whitewater boating. However, boating interests suggested that the Deep Creek Project could be operated to further enhance boating use, without sacrificing the primary purpose of the project or harming other resource values.

Whitewater users also identified a number of component issues involving specific aspects of project operations and their effects on boating. These included insufficient flows for boating during certain times of year, the duration of flow on days when the project operates, the inconvenient timing of some releases and the uncertain scheduling of releases.

Several informational sources were used to evaluate the relationships between power generation and whitewater recreational use of the Youghiogheny River. This examination relied primarily upon the study commissioned by the MDNR to assess the carrying capacity of the Youghiogheny River and conducted by a team of researchers from Penn State University (Graefe et. al. 1989). Many personal contacts were made with authoritative local sources on the river, including interviews with whitewater outfitters and MDNR resource management staff. Information defining the issues and addressing some of their technical aspects was submitted by whitewater user groups. Finally, much of the analysis depended on examination of detailed hydrologic data and generation records.

Hydrologic Background

Whitewater boating is highly dependent upon streamflow patterns. Due to the Deep Creek Project releases into the Youghiogheny River, both natural and regulated flow patterns affect whitewater boating on the Upper Yough.

The drainage area of the Youghiogheny River above Oakland is 134 square miles (U.S. Geological Survey [USGS] 1991). The average discharge of the river at the Oakland gage (No. 03075500) for water years 1961 through 1990 was 311 cubic ft. per second (cfs). The maximum flow recorded during this period was 8,570 cfs on November 5, 1985, while the minimum was 3 cfs on September 18, 1964. Annual peak flows typically reached about 3,700 cfs during this period. Annual minimum flows ranged from 3 to 32 cfs, with these minimum flows typically occurring in September. By month, mean daily flows were highest for March, at 631 cfs, and lowest for September, at 84 cfs. Natural flows of 50 to 70 cfs or less are typical for late summer in this reach.

Corresponding data for the Youghiogheny River gage at Friendsville reflect the influence of a larger drainage area (295 square miles) and water storage releases from the Deep Creek Project. Average discharge over 30 water years from 1961 through 1990 was 645 cfs (U.S. Geological Survey [USGS] 1991). The maximum and minimum flows during the period of record were 10,000 cfs and 8 cfs, respectively. Mean daily flows during this period were approximately 1,221 cfs for March, the highest-flow month of the year. The lowest-flow month was September, with a mean daily flow of 244 cfs.

The overall distribution of flows throughout the year at Friendsville and Oakland is similar. In both cases mean daily flows are highest in March and lowest in September. Also, flows at both locations exceed the corresponding mean annual flow for the months of December through May and are less than mean annual flow for June through November. However, there are some subtle differences in distribution by month between Friendsville and Oakland. Based on the respective mean daily flows as a proportion of mean annual flow, Youghiogheny River flows at Friendsville are relatively higher than at Oakland from July through October, and lower from November through March; the respective proportions are equal for May and June. This pattern is largely due to the annual pattern of storage and release of water from Deep Creek Lake.

The Deep Creek Project has two turbines that each have a flow capacity of approximately 320 cfs, for a total plant capacity of approximately 640 cfs. The plant is operated as a peaking resource, with generation scheduled to provide power at times of maximum customer demand for electricity on the integrated GPU system. On a weekly basis, this results in plant operations concentrated to coincide with the demand peaks that generally occur on weekdays between 8 a.m. and 8 p.m. In addition to demand patterns, however, the generating pattern is dependent upon inflow to Deep Creek Lake and the amount of stored water available in the lake. Based on hydrologic data for 1970 through 1989, average monthly net inflow (including evaporation) to the lake peaks in March at about 232 cfs, and decreases steadily to an annual minimum monthly average of about 17 cfs for September. Inflow then increases again from October through March (Table 3-20).

Total generating hours at Deep Creek have been highest from December through April, averaging nearly 150 hours each month. Generation from June through September has ranged from 105 to 125 average hours per month (Table 3-20).

The operating history of the Deep Creek Project over the 1981-1990 period is summarized in Table 3-21. Over this 10-year period, the plant operated on an average of 70 percent of all days from April through October. Virtually all days of operation during the whitewater boating season involved two-turbine releases. By month over the entire year, two-turbine operations ranged from an average of about 14 days in February to over 23 days in September. One-turbine operations were relatively common in winter, occurring on 20 percent of days in January through March, but were rare in the rest of the year.

Boating Dependence on Releases

Whitewater boaters judge the navigability of the Upper Yough run at any given time based on river level readings, measured in ft., taken from simple river gages at the Sang Run bridge and in Friendsville. Outfitters and experienced private boaters know the minimum and maximum readings at which the river can be safely run. They also know the Sang Run level corresponding to a given Friendsville reading and vice versa. These relationships are summarized for key river levels in Table 3-22 along with the

Table 3-20 Deep Creek Project average monthly inflow, generating hours and outflow, 1970 - 1989.[1/]

Month	Average Net Inflow (cfs)	Average Generating Hours	Average Outflow (cfs)
January	127	150.5	130
February	187	128.2	122
March	232	161.2	140
April	197	166.6	148
May	128	136.1	117
June	86	105.4	94
July	55	122.2	106
August	20	115.1	99
September	17	124.7	111
October	37	89.6	76
November	104	90.7	81
December	164	141.2	122
Annual	112	127.7	112

[1/] Based on historical plant releases.

Table 3-21 Deep Creek Project operation mode, by month, 1981-1990.

	Average Number of Days		
Month	No Operation	One-Turbine Operation	Two-Turbine Operation
January	6.6	7.6	16.8
February	6.7	6.9	14.4
March	9.8	3.5	17.7
April	9.4	0.8	19.8
May	9.9	0	21.1
June	8.3	0	21.7
July	8.5	0	22.5
August	7.9	0.1	23.0
September	5.8	0.9	23.3
October	11.9	1.9	17.2
November	14.1	0.2	15.7
December	8.6	0	22.4
April-October	61.7	3.7	148.6
Annual Total	107.5	21.9	235.6

Source: Penelec.

Table 3-22 Selected Youghiogheny River levels and flows at Friendsville and Sang Run.

Friendsville Gage River Level (ft)	Friendsville Gage Flow (cfs)	Sang Run Gage River Level (ft)
2.95	410	1.6
3.05	490	1.7
3.15	570	1.8
3.25	660	1.9
3.35	770	2.0
3.45	890	2.1
3.55	1010	2.2
3.65	1140	2.3
3.75	1280	2.4
3.85	1430	2.5

Source: Graefe et. al., 1989.

approximate river flows in cfs that correspond to the respective river levels at Friendsville. Because there is minimal inflow between Sang Run and Friendsville during much of the boating season, the flows at Sang Run for a given level will be nearly equivalent to the cited flows at Friendsville.

According to the Penn State study, the minimum river level required for kayakers and commercial rafters to run the Upper Yough is 1.9 ft. on the Sang Run gage. (This represents the reading on the "new" Sang Run gage, installed after bridge repairs in mid-1988. Water levels on the "old" gage read approximately 0.1 ft. higher.) This river level corresponds to a flow of approximately 660 cfs at Friendsville. Flows in this range are typical of a two-turbine Deep Creek release at times of low natural flow. Flows below 660 cfs make parts of the river very difficult for both rafters and kayakers to navigate, as more rocks are exposed and the channels between rocks are narrowed. The Penn State team concluded that kayaking would still be physically possible, but not desirable, at river levels below 1.9 ft. (660 cfs), while rafting would not be feasible because rafts are larger and less maneuverable (Graefe, et.al. 1989). However, at least one published whitewater guidebook reports the minimum runnable level of the Upper Yough as 1.6 ft. (about 410 cfs) on the Sang Run gage (Grove et. al. 1987). Contacts by Penelec with six outfitters resulted in reported minimum runnable levels ranging from 1.8 to 2.0 ft.

The range of Upper Yough flows that are considered ideal for boating is apparently rather small. Grove et. al. (1987) reported that many kayakers and canoeists will not use the river at Sang Run gage levels above 2.1 ft. (890 cfs), and that levels above 2.4 ft. (1,280 cfs) are essentially navigable only by experts. Grove et. al. (1987) indicated that 2.5 ft. on the Sang Run gage (1,430 cfs) was the maximum runnable water level, while Graefe et. al. (1989) appeared to place the upper limit for outfitter trips at 2.7 to 2.8 ft. However, in interviews with Penelec, three different outfitters identified 2.9, 3.0 and 3.2 ft. as the maximum runnable level.

Natural flows compatible with whitewater boating are limited for most of the whitewater boating season. The percentage of time that natural flows are within various flow ranges during the boating season is presented in Table 3-23. These data were derived from flow frequency curves for Friendsville that were estimated by the Penn State researchers. Natural flows in April were estimated to exceed 660 cfs approximately 50 percent of the time. However, if 1,280 cfs is (conservatively) considered the maximum navigable flow, they also exceeded this upper limit nearly 20 percent of the time. Consequently, in April the river typically has enough natural flow to support whitewater boating 33 percent of the time. The availability of boatable natural flows decreases significantly after April.

Due to this natural flow pattern, the ability of whitewater boaters to navigate the Upper Yough is usually dependent upon releases from the Deep Creek Project. This is particularly the case for June through September period, when natural flows are rarely sufficient for boating. Historical data on daily peak flows at Friendsville, reflecting the influence of Deep Creek releases and natural flows, indicate the availability of boatable flows on the Upper Yough (Table 3-24). (Average daily flows are not a suitable measure in this case because Deep Creek releases with sufficient water for boating often occur over only a few hours of the day.) Table 3-24 is based on flows only for the 1981-1990 period, which is a short period of record by normal standards for hydrologic analysis. However, this period best represents current operating practice for the Deep Creek Project and also corresponds to the period of significant whitewater boating use on the Upper Yough.

While Tables 3-24 and 3-25 present slightly different measures, the data in these tables can be compared to provide a general

Table 3-23 Percent of time natural flows are within defined range of the Sang Run gage, by month[1/].

Range of Sang Run (new) Gage	Daily Avg River Flow (cfs)	Apr	May	June	July	Aug	Sept
--	0-340	18	47	70	80	85	92
<1.9	340-660	29	26	12	10	2	3
1.9-2.2	660-1010	25	13	8	5	7	3
2.2-2.4	1010-1280	8	2	2	2	3	1
>2.4	>1280	20	12	8	3	3	1

[1/] The period of record on which these data were based was not indicated in the source.

Source: Graefe et. al., 1989.

Table 3-24 Percent of time daily peak Youghiogheny River flows at Friendsville were within defined range, by month, 1981-1990[1/].

Month	Daily Peak River Flow (cfs)				
	0-660	661-1010	1011-1280	1281-1800	1801+
April	23	24	22	20	11
May	26	29	19	15	11
June	25	44	13	9	9
July	29	43	13	9	6
August	40	55	2	2	1
September	43	52	5	1	0
October	53	38	4	3	2

1/ Derived from USGS records of average daily flows and Penelec records of Deep Creek generation.

Table 3-25 Average number of days per month with boatable flows[1/], natural flows vs. total flows.

Month	Natural Flows[2/]	Total Flows (Natural Flows Plus Releases[3/]	Net Change From Releases
April	10	14	4
May	5	15	10
June	3	17	14
July	2	17	15
August	3	18	15
September	1	17	16
October	3	13	10
Total	27	111	84

1/ Defined as flows between 660 cfs and 1,280 cfs, corresponding to Sang Run gauge levels of 1.9 and 2.4 feet, respectively.

2/ Based on Table 3-23.

3/ Based on Table 3-24.

indication of how Deep Creek releases alter the distribution of boatable flows. From Table 3-23, natural flows are too low for boating most of the time during the boating season; specific figures by month range from 47 percent for April to 95 percent for September. In contrast, from 1981 through 1990 the frequency at which daily peak flows (including Deep Creek releases) at Friendsville were insufficient for boating ranged from 23 percent for April to 53 percent for October.

The dependence of Upper Yough whitewater boating on Deep Creek Project releases can best be presented in terms of the number of days per month with boatable flows available. The percentage data on natural flows and total flows (natural flows plus releases) from Table 3-23 and 3-24 have been converted into days per month in Table 3-25. If 1,280 cfs (2.4 ft. on the San Run gage) is considered the maximum boatable flow for most users, natural Upper Yough flows would provide an average of 27 days per year with boatable flows (i.e., flows between 660 and 1280 cfs). On average, 15 of these days (56 percent) would be concentrated in April and May, while only 8 would occur in the summer months of June, July, and August. In contrast, actual Upper Yough flows were within the boatable range for a portion of the day on an annual average of 111 days from 1981 through 1990, or more than 4 times the average number of boatable days with only natural flows. The number of boatable days was also well distributed by month, ranging from 13 to 18 days per month. Some of these daily peak flows from Deep Creek releases may have occurred at times of day when they could not actually be used by boaters, but the project operation is clearly responsible for greatly expanded boating opportunities on the Upper Yough.

The actual amount of whitewater boating use that is possible with natural flows or that is dependent upon releases is not precisely identifiable from the historical data on boating use. The records of whitewater customers submitted by outfitters aggregate use by month, and do not identify use occurring on days of hydropower releases versus non-release days, so it is not possible to associate customer records with generation records. One measure of the dependence on releases is subjective assessment by the outfitters. One operator estimates that up to 90 percent of the trips he operates on the Upper Yough depend at least partially on releases from Deep Creek Lake (personal communication, P. Coleman, Precision Rafting, Friendsville, Maryland, July 13, 1990).

Alternatively, the percentage distribution of total boating use occurring in various months can be used to roughly approximate the proportion of use that is dependent upon releases. From Table 3-23 it can be assumed that virtually all use from June through October would not occur without hydro releases, while use in April and May is much more likely to be possible with natural flows. The distribution of outfitter use from 1981 through 1989 indicates that the June-October period typically accounts for 71.5 percent of total annual use. Consequently, roughly 70 percent of total Upper Yough boating use is likely to be dependent upon Deep Creek releases. Based on the total use estimate from the Penn State study of 10,000 annual users (Graefe, et. al. 1989), this would correspond to 7,000 annual trips dependent on releases. Because this estimate was based on use levels and user characteristics from what appears to be a peak-use year (1988), the average or "normal" number of trips might be less.

<u>Duration of Releases</u>

A second specific issue related to the effects of project operations on downstream recreation involves the duration of daily power generation releases. Particularly during summer low-flow conditions, generation at the Deep Creek plant often occurs for only 2 hours during a given day. Input from whitewater boating interests indicated that releases of this length can provide insufficient water for boaters to clear some of the lower rapids in the Upper Yough run. This resulted in user congestion and an increased risk of rafts pinning on rocks.

The Penn State study of the recreational capacity of the river includes a detailed assessment of river hydrology with respect to travel times and release patterns. Based on hydraulic theory, interviews with river guides, and field measurements of the "rising wave" and "falling wave" produced by the starting and stopping of a Deep Creek release, the researchers determined that a 2-hour release with low natural flows would produce navigable flows lasting only 15 to 20 minutes in the lower Class V section of the river (approximately from Powerful Popper to Cheeseburger Falls and immediately downstream) (Graefe et. al. 1989). Lost and Found rapids was specifically identified as a bottleneck where rafts often become stuck and boats collect above the rapids waiting for a clear passage. The study concluded that about 15 to 20 rafts could navigate Lost and Found with acceptable flows during a 2-hour release; this was considerably less than the number of outfitter rafts (24+) permitted under regulations existing at the time of the study. This limiting condition at Lost and Found occurred relatively infrequently, primarily during June and July of low-flow years, and at times when the river level on the Sang Run gauge was 1.9 ft. during the release. In comparison, the capacity with higher natural flows or a 3-hour release was estimated at 36 rafts.

These conclusions from the Penn State study have several implications. The first is that 2-hour releases can adversely affect whitewater boating enjoyment and safety at times during low-flow conditions, and that boating could be enhanced with longer releases at such times. A second implication is that longer releases, would increase the physical capacity of the Upper Yough run. Indeed, the Penn State study recommended that the then current customer limit of 72 per day be converted to a limit of 24 rafts per day at times when 2-hour releases are likely, and that this be raised to 36 rafts per day when releases are to be 3 hours or longer (Graefe et. al. 1989).

Timing of Releases

The timing of Deep Creek releases represents a separate issue with respect to project operational effects on whitewater recreation. Boating interests have expressed concern over both the time of day and day of week aspects of the typical release pattern.

Penelec considers peak electrical demand hours to be from 8 a.m. to 8 p.m. Approximately 95 percent of the total generating hours for the Deep Creek plant have occurred within this peak-hour period in recent years. Daily operations begin at any time within this 12-hour interval, although the typical starting time during the summer is from late morning to late afternoon. Because weekend power demands are considerably lower than during the week, Deep Creek Station operates infrequently on weekends.

Water released at the Deep Creek plant generally takes about 2 hours to travel the 3.7 miles to Sang Run under low-flow conditions, and about 6 hours total to reach Friendsville (Graefe et. al. 1989). Releases that occur late in the day may not be usable for boating, depending upon the onset of darkness on a given day. The latest feasible starting time for a river trip at Sang Run is about 3 p.m. during mid-summer and 2 p.m. by late summer.

Scheduling

Whitewater interests have expressed concern over the fact that the days and times of Deep Creek releases are not scheduled in a reliable and predictable way. This in turn does not allow Penelec to provide much advance notice of release volumes and times. The uncertainty created by the scheduling and notice situation could cause boaters intending to make a trip on the Upper Yough to postpone or cancel their plans, or decide to use an alternate resource where the availability of water is not a concern.

Scheduling of Deep Creek generation is coordinated with generation in the Mid-Atlantic region through the Pennsylvania-New Jersey-Maryland (PJM) Power Pool, which includes a number of utilities in addition to Penelec. Participating utilities agree to have their own power resources scheduled and dispatched according to the overall load and resource characteristics of the entire PJM Pool. In general, the lowest-cost generation available to pool members is dispatched at any given time. This coordinated operation provides economy to all parties. Generation at Deep Creek is scheduled daily at 7 a.m. according to the time that highest load and highest-cost generation are expected. This time varies considerably by season, month, day of week and time of day, as well as with weather conditions. Because the highest load and highest-cost generation are not fully predictable, Deep Creek generation does not follow a predictable schedule.

Because the load forecast for a given day is not available from GPU until 7 a.m. on that day and because of the unpredictability of the above described factors, Penelec has not been able to provide much advance notice of releases to boaters or other users. Penelec maintains a recorded telephone message that provides schedule information on a 24-hour basis. This recording is updated so as to provide approximate information on likely release times in the early morning on the days of a release; notice of the expected generation schedule is provided one week in advance.

3.9.4.2 Angling

Fishing on the Youghiogheny River and its tributaries is quite popular. Species sought by anglers include rainbow and brown trout, smallmouth bass, and walleye. The distribution of fishing activity is determined largely by river access and fish stocking patterns. In general, both angler effort and MDNR stocking efforts are concentrated where access to the river is easiest.

The Youghiogheny River within the study area can be divided into four locations where fishing activity occurs. These include Swallow Falls, Hoyes Run, Sang Run, and the gorge between Sang Run and Friendsville. The first three are specific locations where access to the river is possible, and from where anglers can range (to some extent, often limited to wading) upstream and downstream. The gorge is a 9.5-mile long reach of river with difficult access at a few very specific locations.

The MDNR manages the Youghiogheny River from Muddy Creek (in Swallow Falls State Park) upstream to the West Virginia state line as a put-and-take trout fishery, stocking legal-size adult fish in rough proportion to the annual catch (personal communication, A. Klotz and M. Dean, Maryland Department of Natural Resources, Fisheries Division, Mt. Nebo District Office, Oakland, Maryland, July 12, 1990). The most popular fishing location in the study area is at Swallow Falls State Park, where there is easy access to the river and to Muddy Creek. This is primarily an early-season fishery that lasts from an early spring opening through about the end of May, with a 5-fish limit. Rainbow trout are stocked twice at Swallow Falls during the spring, but are not stocked later in the year due to low stream flows and high water temperatures that provide poor conditions for trout. Fishing activity continues through the summer at Swallow Falls, but success rates are low.

The MDNR stocks only fingerling fish in the Youghiogheny below Muddy Creek to Sang Run. Float stocking between the Deep Creek tailrace and Sang Run was initiated in 1990 to better distribute fingerlings within the area of high management interest. The reach of the river between Muddy Creek and Sang Run is open to anglers all year, but the daily limit is 2 fish. However, MDNR allows "catch and release" fishing only between the Deep Creek tailrace and Hoyes Run. Trout are the primary species in this reach, including brown trout that are attracted to the relatively cool water released by the Deep Creek Project. Some smallmouth bass also occur. Fly fishing is the predominant gear type and fishing method at both the Hoyes Run and Sang Run locations.

Because of access difficulties there is no stocking program in the gorge between Sang Run and Friendsville. However, some trout and smallmouth bass can be found in the cool, shaded pools of the gorge, as are walleye in the spring. The latter travel from Youghiogheny River Lake into this reach of the river to spawn. Overall, there appear to be more smallmouth than trout in the gorge. Consequently, fishing with spinning gear predominates in this area.

Data on the amount of fishing activity on the river are limited. Based on a 1987 survey, an MDNR researcher estimated that approximately 9,500 anglers made nearly 98,000 trips to the Youghiogheny (including the reach above Swallow Falls), Muddy Creek and Bear Creek (Graefe et. al. 1989). Trout fishing accounted for over 70 percent of the total trips. The distribution of this activity to specific areas was not estimated. However, hundreds of anglers have been reported at Swallow Falls on annual trout season opening days (Graefe et. al. 1989). Fishing pressure in this area reportedly averages 20 to 25 users per day on weekdays and considerably higher on weekends.

Based on discussions with MDNR fisheries staff and other knowledgeable sources, Penelec believes that approximately 60 to 65 percent of all fishing activity in the river study area occurs near Swallow Falls (personal communications, A. Klotz and M. Dean, Maryland Department of Natural Resources, Fisheries Division, Mt. Nebo District Office, Oakland, Maryland, July 12, 1990; K. Christianson, Maryland Department of Natural Resources, Youghiogheny River Management Area, Oakland, Maryland, July 16, 1990; P. Coleman, Precision Rafting, Friendsville, Maryland, July 13, 1990). Due to considerable increases in use over the past 5 years, activity at Hoyes Run is possibly 1/3 to 1/2 the level of

Swallow Falls. The MDNR river manager reports seeing 3 to 5 anglers at Hoyes Run on a typical day, although this use is more continuous throughout the year than at Swallow Falls. Use at Sang Run is perhaps 1/3 to 1/2 as much as at Hoyes Run, or 10 to 15 percent of the total. Fishing activity in the gorge is light by all accounts, and is presumed to account for only 5 to 10 percent of the total.

Graefe et al. (1989) reported that based on surveys of Maryland fishing license holders, anglers made nearly 70,000 fishing trips to the mainstem Youghiogheny or its tributaries between the Swallow Falls area and Friendsville during 1987. Graefe et al. (1989) also indicated that angling below Swallow Falls State Park is limited by a lack of public access to the river, and that a large portion of the angling activity within the corridor occurs in two Youghiogheny River tributaries, Muddy Creek and Bear Creek. A small number of anglers wade the river in areas between Swallow Falls State Park and Hoyes Run. At Hoyes Run, parking is available on Penelec's property for 2-4 vehicles, allowing limited angler-access to the river. Between Hoyes Run and Sang Run, a non-maintained trail exists along the river on riparian land acquired by the state in the 1980s, but dense understory and a lack of publicity presently limits the use of the trail by anglers. At Sang Run, access provided for whitewater boaters at the Natural Lands Trust property also provides access for anglers, but use of the area by anglers is apparently light (Graefe et al. 1989). Between Sang Run and Friendsville, angling activity is low because of limited access. At Friendsville, some anglers wade upriver to fish, but their numbers are not known.

Operations Effects on Angling

Releases from the Deep Creek Project could potentially affect fishing on the Youghiogheny River in two ways. The MDNR has indicated that the rising water elevations and higher flow velocities that occur on the river with a release can create hazards for anglers in the river. Secondly, stream anglers often have preferences for river flows within a specified range, due to adverse fishing conditions with particularly low or high flows. Consequently, fluctuating river levels could conceivably have an impact on the quality of fishing opportunities in the downstream area.

Angler Safety

Discharge from the plant tailrace can change from virtually zero to approximately 640 cfs on a nearly instantaneous basis. This rapid increase in flow travels down the Youghiogheny River as a "rising wave" that increases the elevation of the river as well as the velocity. If the river is at low natural flows, the rising wave of a full 640 cfs release is super-imposed on a base flow that could typically be 50 to 70 cfs.

Assessment of the significance of the physical changes in flow associated with a release is difficult, and must be based on direct observations by people who use the river or are familiar with it. Penelec contacted the MDNR's Youghiogheny River manager, local MDNR fisheries staff, and selected river users to provide background on the angler safety issue. Information obtained through these contacts is summarized in the following observations:

- Releases pose different degrees of safety concern in different locations on the river. Due to distance and channel morphology differences, a 640 cfs release may create hazard situations at Hoyes Run and in the gorge but would not be particularly difficult for a wading angler at Sang Run. The river is somewhat constricted as it makes a major bend at Hoyes Run, whereas the channel is broader and shallower at Sang Run. Water levels can rise quite rapidly in the gorge, particularly in the section below Gap Falls. Angling pressure in the gorge is light due to its relative inaccessability. Anglers that fish this area need to leave the river quickly when it rises.

- Most anglers simply leave the river when they notice the water level rising but some anglers have been observed continuing to fish during a release. Two of the individuals contacted reported having fished at Sang Run themselves during a full release.

- Minimal specific reports of actual emergency situations were obtained through these contacts. A whitewater outfitter who is on the Upper Yough nearly every day there is a release during the boating season reported picking up stranded anglers in the gorge about twice in 10 years.

- One source had the impression that, with the exception of regular local users, anglers generally do not check Penelec's telephone recording to find out when releases will occur.

While this information is admittedly inconclusive, it does suggest that Deep Creek releases do not represent a major hazard to anglers at Sang Run, but anglers at Hoyes Run and in the gorge may be at risk.

<u>Quality of Opportunity</u>
The level of flow in a stream can have a distinct effect on anglers' ability to catch fish and the quality of the experience. Low flows are typically associated with relatively high temperatures, conditions under which trout tend to seek cool, shaded pools and reduce their level of activity. Fishing under those conditions is typically more difficult and less productive. Similarly, the quality of fishing opportunity declines when flows are too high because the water tends to be too murky and fish seek lower-velocity holding areas. Stream anglers therefore tend to

have preferences for moderate flows that avoid either type of adverse condition.

The local sources contacted for fishing information were questioned about their knowledge of local anglers' flow preferences and the apparent effects of project releases on the quality of fishing opportunity. None of the sources indicated an awareness of specific angler flow preferences stated in terms of stage height or cfs. There was some feedback that local anglers know that fishing conditions would be better before a release than during or after, because the water would be clearer. However, there were also contradictory indications that it was worthwhile to continue fishing during a release if the fish had been biting well before, and that youths in Friendsville were known to head for the river to fish when "the tide is in."

On balance, the lack of a definitive response on this issue may well indicate that it is not a significant concern. Particularly when there are relatively low flows in the river, the addition of 640 cfs does not make the river a torrent or eliminate the pools and other favorable habitat. To the extent that releases may adversely affect the quality of opportunity, it is probably out of anglers' concerns for safety and not due to drastic changes in fishing success conditions.

3.10 HISTORICAL AND ARCHEOLOGICAL RESOURCES

This cultural resources investigation entailed cartographic and documentary research in the files of the Maryland Historic Trust, and a site inspection that included the power plant structures. Plans and photographs of the facility were analyzed by Duncan Hay of the New York State Museum.

3.10.1 Historic Structures

Penelec's plant itself is listed in the historic building survey files of the Maryland Historic Trust, as G-III-A-075. It was built between 1923 and 1925. The facility is a typical and architecturally unremarkable example of the numerous hydroelectric plants constructed throughout the nation in that period. In Hay's opinion, the facility is probably not eligible for the National Register under Criterion C. However, there are only two plants of this period in the State of Maryland, so the structures might be worthy of listing on the state's register.

Previously surveyed structures which are located close to the shore of Deep Creek Lake, and therefore could conceivable (albeit improbably) be affected by induced changes in Deep Creek Lake's water elevation, include:

- G-III-B-83 - Glendale Bridge, a camelback truss bridge built in 1924 by the McClintic-Marshall Company of Pittsburgh.
- G-IV-B-89 - Holy Cross House, built circa 1900, used as a college dormitory since 1930.
- G-IV-B-90 - Holy Cross Camp, a frame recreation hall, built in 1930, and several more modern buildings.
- G-IV-B-83 - The Mar-Jo Lodge, a vacation house built in the mid-1920s by Dr. Frank Wilson; Albert Einstein vacationed here as Wilson's guest in September 1946.

None of these surveyed sites has been nominated to or listed in the National Register of Historic Places (NRHP).

3.10.2 Prehistoric Sites

Thirty-four prehistoric sites were discovered along the reservoir shoreline by Frank R. Corliss, and reported by him to the Maryland Geological Survey (MGS) in 1970. Site description in MHT files are generally minimal, recording only the presence of prehistoric artifacts but not the size of the sites or their temporal or functional components.

Elizabeth Ragan of the MGS re-visited some of Corliss's sites in 1986 but could find no surface indications of their existence. She concluded that shoreline erosion might have removed all vestiges of the former sites.

The large number of reported sites from the Deep Creek Lake shoreline probably reflects not only favorable conditions for recognition of deflated sites, but also the attractiveness of the local environment for prehistoric occupation. Prior to creation of the reservoir by damming in 1925, the area was a large upland swamp, which presumably offered abundant and diverse resources. A study of archeological collections from the Deep Creek area by Wall (1981) yielded a rudimentary chronological framework for the region. Only one Paleo-Indian (9500-8000 B.C.) fluted point was reported, from the Glades area northeast of the lake. The Early Archaic (8000-6000 B.C.) was represented by three components which yielded Kirk and Amos points. Six Middle Archaic (6000-4000 B.C.) components were recognized, based on presence of bifurcate base and Morrow Mountain points. The Late Archaic period (4000-1000 B.C.) is represented by 27 components. Numerous points of Brewerton types are known, as well as Otter Creeks, corner-notched and stemmed points, and some broadspears. Seventeen Early Woodland (1000 B.C.-A.D. 100) components, characterized mainly by lobate-based Adena-like points, are reported. The Middle Woodland (A.D. 100-1000) is represented by 20 components, about half of which contain Jack's Reef points; Middle Woodland components also are characterized by small side-notched forms. Only three Late Woodland (A.D. 1000-1600) components typified by triangular points, are reported by Wall. The Late Woodland Hoye site is located approximately 2.5 miles north of Deep Creek Station and 1.5 miles west of the transmission line. This Monongahela phase village was tested by avocational archaeologists in the 1930s and 40s, and by the Carnegie Museum in 1950-51. Finds include burials, postmolds, shell-tempered pottery, and an Adena point that suggests that an Early Woodland occupation was located in the same area. The Hoye site is listed in the NRHP.

3.11 CONSUMPTIVE WATER USE

Consumptive withdrawal of water from Deep Creek Lake is minimal and has been limited to fire department use, water required for gypsy moth pesticide applications, and a single agricultural withdrawal for irrigation located in Harveys Peninsula Cove. Other, indirect factors which may influence hydrologic patterns include groundwater withdrawals for potable water, especially in the developed areas around Deep Creek Lake.

4.0 PROPOSED CHANGES TO EXISTING PROJECT

This section describes the operational changes and new project facilities proposed by Penelec for the Deep Creek Station hydroelectric project. Section 4.1 outlines the proposed operating rules and describes their objectives. The proposed operating rules are set forth in flow chart fashion on Figures 4-1 through 4-13. Sections 4.2 through 4.5 discuss the enhancements to the environmental and recreational resources expected to result from the proposed operating rules and the new project facilities. In particular, Sections 4.2 and 4.3 describe the proposed new facilities (tailrace weir and flow bypass, respectively).

4.1 PROPOSED OPERATING RULES

4.1.1 Project Operational Objectives and Operating Criteria

The Deep Creek Station hydroelectric project will be operated to meet the following objectives: (1) maintain project capacity, energy, and reliability; (2) support recreation on Deep Creek Lake; (3) enhance fish habitat in the Youghiogheny River; (4) enhance water temperatures in the Youghiogheny River for brown and rainbow trout; (5) enhance whitewater boating opportunities in the Youghiogheny River; (6) minimize the potential for lake shoreline erosion; and (7) reduce the potential for entrainment of walleye and perch fry.

Based on consultations with resource agencies, interested parties, and studies conducted by Penelec, operating criteria were established to meet each of the above described operational objectives.

To maintain power and energy benefits (Objective 1), the project should continue to operate as a peaking plant, available to generate a minimum of two hours per day on any given week day. Normally, generation is scheduled during weekdays to take advantage of the relatively higher power values. The plant should also remain available to generate when needed during infrequent power system emergency conditions. Normally, generation should be at most efficient capacity (estimated 560 cfs).

To support recreation on Deep Creek Lake (Objective 2), lake levels should be maintained above elevation 2,458 ft. from early May through mid-October. Drawdown also should be limited each month to permit adjustment of boat docks.

To enhance fish habitat in the Youghiogheny River (Objective 3), low river flows should be augmented with releases from Deep Creek Lake. This objective is best met through a flow bypass around Deep Creek Station. Based on the weighted usable area curves for brown trout, trout habitat increases with river flow up to about 300 cfs.

To enhance the trout fishery in the river downstream of the project tailrace (Objective 4), releases should be made to cool the river during hot, low flow periods. It is desirable to keep water temperatures at or below 25°C to minimize adverse effects on brown trout.

To enhance whitewater boating opportunities in the Youghiogheny River (Objective 5), appropriate operational criteria should be effected during a defined whitewater boating season. Since significant whitewater boating activity occurs April 15 through October 15, this period should be established as the whitewater boating season. Effecting the following operational criteria from April 15 through October 15 would enhance whitewater boating requirements:

(a) When possible, generation should be scheduled to provide river flows suitable for boating during whitewater boating hours: the minimum suitable flow is considered to be approximately 660 cfs (Section 3.9.4.1); the ideal flow is considered to be in the range of 1000-1200 cfs (personal communication, Mr. Dave Bassage, North American River Runners, March 15, 1994); the maximum suitable flow is estimated as approximately 2500 cfs (personal communication, Mr. Dave Bassage, North American River Runners, March 15, 1994).

(b) For quality whitewater boating experiences, generation should be scheduled for at least three-hour periods, particularly during low river flow conditions; generation should begin in sufficient time to allow whitewater boaters to complete their trips before darkness.

(c) Among weekdays, Friday is the preferred day for whitewater boating, followed by Monday; this should be recognized in scheduling generation.

(d) Generation on designated weekend days would be desirable.

To minimize the potential for erosion of sensitive lake shoreline areas (Objective 6), lake levels should not exceed 2461.0 ft.

To reduce the potential for entrainment of walleye and perch fry in Deep Creek Lake (Objective 7), generation during the early spring should be minimized.

4.1.2 Project Operation Studies

Penelec developed a computer model of historical lake inflow, storage, and generation to simulate historic operation and to evaluate alternative operating strategies.

Penelec analyzed a number of cases that included combinations of minimum instream flows, temperature enhancement, whitewater enhancement, monthly allowable drawdown, and operating rule bands using a specially designed computer simulation model. Model details are discussed in Appendix C.

4.1.3 Proposed Project Operating Rules

Operating rules for the normal daily operation of the Deep Creek Station project were developed in consultation with MDNR and public interest groups to best meet the objectives and criteria described in Section 4.1.1. The operating rules are related to Upper and Lower Rule Bands that define the highest and the lowest desirable reservoir levels, respectively (Table 4-1). The operating rules are set forth in and defined by the information and logic (flow) diagrams on Figures 4-1 through 4-13.

The operating rules specify how the project will normally be operated for various lake levels, and river flow and temperature conditions. However, daily operations, within any given period, are not intended to be uniform and would not necessarily result in uniform drawdown/build-up of the lake during the period. Such operating flexibility will be required to meet the needs of resources management, recreation and energy generation.

Unusual or Emergency Conditions - The following unusual or emergency conditions will supersede the operating rules:

(a) SITE EMERGENCY - A Site Emergency will have the highest operating priority. A Site Emergency is defined as an emergency affecting the Deep Creek Station dam, intake, power tunnel, penstocks, Johnson valves, generating units (turbines and generators), transmission line, tailrace and the Youghiogheny River. A Site Emergency has the potential to cause loss of life, personal injury or high losses to property and equipment. A Site Emergency would include, but not be limited to, flooding on the Youghiogheny River downstream from Deep Creek Station, failure of equipment at Deep Creek Station (e.g., turbines or transmission line) or impending dam failure. During a Site Emergency, generation and flow releases will be dictated by the circumstances of the emergency and may include continuous maximum generation for maximum lake draw down.

Table 4-1 Deep Creek Operating Rule Band[1/]

Month	Upper Band Elev. (ft.)	Lower Band Elev. (ft.)
Jan	2457.9	2455.0
Feb	57.9	56.0
Mar	59.5	58.0
Apr	61.0	59.6
May	61.0	60.0
Jun	61.0	60.0
Jul	60.0	59.0
Aug	59.0	58.0
Sep	58.5	57.0
Oct	57.9	56.0
Nov	57.9	55.0
Dec	57.9	55.0

1/ End-of-Month Lake Elevations

1. OPERATION WILL BE ACCORDING TO THE OPERATING RULES DEFINED BY FIGURES 4-2 THROUGH 4-13, EXCEPT THAT THE FOLLOWING UNUSUAL OR EMERGENCY CONDITIONS WILL SUPERSEDE THE OPERATING RULES:

A. SITE EMERGENCY - A SITE EMERGENCY WILL HAVE THE HIGHEST OPERATING PRIORITY. A SITE EMERGENCY IS DEFINED AS AN EMERGENCY AFFECTING THE DEEP CREEK STATION DAM, INTAKE, POWER TUNNEL, PENSTOCKS, JOHNSON VALVES, GENERATING UNITS (TURBINES AND GENERATORS), TRANSMISSION LINE, TAILRACE AND THE YOUGHIOGHENY RIVER. A SITE EMERGENCY HAS THE POTENTIAL TO CAUSE LOSS OF LIFE, PERSONAL INJURY, OR HIGH LOSSES TO PROPERTY AND EQUIPMENT. A SITE EMERGENCY WOULD INCLUDE, BUT NOT BE LIMITED TO, FLOODING ON THE YOUGHIOGHENY RIVER DOWNSTREAM FROM DEEP CREEK STATION, FAILURE OF EQUIPMENT AT DEEP CREEK STATION (E.G., TURBINES OR TRANSMISSION LINE) OR IMPENDING DAM FAILURE. DURING A SITE EMERGENCY, GENERATION AND FLOW RELEASES WILL BE DICTATED BY THE CIRCUMSTANCES OF THE EMERGENCY AND MAY INCLUDE CONTINUOUS MAXIMUM GENERATION FOR MAXIMUM LAKE DRAW DOWN.

B. MAINTENANCE OUTAGES ARE NECESSARY TO REPAIR, REHABILITATE, UPGRADE, REPLACE, INSPECT OR TEST THE POWER INTAKE, TUNNEL, PENSTOCKS, JOHNSON VALVES, GENERATING UNITS OR TRANSMISSION LINE. DURING MAINTENANCE OUTAGES, GENERATION RELEASES WILL BE LIMITED (TO ONE UNIT OPERATION) OR ELIMINATED AND MINIMUM FLOW RELEASES MAY NOT BE POSSIBLE. PLANNED MAINTENANCE OUTAGES WILL, TO THE EXTENT POSSIBLE, BE SCHEDULED TO BE PERFORMED DURING THE OCTOBER-APRIL TIME PERIOD. DURING MAINTENANCE OUTAGES REQUIRING DEWATERING OF THE TUNNEL AND PENSTOCKS, IT WILL NOT BE POSSIBLE TO MAKE RELEASES FOR WHITEWATER BOATING, TEMPERATURE ENHANCEMENT OR MINIMUM RIVER FLOW.

MAINTENANCE OUTAGES MAY REQUIRE LOWERING THE LAKE BELOW THE LOWER RULE BAND TO ACCESS FACILITIES AND/OR TO PROVIDE STORAGE TO CONTROL LAKE INFLOW. PENELEC WILL NOTIFY MDNR IN ADVANCE IF A MAINTENANCE OUTAGE WILL REQUIRE LOWERING THE LAKE BELOW THE LOWER RULE BAND.

UNPLANNED MAINTENANCE OUTAGES ARE GENERALLY FOR THE PURPOSE OF DOING MINOR MAINTENANCE TO THE GENERATING UNITS OR THE TRANSMISSION LINE. OUTAGES OF THIS TYPE GENERALLY HAVE LIMITED IMPACT ON RELEASES AND WATER LEVEL IN THE LAKE.

C. DAM OR LAKE SHORELINE MAINTENANCE - MAINTENANCE OF THE DAM (AND ITS APPURTENANT STRUCTURES, SUCH AS THE SPILLWAY) AND REPAIR OF LAKE SHORELINE EROSION MAY REQUIRE LOWERING THE LAKE BELOW THE LOWER RULE BAND TO ACCESS REPAIR AREAS AND/OR TO PROVIDE STORAGE TO CONTROL LAKE INFLOW. PENELEC WILL NOTIFY THE MDNR IN ADVANCE IF DAM OR LAKE SHORELINE MAINTENANCE WILL REQUIRE LOWERING THE LAKE BELOW THE LOWER RULE BAND.

D. SYSTEM EMERGENCY - A SYSTEM EMERGENCY IS DEFINED AS THE OCCURANCE OF ONE OF THE FOLLOWING THREE CONDITIONS: (1) MAXIMUM EMERGENCY GENERATION, (2) ENERGY LOADING OF SPINNING RESERVE CAPACITY, AND (3) EMERGENCY CONTROL OF TRANSMISSION FACILITY LOADING. DEEP CREEK STATION WILL OPERATE AT FULL PLANT OUPUT WHEN A MAXIMUM EMERGENCY GENERATION CONDITION IS DECLARED OR EMERGENCY LOADING OF SPINNING RESERVE IS CALLED FOR BY THE PENNSYLVANIA - NEW JERSEY - MARYLAND INTERCONNECTION (PJM). IF EMERGENCY CONTROL OF TRANSMISSION FACILITY LOADING IS REQUIRED, DEEP CREEK STATION WILL OPERATE AS NEEDED TO CONTROL POWER FLOWS.

E. SPILL CONTROL OPERATION - DURING OCCURENCES OF EXTRAORDINARILY HEAVY RUNOFF OR FORECAST HEAVY RAINFALL, IT MAY BE NECESSARY TO GENERATE FOR MORE HOURS THAN STATED IN THE OPERATING RULES IN ORDER TO CONTROL SPILL AS FOLLOWS:

(1) LAKE LEVEL 2460.0-2460.4 - LIMIT LAKE LEVEL RISE TO 0.3 FEET IN 24 HOURS,
(2) LAKE LEVEL 2460.5-2460.9 - LIMIT LAKE LEVEL RISE TO 0.2 FEET IN 24 HOURS,
(3) LAKE LEVEL 2461.0-2461.4 - LIMIT LAKE ELVEL RISE TO 0.1 FOOT IN 24 HOURS,
(4) LAKE LEVEL 2460.3 OR HIGHER-CONTINUOUS GENERATION PERMITTED FOR NEXT 24 HOURS WHENEVER WEATHER FORECAST FOR GARRETT COUNTY CALLS FOR:
(i) 1-INCH OR MORE OF RAIN AND GROUND IN DEEP CREEK WATERSHED IS SATURATED, OR
(ii) FLASH FLOODING.

PENELEC TO MONITOR THIS SITUATION AND CEASE GENERATION IF FORECAST DOES NOT MATERIALIZE.

2. DEFINITIONS

URB - UPPER RULE BAND
LRB - LOWER RULE BAND
UNIT-HOUR - GENERATION OF ONE DEEP CREEK STATION TURBINE/GENERATOR UNIT AT POINT OF MAXIMUM EFFICIENCY FOR ONE HOUR
RIVER FLOW - YOUGHIOGHENY RIVER DISCHARGE IMMEDIATELY UPSTREAM OF CONFLUENCE WITH DEEP CREEK TAILRACE
TWO UNIT GENERATION - GENERATION WITH BOTH DEEP CREEK STATION TURBINE/GENERATOR UNITS
GENERATION UNLIMITED - NO RESTRICTIONS ON GENERATION

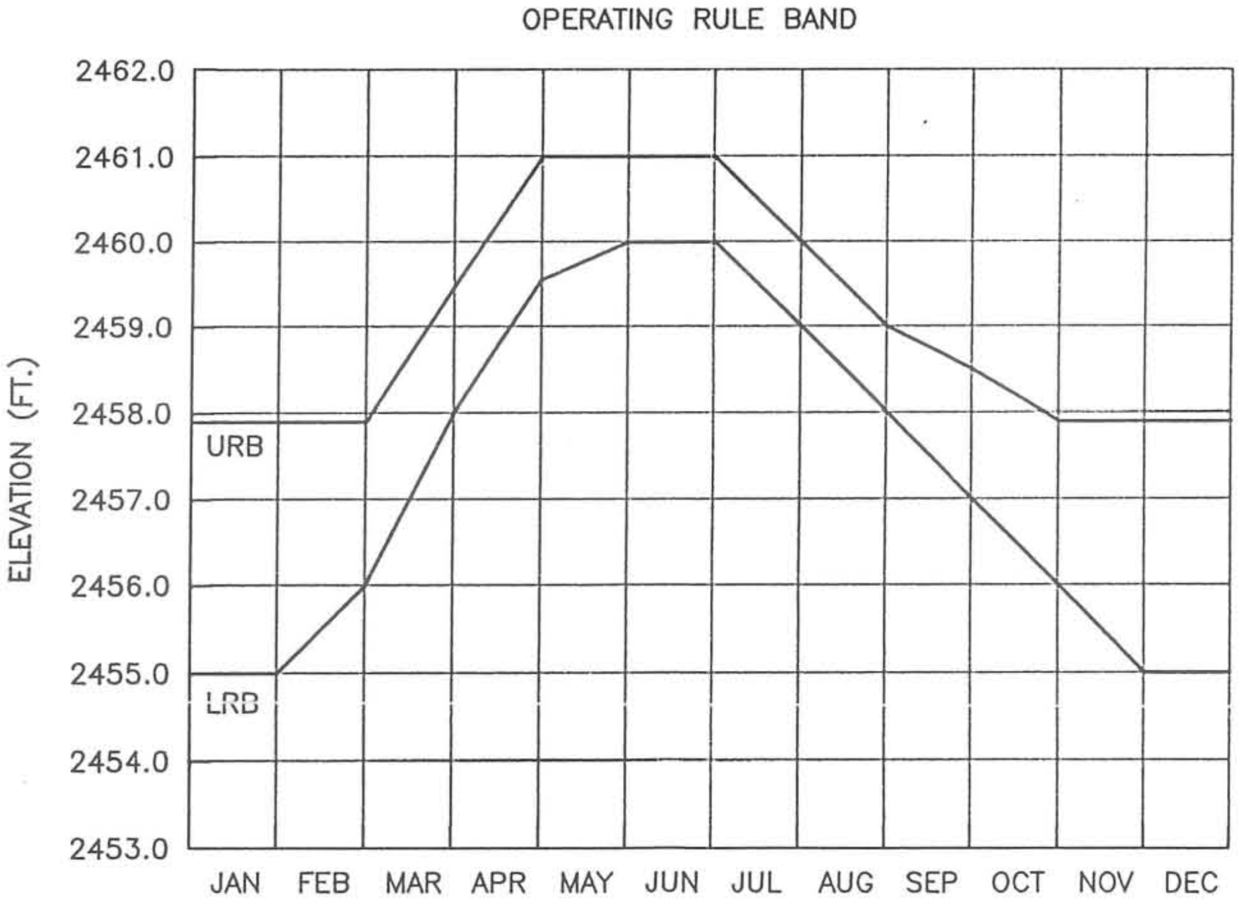
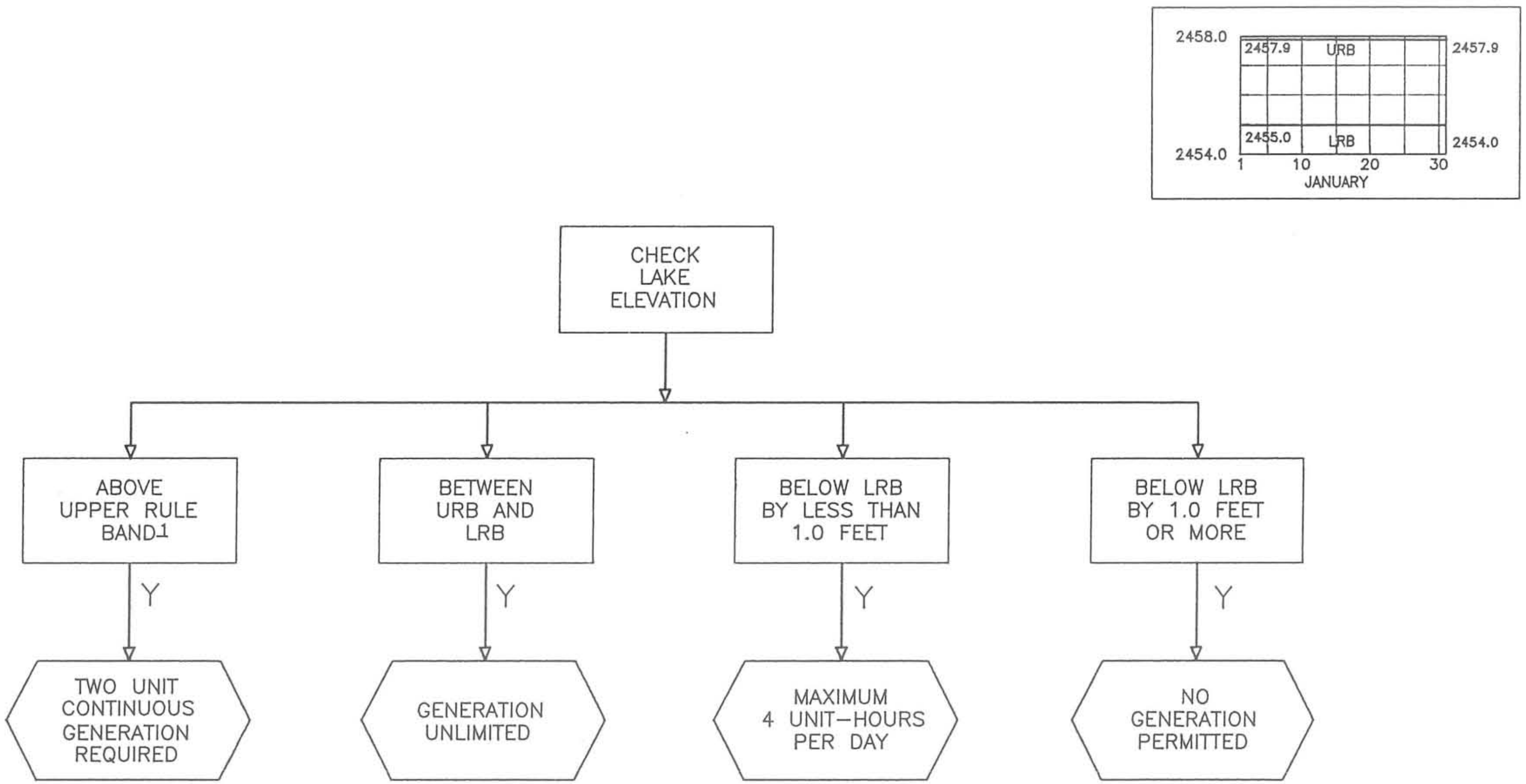
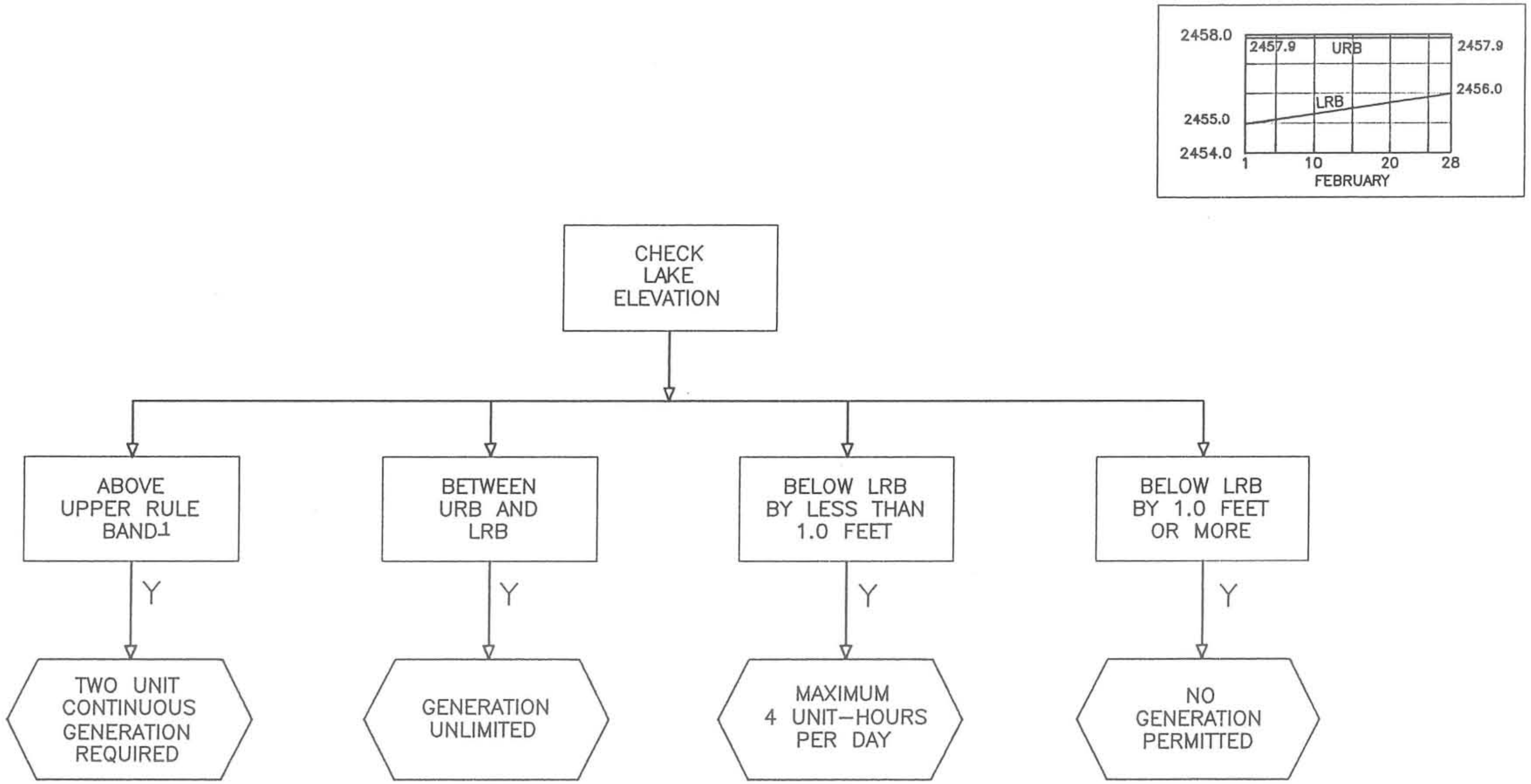


Figure 4-1. Deep Creek Station Operating Rules - Notes



1/ Upper rule band of 2457.9 feet is maximum allowable lake level due to ice loading.

Figure 4–2. Deep Creek Station Operating Rules – January



1/ Upper rule band of 2457.9 feet is maximum allowable lake level due to ice loading.

Figure 4-3. Deep Creek Station Operating Rules - February

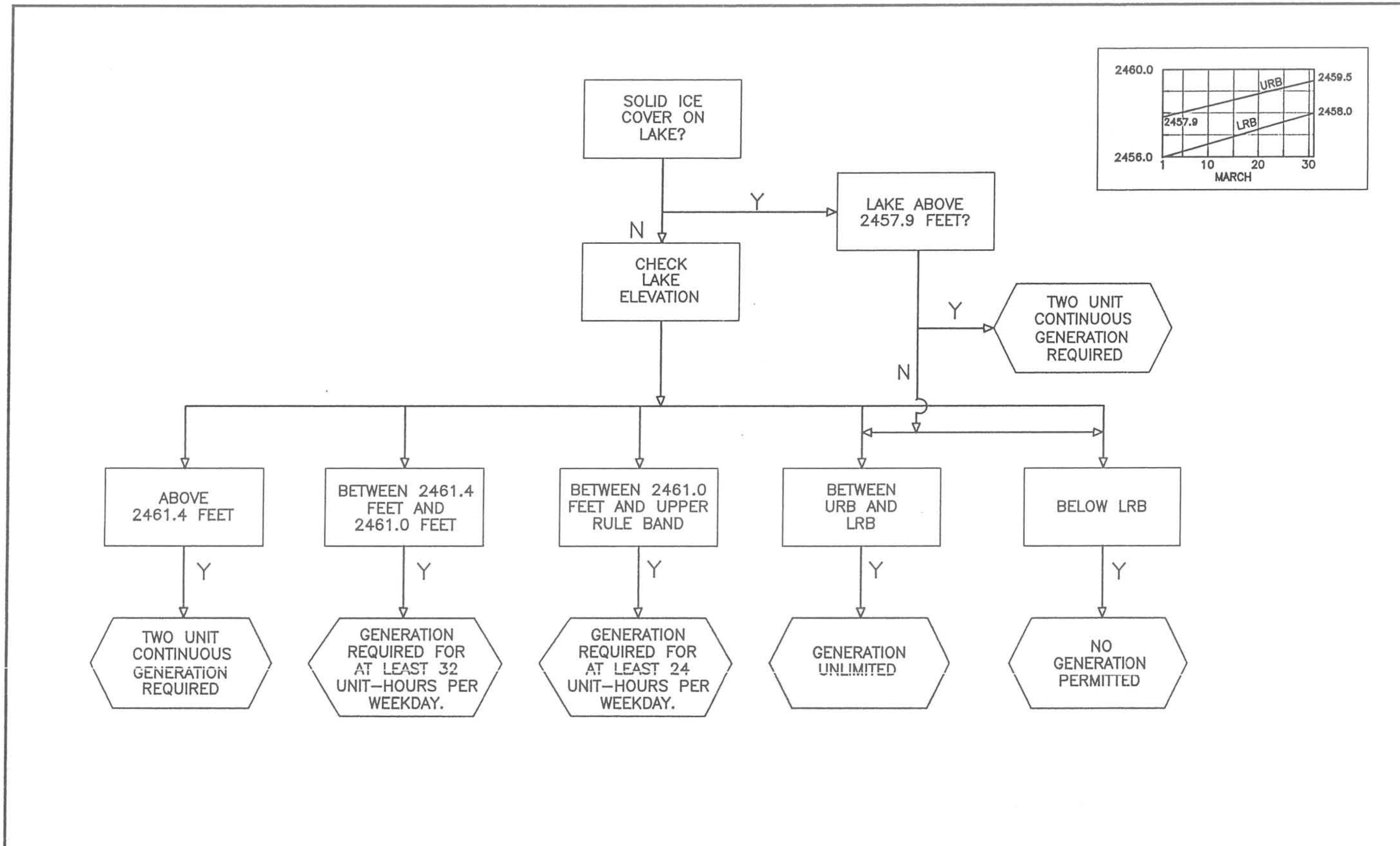


Figure 4–4. Deep Creek Station Operating Rules – March

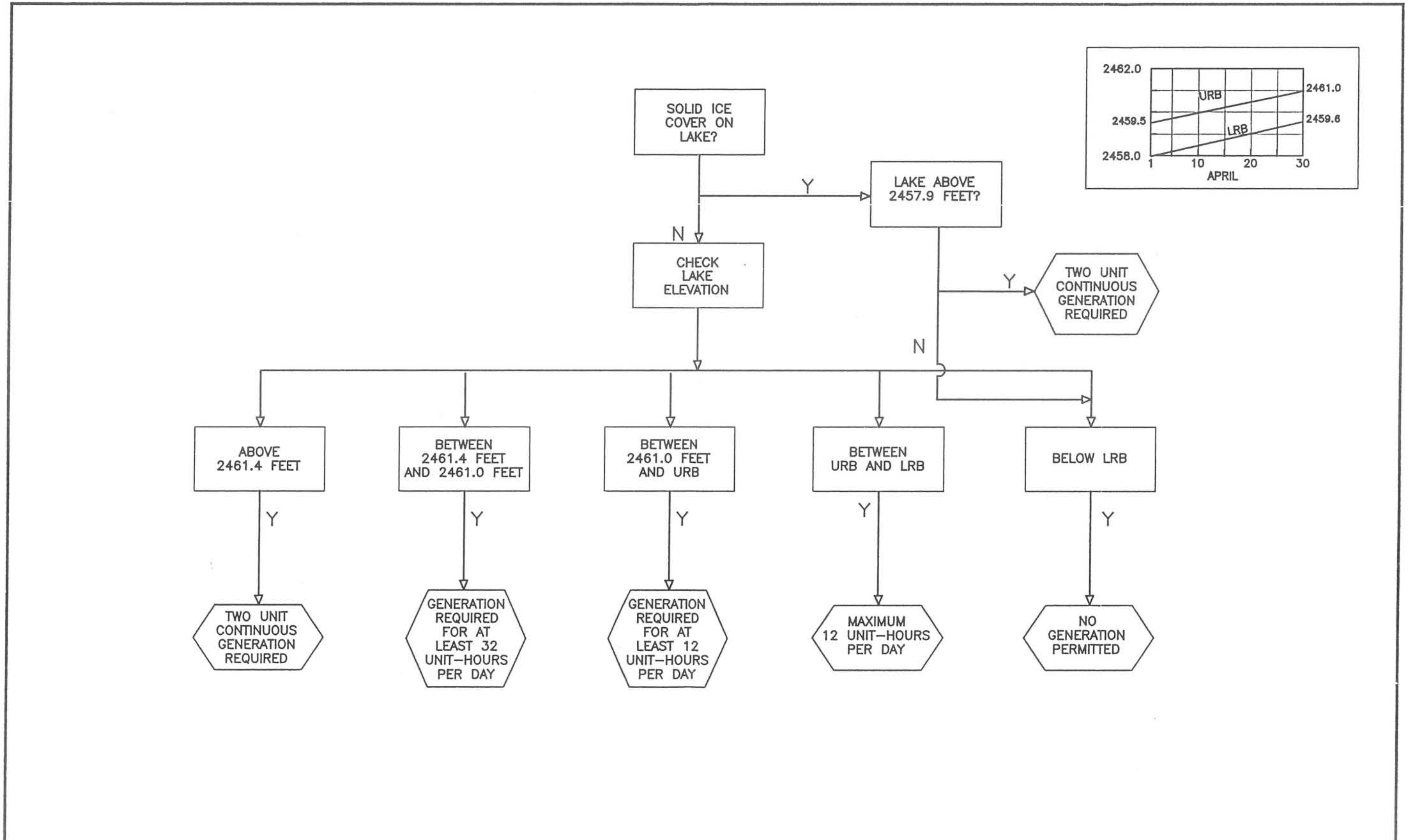


Figure 4-5a. Deep Creek Station Operating Rules - April 1-14

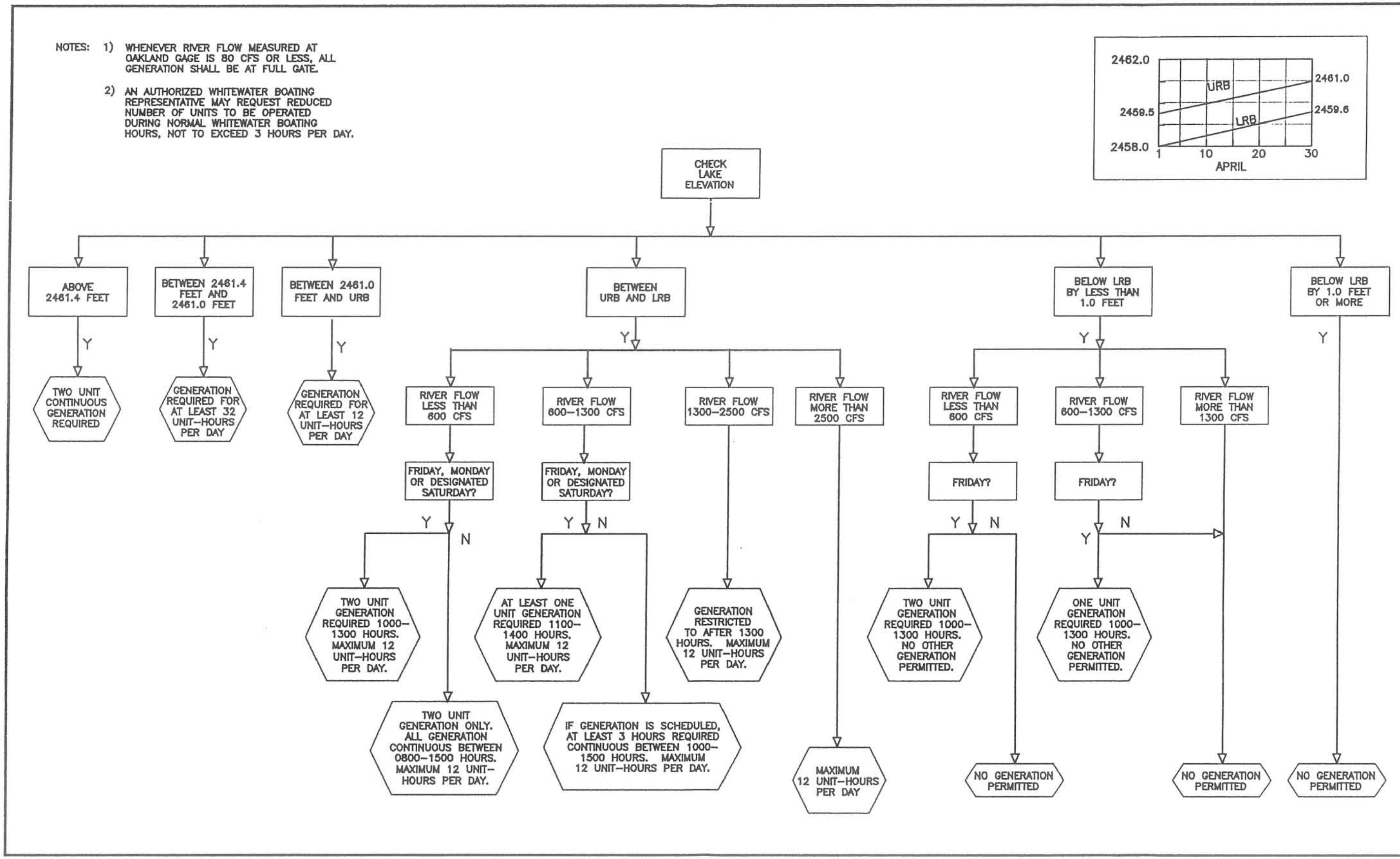


Figure 4-5b. Deep Creek Station Operating Rules - April 15-30

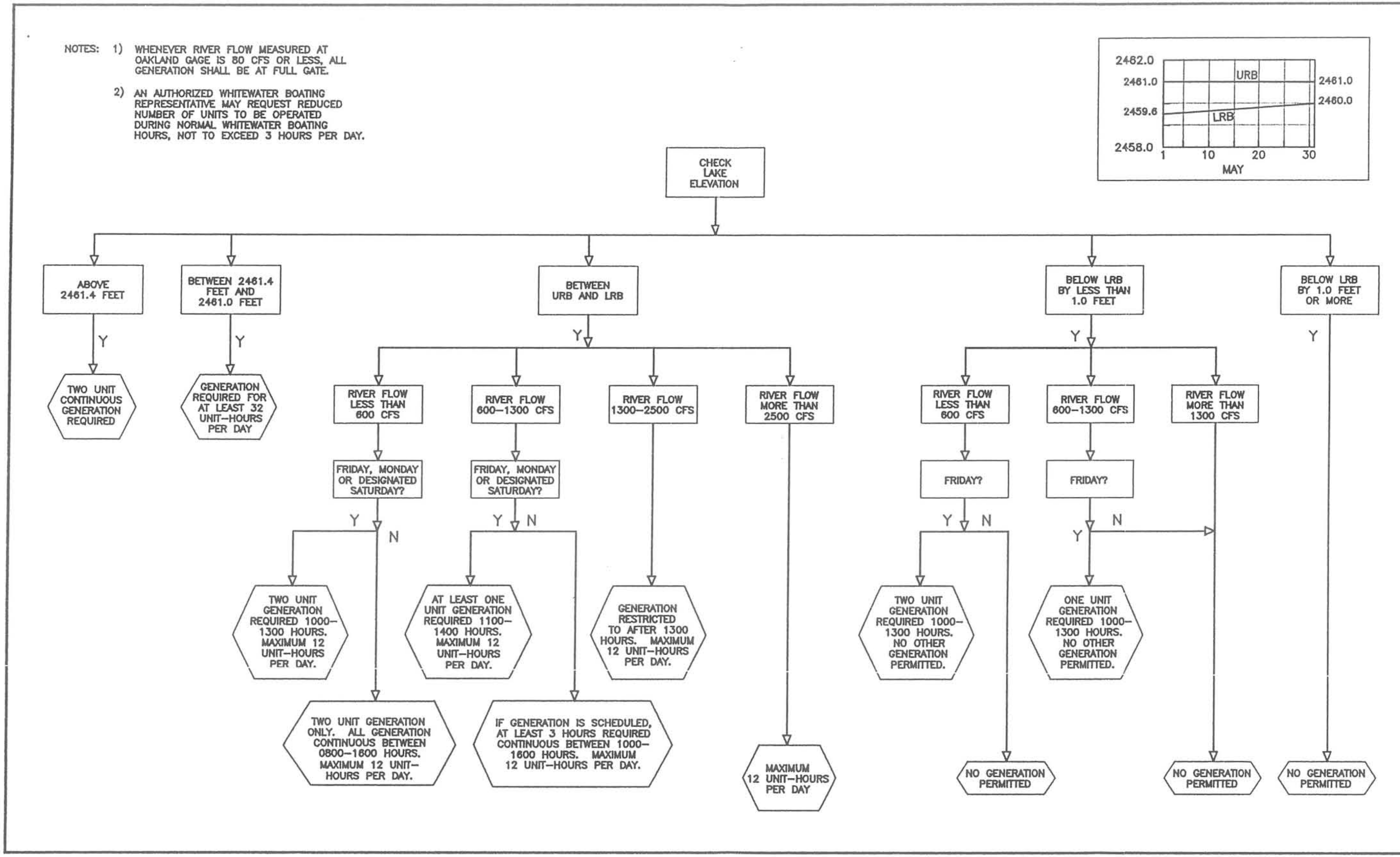


Figure 4-6. Deep Creek Station Operating Rules - May

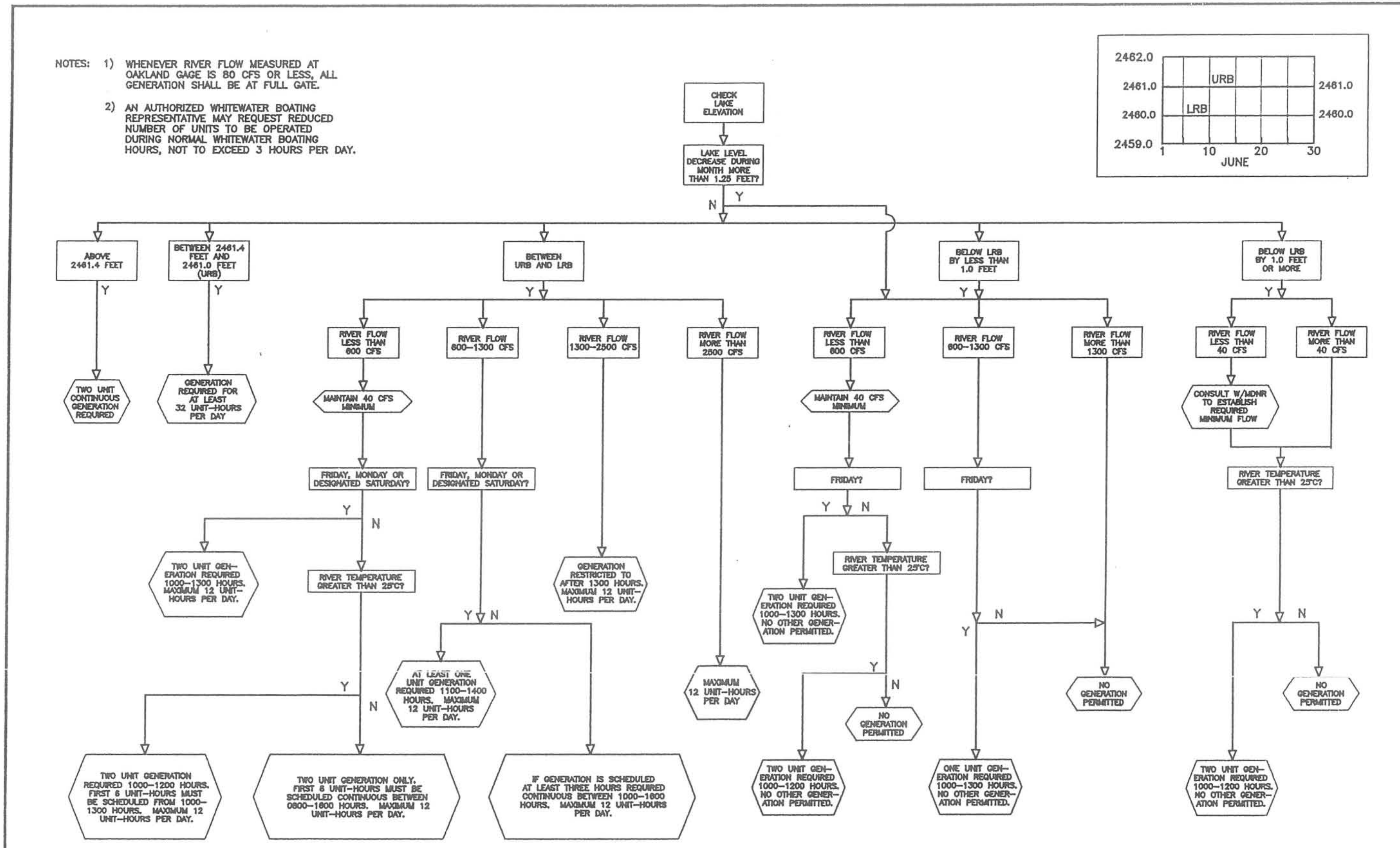


Figure 4-7. Deep Creek Station Operating Rules - June

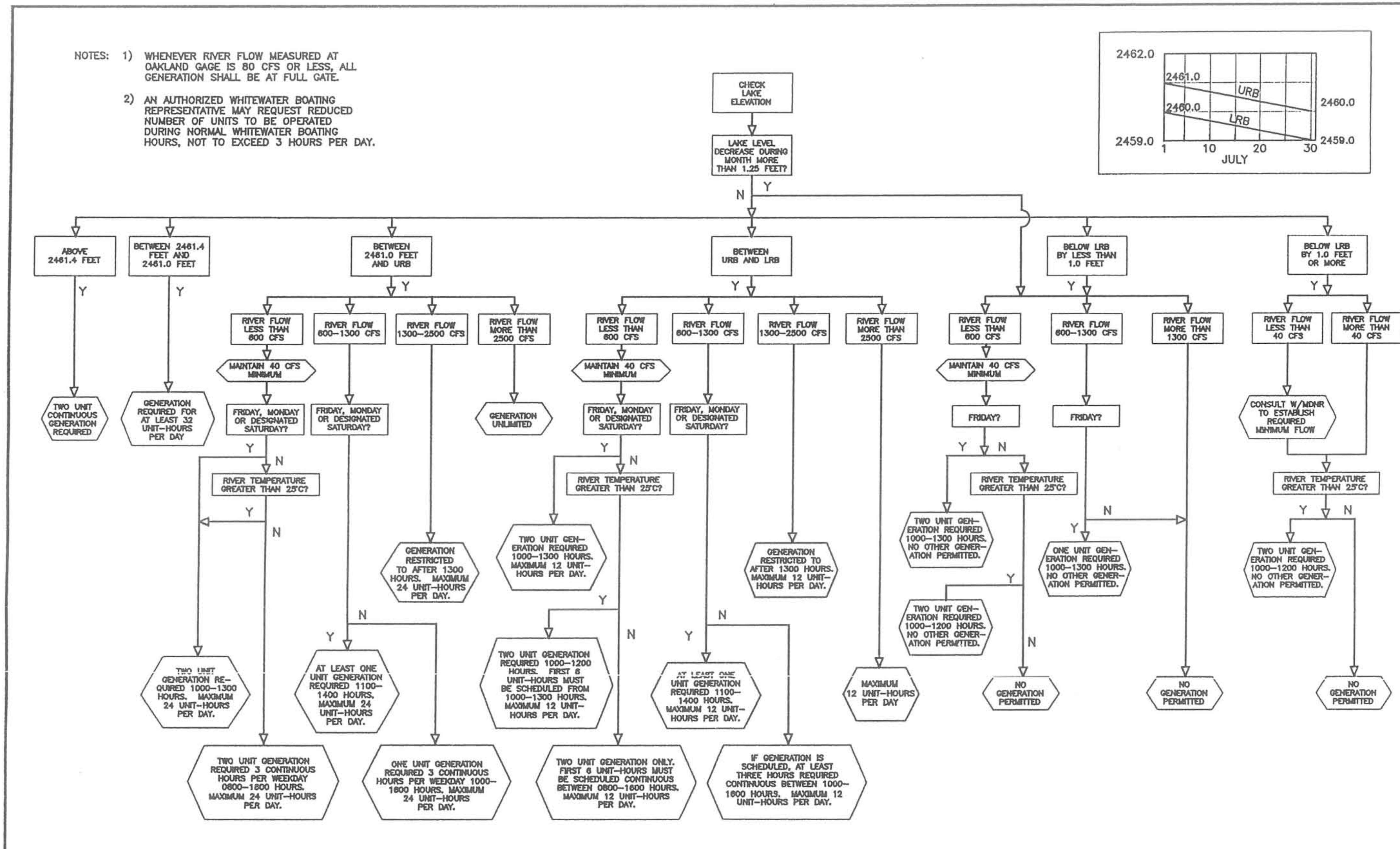


Figure 4–8. Deep Creek Station Operating Rules – July

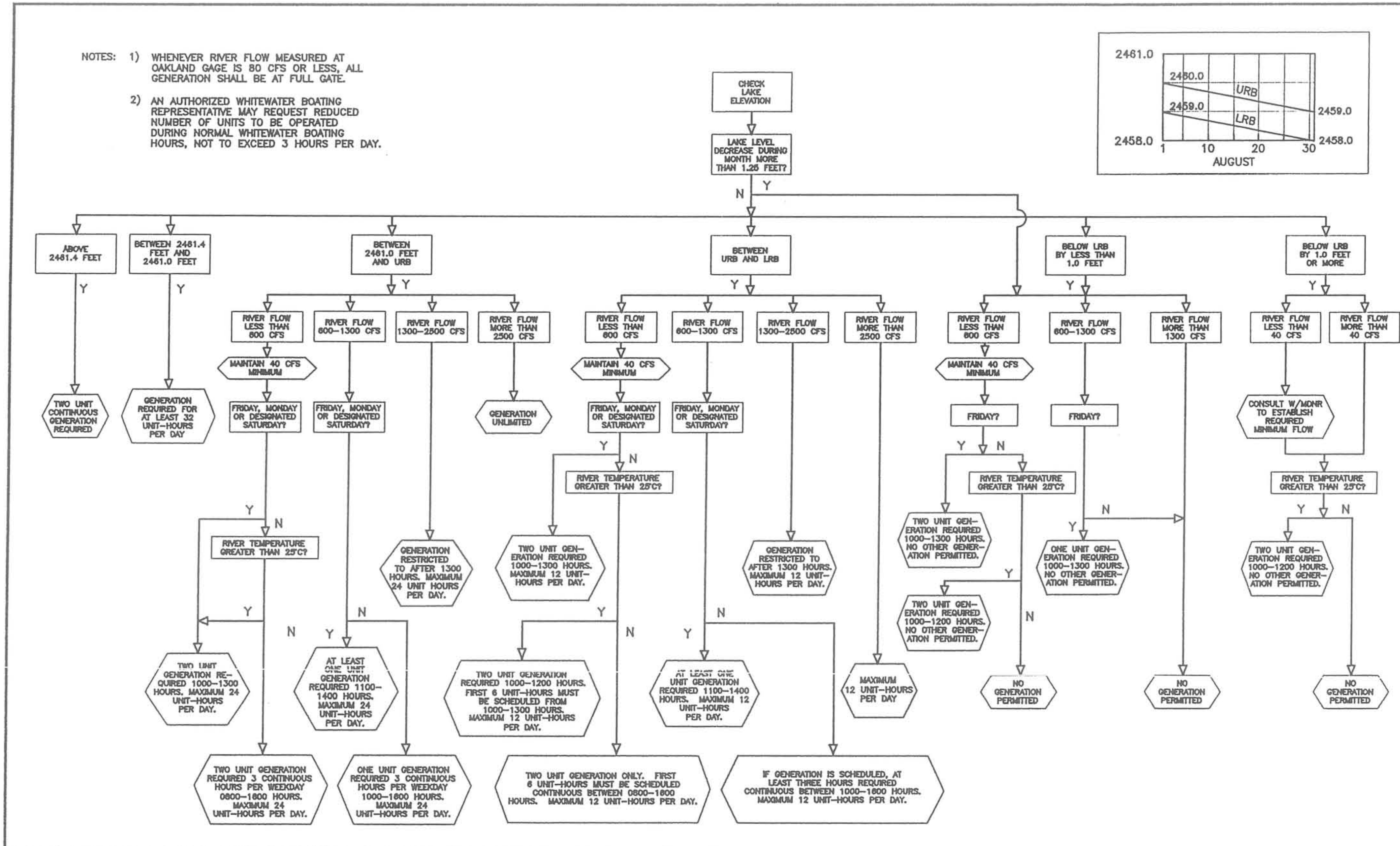


Figure 4–9. Deep Creek Station Operating Rules – August

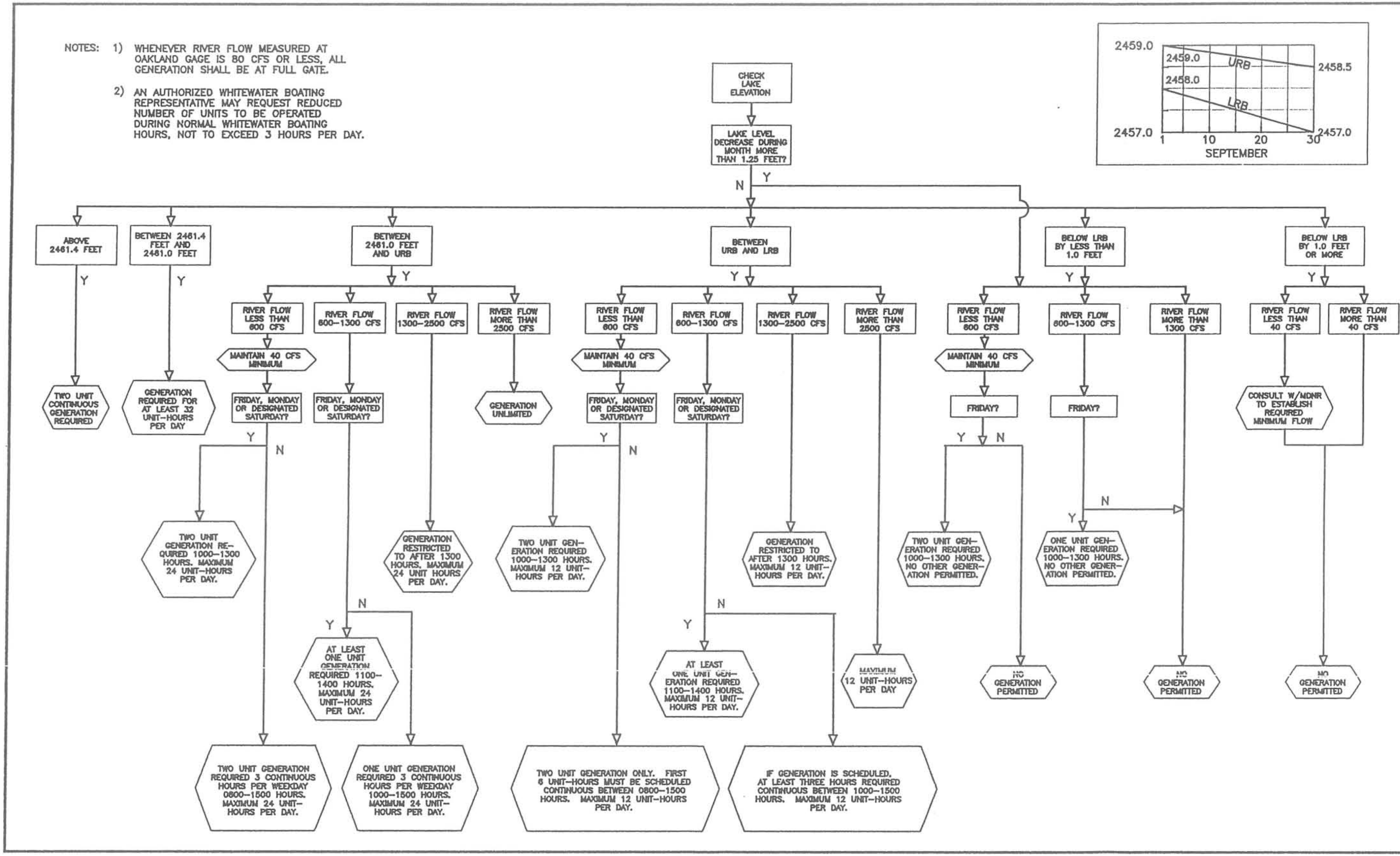


Figure 4-10. Deep Creek Station Operating Rules - September

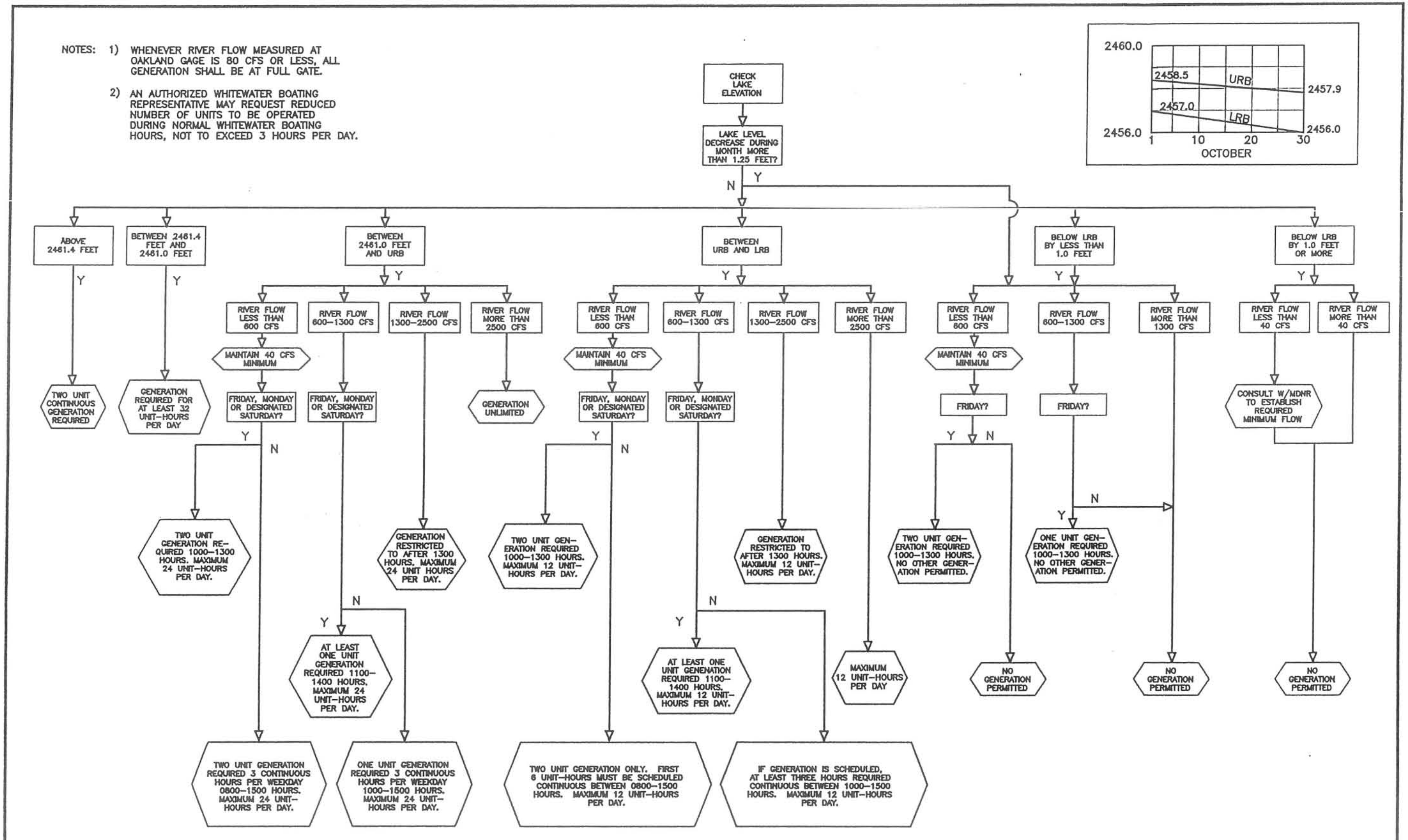


Figure 4-11a. Deep Creek Station Operating Rules – October 1-15

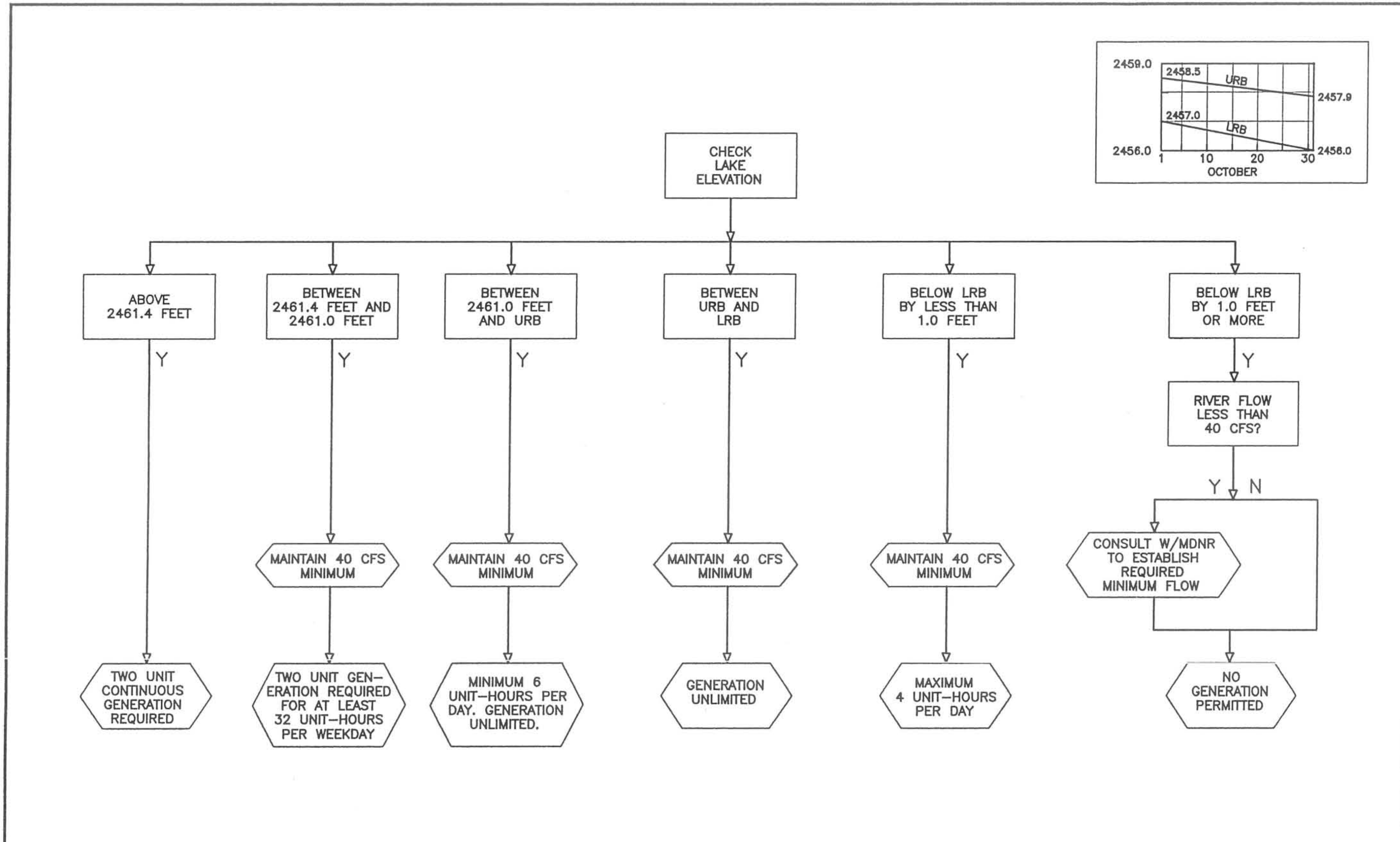


Figure 4–11b. Deep Creek Station Operating Rules – October 16–31

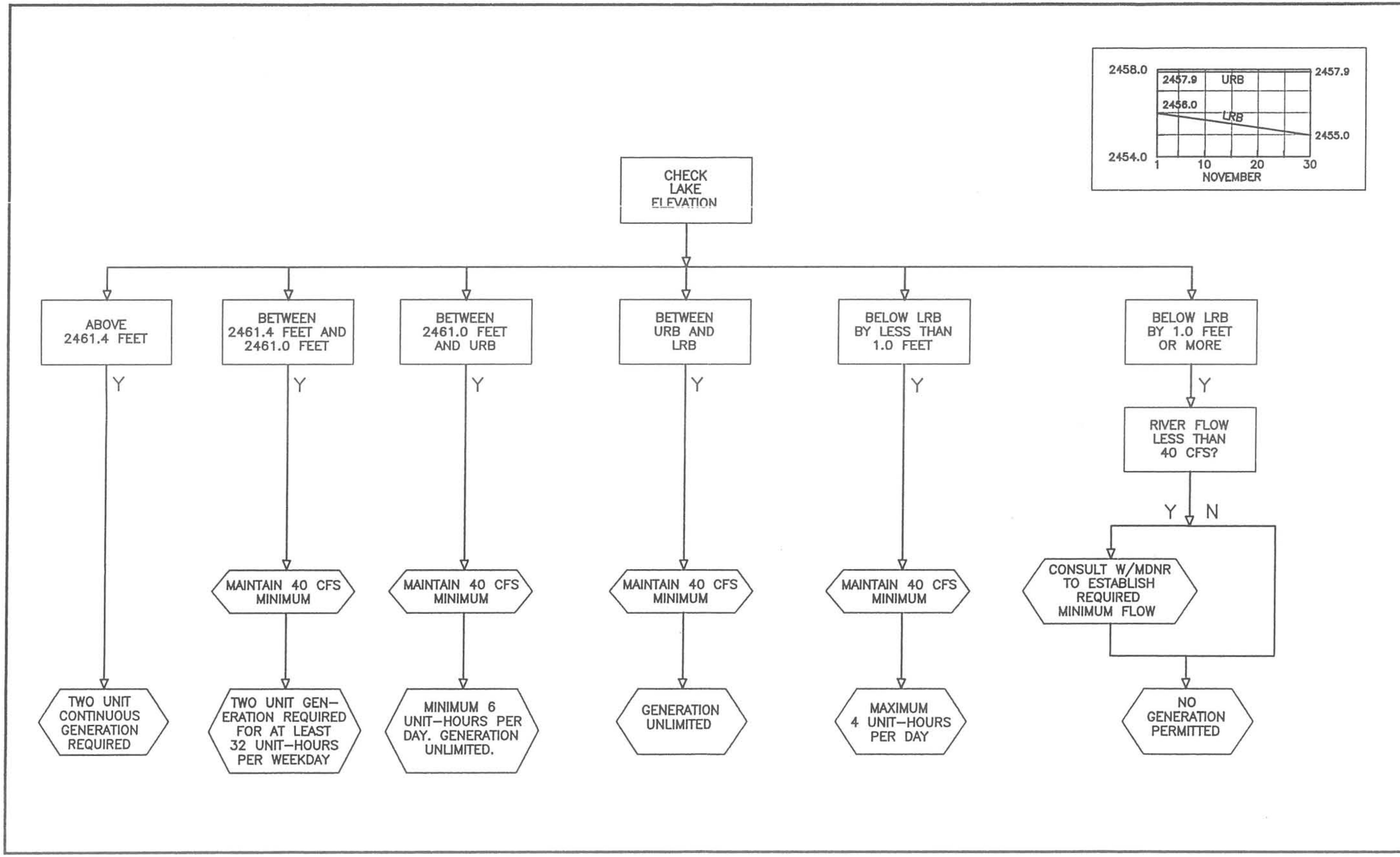
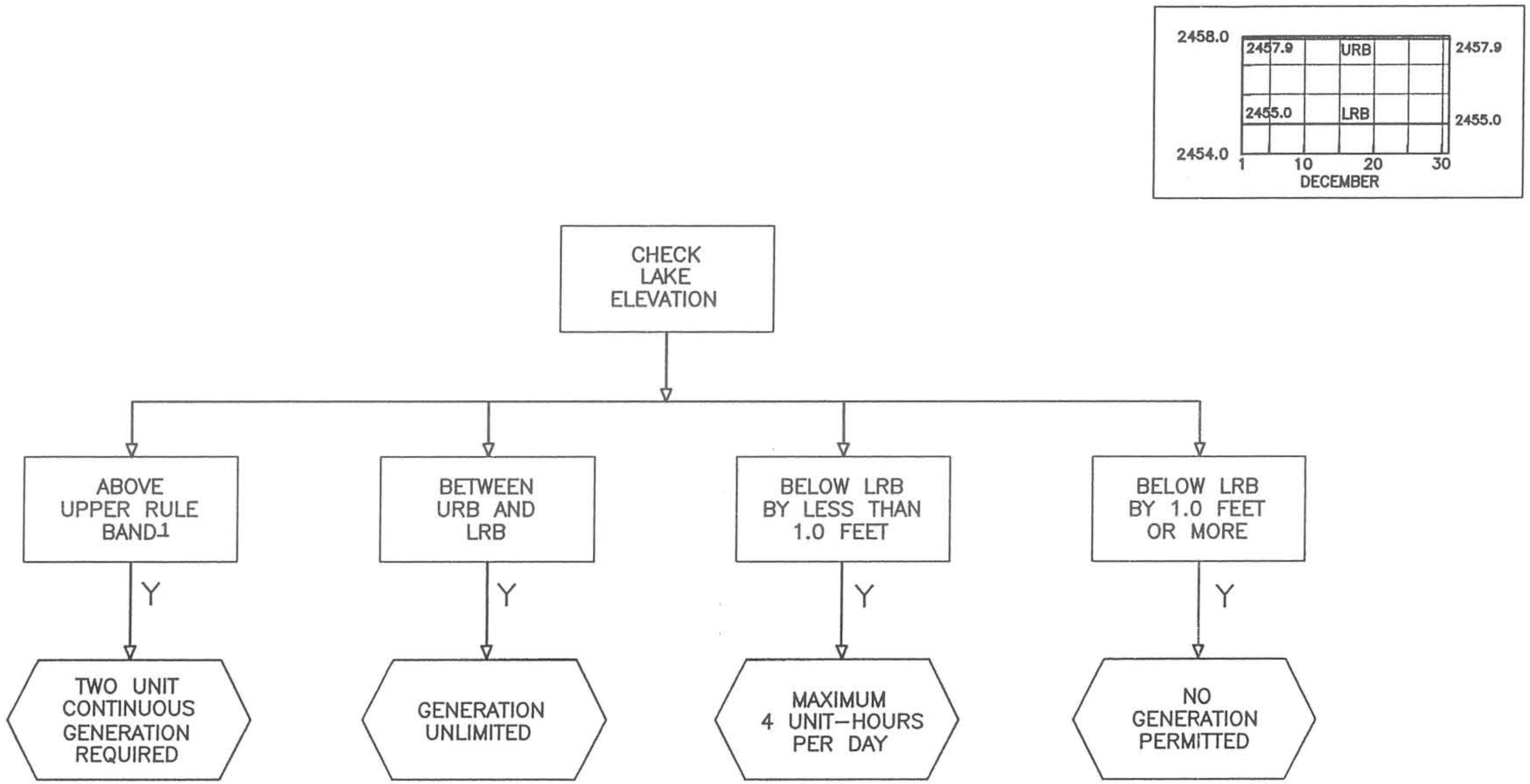


Figure 4-12. Deep Creek Station Operating Rules - November



1/ Upper rule band of 2457.9 feet is maximum allowable lake level due to ice loading.

Figure 4-13. Deep Creek Station Operating Rules - December

(b) **MAINTENANCE OUTAGE** - Maintenance Outages are necessary to repair, rehabilitate, upgrade, replace, inspect or test the power intake, tunnel, penstocks, Johnson valves, generating units (turbines and generators) or transmission line. Maintenance Outages are of two types, those that are scheduled or planned and those that are forced or unplanned. During Maintenance Outages, generation releases will be limited (to one unit operation) or eliminated and minimum flow releases may not be possible. Planned Maintenance Outages will, to the extent possible, be scheduled to be performed during the October-April time period.

Planned Maintenance Outages requiring dewatering of the tunnel and penstocks are required every 5 - 10 years. Such outages have historically been and will continue to be scheduled for the fall, when runoff is low, and before the advent of freezing temperatures. When the tunnel and penstocks are dewatered, it will not be possible to make releases for whitewater boating, temperature enhancement or minimum river flow. Planned Maintenance Outages of the generating units will be scheduled one unit at a time, in winter.

In addition to the impact on releases, Maintenance Outages may require lowering the lake below the Lower Rule Band to access facilities and/or to provide storage to control lake inflow. Penelec will notify MDNR in advance if a Maintenance Outage will require lowering the lake below the Lower Rule Band.

Unplanned Maintenance Outages can occur at any time of the year. For the most part these outages last one day or less and are generally for the purpose of doing minor maintenance to the generating units or the transmission line. Outages of this type generally have limited impact on releases and water level in the lake.

(c) DAM OR LAKE SHORELINE MAINTENANCE - Maintenance of the dam (and its appurtenant structures, such as the spillway) and repair of lake shoreline erosion may require lowering the lake below the Lower Rule Band to access repair areas and/or to provide storage to control lake inflow. Dam or Lake Shoreline Maintenance will, to the extent possible, be scheduled for the fall, when runoff is low, and before the advent of freezing temperatures. Penelec will notify the MDNR in advance if Dam or Lake Shoreline Maintenance will require lowering the lake below the Lower Rule Band.

(d) SYSTEM EMERGENCY - A System Emergency is defined as the occurrence of one of the following three conditions: (1) maximum emergency generation, (2) energy loading of spinning reserve capacity, and (3) emergency control of transmission facility loading. Deep Creek Station will operate at full plant output when a maximum emergency generation condition is declared or emergency loading of spinning reserve is called for by the Pennsylvania - New Jersey - Maryland Interconnection (PJM). If emergency control of transmission facility loading is required, Deep Creek Station will operate as needed to control power flows.

(e) SPILL CONTROL OPERATION - During occurrences of extraordinarily heavy runoff or forecast heavy rainfall, it may be necessary to generate for more hours than stated in the operating rules in order to control spill. To accomplish this, Penelec proposes the following guideline, based upon experience with prior spill events. The guideline would apply only when the lake is at a high level. Specifically, the guideline will allow Penelec to limit the rate of rise of the lake and, when heavy precipitation is forecast, to lower the lake in advance to provide storage for the expected high inflow.

Spill Control Operation Guideline - Generation may exceed the generation allowed under the operating rules in the following circumstances:

(1) When the lake level is at or above El. 2460.0 but below El. 2460.5, Penelec may generate to limit the rate of rise of the lake level to 0.3 ft. in 24 hours.

(2) When the lake level is at or above El. 2460.5 but below El. 2461.0, Penelec may generate to limit the rate of rise of the lake level to 0.2 ft. in 24 hours.

(3) When the lake level is at or above El. 2461.0 but below El. 2461.4, Penelec may generate to limit the rate of rise of the lake level to 0.1 ft. in 24 hours.

(4) If the lake level is at or above El. 2460.3, Penelec may generate continuously for the next 24-hour period to provide advance storage for the expected inflow to the lake whenever the National Weather Service forecast for Garrett County for the next 24-hour period calls either for (i) 1-inch or more of rain and the ground in the Deep Creek watershed is saturated or (ii) flash flooding. Penelec will monitor this situation at suitable intervals during the 24-hour period and cease generation accordingly if the amount of rain is reduced in the forecast or if the rain does not materialize.

Summary of Operating Rules - The following summarizes the proposed operating rules. The operating rules themselves are set forth in the logic diagrams on Figures 4-1 through 4-13.

(a) Minimum Flow Requirements. Unless the Deep Creek Lake elevation is below the Lower Rule Band by one foot or more, Penelec will release sufficient water from a bypass line around Deep Creek Station to maintain a minimum continuous flow of 40 cfs in the Youghiogheny River immediately downstream of the Deep Creek Station tailrace from June through November. At an elevation one foot or more below the Lower Rule Band, Penelec will consult with the MDNR and, as appropriate, will reduce the minimum flow as directed by the MDNR. Historically, Youghiogheny River flows have not decreased below 40 cfs in the December through May period.

(b) Youghiogheny River Temperature Enhancement. From June through August, Penelec will operate Deep Creek Station to attempt to maintain water temperatures at or below 25°C in the Youghiogheny River between the Deep Creek Project tailrace and the Sang Run bridge. Based upon test releases conducted in 1991 and river temperature modeling by MDNR a two-hour release commencing between 10:00 a.m. and 11:00 a.m. will maintain water temperatures at or below 25°C in the reach between the tailrace and Sang Run when the natural river temperature would otherwise be as high as 29.5°C at Sang Run. Based on water temperature measurements from 1987 to 1990, river water temperatures do not exceed 25°C when the Youghiogheny River flow (at Deep Creek Station) is greater than 100 cfs. Thus, Penelec proposes to make river temperature enhancement releases only when river flows are less than 100 cfs. Penelec will make temperature enhancement releases between 10:00 a.m. and 12:00 p.m. or as otherwise determined in accordance with a water temperature enhancement protocol that Penelec will develop in consultation with MDNR. MDNR and Penelec estimate that temperature enhancement releases will be required an average of about 21 days per year (Versar Inc., 1992).

(c) Enhancement of Whitewater Boating Opportunities. Penelec will schedule generation to increase whitewater boating opportunities from April 15 through October 15. Generation may be restricted if natural Youghiogheny River flows are navigable (600-2500 cfs at Friendsville as estimated using the Oakland gage). If natural flows are between 1300 and 2500 cfs, generation will be restricted to after 1:00 p.m. when lake levels are between 2461.0 feet and the Lower Rule Band (between Upper and Lower Rule Bands during the period April 15-30). When two-unit generation is scheduled, but would cause flow in the Youghiogheny River to be above the optimum level (i.e., 1000-1200 cfs), Penelec will operate one unit only for at least three hours upon receiving a telephone request from designated representatives of the whitewater boaters. When natural flows at the Oakland gage are 80 cfs or less (approximately 100 cfs at Deep Creek Station), generation will be at maximum capacity (estimated 640 cfs) to ensure the minimum suitable river flow.

In other circumstances when lake levels are between the rule bands, the proposed operating rules provide that the first three hours of scheduled generation be consecutive hours occurring during times that will provide additional boating opportunities.

Specifically, Deep Creek Station will generate from 10:00 a.m. to 1:00 p.m. every Friday and Monday, and for one designated Saturday per month from April 15 to October 15 provided the Deep Creek Lake level is above the Lower Rule Band, and the natural Youghiogheny River flows are less than 600 cfs. When natural Youghiogheny River flows are in the 600 - 1300 cfs range, Deep Creek Station will generate from 11:00 a.m. to 2:00 p.m. on designated whitewater release days. Monday and Saturday releases will be discontinued when the lake level is below the Lower Rule Band. Friday releases will be discontinued when the lake level is one foot or more below the Lower Rule Band. The schedule for

Saturday whitewater releases will be the last Saturday in April, the Saturday before Memorial Day, and the first Saturday of June, July, August, September, and October, unless the MDNR directs otherwise.

Penelec proposes to schedule releases for the "August race day" and on weekdays during the week of the "Gauley River Festival" if a request is made by the MDNR one month in advance of such event, provided the lake level is above the Lower Rule Band.

(d) Energy Generation Needs

(i) Operation When Deep Creek Lake Elevation Is Higher Than Upper Rule Band. When lake elevation exceeds the Upper Rule Band, generation will generally be unlimited. In addition, certain amounts of generation are required as presented on Figures 4-2 through 4-13, including: (a) continuous generation when the lake is above El. 2461.4 ft. to minimize the probability of spill; and (b) continuous generation when the lake level exceeds El. 2457.9 ft. during December, January and February to avoid ice loading pressures against the spillway. Continuous generation is also required in March if the lake level exceeds El. 2457.9 ft. as long as there is a solid ice cover on the lake.

(ii) Operation When Deep Creek Lake Elevation Is Between Rule Bands. When Deep Creek Lake elevation is between the rule bands, there will be no limitations to generation from October 15 through March. Generation from April 1 to April 14 will be limited to 12 unit-hours per day. Generation from April 15 through October 15 will be based on Youghiogheny River flows, water temperature and the designated whitewater release schedule and will be limited to 12 unit-hours per day. The first three hours of scheduled daily generation will be continuous and will occur during times usable by whitewater boaters.

(iii) Operation When Deep Creek Lake Elevation Is Below the Lower Rule Band. From October 15 through February, generation will be a maximum of 4 unit-hours per day if the Deep Creek Lake elevation is below the Lower Rule Band by less than 1.0 foot; if the lake level is one foot or more below the Lower Rule Band, no generation will be permitted. From March through October 15, no generation will be permitted except for the Friday releases for whitewater boating and the temperature enhancement releases; at one or more feet below the Lower Rule Band, the Friday release for whitewater boating will be eliminated.

(e) Maximum Summer Lake Level Decrease. To maintain stable and adequate lake levels for summer recreation, generation will be restricted to limit lake drawdown to no more than 1.25 feet per month (from the first of the month) during June, July, August and September. If the lake level decreases by more than 1.25 feet from the beginning of the month during any of these months, only generation for temperature enhancement and Friday whitewater boating will be permitted for the remainder of that month.

(f) Spring Storage. The Upper and Lower Rule Bands are designed to enhance the prospects of filling Deep Creek Lake by the end of May and to provide for whitewater boating opportunities commencing April 15. Storage during the March, April, and May period will have an incidental benefit of reducing walleye and perch fry entrainment in Deep Creek Lake.

4.1.4 Project Operation Simulation

Penelec simulated monthly project operations with the proposed operating rules (i.e., Upper and Lower Rule Band, 40 cfs minimum instream flow, temperature enhancement, whitewater boating releases on Fridays, Mondays, and designated Saturdays and maximum 1.25 feet monthly drawdown June, July, August, and September) assuming historic inflow for the period 1962 to 1992 (Appendix D). Project operations were simulated assuming 10 hours generation per month for emergency conditions. (Actual emergency generation has averaged less than 4 hours per month from 1984-1992.)

The results indicated that under the proposed operating rules Deep Creek Lake will fill to at least 2459.1 feet by the end of May, and more typically will average about 2460.8 feet. Summer lake levels will be significantly higher than the historic (1962-1992) average (Figure 4-14).

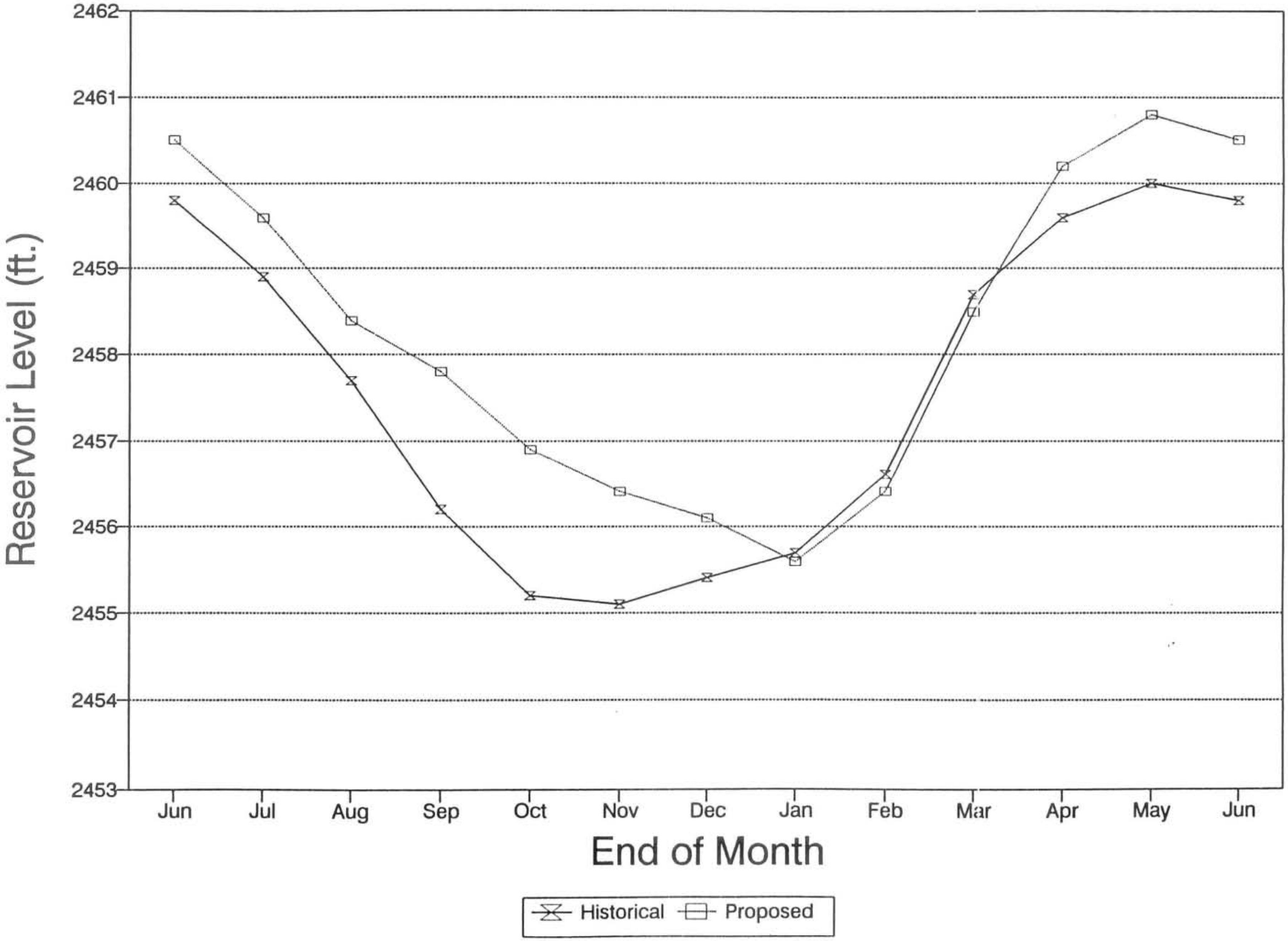
4.2 PROPOSED YOUGHIOGHENY RIVER WATER QUALITY ENHANCEMENT

4.2.1 Dissolved Oxygen

As discussed in Section 3.5.3, releases of water for hydroelectric generation at Deep Creek Station have a pronounced impact on dissolved oxygen (DO) in the Youghiogheny River. When conditions of hypolimnetic oxygen depletion exist in Deep Creek Lake, DO levels during generation have been measured as low as 3 mg/l after startup. During startup, DO concentrations as low as zero have been observed for the first 12 minutes (with two-unit generation).

Penelec conducted a feasibility study of alternative means of meeting Maryland State dissolved oxygen standards of 5 mg/l instantaneous and 6 mg/l average in the river over a 24-hour period

Figure 4-14 Monthly Lake Levels



(Appendix E). A tailrace weir and an oxygen injection system were identified as the most promising alternatives. A tailrace weir with an effective head of approximately 3 feet during high tailwater conditions is proposed to meet the following design criteria: (1) increase the DO concentration in the tailrace to 5 mg/l when the DO concentration is 2 mg/l (minimum measured DO concentrations during project operations are about 3 mg/l), and (2) increase DO concentration by at least 4 mg/l when DO concentrations are close to zero during the startup period. Maintaining a DO concentration in the tailrace of 6 mg/l during generation was considered unnecessary because the natural DO concentration in the river during non-generation periods is high enough to maintain a 6 mg/l average concentration over a 24-hour period. During extremely rare conditions of (1) a lake level above 2461.0 feet, and (2) Deep Creek Lake stratification, Deep Creek Station would operate for between 16 and 24 hours per day and the average DO concentration in the river could fall below 6 mg/l. However, under such conditions, there would usually be high flows in the Youghiogheny River and the DO levels in the river would not be of significant concern.

The tailrace weir will be located in the tailrace channel within the first 150 feet of the tailrace downstream of the powerhouse. The weir will have a "W" shape in order to accommodate its 430-foot length within the 40-foot width of the tailrace channel. The weir will be approximately 8.4 feet high, with the crest at El. 2028 feet. The weir will cause a reduction in energy production of about one percent.

Releases with very low DO concentrations in the power tunnel may remain below 5 mg/l immediately downstream of the tailrace weir for a few minutes during startup, particularly when Youghiogheny River levels are high, causing a low effective head on the weir. The DO concentration of release waters will be a minimum of 4 mg/l after passing over the weir, except for unusual circumstances of extremely low DO concentrations and high Youghiogheny River flow conditions.

In order to increase the DO concentration of the generation releases to 5 mg/l for all conditions during the startup period, the weir height would need to be increased by an additional 2.8 feet, thereby resulting in additional energy losses (i.e., an additional 0.7 percent). The higher weir is not justified because the minor additional fisheries benefits from the higher DO concentrations (i.e., about one mg/l) would occur for only a few minutes at the start of each release.

During the period of stratification, the minimum DO concentrations at startup typically will be about 5 mg/l when Youghiogheny River flows are between 600 and 1300 cfs. This is due to the fact that one unit generation only will normally be requested by whitewater boating representatives when Youghiogheny River flows are between 600 and 1300 cfs. The lower tailwater levels below the weir stemming from one unit generation with resulting higher effective head over the tailrace weir, and improved reaeration efficiency from the reduced discharge per unit length of weir, will enhance DO concentrations.

The tailrace weir is superior to oxygen injection because of its enhanced reliability and minimal maintenance requirements. Although oxygen injection tests at other projects have achieved satisfactory results, operating experience is limited and long term maintenance requirements unknown. Electronic and mechanical component failures could result in prolonged non-attainment of State DO standards. In the event of a failure of the oxygen injection system, shutdown of the plant to maintain the system would curtail temperature and whitewater boating releases.

4.2.2 Temperature

As discussed in Section 3.5, operation of the project has a substantial effect on river temperatures, at least as far downstream as Sang Run. During cold weather in winter, 4°C water discharged from the project raises the river water temperatures, which are often near 0°C when air temperatures are below 0°C. During summer, releases cause a dramatic and rapid decline in river water temperature downstream of the project tailrace, with the temperature drop often on the order of 10 C°. It takes about two hours for a two-unit release to reach Sang Run.

MDNR personnel have identified that the 9 cfs leakage from Deep Creek Station during non-generation periods provides cold water refugia for trout in the river downstream to Hoyes Run. Lethal or near-lethal water temperatures (26-27°C) for trout have been observed in the Youghiogheny River between Hoyes Run and Sang Run when flows less than 100 cfs occur during hot weather. The high water temperatures have occurred after 1:00 p.m., with peak temperatures occurring about 6:00 p.m.

4.2.2.1 Water Temperature Enhancement

Potential ways to enhance trout survival during periods of critical temperatures in the Youghiogheny River downstream from the Deep Creek Station tailrace include providing additional cool water through power generation or through supplemental flow releases via a bypass around the powerhouse.

Modeling analysis conducted by MDNR's consultant, Versar Inc., suggests that there could be several possible generation release scenarios that could maintain river water temperatures at or below 25°C between the Deep Creek tailrace and Sang Run. Experience indicates that during daylight hours water temperature at Sang Run increases about 1°C per hour under high temperature conditions. In 1991, Penelec tested a number of generation release alternatives during low flow and hot weather conditions to determine the most effective method for enhancing water temperatures (Appendix F). Penelec concludes from the test releases, that a two-hour, two-unit release commencing between 10:00 a.m. and 11:00 a.m. is sufficient to keep water temperatures at or below 25°C at Sang Run.

The river water temperature modeling performed by Versar Inc. indicates that a bypass flow of up to 100 cfs would be required to maintain river water temperatures at or below 25°C at Sang Run. Based on worst case conditions that occurred on July 22-23, 1987, a release of approximately 100 cfs would be required for ten hours to maintain water temperatures at or below 25°C at Sang Run throughout the day. The additional capital cost of a 100 cfs bypass system, and its adverse effects on energy generation and whitewater boating opportunities, render this option less attractive than the alternative of enhancing water temperatures through project operation.

4.2.2.2 Procedure For River Water Temperature Enhancement Through Project Generation

Penelec proposes to operate Deep Creek Station to attempt to maintain water temperatures at or below 25°C in the reach between the Deep Creek tailrace and Sang Run. Penelec will monitor flow in the Youghiogheny River. Early morning on each day in the period June through August, when river flows are below 80 cfs at the Oakland gage (i.e., about 100 cfs at Deep Creek Station), Penelec will predict the likely maximum water temperature at Sang Run using a method to be developed in consultation with MDNR. If the predicted daily maximum water temperature at Sang Run exceeds 25°C, both units will be operated for two hours commencing at 10:00 a.m. (Based on modeling studies conducted by Versar, Inc., generation may need to begin not earlier than 10:30 a.m. to ensure that water temperatures remain at or below 25°C. If this method does not keep water temperatures at or below 25°C, Penelec will modify the release times so that they begin not earlier than 10:30 a.m.) Otherwise, Penelec will continue monitoring water temperatures at intervals through 3:00 p.m., and if necessary, operate the project for up to two hours with both units in an attempt to keep temperatures at or below 25°C.

4.3 PROPOSED YOUGHIOGHENY RIVER LOW FLOW ENHANCEMENT

Penelec proposes to construct a flow bypass around Deep Creek Station to augment low flows in the Youghiogheny River to enhance brown trout habitat in the river below the tailrace (see Appendix G). The bypass pipe will run from the Unit 2 penstock around the west side of the powerhouse to discharge into the tailrace channel upstream of the proposed tailrace weir. A Polyjet valve will control the flow rate and dissipate energy prior to discharge into the tailrace.

Penelec proposes to maintain a minimum flow of 40 cfs in the Youghiogheny River at the Deep Creek Station tailrace. This will be accomplished by accessing the Corps of Engineers' "River Bulletin Board" via a modem to determine the Youghiogheny River flow at Oakland. The river flow at Oakland will be adjusted to the Deep Creek tailrace site using the equation $Q_{DC} = 1.68 \times Q_O^{0.97}$, where Q_{DC} is the estimated flow at Deep Creek in cfs and Q_O is the flow at Oakland. The equation was derived by interpolation of the flow correlation between the Oakland and Friendsville gages, according to the drainage area at the tailrace site. If the estimated river discharge at Deep Creek Station is less than 40 cfs, the flow will be augmented by the bypass flow to ensure a minimum of at least 40 cfs immediately downstream of the tailrace. Under normal present operations, there is a continuous leakage flow (estimated at 9 cfs) during non-generation periods; if present this leakage flow will be counted as part of the flow augmentation. Penelec will adjust the flow twice daily to ensure that the 40 cfs minimum is maintained and that unnecessary releases are minimized.

Penelec considered a new gaging station either upstream or downstream of the tailrace. A new gaging system would provide the most accurate flow data, but it would cost upwards of $20,000 to install the gage and a weir for measuring low flows, and develop a rating curve. Penelec believes it is sufficiently accurate and more cost effective to use the existing gage at Oakland.

Penelec considered and rejected the concept of adding a small turbine to the bypass line. The infrequent operation of such a turbine would make it uneconomic.

4.4 RECREATIONAL RESOURCE ENHANCEMENT

Deep Creek Lake and the Youghiogheny River are and will continue to be very popular regional recreational resources. Penelec believes that the proposed project operating rules will enhance the lake and river recreational resources (see Section 4.1.3).

4.4.1 Deep Creek Lake Recreation

Penelec recognizes the importance of water based recreation at Deep Creek Lake and proposes operating rules designed to fill Deep Creek Lake to a minimum elevation of 2460 feet by the end of May. The operating rules are designed to keep the lake levels high during the summer and early fall, drawing the lake down slowly during the months of June, July and August. The lake level will permit boating to take place through Autumn Glory days (i.e., mid October). Although lake levels could fall below 2458 feet during the month of September, the lake levels will be sufficiently high to permit the use of existing boat ramps.

4.4.2 Youghiogheny River Whitewater Boating

Penelec proposes to increase the number of usable whitewater boating opportunities in the upper Youghiogheny River from April through October 15. These measures are described in Section 4.1.3. Penelec proposes to operate Deep Creek Station in a manner that permits the whitewater boaters to take maximum advantage of natural flows by (a) not operating at times when natural flows are "boatable" and operation would make the flows dangerous to boating (i.e., between 1300 cfs and 2500 cfs) and (b) operating one unit when requested to do so by the whitewater boating representatives when flows are between 600 and 1300 cfs. Operating in this manner, limiting the number of hours of daily operation from April through October 15, and committing to boatable releases on Fridays, Mondays, and designated Saturdays will enhance boating, particularly during the months of June, July, and August.

Releases for temperature enhancement may provide additional whitewater boating opportunities since they will occur during "boatable" hours. Penelec was asked to consider scheduling temperature releases one or two days in advance, to increase the opportunity for boaters to use the releases. However, the uncertainty of predictions 24 or 48 hours in advance of temperature enhancement releases is too great to make the predictions reliable. Many unnecessary releases could be made if the predicted water temperatures do not materialize after a water temperature release has been scheduled. Therefore, Penelec proposes to focus on predicting a release during the morning hours, no more than three hours before a potential release. This would probably permit only those recreationists within a two-three hour drive of the Youghiogheny River to take advantage of these releases.

Penelec intends to provide a recorded message service for <u>all</u> scheduled daytime releases. Late day releases will be announced for the information of other interested recreational users. "Forecast" release information will be placed on the recorded message each Thursday for the following week and "scheduled" release information for each day will be placed on the recorded message between 7:00 a.m. and 8:00 a.m. Note, however, that Penelec may need to cancel releases if unforeseen circumstances occur (e.g., occurrence of a system emergency earlier in the week or unplanned maintenance outage).

4.4.3 Angler Safety

In order to warn anglers of the risk associated with rapidly rising water when generation commences, Penelec plans to post warning signs at Hoyes Run and strategic locations, selected in consultation with MDNR.

4.5 OTHER RESOURCE ENHANCEMENTS

4.5.1 Fish Resources in Deep Creek Lake

Only limited opportunities are available for improving or enhancing the Deep Creek Lake fishery. Storage during the March, April, and May period may result in a reduction in hydroelectric power generation during this period when larval walleye and perch are most susceptible to entrainment.

Fluctuations in reservoir levels were not identified as having an adverse effect on lake spawning. Nonetheless, Penelec's proposed operational changes will lead to less drawdown in the summer and fall than has historically occurred. Reservoir drawdown may, however, be more rapid in late fall, but this will occur at a time when drawdown is not likely to adversely affect the fishery resource.

4.5.2 Historical and Archeological Resources

Penelec contacted the Maryland State Historic Preservation Officer (SHPO) in 1989-91 to determine the resource issues that were of concern to the SHPO. The SHPO noted the need for a comprehensive study of archeological resources in the Deep Creek vicinity (letter from William Pencek, Chief, Office of Preservation Services, Maryland Historical Trust, May 4, 1989). (Thirty-four prehistoric sites had previously been discovered along the reservoir shoreline and reported to the Maryland Geological Survey in 1970.) However, during subsequent discussions, the SHPO informed Penelec that no further studies were needed from Penelec and that no further analysis of the 34 prehistoric sites other than the site reconnaissance already conducted by Penelec was necessary (personal communication Dr. Ethel Eaton, Maryland Historic Trust, January 8, 1990 and personal communication, Elizabeth Cole, Maryland Historic Trust, March 8, 1991).

Deep Creek Station is probably not eligible for the National Register of Historic Places (NRHP), but may be historically significant within the more limited State context. Therefore, any proposed major alterations to the building's interior or exterior would be assessed for their possible effect on the structure's architectural/aesthetic integrity.

Maintaining higher Deep Creek Lake water levels than occurred historically may cause accelerated erosion of reported prehistoric sites at the lake shore (see Figure 4-14); however, none of these has been shown to be NRHP-eligible. Should accelerated erosion begin to occur along the shoreline because of the higher water levels, Penelec would consult MDNR and the SHPO to develop remedial measures.

4.5.3 Endangered and Threatened Species

Federally listed and State-listed endangered, threatened, and rare species within the project area are a main concern of the resource agencies. The only such species known to occur within the immediate project area are the stonecat, hellbender, mudpuppy, cheat minnow, southern water shrew, and the planarian. These are all aquatic species. Current project operations are not known to adversely affect any such species.

However, the Maryland Heritage Program is concerned that low dissolved oxygen concentration below the plant tailrace may affect the hellbender population in the river near the project (personal communication Ed Thomson, Maryland Heritage Program, January, 1991).

The dissolved oxygen enhancement of the powerplant discharges would be beneficial to the hellbender and mudpuppy populations in the Youghiogheny River because these species prefer well-oxygenated water at moderate flows. Also, the proposed minimum flow maintenance will improve habitat conditions.

5.0 PUBLIC INTEREST CONSIDERATIONS

The proposed operating rules for Deep Creek Station recognize four important purposes in addition to power generation: (1) recreational boating at Deep Creek Lake, (2) enhancement of brown and rainbow trout habitat in the Youghiogheny River between the project tailrace and Sang Run, (3) whitewater boating in the Youghiogheny River, and (4) walleye and perch enhancement in Deep Creek Lake (see Section 4). These purposes are sometimes complementary and sometimes in competition with power generation and with each other. The proposed project operating rules try to balance the needs of each of these purposes to best serve the public interest. This section summarizes the water requirements of each purpose and presents Penelec's viewpoint on how the proposed project operation is in the public interest.

5.1 DESIRED OPERATING OBJECTIVES

For maximum benefit to Penelec's customers, the project should be operated as a peaking hydroelectric plant. The large volume of storage in the lake generally permits Penelec to utilize the limited amount of water for generation during hours of high demand for electricity, when the value of electricity is relatively high and the plant's electric generating capacity is most needed. The plant needs to be capable of being dispatched during a system emergency. In general the value of peaking energy tends to be higher during the summer and winter than the spring and fall. However, unusual weather conditions and maintenance and emergency outages of large thermal power plants during spring and fall can affect the relative value of peak generation.

To provide satisfactory conditions for recreational boating at Deep Creek Lake, lake levels should be kept above 2458 feet from early May through mid October. Boat ramps at Deep Creek begin to reach the end of their operating ranges at elevation 2458 feet, although a number of ramps are operable for launching and boat removal at lower levels. As the lake level decreases from an optimum recreation level of about 2461 feet, shallow areas, particularly coves, can become too shallow for boating and docking of boats. Difficulties with these areas become increasingly worse as levels drop below 2458 feet. Also, in order to minimize the potential for grounding of docked boats during lowering of lake levels, lake levels should be lowered gradually to allow time for dock owners to adjust their docks or move their boats if their docks are not adjustable.

Enhancement of the fishery resource for brown and rainbow trout in the Youghiogheny River downstream of the project tailrace can be achieved by (1) augmenting low natural Youghiogheny River flows via continuous flow releases at Deep Creek Station and (2) releasing cool water during hot weather, low flow conditions via project generation releases. Typically, low river flows occur between late June and early November, and the hot weather conditions occur in June, July, and August.

Normally, generation at Deep Creek Station is required to make the Youghiogheny River suitable for whitewater boating. Two-unit generation of Deep Creek Station for two or more hours is normally required for satisfactory whitewater boating conditions, with a three-hour release being preferred. With higher Youghiogheny River flows, satisfactory whitewater boating flows can be achieved with only one unit generation. At even higher Youghiogheny River flows, generation releases can make the river unsuitable for boating. Advanced notice of generation is also desirable so that the whitewater boaters can take full advantage of project generation releases.

Enhancement of the walleye and perch fishery in Deep Creek Lake can be accomplished by reducing entrainment through reduced power generation during the larval life stage of these fish. This period typically occurs from late March through May.

5.2 BALANCING OF OPERATING OBJECTIVES

The proposed operating rules described in Section 4 are the result of comprehensive studies of the effects of alternative operating strategies to meet the objectives described above. The studies accounted for natural variations in inflow into Deep Creek Lake and lake evaporation. The proposed operating strategies to best meet each purpose were combined and balanced to best meet the needs of all the purposes.

The several purposes are best served if the lake is full at the beginning of summer. Accordingly, the operating rules limit generation during the April and May period to increase the likelihood that the lake will fill to elevation 2461 feet by the end of May. The operating rules will normally result in the lake being filled by the end of May. Based on 30 years of flow simulations, Deep Creek Lake would fill to about 2458.2 feet during an extremely dry spring. An operating plan that would fill the lake to 2461 feet in all years would severely restrict the drawdown and power generation in the winter. Furthermore, during years with normal and high inflow into Deep Creek Lake, substantial generation could be required during the spring to prevent flow from being discharged over the spillway. Such operation would not best meet power generation needs, would increase walleye and perch larval entrainment, and could have an adverse effect on whitewater boating if the combination of operational flows and natural river flows make the river flow too high for whitewater boating. Even with the minimum end of May lake level of 2458.2 feet during an extremely dry sequence, the analysis of 30 years of flow data indicates that Deep Creek Lake levels would remain high enough during the summer months to support water-based recreation.

During the June through October period, if lake levels are below the lower rule band, releases for cool water temperatures and minimum flows in the Youghiogheny River will have a higher operating priority than scheduled generation, releases for whitewater boating, and higher lake levels. The optimum maximum water temperature for adult brown trout is about 22°C. In selecting the minimum flow and maximum desired water temperature in the Youghiogheny River, consideration was given to the effects that these fishery enhancements would have on the other objectives, most notably power generation, lake recreation, and whitewater boating. A minimum Youghiogheny River flow of 40 cfs (as measured immediately downstream of the tailrace) and a maximum river temperature of 25°C were selected.

A minimum flow of 40 cfs provides about 48 percent of the maximum habitat for adult brown trout in the reach between the tailrace and Sang Run. A flow of 60 cfs would provide 60 percent of the maximum habitat, but during a summer with very low flows would lower Deep Creek Lake by an additional foot relative to a 40 cfs minimum flow over the June, July, August period. For an extremely dry year such as occurred in 1965, the Deep Creek Lake level would be at about 2456.5 feet at the end of August. Also, the incremental flow of 20 cfs (over the proposed 40 cfs minimum flow) would reduce project generation by about 77 hours and would reduce the number of whitewater boating opportunities.

Water temperature enhancement through project operation permits whitewater boating and power generation. Even during severe temperature conditions such as occurred in 1991, lake levels could be maintained above 2458 feet through the end of September with a water temperature threshold of 25°C. Trying to keep water temperatures below 22°C would require a substantial increase in the number and duration of releases and lower lake levels.

During dry summers when water demands on Deep Creek Lake are greatest and lake levels are low, lake recreation would be enhanced by minimizing dewatering of shallow areas and maintaining adequate depths for boat ramps. This requires that generation be curtailed, except during emergency situations, when lake levels reach threshold levels. The threshold levels (i.e., lower rule band) were developed to permit releases for downstream water temperature enhancement and minimum downstream flows to be continued. Therefore, as the summer progresses, the lower rule band continuously decreases. During the thirty year simulation of project operations, summer and fall lake levels stayed within acceptable levels during most years, and above historical levels. During years with very low flows, lake levels will not be at optimum levels, but will be at acceptable levels for the majority of lake users.

In order to conserve water during dry periods and prevent grounding of boats docked in shallow areas, drawdown will be limited to a maximum of 1.25 feet per month. This drawdown is typically sufficient to accommodate lake evaporation, releases for water temperature enhancement, minimum downstream flows, whitewater boating releases on Fridays and designated Saturdays (see below), and emergency power generation.

Whitewater boating will be enhanced through provision of scheduled releases on Fridays and one designated Saturday each month for the May - September period. These scheduled whitewater releases will be from 10 a.m. to 1 p.m. The Saturday releases will be curtailed during dry periods if Deep Creek Lake is below the lower rule band in order to conserve water and maintain suitable lake levels for recreation. At one or more feet below the lower rule band, the Friday releases will be curtailed to conserve water.

Advance notice of project generation at other times will be accomplished by providing a weekly recording of scheduled releases each Tuesday for the following week. However, the project generation may be modified if circumstances surrounding the schedule projections change during the week, such as unexpected operation for emergency generation.

Generation will be restricted during prime whitewater boating hours when natural flows or natural flows plus the flow from one unit operation are in the boatable range. In this way, whitewater boaters will be able to take maximum advantage of project generation.

In summary, Penelec has considered the available water resource and developed proposed operating rules that are believed to reflect the best public interest. Penelec's proposed operating rules will protect the interests of Penelec's customers, provide suitable lake recreation levels, enhance the downstream fishery through minimum flow releases and water temperature control, enhance whitewater boating by providing dependable flows and increasing the number or whitewater boating opportunities, and enhance the walleye and perch fishery in Deep Creek Lake.

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APPENDIX A

FISH ENTRAINMENT STUDIES

Table A-1. Yellow perch larvae sampling results for Deep Creek Lake and tailrace discharge.

Date	Sample[a/] Station	Minutes Sampled	Estimated Sampled[b/] Volume (m^3)	Depth (m)	Total Larvae Collected	Density (10 m^3)	Mean Length[c/] (mm)
5-Apr-90	B	5	02.72	1.5	0	0.0	0 (0)
5-Apr-90	B	1	00.54	2.0	0	0.0	
5-Apr-90	B	4	02.18	2.5	0	0.0	
5-Apr-90	C	5	02.72	1.0	0	0.0	0 (0)
5-Apr-90	C	5	06.36	2.5	0	0.0	
5-Apr-90	C	4	02.18	4.0	0	0.0	
5-Apr-90	D	5	02.72	1.0	0	0.0	0 (0)
5-Apr-90	D	5	02.72	2.5	0	0.0	
19-Apr-90	A	5	03.03	1.0	0	0.0	0 (0)
19-Apr-90	A	4	02.18	3.0	0	0.0	
19-Apr-90	A	5	04.13	6.0	0	0.0	
19-Apr-90	B	5	03.79	1.0	0	0.0	0 (0)
19-Apr-90	B	5	02.95	3.0	0	0.0	
19-Apr-90	C	5	03.54	1.0	1	2.8	6.60 (2)
19-Apr-90	C	5	02.86	3.0	1	3.5	
19-Apr-90	C	5	03.47	6.0	0	0.0	
19-Apr-90	D	5	03.99	1.0	0	0.0	0 (0)
19-Apr-90	D	5	03.32	3.0	0	0.0	
19-Apr-90	D	5	03.20	6.0	0	0.0	
2-May-90	A	5	02.72	1.0	1	3.7	7.64 (5)
2-May-90	A	5	01.32	3.0	4	30.4	
2-May-90	A	5	01.50	6.0	0	0.0	
2-May-90	B	5	02.48	1.0	40	161.4	7.82 (88)
2-May-90	B	5	02.90	3.0	22	75.8	
2-May-90	B	5	02.76	3.0	27	97.8	
2-May-90	C	5	02.72	1.0	33	121.3	7.78 (48)
2-May-90	C	5	01.92	3.0	8	41.6	
2-May-90	C	9	02.08	6.0	0	0.0	
2-May-90	D	5	02.72	1.0	0	0.0	7.94 (18)
2-May-90	D	5	02.72	3.0	18	66.2	
2-May-90	D	5	02.72	6.0	1	3.7	
10-May-90	A	5	02.14	1.0	0	0.0	8.80 (4)
10-May-90	A	5	01.72	3.0	3 (1)[d/]	17.4	
10-May-90	A	5	03.34	6.0	1	3.0	
10-May-90	B	5	03.03	1.0	1	3.3	9.10 (14)
10-May-90	B	5	02.88	3.0	15	52.0	
10-May-90	C	5	03.38	1.0	0	0.0	8.81 (12)
10-May-90	C	5	02.98	3.0	6	20.2	
10-May-90	C	5	02.72	6.0	7	25.8	
10-May-90	D	5	02.96	1.0	0	0.0	9.50 (2)
10-May-90	D	5	03.93	6.0	2	5.1	
17-May-90	A	5	02.72	1.0	0	0.0	0 (0)

Table A-1. (Continued)

Date	Sample[a/] Station	Minutes Sampled	Estimated Sampled[b/] Volume (m^3)	Depth	Total Larvae Collected	Density (10 m^3)	Mean Length[c/] (mm)
17-May-90	A	5	02.72	3.0	0	0.0	
17-May-90	A	5	02.72	6.0	0	0.0	
17-May-90	B	5	02.22	1.0	1	4.5	10.72 (4)
17-May-90	B	5	03.01	3.0	4	13.3	
17-May-90	C	5	03.45	1.0	8	23.2	11.08 (20)
17-May-90	C	5	04.25	3.0	11	25.9	
17-May-90	C	5	02.27	6.0	4	17.6	
17-May-90	D	5	03.61	1.0	0	0.0	11.60 (3)
17-May-90	D	5	02.69	3.0	3	11.2	
17-May-90	D	5	02.34	6.0	0	0.0	
24-May-90	A	5	02.10	1.0	2	9.5	10.24 (3)
24-May-90	A	5	02.48	3.0	1	4.0	
24-May-90	A	5	02.27	6.0	0	0.0	
24-May-90	B	5	01.96	1.0	0	0.0	11.13 (3)
24-May-90	B	5	02.64	3.0	3	11.3	
24-May-90	C	5	02.13	1.0	0	0.0	11.65 (2)
24-May-90	C	5	02.68	3.0	2	7.5	
24-May-90	C	5	02.16	6.0	0	0.0	
24-May-90	D	5	02.35	1.0	0	0.0	11.60 (1)
24-May-90	D	5	04.73	3.0	2	4.2	
24-May-90	D	5	02.02	6.0	0	0.0	
31-May-90	A	5	02.21	1.0	0	0.0	12.78 (5)
31-May-90	A	5	02.86	3.0	2	7.0	
31-May-90	A	5	02.91	6.0	4	13.8	
31-May-90	B	5	02.22	1.0	0	0.0	15.60 (1)
31-May-90	B	5	02.39	3.0	3	12.6	
31-May-90	C	5	01.83	1.0	0	0.0	15.60 (1)
31-May-90	C	5	02.22	3.0	1	4.5	
31-May-90	C	5	01.59	6.0	0	0.0	
31-May-90	D	5	01.92	1.0	3	15.6	15.53 (4)
31-May-90	D	5	02.18	3.0	1	4.6	
31-May-90	D	5	01.78	6.0	0	0.0	
14-Jun-90	A	5	04.55	1.0	0	0.0	0 (0)
14-Jun-90	A	5	02.45	3.0	0	0.0	
14-Jun-90	A	5	02.71	6.0	0	0.0	
14-Jun-90	B	5	02.34	1.0	0	0.0	0 (0)
14-Jun-90	B	5	02.27	3.0	0	0.0	
14-Jun-90	C	5	02.77	1.0	0	0.0	0 (0)
14-Jun-90	C	5	02.87	3.0	0	0.0	
14-Jun-90	C	5	02.72	6.0	0	0.0	
14-Jun-90	D	5	02.48	1.0	0	0.0	0 (0)
14-Jun-90	D	5	02.40	3.0	0	0.0	
14-Jun-90	D	6	04.42	6.0	0	0.0	

Table A-2. Continued.

Date	Net Location a/	Start Time	End Time	Species	Number b/	Length(mm)	Body Parts	Comment
31 Aug	2	0900	1525	Marked (Yellow)	9	--	Whole	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Marked (Yellow)	3	--	Heads	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Marked (Yellow)	4	--	Other	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Marked (Red)	9	--	Whole	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Marked (Red)	6	--	Heads	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Marked (Red)	4	--	Other	Efficiency test fish (minnows: 60-100mm)
31 Aug	2	0900	1525	Yellow Perch	1	55	Whole	Underyearling, no generation 9/1/90
10 Oct	1	1815	2100	Largemouth Bass	1	51	Whole	Underyearling, night sample.
10 Oct	2	1815	2100	No Fish	0	--	--	Night sample.
11 Oct	1	0900	1300	No Fish	0	--	--	Night sample.
11 Oct	2	0900	1300	No Fish	0	--	--	Night sample.
11 Oct	1	1800	2000	Largemouth Bass	1	108	Whole	Underyearling, night sample.
11 Oct	1	1800	2000	Largemouth Bass	1	71	Whole	Underyearling, night sample.
11 Oct	2	1800	2000	Sunfish	1	64	Whole	Underyearling, night sample.
11 Oct	2	1800	2000	Sunfish	1	44	Whole	Underyearling, night sample.
27 Nov	1	1600	2000	No Fish	0	--	--	Night sample.
27 Nov	2	1600	2000	No Fish	0	--	--	Night sample.
28 Nov	1	0700	1100	Black Crappie	1	93	Whole	
28 Nov	1	0700	1100	No Fish	0	--	--	Night sample.

a/ Net location numbers 1 to 4 for the four turbine discharge openings at the powerhouse.
b/ Only fish entrained, does not include resident river fish captured.

Table A-2. Juvenile and Adult Fish Entrainment Sampling at Deep Creek Lake Powerhouse Discharge.

Date	Net Location a/	Start Time	End Time	Species	Number b/	Length(mm)	Body Parts	Comments
10 May	1	1005	1057	Yellow Perch	1	40	Whole	Initial test, not used for entrainment estimates.
10 May	2	0955	1057	No fish	0	--	--	Initial test, not used for entrainment estimates.
11 May	1	0904	1200	Yellow Perch	68	50-87	Whole	Yearling.
11 May	1	0904	1200	Pumpkin Seed	1	80	Whole	
11 May	2	0906	1200	Yellow Perch	84	--	Whole	Yearling.
18 May	3	1125	1300	Yellow Perch	1	31	Whole	
18 May	4	1135	1300	Walleye	1	350	Whole	Signs of Turbine Blade Impact.
25 May	1	1023	1200	No fish	0	--	--	
25 May	2	1027	1200	No fish	0	--	--	
10 July	2	2000	2200	No fish	0	--	--	Net 3 fished, tangled with no fish; data not used.
11 July	3	0930	2200	Yellow Perch	78	--	--	Most less than 50mm long, underyearlings.
11 July	3	0930	2200	Rainbow Trout	1	381	Whole	Net 2 fished, ripped with no fish; data not used.
11 July	3	0930	2200	Rainbow Trout	1	--	Head	Head length 64mm.
11 July	3	0930	2200	Largemouth Bass	1	--	Head	Head length 76mm.
31 Aug	1	0900	1525	Marked (Yellow)	7	--	Whole	Efficiency test fish (minnows: 60-100mm)
31 Aug	1	0900	1525	Marked (Yellow)	2	--	Heads	Efficiency test fish (minnows: 60-100mm)
31 Aug	1	0900	1525	Marked (Yellow)	3	--	Tails	Efficiency test fish (minnows: 60-100mm)
31 Aug	1	0900	1525	Marked (Red)	4	--	Whole	Efficiency test fish (minnows: 60-100mm)
31 Aug	1	0900	1525	Marked (Red)	5	--	Heads	Efficiency test fish (minnows: 60-100mm)
31 Aug	1	0900	1525	Marked (Red)	3	--	Tails	Efficiency test fish (minnows: 60-100mm)

Table A-1. (Continued)

Date	Sample Station[a/]	Minutes Sampled	Estimated Sampled Volume (m^3)[b/]	Depth	Total Larvae Collected	Density (10 m^3)	Mean Length (mm)[c/]
20-Apr-90	T(1)	37	22.42	-	0	0.0	0 (0)
20-Apr-90	T(2)	35	18.11	-	0	0.0	0 (0)
11-May-90	T(1)	62	29.15	-	145	49.7	9.36 (24)
11-May-90	T(2)	59	27.74	-	45	16.2	9.38 (44)
18-May-90	T(1)	60	28.21	-	67	23.8	10.50 (66)
18-May-90	T(2)	15	07.05	-	14	19.9	10.58 (13)
25-May-90	T(1)	60	28.21	-	54	19.1	12.02 (62)
25-May-90	T(2)	22	10.34	-	12	11.6	11.87 (11)
1-Jun-90	T(1)	60	13.14	-	16	12.2	12.03 (15)
1-Jun-90	T(2)	30	13.13	-	5	3.8	13.32 (4)
1-Jun-90	T(3)	45	22.59	-	7	3.1	12.27 (6)
1-Jun-90	T(4)	15	06.92	-	5	7.2	11.64 (4)
1-Jun-90	T(5)	05	02.01	-	1	5.0	12.4 (1)
15-Jun-90	T(1)	60	31.00	-	1	0.3	14.3 (1)
15-Jun-90	T(2)	60	34.14	-	0	0.0	0 (0)

a/ Stations A,B, C and D on lake; T= tailrace with bracketed number indicating order samples collected.

b/ Samples without flow meter readings were estimated using average flow per minute for the appropriate area sampled (lake or tailrace).

c/ Mean length averaged by station and date in the lake; number measured in brackets.

d/ 1 walleye larvae, 7.9 mm long also collected.

APPENDIX B

INSTREAM FLOW STUDIES

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CAL4    7.0    95.880    300.00      0.00
VEL4    7.0
VEL4    7.0
VEL4    7.0
CAL5    7.0    97.870   1200.00      0.00
VEL5    7.0
VEL5    7.0
VEL5    7.0
XSEC    6.0     200.01.00    91.6000.00160000
        6.0  0.0100.7  1.0 99.6  4.0 97.3 10.0 96.4 11.0 95.3 16.0 94.9
        6.0 26.0 93.3 36.0 92.4 46.0 91.6 56.0 91.7 66.0 92.1 76.0 93.4
        6.0 86.0 92.2 96.0 92.4106.0 93.2116.0 93.3126.0 93.5136.0 92.9
        6.0146.0 93.7156.0 93.3166.0 93.6176.0 93.5186.0 93.5196.0 93.9
        6.0206.0 93.9214.0 95.3220.0 98.7224.0 99.4228.0100.2
NS      6.0      12.9      12.9      12.9      12.9      12.9      17.9
NS      6.0      17.9      87.4      87.5      78.3      78.2      76.2
NS      6.0      76.3      78.6      67.4      67.5      76.2      78.4
NS      6.0      78.2      67.8      76.7      65.6      76.5      56.8
NS      6.0      65.8      12.9      12.9      12.9      12.9
CAL1    6.0    93.420     73.32      0.00
VEL1    6.0
VEL1    6.0
VEL1    6.0
CAL2    6.0    95.300    780.00      0.00
VEL2    6.0                          0.12 0.50 0.75 1.20 1.50 1.70 2.50
VEL2    6.0 1.80 1.50 2.20 2.90 2.00 1.50 1.60 2.10 2.40 1.90 2.00 1.70
VEL2    6.0 1.30
CAL3    6.0    93.080     40.00      0.00
VEL3    6.0
VEL3    6.0
VEL3    6.0
CAL4    6.0    94.440    300.00      0.00
VEL4    6.0
VEL4    6.0
VEL4    6.0
CAL5    6.0    96.130   1200.00      0.00
VEL5    6.0
VEL5    6.0
VEL5    6.0
XSEC    5.0     200.01.00    91.3000.00160000
        5.0  3.0 97.1  8.0 96.4 14.0 96.0 17.0 96.3 18.0 94.7 20.0 92.1
        5.0 30.0 92.1 40.0 91.5 50.0 91.3 60.0 91.6 70.0 91.4 80.0 91.9
        5.0 90.0 92.1100.0 92.4110.0 92.5120.0 92.6130.0 92.0140.0 92.3
        5.0150.0 92.7160.0 93.1170.0 92.8180.0 93.0185.0 92.9190.0 92.9
        5.0200.0 93.1204.0 94.7205.0 95.8209.0 96.4215.0 97.4
NS      5.0      12.9      12.9      12.9      12.9      12.9      98.1
NS      5.0      87.6      76.5      76.3      78.5      78.7      87.8
NS      5.0      62.8      76.6      67.5      76.6      87.3      76.4
NS      5.0      87.8      65.6      65.7      54.8      56.8      65.4
NS      5.0      67.6      12.9      12.9      12.9      12.9
CAL1    5.0    93.360     73.32      0.00
VEL1    5.0
VEL1    5.0
VEL1    5.0
CAL2    5.0    94.700    780.00      0.00
VEL2    5.0                          0.66 1.42 2.62 2.23 2.06 1.83 1.70
VEL2    5.0 1.05 1.88 1.63 1.77 1.86 1.59 1.83 2.54 1.96 2.05 1.64 0.47
VEL2    5.0 1.13
```

```
CAL3   5.0    92.950     40.00       0.00
VEL3   5.0
VEL3   5.0
VEL3   5.0
CAL4   5.0    93.720    300.00       0.00
VEL4   5.0
VEL4   5.0
VEL4   5.0
CAL5   5.0    95.710   1200.00       0.00
VEL5   5.0
VEL5   5.0
VEL5   5.0
XSEC   5.0     200.00.00     91.3000.00160000
       5.0  3.0 97.1  8.0 96.4 14.0 96.0 17.0 96.3 18.0 94.7 20.0 92.1
       5.0 30.0 92.1 40.0 91.5 50.0 91.3 60.0 91.6 70.0 91.4 80.0 91.9
       5.0 90.0 92.1100.0 92.4110.0 92.5120.0 92.6130.0 92.0140.0 92.3
       5.0150.0 92.7160.0 93.1170.0 92.8180.0 93.0185.0 92.9190.0 92.9
       5.0200.0 93.1204.0 94.7205.0 95.8209.0 96.4215.0 97.4
NS     5.0      12.9      12.9      12.9      12.9      12.9      98.1
NS     5.0      87.6      76.5      76.3      78.5      78.7      87.8
NS     5.0      62.8      76.6      67.5      76.6      87.3      76.4
NS     5.0      87.8      65.6      65.7      54.8      56.8      65.4
NS     5.0      67.6      12.9      12.9      12.9      12.9
CAL1   5.0    93.360     73.32       0.00
VEL1   5.0
VEL1   5.0
VEL1   5.0
CAL2   5.0    94.700    780.00       0.00
VEL2   5.0                           0.66 1.42 2.62 2.23 2.06 1.83 1.70
VEL2   5.0 1.05 1.88 1.63 1.77 1.86 1.59 1.83 2.54 1.96 2.05 1.64 0.47
VEL2   5.0 1.13
CAL3   5.0    92.950     40.00       0.00
VEL3   5.0
VEL3   5.0
VEL3   5.0
CAL4   5.0    93.720    300.00       0.00
VEL4   5.0
VEL4   5.0
VEL4   5.0
CAL5   5.0    95.710   1200.00       0.00
VEL5   5.0
VEL5   5.0
VEL5   5.0
ENDJ
```

```
Youghiogheny River below Deep Creek Station, Maryland.  IFG4 production Deck.
Segment 2. Deep Creek Station to Hoyes Run.
IOC       00001000000000100000010
NMAX      0.10
QARD    20
QARD    40
QARD    60
QARD    80
QARD   100
QARD   120
QARD   140
QARD   160
QARD   180
QARD   200
QARD   220
QARD   240
QARD   260
QARD   280
QARD   300
QARD   350
QARD   400
QARD   500
QARD   600
QARD   700
QARD   800
QARD   900
QARD  1000
QARD  1100
QARD  1200
QARD  1500
QARD  2000
XSEC       4.0       0.01.00     93.8000.00290000
           4.0  0.0 99.4 12.0 98.3 24.0 95.9 34.0 95.6 36.0 96.7 44.0 96.2
           4.0 46.0 95.8 54.0 95.7 58.0 94.8 68.0 94.8 78.0 94.7 88.0 94.6
           4.0 98.0 94.4108.0 94.3118.0 93.8128.0 94.4138.0 93.9148.0 94.5
           4.0158.0 94.3168.0 94.6178.0 93.9188.0 94.1198.0 93.8208.0 93.9
           4.0218.0 94.3228.0 94.1238.0 94.2248.0 94.4258.0 94.2268.0 94.0
           4.0278.0 94.1288.0 94.5298.0 94.8308.0 94.9310.0 95.7314.0 95.7
           4.0316.0 95.1320.0 95.7329.0 99.6
NS         4.0       12.9       12.9       12.9       12.9       12.9       12.9
NS         4.0       12.9       12.9       54.8       65.4       67.4       56.3
NS         4.0       76.2       76.2       78.3       78.8       78.4       67.3
NS         4.0       76.7       76.3       78.4       68.7       76.7       87.7
NS         4.0       87.8       87.7       72.9       72.9       72.8       72.8
NS         4.0       76.8       87.4       65.3       27.9       12.9       12.9
NS         4.0       12.9       12.9       12.9
CAL1       4.0     94.750      73.32       0.00
VEL1       4.0
VEL1       4.0
VEL1       4.0
VEL1       4.0
CAL2       4.0     95.700     712.00       0.00
VEL2       4.0                                            1.50 2.33 2.83 1.47
VEL2       4.0 3.27 3.11 1.82 2.35 1.88 1.94 2.09 2.77 0.93 2.57 1.70 2.09
VEL2       4.0 1.31 2.84 2.08 2.55 1.73 1.53 2.30 2.16 2.19 0.74
VEL2       4.0 0.19
CAL3       4.0     94.580      40.00       0.00
VEL3       4.0
```

```
VEL3   4.0
VEL3   4.0
VEL3   4.0
CAL4   4.0    95.190    300.00      0.00
VEL4   4.0
VEL4   4.0
VEL4   4.0
VEL4   4.0
CAL5   4.0    96.200   1200.00      0.00
VEL5   4.0
VEL5   4.0
VEL5   4.0
VEL5   4.0
XSEC   3.0     300.01.00    85.8000.00290000
       3.0  0.0 99.2  7.0 95.7 13.0 89.1 18.0 87.2 28.0 86.9 38.0 87.2
       3.0 48.0 86.7 53.0 86.6 58.0 87.4 63.0 86.4 68.0 86.7 73.0 85.8
       3.0 78.0 85.8 83.0 86.9 88.0 86.4 93.0 86.9 98.0 87.3 98.5 87.8
       3.0108.0 86.5108.5 86.7118.0 86.9128.0 87.3138.0 86.9148.0 88.3
       3.0152.5 89.1168.0 93.8180.0 97.4185.0 98.9
NS     3.0      12.9      12.9      12.9      87.1      87.1      87.1
NS     3.0      87.1      87.1      87.1      87.1      87.1      87.2
NS     3.0      87.6      89.2      87.1      87.1      78.1      78.2
NS     3.0      89.1      98.4      98.3      76.2      76.7      65.9
NS     3.0      12.9      12.9      12.9      12.9
CAL1   3.0    87.520     79.00      0.00
VEL1   3.0
VEL1   3.0
VEL1   3.0
CAL2   3.0    89.100    712.00      0.00
VEL2   3.0                0.64 1.30 2.65 3.59 4.97 5.97 4.12 6.29 3.45
VEL2   3.0 1.39 0.96 3.44 4.04 2.85 4.10 0.42 2.31 2.20 1.47 2.66 1.99
VEL2   3.0
CAL3   3.0    87.270     40.00      0.00
VEL3   3.0
VEL3   3.0
VEL3   3.0
CAL4   3.0    88.300    300.00      0.00
VEL4   3.0
VEL4   3.0
VEL4   3.0
CAL5   3.0    89.880   1200.00      0.00
VEL5   3.0
VEL5   3.0
VEL5   3.0
XSEC   2.0     100.01.00    90.5000.00290000
       2.0  5.0100.3 10.0 97.2 12.0 94.6 19.5 93.3 22.0 92.3 25.0 92.4
       2.0 30.0 92.3 40.0 92.2 50.0 91.9 60.0 91.7 70.0 91.3 80.0 91.1
       2.0 90.0 90.8100.0 91.1110.0 90.8120.0 91.1130.0 90.5140.0 91.3
       2.0150.0 90.7160.0 91.4170.0 91.4180.0 91.7185.0 91.7190.0 93.0
       2.0191.0 93.3201.0 95.9210.0 98.3
NS     2.0      12.9      12.9      12.9      12.9      89.4      98.2
NS     2.0      89.2      87.1      76.6      76.4      78.7      67.8
NS     2.0      67.8      76.7      78.4      76.8      76.8      78.6
NS     2.0      76.3      87.2      72.9      62.9      62.8      72.7
NS     2.0      12.9      12.9      12.9
CAL1   2.0    91.820     73.32      0.00
VEL1   2.0
VEL1   2.0
```

```
VEL1    2.0
CAL2    2.0     93.300    712.00       0.00
VEL2    2.0                       0.10 0.27 0.82 3.19 3.60 2.94 3.35 3.44
VEL2    2.0 2.78 3.13 3.24 3.26 2.96 1.23 2.33 1.56 1.89 1.45 1.45 1.45
VEL2    2.0
CAL3    2.0     91.600     40.00       0.00
VEL3    2.0
VEL3    2.0
VEL3    2.0
CAL4    2.0     92.570    300.00       0.00
VEL4    2.0
VEL4    2.0
VEL4    2.0
CAL5    2.0     94.010   1200.00       0.00
VEL5    2.0
VEL5    2.0
VEL5    2.0
XSEC    1.0      300.01.00     90.6000.00290000
        1.0  7.0 99.8 13.0 96.1 21.0 92.8 25.0 91.6 30.0 91.6 40.0 91.4
        1.0 50.0 91.4 60.0 91.5 70.0 91.6 80.0 91.6 90.0 92.0100.0 92.2
        1.0110.0 91.5120.0 91.2130.0 90.8140.0 90.7150.0 91.1160.0 90.9
        1.0170.0 90.7180.0 90.8190.0 91.7200.0 91.7209.0 90.9210.0 92.7
        1.0214.0 90.6220.0 91.3230.0 92.1240.0 91.2245.0 91.4250.0 92.2
        1.0253.0 92.8265.0 96.6275.0 99.8
NS      1.0       12.9      12.9      12.9      78.4      78.1      76.1
NS      1.0       76.2      67.5      67.6      65.9      67.9      56.2
NS      1.0       76.8      76.3      27.9      72.9      72.9      72.9
NS      1.0       72.8      76.8      76.7      67.7      67.4      96.2
NS      1.0       69.1      76.4      67.9      76.9      76.3      86.0
NS      1.0       12.9      12.9      12.9
CAL1    1.0     91.700     73.32       0.00
VEL1    1.0
VEL1    1.0
VEL1    1.0
CAL2    1.0     92.800    712.00       0.00
VEL2    1.0                  0.46 1.93 3.35 3.71 3.19 2.93 2.39 1.15 0.41
VEL2    1.0 1.10 1.64 2.21 2.27 3.10 3.80 3.62 3.35 3.86 2.21 3.80 1.48
VEL2    1.0 2.96 3.70 3.78 2.72 0.24 0.17
CAL3    1.0     91.510     40.00       0.00
VEL3    1.0
VEL3    1.0
VEL3    1.0
CAL4    1.0     92.260    300.00       0.00
VEL4    1.0
VEL4    1.0
VEL4    1.0
CAL5    1.0     93.330   1200.00       0.00
VEL5    1.0
VEL5    1.0
VEL5    1.0
XSEC    1.0      300.00.00     90.6000.00290000
        1.0  7.0 99.8 13.0 96.1 21.0 92.8 25.0 91.6 30.0 91.6 40.0 91.4
        1.0 50.0 91.4 60.0 91.5 70.0 91.6 80.0 91.6 90.0 92.0100.0 92.2
        1.0110.0 91.5120.0 91.2130.0 90.8140.0 90.7150.0 91.1160.0 90.9
        1.0170.0 90.7180.0 90.8190.0 91.7200.0 91.7209.0 90.9210.0 92.7
        1.0214.0 90.6220.0 91.3230.0 92.1240.0 91.2245.0 91.4250.0 92.2
        1.0253.0 92.8265.0 96.6275.0 99.8
NS      1.0       12.9      12.9      12.9      78.4      78.1      76.1
```

```
NS      1.0       76.2       67.5       67.6       65.9       67.9       56.2
NS      1.0       76.8       76.3       27.9       72.9       72.9       72.9
NS      1.0       72.8       76.8       76.7       67.7       67.4       96.2
NS      1.0       69.1       76.4       67.9       76.9       76.3       86.0
NS      1.0       12.9       12.9       12.9
CAL1    1.0     91.700      73.32       0.00
VEL1    1.0
VEL1    1.0
VEL1    1.0
CAL2    1.0     92.800     712.00       0.00
VEL2    1.0                  0.46 1.93 3.35 3.71 3.19 2.93 2.39 1.15 0.41
VEL2    1.0 1.10 1.64 2.21 2.27 3.10 3.80 3.62 3.35 3.86 2.21 3.80 1.48
VEL2    1.0 2.96 3.70 3.78 2.72 0.24 0.17
CAL3    1.0     91.510      40.00       0.00
VEL3    1.0
VEL3    1.0
VEL3    1.0
CAL4    1.0     92.260     300.00       0.00
VEL4    1.0
VEL4    1.0
VEL4    1.0
CAL5    1.0     93.330    1200.00       0.00
VEL5    1.0
VEL5    1.0
VEL5    1.0
ENDJ
```

```
**************************************************
*      PHYSICAL HABITAT SIMULATION SYSTEM        *
*      INSTREAM FLOW GROUP, USFWS                *
*      VERSION 2.1 JULY, 1989                    *
*      RUN DATE 91/07/26.  TIME 03.54.42.        *
**************************************************


                                                LL         SSSSS   TTTTTTTT     CCCC     PPPPPP
                                                LL        SS    S     TT      CC   CC    PP    PP
                                                LL        SS          TT     CC          PP    PP
                                                LL         SSSSS      TT     CC          PPPPPP
                                                LL             SS     TT     CC          PP
                                                LL    LL  S     SS    TT      CC   CC    PP
                                                LLLLLLL    SSSSS      TT        CCCC     PP

          PROGRAM LSTCP       VERSION NUMBER 2.1
          LAST MODIFIED ON 07/**/89.
```

BROWN TROUT SUITABILITY CURVES (RALEIGH AND ZUCKERMAN 1986)

```
H  11111   6   4 10   0 BROWN TROUT                                  SPAWNING
V  11111  0.00  0.00  0.30  0.00  0.70  1.00  1.70  1.00  3.90  0.00100.00  0.00
D  11111  0.00  0.00  0.20  0.00  0.80  1.00100.00  1.00
S  11111  0.00  0.00  1.00  0.00  2.00  0.00  3.00  1.00  4.00  1.00  5.00  0.70
S  11111  6.00  0.00  7.00  0.00  8.00  0.00100.00  0.00
```

BROWN TROUT SUITABILITY CURVES (RALEIGH AND ZUCKERMAN 1986)

```
H  11112   7   7 12   0 BROWN TROUT                             FRY
V  11112  0.00   0.00   0.10   0.38   0.60   1.00   0.90   0.94   1.20   0.47   2.90   0.00
V  11112100.00   0.00
D  11112  0.00   0.00   0.66   0.19   1.31   1.00   1.61   1.00   2.30   0.82   4.60   0.00
D  11112100.00   0.00
S  11112  0.00   0.76   1.00   0.76   2.00   0.76   3.00   1.00   4.00   1.00   5.00   1.00
S  11112  6.00   0.35   7.00   0.35   8.00   0.04   9.00   0.04  10.00   0.04100.00   0.00
```

BROWN TROUT SUITABILITY CURVES (RALEIGH AND ZUCKERMAN 1986)

```
H  11113   9   9 12   0 BROWN TROUT                                   JUVENILE
V  11113  0.00   0.58   0.10   0.88   0.50   1.00   1.00   0.92   1.50   0.70   2.00   0.26
V  11113  3.50   0.05   4.30   0.00100.00   0.00
D  11113  0.00   0.00   0.50   0.12   1.00   0.61   2.00   0.84   3.00   1.00   4.00   0.27
D  11113  7.00   0.24   8.00   0.08100.00   0.08
S  11113  0.00   0.66   1.00   0.66   2.00   0.66   3.00   1.00   4.00   1.00   5.00   1.00
S  11113  6.00   0.97   7.00   0.97   8.00   0.12   9.00   0.12 10.00   0.12100.00   0.12
```

BROWN TROUT SUITABILITY CURVES (RALEIGH AND ZUCKERMAN 1986)

```
H  11114 10   9 12   0 BROWN TROUT                                  ADULT
V  11114  0.00  0.21  0.10  0.70  0.50  1.00  1.00  0.69  1.50  0.50  2.40  0.20
V  11114  3.10  0.03  5.00  0.03  6.00  0.00100.00  0.00
D  11114  0.00  0.00  1.60  0.87  2.00  0.95  2.60  1.00  3.60  0.84  4.00  0.45
D  11114  5.00  0.30  7.00  0.21100.00  0.21
S  11114  0.00  1.00  1.00  1.00  2.00  1.00  3.00  0.54  4.00  0.54  5.00  0.54
S  11114  6.00  0.86  7.00  0.86  8.00  0.12  9.00  0.12 10.00  0.12100.00  0.12
```

```
Youghiogheny River below Deep Creek Station, Maryland.  IFG4 production Deck.
Segment 1. Hoyes Run to Sang Run Bridge.
IOC         00001000000000100000010
NMAX        0.10
QARD    20
QARD    40
QARD    60
QARD    80
QARD   100
QARD   120
QARD   140
QARD   160
QARD   180
QARD   200
QARD   220
QARD   240
QARD   260
QARD   280
QARD   300
QARD   350
QARD   400
QARD   500
QARD   600
QARD   700
QARD   800
QARD   900
QARD  1000
QARD  1100
QARD  1200
QARD  1500
QARD  2000
XSEC     9.0        0.01.00     93.3000.00170000
         9.0  0.0 98.3  2.0 96.7  4.0 95.5  5.0 95.3  8.0 94.5 18.0 94.0
         9.0 28.0 94.1 38.0 94.2 48.0 94.4 58.0 94.3 68.0 94.4 78.0 94.1
         9.0 88.0 94.3 98.0 94.1108.0 93.9118.0 93.8128.0 93.7138.0 93.3
         9.0148.0 93.5158.0 93.6168.0 93.7178.0 94.1188.0 94.2193.0 94.3
         9.0196.5 95.3199.5 96.2203.0 97.6208.0 98.5
NS       9.0       12.9       12.9       12.9       12.9       54.7       45.9
NS       9.0       54.9       54.9       54.9       54.9       54.9       54.9
NS       9.0       56.9       56.9       56.9       65.8       65.8       65.8
NS       9.0       65.6       65.6       76.7       87.5       97.4       68.2
NS       9.0       12.9       12.9       12.9       12.9
CAL1     9.0     94.390      73.32       0.00
VEL1     9.0
VEL1     9.0
VEL1     9.0
CAL2     9.0     95.300     805.00       0.00
VEL2     9.0                       1.11 2.58 3.20 2.97 2.98 2.81 3.00 2.65
VEL2     9.0 3.05 3.32 1.83 2.79 2.84 3.41 2.97 1.91 1.15 2.26 1.17 0.63
VEL2     9.0
CAL3     9.0     94.220      40.00       0.00
VEL3     9.0
VEL3     9.0
VEL3     9.0
CAL4     9.0     94.820     300.00       0.00
VEL4     9.0
VEL4     9.0
VEL4     9.0
```

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CAL5   9.0    95.780   1200.00      0.00
VEL5   9.0
VEL5   9.0
VEL5   9.0
XSEC   8.0     200.01.00    92.1000.00170000
       8.0  0.0 97.0  5.5 95.2 10.0 94.2 15.0 93.0 20.0 92.6 30.0 92.1
       8.0 40.0 92.6 50.0 93.1 60.0 93.4 70.0 93.0 80.0 93.5 90.0 93.0
       8.0100.0 92.5110.0 93.2120.0 93.2130.0 93.2140.0 93.5150.0 93.4
       8.0160.0 93.6170.0 93.6180.0 93.7190.0 93.6200.0 94.4205.0 94.6
       8.0207.0 95.2207.1 97.1215.0 98.9
NS     8.0      12.9      12.9      91.9      78.4      87.3      76.8
NS     8.0      65.4      65.5      76.7      75.7      67.6      67.3
NS     8.0      76.6      67.8      67.8      78.4      87.2      76.6
NS     8.0      78.3      67.7      56.2      65.7      78.2      89.4
NS     8.0      12.9      12.9      12.9
CAL1   8.0    94.020     73.32      0.00
VEL1   8.0
VEL1   8.0
VEL1   8.0
CAL2   8.0    95.200    805.00      0.00
VEL2   8.0            0.17 0.99 2.11 2.25 2.15 2.70 2.44 1.98 2.46 1.93
VEL2   8.0 1.95 2.47 2.13 1.85 2.40 1.79 2.05 1.95 2.30 2.31 0.90 0.11
VEL2   8.0
CAL3   8.0    93.740     40.00      0.00
VEL3   8.0
VEL3   8.0
VEL3   8.0
CAL4   8.0    94.470    300.00      0.00
VEL4   8.0
VEL4   8.0
VEL4   8.0
CAL5   8.0    95.920   1200.00      0.00
VEL5   8.0
VEL5   8.0
VEL5   8.0
XSEC   7.0     200.01.00    92.9000.00170000
       7.0  0.0 99.6  4.0 99.3 10.0 99.6 14.0 98.5 22.0 96.9 25.0 95.3
       7.0 30.0 94.9 40.0 95.1 50.0 93.8 60.0 93.3 65.0 93.6 70.0 93.5
       7.0 75.0 93.2 80.0 92.9 85.0 93.0 90.0 93.7 95.0 93.7100.0 93.5
       7.0105.0 93.9110.0 94.7120.0 94.8130.0 95.7140.0 95.2145.0 95.4
       7.0151.0 96.9159.0 99.0163.0102.0162.0101.2
NS     7.0      12.9      12.9      12.9      12.9      12.9      12.9
NS     7.0      52.9      55.6      76.4      76.3      87.2      79.2
NS     7.0      92.8      78.2      92.9      87.9      78.8      87.4
NS     7.0      98.3      87.3      89.2      98.1      98.1      89.1
NS     7.0      12.9      12.9      12.9      12.9
CAL1   7.0    95.670     73.32      0.00
VEL1   7.0
VEL1   7.0
VEL1   7.0
CAL2   7.0    96.900    805.00      0.00
VEL2   7.0                           0.57 0.91 1.68 1.81 1.59 3.77 3.65
VEL2   7.0 1.78 3.41 3.28 3.44 3.41 3.50 2.46 3.19 1.87 3.60 1.58 0.31
VEL2   7.0
CAL3   7.0    95.140     40.00      0.00
VEL3   7.0
VEL3   7.0
VEL3   7.0
```

Instream Flow Input and Output Files

1. Youghiogheny River IFG4 Hydraulic Simulation Input Data Decks, Sections 1 and 2

2. Brown Trout Suitability Curves(LSTCP) Employed in Habitat Simulation Runs.

3. Weighted Usable Area verse Discharge Output (HABOUTA) from Habitat Simulation Program.

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*************************************************
*       PHYSICAL HABITAT SIMULATION SYSTEM      *
*       INSTREAM FLOW GROUP, USFWS              *
*       VERSION 2.1 JULY, 1989                  *
*       RUN DATE 91/07/26.  TIME 03.57.40.      *
*************************************************
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HH    HH     AAA     BBBBBB      OOO     UU    UU  TTTTTTTT     AAA
HH    HH    AA AA    BB    BB   OO OO    UU    UU     TT       AA AA
HH    HH   AA   AA   BB    BB  OO   OO   UU    UU     TT      AA   AA
HHHHHHHH   AAAAAAA   BBBBBB    OO   OO   UU    UU     TT      AAAAAAA
HH    HH   AA   AA   BB    BB  OO   OO   UU    UU     TT      AA   AA
HH    HH   AA   AA   BB    BB   OO OO     UUUUU       TT      AA   AA
HH    HH   AA   AA   BBBBBB      OOO       UUU        TT      AA   AA
```

PROGRAM HABOUTA   VERSION NUMBER 2.1
LAST MODIFIED ON 07/**/89.

Youghiogheny River below Deep Creek Station, Maryland. IFG4 production deck

Segment 2. Deep Creek Station to Hoyes Run.

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR TOTAL AREA

	Q	AREA
1	20	112063
2	40	143398
3	60	164655
4	80	176064
5	100	185101
6	120	189902
7	140	192689
8	160	195489
9	180	199421
10	200	202773
11	220	205192
12	240	206545
13	260	207215
14	280	207659
15	300	208081
16	350	209057
17	400	209942
18	500	211504
19	600	213230
20	700	217159
21	800	220370
22	900	221914
23	1000	222771
24	1100	223533
25	1200	224251
26	1500	226419
27	2000	229923

Q IN CUBIC FEET PER SECOND, WUA IN SQUARE FEET PER 1000 FEET

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR BROWN TROUT

	Q	SPAWNING	FRY	JUVENILE	ADULT
1	20	0	95	1126	2148
2	40	0	172	2318	3410
3	60	0	263	3587	4349
4	80	0	349	4694	5088
5	100	0	424	5642	5680
6	120	0	488	6396	6164
7	140	0	551	7048	6553
8	160	0	607	7603	6858
9	180	0	650	8064	7102
10	200	0	679	8432	7310
11	220	0	699	8704	7480
12	240	0	708	8897	7624
13	260	0	714	9044	7742
14	280	0	716	9128	7828
15	300	0	720	9167	7888
16	350	0	708	9076	7948
17	400	0	691	8908	7923
18	500	0	649	8435	7677
19	600	0	590	7783	7218
20	700	0	527	7076	6690
21	800	0	473	6419	6122
22	900	0	434	5818	5589
23	1000	0	406	5352	5121
24	1100	0	379	4917	4717
25	1200	0	353	4529	4366
26	1500	0	286	3690	3507
27	2000	0	246	2809	2692

Q IN CUBIC FEET PER SECOND, WUA IN SQUARE FEET PER 1000 FEET

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*************************************************
*      PHYSICAL HABITAT SIMULATION SYSTEM       *
*      INSTREAM FLOW GROUP, USFWS               *
*      VERSION 2.1 JULY, 1989                   *
*      RUN DATE 91/07/26.  TIME 03.56.04.       *
*************************************************
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HH    HH      AAA     BBBBBB      OOO     UU    UU  TTTTTTTT     AAA
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HH    HH    AA   AA   BB    BB  OO   OO   UU    UU     TT      AA   AA
HHHHHHH     AAAAAAA   BBBBBB    OO   OO   UU    UU     TT      AAAAAAA
HH    HH    AA   AA   BB    BB  OO   OO   UU    UU     TT      AA   AA
HH    HH    AA   AA   BB    BB   OO OO     UUUUU       TT      AA   AA
HH    HH    AA   AA   BBBBBB      OOO       UUU        TT      AA   AA
```

PROGRAM HABOUTA   VERSION NUMBER 2.1
LAST MODIFIED ON 07/**/89.

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR TOTAL AREA

	Q	AREA
1	20	94995
2	40	124143
3	60	144006
4	80	156762
5	100	165613
6	120	168816
7	140	170097
8	160	173114
9	180	173748
10	200	174432
11	220	175110
12	240	175743
13	260	176339
14	280	176755
15	300	177108
16	350	177921
17	400	178655
18	500	179984
19	600	181348
20	700	182517
21	800	183055
22	900	183545
23	1000	183978
24	1100	184356
25	1200	184710
26	1500	185654
27	2000	187623

Q IN CUBIC FEET PER SECOND, WUA IN SQUARE FEET PER 1000 FEET

Q VS. AVAILABLE HABITAT AREA PER 1000 FEET OF STREAM FOR BROWN TROUT

	Q	SPAWNING	FRY	JUVENILE	ADULT
1	20	0	183	2884	3100
2	40	0	323	4252	4740
3	60	0	426	5446	5966
4	80	0	521	6435	6873
5	100	0	618	7289	7611
6	120	0	692	8071	8197
7	140	0	750	8763	8654
8	160	0	805	9265	8976
9	180	0	854	9714	9204
10	200	0	892	10142	9355
11	220	0	915	10497	9458
12	240	0	922	10783	9523
13	260	0	919	10981	9553
14	280	0	909	11092	9559
15	300	0	897	11156	9545
16	350	0	847	11122	9423
17	400	0	792	10950	9219
18	500	0	698	10224	8671
19	600	0	624	9068	8022
20	700	0	583	7883	7348
21	800	0	547	6848	6679
22	900	0	511	6034	6003
23	1000	0	473	5371	5351
24	1100	0	429	4787	4779
25	1200	0	383	4308	4252
26	1500	0	289	3247	3028
27	2000	0	199	2047	1930

Q IN CUBIC FEET PER SECOND, WUA IN SQUARE FEET PER 1000 FEET

APPENDIX C

PROJECT OPERATION MODEL

PROJECT OPERATION MODEL

Introduction

As part of the permitting process, the operation of the Deep Creek reservoir was mathematically modelled to simulate historical operation as well as scenarios of possible future operation to maximize reservoir and downstream recreation, fisheries and power benefits. The computer model is written in FORTRAN 77 and simulates the operation of the Deep Creek reservoir on a monthly basis using historical operating records for the period 1962-92.

The following paragraphs describe salient features of input data, program capabilities and output.

Inflow

There are no gaging stations upstream of the reservoir where streamflow was recorded historically. Monthly net inflows to the reservoir (i.e. reservoir inflow less evaporation, leakage and seepage losses) were, therefore, calculated from the recorded data on turbine flows, changes in the reservoir levels and reservoir level- storage volume relationship. Negative values for inflows appearing during some dry seasons are attributable to greater losses than inflow as well as possible measuring errors in the large reservoir volume relative to inflow.

Evaporation, Seepage and Leakage Losses

Losses from evaporation, seepage or leakages through the turbines are not individually calculated for this study. These are automatically considered at historical levels by using net inflows and are unlikely to be affected significantly with small operational changes.

Fisheries Releases

The program has the capability to incorporate fisheries release contemplated in future operation as water not available for power generation.

Reservoir Operating Strategy

As originally licensed by FERC, the project could be operated for power generation without recreational or fisheries constraints. However, Penelec has historically operated the project to maximize reservoir recreation to the extent possible. This has resulted in lower power generation from the project.

Several scenarios of future operation of the reservoir were developed to provide overall improvement to water quality and all water uses including lake recreation, downstream fisheries habitat and white water boating.

Estimates of water volumes that may be diverted to improve downstream water quality and fisheries habitat, which is not available for power generation, are input to the program as data. Short duration power generation to improve downstream water temperatures, without loss of water volume for power generation is treated outside of the program to assess any loss of value of generation due to such operation. White water boating needs generally coincide with power flows and were simulated by extended generation hours to provide for enhanced whitewater boating opportunities. Value of generation was however, adjusted downward to reflect any weekend power generation to provide for weekend white water boating.

Improvements to lake recreation are simulated as allowable limits to lake level changes during the summer months. Constraints may be imposed to restrict generation in the Spring months to ensure an acceptable minimum reservoir level at the beginning of June to provide for lake recreation during all the years except for the very dry ones.

Power generation needs are input as minimum required periods of generation each month. In addition, target generation for each month based on system requirements and projected power values are input to maximize total generation values.

Water levels during the months of December, January and February are constrained to a maximum level of El 2457.9 ft. consistent with project safety criteria.

The priorities of the various conflicting requirements and constraints are specified in the program. These may be altered to assess the sensitivity of project benefits to each of the constraints. In the current set up of the program, project safety considerations have the highest priority, followed by any fisheries release requirements. Minimum levels of generation has the next priority. White water boating interests generally coincide with generation requirements in summer. Restrictions to spring generation and restrictions to lake level changes have the next priority.

Plant Characteristics

The model simulates the operation of the two generating units based on plant characteristics.

Net Head for Generation

For this study, a constant tailwater elevation of 2025 ft has been assumed. Friction losses in the water conduits are estimated based on typical friction coefficients for water passages.

Energy and Capacity Values

Composite energy and capacity values were determined by averaging estimated hourly billing rates (1995) for every specific hour (e.g. 10 a.m.) for each weekday (Monday-Friday). Actual value of generation at any time will depend upon electric demand, unit availability in the system etc. Averaging the hourly values for each week-hour provides an under-estimate of the actual billing rates. This results in an under-estimate of power "losses" attributable to environmental enhancements studied.

Program Output

The program output includes for each simulated month, calculated monthly net inflows to the reservoir, fisheries releases, reservoir levels, plant generation hours and estimated value of generation in 1995 dollars. Annual and total period summaries are also calculated.

APPENDIX D

PROJECT OPERATION SIMULATION

1

MODIFIED WHITEWATER OPERATING RULES

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1962-1963 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	3.9	1.1	-1.6	-.3	1.1	4.7	.4	9.8	4.5	33.5	5.1	3.1	65.3
FISH RELEASE	.00	.00	.65	.90	.01	.00	.00	.00	.00	.00	.00	.00	1.56
REL THRU PLANT	4.2	5.3	2.6	2.2	4.6	5.8	2.6	9.8	1.0	20.9	3.2	1.6	64.0
HIST.RELEASE	3.1	4.5	4.6	3.7	6.7	8.8	8.8	3.0	2.1	11.4	5.1	4.2	66.0
EOM ELEVATION	2460.4	2459.3	2458.0	2457.0	2456.0	2455.7	2455.0	2455.0	2456.0	2459.5	2460.0	2460.4	2457.7
HIST.ELEVATION	2460.7	2459.8	2458.1	2457.0	2455.4	2454.2	2451.6	2453.7	2454.4	2460.6	2460.6	2460.3	2457.2
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.0	1.0	.9	1.8	2.2	1.0	3.8	.4	8.0	1.2	.6	24.6
TOTAL GEN HRS	91.0	114.0	56.1	48.3	99.8	126.0	56.9	212.0	22.7	452.2	69.0	34.0	1382.1
95 BILL(x1000)	78.9	101.8	51.1	40.8	87.9	111.8	55.1	206.9	22.1	354.6	60.0	28.3	1199.4

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1963-1964 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	6.3	1.4	.1	-.1	-1.6	1.2	3.1	8.9	4.6	25.3	14.8	4.5	68.5
FISH RELEASE	.00	.00	.01	.04	.83	.04	.00	.00	.00	.00	.00	.00	.92
REL THRU PLANT	4.2	5.3	4.7	2.4	2.0	5.8	4.5	8.9	1.2	12.8	9.3	4.5	65.5
HIST.RELEASE	4.1	5.5	5.9	5.2	6.9	5.8	6.3	3.7	3.3	5.7	6.3	9.4	68.1
EOM ELEVATION	2461.0	2459.9	2458.7	2458.0	2456.8	2455.4	2455.0	2455.0	2456.0	2459.5	2461.0	2461.0	2458.1
HIST.ELEVATION	2460.9	2459.8	2458.2	2456.7	2454.2	2452.8	2451.8	2453.4	2453.8	2459.4	2461.7	2460.4	2456.9
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.0	1.8	.9	.8	2.2	1.7	3.4	.5	4.9	3.6	1.7	25.2
TOTAL GEN HRS	91.0	114.0	100.8	51.0	42.3	126.0	97.0	192.1	26.1	275.8	200.7	97.9	1414.8
95 BILL(x1000)	78.9	101.8	90.2	43.0	38.1	111.8	92.5	188.7	25.4	240.6	166.7	79.5	1257.3

1

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1964-1965 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.6	-.2	-1.1	-.8	-1.4	1.6	6.0	13.7	9.7	15.1	12.5	2.5	59.3
FISH RELEASE	.00	.25	.90	1.46	.53	.44	.00	.00	.00	.00	.00	.00	3.59
REL THRU PLANT	4.2	4.4	2.5	1.1	1.1	4.5	6.0	12.7	7.3	8.0	3.2	1.6	56.5
HIST.RELEASE	5.0	4.2	4.3	4.0	4.0	4.2	6.4	3.7	5.5	4.9	7.3	5.5	58.9
EOM ELEVATION	2460.3	2459.0	2457.8	2456.8	2456.0	2455.0	2455.0	2455.3	2456.0	2458.0	2460.5	2460.8	2457.5
HIST.ELEVATION	2459.5	2458.3	2456.8	2455.4	2453.8	2453.0	2452.9	2455.9	2457.1	2459.9	2461.3	2460.5	2457.0

UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.7	.9	.4	.4	1.7	2.3	4.9	2.8	3.1	1.2	.6	21.7
TOTAL GEN HRS	91.0	95.2	53.1	22.8	23.4	96.2	130.5	274.0	158.4	173.6	69.0	34.0	1221.2
95 BILL(x1000)	78.9	85.6	48.4	19.5	21.2	86.2	122.9	261.8	146.5	156.9	60.0	28.3	1116.2

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1965-1966 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	.2	-1.0	-.1	-.1	-.6	.4	.5	5.2	13.0	11.4	12.4	8.7	50.0
FISH RELEASE	.41	1.10	1.23	1.37	.39	.21	.00	.00	.00	.00	.00	.00	4.71
REL THRU PLANT	2.8	2.7	2.5	1.1	2.1	3.6	.5	5.2	9.5	4.4	3.2	6.8	44.5
HIST.RELEASE	4.3	2.3	3.1	2.4	6.3	6.8	8.4	3.1	1.3	2.0	1.8	6.0	47.8
EOM ELEVATION	2460.0	2458.7	2457.6	2456.9	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2460.5	2461.0	2457.5
HIST.ELEVATION	2459.4	2458.5	2457.6	2456.9	2454.9	2453.0	2450.5	2451.2	2454.8	2457.5	2460.4	2461.1	2456.3
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.1	1.0	.9	.4	.8	1.4	.2	2.0	3.7	1.7	1.2	2.6	17.1
TOTAL GEN HRS	60.9	58.3	53.1	22.9	45.7	78.7	11.8	113.0	206.0	94.8	69.0	148.0	962.1
95 BILL(x1000)	53.4	53.2	48.4	19.6	41.1	71.0	11.5	113.8	187.3	87.9	60.0	118.0	865.2

1

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1966-1967 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	.3	-1.7	-.3	-.4	.0	1.0	3.2	4.3	7.8	26.4	7.9	16.3	64.8
FISH RELEASE	.14	.75	.92	.89	.00	.00	.00	.00	.00	.00	.00	.00	2.70
REL THRU PLANT	3.9	2.8	2.5	1.1	3.0	4.4	3.2	4.3	4.4	13.9	3.2	15.5	62.1
HIST.RELEASE	4.8	4.5	5.4	3.8	4.8	5.3	5.2	2.6	1.5	3.9	6.1	16.3	64.1
EOM ELEVATION	2460.0	2458.5	2457.5	2456.9	2456.0	2455.0	2455.0	2455.0	2456.0	2459.5	2460.8	2461.0	2457.6
HIST.ELEVATION	2459.9	2458.2	2456.6	2455.4	2454.0	2452.7	2452.1	2452.6	2454.5	2460.8	2461.3	2461.3	2456.6
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.5	1.1	.9	.4	1.2	1.7	1.2	1.6	1.7	5.3	1.2	6.0	23.9
TOTAL GEN HRS	84.6	61.4	53.1	22.9	65.8	95.6	70.0	91.9	94.1	299.6	69.0	334.8	1342.7
95 BILL(x1000)	73.5	55.9	48.4	19.6	58.7	85.7	67.4	93.3	89.0	258.9	60.0	248.5	1158.9

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1967-1968 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.0	3.8	-.2	-.8	.5	1.3	9.0	5.0	6.9	15.1	3.9	16.0	61.6
FISH RELEASE	.00	.00	.00	.52	.08	.00	.00	.00	.00	.00	.00	.00	.60

REL THRU PLANT	4.2	5.3	4.4	2.4	4.9	5.5	9.0	5.0	3.4	8.0	.9	8.0	61.0
HIST.RELEASE	5.5	4.2	4.6	5.3	6.5	8.3	8.3	5.3	3.2	3.3	2.8	4.6	61.9
EOM ELEVATION	2460.1	2459.7	2458.5	2457.5	2456.2	2455.0	2455.0	2455.0	2456.0	2458.0	2458.8	2461.0	2457.6
HIST.ELEVATION	2460.1	2460.0	2458.7	2457.0	2455.3	2453.2	2453.4	2453.3	2454.4	2457.8	2458.1	2461.2	2456.9
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.0	1.7	.9	1.9	2.1	3.5	1.9	1.3	3.1	.3	3.1	23.4
TOTAL GEN HRS	91.0	114.0	95.2	51.0	105.5	119.1	194.5	108.4	74.4	172.8	19.4	171.8	1317.2
95 BILL(x1000)	78.9	101.8	85.4	43.0	92.7	105.8	179.5	109.4	71.0	156.2	17.2	136.1	1177.0

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1968-1969 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	5.9	-.4	.0	-.8	.0	4.5	7.7	6.2	5.4	8.4	6.9	2.5	46.2
FISH RELEASE	.00	.09	.09	.37	.25	.00	.00	.00	.00	.00	.00	.00	.79
REL THRU PLANT	5.9	4.1	4.5	2.4	4.1	5.8	10.6	6.3	2.0	1.3	1.3	1.1	49.6
HIST.RELEASE	10.4	5.8	5.0	1.0	5.5	6.2	7.0	5.5	3.4	3.6	3.0	.3	56.6
EOM ELEVATION	2461.0	2459.8	2458.5	2457.5	2456.3	2455.9	2455.0	2455.0	2456.0	2458.0	2459.5	2459.9	2457.7
HIST.ELEVATION	2460.0	2458.3	2456.9	2456.4	2454.8	2454.3	2454.5	2454.7	2455.3	2456.7	2457.8	2458.4	2456.5
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	2.3	1.6	1.7	.9	1.6	2.2	4.1	2.4	.8	.5	.5	.4	19.1
TOTAL GEN HRS	127.8	89.0	97.6	51.0	88.9	126.0	229.0	137.0	42.9	29.1	28.4	24.2	1070.9
95 BILL(x1000)	109.3	80.2	87.4	43.0	78.6	111.8	209.2	136.9	41.5	27.6	25.1	20.2	971.0

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1969-1970 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	.3	1.7	1.5	.7	-.5	1.7	5.7	9.6	10.3	15.8	21.3	3.5	71.4
FISH RELEASE	.17	.13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.31
REL THRU PLANT	2.9	2.3	4.9	2.4	3.9	5.8	6.0	9.6	6.8	8.4	10.6	3.5	67.0
HIST.RELEASE	1.0	1.7	4.3	4.6	4.0	4.4	6.7	4.2	3.6	7.5	18.3	7.5	67.8
EOM ELEVATION	2459.1	2458.9	2458.0	2457.5	2456.3	2455.1	2455.0	2455.0	2456.0	2458.1	2461.0	2461.0	2457.6
HIST.ELEVATION	2458.2	2458.2	2457.4	2456.3	2455.0	2454.2	2453.9	2455.5	2457.4	2459.7	2460.5	2459.4	2457.1
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.1	.9	1.9	.9	1.5	2.2	2.3	3.7	2.6	3.2	4.1	1.3	25.8
TOTAL GEN HRS	61.8	49.7	105.4	51.0	84.6	126.0	129.1	206.8	147.7	182.0	228.5	74.8	1447.6
95 BILL(x1000)	54.2	45.5	94.2	43.0	75.0	111.7	121.7	202.1	137.1	164.0	188.0	61.2	1297.8

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1970-1971 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	8.9	1.9	.4	-.5	-.5	3.1	11.7	11.5	17.4	14.3	4.6	9.7	82.4
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	8.9	5.3	5.0	2.4	4.0	5.8	10.6	12.7	10.6	8.5	3.2	5.5	82.4
HIST.RELEASE	6.0	7.0	7.2	5.7	2.9	2.7	5.2	6.9	6.5	20.6	6.4	3.5	80.6
EOM ELEVATION	2461.0	2460.1	2458.8	2458.1	2456.8	2456.0	2456.3	2456.0	2457.9	2459.5	2459.9	2461.0	2458.4
HIST.ELEVATION	2460.2	2458.8	2456.9	2455.1	2454.1	2454.2	2456.1	2457.4	2460.4	2458.7	2458.2	2459.9	2457.5
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	3.4	2.0	1.9	.9	1.5	2.2	4.1	4.9	4.1	3.3	1.2	2.1	31.7
TOTAL GEN HRS	192.6	114.0	107.9	51.0	85.9	126.0	229.0	274.0	229.2	182.7	69.0	119.7	1781.1
95 BILL(x1000)	161.2	101.8	96.3	43.0	76.1	111.8	209.4	262.2	206.7	164.5	60.0	96.4	1589.4

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1971-1972 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.8	-.6	2.0	9.6	1.4	4.5	13.3	8.4	7.5	23.6	18.4	6.1	95.8
FISH RELEASE	.00	.14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.14
REL THRU PLANT	4.2	4.2	5.3	8.1	5.0	5.8	10.6	12.7	9.5	11.3	12.8	6.1	95.7
HIST.RELEASE	3.6	4.2	6.9	7.4	9.7	6.8	8.2	5.7	5.7	14.9	18.0	9.1	100.2
EOM ELEVATION	2460.3	2459.0	2458.1	2458.5	2457.5	2457.1	2457.9	2456.7	2456.1	2459.5	2461.0	2461.0	2458.6
HIST.ELEVATION	2459.4	2458.1	2456.7	2457.3	2454.9	2454.2	2455.7	2456.5	2457.0	2459.4	2459.5	2458.7	2457.3
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.6	2.0	3.1	1.9	2.2	4.1	4.9	3.7	4.3	4.9	2.4	36.8
TOTAL GEN HRS	91.0	91.0	114.0	174.3	109.0	126.0	229.0	274.0	206.0	244.3	276.6	132.3	2067.5
95 BILL(x1000)	78.9	81.9	101.5	140.6	95.6	111.8	209.4	262.2	187.4	215.5	223.6	106.0	1814.6

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1972-1973 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	9.9	5.5	.0	-.7	1.4	13.1	21.7	4.3	8.9	11.4	22.4	7.5	105.4
FISH RELEASE	.00	.00	.00	.08	.00	.00	.00	.00	.00	.00	.00	.00	.08
REL THRU PLANT	9.9	8.1	4.8	2.4	5.0	10.3	21.7	12.7	7.2	4.3	11.4	7.5	105.3
HIST.RELEASE	5.9	9.9	9.3	3.1	.0	5.1	17.3	15.0	4.3	4.9	17.7	11.5	103.9
EOM ELEVATION	2461.0	2460.3	2459.0	2458.1	2457.1	2457.9	2457.9	2455.5	2456.0	2458.0	2461.0	2461.0	2458.6
HIST.ELEVATION	2459.8	2458.6	2456.0	2454.9	2455.3	2457.6	2458.8	2455.8	2457.1	2458.9	2460.2	2459.1	2457.7
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	3.8	3.1	1.8	.9	1.9	4.0	8.3	4.9	2.8	1.6	4.4	2.9	40.5
TOTAL GEN HRS	213.8	174.7	103.7	51.0	109.0	223.3	468.3	274.0	156.4	92.6	246.3	161.9	2275.0
95 BILL(x1000)	177.8	153.0	92.7	43.0	95.6	191.9	374.7	262.2	144.8	85.9	201.4	128.6	1951.7

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1973-1974 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	3.3	.3	1.9	.8	3.9	6.9	13.2	18.9	4.8	8.5	9.7	6.6	79.1
FISH RELEASE	.00	.00	.00	.31	.00	.00	.00	.00	.00	.00	.00	.00	.31
REL THRU PLANT	4.2	5.0	5.3	2.4	5.0	6.5	13.2	18.9	9.5	3.4	3.2	2.1	78.8
HIST.RELEASE	6.6	5.7	4.7	3.6	4.6	4.2	4.4	12.7	11.4	8.5	4.6	3.3	74.3
EOM ELEVATION	2460.8	2459.5	2458.6	2458.1	2457.8	2457.9	2457.9	2457.9	2456.6	2458.0	2459.8	2461.0	2458.7
HIST.ELEVATION	2458.2	2456.7	2455.9	2455.1	2454.9	2455.7	2458.2	2459.9	2458.1	2458.1	2459.5	2460.4	2457.6
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.9	2.0	.9	1.9	2.5	5.1	7.3	3.7	1.3	1.2	.8	30.3
TOTAL GEN HRS	91.0	107.2	114.0	51.0	109.0	140.0	285.8	409.2	206.0	73.9	69.0	45.8	1701.8
95 BILL(x1000)	78.9	96.0	101.5	43.0	95.6	123.6	256.1	361.3	187.4	69.1	60.0	37.9	1510.5

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1974-1975 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	10.5	1.5	-.5	.1	-.7	.4	11.1	19.3	14.2	13.6	10.9	10.4	91.0
FISH RELEASE	.00	.00	.03	.00	.05	.00	.00	.00	.00	.00	.00	.00	.08
REL THRU PLANT	10.5	5.3	4.1	2.4	3.7	5.8	10.6	12.7	12.4	8.4	4.7	10.4	91.0
HIST.RELEASE	7.2	10.4	6.4	6.0	4.7	4.0	3.9	7.4	10.2	12.9	8.0	8.9	89.9
EOM ELEVATION	2461.0	2460.0	2458.7	2458.1	2456.9	2455.3	2455.5	2457.4	2457.9	2459.3	2461.0	2461.0	2458.5
HIST.ELEVATION	2461.3	2458.9	2457.0	2455.3	2453.7	2452.6	2454.8	2458.2	2459.3	2459.5	2460.3	2460.7	2457.6
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	4.0	2.0	1.6	.9	1.4	2.2	4.1	4.9	4.8	3.2	1.8	4.0	35.0
TOTAL GEN HRS	227.1	114.0	88.2	51.0	80.1	126.0	229.0	274.0	266.9	182.0	101.7	225.4	1965.4
95 BILL(x1000)	187.9	101.8	79.3	43.0	71.1	111.8	209.2	262.2	236.9	164.0	87.4	175.4	1729.8

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1975-1976 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.8	1.7	4.2	5.8	6.4	1.9	3.9	10.6	12.4	7.7	4.4	1.5	65.3
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	4.8	5.3	8.0	7.6	8.5	5.8	10.1	10.6	9.0	.6	.9	1.1	72.4
HIST.RELEASE	7.8	5.7	5.7	6.5	7.1	7.6	7.3	7.2	6.0	7.0	4.4	4.0	76.3
EOM ELEVATION	2461.0	2460.0	2459.0	2458.5	2457.9	2456.8	2455.0	2455.0	2456.0	2458.0	2459.0	2459.1	2457.9
HIST.ELEVATION	2459.9	2458.8	2458.4	2458.2	2458.0	2456.4	2455.4	2456.4	2458.2	2458.4	2458.4	2457.7	2457.8
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.8	2.0	3.1	2.9	3.3	2.2	3.9	4.1	3.5	.2	.3	.4	27.8
TOTAL GEN HRS	103.5	114.0	173.2	163.9	184.5	126.0	218.1	229.4	194.1	13.9	19.4	24.2	1564.3

95 BILL(x1000)	89.3	101.8	151.5	132.6	158.1	111.8	200.1	222.6	177.2	13.3	17.2	20.2	1395.6

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1976-1977 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.4	.3	-.5	-.1	10.5	5.4	5.5	1.8	8.0	18.2	9.2	3.7	66.3
FISH RELEASE	.00	.00	.14	.39	.00	.00	.00	.00	.00	.00	.00	.00	.53
REL THRU PLANT	1.3	3.6	3.0	2.4	8.0	5.8	10.6	6.4	4.5	8.4	3.2	1.6	58.8
HIST.RELEASE	4.0	3.8	2.3	2.3	5.3	7.5	7.6	4.5	5.6	4.7	5.5	3.3	56.4
EOM ELEVATION	2459.9	2459.0	2458.0	2457.2	2457.9	2457.8	2456.3	2455.0	2456.0	2458.8	2460.4	2460.9	2458.1
HIST.ELEVATION	2457.8	2456.8	2456.0	2455.3	2456.8	2456.2	2455.6	2454.8	2455.5	2459.3	2460.3	2460.4	2457.1
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	.5	1.4	1.2	.9	3.1	2.2	4.1	2.5	1.7	3.2	1.2	.6	22.6
TOTAL GEN HRS	28.8	77.4	65.1	51.0	171.8	126.0	229.0	139.1	98.1	182.0	69.0	34.0	1271.3
95 BILL(x1000)	25.6	70.1	59.1	43.0	147.8	111.8	209.4	139.1	92.7	164.0	60.0	28.3	1150.8

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1977-1978 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.6	.8	.6	-.2	2.5	7.3	14.1	8.5	1.7	22.5	12.4	13.8	85.6
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	4.2	5.3	4.4	2.4	5.0	5.8	10.8	12.7	4.3	9.9	6.9	13.8	85.5
HIST.RELEASE	3.5	5.2	5.3	3.7	3.2	3.8	7.3	14.7	10.7	7.3	6.5	14.5	85.6
EOM ELEVATION	2460.3	2459.0	2458.0	2457.3	2456.6	2457.0	2457.9	2456.7	2456.0	2459.5	2461.0	2461.0	2458.4
HIST.ELEVATION	2459.9	2458.7	2457.4	2456.3	2456.1	2457.1	2459.0	2457.3	2454.7	2459.0	2460.6	2460.4	2458.1
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.0	1.7	.9	1.9	2.2	4.2	4.9	1.6	3.8	2.6	5.3	32.9
TOTAL GEN HRS	91.0	114.0	94.3	51.0	109.0	126.0	234.2	274.0	92.4	214.6	148.4	297.4	1846.4
95 BILL(x1000)	78.9	101.8	84.7	43.0	95.6	111.8	213.8	262.2	87.6	191.3	125.5	225.4	1621.4

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1978-1979 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.6	7.3	1.4	.5	.0	1.9	17.7	12.6	11.7	23.5	7.8	7.9	96.8
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	4.6	9.9	6.2	2.4	4.5	5.8	11.4	12.7	11.6	17.6	3.2	7.0	96.8
HIST.RELEASE	5.0	9.1	7.6	4.5	4.5	4.3	7.5	10.1	10.2	21.3	13.0	5.3	102.4
EOM ELEVATION	2461.0	2460.3	2459.0	2458.5	2457.3	2456.1	2457.9	2457.9	2457.9	2459.5	2460.8	2461.0	2458.9

HIST.ELEVATION	2460.3	2459.8	2458.1	2457.0	2455.7	2455.0	2457.9	2458.6	2459.0	2459.6	2458.2	2458.9	2458.2
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.8	3.8	2.4	.9	1.7	2.2	4.4	4.9	4.5	6.8	1.2	2.7	37.2
TOTAL GEN HRS	100.3	213.2	133.3	51.3	96.6	126.0	247.1	274.0	250.2	380.7	69.0	150.5	2092.2
5 BILL(x1000)	86.6	184.4	118.0	43.2	85.1	111.8	224.5	262.2	223.7	312.6	60.0	120.0	1832.1

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1979-1980 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.0	2.1	1.0	2.1	11.0	4.2	5.1	4.3	5.0	15.3	16.2	13.9	81.1
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	4.2	5.3	5.3	2.4	11.4	5.8	10.6	7.3	1.5	8.3	5.1	13.9	81.1
HIST.RELEASE	4.2	4.2	4.9	3.8	7.5	6.6	4.8	6.7	5.3	2.6	10.3	13.2	74.0
EOM ELEVATION	2460.1	2459.3	2458.1	2458.0	2457.9	2457.4	2455.9	2455.0	2456.0	2458.0	2461.0	2461.0	2458.1
HIST.ELEVATION	2458.0	2457.4	2456.3	2455.8	2456.8	2456.1	2456.2	2455.5	2455.4	2459.0	2460.6	2460.8	2457.3
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.0	2.0	.9	4.4	2.2	4.1	2.8	.6	3.2	2.0	5.4	31.2
TOTAL GEN HRS	91.0	114.0	114.0	51.0	245.5	126.0	229.0	157.5	33.3	178.4	110.6	301.1	1751.5
95 BILL(x1000)	78.9	101.8	101.5	43.0	206.0	111.8	209.4	156.6	32.4	160.9	94.7	227.8	1524.8

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1980-1981 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	9.0	1.1	5.6	.7	-.2	3.6	7.2	1.0	13.4	7.8	13.8	6.9	69.9
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	9.0	5.3	8.8	2.5	4.3	5.8	10.6	3.1	9.5	1.2	3.2	6.4	69.9
HIST.RELEASE	12.3	8.8	9.8	11.2	2.1	.0	1.4	2.3	3.2	6.4	6.8	8.0	72.5
EOM ELEVATION	2461.0	2459.9	2459.0	2458.5	2457.3	2456.6	2455.6	2455.0	2456.1	2458.0	2460.9	2461.0	2458.2
HIST.ELEVATION	2459.9	2457.8	2456.6	2453.5	2452.8	2453.9	2455.6	2455.2	2458.1	2458.5	2460.4	2460.1	2456.9
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	3.5	2.0	3.4	1.0	1.7	2.2	4.1	1.2	3.7	.5	1.2	2.5	26.9
TOTAL GEN HRS	194.2	114.0	190.6	54.0	93.3	126.0	229.0	67.8	206.0	26.8	69.0	139.3	1510.1
95 BILL(x1000)	162.5	101.8	165.7	45.5	82.4	111.8	209.4	69.6	187.3	25.5	60.0	111.4	1332.8

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1981-1982 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	12.5	3.2	1.3	3.3	2.2	2.6	9.7	7.1	13.3	20.6	5.8	1.4	83.0

FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	12.5	5.8	6.1	5.1	5.0	5.8	10.6	12.5	9.5	8.4	3.2	1.6	86.2
HIST.RELEASE	11.0	7.6	6.7	9.0	2.9	5.7	6.6	10.9	10.5	10.6	5.1	2.1	88.9
EOM ELEVATION	2461.0	2460.3	2459.0	2458.5	2457.7	2456.8	2456.6	2455.0	2456.1	2459.5	2460.2	2460.1	2458.4
HIST.ELEVATION	2460.5	2459.3	2457.8	2456.2	2456.0	2455.1	2456.0	2454.9	2455.7	2458.5	2458.7	2458.5	2457.3
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	4.8	2.2	2.3	2.0	1.9	2.2	4.1	4.8	3.7	3.2	1.2	.6	33.1
TOTAL GEN HRS	270.2	125.0	131.2	110.7	109.0	126.0	229.0	270.0	206.0	182.0	69.0	34.0	1862.2
95 BILL(x1000)	220.1	111.2	116.2	91.2	95.6	111.8	209.4	258.6	187.3	164.0	60.0	28.3	1653.7

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1982-1983 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	6.3	5.7	.1	-.1	-.5	1.8	5.3	2.0	5.5	13.7	15.5	14.0	69.4
FISH RELEASE	.00	.00	.00	.04	.00	.00	.00	.00	.00	.00	.00	.00	.04
REL THRU PLANT	4.2	7.2	4.9	2.4	4.0	5.8	8.5	2.0	2.1	6.6	4.5	14.0	66.2
HIST.RELEASE	2.3	4.9	4.8	6.0	5.8	3.8	2.6	2.4	1.7	3.3	11.8	12.6	62.0
EOM ELEVATION	2460.7	2460.3	2459.0	2458.3	2457.1	2455.9	2455.0	2455.0	2456.0	2458.0	2461.0	2461.0	2458.1
HIST.ELEVATION	2459.6	2459.8	2458.5	2456.8	2455.0	2454.4	2455.2	2455.1	2456.2	2459.1	2460.1	2460.5	2457.5
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	2.8	1.9	.9	1.5	2.2	3.2	.8	.8	2.5	1.7	5.4	25.4
TOTAL GEN HRS	91.0	156.0	105.1	51.0	86.4	126.0	182.6	44.0	44.6	142.9	96.4	303.5	1429.5
95 BILL(x1000)	78.9	137.4	93.9	43.0	76.5	111.8	169.4	45.5	43.1	130.3	83.0	229.3	1242.2

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1983-1984 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	3.5	-.3	-.4	-.8	.9	6.3	11.4	2.6	16.8	14.0	19.2	7.3	80.6
FISH RELEASE	.00	.01	.17	.27	.04	.00	.00	.00	.00	.00	.00	.00	.49
REL THRU PLANT	4.2	4.3	4.0	2.4	5.0	5.8	10.6	7.9	9.5	8.4	10.5	7.3	80.1
HIST.RELEASE	6.8	4.5	3.6	3.1	2.3	5.7	14.2	6.0	3.3	6.0	21.7	8.8	85.8
EOM ELEVATION	2460.8	2459.5	2458.3	2457.3	2456.2	2456.3	2456.5	2455.0	2457.1	2458.7	2461.0	2461.0	2458.1
HIST.ELEVATION	2459.6	2458.3	2457.2	2456.1	2455.7	2455.9	2455.1	2454.1	2458.0	2460.2	2459.5	2459.1	2457.4
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.7	1.6	.9	1.9	2.2	4.1	3.1	3.7	3.2	4.0	2.8	30.8
TOTAL GEN HRS	91.0	93.1	87.4	51.0	109.0	126.0	229.0	171.8	206.0	182.0	227.3	158.1	1731.7
95 BILL(x1000)	78.9	83.8	78.7	43.0	95.6	111.8	209.4	170.1	187.4	164.0	187.1	125.7	1535.6

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1984-1985 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
NFLOW	.5	10.0	7.5	-1.1	.4	4.5	12.6	3.8	12.1	12.3	7.4	6.4	76.3
ISH RELEASE	.00	.00	.00	.13	.01	.00	.00	.00	.00	.00	.00	.00	.13
REL THRU PLANT	4.2	8.9	12.3	2.4	4.8	5.8	10.6	10.5	8.6	5.2	1.6	1.6	76.5
HIST.RELEASE	2.7	5.6	11.6	7.8	6.9	2.4	3.9	7.7	6.1	9.4	4.5	1.6	70.0
EOM ELEVATION	2460.0	2460.3	2459.0	2458.0	2456.8	2456.4	2456.9	2455.0	2456.0	2458.0	2459.6	2460.9	2458.1
HIST.ELEVATION	2458.5	2459.7	2458.6	2456.1	2454.2	2454.8	2457.3	2456.2	2457.9	2458.7	2459.5	2460.8	2457.7
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	3.4	4.7	.9	1.9	2.2	4.1	4.0	3.3	2.0	.6	.6	29.4
TOTAL GEN HRS	91.0	192.0	266.3	51.0	104.0	126.0	229.0	227.0	186.7	112.4	33.7	34.0	1653.1
95 BILL(x1000)	78.9	167.2	225.6	43.0	91.4	111.8	209.4	220.9	170.9	103.5	29.7	28.3	1480.6

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1985-1986 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	7.7	13.7	.3	-1.1	.9	27.8	7.7	4.9	22.1	11.4	6.4	2.4	104.2
FISH RELEASE	.00	.00	.00	.42	.02	.00	.00	.00	.00	.00	.00	.00	.43
REL THRU PLANT	7.3	16.3	5.1	2.4	5.0	23.8	10.6	12.1	12.0	8.4	3.2	1.1	107.3
HIST.RELEASE	9.2	14.4	4.7	2.2	2.7	19.8	21.7	5.9	12.2	11.4	3.1	1.6	109.0
EOM ELEVATION	2461.0	2460.3	2459.0	2457.9	2456.8	2457.9	2457.1	2455.0	2457.9	2458.7	2459.6	2459.9	2458.4
HIST.ELEVATION	2460.4	2460.2	2459.0	2458.1	2457.6	2459.8	2455.9	2455.6	2458.4	2458.4	2459.3	2459.5	2458.5
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	2.8	6.3	1.9	.9	1.9	9.1	4.1	4.7	4.6	3.2	1.2	.4	41.3
TOTAL GEN HRS	158.7	352.1	109.2	51.0	109.0	513.6	229.0	261.7	259.0	182.0	68.8	24.2	2318.3
95 BILL(x1000)	134.4	285.8	97.4	43.0	95.6	371.2	209.4	251.5	230.8	164.0	59.9	20.2	1963.3

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1986-1987 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	.9	9.5	.0	-.8	3.1	11.7	10.5	5.7	4.1	8.2	18.1	2.8	73.8
FISH RELEASE	.00	.00	.00	.35	.00	.00	.00	.00	.00	.00	.00	.00	.36
REL THRU PLANT	1.8	7.2	4.8	2.4	5.0	10.2	10.6	12.7	3.8	1.1	7.0	2.8	69.6
HIST.RELEASE	.5	7.0	8.8	11.0	.0	.0	15.2	10.7	4.1	1.5	7.4	4.3	70.5
EOM ELEVATION	2459.7	2460.3	2459.0	2458.0	2457.5	2457.9	2457.9	2455.9	2456.0	2458.0	2461.0	2461.0	2458.5
HIST.ELEVATION	2459.6	2460.3	2457.9	2454.5	2455.4	2458.7	2457.4	2456.0	2456.0	2457.9	2460.8	2460.4	2457.9
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	.7	2.8	1.9	.9	1.9	3.9	4.1	4.9	1.5	.4	2.7	1.1	26.8
TOTAL GEN HRS	39.8	156.2	104.0	51.0	109.0	220.5	229.0	274.0	82.1	23.7	152.3	61.1	1502.8
95 BILL(x1000)	35.2	137.6	93.0	43.0	95.6	189.7	209.4	262.2	78.1	22.6	128.6	50.3	1345.4

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1987-1988 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	1.5	-1.3	-.9	2.1	-.7	3.1	11.3	7.8	8.6	7.8	5.9	16.0	61.1
FISH RELEASE	.00	.13	.43	.05	.00	.00	.00	.00	.00	.00	.00	.00	.61
REL THRU PLANT	4.2	3.3	2.3	2.4	3.8	5.8	10.6	11.5	5.1	.7	.9	9.9	60.5
HIST.RELEASE	2.2	1.3	2.7	15.1	5.0	1.1	4.2	8.4	4.7	2.8	.8	12.3	60.7
EOM ELEVATION	2460.3	2459.0	2458.0	2457.9	2456.7	2455.9	2456.1	2455.0	2456.0	2458.0	2459.4	2461.0	2457.8
HIST.ELEVATION	2460.2	2459.5	2458.5	2454.8	2453.1	2453.7	2455.8	2455.6	2456.7	2458.1	2459.5	2460.5	2457.2
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.3	.9	.9	1.5	2.2	4.1	4.4	2.0	.3	.3	3.8	23.3
TOTAL GEN HRS	91.0	70.3	49.2	51.0	81.5	126.0	229.0	248.9	111.1	15.7	19.4	214.5	1307.5
95 BILL(x1000)	78.9	63.9	44.9	43.0	72.2	111.8	209.4	240.1	104.4	14.9	17.2	167.5	1168.3

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1988-1989 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	.6	-1.2	-.7	.7	.8	6.4	4.6	11.7	10.5	15.2	4.4	15.2	68.3
FISH RELEASE	.05	.68	1.07	.33	.00	.00	.00	.00	.00	.00	.00	.00	2.12
REL THRU PLANT	4.2	2.8	2.4	2.4	4.5	5.8	8.5	11.7	7.0	8.1	.9	7.7	66.1
HIST.RELEASE	2.5	1.0	2.2	5.8	5.0	4.6	5.3	10.3	10.5	7.7	3.0	8.9	66.8
EOM ELEVATION	2460.0	2458.8	2457.6	2457.1	2456.0	2456.2	2455.0	2455.0	2456.0	2458.0	2459.0	2461.0	2457.5
HIST.ELEVATION	2460.0	2459.4	2458.6	2457.2	2456.0	2456.5	2456.3	2456.7	2456.7	2458.8	2459.2	2460.9	2458.0
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.1	.9	.9	1.7	2.2	3.3	4.5	2.7	3.1	.3	3.0	25.4
TOTAL GEN HRS	91.0	61.4	52.1	51.0	97.0	126.0	184.3	252.5	152.1	175.9	19.4	166.4	1429.1
95 BILL(x1000)	78.9	55.9	47.5	43.0	85.5	111.8	170.9	243.0	141.0	158.8	17.2	132.0	1285.5

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1989-1990 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	8.1	6.8	1.7	.0	3.0	7.0	4.4	14.5	9.7	2.6	5.7	7.9	71.4
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	8.1	9.4	6.4	2.4	5.0	6.6	10.6	12.7	9.5	.5	.9	1.6	73.7
HIST.RELEASE	8.5	9.4	6.8	14.4	12.8	.3	1.1	7.7	9.7	.1	.2	1.3	72.2
EOM ELEVATION	2461.0	2460.3	2459.0	2458.4	2457.8	2457.9	2456.1	2456.7	2456.7	2457.3	2458.7	2460.4	2458.4
HIST.ELEVATION	2460.8	2460.1	2458.7	2454.6	2451.6	2453.7	2454.7	2456.7	2456.7	2457.4	2458.9	2460.7	2457.1
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	3.1	3.6	2.5	.9	1.9	2.6	4.1	4.9	3.7	.2	.3	.6	28.3

TOTAL GEN HRS	174.7	202.3	139.2	51.0	109.0	143.3	229.0	274.0	206.0	10.3	19.4	34.0	1592.3
95 BILL(x1000)	147.2	175.6	122.9	43.0	95.6	126.5	209.4	262.2	187.4	9.8	17.2	28.3	1425.2

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EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1990-1991 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.3	22.0	6.6	-1.5	5.1	5.0	11.7	11.7	14.8	2.5	5.8	15.0	102.9
FISH RELEASE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
REL THRU PLANT	4.2	22.4	11.4	2.4	5.3	5.8	10.9	12.7	13.8	2.1	.9	8.9	100.7
HIST.RELEASE	5.0	21.2	5.8	5.2	7.7	6.8	14.9	13.1	15.9	2.5	3.0	5.6	106.6
EOM ELEVATION	2460.4	2460.3	2459.0	2457.9	2457.9	2457.7	2457.9	2457.6	2457.9	2458.0	2459.3	2461.0	2458.8
HIST.ELEVATION	2460.5	2460.7	2460.9	2459.1	2458.4	2457.9	2457.0	2456.6	2456.3	2456.3	2457.1	2459.7	2458.4
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	8.6	4.4	.9	2.0	2.2	4.2	4.9	5.3	.8	.3	3.4	38.7
TOTAL GEN HRS	91.0	483.2	245.6	51.0	114.9	126.0	234.9	274.0	297.7	45.8	19.4	191.3	2174.8
95 BILL(x1000)	78.9	360.7	209.6	43.0	100.6	111.8	214.3	262.2	259.5	43.3	17.2	150.5	1851.5

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

FOR YEAR 1991-1992 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.3	-2.6	-1.5	-.5	-1.7	-2.7	2.6	6.8	8.0	4.1	10.1	10.6	37.8
FISH RELEASE	.43	.68	1.37	1.45	1.08	.37	.00	.00	.00	.00	.00	.00	5.38
REL THRU PLANT	4.2	3.6	2.5	1.1	.9	.5	1.5	6.8	4.6	.5	1.3	5.0	32.4
HIST.RELEASE	1.7	1.1	.7	1.3	.9	.2	4.0	6.4	8.7	3.1	4.4	3.7	36.3
EOM ELEVATION	2460.9	2459.1	2457.6	2456.7	2455.7	2454.7	2455.0	2455.0	2456.0	2457.0	2459.5	2461.0	2457.4
HIST.ELEVATION	2460.4	2459.4	2458.8	2458.3	2457.6	2456.8	2456.4	2456.5	2456.3	2456.6	2458.2	2460.1	2458.0
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
GWH AT PLANT	1.6	1.4	1.0	.4	.4	.2	.6	2.6	1.8	.2	.5	1.9	12.5
TOTAL GEN HRS	91.0	77.4	54.2	22.8	20.4	10.0	31.8	146.4	99.3	10.3	28.4	108.2	700.2
95 BILL(x1000)	78.9	70.0	49.4	19.5	18.5	9.2	31.1	145.9	93.8	9.8	25.1	87.5	638.7

EBASCO SERVICES INCORPORATED

PENELEC-DEEP CK 62-92; CASE 1227RUN-TM+WW+MIN GEN 10HR; REV RB; 40CFS;MAX EFF

SUMMARY FOR YEARS FROM 1962 TO 1992 --- FLOWS IN 1000 ACRE-FEET

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	YEAR
INFLOW	4.3	3.1	.9	.5	1.6	4.7	8.4	8.1	9.8	14.3	10.6	8.1	74.5
FISH RELEASE	.04	.13	.23	.31	.11	.04	.00	.00	.00	.00	.00	.00	.86
REL THRU PLANT	5.3	6.2	5.0	2.6	4.6	6.4	9.2	9.9	7.0	7.0	4.2	6.0	73.6
HIST.RELEASE	5.2	6.2	5.5	5.6	4.9	5.1	7.5	7.1	6.4	7.1	7.2	6.7	74.5

EOM ELEVATION	2460.5	2459.6	2458.4	2457.8	2456.9	2456.4	2456.1	2455.6	2456.4	2458.5	2460.2	2460.8	2458.1
HIST.ELEVATION	2459.8	2458.9	2457.7	2456.2	2455.2	2455.1	2455.4	2455.7	2456.6	2458.7	2459.6	2460.0	2457.4
UPPER RULE EL.	2461.0	2460.3	2459.0	2458.5	2457.9	2457.9	2457.9	2457.9	2457.9	2459.5	2461.0	2461.0	2459.2
LOWER RULE EL.	2460.0	2459.0	2458.0	2457.0	2456.0	2455.0	2455.0	2455.0	2456.0	2458.0	2459.6	2460.0	2457.4
WH AT PLANT	2.0	2.4	1.9	1.0	1.8	2.5	3.5	3.8	2.7	2.7	1.6	2.3	28.3
TOTAL GEN HRS	113.5	133.7	108.5	57.1	100.0	138.7	199.4	214.2	152.0	151.2	91.8	129.3	1589.6
95 BILL(x1000)	96.7	115.7	96.2	47.7	87.5	119.9	181.2	206.6	138.9	133.3	77.6	101.5	1402.9

MIN. LEVEL	2459.1	2458.5	2457.5	2456.7	2455.7	2454.7	2455.0	2455.0	2456.0	2457.0	2458.7	2459.1
MIN. GEN.HRS	28.8	49.7	49.2	22.8	20.4	10.0	11.8	44.0	22.7	10.3	19.4	24.2

FOR A RATED CAPACITY OF 17600. KW:

THE RATED DISCHARGE = 580. CFS
THE RATED HEAD = 410. FEET
THE WEIGHTED HEAD = 417. FEET
THE PLANT FACTOR = .18

APPENDIX E

DISSOLVED OXYGEN CONCEPTUAL ENGINEERING REPORT

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Pennsylvania Electric Company (Penelec) has applied to the State of Maryland Department of Natural Resources (MDNR) for a permit to appropriate and use waters of the State for the Deep Creek hydroelectric project. As part of the State permit process for the project, the State of Maryland is requiring the powerhouse discharge to be in compliance with State water quality standards as the discharge enters the Youghiogheny River. MDNR is also requiring Penelec to provide a bypass flow around the Deep Creek power plant during low flow conditions in the Youghiogheny River. This bypass flow will also need to meet State water quality standards.

The Deep Creek Station powerhouse discharge currently does not meet the Maryland State water quality standard of 5 milligrams per liter (mg/l) for dissolved oxygen (DO) during the period of the year when Deep Creek Lake is stratified (i.e. approximately July through September). During this stratification period, when Deep Creek Station commences generation after a shutdown of about 20 hours or more, water in the power tunnel and penstocks is essentially devoid of dissolved oxygen; the DO concentration of the powerplant discharge remains close to 0 mg/l until the water in the power tunnel and penstocks is replaced by water drawn into the intake. For two-unit generation, it takes about 15 minutes after start-up to replace the water in the power tunnel and penstocks. After this 15 minute period, DO concentrations typically increase to 3 mg/l or higher for the remainder of the generation period.

The recommended solution is the construction of a tailrace weir. The recommended solution will permit Deep Creek Station to meet water quality standards during project operation after the start-up period. During start-up, instantaneous DO concentrations may be less than 5 mg/l. MDNR and Maryland Department of the Environment (MDE) have notified Penelec that they will not oppose construction of a tailrace weir provided that DO concentrations during start-up are sufficiently high to prevent fish kills or adverse fishery impacts. The total project cost for the weir is $283,000. A one to two month unit outage may be required for installation. Discussion with MDNR and MDE personnel indicate that the tailrace weir must be installed by the summer of 1994. To meet this requirement, construction during March/April 1994 is proposed. This project has been determined to be capital and O&M. The estimated funding requirements through 1995 are as follows:

	1993	1994	1995	Total
Capital	$60,000	$223,000 [1/]	$0	$283,000
O&M			$5,750	$5,750

This completes EWR #SW-90-46.

[1/] Assumes 5 percent escalation.

INTRODUCTION

Penelec has submitted an Application For A Permit To Appropriate And Use Waters Of The State to the MDNR. The permit will require the discharge during project operation and after initial start-up, to be in compliance with State water quality standards as the discharge enters the Youghiogheny River. The permit will also require Penelec to provide a bypass flow around the Deep Creek powerhouse during low flow conditions in the Youghiogheny River. The bypass flow will need to meet State water quality standards.

The Youghiogheny River is designated as Class III Waters (natural trout waters). The DO concentration of Class III waters may not be less than 5.0 mg/l at any time, with a minimum daily average of not less than 6.0 mg/l. Since Deep Creek discharge is often substantially greater than the Youghiogheny River flow at the confluence of the tailrace and Youghiogheny River, the Deep Creek powerhouse discharge will need to meet the Class III water quality criteria in order for the Youghiogheny River to be within State water quality standards.

Currently, the powerhouse discharge does not meet the DO standard of 5 mg/l during the period of the year when Deep Creek Lake is stratified (i.e., July, August and September[2/]). During stratified conditions, water discharged by the plant originates primarily from the hypolimnion because the Deep Creek Station intake is located at the bottom of Deep Creek Lake, approximately 50 feet below the normal surface water elevation. The withdrawal rate of water from Deep Creek Lake is not large enough to fully overcome the density differential between the upper layer and the lower layer.

[2/] Deep Creek Lake normally becomes stratified during the month of July. During the spring and early summer, surface waters at Deep Creek Lake warm faster than bottom waters. This leads to a density difference between the warmer upper layer (epilimnion) and the cooler bottom layer (hypolimnion), which in turn inhibits mixing of the lake waters. Because the upper layer isolates the hypolimnion from the atmosphere, the oxygen content of the lower layer is gradually depleted as oxygen is consumed by the decay of organic matter.

Consequently, most of the water comes from the hypolimnion which can have a DO concentration near 0 mg/l during stratified reservoir conditions.

With two-unit generation, withdrawal rates from Deep Creek Lake are about 640 cfs at full gate operation and about 560 cfs at the point of maximum efficiency. The 640 and 560 cfs withdrawal rates partially overcome the density differential between the epilimnion and the hypolimnion. The net result is a mixture of water entering the intake that has a DO concentration of 3 mg/l or higher during full gate operation. This concentration is unaffected by project operations, resulting in powerhouse discharge that has a DO concentration of at least 3 mg/l.

Deep Creek Station operates as a synchronous condenser when it is not generating power. During this mode of operation, a leakage flow estimated at 9 cubic feet per second (cfs) passes through the turbines and is discharged to the tailrace. This low flow is drawn through the intake structure exclusively from the hypolimnion. Although the water is very low in dissolved oxygen when it passes through the intake, it is reoxygenated as it passes through the turbines and does not violate State water quality DO standards. The leakage flow takes about 16 hours to travel from the intake to the powerhouse.

When Deep Creek Station commences generation, the water is no longer reoxygenated as it passes through the turbines. Since the water in the power tunnel and penstocks at the commencement of generation has generally originated from the leakage flow and is essentially devoid of DO, the DO concentration of the power plant discharge can remain close to 0 mg/l until the water in the penstocks and power tunnel is replaced by water drawn into the intake after startup. For two-unit generation at full gate, it takes about 15 minutes for this higher DO water to reach the plant. Similarly for 1-unit generation, it takes about 30 minutes for the higher DO water to reach the plant.

The objectives of this study are to investigate potential techniques to increase dissolved oxygen in the Deep Creek Station tailrace and recommend the most feasible technique considering construction cost, operation and maintenance requirements, effectiveness, and reductions in Deep Creek Station power production when DO is being enhanced.

POTENTIAL SOLUTIONS

The following possible solutions were considered in this CER:

Option 1 - Installation of a tailrace weir

Option 2 - Turbine venting

Option 3 - Combination of a tailrace weir and turbine venting

Option 4 - Direct injection of oxygen

Option 1: Installation of a tailrace weir

A tailrace weir is essentially just a waterfall. It adds oxygen to water by several mechanisms, but about 95 percent of the benefit results from air bubbles being entrained by the falling water and driven below the downstream pool level, where they dissolve.

An aerating tailrace weir installed at Canyon Dam by the Waco Power Company in Texas was constructed to meet requirements similar to those at Deep Creek. Canyon Dam has a maximum flow of almost 600 cfs with low DO levels. The solution to the DO problem at Canyon Dam was a combination of turbine venting and an aerating weir. The weir has an effective height of 2 to 3 feet (depending on tailwater elevation) and provides DO uptakes of 2.5 to 5 mg/L depending on incoming DO level and water flow. The weir is a labyrinth shape with a 385 foot long crest resulting in a unit flow of 1.5 cfs/ft at maximum flow. The aeration results at Canyon Dam can be predicted using equations by Avery and Novak (Reference 7). Applying these equations to Deep Creek, a weir with a 3 foot effective height and 430 feet long (with overall dimensions of 40 feet by 120 feet) could be expected to provide at least the 2 mg/L required for reaching 5 mg/L during normal operation. This weir might also be suitable for aerating the start-up flow. The low DO during start-up could possibly be increased sufficiently to meet the State standards since the tailwater is one to two feet lower during start-up and would therefore provide a greater effective height for the weir. An operational change to using only one unit for the beginning of each start-up would decrease the unit flow over the weir to about 0.7 cfs/ft. This flow would result in more effective aeration by the weir by prolonging the low tailwater condition. However, the DO concentration of the water drawn into the power tunnel would be lower because less water is drawn from the epilimnion during one unit operation.

The negative aspects of a tailrace weir at Deep Creek are: (1) a reduction in the available habitat for fisheries in the tailrace, (2) a reduction in project electrical generation due to the reduced hydraulic head, (3) lack of flexibility in meeting variable operational requirements, (4) the risk that the weir might not perform as well as expected, and (5) the potential adverse effect on the wild and scenic aspects of the Youghiogheny River. During installation of the weir, there would be significant disruption to fish in the tailrace due to the impact of cofferdam installation, excavation to bedrock, concrete placement, etc. Also, Deep Creek Station could be out of service for 1-2 months during installation. Permit conditions, such as allowable suspended sediment concentration during construction, could require costly mitigation. To reduce the installation time, the weir could be constructed in precast sections. Because the Youghiogheny River is a Class III trout stream, construction could be limited to the summer period. This would be in conflict with State in-service date requirements. Further, construction during the summer period could result in the discharging of water from Deep Creek Lake over the spillway and into the bypass channel in order to maintain recreational water levels in Deep Creek Lake. This could adversely affect wetlands within the bypass channel.

With a crest elevation of about 2027.4 feet, the weir would have an effective height of 3 feet at higher summer Youghiogheny River flows (i.e., greater than 1,000 cfs) to ensure that sufficient aeration to meet State standards would occur at all reasonable river flow conditions. Most of the time, Youghiogheny River flows would be lower, resulting in an effective height of about 4 feet. With a 4 foot increase in tailwater elevation, Deep Creek Station, with an effective operating head of 400 feet, would lose approximately one percent of the energy generated when compared to the energy that would be generated without the weir. Since the oxygen deficiency occurs only when the reservoir is stratified, flap gates could be installed to avoid derating the plant during the rest of the year. If flap gates are installed, the weir would cause a head loss of about 0.4 feet (i.e., one velocity head) when the gates are in the down position.

Slide gates or a pipe with a valve would be installed to enable the weir to be drained. Draining of the water upstream of the weir to normal non-operating tailwater levels of about 2023 feet would allow maintenance to be performed on the water wheel of each unit without inundating the maintenance platform that is placed in the draft tube for this purpose. The bottom of the platform is at elevation 2025.5 feet.

If water wheel maintenance from the draft tube platform is required during the lake stratification period, it would be necessary to use stoplogs at the powerhouse discharge to isolate the unit from the water in the tailrace channel when generation from the second unit is desired. During the remainder of the year, one-unit generation could occur during water wheel maintenance on the other unit if the unit being maintained is isolated by use of stoplogs or flap gates are used to keep the water levels upstream of the weir below 2025 feet.

The total direct installation cost of the weir option is estimated to be $283,000. Based on the distribution of monthly energy from project operation simulations, annual energy losses would be about 75 MWh (i.e., $3,800 @ $50/MWh), assuming flap gates are installed and that the weir would operate only during the July-September period. (Without flap gates, the annual energy loss would be about 300 MWH (i.e., $15,000 @ $50/MWH)). The weir would be relatively maintenance free, requiring only annual opening and closing of the flap gates if they are installed. With the replacement generation cost included, the Present Worth of the single tailrace weir option is $362,000. See the attachments for details of these costs.

Option 2: Turbine venting

Turbine venting takes advantage of the hydrodynamic/hydraulic properties of the turbine which create low-pressure regions downstream of the turbine blades. These subatmospheric pressures, when vented to the atmosphere cause air to be drawn into the water flow. The existence and magnitude of a subatmospheric pressure in the draft tube are dependent upon the operating conditions, the flow rate, geometric properties of the turbine and draft tube, and headwater and tailwater elevations. The air flow rate into the water flow is a function of the pressure differential between the atmosphere and the draft tube and the losses in the aeration supply line.

In this investigation, two methods of turbine venting were evaluated. Most Francis turbines, including Deep Creek Station's, are fitted with a vacuum breaker system, in which a cam-operated valve automatically opens at low discharge (i.e., low load) conditions (approximately 50 percent flow) to vent the draft tube to the atmosphere, pulling in air and smoothing turbine performance. The vacuum breaker system at Deep Creek Station is connected to 4-inch diameter pressure equalization lines which penetrate both the draft tube and the turbine behind the pressure seals immediately upstream of the turbine runner. The first method of turbine venting would involve the vacuum breaker system and the equalization lines. The second method of turbine venting (also referred to as draft tube venting) would involve penetrating the draft tube and constructing a ring within the draft tube to allow air to be forced or drawn into the draft tube.

Use of Existing Equalization Lines

The turbine runner distributor at Deep Creek is set 10 feet above normal tailwater elevation. The high setting of the turbine results in very low pressures below the turbine. The low pressure can be used to draw air in from an opening to the atmosphere for turbine venting. During a test to assess the viability of turbine venting at Deep Creek, the vacuum breaker piping drew air during generation at normal conditions indicating potential for turbine venting without need for baffles or other devices to create localized low pressure areas. The major requirement for turbine venting to work is a large air passage through the head cover into the low pressure area below the turbine. Increased air flow rates might be achieved with some sort of baffle if the air passage is sufficient.

Site observation of the vacuum breaker line by Penelec operating personnel indicated that the 1-1/2 inch vacuum breaker line tees into one of the 4-inch diameter (pressure) equalization lines that penetrate the turbine head cover. This indicates that there is some potential for turbine venting through this 4-inch diameter line. Preliminary calculations indicate optimal turbine venting conditions would require a 6-inch or larger opening into the head cover. Such an opening could be modified to draw in significant amounts of air. However, some benefit in turbine venting is likely to occur even with the 4-inch line.

The feasibility of modifying the 4-inch diameter lines to attain satisfactory turbine venting results has yet to be determined. The upper leg of the pressure equalization line is probably unsuitable for turbine venting because it penetrates the turbine behind the seals. The lower leg of the equalization lines could possibly draw air into the water flow but would be less effective since it is connected to the draft tube at a lower elevation than the upper leg of the equalization lines, and therefore would have a higher pressure.

Use of the existing 4-inch diameter line for turbine venting would not require a major capital investment to reconfigure the piping for turbine venting. However, there are concerns regarding possible cavitation and the loss of function of the equalization lines. The operating costs would stem from the increase in pressure below the runner with the addition of air. The air lowers the effective head on the turbine and generally costs about 1/2 percent of efficiency per 1 percent by volume of air.

The DO uptake using the 4-inch diameter lines for turbine venting would probably be less than 2 mg/L at normal generating conditions. This amount of aeration would neither supply the needs for normal generation nor would it be effective in increasing the low DO slug at turbine start-up to meet the 5 mg/L State standard. (During the turbine venting test, the vacuum breaker valve was blocked open and blew water out at the very beginning of start-up, indicating positive and not negative pressures.) Turbine venting also would not aerate the bypass flow. Therefore, use of the existing 4-inch diameter lines for turbine venting is not a technically acceptable option by itself.

Draft Tube Modifications

The 10 foot elevation differential between the scrollcase centerline and the normal tailwater elevation indicates that the Deep Creek units would probably have low enough pressures at the draft tube to draw in significant amounts of air from the atmosphere. However, this would require penetration of the draft tube with a large diameter line (i.e., approximately 8-inch diameter) and construction of ring headers within the draft tubes. The drawbacks to this option are the tight quarters in the plant around the draft tube and the requirement for large air passageways for the desired DO uptakes. This would require concrete removal and possibly restrict access to the draft tube man-door. Since the pressures in the draft tube are somewhat higher than those directly under the turbine, some sort of draft tube baffle may have to be designed and installed to get the desired air flow rates.

Even under the most favorable conditions draft tube venting can only supply about 30 percent of the theoretical oxygen deficiency (References No. 2 and 6). At typical plant conditions during start-up, 30 percent of the calculated oxygen saturation concentration (about 9.3 mg/l) would yield a maximum possible benefit of only about 2.8 mg/l, not enough to meet the design start-up requirement of 5 mg/l. Turbine venting through the draft tube also would not aerate the bypass flows.

The poor oxygenation performance of draft tube venting is a function of the short contact time available, and of the fact that air contains only about 21 percent oxygen. For better effectiveness, air could be forced into the draft tube under pressure, but this further degrades turbine performance, risks supersaturating the tailrace with nitrogen, and increases the potential for turbine damage. Also, expensive air compressors (powered by electricity at peaking rates) would be required, eliminating any cost or simplicity advantages that turbine venting might have offered. Instead of air, oxygen could be injected into the draft tube, but turbine performance penalties would remain and oxygen utilization would be poor due to the short contact time. If oxygen is injected, it is much better to do so at a high pressure location.

There are several additional disadvantages to this scheme:

- Each unit would be out of service for approximately 8 weeks for the installation of air piping into the draft tubes of the turbine and ring headers within the draft tubes themselves.
- The installation costs would be very high.
- Turbine venting has historically resulted in increased turbine cavitation and consequent damage.

For the reasons stated, modifying the draft tube to provide turbine venting is not a technically acceptable option, and is not developed further.

Option 3: Combination of a tailrace weir and turbine venting

Combinations of turbine venting with other methods were considered to make up the shortfall in turbine venting performance; the most promising is a combination of turbine venting using the existing 4-inch diameter equalization lines and a tailrace weir. In this scenario the turbine would be vented only during the initial 15 minutes or so of start-up, when the deficit is greatest. The tailrace weir would be sized as discussed in Option 1 to produce the balance of the required dissolved oxygen during start-up, and also to provide all of the required dissolved oxygen after the first 15 minutes in service when turbine venting would be discontinued. This option has all the advantages and disadvantages of the tailrace weir described in Option 1 above, as well as the following disadvantages:

- For the first 15 minutes of start-up, venting the turbine to atmosphere would negate the normal partial vacuum downstream of turbine, resulting in decreased operating hydraulic head and a power loss of approximately 154 KW per turbine.

- The presence of a tailrace weir increases the tailrace water elevation, thus decreasing the relative vacuum below the turbine that makes turbine venting possible.

This option would be feasible only if the tailrace weir is selected, State DO requirements are not met during initial start-up, and adverse fishery impacts occur. The occurrence of adverse fishery impacts with the tailrace weir is considered very unlikely.

Option 4: Direct injection of oxygen

Direct oxygen injection is conceptually a simple matter of bubbling oxygen into the water at some suitable point. Oxygen absorption at a given flow rate is enhanced by higher pressures and by smaller bubble size, which equates to a larger number of bubbles with greater total gas-water surface area over which the absorption can take place. To achieve the required bubble diameters, specially designed diffusers are essential. The necessary pressure is provided by depth of submergence of the diffusers; any point from the bottom of the reservoir through the power tunnel and penstocks is suitable in this regard, as long as sufficient reaction time is provided.

Three sources of oxygen were considered:

- Purchase from commercial vendors in the liquid form for storage on-site in a leased vessel

- On-site production from ambient air by traditional cryogenic methods (i.e. the separation of oxygen from nitrogen and other components of liquified air by distillation)

- On-site production by the pressure swing absorption (PSA) process. (PSA is a relatively new process that forces air into a special zeolite - a naturally occurring ion exchange material - under pressure. Nitrogen is absorbed by the zeolite, leaving a concentrated oxygen product which is collected for use. Releasing pressure on the zeolite allows the nitrogen to escape to the atmosphere, and the process, the "pressure swing", is ready to be repeated).

The economics of cryogenic oxygen production are such that it is not viable for consumption rates of less than approximately 25 to 40 tons per day. Deep Creek's requirement is for less than one half ton per day, so this method is not recommended.

Pressure swing absorption (PSA), is most economical for moderate flow rates over an extended period. For Deep Creek's long periods of low demand and relatively short periods of higher demand this equipment is not suitable without extensive storage capacity. In addition to the compressors, boosters are needed to overcome the local pressure at the chosen injection point. A manufacturer of this equipment, AirSep, was not optimistic that it could be cost effective for Deep Creek's application.

An additional problem with PSA is the limitation that it will produce a product stream with a maximum practical oxygen content of 93 percent. The balance is nitrogen, which might lead to nitrogen supersaturation of the tailrace, depending on the (unknown and variable) ambient dissolved nitrogen content of the reservoir. Supersaturation of water with nitrogen is lethal to fish; therefore any schemes using gas injection upstream of the turbine would have to be based on pure oxygen, and PSA is rejected. The recommended source is therefore commercially prepared liquid oxygen, to be stored on-site in a leased vessel.

Five potential locations for oxygen injection are available:

- The reservoir

- The power tunnel at the intake

- The power tunnel at the surge tank
- The draft tube
- The tailrace

Reservoir Oxygen Injection

Injection into the cold, oxygen-poor lower strata of the reservoir (the hypolimnion) would be beneficial to recreational fishing in addition to solving the tailrace DO problem. Another advantage of reservoir injection is that oxygen would be metered out at a constant, low rate, greatly simplifying control requirements. (If air were injected into the reservoir 5 times the volume of oxygen would be required.)

Reservoir injection could be accomplished by locating the oxygen storage tank at the intake structure and running the oxygen supply header upstream along the bottom of Deep Creek lake for a distance of one to two miles to the diffuser array, or possibly by locating the oxygen storage facility near the diffusers. Alternatively, reservoir injection could be accomplished by placing a diffuser array on the bottom of the reservoir close to the intake, as TVA and the Army Corps of Engineers have done.

For either alternative, oxygen injection into the reservoir would have higher installation costs and much higher oxygen consumption than injection in the power tunnel. For a storage tank location at the intake, stainless steel oxygen header piping, including fittings and anchors, would be required for a length of potentially more than 10,000 feet, at a cost of approximately $8.75 per foot, not including underwater installation. If the storage tank is located at a remote location, security would have to be provided, and permits would have to be obtained. For either reservoir oxygen injection alternative, more diffusers would be required at the injection point, in proportion to the increase in oxygen consumption than for the oxygen injection in the penstock. The rate of oxygen consumption would at least double due to the oxygen demands of decaying organic matter, silt, pollution, and the living biomass of the reservoir. With the oxygen header running along the bottom of the reservoir, occasional damage from boat anchors should be expected. Maintenance costs would include periodic underwater inspections.

Reservoir injection has the following advantage relative to power tunnel/penstock injection:

- Better accessibility to the diffusers for periodic inspection and eventual replacement

The high capital and operating costs relative to other oxygen injection techniques are not considered to be justified, so reservoir injection is not pursued further.

Oxygen Injection At The Intake

This system would meet all the DO requirements for Deep Creek by injecting gaseous oxygen into the power tunnel immediately downstream of the intake. (See Attachment 5 for a description of the oxygen injection system, equipment operation, and construction details). Liquid oxygen (LO_X) would be stored in a tank located at the intake area. The oxygen would be diffused through 60 porous hoses mounted on the tunnel floor. By continuously supplying enough oxygen to raise the DO level in the bypass or leakage flow by 5 mg/L, the water in the power tunnel would be kept high in DO content eliminating low DO start-up conditions and the need to oversize the aeration system to handle those conditions. The location of the storage tank at the intake area would minimize the supply piping and position the tank above the headwater elevation of the project eliminating water back flow problems. The intake area is accessible by tanker truck for oxygen delivery. The oxygen supply tank would be remote from the powerhouse. However, it would be within a fenced enclosure. Therefore, vandalism is not expected to be a problem.

The oxygen flow rate would be adjusted to meet the DO requirements of any flow rate including the bypass flow. Injection of the oxygen at the upstream end of the power tunnel would allow maximum time for the oxygen to be absorbed into the water flow. During unit operation, the majority of the gas that is not absorbed would travel along the top of the tunnel and be safely discharged at the surge tank opening. Some gas pockets may tend to travel back upstream along the top of the tunnel to exit at the intake air vent (this can be minimized, if not prevented, with a deflector that is to be tested at Tims Ford). All of the gas not absorbed during bypass or leakage flow would exit at the air vent. The escaping flow of oxygen at the air vent is not expected to be a problem since it is vented to atmosphere, (as long as the manhole seal is good enough to prevent an enriched oxygen environment in the intake gate house.)

The major benefits are that one very efficient system would handle all DO requirements with flexibility to match seasonal variations. The power impacts would be negligible, and the installation and operation costs would be reasonable. The diffuser system would be installed to withstand flow velocities encountered during filling of the power tunnel via the 18-inch filler gates located at the intake. (This would occur approximately once every 5 years.) On the negative side would be the storage and handling of cryogenic liquid oxygen and gaseous oxygen piping hazards. Logistics of getting oxygen supply trucks to the site in a timely manner would have to be handled. Repairs to the oxygen injection system could require temporary shut down of Deep Creek Station, particularly if the repairs are in the power tunnel. The oxygen injection system would require annual maintenance by a diver, at least for the first few years. Diffuser lines also may need to be replaced every 8 to 10 years.

Oxygen Injection In The Power Tunnel Near The Surge Tank

Injection into the power conduit at the surge tank makes the initial installation of the oxygen system more difficult than at the intake and reduces the contact time between the water and oxygen bubbles. Nonetheless, due to the higher pressures within the power tunnel and conduit, and the total containment of the water, 100 percent oxygen utilization is achievable.

For injection into the power tunnel or penstocks, the location would have to be far enough upstream of the turbine to allow sufficient time for the oxygen to dissolve. Wilfley-Weber, a leading manufacturer of diffusers, recommends a 2 minute reaction time to insure that an oxygen stream having a 2 to 3 millimeter nominal bubble diameter will dissolve completely. Given the geometry and hydraulics of the Deep Creek Station penstocks/power tunnel, this would place the closest injection point to the turbines at the surge tank.

Injection of oxygen more than a few feet downstream of the surge tank is also not recommended because it is desirable to have divers pe[illegible]n annual inspections. Since the tunnel slope is very steep (i.[illegible] about 20 percent) immediately downstream of the surge tank, the higher pressures would make diving operations a short distance downstream of the surge tank extremely expensive or prohibitive. (Alternately, the entire power conduit could be drained for annual inspections but this would cause additional expense.) Further, it is better to locate the diffusers just upstream of the surge tank rather than just downstream, for the following reasons:

- The equivalent depth at the surge tank is about 100 feet. Two hundred feet downstream, the equivalent depth is 140 feet. The greater depth directly equates to reduced diver safety margin in terms of increased time and distance to safety, increased susceptibility to decompression sickness and nitrogen narcosis, and reduced air supply (a tank of air will last only one-fourth as long at a depth of 100 feet, due to increased air density, as it would last at atmospheric pressure).

- The leakage flow rate, approximately 9 cfs, will cause a current in the tunnel that is significant, but not dangerous for diving operations. Whenever possible, divers prefer to work upstream of their route of egress, so that the current is pushing them towards safety, rather than away from it.
- Tools dropped on the steeper downstream slope would quickly roll or slide, with assistance from the current, all the way to the turbines (impaired manual dexterity is a significant fact of life for divers).
- The carbon steel tunnel liner installed approximately 50 feet downstream of the tank (but not upstream) would be attacked by galvanic corrosion if allowed to come in contact with the new stainless steel piping. Carbon steel wastage would increase the clearance between the pipe and concrete tunnel wall, allowing the oxygen header to oscillate, inevitably resulting in structural failure.
- The steel liner is an additional impediment to anchor bolt installation.

At some point in early to mid-summer before the lake stratifies, divers could enter the surge tank through the existing manway and descend to the bottom of the vertical flooded shaft, through the nine-foot diameter opening, and into the power tunnel to inspect and service the diffusers as required. Depending on reservoir level, the divers would be working at a maximum depth of 93 to 104 feet, which is within the comfortable range for commercial diving operations. Most of these visits would involve only inspections; when diffuser replacement becomes necessary the diffusers would be removed and replaced as appropriate.

The potential for significant oxygen wastage, by bubbling up into the surge tank during no-generation conditions, was considered and found not to be a problem. The small bubbles (2 to 4 mm) produced by the diffusers have a low rise rate and are effectively entrained by the turbulent flow, even at the no-generation water velocity, and then carried down the conduit to the turbines.

Injection of oxygen at the surge tank allows the oxygen storage facility to be located relatively close to the powerhouse and within the existing security fence of the power plant area, diminishing the risks of vandalism, tampering, accidents, etc., and facilitating operation of the oxygen injection system. Operator time and expenses would be reduced because oxygen flow could be monitored and controlled directly from the powerhouse. The existing road to the surge tank is marginal at best, and would require expensive upgrades to permit oxygen deliveries by tanker trucks. The visual setting of the Deep Creek Lake intake area would not be compromised by the oxygen storage facility.

The oxygen supply line would be above ground and would extend from the storage vessel to the surge tank, along the same general route as the penstocks and power tunnel. This route would pose engineering and construction difficulties on the almost vertical hillside immediately downstream of the surge tank. Also, access into the surge tank itself for construction and maintenance of the diffuser system would be difficult.

An alternate routing would involve running the oxygen supply line parallel to the penstocks as before, but then penetrating into the power tunnel just upstream of the bifurcation (still inside the fence), and running the supply line along the inside of the steel lined power tunnel for a distance of approximately 484 feet to the injection point below the surge tank. This method would not expose any portion of the system, thus offering better security. The drawbacks to this routing are the slope within the power tunnel, possible difficulties in drilling through the old steel tunnel liner to secure the oxygen supply line, and galvanic corrosion problems caused by contact of the new stainless steel piping with the old carbon steel tunnel liner (the power tunnel is not steel lined upstream of the surge tank where the diffusers would be located). While plastic pipe and anchor straps would not create galvanic problems, the lower strength of plastic would require more attachment points.

Although security would be improved, visual impacts would be negligible, and oxygen injection monitoring at the powerhouse would be facilitated, the lack of suitable site access, the supply line construction difficulties, the diffuser maintenance difficulties, the higher construction cost relative to construction at the intake, and the lower oxygen contact time make this option inferior to oxygen injection in the power tunnel immediately downstream of the intake.

Draft Tube Oxygen Injection

Injection of oxygen into the draft tube would allow all of the oxygen related equipment to be located in the immediate powerhouse area. The tank could be easily monitored and would not be susceptible to vandalism. However, the disadvantages of this option are more significant. In order to disperse the oxygen into the draft tube, some sort of manifold would have to be built into the draft tube. This would require removal of concrete and spacing of discharge points around the periphery of the draft tube. The oxygen supply piping to the draft tube would be run through the plant, requiring further removal of concrete as well as ventilation and other safety precautions. The expected oxygen transfer efficiency (OTE) for a draft tube injection system would be about 45 percent. This means that the oxygen requirement for normal 2 unit flow would be 129 scfm, significantly more than more efficient injection locations. Furthermore, aerating the low DO start-up slug would require an oxygen system capacity of greater than 350 scfm. The bypass flow also would not be aerated. For these reasons, further study of draft tube oxygenation was discontinued in favor of more efficient options.

Tailrace Oxygen Injection

Injection of oxygen into the tailrace would involve the installation of at least 75 flexible membrane discs in the tailrace. (There is insufficient room for the porous hoses.) The flexible membrane discs would be mounted above the oxygen supply header in a manner that would withstand the tailrace velocities. Injection into the tailrace would allow the oxygen system to be located near the powerhouse. The major disadvantage of this system is that the OTE is not expected to exceed 20 percent. This low efficiency is due to the shallow depths of the tailrace and requires an oxygen system capacity of almost 300 scfm to aerate the normal 2 unit flow and 725 scfm to aerate the low DO start-up slug. Further disadvantages are that this system would intrude into the habitable portion of the tailrace and would require disturbances during installation in the tailrace. For these reasons tailrace oxygen diffusion was not studied further. (If air injection in the tailrace were selected, at least 5 times the flow rate and 375 flexible membrane discs would be required. This arrangement was not considered feasible.)

RECOMMENDED SOLUTION DESCRIPTION

The recommended solution is the construction of a labyrinth tailrace weir (See Figure 1, Attachment 3). The weir would be 430 feet long and would have an effective height of 3 feet during moderate and high flow conditions in the Youghiogheny River. The weir may be constructed with or without flap gates, may be precast or constructed using cofferdams, and may be constructed of reinforced concrete or sheet metal. These latter items should be considered during detail design.

REASONS AND BENEFITS

Construction of a labyrinth tailrace weir is recommended for the following reasons:

1) Present worth cost is lower than the present worth cost of other alternatives,
2) Maintenance requirements are minimal,
3) Continuous DO monitoring may not be required after weir performance is evaluated for various operating conditions, and
4) Tailrace weir life expectancy should be 40 years or more.

EFFECT ON PLANT OPERATIONS

- The tailrace weir should be inspected annually.

- Net head and energy production of station would be reduced by up to one percent.

PERMITS REQUIRED

Installation of the tailrace weir will require a construction permit from Garrett County. State approval will be required, but this should be granted through the Permit To Appropriate And Use Waters Of The State. Approval from the State to construct in a floodplain may also be required. Special aesthetic considerations may be needed to comply with Maryland Wild and Scenic River requirements.

ATTACHMENTS

LIST OF ATTACHMENTS

1. Cost Data for single weir option and direct oxygen injection into the power conduit

2. Table of weir heights

3. Figure 1. Tailrace weir

4. Layout and photographs of Canyon Dam tailrace weir

5. Oxygen Injection System - Power Tunnel Intake Description and Photographs of Tims Ford oxygen injection diffuser system

6. References

ATTACHMENT 1

COST DATA

Tailrace Weir

The effective height of the weir is defined as the upstream water elevation minus the downstream water elevation. Therefore the weir height is equal to the effective weir height plus the existing tailrace water depth less the depth of water flowing over the crest of the weir. For the maximum powerhouse flow rate of 640 cfs, the actual weir structure height would be about 8.4 feet (i.e., effective weir height of 4 feet [3 feet at higher Youghiogheny River flows] plus maximum flow depth of 5 feet less overflow depth of 0.6 feet.) Because the tailrace is deeper at the powerhouse this analysis assumes that the weir is placed further downstream. Using this height, a weir thickness of one foot, and a foundation one foot thick and five feet wide, the weir would require 134 cubic yards of concrete for its vertical portion and 80 cubic yards for the foundation over the 430 foot crest length.

Means Building Cost Data, 1992 (Reference No. 10) gives an estimated cost of $385 per cubic yard for 12-inch thick grade walls, and $4.80 per square foot for cast-in-place ground slabs including forms and reinforcing. This produces an approximate materials cost of $62,000. An additional $10,000 allowance is made for abutments and special concrete work. Four flap gates, each 8 feet long and 6 feet high, would add $2,500 each to the cost. In order to drain the weir, two 18-inch slide gates would be installed, costing $2,000 each. The materials and gate cost estimate of $79,000 compares favorably with the Canyon Dam tailrace which was constructed in 1989. The cost for the walls, slab, and galvanized steel gates for the Canyon Dam tailrace was $60,000.

A temporary cofferdam would be required to allow the powerplant to operate during weir construction. This coffer dam would involve the placing, compacting, and removing of approximately 700 cubic yards of material at a cost of approximately $20,000. Alternately, sheet piles might be used for this purpose, if there is not enough space available for an earthen dam. After dewatering, approximately 38 cubic yards of rock would have to be removed for the foundation, at $100 per yard. Miscellaneous costs include rock anchors, abutment drainage, gangways, and handrails. These costs are estimated to be $15,000. Alternative construction methods may also be employed that would not require a cofferdam. However, it is estimated that the costs for these techniques would be comparable to the estimate with a cofferdam. The total capital cost of the tailrace weir is estimated to be $283,000 (Table 1).

Based on a one percent energy loss during the period of operation of the tailrace weir (July-September) and average energy production of 5,300 MWh during this period, and a 0.1 percent energy loss during the remainder of the year, the total lost revenue would approximate $3,800 (at $50 per MWh). If the weir has a life expectancy of 40 years, the insurance per year should be approximately 1/40 of the installation costs (less engineering fee), or $3,750. Maintenance and labor costs (to raise and lower flap gates and occasional cleaning) are estimated to be $2,000 per year.

Summary of Annual Costs:

Maintenance/Labor	$2,000
Insurance (2.5% of installation):	3,750
Lost Power Revenues:	3,800
Total Annual Costs:	$9,550

The present worth of the annual costs over a 40 year period at 12 percent interest is $79,000.

Total Present Worth:

Initial Installation	$283,000
Annual Costs, Present Worth	79,000
Total Present Worth:	$362,000

TABLE 1

Tailrace Weir Capital Cost

Mobilization and Demobilization:	$ 5,000
Weir Construction (430 feet):	62,000
Weir Abutments/specialties:	10,000
Flap Gates (4 at $2500 each):	10,000
Slide Gates (2 at $2,000 each):	4,000
Temporary Dam:	20,000
Rock Excavation:	4,000
Disposal of Rock and Dredged Material	5,000
Geotechnical Investigation:	15,000
Miscellaneous:	15,000
Installation Cost:	$150,000
Engineering:	
- A/E	41,000
- Penelec	3,000
Project Management and Construction Supervision (15%):	23,000
Subtotal:	$217,000
Escalation (5%):	$ 15,000
Subtotal:	$232,000
Contingency (20%):	$ 46,000
Subtotal	$278,000
AFUDC:	$ 5,000
Total Project Costs:	$283,000

Direct oxygen injection into the power tunnel

Installation of the oxygen injection system is straightforward, and does not cause any reduction in plant output. The capital cost for installation is estimated to be $193,000 (Table 2). Annual costs include the oxygen, at a budget price of $90/ton delivered, insurance (1/40 of installed costs, less engineering), rental of the storage tank, annual inspections by a diver, and labor estimated at two hours per day when the plant is generating (130 hours/year at $30/hr.)

Oxygen:		$ 4,500
Insurance (2.5% of Installation):		2,100
Storage Rental:		10,000
Materials		1,000
Diver Inspection		1,000
Labor:		3,000
	Total Annual Costs:	$21,600

The present worth of the annual costs over a 40 year period at 12 percent interest is $177,000.

The present worth cost to replace the diffuser lines every 10 years over a 40 year period at 12 percent discount rate and 5 percent inflation is $20,000.

Total Present Worth:

Initial Installation:	$193,000
Annual Costs, Present Worth:	177,000
Diffuser Line Replacement, Present Worth:	20,000
	$390,000

TABLE 2
Oxygen Injection System Capital Cost

Mobilization and Demobilization		$ 5,000
Diffusers:		
Hoses: 60 - 1/2" × 50' @ 15/ea		$ 1,000
Brackets: 260 - 1/8" aluminum straps		$ 2,600
Fasteners: 1,040 concrete stud anchors		$ 1,000
Labor:		$ 15,000
	Total:	$ 19,600
Supply Piping:		
Pipe outside intake structure: 400 - 1" ss		$ 2,000
Pipe trench to intake walkway:		$ 1,000
Protective outer pipe: 400 - 2" ss		$ 7,000
Pipe and fittings in air vent: 60 - 1" ss		$ 400
Pipe inside penstock: 700 - 1" ss		$ 1,400
Headers: 10 - ss; 6 - 1" Ts w/ 3/4" red, 3" oc, 9'		$ 2,000
Fasteners: 200 - 2 hole ss, shot anchors		$ 500
Labor:		$ 25,000
	Total:	$ 39,300
Instrumentation and Control:		
Flow totalizer: vortex flowmeter and analyzer		$ 4,000
Pressure transmitter:		$ 1,500
Temperature transmitter:		$ 500
Remote operated valve:		$ 500
Labor:		$ 6,000
	Total:	$ 12,500
LO_x Storage Tank:		
Tank support pad: concrete w/mounting bolts		$ 7,000
Truck access: concrete unloading area		$ 3,000
Tank: 3 days max use = 3,000 gallons		$ Rent
Evaporators: max rate × 2 × $25/scfm		$ Rent
Piping:		$ Rent
Fence and signs:		$ 4,000
Installation/labor:		$ Rent
	Total:	$ 14,000
Total Direct Costs:		$ 90,400
Engineering Costs:		
- Penelec		$ 3,000
- A/E		$ 41,000
Project Management and Construction Supervision (15%):		$ 14,000
	Subtotal:	$ 148,000
Escalation:		$ 9,000
	Subtotal:	$ 157,000
Contingency:		$ 31,000
	Subtotal:	$ 188,000
AFUDC		$ 5,000
Total Project Costs:		$ 193,000

ATTACHMENT 2

TABLE OF WEIR HEIGHTS

The following tabulated values are the required total effective height, in feet, of a weir to increase the dissolved oxygen content, in mg/l, over the range shown on the vertical scale, at the temperatures shown, for Deep Creek's normal barometric pressure. Total effective height is the difference between the upstream water level and the downstream water level, and includes the depth of water flowing over the weir.

	15°C	16°C	17°C	18°C	19°C	20°C
0.0-1.0	0.48	0.48	0.47	0.47	0.47	0.47
0.0-2.0	1.11	1.11	1.11	1.11	1.11	1.11
0.0-2.5	1.51	1.51	1.52	1.52	1.52	1.52
0.0-3.0	1.99	2.00	2.01	2.01	2.02	2.03
0.0-3.5	2.58	2.59	2.61	2.63	2.65	2.67
0.0-4.0	3.31	3.35	3.38	3.42	3.45	3.50
0.0-4.5	4.27	4.33	4.39	4.47	4.54	4.62
0.0-5.0	5.57	5.69	5.82	5.97	6.12	6.29
0.0-5.5	7.54	7.80	8.09	8.42	8.80	9.24
1.0-5.0	4.22	4.31	4.40	4.50	4.60	4.72
1.0-5.5	5.70	5.87	6.05	6.26	6.49	6.74
2.0-5.0	3.03	3.08	3.14	3.21	3.28	3.36
2.0-5.5	4.17	4.28	4.40	4.54	4.68	4.84
2.5-5.0	2.47	2.52	2.56	2.62	2.67	2.73
2.5-5.5	3.48	3.57	3.67	3.78	3.89	4.02
3.0-5.0	1.94	1.97	2.01	2.05	2.09	2.14
3.0-5.5	2.83	2.90	2.98	3.06	3.15	3.25
3.5-5.0	1.43	1.45	1.48	1.51	1.54	1.57
3.5-5.5	2.21	2.27	2.33	2.39	2.46	2.53

ATTACHMENT 3

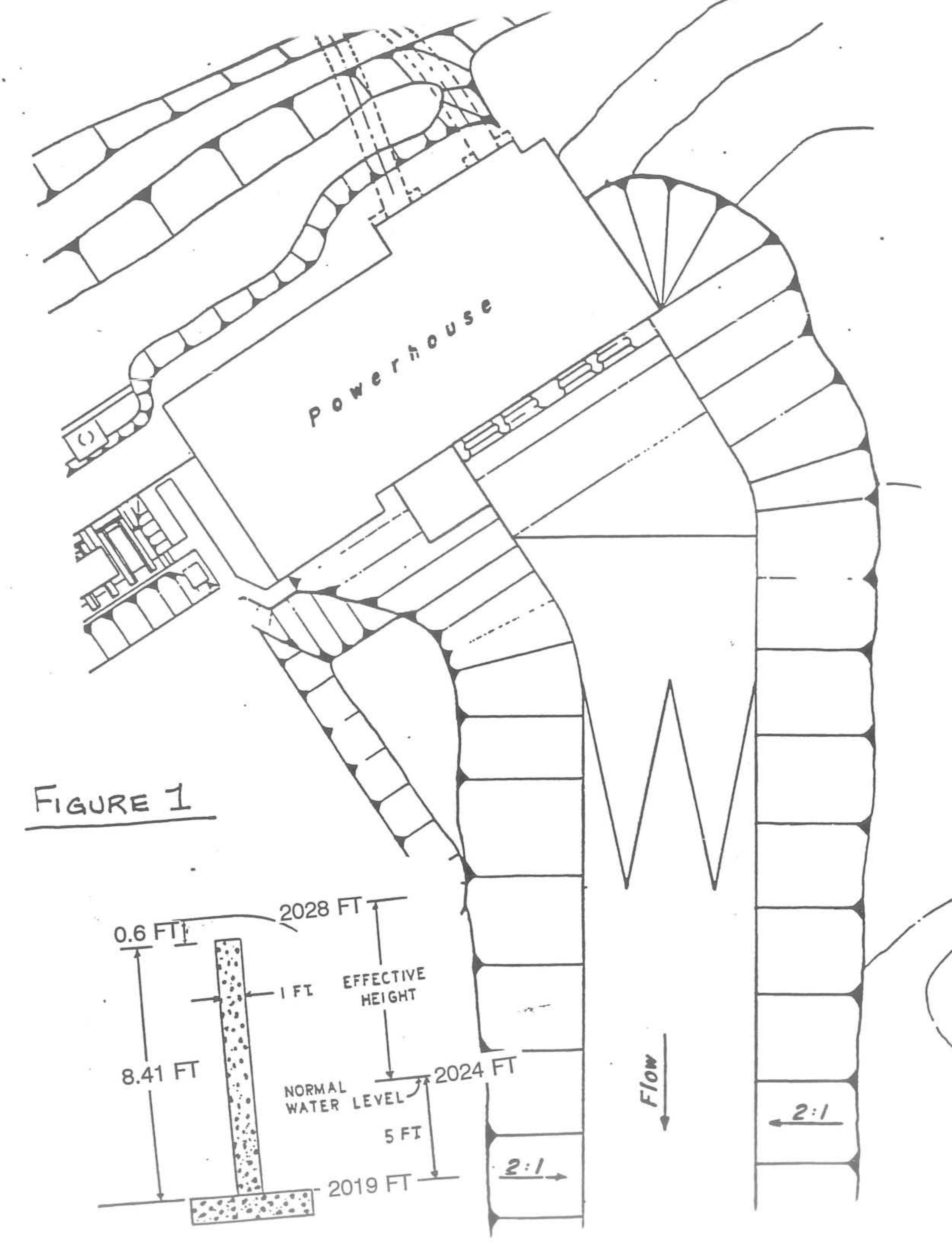

Powerhouse
2028 FT
0.6 FT
1 FT
EFFECTIVE HEIGHT
8.41 FT
NORMAL WATER LEVEL
2024 FT
5 FT
2019 FT
Flow
2:1
2:1

FIGURE 1

ATTACHMENT 4

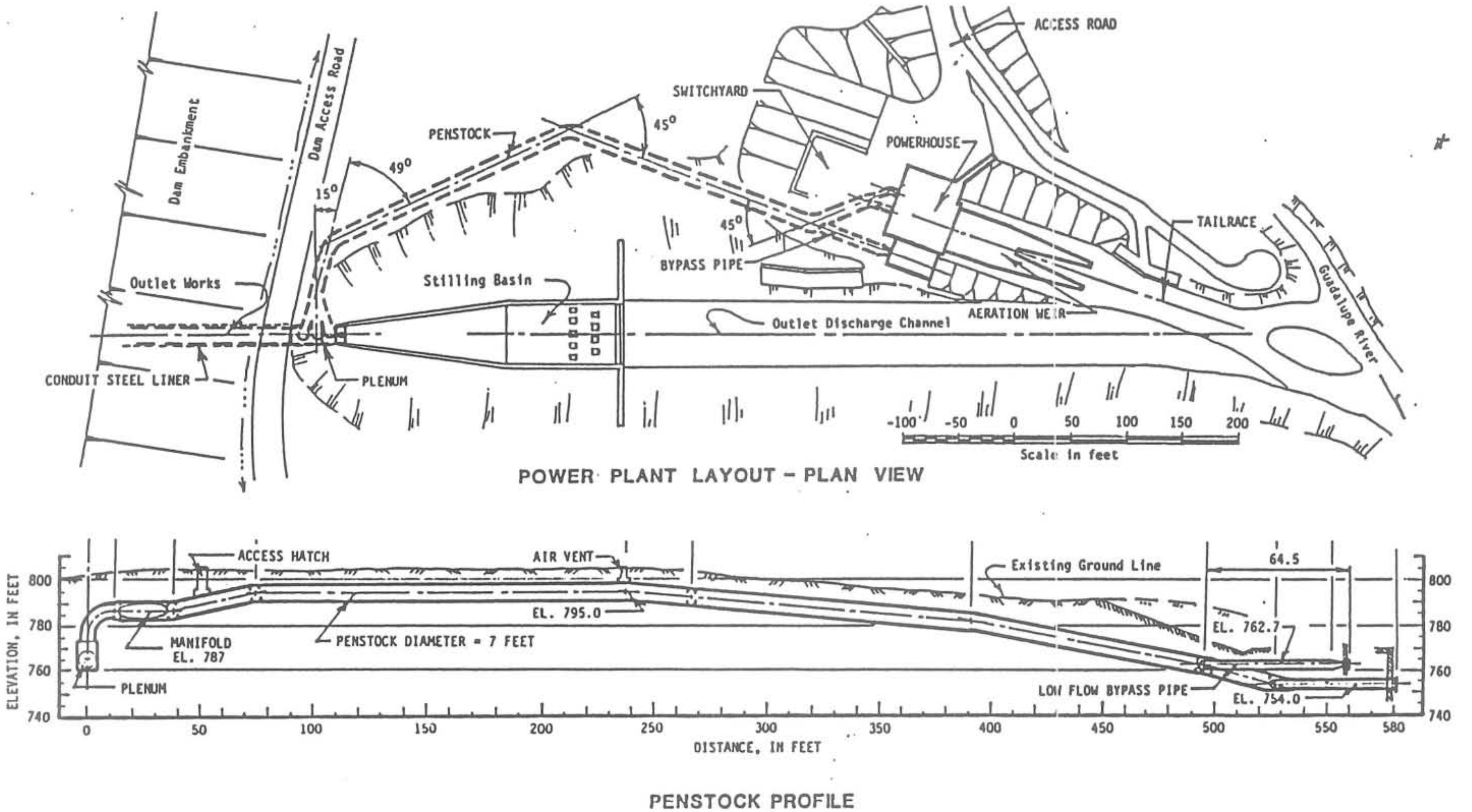
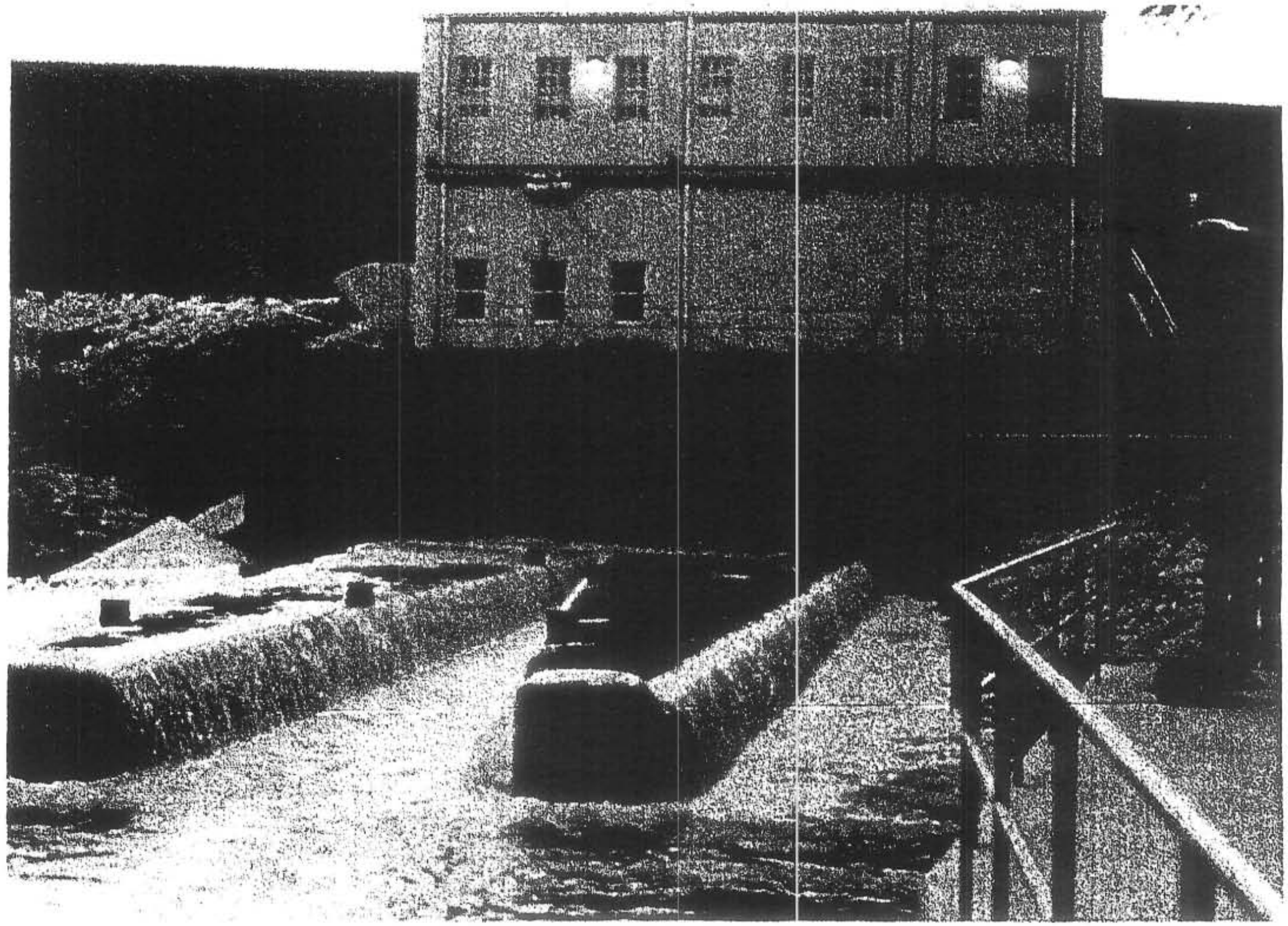


Figure 4. Canyon Power Plant Layout.

CANYON DAM
WEIR



CANYON DAM

ATTACHMENT 5

Oxygen Injection System - Power Tunnel Intake Description

Description of Equipment - An oxygen injection system for the upstream end of Deep Creek power tunnel would include: a liquid oxygen storage (LO_X) tank, vaporizer, flow controls, supply piping, and 60 diffuser hoses. The LO_X tank would be located within the fenced area at the project intake. A 3,000 gallon tank would provide sufficient liquid oxygen storage for about 3 weeks under normal operating conditions (i.e., 2-unit operation 5 hours per weekday). An ambient air vaporizer would be used with the tank to supply gaseous oxygen. The tank would be supplied with a low temperature shut off valve and a low pressure shut off valve. Pressure, liquid level or flow indication instruments may be desirable. Supply piping would be run underground to the intake walkway. It would be suspended underneath the walkway and enter the power tunnel through the intake tower air vent. A 1-1/2 inch header would be fastened along the floor of the tunnel to supply 60 diffuser hoses through 5 branch headers. The diffuser hoses would cover an area 4 feet wide by 270 feet long on the floor of the tunnel. Dewatering of the power tunnel would be necessary for installation of the portion of the system inside the tunnel or the intake air vent.

Operation of Equipment - An oxygen flow of 73 scfm is required to provide the desired 2 mg/L increase in DO for a 2-unit turbine flow of 640 cfs and an oxygen transfer efficiency (OTE) of 80 percent. (Tests at TVA's Tims Ford hydroelectric project have resulted in an OTE around 90 percent with a 600 foot long penstock and more closely packed hoses but Tims Ford does not allow the oxygen to vent before the turbine. No reliable measurement of the OTE along the penstock alone is practical due to nonuniform mixing.) The system would be set up to handle 3 flow rates, 73 scfm for 2 units in operation (i.e., a 2 mg/l increase in DO), 36 scfm for 1 unit (i.e., a 2 mg/l increase in DO) and 9 scfm continuously for the maximum bypass flow rate (i.e., a 5 mg/l increase in DO). An indication of tank level could be instrumented for display in the powerhouse for oxygen delivery requirements. Manual adjustment of a pressure regulator or control valve on a weekly basis should be sufficient based on DO in the tailrace.

Construction Details - The liquid oxygen storage tank would be mounted on a 10 foot × 10 foot × 14 inch concrete pad. The vaporizer would be mounted on a reinforced concrete pad 8 feet × 8 feet × 6 inches. An additional pad at least 12 feet × 12 feet x 6 inches would provide a safe unloading area for the oxygen tank truck. The unloading area must be positioned so that the truck is level and so that the off-loading pump at the back end of the truck is within 12 feet of the tank fill connection. The tank and truck would be positioned away from overhead powerlines and distanced from any buildings, walls or public parking as specified in NFPA 50.

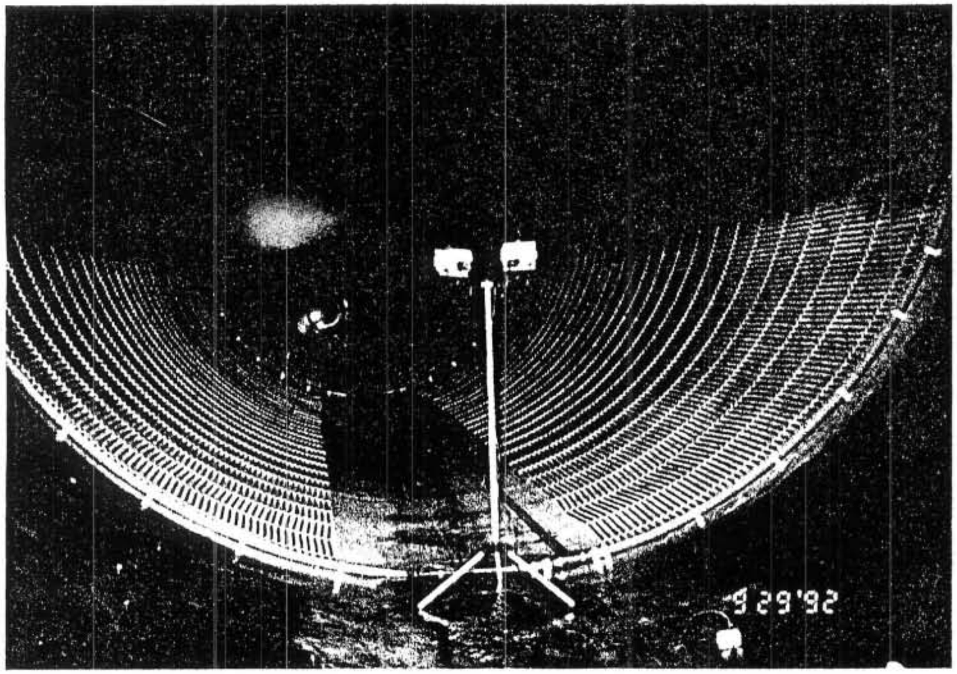
A fenced enclosure around the oxygen tank would be required for security. The fence would include a 4 foot gate for filling access. Signs warning the public of oxygen storage would be attached to the fence. Notification to local fire fighting authorities of the bulk liquid oxygen storage is required.

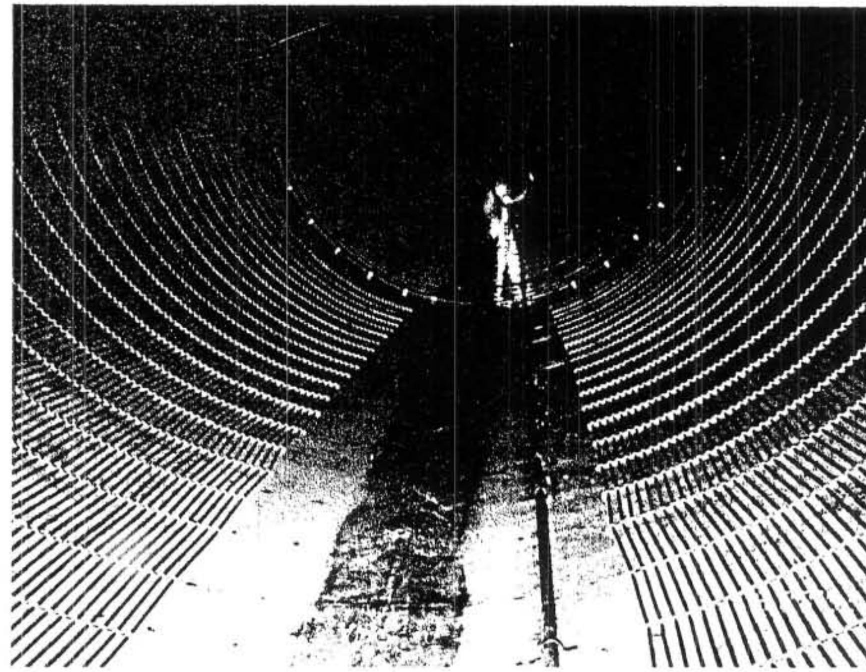
The oxygen supply tank would be equipped with a pressure build circuit, low temperature shut-off, low pressure shut-off, and tank pressure and liquid level indication. The piping supplied by the vendor would include a pressure regulator, bypass and manual control valve. (A flow meter and indicator would cost about $4,000 if desired.) The supply piping would have three parallel pressure regulators and valves to set the flow rates for 1 unit, 2 unit, and bypass flows. Slow opening remote operated valves would be used for automatic switching between chosen oxygen flow rates.

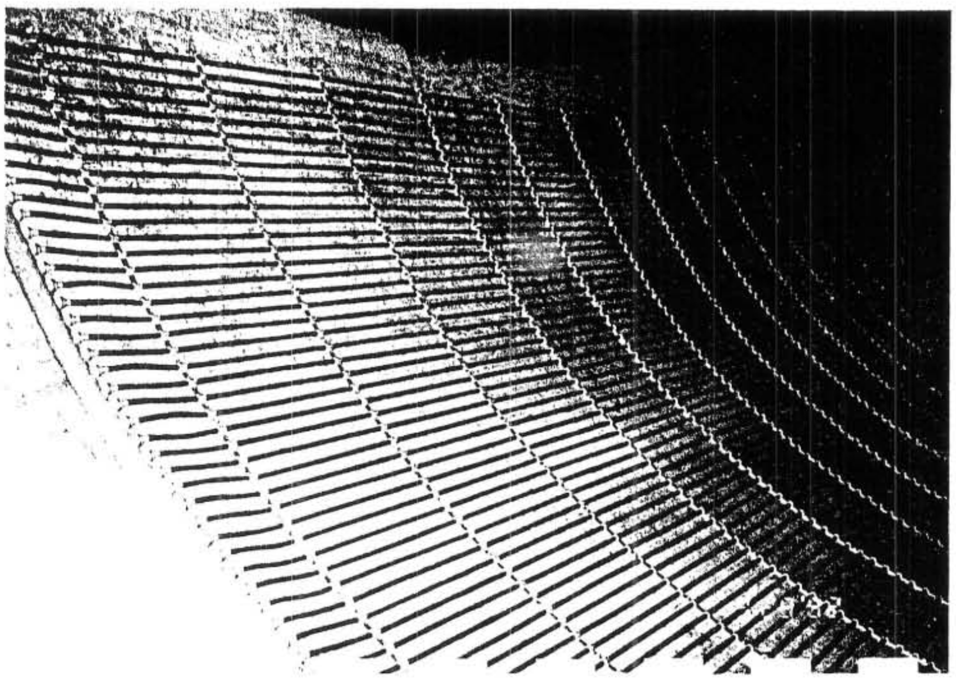
Supply piping for the system would be 1 inch diameter stainless steel. The piping would be installed in a trench from the fenced tank enclosure to the intake tower walkway. The pipe would run under the walkway and into the air vent in the intake tower wall.

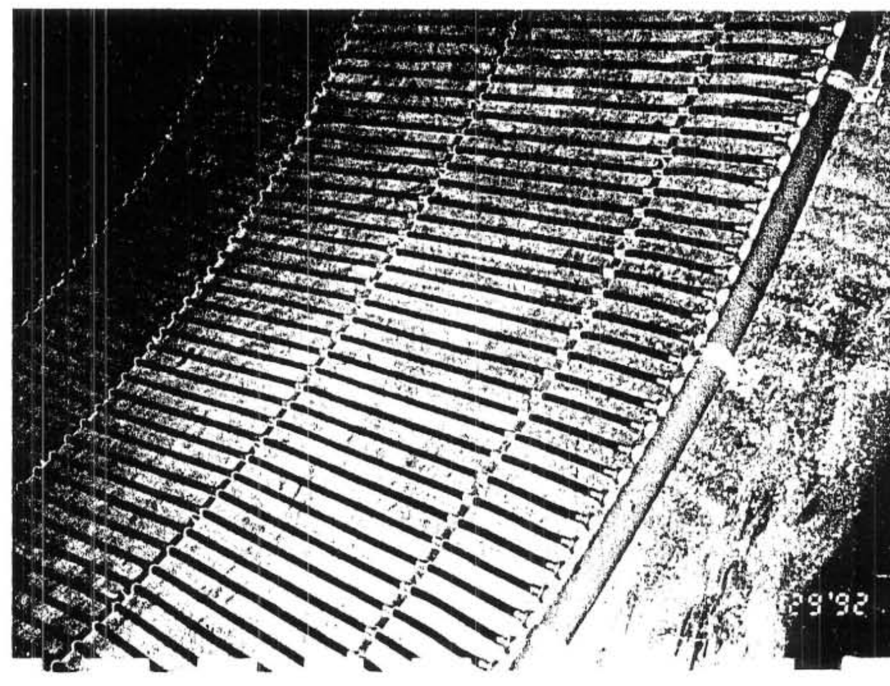
These portions of piping would be run inside a larger protective pipe. The penstock would be dewatered for the installation of the remainder of the supply piping and the diffuser hoses. The piping would be fastened to the air vent wall within reach of the manway ladder down to the elevation of the power tunnel opening. The concrete inside the power tunnel in the area of the diffusers would be cleaned to facilitate access and installation. Preshaped piping would be used to follow the curvature of the power tunnel wall from the air vent opening to the floor. The supply piping would turn downstream and be fastened along the floor of the power tunnel near to the wall. At a distance of about 20 feet from the intake entrance the supply piping would join the main oxygen header. This header would be 1 inch in diameter, 270 feet long, and would supply the 5 branch headers of the system. Each branch header would be 3/4 inch diameter and supply 12 diffuser hoses. Oxygen flow from the branch headers into each hose would be controlled through a 1/16th-inch diameter orifice valve. The hoses would be 3 inches apart, 50 feet long and secured to the tunnel floor with stainless steel straps every 2 feet. All fastening along the power tunnel and air vent could be done with shot fasteners or studs. Conventional pipe hangers could be used along the intake walkway.

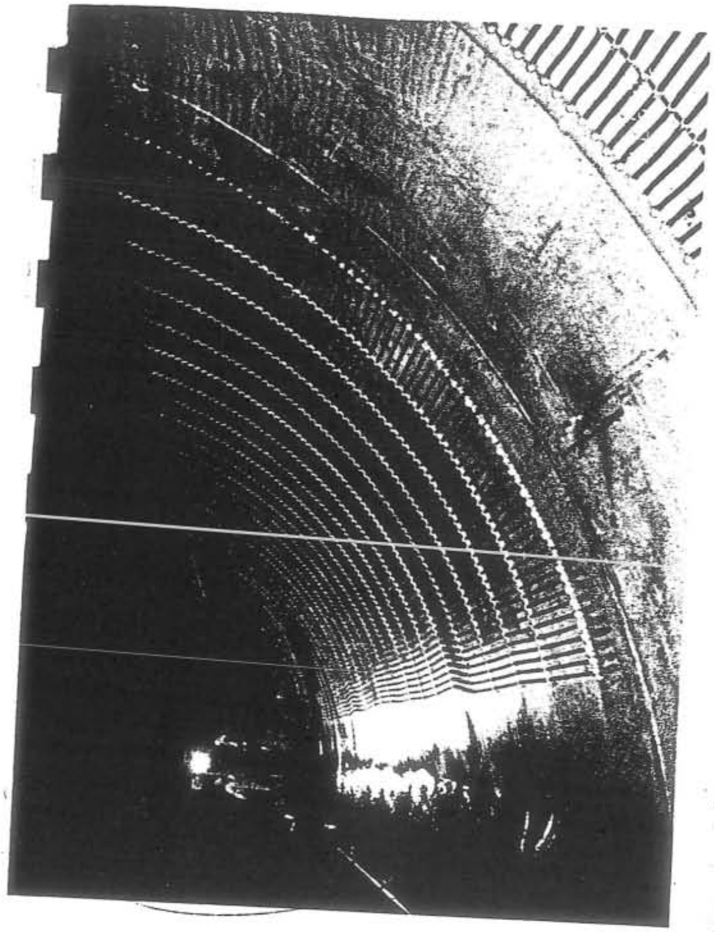
C-LINE #52564
35MM PRINTS

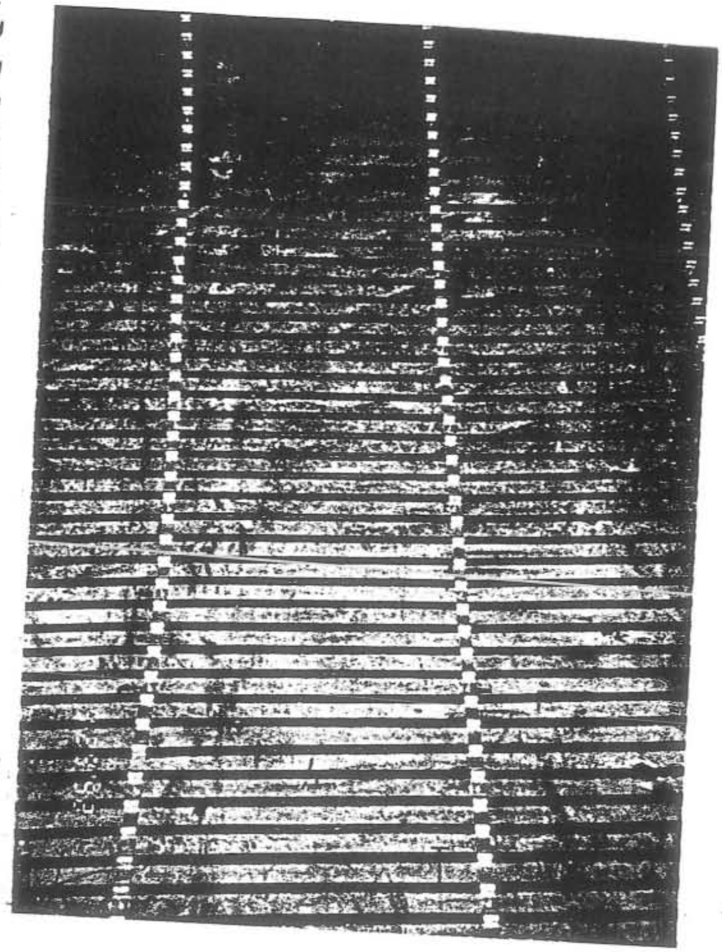


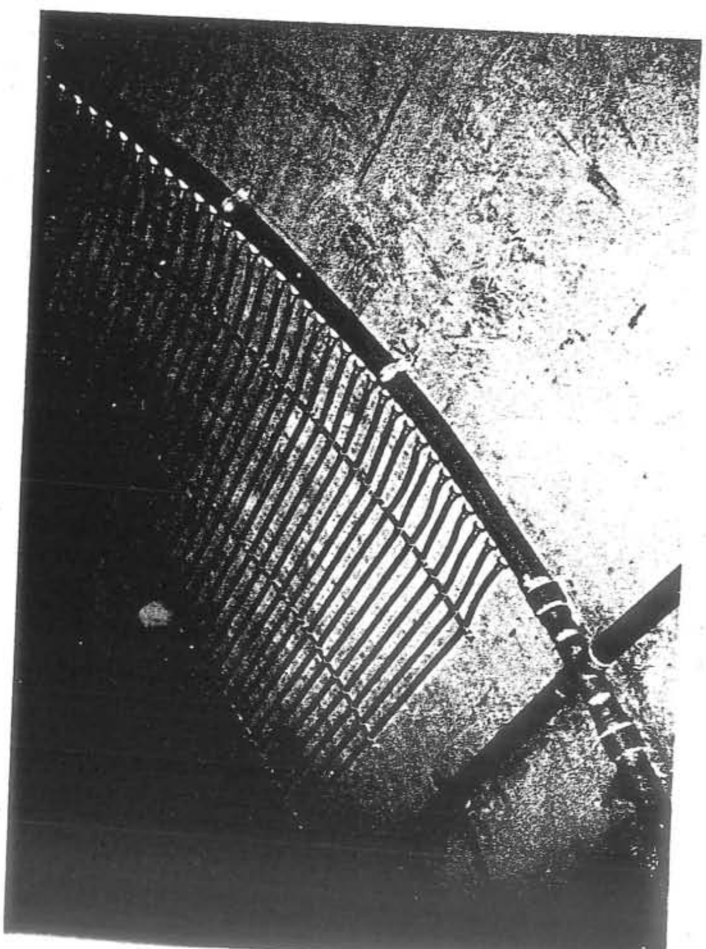













9 28 '92

ATTACHMENT 6

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APPENDIX F

1991 TEMPERATURE ENHANCEMENT TEST RELEASE

APPENDIX F

The first test release consisted of four one-hour releases of one turbine at reduced gate on June 27 (i.e., approximately 200 cfs). Flow above the tailrace was about 28 cfs. With this release pattern, the peak temperature at Sang Run was 25.8°C, as compared with 26.5°C on the previous day which likely had less warming than occurred on June 27. The temperature exceeded 25°C for only one hour on June 27, as compared with 4.8 hours the previous day.

The second test release consisted of four one-half hour releases of one turbine on July 17 (i.e., about 320 cfs). Flow above the tailrace was about 21 cfs. The peak temperature at Sang Run was 26.9°C, as compared with 26.2°C at the same location on the previous day when no generation occurred. The day of the test release probably had considerably more warming than the previous day, as indicated by the maximum water temperatures above the tailrace (25°C versus 23.5°C). Temperature was 25°C or higher for 3.8 hours with the test release, as compared with 4.7 hours on July 16.

The third test release consisted of one three-hour release of two turbines at full gate on July 19. Flow above the tailrace was about 16 cfs. The highest temperature in the river below the tailrace was 21.7°C at Sang Run, as compared to peaks of 28.1°C and 26.6°C at Sang Run on July 18 and 20, respectively. However, the day of the test release probably had less warming than the day before of after.

A fourth test release occurred on July 26 and consisted of a two-hour release commencing at 11 a.m. Flow above the tailrace was about 26 cfs. The highest temperature in the river below the tailrace was 21.1°C at Sang Run. On the previous day, which was somewhat warmer, the temperature reached 26.2°C at Sang Run.

A fifth release occurred on August 2 and consisted of a two-hour release which commenced at 12 p.m. Flow above the tailrace was about 21 cfs. The highest temperature in the river below the tailrace was 26.2°C at Sang Run. However, the temperature at Sang Run exceed 25°C for only about 30 minutes, indicating that an 11:30 a.m. release probably would have kept the river temperature below 25°C.

The final test release occurred on August 29 and consisted of a one-hour release commencing at 11 a.m. Flow above the tailrace was about 25 cfs. The highest temperature in the river was 25.7°C at a location between Hoyes Run and Steep Run.

APPENDIX G

FLOW BYPASS CONCEPTUAL ENGINEERING REPORT

CONCEPTUAL ENGINEERING REPORT

DEEP CREEK STATION

FLOW BYPASS SYSTEM

by

Ebasco Services Incorporated

June 1993

CONTENTS

1.0 EXECUTIVE SUMMARY

This report presents the conceptual design of a Flow Bypass System for the Deep Creek Station Hydroelectric Project. The purpose of the system is to release sufficient water from Deep Creek Lake via the Station's penstocks to maintain a minimum flow of 40 cubic feet per second (cfs) in the Youghiogheny River.

The most feasible and cost-effective method of providing the bypass is a bolted "tee" connection to the Unit 2 penstock, at a manhole located immediately upstream from the powerhouse. The bypass pipeline will be installed on the west side of the powerhouse and will discharge into the Station tailrace channel. A Polyjet valve will be used to dissipate energy; the Polyjet is preferred over a Howell-Bunger valve because it has a lower maintenance cost. Bids should be solicited for both types, however.

Either manual (outdoor) or remote (indoor) control of the regulating valve and its guard valve is feasible, with insignificant cost. However, since the station is attended only during the day shift on weekdays, remote operation from the Johnstown Control Center is recommended. Automatic control would require a flow measuring device in the river, and is not considered practical or economical.

The most cost-effective method of determining the flow in the river, to determine the valve setting, is to use satellite data presently available from the upstream river flow gauge in Oakland. The flow at Oakland will be obtained by accessing the Corps of Engineers' "River Bulletin Board" via a modem, and adjusting the flow to the site using a formula obtained by correlation analysis. Installing a gauge at the site may also be cost-effective if a weir is not needed to form a control section (see Section 3.1).

The estimated cost of installation of the Flow Bypass System is $186,300 including remote controls for operation from Johnstown. Operation and maintenance costs are expected to be minimal.

2.0 INTRODUCTION

The Deep Creek Station Hydroelectric Project consists of a large reservoir on Deep Creek (a tributary of the Youghiogheny River), a tunnel and two penstocks, and a power station with two Francis-type turbines, discharging to the Youghiogheny River. The watershed area of the Deep Creek Lake is 65 square miles. The watershed area of the Youghiogheny River just upstream of Deep Creek Station is 184 square miles, excluding the watershed of the lake. During dry periods in the summer and fall, the flow in the river may be less than 40 cfs. When both units of the Deep Creek Station are operating at maximum output, about 640 cfs are added to the river flow. It is proposed that a bypass system be installed to maintain a river flow of 40 cfs when the Station is not operating.

The FERC license for Deep Creek Station expires on December 31, 1993. It is anticipated that the Station will be operated under a Water Use or Appropriation Permit to be issued by the Maryland Department of Natural Resources (MDNR), effective January 1, 1994.

Alternative power generating schedules and quantities of instream flow releases have been evaluated to determine the optimum levels of benefits to water quality, recreation, fisheries and power generation. The proposed Project Operating rules, tentatively accepted by the MDNR, include the maintenance of a recommended minimum flow of 40 cfs in the Youghiogheny River downstream from the Station. The minimum estimated historical river flow at the Station was six cfs; thus the required capacity of the bypass system is 34 cfs. The 40 cfs minimum flow will increase the percent of total available brown trout habitat from 20% for the historical minimum flow to 48%. The release would also provide some incidental benefit of water temperature reduction during the summer period.

The bypass system will consist of an energy dissipating valve, a butterfly guard valve, a gate valve for shut off during maintenance and off-season, piping, and controls. A shutdown of the turbines and drainage of the Unit 2 penstock will be required to connect the bypass system. If the pipe flange is designed to fit the mandoor flange, the shutdown should not exceed two days.

3.0 ALTERNATIVE SOLUTIONS

3.1 Determination of Required Release

Flows in the Youghiogheny River are measured at U.S. Geological Survey (USGS) gauges upstream and downstream from the Station. The upstream gauge (No. 03075500) is located near Oakland, 10.0 miles upstream from the Deep Creek Station. The drainage area at the gauge is 134 square miles and mean daily flows have been recorded since 1941. The downstream gauge (No. 03076500) is located at Friendsville, 12.8 miles downstream from the Station. Records are available since 1940 and the drainage area is 295 square miles. Both gauges are equipped with Handar "560" transmitters as part of a data collection platform (DCP). Instantaneous flow data is transmitted by satellite to the Corps of Engineers' Pittsburgh office.

When the Station is not operating and the reservoir is not spilling, the reservoir watershed of 65 square miles does not contribute to the river flow, and the effective watershed area at Friendsville is 230 square miles. Under these conditions the effective watershed area of the Youghiogheny River at the Station is 184 square miles.

To determine whether to operate the bypass system and the required setting of the valve, the river flow at the time must be ascertained. The following alternative methods for determining the flow were considered:

1- Correlating the tailrace staff gauge at the Station with river flow;

2- Using the downstream Friendsville gauge;

3- Using the upstream Oakland gauge;

4- Constructing a new stream gauging station in the river upstream from the Station tailrace channel.

<u>Alternative Method 1</u> is not feasible. When low flow exists in the river, and the Station is not operating, there is a control section between the tailrace gauge and the middle of the river. The tailrace water level has poor correlation with the river flow; i.e. for a given tailrace stage value, a wide range of river flows from 20 to 100 cfs has been observed.

<u>Alternative Method 2</u>, the use of the Friendsville gauge, is clearly feasible during times when the Station is not operating. However, when the Station is operating, the gauge at Friendsville registers the power plant component of the flow as a rapidly rising, but gradually declining discharge. Table 1 shows recorded hourly discharges at Friendsville corresponding to two- to four-hour generating periods of the Station. For a typical power release occurring between 1 p.m. and 4 p.m., the flow at Friendsville generally begins to rise about 6 p.m., and does not return to the low flow value until about 11 a.m. of the following day. This would interfere with the use of the gauge to determine valve settings in the mornings.

<u>Alternate Method 3</u>, use of the Oakland gauge to estimate river flow at Deep Creek Station, would be a straightforward application of an adjustment formula to a gauge reading obtained at any time the valve may need to be adjusted.

Telemetric equipment is installed at the gauge, and can be accessed by the River Bulletin Board, a public information service of the Corps of Engineers. A personal computer and 2400-baud modem are required to access the Bulletin Board. Hourly flows at Oakland are available, with a four-hour time lag between the observation and its availability. The flow obtained would be adjusted to the Station site by applying a drainage area adjustment derived from correlation analysis between the Oakland and Friendsville gauges. The derivation of the adjustment formula is given in Appendix B, and the formula is as follows:

$$Q_{DC} = 1.68 \times Q_0^{0.97} \qquad \text{(Q's in cfs)}$$

The above formula is also shown graphically in Figure 1 (Appendix A). The required bypass flow would be 40 cfs minus the estimated river flow Q_{DC}, minus the estimated 7 to 9 cfs leakage flow through the turbines (if appropriate).

Flows obtained from the upstream Oakland gauge would be recorded well in advance of arriving at the Deep Creek Station. Thus the four-hour time lag would not reduce the usefulness of the Oakland data.

The most accurate possible data would be obtained by <u>Alternate Method 4,</u> constructing a new stream gauging station in the Youghiogheny River upstream from the Station tailrace channel. This would eliminate the errors due to time lag. To obtain a control section in the river which can be accurately rated for low flows, it may be necessary to construct a concrete weir in the river channel, depending on the stability of the natural channel.

To measure low flows only, a gauge installation would consist of 3-inch piping from the center of the channel to a shore unit consisting of a pressure gauge, a speech modem, a 4-cubic-foot housing, and a phone line to the Station. The initial cost of such an installation would be on the order of $3500. The USGS would make a series of flow measurements to develop a rating curve, at an additional cost of about $3500. Installation of a weir, if necessary, could cost from $5000 to $15,000 depending on the configuration and the subsurface conditions. The weir could pose an obstacle to fish. A computer to download the data for a permanent record would be a desirable option.

3.2 Layout of Facilities

The penstock tap and pipeline route offer one clear choice of a layout, and it is not necessary to consider any alternative alignments. A trip to the Deep Creek Station in November 1992 resulted in the observation that connecting the bypass system to the penstock of Unit 2 at the mandoor just upstream of the Station is a practical and economical location. Also, the most direct path for the pipeline from the penstock to the tailrace channel is around the west side of the powerhouse. The concrete powerhouse wall provides a readily available support for the 16-inch pipe. The arrangement is shown in Figure 2.

There is a choice between a two-valve and a three-valve system. At least two valves are necessary, and a third valve is recommended. The downstream valve would be a control valve which would dissipate the head between the tailrace and Deep Creek Lake, and set the release rate to the required value. A guard valve is also required to eliminate pressure on the regulating valve seat and thus reduce maintenance. A gate valve should also be installed near the penstock tap, to shut off the bypass system for maintenance of the guard valve and control valve, and to permit draining of the bypass pipeline in the winter to prevent freezing. The guard valve could serve this latter purpose; however if the gate valve were not provided, dewatering the penstock would be necessary to service the guard valve. In order to prevent damage from freezing of water trapped in the bottom of the valves and the low elevations of the piping, drain lines should be provided as necessary.

3.3 Equipment

The following head-dissipating flow control valves were considered:

1- Polyjet Valve

2- Howell-Bunger Valve

Option 1, the Polyjet valve, is described in Appendix C. The range of flow will be 0 to 34 cfs. Dissipation of the 400-foot head occurs within the valve. The water is released to the tailrace with almost no energy remaining. Very little maintenance is required. For example, three valves supplied to the City of Bogota, Columbia in 1977 have been operated continuously without needing any replacement parts.

Option 2, the Howell-Bunger valve, is described in Appendix D. The range of flow will be 2 to 34 cfs. Dissipation of the 400-foot head occurs as the water is released in a spray at a velocity of about 150 feet per second. If the spray is not contained in a hood, the water may cause soil or rock damage around the tailrace channel. This may not necessarily be a benefit, if a weir is to be provided for aeration of the operational flows. The valve would have to be located at the end of the bypass, a less convenient location than the Polyjet valve. Historically the Howell-Bunger valve requires more maintenance than the Polyjet valve. The spray would provide aeration of the water released.

An electric chain hoist may be appropriate to lift the Polyjet valve for servicing when necessary. The electric chain hoist could be mounted on an overhead WF beam depending on how the valve is to be serviced.

A gate valve provided as the furthest upstream shutoff valve may require special features to be operated under 410 feet of head. A gearing system would be sufficient for operation against the high head.

3.4 Operation

Either the Polyjet valve or the Howell-Bunger valve can be manually or remotely controlled. It is proposed to provide a wall-mounted control panel inside the powerhouse to allow remote operation of both the guard valve and the energy-dissipating valve. Telemetry equipment and a special phone line will additionally be required to operate the valve from Johnstown. The guard valve will be fully opened or fully closed by a signal from a 3-position, spring-return-to-neutral control switch. The energy-dissipating valve will be provided with an inching control and will be positioned by a 3-position, spring-return-to-neutral control switch at the control panel. A position transducer will be provided at the energy-dissipating valve, and will be connected to the valve position indicator at the control panel. A combined circuit breaker and starter will be provided for each valve, either installed inside of the control panel or locally at the valves. All three valves will be provided with security locks.

The river flow may rise or fall significantly within a 24-hour period, depending on hydrologic conditions. The control valve will initially be set to provide a total river flow of 40 cfs immediately after the Station ceases operation. If the ambient river flow decreases prior to the next plant operation, and the valve is not adjusted, trout habitat would be less than the desired level temporarily. If the ambient flow increases and the valve is not adjusted, a small amount of avoidable reservoir depletion would occur. The two types of events would occur in approximately equal number. Thus if only one daily valve setting is made, there would be no net change in the total reservoir volume used to maintain the minimum flow.

Receding hydrographs during low flow periods typically fall at 2 to 3 cfs per day, based on hourly flow data at Oakland. Following rainfalls, more rapid dropoffs of about 7 to 11 cfs in 24 hours have occurred. These dropoffs after rainfall events have occurred as frequently as five times during one summer. On August 22, 1988, the flow at Oakland dropped from 40 to 20 cfs in 24 hours. This indicates that the flow should be determined at least twice daily to sustain the 40 cfs minimum flow.

In November when low flows are no longer anticipated, the pipeline will be drained. The gate valve will be closed and the control valve and guard valve will be opened. An air inlet valve must be provided just downstream of the gate valve. Heating or insulation of the bypass system as far as, and including the gate valve, should be provided.

4.0 RECOMMENDED SOLUTION

The flow bypass system should be connected at the mandoor flange of the Unit 2 penstock, located directly upstream of the Station. The bypass system will consist of a gate valve, a butterfly guard valve, necessary piping and fittings, an energy dissipating valve such as a Polyjet valve (preferred), or a Howell-Bunger valve, and controls. The layout is shown in Figure 2.

To determine the required bypass flow, stream flow should be determined by accessing the Oakland gauging station, and applying an adjustment formula to the flow at Oakland (Alternative Method 3). The Oakland gauge data can be obtained by accessing the Corps' River Bulletin Board.

5.0 REASONS AND BENEFITS

In order to make the final selection of the control valve type, firm prices should be obtained at the time of design for both Polyjet and Howell-Bunger valves. The Howell-Bunger valve is expected to have a capital cost that is approximately $10,000 less than the Polyjet valve. This will be offset by additional costs for the hood to contain the spray, for locating the valve at the end of the bypass, and for increased maintenance. The capacity of the bypass system should be 34 cfs, which is equal to 40 cfs minus the minimum historical flow. The capacity should not be reduced by the 7 to 9 cfs turbine leakage, to allow for a future upgrade of the turbines or for changed operational procedures which might eliminate the leakage.

It is recommended that during normal operation of the Station, the valve setting should be adjusted every morning, and again after each operation of the Station. If the Station does not operate, the flow should be determined late in the day and the valve adjusted again if necessary.

The use of the Friendsville gauge to determine the required bypass valve settings requires only the addition of a modem and phone line to the "River Bulletin Board". However, the power plant releases introduce uncertainty into the Friendsville data, and also limit the time periods when the Friendsville gauge is registering low flows. Significant errors may occur when the power plant operates, because of the 18-to-20-hour unavailability of low flow readings at Friendsville. Use of the Oakland data with the adjustment formula is simpler and sounder. Additional data is available to update the correlation analysis between the Oakland and Friendsville gauges which was used to derive the formula (Appendix B). This analysis should be performed at the design stage of the Bypass System.

6.0 EFFECTS ON PLANT OPERATION

Based on a 30-year simulation of flows in the Youghiogheny River upstream of the Deep Creek Station, using gauge data from Oakland and Friendsville, monthly flow duration curves have been prepared (Figure 3). Flows less than 40 cfs are expected to occur in the months of June through November. The shaded area in Figure 3 is proportional to the volume of flow that would need to be released with the Bypass System, except that the System would not operate when the Station is generating. River flow is less than 40 cfs 7% of the time in June, 14% in July, 20% in August, 30% in September, 15% in October, and 4% of the time in November.

The effects of the Proposed Operating Strategy, including the 40 cfs minimum flow, on the Station operation were previously evaluated. Provision of minimum instream flows could significantly affect the energy benefit, as well as Deep Creek Lake recreation and whitewater boating. The proposed 40-cfs minimum flow would reduce the average annual energy generation of the Project by 100 MWH, a loss of revenue of $5000 (assuming $50/MWH), and would generally not have a significant effect on Deep Creek Lake water levels or the number of hours of generation in a particular month. For the 20-year simulation period (1970-1990), the lowest Deep Creek Lake summer water levels would be 0.1 ft. lower due to the required releases. Generally, in those months when Youghiogheny River flows would be augmented to maintain 40 cfs, project operation would be reduced by 6 to 8 hours per month. In the driest summer of the 20-year simulation (1988), annual generation would be reduced by 40 hours. Thirty-three of these hours would have occurred in July, August, and September of that year. The cost of providing the minimum flow would be $40,000 in a year like 1988.

7.0 COST ESTIMATES

7.1 Construction Costs

Gate Valve	$ 8,000
Butterfly Guard Valve with Manual Control	5,000
Polyjet or Howell-Bunger Valve with Manual Control	70,000
Piping and Supports	8,000
Relocation of Stairs	2,000
3-Ton Electric Chain Hoist (Optional)	4,000
Controls (at Station)	1,100
Remote Controls from Johnstown (not including monthly phone line charges)	6,300
Computer and Software for Flow Data (if not existing)	2,200
Installation	20,000
Engineering	38,700
Contingency	25,000
Total Installed Cost	$190,300

7.2 Operational Costs

Operational costs are expected to be minimal. Maintenance will be carried out by existing staff. Operational costs will include a monthly phone line charge for remote control from Johnstown.

TABLE 1

Friendsville Gauge-Flow Readings in cfs

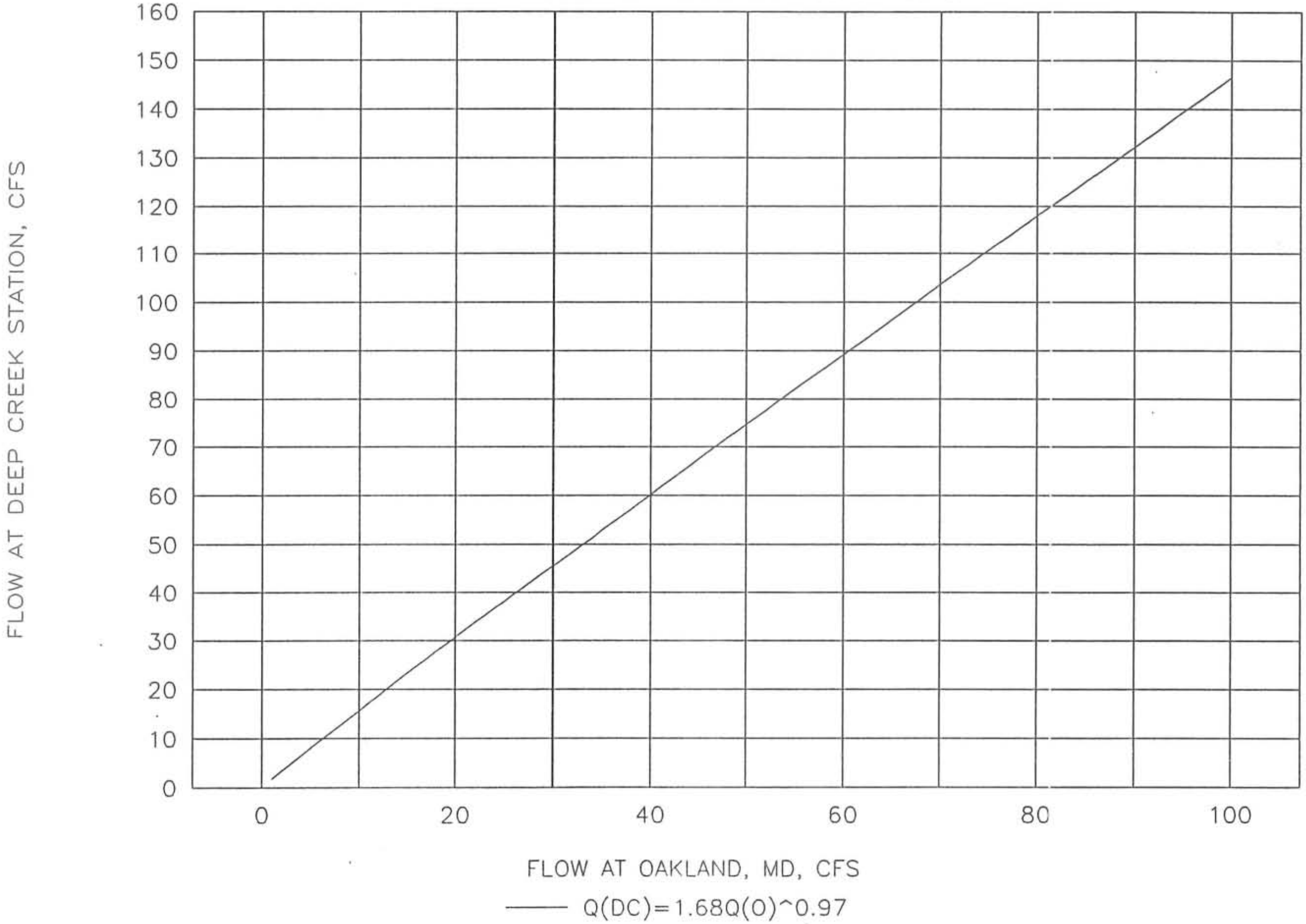
Time	Flow 2-Hour Release July 8, 1988 1300-1500	Flow 3-Hour Release August 12, 1988 1300-1600	Flow 4-Hour Release August 15, 1988 1300-1700
1800	41.1	29.9	39.7
1900	56.9	29.9	102.8
2000	380.0	584.1	680.9
2100	277.6	400.2	567.2
2200	207.1	283.1	386.6
2300	160.2	211.7	277.7
2400	127.2	160.2	207.1
0100	102.8	127.2	160.2
0200	85.8	102.8	124.0
0300	73.5	85.8	100.0
0400	64.9	71.7	83.6
0500	56.9	63.3	71.7
0600	52.4	55.4	63.3
0700	48.1	49.5	55.4
0800	45.2	45.2	49.5
0900	42.5	39.7	45.2
1000	42.5	37.1	41.1
1100	41.1	34.5	38.4

APPENDIX A

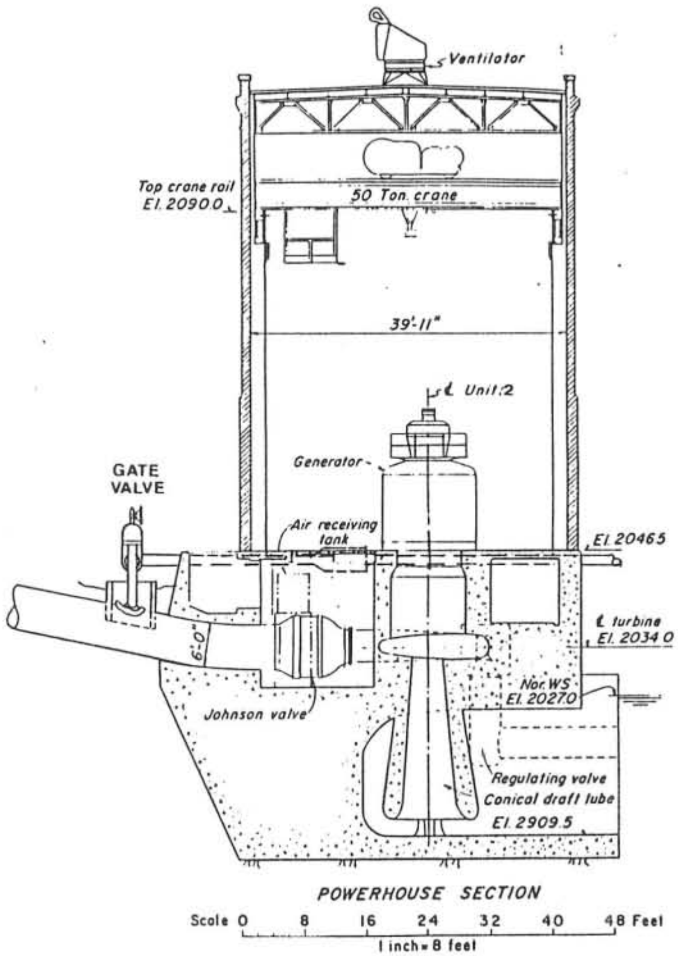
CONCEPTUAL DRAWINGS AND FIGURES

FIGURE 1

FLOW AT DEEP CREEK STATION VS. OAKLAND



This drawing prepared by Harza Engineering Company from drawings and measurements supplied by Pennsylvania Electric Company.



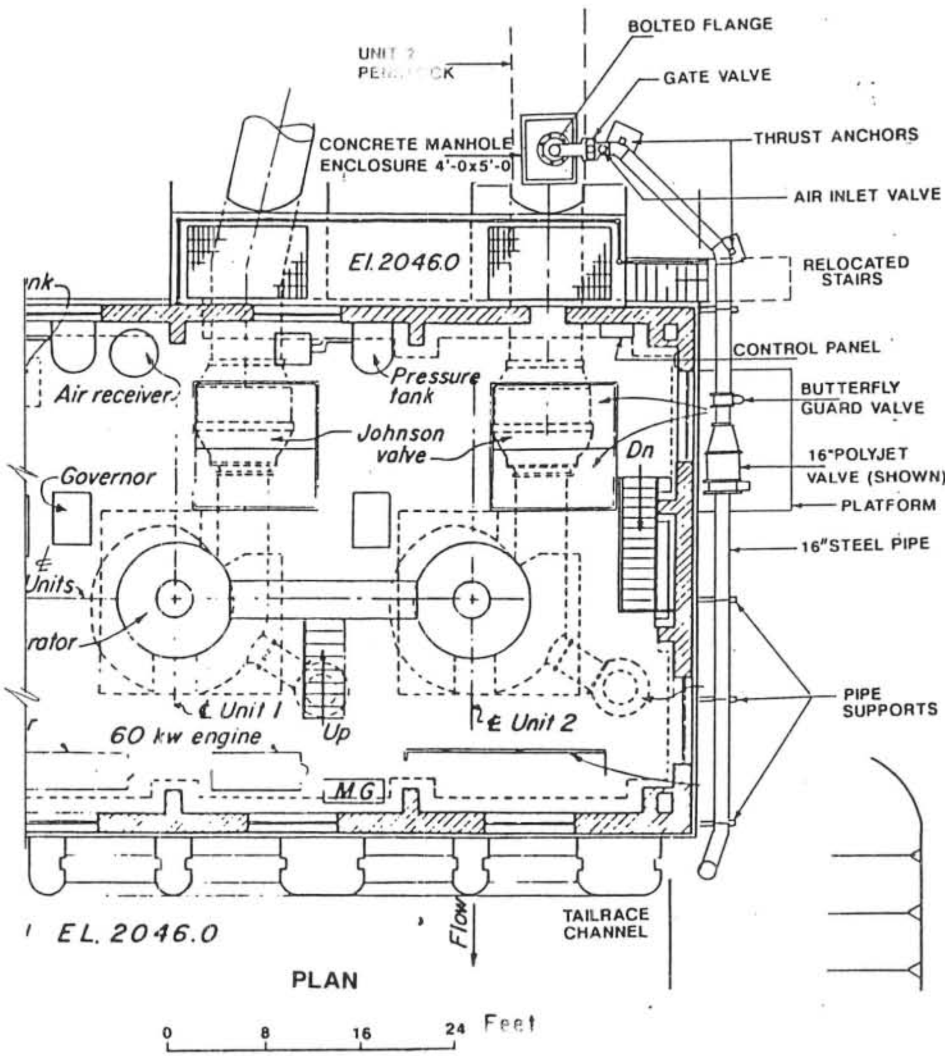
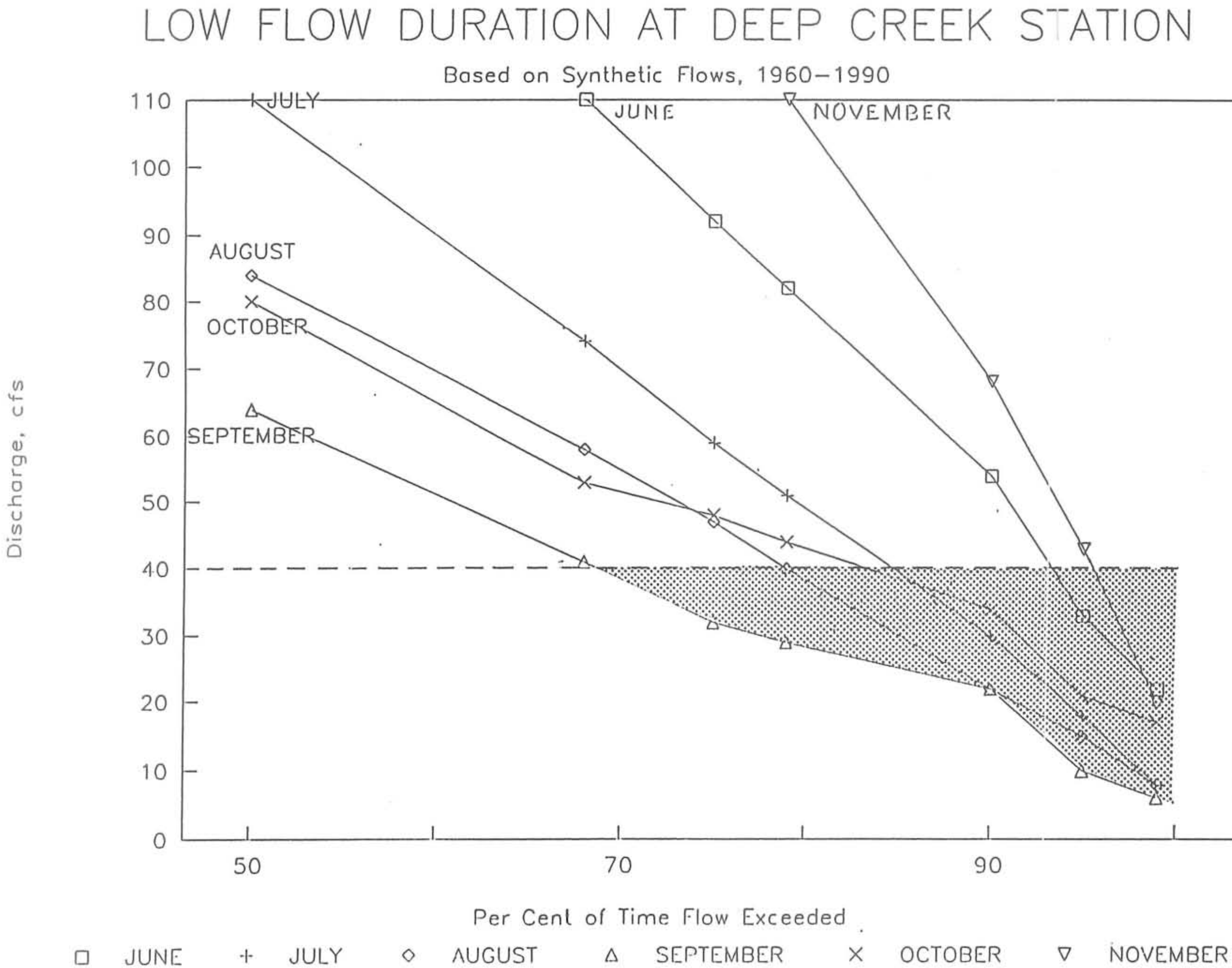


FIGURE 2
CONCEPTUAL LAYOUT OF FLOW BYPASS SYSTEM

FIGURE 3


LOW FLOW DURATION AT DEEP CREEK STATION
Based on Synthetic Flows, 1960–1990
JULY
JUNE
NOVEMBER
AUGUST
OCTOBER
SEPTEMBER
110
100
90
80
70
60
50
40
30
20
10
0
50
70
90
Discharge, cfs
Per Cent of Time Flow Exceeded
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

APPENDIX B

HYDROLOGIC ANALYSIS

APPENDIX B

HYDROLOGIC ANALYSIS

The drainage area at the USGS Oakland gauge, upstream from Deep Creek Station, is 134 square miles. The area at the downstream Friendsville gauge is 230 square miles, excluding the 65 square miles controlled by Deep Creek Station.

A logarithmic regression analysis was carried out using daily flow data from both gauges at times when the Station was not operating. The correlation was excellent, with a correlation coefficient (R^2) of 0.99 for the full range of flows and 0.95 for flows less than 100 cfs at Oakland. The relationship for the lower range of flows is given by:

$$Q_F = 2.3 \times Q_0^{0.957} \qquad \text{(Q's in cfs)} \qquad \text{(Equation 1)}$$

where F indicates the flows at Friendsville and O refers to Oakland.

For any point between the two gauges, the difference in flows can be proportioned by drainage area ratio. The total inflow between the gauges is:

$$Q_F - Q_0 = 2.3 \times Q_0^{0.957} - Q_0$$

Thus the flow at Deep Creek Station (DC), where the drainage area is 184 square miles, is given by:

$$Q_{DC} = Q_0 + \frac{184 - 134}{230 - 134} \times (2.3Q_0^{0.957} - Q_0)$$

or $$Q_{DC} = 1.2 \times Q_0^{0.957} + 0.48 \times Q_0 \qquad \text{(Equation 2)}$$

A simpler formula which very closely approximates the above is:

$$Q_{DC} = 1.68 \times Q_0^{0.97} \qquad \text{(Equation 3)}$$

Equation 3 is shown graphically in Figure 1. The difference between Equations 2 and 3 is less than 0.2 cfs for all flows at Oakland up to 100 cfs.

APPENDIX C

CATALOG DESCRIPTION OF POLYJET VALVE

Model 810 Inline

Model 810 Polyjet Valve

DESCRIPTION

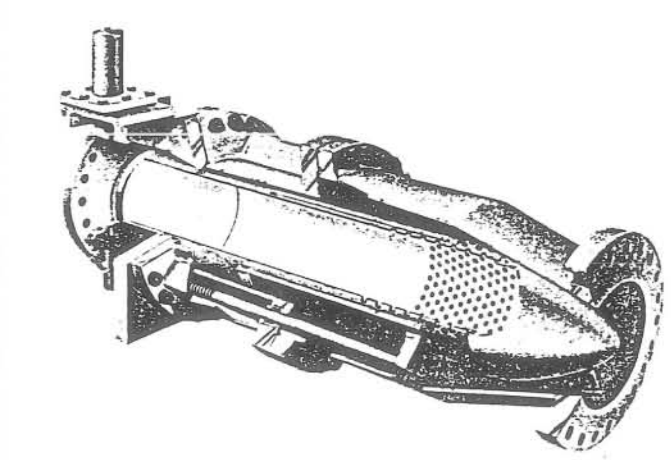
The Model 810 Inline Polyjet Valve is designed for inline applications where control of flow over a wide range is required. The valve operates cavitation-free at pressure drops and capacities that would cause severe cavitation damage in conventional control valves. A high unit flow factor permits operation at high flow rates with low differential heads.

The inline design of the Model 810 allows the valve to be used in series with other Polyjet valves with each capable of breaking more than 1000 feet of head. This allows the designer to simplify pressure reducing stations in high pressure drop applications.

- SIZES: 8 to 60 inches with 150#, 300#, 400#, or 600# flanges as required.
- **Available with cleanout and backwash features for ease of maintenance.** U.S. PATENT NO. 4508138
- CAPACITIES: 1 CFS to 590 CFS.
- Capable of breaking more than 1,000 feet of head.

APPLICATION DATA

Bailey personnel are prepared to provide assistance in valve selection. Submit preliminary specification such as upstream head, downstream head, and flow requirements for recommendations. Bailey engineers will assist system designers with layouts, control systems, and in meeting design requirements. (See page 9 for Model 810 performance curves.)

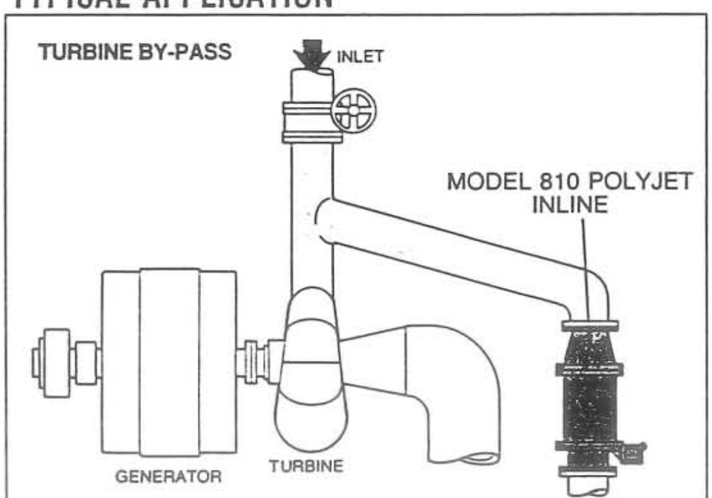


U.S.PATENT NO. 3605787

OPERATING PRINCIPLE

The operating principle of the Model 810 valve is based on throttling across multiple orifices that are specially sized, tapered, and positioned around a circular valve port. Valve opening characteristics are normally linear throughout the stroke, but can be made proportional or characterized for special applications. Control of the valve is normally motor operated. The operator can be made compatible with any standard control system. The valve is suitable for pressure reducing, relief, rate of flow, liquid level, surge suppression, and other similar water control applications.

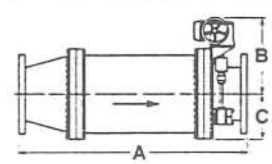
TYPICAL APPLICATION



DIMENSIONS – IN INCHES

SIZE	A	B	C
8"	50	27	12
12"	72	33	16
14"	78	33	16
16"	82	35	18
20"	100	37	20
24"	110	39	23
30"	115	41	27
36"	125	50	33
42"	150	55	36

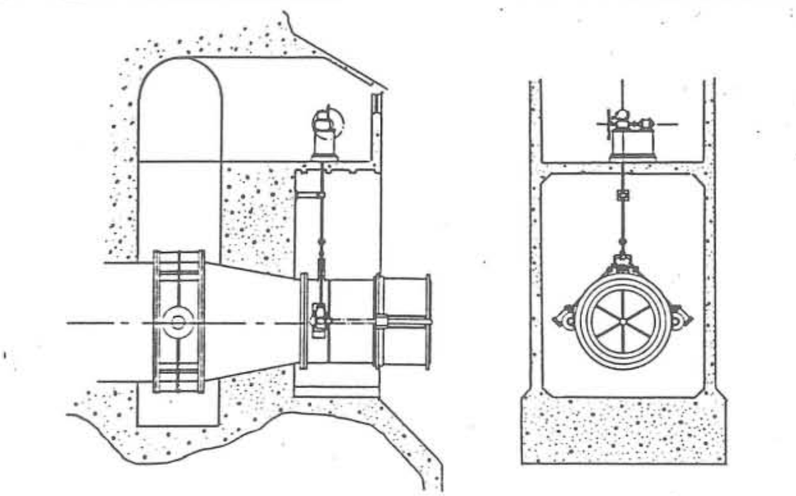
SIZE	A	B	C
48"	180	58	39
54"	210	63	44
60"	240	70	50

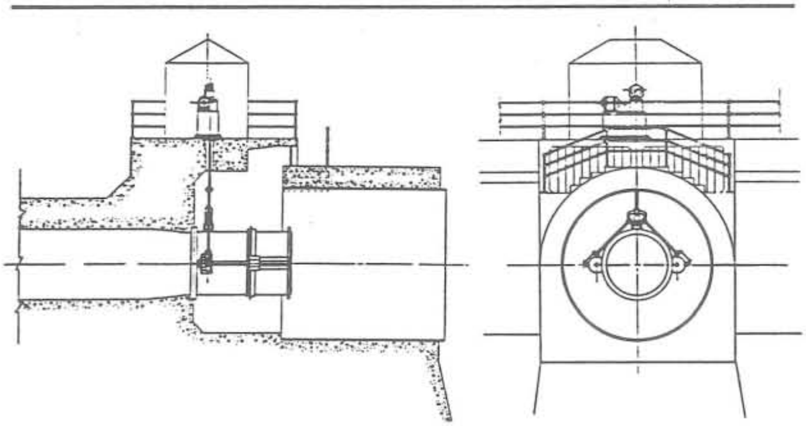


NOTE: All dimensions are approximate. Contact Bailey for specifics.

APPENDIX D

CATALOG DESCRIPTION OF HOWELL-BUNGER VALVE





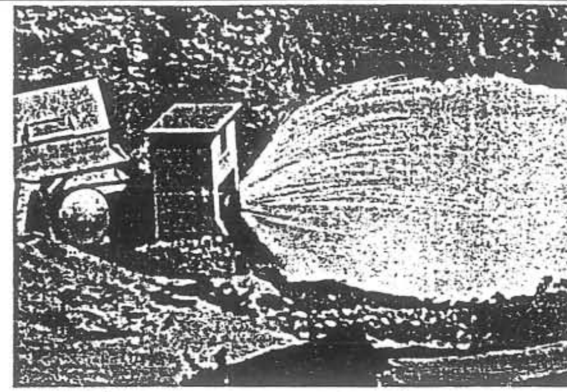


Fig. 3 — A 54-inch HOWELL-BUNGER valve under 138.5-foot head at Valle de Bravo Dam, Miguel Aleman System Comision Federal de Electricidad, Mexico, is shown discharging into atmosphere.

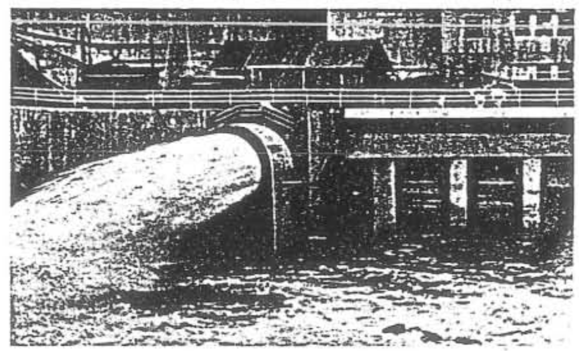
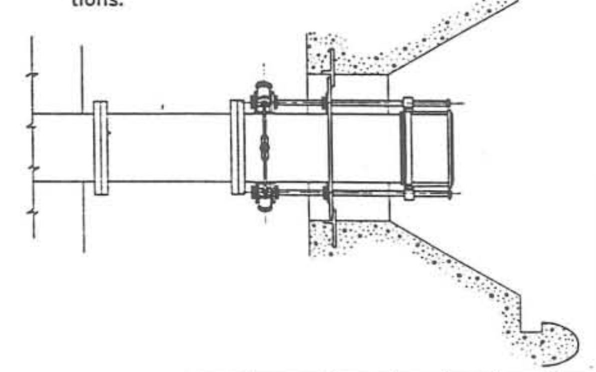
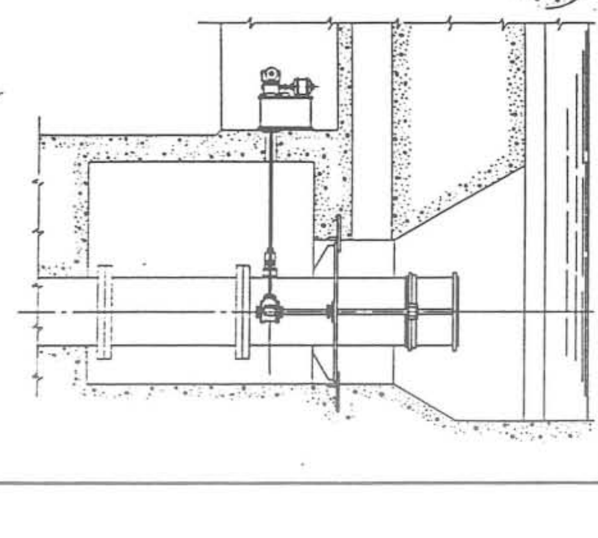


Fig. 4 — A 66-inch HOWELL-BUNGER valve discharging through a steel-lined hood at Alder Dam, Second Nisqually Power Project, City of Tacoma, Washington.

Fig. 5 — Submerged discharge arrangement. NOTE: submerged applications should be referred to Allis-Chalmers for recommendations.





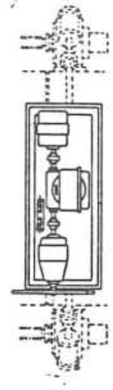


Fig. 6 — For subfreezing temperatures installation, the HOWELL-BUNGER valve shown has heaters and special discharge chamber. (See shop assembly in Fig. 16.)